The impact of thumb carpometacarpal osteoarthritis and the effectiveness of splinting

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A thesis submitted for the degree of
Doctor of Philosophy

At the University of Otago, Dunedin,
New Zealand

6 November 2020

Abstract

Background: Thumb carpometacarpal (CMC) osteoarthritis (OA) is a common, disabling condition, affecting substantial numbers of working and older-age people. It is the single commonest site affected by OA yet its unique characteristics, distinct from general hand OA, have received little individual attention – far less than hip and knee OA. In particular, little is known from patients' perspectives about the impact of thumb CMC OA. Furthermore, international guidelines recommend splinting as a non-surgical, non-pharmacological treatment option for CMC OA; however, evidence supporting splinting in people with thumb CMC OA is sparse and inconsistent.

The aims of this research were to: 1) explore the impact of thumb CMC OA from the perspective of people living with the condition; 2) investigate the effectiveness of splinting interventions for thumb CMC OA.

Methods: Three main studies were conducted: 1) a pragmatic qualitative study exploring the impact of thumb CMC OA in 30 individual interviews of people with the condition; 2) a systematic review with meta-analyses of previous studies reporting on the effectiveness of splinting for thumb CMC OA; 3) a feasibility study for a future fully-powered randomised controlled trial (RCT) investigating the effectiveness of a soft splint intervention combined with standardised best practice usual care vs best practice usual care alone comparator intervention. Design of the feasibility study was based on the findings from the qualitative study and the systematic review.

Results: The qualitative study identified five main themes representing five inter-related levels of health impact: negative experience of symptoms, functional limitations, restricted social activities and roles, negative thoughts and feelings, and altered sense of self. Pain, including pain at night, was the major concern. CMC OA impact was influenced by: dominant hand involvement; cold climate; people's financial, social, and societal support; and attitudes to the condition. Many areas of impact are unidentified and missing in currently recommended patient-reported outcomes. The study found a strong desire for access to high-quality information about self-management and effective non-surgical, non-pharmacological treatment options.

All evidence for splinting was of low quality. Splints cause a moderate-to-large reduction in pain (SMD -0.7 [95% CI -1.04, -0.35], < 0.0001) and small-to-moderate improvement in function (SMD -0.42 [-0.77, -0.08], p = 0.02) in the medium-term (3-12 months). No effect exists in the short-term. The review identified: variability in self-reported outcomes, case definitions, and rationale for splinting; low and variable splint dosage; lack of standardised usual care; unassessed QoL; and inappropriate study designs.

In the feasibility study, all primary outcomes surpassed the a priori thresholds for feasibility. Of thirty enrolled participants, 29 (97%) were retained at the 4-week and 6-month follow-ups. Interventions were acceptable and safe. Preliminary clinical findings suggested greater improvements in pain in the splint group vs comparator intervention in the short-term.

Conclusions: Thumb CMC OA has a profound impact on a person's health and well-being. Splinting is an acceptable and promising intervention although good quality evidence to support its use is lacking. A full RCT of splinting in addition to standardised best practice usual care for thumb CMC OA pain is feasible but should be preceded by exploration of dose effect and optimisation of outcome measures.

Acknowledgements

First of all, thank you to the study participants, without whom this work could not have been completed.

To my supervisory team, Dr Cathy Chapple, Professor G. David Baxter, and Associate Professor Simon Stebbings, for their excellent advice, guidance, and encouragement at every step, my sincere thanks. To Cathy, for opening this door and for inspiring my curiosity and critical thinking, thank you. Dave, for sharing your vast experience and wisdom in conducting research, many thanks. Simon, thank you for always offering a different perspective and coaching clear thinking. I am so grateful for what I have learned and I look forward to future projects and collaborations.

Sincere thanks to my international advisor, Professor Jo Adams, for generously sharing her knowledge of hand OA research online in virtual discussions at her kitchen table, on the other side of the world. Thank you to Katrina Pōtiki-Bryant, Associate Professor David Gwynne-Jones, and Bahram Sangelaji for advice, support, and collaboration, and to Professor Terence Doyle for x-ray reading.

Special thanks go to the wonderful Donna Keen for her superior ability to make all things research happen. Thank you to Marina Moss for her assistance in research administration. For their contribution as study assessors, I thank Hui Xiao, Ange McMaster, and Suranga Dessanayake.

My work colleagues at Dunedin Hospital and across the district deserve thanks for their enormous support, as do the staff and my PhD colleagues at the School of Physiotherapy for their warm collegiality, including Rani Othman and the Room 210 team. Thank you to Southern District Health Board managers and professional leaders for enabling part-time clinical work to align with research training.

This doctoral research was made possible by a part-time University of Otago doctoral scholarship. Financial support was received from the Physiotherapy New Zealand

Scholarship Trust and the Otago Medical Research Foundation Jack Thomson Arthritis Award.

To my whānau and friends, thank you for all your strength, friendship, and faith. Thanks to Robert Tait for masterful proof-reading. To my parents, Krishna and Rudi Bűhler, thank you for your support and encouragement over a lifetime.

Thank you to my daughter Miriam, son Isaac, and my partner Andrew for your love, support, and tolerance in this major commitment. I look forward to having more time to share.

This thesis is dedicated to my grandmother, Diane Francis, who has inspired discovery and action for my whole life, my cousin, Robert Francis, whom I remember with love, and my sister-in-law Jennifer Tait, who taught me grace.

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Publications

Peer reviewed journal

Bűhler, M., Chapple, C. M., Stebbings, S., Adams, J., Gwynne-Jones, D., & Baxter, G. D. (2020). Splinting for thumb carpometacarpal osteoarthritis: protocol for a feasibility randomized controlled trial. *Physical Therapy Reviews*, 1-9. doi:10.1080/10833196.2020.1763662

The candidate conceived and designed the study; was primary author, drafted and revised the manuscript.

Bűhler, M., Chapple, C. M., Stebbings, S., Pōtiki-Bryant, K., & Baxter, G. D. (2019). Impact of thumb carpometacarpal osteoarthritis: a pragmatic qualitative study. *Arthritis Care & Research*. doi:10.1002/acr.24124

The candidate conceived and designed the study; acquired, analysed and interpreted the data; was primary author, drafted and revised the manuscript.

Bűhler, M., Chapple, C. M., Stebbings, S., Sangelaji, B., & Baxter, G. D. (2019). Effectiveness of splinting for pain and function in people with thumb carpometacarpal osteoarthritis: a systematic review with meta-analysis. *Osteoarthritis and Cartilage, 27*(4), 547-559. doi:10.1016/j.joca.2018.09.012

The candidate conceived and designed the study; acquired, analysed and interpreted the data; was primary author, drafted and revised the manuscript.

Peer reviewed conference

Oral presentations

Bűhler, M. (2020). Splinting options and effectiveness in thumb CMC OA (invited speaker), 12APFSSH/8APFSHT – Asian Pacific Federation of Societies for Surgery/Hand Therapy Congress, Melbourne, Australia. 14 March, 2020.

The candidate designed the study; acquired, analysed and interpreted the data; composed and gave the presentation.

Bűhler, M., Chapple, C., Stebbings, S., Pōtiki-Bryant, K., Baxter, D. (2018). Impact of thumb base osteoarthritis: a qualitative study of patients' perspectives. Platform

presentation (free paper), Physiotherapy New Zealand biennial national conference, Dunedin, New Zealand. 15 September,1 2018. http://hdl.handle.net/10523/8477

The candidate designed the study; acquired, analysed and interpreted the data; composed and gave the presentation.

Bűhler, M., Chapple, C., Stebbings, S., Pōtiki-Bryant, K., Baxter, D. (2018). Impact of thumb base osteoarthritis: what do patients tell us and what does that mean for outcome measurement? Platform presentation (free paper), NZ Society for Surgery of the Hand biennial national meeting, Queenstown, New Zealand. 25 July, 2018.

The candidate designed the study; acquired, analysed and interpreted the data; composed and gave the presentation.

Poster presentations

Bűhler, M., Chapple, C., Stebbings, S., Baxter, D. (2016). The effectiveness of splinting for reducing pain and improving functional status and health-related quality of life in individuals with thumb base OA: a systematic review. Poster presentation, IFSSH/IFSHT – International Federation of Societies for Surgery of the Hand/Hand Therapy triennial international congress, Buenos Aires, Argentina. 24 October, 2016.

The candidate designed the study; acquired, analysed and interpreted the data; composed and produced the poster.

Other outputs

Public platforms

Bűhler, M. (2020). Basal thumb arthritis. *NZ Health Navigator* https://www.healthnavigator.org.nz/health-a-z/b/basal-thumb-arthritis/

Lay summaries

Bűhler, M. (2018). "My thumb's the captain of the ship" – a qualitative study of the impact of thumb base osteoarthritis. *University of Otago Centre for Health, Activity and Rehabilitation Research (CHARR).* www.otago.ac.nz/thumb-base-oa

Other publications produced during PhD

Peer reviewed journal

Bűhler, M. (2019). Dealing with hand arthritis. *Physical Therapy Reviews, 24*(3-4), 82-83. doi:10.1080/10833196.2019.1660031

Peer reviewed conference

Bűhler, M. (2019). Thumb CMC OA – getting a grip. Platform presentation (invited speaker), Hand Therapy NZ biennial national conference, Wellington, New Zealand. 13 September, 2019.

List of abbreviations

ACR	American College of Rheumatology
ADLs	Activities of daily living
AFQ	Additional Functional Questionnaire
AOL	Anterior oblique ligament
AP	Adductor pollicis
APB	Abductor pollicis brevis
APL	Abductor pollicis longus
AUSCAN	Australian/Canadian Hand Osteoarthritis Index
BMI	Body Mass Index
CI	Confidence interval
CMC	Carpometacarpal joint
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
dAOL	deep anterior oblique ligament
DASH	Disabilities of the Arm, Shoulder, and Hand questionnaire
DIML	Dorsal intermetacarpal ligament
DIP	Distal interphalangeal
DLC	Dorsal ligament complex
DRL	Dorsal radial ligament
DT-II MC	Dorsal trapezial-second metacarpal ligament
DTT	Dorsal trapezial-trapezoid ligament
E-L	Eaton-Littler
EPB	Extensor pollicis brevis
EPL	Extensor pollicis longus
EQ-5D-3L	EuroQuol 5-Dimension, 3-Level
EQ-5D-5L	EuroQuol 5-Dimension, 5-Level
FIHOA	Functional Index for Hand Osteoarthritis
FCR	Flexor carpi radialis
FDI	First dorsal interosseous
FPB	Flexor pollicis brevis
FPL	Flexor pollicis longus
GAT	Grip Ability Test
GP	General practitioner
GROC	Global Rating of Change score
HAQ	Health Assessment Questionnaire
HR-QoL	Health-related quality of life
IDD	Inter-digit distance
IL-1β	Interleukin-1β
IML	Intermetacarpal ligament
IP	Interphalangeal joint
JSN	Joint space narrowing
k	Kappa
KgF	Kilogram-force
K-L	Kellgren-Lawrence
MC1	first metacarpal
MC2	second metacarpal

MCID	Minimal clinically important difference
MCP	Metacarpophalangeal joint
MD	Mean difference
MDC	Minimal detectable change
MGP	Matrix Gla protein
MHQ	Michigan Hand Questionnaire
MMP	Matrix metalloprotease
MRI	Magnetic resonance imaging
NA	Not available
NC	No change
NICE	National Institute for Health and Care Excellence
NK	Not known
NRS	Numeric rating scale
NS	Not specified
NSAIDs	Non-steroidal anti-inflammatories
OA	Osteoarthritis
OARSI	Osteoarthritis Research Society International
OMERACT	Clinical Trials Response Criteria Initiative and Outcome Measures in Rheumatology
OP	Opponens pollicis
PI	Prediction interval
PIP	Proximal interphalangeal
POL	Posterior oblique ligament
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRWHE	Patient-Rated Wrist and Hand Evaluation
QuickDASH	Quick Disabilities of the Arm, Shoulder, and Hand questionnaire
RA	Rheumatoid arthritis
RCT	Randomised controlled trial
ROM	Range of motion
SAOL	Superficial anterior oblique ligament
SD	Standard deviation
SMD	Standardised mean difference
ST	Scapho-trapezial
STT	Scapho-trapezial-trapezoid
TNF	Tumour necrosis factor
UCL	Ulnar collateral ligament
VAS	Visual analogue scale
WINZ	Work and Income New Zealand
YLD	Years lived with disability

Chapter 1

Introduction

1.1 Thesis aims and outline

Thumb carpometacarpal (CMC) osteoarthritis (OA) is a common and disabling condition, but little is known about its impact from the perspective of people with thumb CMC OA. Therefore, the first aim of this thesis is to explore the impact of thumb CMC OA from the perspective of people with the condition. Splinting is a non-surgical, non-pharmacological treatment option for thumb CMC OA which is recommended in international guidelines. However, evidence of the effectiveness of splinting for people with thumb CMC OA is sparse and inconsistent, and recommendations can only be speculative. Therefore, the second aim of this thesis is to investigate the effectiveness of orthotic (splinting) interventions for the management of thumb CMC OA.

The thesis is presented in three parts, structured around the three studies conducted as part of the research (Figure 1.1). Each study represents a stand-alone inquiry, but all are inter-related. The first is a qualitative study exploring the impact of thumb CMC OA from the perspective of people with the condition. This study follows a pragmatic methodological approach oriented to the clinical questions: 'what needs to be treated?' and 'how should we do it?'. The second study is a systematic review of studies reporting effectiveness of splinting for thumb CMC OA. The third is a feasibility study informed by the first two studies and designed to test the study elements for a future randomised controlled trial (RCT) of splinting for thumb CMC OA.

Chapter 1 introduces the problem of thumb CMC OA and outlines the research questions for the thesis. Chapter 2 reviews the anatomy, aetiology, clinical assessment, and classification of thumb CMC OA to understand the problem from a biomedical perspective. Chapter 3 reports the qualitative study which explores the impact of thumb CMC OA for people with the condition; it includes relevant literature, the methodology, and results, and discusses the study findings which inform, from the patient perspective, the subsequent chapters. Chapter 4 reports the systematic review of studies exploring the effectiveness of splinting for reducing pain, increasing function,

and quality of life in people with thumb CMC OA. Findings are synthesised narratively. Selected findings are also synthesised quantitatively in meta-analyses. This chapter examines both the state of the existing literature and identifies features of splint use and design, outcome measures, and study design to inform a future study to investigate the effectiveness of splinting. Chapter 5 presents the final empirical work of this thesis, a feasibility study designed to examine the study elements identified in Chapters 3 and 4 and required for conducting a future high-quality trial powered to investigate the effectiveness of splinting for thumb CMC OA when compared with a standardised best practice usual care comparator intervention. Chapter 6 completes the thesis by bringing together the key findings of the three studies and knowledge of the condition from Chapter 2 and discusses their implications for clinical practice, health service delivery, and future research.

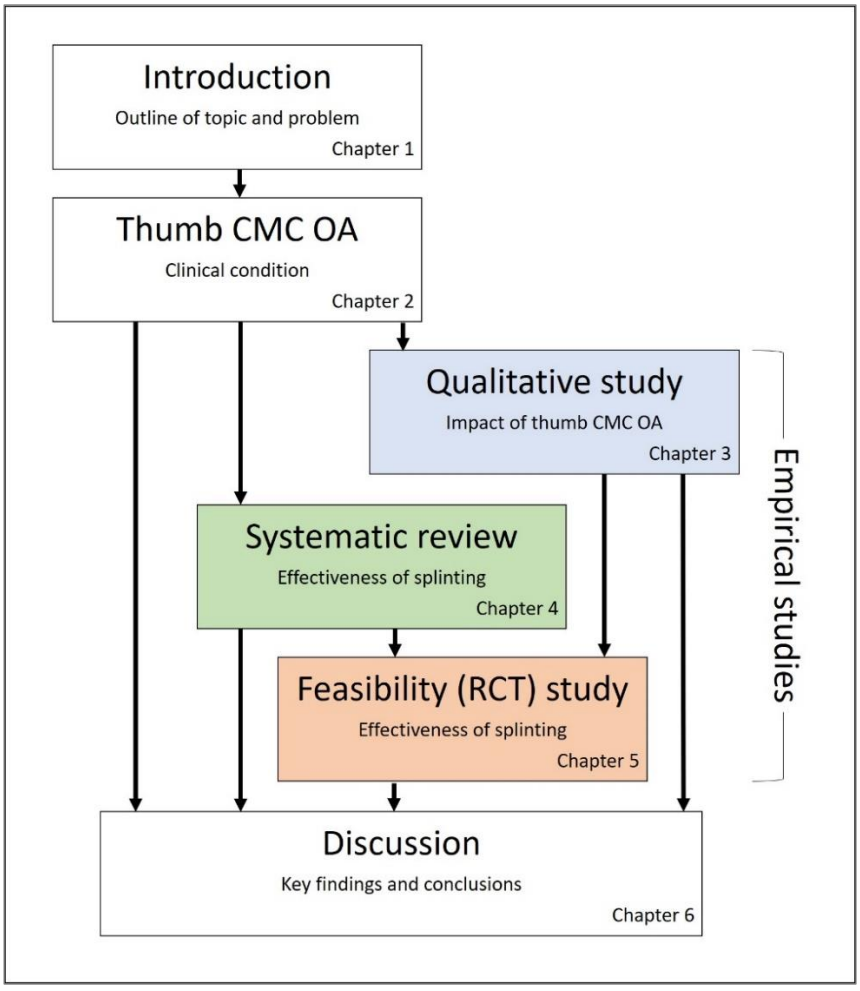


Figure 1.1 Schema of the structure of the thesis

1.2 The problem

1.2.1 Osteoarthritis including the thumb CMC joint

Osteoarthritis involving the CMC joint of the thumb causes persisting pain, limits hand function, and interferes with health-related quality of life (HR-QoL) (Bijsterbosch, Wassenaar, et al., 2010; Marshall et al., 2009). The thumb CMC joint is the commonest site of radiographic OA (Dahaghin et al., 2005; Haara et al., 2004; Wilder, Barrett, & Farina, 2006), yet thumb CMC OA, as a distinct entity, has received little attention to date compared with large joint OA of the hip and knee (Kloppenburg & Kwok, 2012; Kloppenburg, van Beest, & Kroon, 2017).

Thumb CMC OA involves the CMC joint of the thumb, a small-shaped saddle joint comprising the base of the thumb (1st) metacarpal and the trapezium bone in the wrist (Figure 1.2). Its shallow, biconcave surfaces are only congruous when the joint is fully rotated into opposition (Edmunds, 2011; Ladd et al., 2014). The joint's relative incongruence along with its loose capsule allows greater planes of motion than at adjacent joints (Komatsu & Lubahn, 2018). Its comparative instability is intensified by the location of its base, the trapezium, at the radial side of the wrist with no radial buttress and no fixed base of support on the mobile scaphoid (Bettinger, Linscheid, Berger, Cooney, & An, 1999).

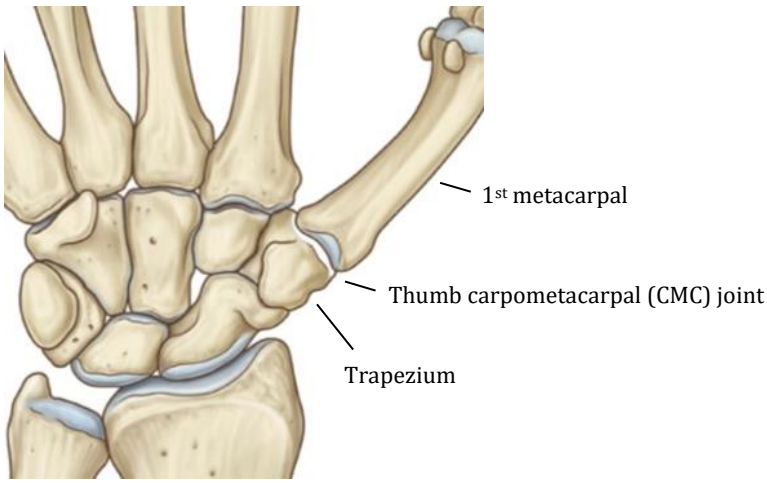


Figure 1.2 The thumb carpometacarpal (CMC) joint. (Reprinted from Gray's basic anatomy Fig. 7.82 (Drake, 2018), with permission from Elsevier) (Appendix A)

Because of its inherent instability, the thumb CMC joint is highly reliant on ligamentous structures and coordinated motor activity for functional use (Komatsu & Lubahn, 2018; Zancolli, Ziadenberg, & Zancolli, 1987). Balanced muscle forces in concert with ligament complexes are required to transform the mobile thumb CMC unit suited to fine manipulation into a stable column for power grip (Bettinger et al., 1999; Edmunds, 2011). The joint forces endured by the thumb CMC joint with everyday activities are high. In a 70 Kg person, thumb CMC joint reactive forces with power grasp are up to 120 Kg (Cooney & Chao, 1977). The concentrated shear forces that occur when the thumb CMC joint is under load are currently thought to be the main mechanism governing onset of OA at this joint (Edmunds, 2011; Ladd et al., 2014; Riordan et al., 2018). Like at other joints, the onset or progression of primary or idiopathic OA is influenced by multiple potential risk factors including genetic, metabolic, biomechanical factors, and increasing age. (Dieppe, 2011; Martel-Pelletier et al., 2016). The resultant condition has been found to involve all joint structures with the presence of inflammation suggestive of an active repair process (Dieppe, 2011).

The clinical presentation of thumb CMC OA has been described to reflect that of OA generally with joint-specific signs and symptoms. Pain, stiffness, swelling, and loss of function are typically reported (Sellam & Berenbaum, 2010; van Heest & Kallemeier, 2008). Physical examination may find pain on loading or palpation of the joint, warmth, crepitus, bony deformity, muscle atrophy, shortening of the first web space, and joint collapse (van Heest & Kallemeier, 2008). A more detailed description of the anatomy, potential mechanisms, and definition of thumb CMC OA are given in Chapter 2.

A challenge in understanding the problem of thumb CMC OA is that there is no agreed case definition – thumb CMC OA is usually considered part of hand OA. However, because thumb CMC OA often occurs in isolation and has a different clinical profile to nodal OA, it is arguably a distinct disease entity (Bijsterbosch, Visser, et al., 2010; Dahaghin et al., 2005) requiring specific treatment approaches (Kloppenburg & Kwok, 2012; Kloppenburg et al., 2017; Zhang et al., 2009). Furthermore, thumb CMC OA appears to contribute to more pain and disability than other hand joint OA (Bijsterbosch, Visser, et al., 2010; Dahaghin et al., 2005; Tenti et al., 2020), though not all studies concur (Spacek et al., 2004).

Osteoarthritis affecting one or more joints has long been recognised as one of the most prevalent long-term conditions with substantial individual, economic, and societal burdens (March et al., 2016; March & Bachmeier, 1997; Martel-Pelletier et al., 2016). World-wide, OA is reported as affecting around 240 million people; however, this underestimates true impact of the condition as this statistic includes only hip and knee OA (Vos et al., 2016). Furthermore, most of the published data on prevalence derive from radiographic surveys; plain radiographs are insensitive to early disease so these studies also tend to underestimate the prevalence of disease (O'Neill, McCabe, & McBeth, 2018).

Osteoarthritis accounts for 2.4% of total global years lived with disability (YLD) and has been ranked as the 10th leading contributor to global YLDs (March et al., 2016). By 2030 the overall number of people with OA is predicted to increase by a further 50% (Ackerman, Pratt, Gorelik, & Liew, 2018) due to ageing populations and other health and lifestyle factors including obesity (Ackerman et al., 2018; Turkiewicz, Petersson, Björk, Dahlberg, & Englund, 2013). The World Health Organisation recognised this in declaring the 'Bone and Joint Decade' 2000-2010 (Lidgren, 2003). In New Zealand in 2018 arthritis, of which OA was the most common type, was associated with annual health sector costs of $993 million, other financial costs including carer costs and productivity costs of $3.3 billion, and loss of well-being estimated at $7.9 billion (Deloitte Access Economics, 2018). Osteoarthritis contributed to more than one third of these costs.

1.2.2 Thumb CMC OA problem

The natural history of thumb CMC OA can either result in less symptomatic or stable end stage disease (Bijsterbosch, Watt, et al., 2011), or progress to pain and functional limitations interfering with people's lives (Bijsterbosch, Watt, et al., 2011; Dahaghin et al., 2005; Michon, Maheu, & Berenbaum, 2011; Sonne-Holm & Jacobsen, 2006).

The estimated prevalence of symptomatic thumb CMC OA is comparable to, or greater than that of hip and knee OA. Symptomatic thumb CMC OA has an estimated age-adjusted prevalence of 22% in the U.K. community-dwelling population aged 50 years and over (Marshall, van der Windt, Nicholls, Myers, & Dziedzic, 2011). In comparison,

symptomatic hip OA has an estimated prevalence of 4.2% to 9% in similar aged United States and European populations (Kim 2014), and for knee OA, 7% to 19% (Neogi, 2013). In a North American population the life-time risk of developing symptomatic hand OA by age 85 was reported as 40% (Qin et al., 2017), compared to 45% for knee OA (Neogi, 2013). The thumb CMC joint is the single most commonly affected site in the hand (Haara et al., 2004), often occurring in isolation (Bijsterbosch, Visser, et al., 2010) and may be the primary source of symptoms (Dahaghin et al., 2005; Kloppenburg & Kwok, 2012; Kloppenburg et al., 2017). These data indicate that thumb CMC OA presents a substantial individual and societal burden, and an aging population heralds a rapidly rising prevalence.

Despite the high prevalence and significant burden of thumb CMC OA, it attracts far less attention than hip or knee OA in both clinical health practice and research, (Kloppenburg et al., 2017). Osteoarthritis affecting the hand, compared with lower limb OA, appears to attract a lower quality of care, as measured on quality indicator questionnaires including, for example, patient education and information, regular assessments, referrals, and pharmacological treatment (Osteras, Hagfors, & Hagen, 2016). In the clinical setting this has been attributed, in part, to clinical uncertainty regarding optimal management – insufficient research in the area results in insufficient evidence for treatments – and creates the impression that 'nothing helps'; consequently treatment is seldom offered (Hill, Dziedzic, & Nio Ong, 2011). Furthermore, thumb CMC OA is less visible than hip or knee OA: the patient does not limp into the office; personal care tasks can be delegated or strategically managed to keep up appearances; limitations in most activities of daily living (ADLs) are not evident; and hand function and capacity are often felt to be more personal in nature, for example in personal hygiene, social relations, and self-identity (Bromann Bukhave, la Cour, & Huniche, 2014; Hill et al., 2011). In nearly all settings the significant economic impact of surgical management for hip and knee OA, and public expectations around this, command the overwhelming majority of academic, policy, public, and clinician attention (Deloitte Access Economics, 2018; Vos et al., 2016); hence the impact of OA affecting the hand, including the thumb CMC, remains underestimated and under-investigated (Deloitte Access Economics, 2018; Michon et al., 2011; Vos et al., 2016).

1.3 Management of thumb CMC OA

A diverse range of treatments is suggested to manage thumb CMC OA and all have benefits and limitations. Treatments include:

- Surgical interventions;
- Pharmacological therapies; and
- Non-surgical, non-pharmacological therapies.

1.3.1 Surgical interventions

Surgical intervention can provide relief for thumb CMC OA but is associated with high health system costs, common adverse events, such as complex regional pain syndrome, scar contracture or tenderness, nerve injury, or unstable thumb base (Rhee & Shin, 2014), and does not provide definitive benefit as in the hip or knee (Spaans et al., 2015; Wajon, Vinycomb, Carr, Edmunds, & Ada, 2015); therefore, surgery is usually reserved as the last option. Furthermore, surgery is not available to everyone, not least because of a lack of appropriately trained surgeons.

There is very little research, based on outcomes, into surgery for thumb CMC OA, compared with hip and knee replacements (Wajon et al., 2015). Several procedures are in common use: removal of the trapezium bone (trapeziectomy); trapeziectomy with ligament reconstruction; trapeziectomy with ligament reconstruction and coiled tendon interposition arthroplasty, designed to maintain height; and joint fusion (arthrodesis). Joint resurfacing and arthroplasty options are also available but not widely used. Joint replacement has not proven as successful in the hand as it has for hip or knee OA (Thillemann, Thillemann, Munk, & Kroner, 2016; Wajon et al., 2015). No procedure has yet demonstrated superiority over another in terms of pain, physical function, adverse events, failure, i.e. re-surgery, or imaging (Wajon et al., 2015). Low quality evidence suggests the more complicated procedures confer no benefit over trapeziectomy alone and may have more adverse events; however, most studies had an unclear risk of most biases (Wajon et al., 2015). No studies have compared surgery with sham surgery or surgery with non-surgical interventions (Wajon et al., 2015). More high-quality research investigating the benefits of surgical techniques for thumb CMC OA, with a

focus on robust patient-reported outcomes, has been recommended (Wajon et al., 2015).

1.3.2 Pharmacological therapies

Pharmacological treatments for thumb CMC OA include injection, oral, and topical treatments; these are directed at symptomatic relief and confer little or no disease-modifying effects (Spaans et al., 2015). Conflicting findings and recommendations reflect a lack of high-quality evidence (Spaans et al., 2015).

While injection therapies, hyaluronate more so than corticosteroid, have previously reported some benefit (Spaans et al., 2015), more recent evidence indicates no clear benefit from any injection therapy over placebo (Riley et al., 2019) and recent guidelines only conditionally support injection (Kolasinski et al., 2020) or do not recommend them (Kloppenburg et al., 2019). There are also concerns associated with the potential long-term effects of injected therapies which are unknown (Riley et al., 2019). The lack of robust outcome measures may be an additional factor in determining effectiveness of these interventions.

Oral non-steroidal anti-inflammatories (NSAIDs) remain the main-stay of the pharmacological treatment of OA (Kolasinski et al., 2020) though have been investigated primarily for their short-term effect (Kloppenburg et al., 2019; Kolasinski et al., 2020). NSAIDs are only recommended for short term use at the lowest possible dose due to risks such as adverse gastrointestinal, cardiovascular, and renal events, especially in the older population (Altman, 2010a; Kloppenburg et al., 2019; Kolasinski et al., 2020). Paracetamol (Acetaminophen) is conditionally recommended for short-term use but has small effect sizes and there are growing concerns about its risk profile (Kloppenburg et al., 2019; Kolasinski et al., 2020). Other medications conditionally recommended in hand OA are Duloxetine and Tramadol (Kolasinski et al., 2020). Limited evidence is available to demonstrate the effectiveness of neutraceuticals for hand OA; only one well-performed study investigating the effect of chondroitin sulfate has indicated benefits in terms of improved pain and function (Kloppenburg et al., 2019).

Topical NSAIDs are a preferred approach for hand OA as their effectiveness appears to be similar to that of oral NSAIDs but with an improved safety profile (Altman, 2010b; Kloppenburg et al., 2019). Although topical NSAIDs are strongly recommended for hand OA in recent European guidelines (Kloppenburg et al., 2019), they remain conditionally recommended in recent United States guidelines due to the small body of evidence (Kolasinski et al., 2020). Topical Capsaicin is not recommended for hand OA as there is no direct evidence of its effectiveness, and greater risk of eye contamination (Kolasinski et al., 2020). Further research into the effectiveness of all pharmacological treatments for thumb CMC OA is required.

1.3.3 Non-surgical, non-pharmacological therapies

Non-surgical, non-pharmacological therapies for thumb CMC OA include a range of social and behavioural interventions, physical therapies and modalities, complementary therapies, and orthoses. Although these options are lower cost and lower risk than surgical and pharmacological treatments, they are seldom investigated in hand OA and even less frequently in thumb CMC OA.

Education is a key component of all OA guidelines, including training in joint care principles and assistive devices and support in self-management and self-efficacy (Kloppenburg et al., 2019; Kolasinski et al., 2020; NICE, 2014). However, evidence for educational interventions is available for hand OA only and no studies have investigated this specifically for thumb CMC OA. Findings for hand OA have been mixed. In one study, those who received joint protection education in addition to a leaflet and advice were statistically more likely to be responders to treatment 6 months later (33% vs 21%) (Dziedzic et al., 2015); in contrast, another study found no benefit for an intensive multi-modal intervention of self-management education, ergonomic principles, and exercises (Stukstette et al., 2013). Issuing assistive devices together with information has been found to be effective at 6 months in hand OA (Amaral et al., 2018). Cognitive behavioural therapy has also been conditionally recommended in hand OA (Kolasinski et al., 2020).

Exercise is now recommended by all OA guidelines as a core intervention (Kloppenburg et al., 2019; Kolasinski et al., 2020; NICE, 2014; Sankah, Stokes, & Adams, 2019). While

exercise has proven beneficial in knee and hip OA, there has been a lack of evidence to date in hand OA and therefore only non-specific recommendations regarding exercise have been made. A Cochrane review of the effect of exercise for hand OA found only a small effect on pain and function, but the evidence was of low quality and no specific recommendations for thumb CMC OA were reported (Osteras et al., 2017). Some exercise programmes specifically designed for thumb CMC OA have been investigated; however, these are small studies of low quality (Davenport, Jansen, & Yeandle, 2012; DeMott, 2017; O'Brien & Giveans, 2013; Villafañe & Valdes, 2013).

Very little is known about the mechanistic effects of exercises prescribed for thumb CMC OA in living models, including to what degree exercises should target dynamic stability rather than strength or range of motion (ROM). The restoration of thumb CMC dynamic stability, defined as "… where musculo-tendinous units stabilise articular surfaces during movement or gripping to excessive shear forces or subluxation of the joint." (O'Brien & Giveans, 2013; Taylor, 2000), has been promoted as the primary goal of exercises for thumb CMC OA (O'Brien & Giveans, 2013) and of management of the condition generally (Colditz, 2000). However, there is little evidence that this can be achieved. A small retrospective study of exercise for thumb CMC OA using a dynamic stability modelled approach found promising results for pain and function (O'Brien & Russell Giveans, 2013). However, there are conflicting views on the relative importance of different musculature and neuromuscular training approaches (Colditz, 2013; O'Brien & Giveans, 2013; Valdes & Von Der Heyde, 2013). Few studies have investigated electromyography of thumb muscles during functional tasks and these have only preliminary findings (Calder, Galea, Wessel, MacDermid, & MacIntyre, 2011; Ooishi, Izumi, Ueba, & Ikeuchi, 2019). Other literature upon which exercises are based is limited to mathematical or cadaveric methods (Valdes & von der Heyde, 2012). Exercises may also include techniques to improve ROM, for example, for palmar abduction, or pain-relieving techniques such as traction (Scott, 2018; Taylor, 2000). Overall, the current literature on exercise prescription in this population is incomplete and treatments are more commonly informed by expert opinion and experience (Colditz, 2000, 2013; Dziedzic et al., 2015; Kjeken et al., 2013; O'Brien & Giveans, 2013; Scott, 2018; Shankland, Beaton, Ahmed, & Nedelec, 2017; Stamm et al., 2002; Taylor, 2000).

Manual therapy, taping, and acupuncture are examples of other therapeutic or complementary modalities used for thumb CMC OA; however, the evidence for their effectiveness is of low quality (Kolasinski et al., 2020; Spaans et al., 2015). Heat and cold are low risk and easily available options; however, there is little or no evidence for their effectiveness (Kloppenburg et al., 2019; Kolasinski et al., 2020; Spaans et al., 2015).

Orthoses, also known as 'splints' especially when applied to the hand, (Australian Orthotic Prosthetic Association, 2020) are proposed for thumb CMC OA to provide external support to the thumb CMC joint, to reduce pain, prevent contracture, and maintain hand function (Colditz, 2000; Poole & Pellegrini, 2000). Clinicians commonly prescribe splints (Davenport, 2009; O'Brien & McGaha, 2014) and previous clinical studies have shown positive results, with significant reductions in pain and reduced demand for surgery (Berggren, Joost-Davidsson, Lindstrand, Nylander, & Povlsen, 2001; Gomes Carreira, Jones, & Natour, 2010; Rannou et al., 2009). However, because the strength and quality of the published evidence for splinting in thumb CMC OA is variable and often poor, international treatment guidelines make only weak recommendations for the use of splints for thumb CMC OA (Hochberg et al., 2012; Zhang et al., 2007). A recent guideline update advocates long-term use of splints but this is based on an older single study of participants wearing a thermoplastic splint at night for 12 months (Kroon, Carmona, Schoones, & Kloppenburg, 2018; Rannou et al., 2009), a protocol neither widely used nor well-aligned to the commonly proposed mechanisms of effect, i.e. to provide support during function (Colditz, 2000; Deveza et al., 2017; O'Brien & McGaha, 2014; Poole & Pellegrini, 2000).

The role of biomechanical interventions such as splints has been highlighted as a key area of OA management in need of more research (NICE, 2014). Previous systematic reviews have examined the effectiveness of splinting for thumb CMC OA, with mixed results (Egan & Broisseau, 2007; Lue, Koppikar, Shaikh, Mahendira, & Towheed, 2017; Mahendira & Towheed, 2009; Spaans et al., 2015; Towheed, 2005; Valdes & Marik, 2010; Ye, Kalichman, Spittle, Dobson, & Bennell, 2011). Furthermore, little information exists about which type of splint is more effective or for whom, nor are the mediating effects of splints clear. The systematic review reported in Chapter Four and the feasibility RCT described in Chapter Five, aim to address this uncertainty.

In summary, there exists a dearth of high-quality evidence to support clinicians, patients, and policy makers in decision-making about interventions for thumb CMC OA. The key challenges which impede progress in this area are outlined below.

1.3.4 Challenges in thumb CMC OA

Studies of thumb CMC OA face several challenges. In addition to the lack of agreed case definition described above, other challenges are 1) no gold standard outcome measure and 2) limited knowledge of patients' perspective of the impact of thumb CMC OA.

A core set of outcome domains for investigating potential interventions for hand OA has been recommended, namely, pain, physical function, HR-QoL, joint activity, and hand strength (Kloppenburg, Maheu, et al., 2015); however, in studies investigating interventions such as splinting for thumb CMC OA, there appears to be no consensus about which measurement tools to use (Kloppenburg, Maheu, et al., 2015). In addition to being non-specific for thumb CMC OA, some tools also have other problems. The two instruments recommended by Osteoarthritis Research Society International (OARSI) for design and conduct of clinical trials for hand OA to assess self-reported function – the Functional Index of Hand Osteoarthritis (FIHOA), and the Australian/Canadian Hand Osteoarthritis Index (AUSCAN) – are clinician-centric in their development and have in recent years faced criticism for being outmoded (Kloppenburg, Maheu, et al., 2015; Stamm et al., 2009; Wittoek et al., 2019). For example, the AUSCAN was principally developed from eight existing health status measures and an iterative process involving four rheumatologists, two physiotherapists and an orthopaedic surgeon (Bellamy et al., 2002). Furthermore, access to the AUSCAN requires permission and payment of a fee (Kloppenburg, Maheu, et al., 2015).

Little is known about the specific impact of thumb CMC OA from the perspective of those with the condition, and this contributes to the deficiency of the current evidence for interventions for thumb CMC OA. Previous studies of patients' perspective of the impact of thumb CMC OA have been limited to clinician-derived surveys and questionnaires which have been conducted, almost exclusively, in northern-hemisphere Western European populations (Bijsterbosch, Visser, et al., 2010; Bijsterbosch, Watt, et al., 2011; Calfee, Chu, Sorensen, Martens, & Elfar, 2015; Dahaghin, Bierma-Zeinstra Sita,

Hazes, & Koes, 2006; Haara et al., 2004; Hoogendam et al., 2019; Hwang & Ring, 2011; Kwok et al., 2014; Lee, Paik, Lim, Kim, & Gong, 2012; Slatkowsky-Christensen, Haugen, & Kvien, 2010; Spacek et al., 2004; Tenti et al., 2020), with the exception of one study conducted in Korea (Lee et al., 2012). Deeper, richer data are required to better inform the design of better, fit for purpose interventions, and outcome assessment instruments. There is also a need to understand how this condition manifests more broadly, including within the cultural contexts of Aotearoa – New Zealand.

There is a need for clinically effective and cost-effective treatments and care pathways to manage thumb CMC OA for the large and growing number of people who have the condition. It is also necessary to know how thumb CMC OA impacts patients and people with the condition in order to design treatments and care pathways that meet patients' needs, and to evaluate these treatments and pathways on the basis of outcomes that are important to patients – in simple terms, how to deliver patient-centred care for thumb CMC OA.

1.4 Research aims

The principal aims of this thesis are:

1. To explore the impact of thumb CMC OA from the perspective of people with the condition.
2. To investigate the effectiveness of splinting for improving outcomes important for people with thumb CMC OA.

These aims generate the following research questions:

- Question 1: What is the experience of people in New Zealand with thumb CMC OA?
- Question 2: What outcomes are important for people with thumb CMC OA?
- Question 3: What treatment targets are important for people with thumb CMC OA?
- Question 4: What is the existing evidence for the effectiveness of splinting in improving outcomes important to people with thumb CMC OA?

- Question 5: What is a feasible study design to investigate the effectiveness of splinting for outcomes important in people with thumb CMC OA?

The first three questions address the need for an understanding of the needs of individuals with thumb CMC OA from their perspective. In order to elucidate important matters such as how patients are treated and what outcomes should be used to evaluate effectiveness, study designs need to incorporate patients' lived experience and to investigate the outcomes that are important to them. Eliciting patient perspectives about what they feel is important is a main aim of this thesis and drove the design of the study described in Chapter 3. The fourth and fifth questions address the need to determine the evidence for the effectiveness of splinting in addressing the needs of people with thumb CMC OA.

1.5 The terms and scope of this research

This thesis considers the condition of thumb CMC OA which primarily involves the articular surface of the base of the first metacarpal (MC1) and the reciprocal articular surface of the trapezium in the wrist. Further detail regarding relevant anatomy, pathology and aetiology is given in Chapter 2. It is widely recognised that more severe thumb CMC OA can also involve additional articulations of the carpal bones - the scapho-trapezial (ST) articulation between the scaphoid and the trapezium, or the scapho-trapezial-trapezoid (STT) articulations where the trapezoid is also involved. Involvement of the ST or STT articulations is common, some reports indicate occurrences in up to 60% of CMC OA (Katzel et al., 2016). Combined CMC and STT involvement were purported to be more symptomatic (Armstrong, Hunter, & Davis, 1994) although a recent study found little difference in pain intensity between those with or without STT involvement (Hoogendam et al., 2019). Because ST or STT involvement is not routinely reported in studies of CMC OA and is hard to identify clinically, it is recognised that more severe symptoms could be the result of multi-joint involvement. For the purpose of this thesis, the term 'thumb CMC OA' is used to refer to both isolated thumb CMC OA and additional ST or STT involvement, when present.

Advanced or severe thumb CMC OA may present in the presence of a specific subset of severe OA – that of erosive OA which commonly involves the small joints of the hand

more than joints elsewhere (Marshall et al., 2015). Erosive OA frequently affects the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints and, but less commonly, the thumb CMC (Marshall et al., 2015). Specific characteristics are an abrupt onset with inflammation, central erosions with subchondral collapse and subsequent large osteophyte growths (Marshall et al., 2015). Erosive OA is reported to have a higher clinical burden with more severe disability (Marshall et al., 2015; Marshall et al., 2013; Monfort et al., 2015). While erosive OA is an accepted concept, a clearly defined clinical and radiological definition is lacking (Gazeley, Yeturi, Patel, & Rosenthal, 2017; Marshall et al., 2013). Reporting of erosive vs non-erosive OA is not routine in cases of hand OA. This thesis does not differentiate between 'thumb CMC OA' and 'erosive thumb CMC OA'.

This thesis focusses specifically on the condition of 'thumb CMC OA', whilst acknowledging that its classification has yet to be clearly defined. The literature predominantly describes thumb CMC OA as part of the OA phenotype of 'hand OA'; thumb CMC OA is also known as trapeziometacarpal (TMC) OA or 'thumb base OA'.

Accepted classification criteria for hand OA may include thumb CMC OA (Altman et al., 1990). However, a limitation of these criteria is that thumb CMC OA cannot be classified in isolation even though thumb CMC OA is commonly a 'lone' presentation (Dahaghin et al., 2005; Marshall et al., 2011; Zhang et al., 2009). Radiographic and other imaging classification criteria exist. While there is some evidence of a positive association between radiographic hand OA and hand pain (Dahaghin et al., 2006), the poor correlation between imaging results and symptomatology is widely recognized (Calfee et al., 2015; Haugen, Slatkowsky-Christensen, Boyesen, van der Heijde, & Kvien, 2013; Hwang & Ring, 2011; Niu et al., 2003; Zhang et al., 2009). Furthermore, imaging is expensive, not routinely accessible, and has consequences albeit minor, for example, exposure to radiation. This thesis does not aim to offer a definitive classification for thumb CMC OA. Rather, in each of the chapters and studies, classification criteria for study inclusion criteria are appraised or considered according to a pragmatic clinical approach. This thesis considers the clinical syndrome of thumb CMC OA rather than the purely structural disease.

The term 'patient' is used throughout the thesis to describe persons who experience problems related to thumb CMC OA. They may not necessarily be currently, or ever, recipients of health services but they are affected by the condition and may have instigated their own forms of 'treatment' or sought information. The term 'patient' is used interchangeably with 'person' or 'people' and 'public' in preference to other terms such as 'client' or 'consumer' to avoid colluding with transactional or commodified views of health and health care.

1.6 Significance of the research

The studies that make up this thesis are part of a broader programme of OA research that aims to enable equitable access to low cost non-surgical, non-pharmacological treatments to improve daily life and maintain healthy ageing for people with OA in New Zealand. The previous and ongoing clinical experience of the researcher, along with the contribution of other expert clinicians in the study development for the final study, will enhance relevance and uptake of the study findings to the real-world clinical setting.

It is anticipated that results of this research will enable tailoring of treatments and outcome measures to the unique impact of thumb CMC OA. In turn, this will have the potential to improve outcomes for people with the condition, and improve the effectiveness and efficiency of health services. The findings will also enable clinicians, health services, and funders to be better-informed in current evidence about the effectiveness of splinting for thumb CMC OA, and will highlight key gaps in the evidence to assist researchers planning future research. The findings will also provide information about the success of study design elements for use in future research. Specifically, results will inform a future full RCT to investigate the effectiveness of a splint intervention for thumb CMC OA. If shown to be effective, the splint intervention would be a good first-line non-pharmacological, non-surgical option to be prescribed by health professionals or accessed directly by patients.

The importance of patient perspectives in understanding impact, informing the design of interventions, and developing outcome measures is critical to ensure that the needs of people are addressed and evaluated by outcomes that are important to them (Areskoug Josefsson, Andersson, & Lee, 2017; Padgett, 2012). This will contribute

substantially to efficiency and cost-effectiveness in health care and health services. Moreover, using clearly described and justified methods to elicit patient perspectives gives transparency and credibility to the process, i.e. it is made clear from whom views and input were sought, and the method by which those views were sought. Research methods that address, in a credible fashion, the pragmatic needs of health service knowledge requirements are extremely valuable for working towards authentic patient-centred care.

This thesis aims to explore and give voice to the patient perspective but does not approach the topic from either a 'participatory action research' model or 'patient-partner' relationship. Rather, the research topics and questions arise from the author's 17 years' clinical practice as a physiotherapist and hand therapist working in the New Zealand public health system and as the result of encountering many people with thumb CMC OA. The researcher has observed that thumb CMC OA is a common problem causing significant distress, but that referral to therapy services often occurs late in the condition, if at all, and in many cases any initial referrals are made to a surgical or rheumatology specialist rather than allied health services. Practice experience and knowledge of common clinical practice patterns gained over 17 years have revealed that splint interventions seemed to give good results in relieving patients' symptoms, enabling continued function, and in some cases deferring or avoiding medication or surgery. However, evidence for the effectiveness of splint interventions was poorly addressed in the health literature. Furthermore, no literature could be found about the specific impact of thumb CMC OA from the perspective of patients. Both these areas are key to understanding what the need is, and what sensible first-line treatment options should be available to primary health clinicians for managing patients with thumb CMC OA.

1.7 The theoretical framework

In a thesis, a theoretical framework is important to ensure intellectual rigour – it gives consistency to the argument and decisions and makes the major underlying assumptions transparent (Creswell, 2014; Ravitch, 2017).

In this thesis, I have used a post-positivist approach to assess the evidence for treatment effectiveness. However, I have also used constructivism to take a step back and enquire into what it is that needs treating, to explain findings, and to design a study fit for the real-world setting. From these ontological positions follow the epistemological approaches outlined below and the study methodologies. Given the setting of the research in post-colonial, neoliberal Aotearoa New Zealand, I have also employed the additional lens of structural violence. This is elaborated on in the penultimate paragraph of this chapter.

Post-positivism holds that the world is a stable reality independent of human thought but that our knowledge of this reality is only partial (Padgett, 2012). Hence, to best approximate reality, enquiry is necessary by many investigators from many perspectives (Padgett, 2012). Accordingly, a post-positivist epistemology entails measuring and recording empirical observations but recognises error as inherent in any finding (Creswell, 2014; Padgett, 2012). Depending on the research question, a post-positivist methodology may employ either quantitative or qualitative methods or both (Creswell, 2014). A quantitative methodology may engage methods including RCT, with 'pragmatic' RCT being more aligned to post-positivism than to positivism (Creswell, 2014). To answer the fourth research question: "What is the effectiveness of splinting for improving pain, function, and QoL in people with thumb CMC OA?" it is necessary to collect data that enable calculation of measures of effectiveness. While such data and calculations are quantitative, the assumed presence of error yields findings as 'estimates' rather than actual true reality.

In contrast to the philosophical paradigm of post-positivism, constructivism holds that reality is constructed through communication and interaction (Krauss, 2005; Padgett, 2012). Therefore, since the world can be understood in a multitude of ways, the aim is to gain an understanding of one, some, or many of the different realities (Creswell; Krauss, 2005; Padgett, 2012). Thus a multitude of methodologies are available through which to gain knowledge of the world – most of which are underpinned by qualitative methods (Creswell, 2014; Padgett, 2012). The researcher is recognised as an actor in the knowledge acquisition process. Constructivist methodologies aim to produce partial knowledge in context (Krauss, 2005; Padgett, 2012).

The first three research questions deal with the experience of living with thumb CMC OA and, as such, are best addressed by the constructivist paradigm. These questions are approached using a pragmatic qualitative methodology and, in determining the study methods and design, the practical clinical questions of how patients should be treated and what outcomes should be measured were used (Padgett, 2012; Shaw, Connelly, & Zecevic, 2010). The richness of patients' views was sought in order to gain a deep understanding to enable the design of interventions that can match patient need effectively. Interventions can then be evaluated according to what is meaningful to patients. For example, methods can include face-to-face interviews using a semi-structured schedule.

Constructivism is not incongruent with post-positivism (Krauss, 2005; Padgett, 2012). In reacting to the scientistic traditions of positivism, both hold that our knowledge of reality is always uncertain (Creswell, 2014; Padgett, 2012). Although both subscribe to realism (Krauss, 2005), they differ in that post-positivism posits a single, unitary (but un-apprehendable) reality while constructivism posits the existence of multiple realities. Both accept that there are multiple perspectives and the construction of 'data' as susceptible to bias (Padgett, 2012). The two approaches are complementary and can be deployed in parallel to explore reality, to build and test theory, to identify where to study the detail, and to explain and understand findings (Creswell, 2014; Krauss, 2005; Padgett, 2012).

The final research question is premised on a post-positivist approach in that it aims to test a hypothesis, but it includes a constructivist viewpoint that aims to explain findings by understanding their context. This allows a more accurate and successful testing of the theory.

The additional lens of 'structural violence' is used to take a more critical view of the historical and socio-economic forces that put certain populations at greater risk of experiencing health and other problems as well as making them less likely to receive treatment (Padgett, 2012). In New Zealand it can be argued that structural violence operates in a number of ways: through the ubiquitous application of a bio-medical model that, often unconsciously, privileges European cultural traditions over Māori and

Pacific Islands culture; through socio-economic disparities that provide unequal access to healthcare and to health care professions; and through the ongoing consequences of colonisation which have resulted in indigenous people being at greater risk of health and other problems, and less likely to access healthcare (National Ethics Advisory Council, 2020; O'Brien et al., 2020; Perry, Hudson, Clode, Wright, & Baxter, 2015). This lens is used to inform the design of study recruitment strategies and data collection schedules, for example the interview schedule in Chapter 3.

This theoretical framework of a shared post-positivist and constructivist ontology and epistemology viewed through the lens of structural violence, applying quantitative and qualitative methodology as appropriate to each research question, provides the basis for the study designs outlined in Chapters 3 to 5.

Chapter 2

Thumb CMC OA: Anatomy, aetiology, assessment, and classification

In order to understand the biomechanics and pathology that arise at the thumb CMC joint it is helpful first to consider the unique anatomy of this complex and highly evolved joint. The first section in Chapter 2 reviews the key anatomical characteristics of the thumb CMC joint and their relationship to localised thumb CMC OA. The second section appraises contemporary knowledge of the pathophysiology of OA and the specific disease pattern seen at the thumb CMC joint. The third section delineates the signs and symptoms typically seen in thumb CMC OA presentation. In the fourth section, the challenge of classification, both radiographic and clinical, is elucidated. The overall aim of the chapter is to provide an understanding of the biomedical problem of thumb CMC OA as a foundation and context for the work of the following chapters.

2.1 Anatomy

2.1.1 Osseous anatomy

The first CMC articulation is a saddle-type joint, comprising the shallow bi-concave articular surfaces of the base of the MC1 and the trapezium (Bettinger et al., 1999) (Figure 2.1). The articular surfaces have unequal radii of curvature that are congruous only at the ends of motion (Ladd et al., 2014). The volar apex of the metacarpal articular surface protrudes like a 'beak', from which originates the deep anterior oblique ligament (dAOL). The metacarpal beak articulates with a recess on the volar surface of the trapezium, just proximal to the dAOL attachment (Komatsu & Lubahn, 2018). In addition, the trapezium articulates with the second metacarpal, trapezoid, and scaphoid. The trapezium sits at the radial side of the wrist with no radial buttress and no fixed base of support on the mobile scaphoid, making for an unstable platform for the thumb CMC joint (Bettinger et al., 1999).

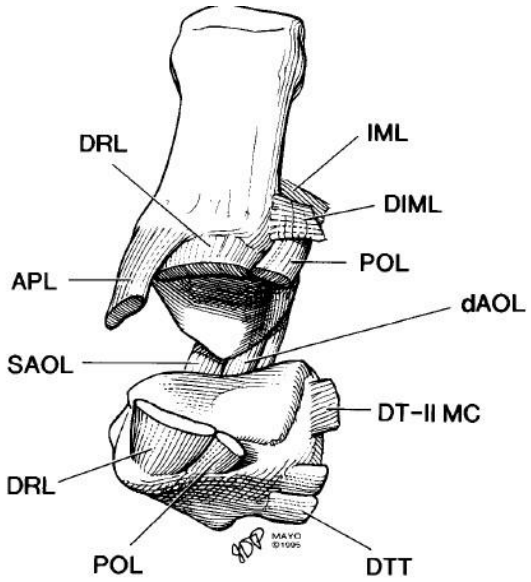


Figure 2.1 The CMC joint has been hinged open from the dorsum to reveal the saddle shaped articular surfaces of the base of the first metacarpal and the trapezium. Also revealed is the deep anterior oblique ligament (dAOL). Anticlockwise from left to right are: DRL, dorsal radial ligament; APL, abductor pollicis longus; SAOL, superficial anterior oblique ligament; DRL, dorsal radial ligament; POL, posterior oblique ligament; DTT, dorsal trapezial-trapezoid ligament; DT-II MC, dorsal trapezial-second metacarpal ligament ; POL (distal attachment); DIML, dorsal intermetacarpal ligament; IML, intermetacarpal ligament. (Used by permission of Mayo Foundation (Bettinger et al., 1999), Appendix A)

The CMC trapezial facet is saddle-shaped in the central-distal part and spherical on the palmar aspect (Zancolli et al., 1987). The spherical portion is convex in all directions and is in contact with the reciprocally concave parts of the MC1, enabling axial rotation (circumduction) of the MC1 during opposition and retroposition movements (Zancolli et al., 1987). The resultant joint mechanics enable the tip of the thumb to be positioned opposite the tips of the remaining digits, thus permitting the areas of highest sensory discrimination to be used during prehension (Zancolli et al., 1987).

Motion at the thumb CMC joint is primarily in two planes: flexion-extension and abduction-adduction. However, just about any angular motion can be achieved when these two planes are superimposed (Komatsu & Lubahn, 2018). Further, a third, rotational plane involving varus-valgus and supination-pronation can occur because the planes are off-set rather than perpendicular (Komatsu & Lubahn, 2018). Only two of the three planes of motion can be controlled by the surrounding musculature. Pronation automatically accompanies flexion to bring the thumb to fingertips for pinch and grasp (Komatsu & Lubahn, 2018). There is no ability to vary the amount of pronation and supination without flexion-extension or abduction-adduction. Independent control of rotation as in ball-and-socket joints at the hip or shoulder would require a greater number of muscles, too bulky for the hand to effectively perform grasp and fine motion functions (Komatsu & Lubahn, 2018).

While the saddle-shape of the thumb CMC provides some bony stability, its relative incongruence and loose capsule allow greater planes of motion than available at adjacent digits and joints (Komatsu & Lubahn, 2018). The semi-constrained osseous arrangement sacrifices stability for mobility, leaving the thumb CMC more reliant for stability on the capsule and ligamentous structures (Gluck, Balutis, & Glickel, 2015; Komatsu & Lubahn, 2018), and coordinated muscular activity (Zancolli et al., 1987).

2.1.2 Ligamentous anatomy

Despite considerable detailed investigation over the past six decades, the complex ligamentous anatomy of this joint has yet to be fully explained and understood (Bettinger et al., 1999; D'Agostino et al., 2014; Komatsu & Lubahn, 2018). The volar ligaments (Figure 2.2) have long been held to contribute the greatest to thumb CMC stability and joint health (Bettinger et al., 1999; Eaton & Littler, 1973; Pellegrini Jr, 1991). However, more recent authors disagree. Compared to the AOL, the dorsal ligament complex (DLC) has been found to be thicker, stiffer, and more important to joint stability (Bettinger et al., 1999; Bettinger, Smutz, Linscheid, Cooney, & An, 2000; Colman, Mass, & Draganich, 2007; D'Agostino et al., 2014; Ladd, Lee, & Hagert, 2012; Zhang, Van Nortwick, Hagert, Yao, & Ladd, 2013). Further, the volar beak insertion in the trapezial recess has recently been identified as the joint's pivot point (Edmunds, 2011), rather than the AOL (Edmunds, 2011).

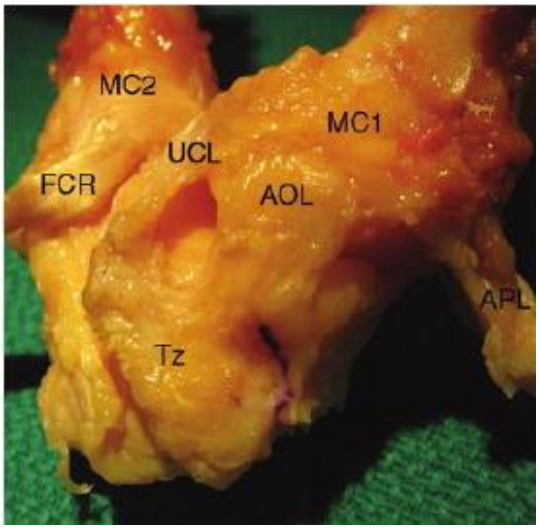


Figure 2.2 The volar thumb CMC ligaments from a right hand, showing the attenuated anterior oblique ligament (AOL) and ulnar collateral ligament (UCL), which course from the trapezial ridge (Tz) onto the volar base of metacarpal 1 (MC1). Also seen are the abductor pollicis longus (APL) and flexor carpi radialis (FCR) tendons, as well as the base of metacarpal 2 (MC2). (Used by permission of Amy L. Ladd, MD (Ladd et al., 2014), Appendix A)

The DLC comprises the dorsal radial ligament (DRL), the posterior oblique ligament (POL), and the ulnar collateral ligament (UCL) (Bettinger et al., 1999) (Figure 2.3). This dorsal complex is overlaid by the abductor pollicis longus (APL) and extensor pollicis longus (EPL) tendons and resists dorsal or dorsal-radial subluxating force and ulnar translation of the MC base during abduction opposition, extension and pronation (Bettinger et al., 1999). The DLC is now understood to operate as part of a cantilever force complex that, in concert with balanced muscle force, transforms the mobile unit into a stable column by locking the volar beak of MC1 into the trapezial recess on opposition (Edmunds, 2011). The dorsal complex has also been found to be more richly innervated with mechano receptors, which support its role in proprioception and dynamic stability (Ladd et al., 2012; Mobargha, Ludwig, Ladd, & Hagert, 2014).

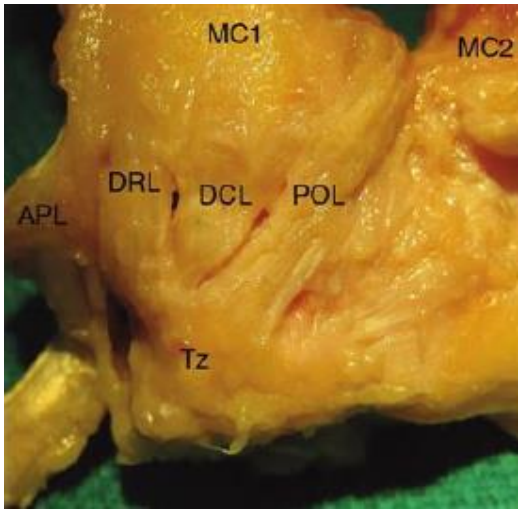


Figure 2.3 The dorsal thumb CMC ligaments from a right hand showing the dorsal ligament complex consisting of the dorsal radial ligament (DRL), dorsal central ligament (DCL), and posterior oblique ligament (POL), all emanating from the dorsal tubercle of the trapezium (Tz). Also seen are the dorsal bases of metacarpal 1 and 2 (MC1, MC2) and the abductor longus (APL) tendon. (Used by permission of Amy L. Ladd, MD (Ladd et al., 2014), Appendix A)

Several other ligaments including the intermetacarpal ligament (IML) (Figure 2.1, Figure 2.4) act along with the DLC to support the volar beak pivot function (Edmunds, 2011) and to tenodese the MC1 to the MC2 (Bettinger et al., 1999; Edmunds, 2011). More proximally, a number of intercarpal ligaments act to secure the trapezium to the trapezoid to compensate for the lack of radial bony buttress and to stabilize the trapezium against cantilever bending forces during pinch (Bettinger et al., 1999). Without these restraints, the trapezium would displace into extension and radial deviation (Abzug & Osterman, 2011; Bettinger et al., 1999) (Figure 2.4).

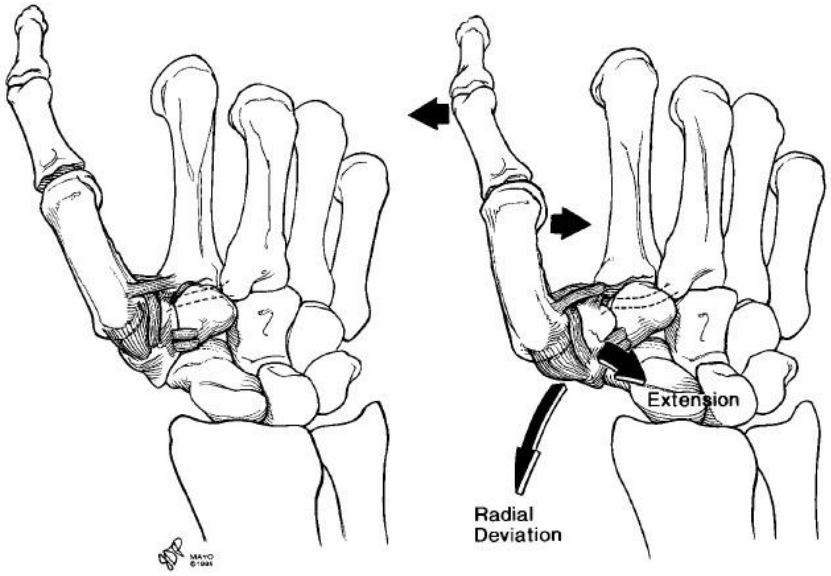


Figure 2.4 Trapezial cantilever bending. This diagram shows the zig-zag collapse of the first ray and the associated radial deviation and extension that occurs in the trapezium due to cantilever bending forces. Also depicted is the presumed laxity of the ligaments restraining the trapezium and CMC joint. (Used by permission of Mayo Foundation (Bettinger et al., 1999), Appendix A)

2.1.3 Muscular anatomy and function

Nine muscles contribute to thumb CMC stability and function (Figure 2.5): the three thenar muscles on the volar aspect of the hand (abductor pollicis brevis [APB], flexor pollicis brevis [FPB], opponens pollicis [OP]); adductor pollicis (AP); the flexor pollicis longus (FPL); the APL and extensor pollicis brevis , and the EPL in the first and third dorsal compartments respectively; and the first dorsal interosseous (FDI) on the ulnar aspect (Taylor, 2000; van Heest & Kallemeier, 2008).

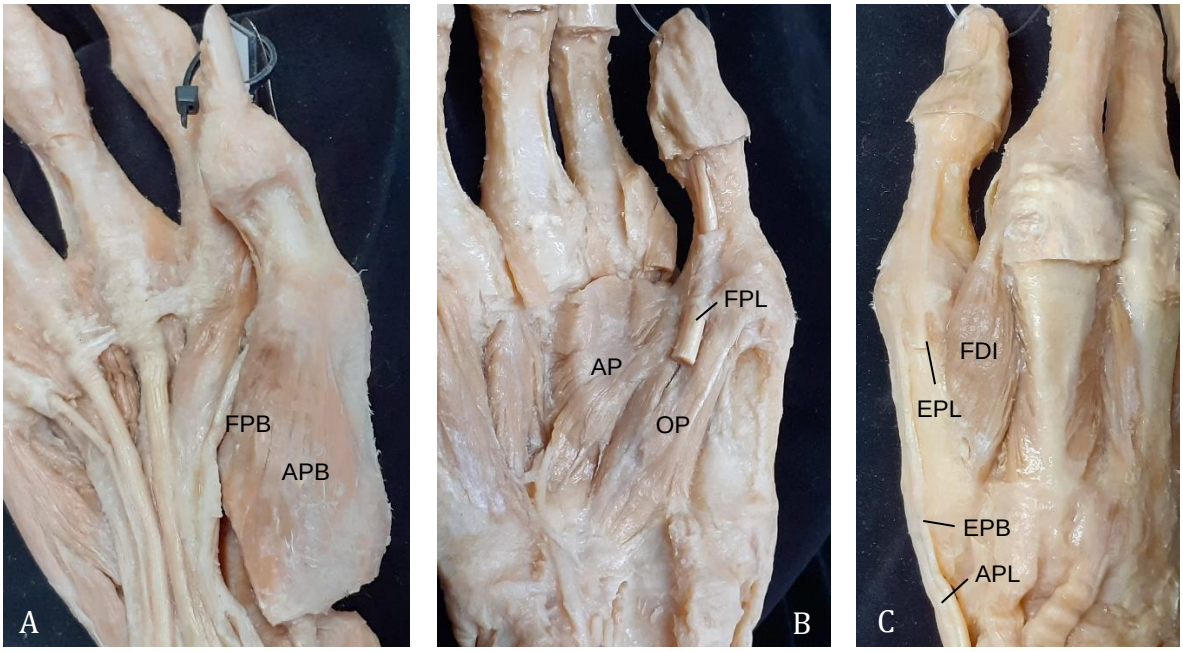


Figure 2.5 The thumb muscles from two right hands showing: ***A.*** *flexor pollicis brevis (FPB), abductor pollicis brevis (APB),* ***B.*** *adductor pollicis (AP), opponens pollicis (OP), and the extrinsic flexor pollicis longus (FPL) on the volar aspect;* ***C.*** *the extrinsic muscles of the first and third dorsal compartments (abductor pollicis longus [APL] and extensor pollicis brevis [EPB], and the extensor pollicis [EPL]) on the dorsal aspect; and the first dorsal interosseous muscle (FDI). (Photographs taken by permission of WD Trotter Anatomy Museum, University of Otago)*

With thumb functions, for example, pinch, normal translation and coupling of movements and forces occur. The intrinsic and extrinsic muscles abduct, translate ulnar-ward, and rotate the thumb CMC (Ladd et al., 2014). The APB, OP, and AP, along with the powerful FPL then contract to lock the volar beak into the trapezial recess, tensioned by the dorsal ligaments (Edmunds, 2011). In addition, the FDI by virtue of its origin on MC2 and insertion into MC1, works to 'seat' the MC1 on the trapezium and to increase medial stability further (van Heest & Kallemeier, 2008). In opposition the thumb CMC is compressed into maximal congruency as it is held near the end of its 'saddle range' (Edmunds, 2011). The rotation that accompanies thumb CMC motion into opposition creates a 'screw home torque' at the thumb CMC joint, converting a lax, unstable incongruous joint into a rigidly stable, congruous joint (Edmunds, 2011). This mechanism is fit for purpose for meeting the demands of both pinch grip and powerful rotational forces such as unscrewing a lid (Taylor, 2000). The unique joint surface topography therefore serves a dual purpose: to permit the mobility required for delicate

precision pinch, and to provide the stability (through dynamic force coupling) necessary for power grip and pinch. Success of the dynamic screw home mechanism is dependent on the integrity of the volar beak and its trapezial recess, and sufficient length in the first web space tissues to achieve the requisite rotation-opposition ROM. Insufficient first web space length is seen as adduction contracture, or loss of palmar abduction ROM.

The forces exerted at the CMC joint with pinch and grasp functions are substantial being up to 12 times higher than those applied at the thumb tip and shear forces are up to 2.5 times greater (Cooney & Chao, 1977). Thumb CMC joint reactive forces with power grasp are up to 120kgF in a 70kg human (Cooney & Chao, 1977). Therefore, it is not surprising that the thumb CMC is such a frequent site of OA (Cooney, Lucca, Chao, & Linscheid, 1981)

In summary, the anatomical design of the thumb CMC joint is one that is inherently unstable, placing it at a distinct disadvantage given its high usage, high loads, small surface area, and high reliance on well-coordinated dynamic control. The joint is most stable in opposition but requires sufficient ligamentous integrity, capsular and first web space length, and motor control to achieve this. The volar beak of the first metacarpal plays an important role in 'locking in' stable opposition. There is a mobility-stability tradeoff to achieve the unique functions of the thumb in the confined space of the hand.

2.2 Aetiology of thumb carpometacarpal osteoarthritis

2.2.1 Pathophysiology of osteoarthritis

Osteoarthritis has long been conceived of as a degenerative disease of articular cartilage, an inevitable consequence of ageing. However, the contemporary understanding is of a multi-factorial disease involving all joint structures (Dieppe, 2011; Martel-Pelletier et al., 2016; Sellam & Berenbaum, 2010). Local and intrinsic factors influence the clinical and structural presentations at any stage up to and including eventual joint destruction (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016). Subchondral bone, ligaments, capsule, synovial membrane, as well as articular cartilage are all recognised as sites of involvement (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016; Sellam & Berenbaum, 2010). Structural changes visualised on x-ray or other

imaging modalities include loss of cartilage seen as joint space narrowing (JSN), osteophyte formation, and subchondral bone changes (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016). These changes, which may or may not be accompanied by clinical signs, can take place gradually over many years or may occur in a series of accelerated phases (Martel-Pelletier et al., 2016; Sellam & Berenbaum, 2010). Peak incidence of symptomatic hand OA has been reported to occur at 45 years (Hart & Spector, 2000).

Osteoarthritis is broadly classified into primary and secondary OA. In secondary OA, previous injury, surgical trauma, or congenital abnormalities contribute to the onset of disease (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016). In contrast, primary or idiopathic OA is a result of multiple potential risk factors including genetic, metabolic, and biomechanical factors and, most commonly, increasing age (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016). The fact that OA does not occur in individuals who have congenital or longstanding upper limb paralysis (Hart & Spector, 2000; Marshall, Watt, Vincent, & Dziedzic, 2018) supports the role of mechanical loading.

2.2.1.1 Articular cartilage changes

At a molecular level cartilage is an avascular tissue with a relatively acellular matrix, poor repair capacity, and no neuronal innervation (Dieppe & Lohmander, 2005). With advancing age and in OA, cartilage has a diminishing capacity to recover or 'turnover' in response to mechanical loading (Martel-Pelletier et al., 2016). Consequently, the cartilage-forming cells (chondrocytes) fall into a state of progressive structural and nutritional decline which can end in chondrocyte death (Martel-Pelletier et al., 2016). This state of disrepair is accompanied by inflammatory and catabolic upregulation which ultimately results in tissues being much less capable of withstanding everyday mechanical loads (Martel-Pelletier et al., 2016).

In OA joints, articular cartilage is seen to undergo molecular changes, including gradual proteolytic degradation of the matrix, associated with intensified synthesis of matrix components by the chondrocytes (Dieppe & Lohmander, 2005). These molecular level changes result in alterations in cartilage morphology that include cartilage surface

fibrillation, cleft formation, and loss of cartilage volume (Dieppe & Lohmander, 2005). Pain in OA joints comes not from cartilage damage itself, but from exposure of subchondral nerve endings when fissures form in the cartilage (Dieppe & Lohmander, 2005). Other sources of joint pain in OA include periosteum, synovium, ligaments, and the joint capsule (Bacon, LaValley, Jafarzadeh, & Felson, 2020); these, like subchondral bone, are richly innervated and contain nerve endings that could relay nociceptive stimuli (Dieppe & Lohmander, 2005).

2.2.1.2 Bony (structural) changes

The onset of bony changes is closely linked to the development of local cartilage pathology; both are responses to altered mechanical loading although it is not yet clear how each contributes to the other (Dieppe & Lohmander, 2005; Martel-Pelletier et al., 2016). Speculation exists that advanced OA changes of bone marrow lesions and subchondral cysts represent a progressively unstable or decompensated OA joint, whereas osteophyte formation likely contributes to joint stability representing a compensated joint state (Dieppe, 2011; Martel-Pelletier et al., 2016). Pain inhibition of neuromotor control can result in further loss of joint stability resulting in a decompensated presentation (Dieppe & Lohmander, 2005). Advanced deformity is usually associated with pronounced loss of movement but is not necessarily more symptomatic having potentially moved on to a compensated state (Dieppe, 2011; Dieppe & Lohmander, 2005).

2.2.1.3 The role of synovitis

Inflammatory processes, particularly those involving the synovial membrane, appear to be directly responsible for several clinical signs in OA and reflect the structural progression of the disease (Bacon et al., 2020; Sellam & Berenbaum, 2010; Wang, Hunter, Jin, & Ding, 2018). The pro-inflammatory and catabolic products produced by cartilage damage appear to involve synovial membrane and synovial fluid in the inflammatory response; this synovial involvement further contributes to chondrocyte deregulation (Martel-Pelletier et al., 2016). Inflammatory mediators detected in synovial fluid of OA joints have been found to derive from cartilage, subchondral bone, and the synovium, all of which undergo histopathological change (Sellam & Berenbaum, 2010). Tumour necrosis factor (TNF) and interleukin-1β (IL-1β) are the two major

cytokines involved in the pathogenesis of OA (Sellam & Berenbaum, 2010). The immunological presentations of advanced OA and rheumatoid arthritis (RA) are similar with the main difference being the divergent profiles of the cytokines released (Sellam & Berenbaum, 2010).

The pathogenic role of synovitis in OA may act via TNF, IL-1β, other soluble mediators, and through large quantities of matrix metalloproteases (MMP-1, MMP-3, MMP-9, and MMP-13) produced by both synovial membrane and chondrocytes (Sellam & Berenbaum, 2010). For example, MMP3, which appears to directly breakdown cartilage, is synthesised predominantly on the border of hyaline cartilage – suggesting it is secreted by OA synovial tissue (Sellam & Berenbaum, 2010). Other work has identified synovial macrophages as possible intermediaries in changes to subchondral bone; and other cytokines, including T cells, interferon-γ, and IL-2 as potential drivers of chronic inflammation (Sellam & Berenbaum, 2010). Overall, these findings indicate that inflammation both contributes to and results from the breakdown products of cartilage extracellular matrix (Sellam & Berenbaum, 2010). Thus, a vicious cycle can ensue in which cartilage breakdown and synovial inflammation occur simultaneously (Sellam & Berenbaum, 2010).

In late phase hand OA, including thumb CMC OA, synovial inflammation has been found to be present and linked to clinical joint signs of swelling and inflammatory pain (Kortekaas et al., 2010; Mathiessen, Slatkowsky-Christensen, Kvien, Hammer, & Haugen, 2016; Sellam & Berenbaum, 2010). Furthermore, synovitis has been identified as a predictor of the appearance and progression of structural changes such as erosions in hand OA (Balueva, Sarapulova, & Teplyakova, 2018; Kortekaas, Kwok, Reijnierse, & Kloppenburg, 2014; Mathiessen et al., 2016). Therefore, therapies that target inflammation or can break the negative feedback cycle may delay or prevent articular cartilage damage and the formation of osteophytes, particularly in early OA (Sellam & Berenbaum, 2010). Such non-pharmacological therapies may include, for example, rest, compression, and thermal effects.

2.2.1.4 Metabolic factors

Obesity is speculated to contribute to the immunological response in OA through induction of pro-inflammatory cytokines in the synovium and chondrocytes by adipokines released by adipose tissue (Martel-Pelletier et al., 2016). There is some evidence that obesity increases the risk of hand OA (Magnusson, Turkiewicz, Timpka, & Englund, 2018; Reyes et al., 2016), but not to the extent seen in knee OA (Dieppe & Lohmander, 2005; Reyes et al., 2016), suggesting a complex interplay between metabolic and other factors, for example, mechanical. The metabolic risk factor of being diabetic has also been found to be associated with radiographic progression of nodal hand OA (Marshall et al., 2019; Neuprez et al., 2018). However, metabolic syndrome was not found to be associated with the presence of hand OA in the large Framingham cohort (Strand, Neogi, Niu, Felson, & Haugen, 2018). No clear associations have yet been identified between metabolic factors and the incidence or progression of thumb CMC OA specifically (Marshall et al., 2019).

2.2.1.5 Genetic factors

While heterogeneity in OA disease manifestations is undoubtedly influenced by environmental factors, a growing body of evidence indicates that genetic and epigenetic factors also play important roles (Jeffries, 2019). In hand OA, only a small body of evidence exists to date; this has shown concordance in monozygotic twins at rates similar to recent moderate and strong findings for knee and hip OA respectively (Doherty, 2000; Jeffries, 2019), with osteophytes at the thumb CMC showing the strongest tendency of all hand joints (Doherty, 2000). Familial aggregation has also been demonstrated for hand OA (Doherty, 2000). A polygenic risk is likely with some candidate genes from a recent genome-wide association study including the association between a matrix Gla protein (MGP) gene variant and increased risk for hand OA caused by a lower expression of MGP; the latter may increase hand OA burden through reduced inhibition of cartilage calcification (den Hollander et al., 2017). However, no specific information is yet available for CMC OA.

Taken together, these data indicate that OA is a heterogeneous, long term whole-of-joint condition influenced by multiple intrinsic and extrinsic factors. Newer imaging modalities and histochemical techniques have negated the view that OA is a disease of

unsalvageable degenerating cartilage, and transformed it into an exciting challenge involving an active repair process (Dieppe, 2011). There is a strong indication that treatment targets include both bio-mechanical factors and synovial inflammation.

2.2.2 Aetiology of thumb CMC OA

Recent investigations have substantially influenced prevailing opinion regarding the aetiology of thumb CMC OA. For a long time laxity of the AOL and shallowness of the trapezial facet (resulting in greater joint incongruency) have been cited as primary factors in the onset of thumb CMC OA (Bettinger et al., 1999; Gluck et al., 2015; Jonsson & Valtysdottir, 1995; Pellegrini Jr, 1991; van Heest & Kallemeier, 2008). Consequently management, including surgical procedures, targeted the AOL to restore stability (Gluck et al., 2015; van Heest & Kallemeier, 2008). In much of this literature authors have also associated both factors with female sex (Gluck et al., 2015; Jonsson & Valtysdottir, 1995; Poole & Pellegrini, 2000; van Heest & Kallemeier, 2008).

However, data supporting these aetiological views came primarily from cadaveric studies and clinical observations because, unlike in hip and knee OA, there is no suitable animal model of thumb CMC OA to gain an appreciation of the manifestations of the disease in living tissues. Contemporary technological advancements, including 3-dimensional computed tomography (CT) imaging, enable more accurate assessments (K. K. Wang et al., 2018). Consequently, the hypothesis that the pathogenesis of thumb CMC OA is primarily due to incompetence of the AOL has been replaced by the understanding that the main mechanism governing onset is the concentrated compressive rotational shear forces in the pivot area of the trapezial recess resulting from screw home torque in the final phase of opposition (Edmunds, 2011; Ladd et al., 2014; Riordan et al., 2018). In advanced disease the volar beak may become so ground off that screw home torque rotation stability is lost and instability sets in (Edmunds, 2011). Furthermore, new CT data do not support incongruency as an aetiological factor (Halilaj et al., 2015) and kinematic analysis suggests no association between sex, handedness, or thumb ROM capability in onset of thumb CMC OA (Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Bruggemann, 2014).

Regarding the pattern of articular changes in thumb CMC OA, consistent wear patterns focused on the volar aspect of MC1, but evenly spread over the trapezial surface have been identified (Miyamura et al., 2019). Osteophyte formation has also been found to be consistent in non-opposing regions of MC1 and trapezium: on the dorsal and volar aspects of the thumb CMC and the radial and ulna borders of the trapezium, creating a net effect of an overall increase in joint mechanical stability (Crisco et al., 2019) and possibly suggesting a tendency towards a compensated joint state. Pain has been associated with loss of cartilage (Crisco et al., 2016) but rate of cartilage thinning has not been found to differ between males and females (Crisco, Moore, Morton, Ladd, & Weiss, 2017).

Some evidence exists that occupational factors play a role in the development of general hand OA (Castano Betancourt, Marchi, & Lipay, 2018; Hart & Spector, 2000). Tasks or postures presumed to cause strain or high load at the thumb CMC joint such as secretaries, dressmakers, and cleaners, repetitive thumb use, and few breaks in the day characterise occupations associated with increased risk for thumb CMC OA (Fontana, Neel, Claise, Ughetto, & Catilina, 2007). However, little data about the role of mechanical factors such as sport and occupation exist for thumb CMC OA in comparison with hip and knee OA (Burkholder, 2000; Castano Betancourt et al., 2018).

The aetiological processes outlined here, in addition to the CMC features described in earlier sections indicated that biomechanical interventions, positively affecting joint stability and reducing articular contact forces, are justified.

2.3 Signs and symptoms

Typical symptoms of OA generally include pain, morning stiffness, and crepitus on joint motion (Martel-Pelletier et al., 2016). Palpable joint swelling may indicate inflamed synovium, or the development of pannus (synovial thickening) (Sellam & Berenbaum, 2010). Other typical signs of inflammation include redness, pain, or heat. Inflammatory OA pain is suggested by a sudden increase in pain, night pain, and morning stiffness that lasts for at least 30 minutes (Sellam & Berenbaum, 2010). However, cardinal features of OA have traditionally been described as “use-related joint pain, relieved by rest”

(Dieppe & Lohmander, 2005), with rest pain and night pain only seen in more advanced cases (Dieppe & Lohmander, 2005).

In thumb CMC OA, physical examination may find pain with pinching and gripping, clicking or grinding, tenderness on palpation of the thumb CMC, as well as swelling and warmth (van Heest & Kallemeier, 2008). Thumb CMC subluxation 'squaring', or 'shoulder sign' (Figure 2.6) may be observed with or without adjacent metacarpophalangeal joint (MCP) collapse into hyperextension or less commonly hyperflexion (van Heest & Kallemeier, 2008). A reduction in joint ROM, first web space contracture, and thenar muscle wasting may also be present (van Heest & Kallemeier, 2008).

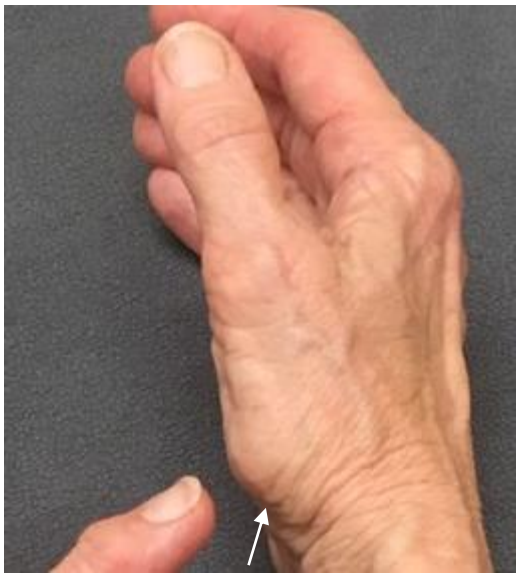


Figure 2.6 Thumb CMC joint shoulder sign: the base of the first metacarpal is mildly subluxed and prominent in relation to the trapezium, giving a 'squared' appearance

Various special tests for thumb CMC OA have also been described, perhaps the most popular is the grind test involving compression and rotation of the thumb CMC (van Heest & Kallemeier, 2008) (Figure 2.7). A positive grind test reproduces pain or crepitus, or both at the thumb CMC. This test has fair interrater reliability (Kappa [*k*] = 0.48) (Merritt, Roddey, Costello, & Olson, 2010). Face validity is considered to be high, and there is good evidence of criterion validity, assessed against radiography, with high

specificity (80% -100%) and low-moderate sensitivity (30% - 64%)(Choa, Parvizi, & Giele, 2014; Merritt et al., 2010; Sela, Seftchick, Wang, & Baratz, 2019). A more recently described test, the pressure shear test, involves compression and anterior-posterior translation of the thumb CMC (Figure 2.7) with pain reproduction or crepitus as a positive test. This test has been found to have excellent validity with both high sensitivity (99%) and specificity (95%) (Sela et al., 2019). Although the measurement properties of these tests appear good, they should not be considered definitive because the studies describing them are not of high-quality.

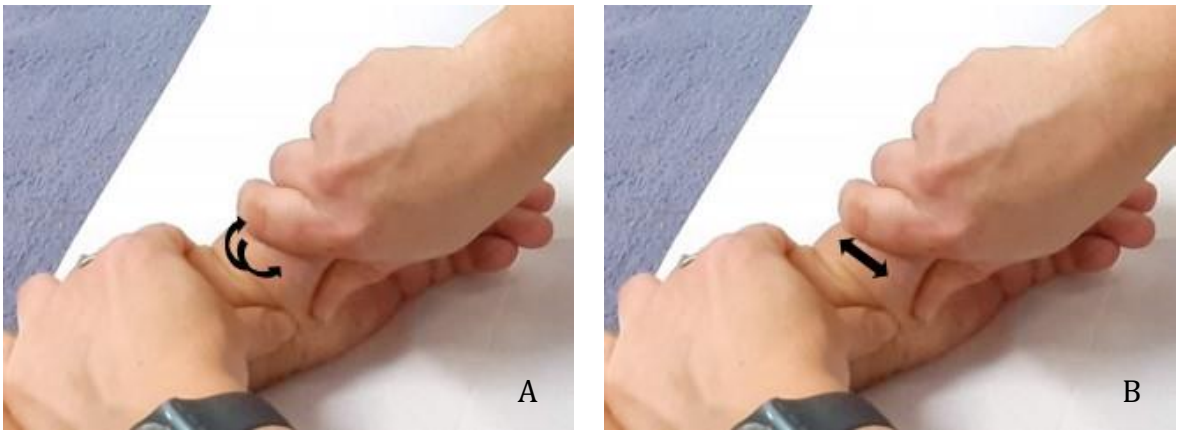


Figure 2.7 Special tests for the thumb CMC joint: A. The grind test involves compression and rotation of the thumb CMC. B. The pressure shear test involves compression and anterior-posterior translation of the thumb metacarpal on the trapezium.

Carpal tunnel syndrome, trigger thumb, STT OA, and de Quervain's tenosynovitis are important differential diagnoses as well as common concurrent presentations (van Heest & Kallemeier, 2008). Along with thumb CMC OA, these conditions have collectively been described as 'basal thumb syndrome' (Melone, Beavers, & Isani, 1987). Other differential diagnoses include scaphoid pathology and flexor carpi radialis tendonitis (van Heest & Kallemeier, 2008).

Like OA at other joints, thumb CMC OA is much easier to diagnose when well established because in the early stages objective features may be subtle or absent on examination (Felson & Hodgson, 2014). Clinical signs are associated with physical limitations and consequently impact negatively on QoL (Martel-Pelletier et al., 2016).

2.4 Classification

2.4.1 Radiographic classification

Classification of thumb CMC OA has traditionally been based on radiographic changes as originally described by Kellgren & Lawrence (1957) (Sonne-Holm & Jacobsen, 2006). While some evidence exists for a correlation between degree of radiological degeneration and self-reported pain (Sonne-Holm & Jacobsen, 2006), many people with radiographic evidence of first CMC OA remain asymptomatic (Niu et al., 2003; Wilkens, Tarabochia, Ring, & Chen, 2019). Furthermore, radiographic criteria can fail to classify up to 20% of people with radiographic changes; combinations of JSN, osteophyte graduations, sclerosis and cysts fall outside the commonly used Kellgren-Lawrence (K-L) classification criteria (Sonne-Holm & Jacobsen, 2006). For all locations, inclusion of asymptomatic radiographic OA as a clinical disease entity in clinical or population studies, is controversial (Hart et al., 1991). Furthermore, there are ethical and practical problems in using radiography (Hart et al., 1991). However, on entry into symptom-modifying or structure-modifying studies radiographic imaging has been recommended at baseline, in order to give insights into who is likely to respond, how better to describe the study population, and to explore any structurally-related factors mediating the effectiveness of interventions (Fitzgerald et al., 2015; Kloppenburg, Maheu, et al., 2015).

There are several limitations to visualisation of the thumb CMC when using radiographic imaging. The complex topography means slight changes in position or x-ray beam can reveal or obscure osteophytes or other structural changes (Hunter et al., 2015). However, it has been recommended that where standard scoring, for example, K-L, is required additional specialised views are not necessary (Hunter et al., 2015). Several radiographic classifications exist, all of which evaluate structural changes including JSN and osteophytes. The K-L system has 0-4 stages with OA being determined at stage 2 or greater (Sonne-Holm & Jacobsen, 2006). The original K-L system's emphasis on the presence of osteophytes has since been modified (Sonne-Holm & Jacobsen, 2006). Reported intra-rater reliability for K-L grading is k = 0.79 and inter-rater k = 0.65 for thumb CMC OA (Sonne-Holm & Jacobsen, 2006). The Eaton-Littler (E-L) system recognises joint space widening indicating effusion or synovitis with early disease (stage 1 of 4) and also accounts for involvement of pan-trapezial articulations with advanced stage 4 of 4 (Berger, Momeni, & Ladd, 2014). Intra-rater

reliability for E-L grading has been reported as k = 0.54 to 0.66 and inter-rater k = 0.11 to 0.56 (Berger et al., 2014). The newer OARSI atlas grades individual features independently, including JSN and osteophytes (Altman & Gold, 2007).

A disadvantage of x-ray imaging is its poor capacity to identify early disease (Hunter et al., 2015). Other imaging modalities such as magnetic resonance imaging (MRI) and CT have better capability for this. They are excellent for capturing soft tissue changes and bony topography respectively; however, both are expensive and come with other limitations, for example, difficulty in acquiring identical repeat images.

Ultrasound is an alternative modality for capturing both soft tissue and bony changes and may be the most feasible alternative to x-ray (Guermazi, Roemer, Crema, Englund, & Hayashi, 2014). Ultrasound can be used to visualise synovial inflammation in osteoarthritic joints (X. Wang et al., 2018) and is sensitive in identifying changes in small joints of the hand, including the first CMC (Balueva et al., 2018; Kortekaas et al., 2014; Kortekaas, Kwok, Reijnierse, Stijnen, & Kloppenburg, 2016; Kortekaas et al., 2010; Mathiessen et al., 2016). However, reproducibility in terms of image acquisition and interpretation remain a challenge and it is highly operator dependent (Hunter et al., 2015). In hand OA, clinimetrics for ultrasound assessment of synovitis, effusion, and osteophytes has been found to be excellent when a binary system is used (Oo et al., 2018), and also substantial on semi-quantitative scoring for synovitis and osteophytes (Oo et al., 2018).

2.4.2 Clinical classification

For non-operative rehabilitation, such as splinting, which focusses on improving symptoms and function established clinical criteria may suffice for determining study inclusion (Fitzgerald et al., 2015). Further, rather than focusing on whether radiographic evidence represents 'disease', it has been argued that symptomatic hand OA reflects the condition of clinical significance and should be the focus of research and clinical practice (Niu et al., 2003). However, a reliable and reproducible clinical examination has long been considered essential (Hart et al., 1991). Classification criteria provide general standards to improve consistency, comparability, and quality of published studies in OA and clinical definitions have been proposed for the knee, hip

and hand (Altman et al., 1990; Altman, 1991); the American College of Rheumatology (ACR) hand OA criteria are problematic due to the multiplicity of joints in the hand. Since thumb CMC OA often occurs in isolation, ACR criteria do not allow it to be reliably captured (Kloppenburg & Kwok, 2012).

Where a condition such as OA is difficult to define, the sensitivity of any given clinical test is likely to be low. One approach that can be used is to have a raft of clinical assessments with high specificity and to use an inclusive approach whereby the presence of one or more positive findings indicates a high likelihood of identifying the presence of the condition. The clinical assessments proposed for this are 1) presence of the shoulder sign; 2) tenderness on palpation of the CMC; 3) a positive grind test; and 4) a positive pressure shear test. Such an approach has been used to classify other conditions with similar diagnostic difficultly such as sacro-iliitis (Castro, Stebbings, Milosavljevic, & Bussey, 2015). It is hypothesised that this approach, as well as a history suggestive of first CMC OA, would successfully identify people with symptomatic thumb CMC OA suitable for inclusion in the clinical study in this thesis (Chapter 5). A history suggestive of OA is a recommended approach to inclusion for studies in hand OA (Kloppenburg & Kwok, 2012); this approach has been described and validated for use in knee OA (Hawker et al., 2008). A history suggestive of thumb CMC OA is hypothesised to suitably include people with symptomatic thumb CMC OA for the qualitative study (Chapter 3). Adaptation of these approaches for thumb CMC OA is considered in Chapters 3 and 5 of this thesis in the study inclusion criteria.

An optimal case definition would identify the population for whom the intervention is to be applied, i.e. distinguish people with thumb CMC OA from those with other conditions and distinguish clinical thumb CMC OA from asymptomatic histopathologic or radiographic OA (Palmer et al., 2012). Identifying those who are likely to benefit is also desirable; that is, identifying modifiable causes of illness enables targeted treatments and the delivery of more accurate prognostic advice to patients (Palmer et al., 2012).

Evidence to date indicates that clinical signs appear to be good at distinguishing thumb CMC OA and, similar to OA at other locations, the clinical signs and symptoms appear to be more strongly associated with patient impact than with structural changes (Calfee et

al., 2015; Dieppe & Lohmander, 2005; Haugen et al., 2013; Hwang & Ring, 2011; Niu et al., 2003; Zhang et al., 2009) . Therefore, clinical classification is more likely to support a patient-centred approach. However, as outlined in Chapter 1, the patient perspective of the impact of thumb CMC OA has not been thoroughly investigated and hence is not well understood. For this reason the thesis aims to contribute to this important area in Chapter 3. Furthermore, and importantly, very little evidence exists to date to suggest which disease characteristics might indicate those likely to respond to a given treatment – this is expanded on in Chapters 4 & 5.

2.5 Summary and implications for related thesis chapters

Thumb CMC OA, like OA at other sites, is a complex interaction of local joint mechanical factors and a range of systemic and environmental factors. Recent developments have begun to make clearer how OA begins and develops at the thumb CMC joint. However, another level of inquiry is how individuals or populations experience the resultant immunological, molecular, and gross morphologic changes (Dieppe & Lohmander, 2005). Understanding the patient perspective of thumb CMC OA is crucial to advancing treatments that address effectively the problem requiring treatment and to developing measurement tools that are meaningful in this regard. Therefore, the patient perspective is the focus for the study that follows in Chapter 3.

Key findings from this review of the literature that have implications for the design of the studies detailed in the following chapters are:

- The thumb CMC joint is an inherently unstable complex that is reliant on a capsular and ligamentous integrity along with dynamic motor control for maintaining joint congruence and mechanical load distribution for joint health.
- Osteoarthritis of the thumb CMC joint is a heterogenous, long term whole-of joint condition in which biomechanical factors and inflammation play significant roles.
- Biomechanical interventions that positively affect joint stability are justified.
- Interventions which may address inflammatory processes, for example, through rest, compression, and thermal effects may also be indicated.
- Radiographic classification for thumb CMC OA is established; however, radiological changes correlate poorly with symptoms and x-rays are poor at

identifying early thumb CMC OA. A patient-centred approach requires identifying those who are symptomatic rather than being based on structural disease.

- Clinical classification based on a history suggestive of thumb CMC OA and one or more positive clinical tests may be well-suited to identifying community-based populations for non-surgical intervention studies. There is good precedent for this approach in knee and hip OA studies (Hawker et al., 2008) and it is recommended in diagnosis of OA generally (NICE, 2014).
- Ultrasound can reliably detect synovitis, a potential treatment target. On entry into a symptom-modifying or structure-modifying study both ultrasound and x-rays may be useful to give insight into who is likely to respond to an intervention or structure-mediating effects (Hunter et al., 2015). Therefore, the feasibility of including x-ray and ultrasound imaging as baseline characteristics for intervention trials should be tested.

Chapter 3

The impact of thumb CMC OA: A pragmatic qualitative study

3.1 Introduction

This third chapter reports the design, conduct, and results of a qualitative study that addresses the first aim of this thesis: to explore the impact of thumb CMC OA from the perspective of people with the condition. The study is orientated to the three research questions which follow from this aim. First, to gain a broad understanding of the impact of thumb CMC OA from patients' perspectives. Second, to identify outcomes that are important and meaningful to people with thumb CMC OA and appraise the relevance of currently recommended self-report measures. Third, to understand what problems treatments should aim to address. The study contributes to the overall thesis both by informing selection of outcome measures and by elucidating which treatments would address the need or needs identified for the feasibility study (Chapter 5). This in turn will inform a future RCT investigating the effectiveness of splinting. In this way the thesis enables study design to incorporate patients' lived experiences and the outcomes that are important to them.

3.2 Background

As outlined in Chapter 1, the challenges faced by studies investigating thumb CMC OA include 1) no agreed case definition despite apparent unique clinical profile and impact, 2) no gold standard outcome measure, and 3) limited knowledge of patients' experiences.

Deeper, richer data are needed to enable the condition of thumb CMC OA to be better understood by clinicians and researchers. This will then inform the design of interventions and of outcome assessment instruments so that they better match patients' needs rather than clinicians' descriptions of the disease. Collecting such data is well-suited to a qualitative approach in which the goals are to gain more in-depth understanding of patients' experiences and to delve into the everyday manifestation of the condition (Padgett, 2012; Starks & Trinidad, 2007). Moreover, qualitative methods

can provide information about contextual factors that may explain some of the variability in disease manifestation, or response to treatments, or in both.

Another necessity is to understand how this condition is experienced in broader contexts, including the multiple cultural contexts of New Zealand. Although the prevalence of OA in New Zealand is lower among Māori (7.1%) compared with New Zealand Europeans (12.5%) (Ministry of Health, 2019) , largely because of the younger Māori age distribution, health care utilisation by Māori for OA is poor (Loyola-Sanchez, Hurd, & Barnabe, 2017). Clearly, OA research conducted in New Zealand must contribute to eliminating this inequity.

The overall aim of this study was to explore the experiences of people in New Zealand with thumb CMC OA in order to understand better the unique impact of this condition, ascertain outcomes of importance, and identify treatment endpoints.

3.3 Methods

This qualitative study was undertaken employing a pragmatic approach. Practical clinical questions of what should be measured and how patients should be treated were used to determine the study methods and design (Shaw et al., 2010). Data were collected using semi-structured interviews.

Consultation was completed with the University of Otago Ngāi Tahu Māori consultation committee (Appendix B). Ethical approval was obtained from the University of Otago Human Ethics Committee (Health), reference H17/032 (Appendix C). To preserve participant confidentiality, all names are pseudonyms. Each participant in the study was reimbursed for expenses incurred with a $20 petrol voucher. Potential participants were provided with an information sheet and consent form (Appendix D) by post or email. The informed consent process was completed by telephone or in person once the participant had had sufficient time to consider the information (see participant flow diagram, Figure 3.1).

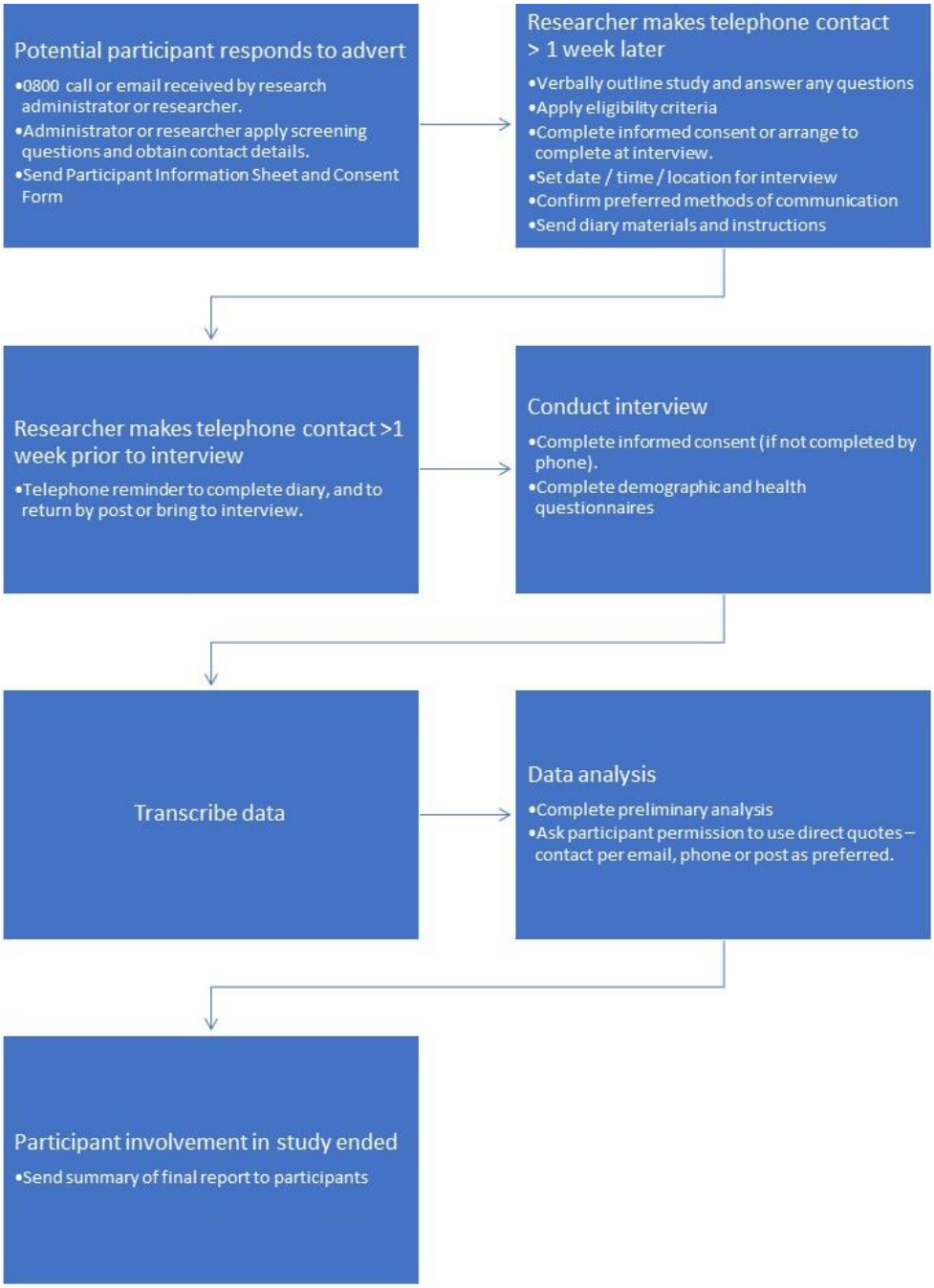


Figure 3.1 Participant flow diagram – Qualitative study

3.3.1 Study participants and setting

A sample size of 30 was chosen based on previous qualitative studies in arthritis in which recruitment of between 26 and 31 participants enabled successful data collection (Bromann Bukhave et al., 2014; Gooberman-Hill et al., 2007; Hill et al., 2011; Hill, Dziedzic, & Ong, 2010; Leung, Li, & Thumboo, 2015). Participants were recruited by posters and flyers (Appendix E) or clinician invitation from community and health settings including general practitioner (GP) and physiotherapy practices, and hospital-based services in two centres in the South Island of New Zealand (Dunedin and Invercargill). A letter of invitation was sent to clinicians inviting them to assist in study recruitment (Appendix F).

Included in the study were those aged 30 years and over with a history suggestive of thumb CMC OA (Hawker et al., 2008); those who were asymptomatic, had previous surgery to the hand, or had inflammatory or auto-immune conditions were excluded (Table 3.1). The age criteria of 30 years was selected based on epidemiological reports of hand OA in people in their 30s (Kwok, Vliet Vlieland, Rosendaal, Huizinga, & Kloppenburg, 2011), the mean age for hand OA being on average 4 years younger than that for general OA (Fautrel et al., 2005), and the researcher's anecdotal experience of thumb CMC OA presenting in patients in their 30s.

3.3.1.1 Engagement and recruitment of Māori

Prior to study design, conversations were initiated to identify specific measures to support the engagement and recruitment of participants of Māori descent. Advice was sought from the University of Otago Facilitator Research Māori, Mark Brunton; the Māori health and research advisor within the PhD researcher's department, Katrina Pōtiki-Bryant (KP); and faculty members from other departments experienced in conducting research involving Māori, Dr Emma Wyeth and Dr Jude Sligo. This consultation resulted in the following actions. First, the second centre (Invercargill) was added for its higher proportion of population identifying as Māori (13.3% (Statistics New Zealand, 2013)), given the relatively small proportion of the population identifying as Māori in the first centre (6.2%) (Statistics New Zealand, 2013). Second, to counter the low rates of treatment utilisation for arthritis by Māori (Loyola-Sanchez et al., 2017), sampling was not restricted to those who had sought medical care. Third, where

possible, consultation regarding the study recruitment and study activities was undertaken with local Māori health providers and the Southern District Health Board. In Invercargill, this identified an exercise and activity group involving older Māori where the study could be promoted and resulted in one Māori health centre offering a room in which interviews could take place. Māori health services in Invercargill and marae-based services in Dunedin agreed to disseminate the study advertisement through their networks. A fourth action was that the recruitment strategies aimed at recruiting Māori were started 4 weeks earlier than general recruitment.

Table 3.1 Inclusion and exclusion criteria – Qualitative study

Inclusion criteria	Exclusion criteria
• Aged 30+ years • Physician diagnosis of thumb CMC OA *or* answer "yes" to the question "Have you experienced aching, discomfort, pain and/or stiffness in or around the joint at the base of either thumb on most days for at least 1 month (15 or more days of the month) during the past year?" and have no other specific diagnosis. • Give written informed consent	• Thumb non-symptomatic for the past month • Previous surgery of the symptomatic joint • Concurrent rheumatoid arthritis or any other significant inflammatory or autoimmune conditions affecting the hand such as scleroderma, systemic lupus erythematosus and psoriatic arthritis, or another kind of chronic pain syndrome or metabolic disorder, such as fibromyalgia, diabetic neuropathy, or gout. • Unable to comprehend instructions and outcome measure instruments in English.

3.3.1.2 Participant characteristics

Demographic and disease characteristics were collected using a tailored questionnaire (Appendix G). Participants completed self-report outcome measures for function (FIHOA score 0-30) (Dreiser, Maheu, Guillou, Caspard, & Grouin, 1995) and quality of life (EQ-5D-3L) (The EuroQol Group, 1990) and hand diagrams for pain (numeric rating scale, NRS 0-10) and abnormal joints, that is, stiffness, swelling, or deformity (Appendix H, Appendix H.1) based on previously used 'hand drawings' (Bijsterbosch, Visser, et al.,

2010; Marshall et al., 2011), adapted with permission of the authors [Marshall; Bijsterbosch: Personal Communications[1]].

3.3.2 Interview methods

Semi-structured face-to-face interviews were conducted with 30 adults with thumb CMC OA. The pilot-tested interview schedule covered six fields of interest; in lay terms: participants' story of their thumb CMC OA; difficulties occurring due to thumb CMC OA; pain experience; impact on health and life; experience of health services for their thumb OA; and what they would most like to change. The main interview questions were accompanied by a series of probing and sensitising questions depending on the responses of participants. The probing questions aimed to elicit deeper and more detailed information. Interview questions and sensitising prompts were generated from the following: concepts included in OARSI-recommended self-report measures; the clinical and qualitative research expertise of the researcher, her three supervisors, and the Māori health research advisor (KP) - the last four are all experienced clinicians and three are experienced qualitative researchers; and previous qualitative research exploring pain in OA (Hawker et al., 2008). Pilot-testing with two PhD colleagues and one lay person with thumb CMC OA resulted in clarification of wording, and no change to the schedule structure. The full interview schedule is given in Appendix I.

Within the interview schedule, the New Zealand Māori holistic health framework of Te Whare Tapa Whā (Durie, 1998), familiar to most New Zealanders, was adopted and invited participants to reflect on four pillars of health: physical, spiritual, thoughts and feelings, and family and community (Tinana, Wairua, Hinengaro, and Whānau, respectively in the Māori language). The Whare Tapa Whā framework was operationalised using a visual tool which likens the impact of a health condition on a person's life to the ripples created and experienced when a stone is dropped into a pool (Whakāro Pōkare in the Māori language) (Bryant, 2016).

Interviews were conducted by the PhD researcher, a female in her early 40s. She is an experienced clinician with formal qualitative research training. She also received

[1]Email communication 30.12.206 with Prof Margreet Kloppenburg on behalf Dr Jessica Bijsterbosch; email communication 21.12.2016 with Dr Michelle Marshall.

expert- and peer-coaching in qualitative interviewing before commencing the study. Her ethnicity is Pākehā (European) New Zealander and she has whānau (family) of Māori and Samoan ethnicity. The clinical interest and expertise of the researcher is in the assessment and management of hand and upper limb conditions. Thumb base OA and hand OA generally are common presentations in her clinical practice. All except one of the study participants were unknown to the researcher prior to the study; this participant was a past patient and not under current care.

The 40- to 50-minute interviews took place in a health setting, for example, School of Physiotherapy or Māori health clinic, or participant's home or place of work, as preferred by each participant. In two cases a family member was present. Interviews were audio recorded on a high-quality audio device (Sony model ICD-UX523F) and field notes made following each interview.

Participants completed written daily diaries for the week before the interview to record impact in a natural setting and enrich interview data (Creswell, 2009). Diaries and an ergonomic pen were posted out to participants and returned at the interview. Following the interview and collection of demographic and disease data, feedback was sought from participants on the research methods by asking the questions, "how did you find completing the daily diary?" and, "how did you find participating in the interview?".

Requests from participants for care for their thumb CMC OA or other health conditions were dealt with by offering to refer to their GP. After the interviews the interviewing researcher, an experienced physiotherapist and hand therapist, offered general advice regarding management of hand OA where appropriate, including written information with links to useful websites and services.

3.3.3 Data analysis

3.3.3.1 Analysis of interview and document data

The PhD researcher transcribed diary entries, interviews, and field notes, entering data in NVivo data management software (NVivo 11 – QSR International Pty Ltd, Melbourne). The same researcher analysed interview and diary data primarily inductively using a systematic method of thematic analysis (Braun & Clarke, 2006). The analysis involved

1) close reading and familiarisation with the data helped by the researcher being the transcriber, 2) generating initial codes, 3) categorising codes and combining to identify themes or concepts, 4) checking themes with the data, 5) developing clear definitions and names for themes, and 6) illustration of themes with compelling extracts (quotes) (Braun & Clarke, 2006). The researcher's field notes were referred to throughout the thematic analysis to provide context and aid understanding of the data. At intervals coding and categorisation were discussed and reflected on with the PhD researcher's primary supervisor and with KP.

The data obtained from participants identifying as Māori were not intended to be compared and contrasted with data obtained from non-Māori participants, but, rather, to ensure that participants identifying as Māori were included in the study. Where concepts specific to Māori participants were identified, these were reviewed with the Māori research advisor (KP).

To aid practical application to the research and clinical setting, results were interpreted using the Health Impact Model of Wilson and Cleary (Wilson & Cleary, 1995). The Model includes psychosocial as well as biological aspects and assists in identifying outcomes that are significant to patients, in understanding how outcomes and impact may vary, and in planning patient-centred care.

Study findings were summarised and sent to participants. Permission was sought for use of individual quotes; no comments or corrections were requested.

3.3.3.2 Analysis of participant demographic and patient-report outcome data

Participant characteristics and patient-reported outcomes were presented using descriptive statistics (case number and percentage or mean and standard deviation [SD]). The EQ-5D-3L levels were dichotomised into 'no problems' (level 1) or 'problems' (level 2 or 3) (van Reenen & Oppe, 2015).

3.4 Results

Data were collected between June and September 2017. Participant characteristics are reported in Table 3.2 Participant characteristics. Current and previous vocations included a wide range of professional, manual, and care work; some were retirees.

Table 3.2 Participant characteristics

Participant characteristics		N = 30 (SD) or (%)
Sex	Male : Female	11 : 19
Age (years)	Mean (SD)	64.5 (11.36)
Descent	European/Pākehā (%) New Zealand Māori (%) Indo-Australian (%)	26 (86.7) 3 (10) 1 (3.3)
Employment status	Part- or full-time (%) Retired (%) Disability pension (%) Student (%) Not working (%) Seeking work (%)	13 (43.3) 12 (40) 2 (6.7) 1 (3.3) 1 (3.3) 1 (3.3)
Involved hand	Dominant (%) Nondominant (%)	21 (70) 24 (80)
OA at other joints	Hand (%) Other location (%)	5 (16.7) 12 (40)
Thumb CMC OA diagnosis	Made by clinician (%) History suggestive (%)	24 (80) 6 (20)
Duration of problem (years)	Mean (SD)	5.74 (5.26)
Previous treatments (non-oral drug)	Splint (%) Physio- or Hand Therapy (%) Topical cream (%) Injection (%) Other[ǂ] (%)	13 (43.3) 11 (36.7) 10 (33.3) 6 (20) 7 (23.3)
Pain relief medication (for thumb CMC OA or other condition)	Paracetamol (%) NSAIDs (%) Codeine (%) Gabapentin (%)	15 (50) 8 (26.7) 4 (13.3) 1 (3.3)
Pain at base of thumb (NRS, 0-10)	Mean (SD)	5.43 (2.1)
Function (FIHOA, 0-30)	Mean (SD)	7.7 (4.68)
EQ-5D-3L dimension	Mobility problem (%) Self-care problem (%) Usual activity problem (%) Pain/discomfort problem (%) Anxiety/depression problem (%)	8 (26.7) 7 (23.3) 19 (63.3) 27 (90) 8 (26.7)
EQ-5D (VAS, 0-100)	Mean (SD)	76.37 (14.83)

CMC,carpometacarpal joint; NSAIDs, non-steroidal anti-inflammatories; NRS, numeric rating scale; FIHOA, Functional Index for Hand Osteoarthritis; EQ-5D-3L, EuroQuol 5-Dimension, 3-Level; VAS, visual analogue scale.
[ǂ]Other: contacted surgical consultant for appointment; glove for warmth; wheat bag (heat); stretches; self-massage.

Of note, several participants, both female and male, expressed offense at the gendered nature of question 7 of the FIHOA questionnaire: “For women: can you sew? For men: can you use a screwdriver?”. Those with a history suggestive of thumb CMC OA, that is, who had not yet sought care and had no clinician diagnosis made up 20% of participants.

All participants completed the daily diaries, some with just a few words on each day and some filling up to 3 pages (each day); completing the diaries was acceptable to all participants. All participants indicated that they found involvement in the study to be a positive experience and the interviews to be acceptable.

3.4.1 Thematic analysis

Five main themes representing five inter-related levels of health impact were identified: negative experience of symptoms, functional limitations, restrictions in social activities and roles, negative thoughts and feelings, and altered sense of self (Figure 3.2). Themes and sub-themes along with exemplary quotes are given in Table 3.3. No new themes or sub-themes were identified in the final three sets of interview data.

The two themes ‘symptom status’ and ‘functional limitations’ matched corresponding levels of the Health Impact Model, while the remaining three themes aligned to the Model levels of ‘General Health Perceptions’ and ‘Overall Quality of Life’. The impact at each level was found to be influenced by personal and environmental factors.

Participant quotes within the text are given italics for clarity.

3.4.1.1 Symptom status

Participants described symptoms of pain, loss of dexterity, weakness, and stiffness. For nearly two-thirds of participants, pain was considered the biggest impact. The most common pain descriptors were ‘dull ache’, followed closely by ‘sharp’ or ‘knife-like’; less common but still frequent were ‘shooting’, ‘stinging’, and ‘spasm’. Few participants described the pain as ‘burning’, ‘throb’ or ‘crunching’. Pain intensity was often moderate to high and in some cases unbearable, causing participants to *“change what I'm doing or just stop... Sometimes tearful"* (Hilary, 59 yr).

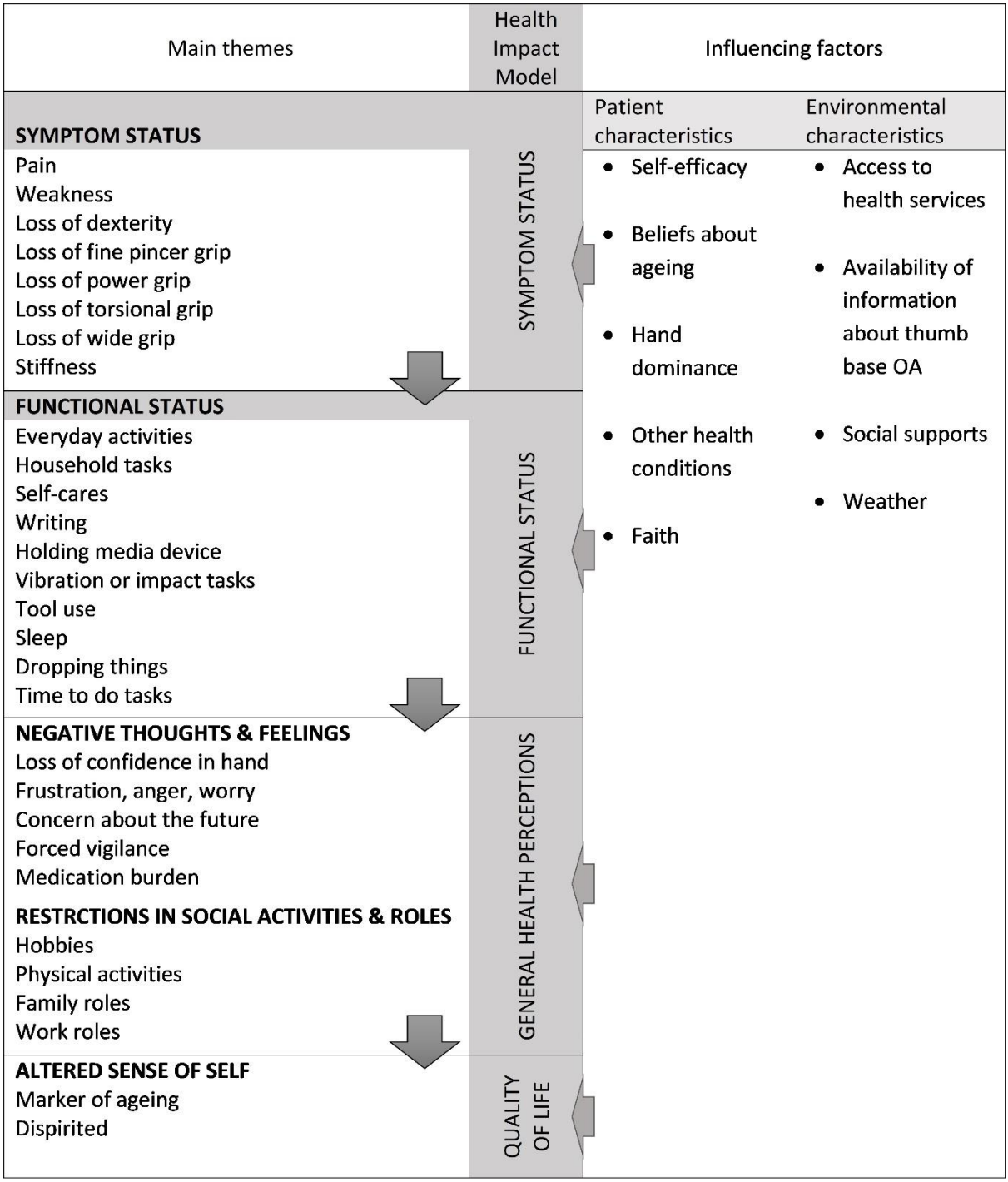


Figure 3.2 The 5 main themes representing 5 interrelated levels of health impact are aligned to the Health Impact Model, along with personal and environmental factors influencing the impact at each level.

Predictability of pain varied with some participants reporting they *"knew what they were in for"* (Neil, 70 yr) while others reported that pain experiences were quite random. Pain was variably reported as both constant and intermittent, or sudden, onset, with constancy most often given as the worst thing about the pain. Delayed onset pain was common; pain at night was a problem for two thirds of participants.

Weakness and loss of grip and dexterity were the biggest impact for around one third of participants and bothered most participants to some degree. Clumsiness and trouble manipulating small things were often associated with pain.

Limited power grip was associated with pain, stiffness, and perceived weakness particularly with heavy lifting. Many participants had problems with torsional grip (gripping to turn) and wide grasp. Stiffness, either in the first web span or the whole thumb digit bothered just under half of the participants and contributed to problems with both fine and gross grips.

3.4.1.2 Functional limitations

Participants reported significant impact on their ability to carry out everyday tasks and self-care, on sleep, and increased time taken to do things. Difficulty undoing lids and dropping things were ubiquitous problems. Opening a variety of containers was problematic, including plastic packets, flip lids, and seals on milk bottles; child-proof lids caused particular difficulty.

Driving was a problem for half of the participants, *"Especially in the new cars with the bigger, thicker steering wheels"* (Tracy, 65 yr), also turning the key, operating seat belts and buckles, opening and closing doors, and changing gear (manual and automatic). One participant reported difficulty controlling the vehicle because her hand *"just completely froze up"* (Marie, 50 yr).

Holding a media device or book was uncomfortable but texting on a cell phone was not. For those who used computers, mouse use was more taxing than the keyboard. Writing was limited for all but three participants whose dominant hand was involved.

Tasks involving impact or vibration were limited, for example, using an axe and carrying heavy items such as the coal bucket or firewood. Operating tools including secateurs frequently caused problems as did turning taps and doorknobs, holding a cup, using scissors, cutting with a knife, peeling vegetables, using a whisk, holding dishes to wash or dry, vacuuming, and ironing.

Dressing, particularly trousers and socks, doing up buttons and bras, and tying shoelaces were the most frequently mentioned personal care tasks causing problems. Other tasks included showering, doing hair, putting on jewellery, cleaning teeth, shaving, and wiping one's bottom.

3.4.1.3 Restrictions in social activities and roles

Participants described restrictions in social and recreational activities, and restrictions in their life roles including family and work.

Commonly restricted physical activities were bike riding, going to the gym, and walking the dog. Pulling on tight clothing was a limiting factor in the gym and swimming. Problems were also reported with golf, tennis, paddling, and hiking, for example, lifting a pack. Kapa haka (cultural dance) was limited because of pain on performing the wiri (rapid hand motion). Similarly, flicking the hand, such as to shake off water, and clapping were painful. Gardening was an activity in which over half the participants experienced difficulties.

Around one quarter of participants had difficulty in or had stopped their arts and crafts, including painting, jewellery making, crochet, knitting, and spinning. A smaller group were similarly impacted in playing musical instruments. Woodwork, photography, sewing, both machine and hand, playing cards and playing computer games were also limited.

Participants described limitations in fulfilling roles in the home, family and community including caring for children and grandchildren. Just over half of the participants said they were limited in their current, prospective or previous paid or voluntary work roles or study because of their thumb CMC OA. Some had to take frequent time off; for several it was the prompt to retirement.

3.4.1.4 Negative thoughts and feelings

Participants expressed negative thoughts and feelings associated with the impact of their thumb problem, including loss of confidence in their hand or hands, frustration with their functional limitations, anger about the pain and restrictions in everyday roles and activities, worry about what was happening in their thumb, and concern about the future. Loss of confidence was associated with a tendency to drop things and often resulted in avoidance behaviour. Feelings of frustration were closely linked to the pain and to the activities of everyday living becoming time-consuming and less enjoyable. The negative feelings contributed to negative mood which impacted on family and those close to them. Concern about the future arose due to difficulty or pain with activities of independent daily living. The importance of thumb function was summed up by one participant who lived alone: *"My thumb is the captain of the ship"* (Paula, 80 yr).

Participants described the mental burden of always being aware of their thumb – an enforced vigilance required to respect functional limitations and manage pain – *"self-preservation"* as one participant put it. Many participants were concerned about the impact of taking medications on their general health or other health conditions, and on their mental state. For the most part, participants were not bothered by the appearance of their thumb or hand.

3.4.1.5 Altered sense of self

Participants described an altered sense of self, relating how they perceived thumb CMC OA as a marker of aging, and in responding to the restrictions placed on them in fulfilling their important life roles.

Some participants described being *"dispirited"* because of the pain, frustration, and seeming lack of options. On the other hand, some individuals had rationalised their problems and saw it as part of getting older, or relatively mild compared to other health conditions or the disability experienced by others.

Table 3.3 Themes, sub-themes and exemplary quotes relating to the impact of thumb carpometacarpal osteoarthritis

Theme 1: Symptom status	
Pain	Louise, 52 yr "I think when it's, when I've got a lot of it, the fact that it never goes away. That it's always sitting there in the background… Once, it stopped sort of self-healing in the days I wasn't working, it was there constantly. Everything that I did caused pain, whether it was turning on a tap, or picking up the kettle, or even patting the cat. So, it was just the constancy of it."
	Stuart, 66 yr " … just a little less pain, and I would actually find that I would use my thumb more."
Loss of dexterity and fine (pincer) grip	Fabian, 62 yr "See um I'm a clock maker by trade, so all my ah, work is done with fingertips and things, so you're pinching, holding, squeezing all the time, tools, whatever you're working on. You know, so, having something like that is an absolute pain..."
Loss of power- and torsional grip	Arthur, 89 yr "I didn't realise I'd lost my grip. I used to have a very strong grip… And then I found that when I clench my fist like that, it gets, it's quite painful in there [base of thumb]"
Inability to grip wide objects	Craig, 69 yr "That wide, wide grasp, yeah, is... grabbing things like turf and trying to pull, like that. I just haven't got the strength to do it."
Stiffness	Joanne, 46 yr "I can't write for as long as I used to because it gets too sore and stiff and my handwriting gets worse and worse…"
	Lauren, 74 yr "The span's limited… which stops you playing the piano."
Theme 2: Functional limitations	
Limited in everyday activities	Tracy, 65 yr "Every single day my thumb problem impacts on my daily life: biking, driving, twisting tops off jars/bottles, sewing, pincer action between thumb and forefinger, knitting and crocheting, gardening, cleaning, wringing out cloths, housework in general (making beds is difficult)."
	Fabian, 62 yr "That's a bloody nuisance, that is [driving]"
Dropping things	Fiona, 65 yr "I'd be quite happy if there was no pain, but I would be happier if I knew I wasn't going to drop stuff if I picked it up… I'll drop plates, I'll drop ah, jars, anything that before I would feel… but now my grip is so weak in my right hand that I drop it."

Takes longer to do things	Lauren, 74 yr "…showering has become more difficult, because your hands just won't do what you want them to do. And I'm longer in the shower, and I'm trying to be quick because I'm in other people's homes. So that, that is a stress actually. Trying to get through that, ah, quickly."
Theme 3: Restrictions in social activities and roles	
Restricted in participating in recreational activities and fulfilling family roles	Moira, 63 yr "…it's taken away my enjoyment of gardening. I used to love that but it's quite hard, now, with both hands like that. Because I can't… pull out the roots (laughs). You know, I'll often break it off... so I just have to garden a bit differently… do it in smaller amounts."
	Kate, 48 yr "…the biggest impact I think it has on me, is not being able to do stuff. I'd like to be able to go out bike riding with her [primary school age daughter] but, brakes, gears... We've got our bikes in the garage… I bought a colouring book cause she [daughter] likes, she loves her arty stuff. I bought an adult's colouring book for me and one for her... I can't even sit down and do that with her."
	Marie, 50 yr "Yeah, kapa haka definitely, it's a huge part of my life and it's... I can still do it but I can't, I could never compete again or anything like that… Because I can't sustain that [wiri] with my hand."
	Jennifer, 64 yr "Well it's me! I've been a pianist since I was eight years old. And I love it, and I feel cut off from it… the thumb is a big deal in playing."
	Adele, 78 yr "It's, um, an inability to do things I could do in the past, because I am, I am a practical person. I do a lot of handcraft, and I had to reduce that activity, fairly drastically. So you just, you just have to give it up... that's past."
	Aaron, 74 yr "[she]… loves having foot massages and shoulder massages. And, I enjoy giving them to her. Jesus, it's painful! When she gets home eleven o'clock at night, really sore shoulders… Yes I can... it really stings!... really annoying that I can't do that without discomfort."
	Lauren, 74 yr "You find they [grandchildren] don't really understand. How could they? So, and you don't like saying, "No no no no, my thumbs are too sore for that".
	Moira, 63 yr "…my two-year-old grandson… I really struggle to pick him up, and because you have to spread around, you know, at their waist and lift them that way, and that's a really painful thing to do,... the other thing I find really difficult is his harnesses, you know like in the pushchair and in the car seat… You know, squashing, pushing."
Restricted in work roles	Susan, 59 yr "Just the writing really and shaking people's hands, that hurts… I sort of try and avoid that, well not so much avoid it but trying not to do it if I can get away with it."

	Kate, 48 yr “Some days I have taken days off because I've been too sore… I can't slow down, and take my time.”
	Amelia, 66 yr “… I've been retired for four years… I did relieving [childcare] until this year and I found that I couldn't lift the kids the same… I used to do nappies and whatever was going... But I can't now… just lifting the kids was just too much.”
Theme 4: Negative thoughts and feelings	
Lost confidence in hand	Fabian, 62 yr “I just don't trust my left at all. I know my left hand, ah will fall open without even me knowing, knowing what's happened... The last thing I dropped was five kilos of oranges in the gateway. And guess where half them went! (laughs)”
	Charles, 76 yr “I wouldn't risk lifting a big heavy pot or, with a handle in my left hand. So I've gotta make sure I use my right hand for those. Anything that… involves sort of strength I've, I've learnt to, avoid.”
Frustration	Joanne, 46 yr “It’s frustrating not being able to accomplish as much as I’d like to some days, but I’d rather not make my condition worse, so I try to rest it and not over use it as much as possible.”
	Aaron, 74 yr “Just, frustration as much as anything else… it's bloody annoying at times…”
Anger	Paula, 80 yr “Oh, I just get angry at it I think. "Bugger old age", really. That's to be honest. You know, I just say, you know, "Bugger this!". I'm really, "Brassed off!" at it. Um, yes I am. Quite angry with it because you... you use this [thumb] all the time.”
	Robert, 56 yr “And that's the irritating thing… that's when yeah I start getting grumpy and then I just disappear out the family's way, because I'm a nasty swine. I don't intend to be and they say they understand it, but that's not the point.”
Worry	Earle, 66 yr “Um, just the fact that it's there. Um, and I know that it means that something’s degrading.”
Concern about the future	Moira, 63 yr “…when I first got diagnosed with it… I immediately thought, "Right, gosh I'll have to shift house, you know, I obviously won't be able to manage on my own in this house."... You know it really upset me and depressed me, you know, for a while, because I was then having to go over in my mind, "Oh, I won't be able to do that, and that... And I'd planned in retirement, and oh I won't be able to do that!".
	Robert, 56 yr “I'm only 56, I'm not old, and these [thumbs]… will get worse as time goes on, cause age will make them worse, the wear will get worse, the bones, well most of it... I want to prolong that distance in time... I'm thinking in five years’ time they're going to be buggered.”

	James, 32 yr “Ahh, it troubles me... you know my livelihood depends on my fingers as well… because I know that I'm not super young, but at the same time I'm not, you know seventy or something. So I need to know what's going on so I can… address them and manage them.”
Mental burden	Fiona, 65 yr “It's impacting on how I would normally live my life, I have to be more aware of what I'm going to do…”
	Fabian, 62 yr “…you just gotta be aware of it, you just gotta have it in your mind all the time.”
Medication burden	Amelia, 66 yr “Normally I'll just try and have two Codeine through the day and then two when I go to sleep, at night. Some days it's really, really quite bad. But I try to stick to that because I don't wanna have too much… I'm on heart pills and other pills as well.”
	Kate, 48 yr “I've been put on Gabapentin. I… used to be on Tramadol and Codeine and all of that. I took myself off them because... it's got addictive tendencies and in my family there is addictive tendencies and I didn't want to get hooked on it… I don't want to be doped up driving round with her [primary school-age daughter] in the car or... anything like that.”
Theme 4(i): Not concerned about appearance	
Sarah, 73 yr “Well, I've noticed, yeah, you know if compared to this one there's a lot more knobbly bits. But, it doesn't bother me, no.”	
Aaron, 74 yr “No, couldn't care less. When you get to my age everything looks different.”	
Hilary, 59 yr “… so long as there's no pain I don't care what it looks like.” (laughs)	
Theme 5: Altered sense of self	
Marker of ageing	Fiona, 65 yr “It is tied up with me getting older, I think. It’s more than just the pain, it’s the notification that I'm starting to get to be an older person… it’s a kind of a holistic thing… it's the whole identity of myself… I'm turning into an older person.”
Dispirited	Hilary, 59 yr “… I'm not prone to depression, but it's quite depressing when you know that it's not going to go away and there's nothing you can really do except stop everything you're doing, which isn't an option.”
	Robert, 56 yr “The actual thing that gets rid of the pain better than anything, or makes me notice it less, is alcohol, which is not a good thing… Then I know if I want to go to sleep I actually need a couple of decent belts down… that's what I find the dispiriting side of it, the debilitating side…”

3.4.1.6 Personal and environmental factors

Personal and environmental factors significantly influenced how thumb CMC OA impacted on each participant. Influencing factors along with exemplary quotes are given in Table 3.4.

Availability of support – family, friends, or paid home help – played a significant role in reducing the impact of the condition. Conversely, having no help increased the impact although some participants took the 'use it or lose it' approach. Cold weather worsened the problem.

Self-efficacy, evident as ingenuity in problem solving often alleviated the impact, *"You just gotta think of different ways to skin the cat that's all"* (Fabian, 62 yr). Many participants took a proactive approach to the care of their thumb or thumbs with self-help modalities including massage, heat – including warm gloves – rest , topical creams, exercises and stretches, and simply avoiding painful tasks. Carrying on because the task needed to be completed and ignoring the pain or difficulty, was another way in which many participants demonstrated self-efficacy. Involvement of the dominant hand compounded the problem.

For some, impact was perceived as less where other health conditions or life circumstances took priority or medication for other conditions masked the problem, while for others, life events exacerbated their thumb CMC OA symptoms. For a small number, religious faith played a role in keeping well in the face of their thumb problems.

In some cases, participants did not seek care because either they had rationalised their problem as part of ageing or their health provider held this view and dismissed the problem. Accessing health care made a difference for several participants. However, access to care was sometimes limited by cost or distance from health services, or both, as was access to adaptive equipment and devices. Participants were motivated to access healthcare when their pain became unbearable or limited them in their most important activities or roles. While pain relief medication was often effective in managing pain, most participants were eager for non-pharmacological interventions. However, nearly all participants had found it hard to come by information about the condition and self-management, even when they sought treatment.

Table 3.4 Themes and exemplary quotes relating to factors influencing the impact of thumb carpometacarpal osteoarthritis

Personal factors:	
Self-efficacy	Neil, 70 yr "It doesn't impact on me at all because I've got that used to compensating, um that, it's just like favouring a sore, sore ankle if you had a sprain. You'll favour it till it comes right. I favour this to the extent that I don't get the pain."
	Charles, 76 yr "…to hold the bottles… sometimes I have to go and put them in the vice."
	Fiona, 65 yr "…we cannot undo cans, or you know screw things, that's when we had to use the pipe-wrench (laughs)."
	Jennifer, 64 yr "…peeling things… That's quite tricky. Now I just do as they say and just wash the carrots off and stick them straight in the oven."
	Kate, 48 yr "I tend to steer clear of buttons. I've got ah like, trackies... very rarely do I wear a pair of jeans that's got a button on it."
	Sarah, 73 yr "I was cleaning toilets at work, and it needed a new Janola thing… couldn't open it, couldn't find a pair of pliers, so I put it on the floor and put my foot on it, then gave it a twist and it worked."
	Robert, 56 yr "I like making pastry, I'm buggered if I'm not going to make it just cause they hurt, I've got to find a way of doing it."
	Tracy, 65 yr "If we do a long bike ride I think, "Ohh" and it's getting really sore. But, you just do it!... Nothing changes really, you just... you adjust."
Carry-on – use it or lose it approach	Clare, 65 yr "Tops off bottles and that… I try not to give in and ask my husband because I know it's a strength thing you don't want to lose."
	Sarah, 73 yr "I tackle anything and everything… As long as I can do things myself I'll do it myself. I realise there'll be a time that I'll need to ask for help. But in the meantime, I'm still doing it."
Dominant hand not involved	Marie, 50 yr "I'm actually glad it's my left hand as I wouldn't be able to do my job if it was the right."
	Charles, 76 yr "… it would actually affect my life, really affect my life and what I can do. But because it's in the left hand, it's livable.

Role of other health conditions and life events	Marie, 50 yr “Since then I have been dealing with other medical issues (I have COPD [chronic obstructive pulmonary disease]) and my hand has been an annoyance as opposed to an issue so I tend to ignore it – until it flares up like this week.”
	Celia, 71 yr “I'm coping with... I've broken two ankles in three years, and I'm having a lot of pain with that. So this is nothing.”
	Lauren, 74 yr “My focus in the last two years has just been survival. Just learning to live um, without your home, and everything you've got is in storage. And also I've struggled with other aspects of my health… apart from my thumb.”
	Paula, 80 yr “Sometimes… if I'm going to bed and it's later at night I won't take Panadol… if I think I don't need it for my knee, and that's when I notice, that's really very bad [base of thumb].”
	Amelia, 66 yr “…[son-in-law] come around… came to say he is going on the fishing boat tomorrow. Their baby is two weeks old. I am very stressed. My thumb started to ache. [Son-in-law] could be away for three months.”
Faith	Jennifer, 64 yr “I'm faithful and I believe that I'm given nothing to cope with that I won't be able to cope with. But, it does really get to me sometimes.”
Beliefs about ageing	Tracy, 65 yr “You just get on and do what you got to do… you just take it as you get older, you think, you know your joints are seizing up a bit.”
	Charles, 76 yr “Nowadays it’s something I can live with quite successfully… in old age, always something gets sore.”
	Lauren, 74 yr “I feel quite grateful that I’m 74 and I’m not crippled with arthritis in other joints, so… this is manageable.”
Motivation to access health services	Robert, 56 yr “And then it gets to the point, after 8, 9 months, when it's just unbearable and you don't get any break, and that's when I go back and get the injection in it.”
	Fabian, 62 yr “If that played up with my sport [shooting], I'd be going… somewhere pretty rapidly.”
	Sarah, 73 yr “If I had mentioned this to my GP two years ago, or three years ago, I probably would have been into the system a lot earlier. But, I didn't put much problem with it. I thought, "Nah, it's just the garden and I'm not getting any younger and I'll... you got to expect it...".”

Environmental factors:	
Social support	Moira, 63 yr “Good team work… I'm managing quite well at work… my job's mainly hand work. But, I'm hoping I'll be able to keep going…”
	Clare, 65 yr “The worst thing… was putting in earrings… my husband's retired and I'm working so he does most of it…(laughs) lets me off the hook.”
	Lauren, 74 yr “Gardening became more difficult… I got some help from WINZ to pay for 2 hours help once a fortnight.”
	Louise, 52 yr “There is some stress in it because I know that I've still got to do... I live alone and I've still got to do the housework and I've still got to do the gardening and change the beds and all that and it doesn't matter whether my hand hurts or not. I don't have a choice in the matter.”
Weather	Tracy, 65 yr “…cold frosty days it seems to be worse. Sometimes when it's raining it seems to be worse. Go to Australia and I don't get any pain.”
	Sarah, 73 yr “Previous to the support [splint], that was painful out in the garden. With the support I've got no trouble, it's great. When I take the support off, it's painful. But only for a wee short while, not for long.”
Access to health services	Robert, 56 yr “The night supports were, marvelous. When I first got those, I had a night's sleep! And that was fabulous. It mightn't seem much but… you're just looking for incremental improvement. I'm not expecting, "Boom, I'm cured"… I can mitigate the ache if I get the painkillers in… if I've been up for more than two hours and haven't taken them, I'm going to have problems for the day.”
	Susan, 59 yr “I had that one X-rayed but it wasn't as bad... But you see it's dropped completely and even the GP said herself she was going to hurry them up... enquired into seeing a hand specialist but… he, she or whatever didn't think it was warranted… otherwise I have to pay to see them. This is on the public system. Something like $400 or something or other to go and see this person [private hand therapist].”
Access to health information	Adele, 78 yr “Well, if I can give things a name, I can control it better… it helps me, um, to know, this is what's wrong, it's got a name, instead of being... uncertain about things.”
	Marie, 50 yr “And then I got anti-inflammatories once off the doctor but then I didn't actually... I don't like taking pills… so is there other stuff I can be doing or is this just a part of getting old?... should I be using those little balls to strengthen it or is that aggravating it?

	Aaron, 74 yr “I said to the doctor, "I've got something wrong with my thumb, it's this, and this is how it affects me", and he said, "Oh, yeah, that'll be um arthritis. Here's your prescription for your blood pressure... See you later." So I thought, "Oh yeah, tough!" (laughs)”

WINZ Work and Income New Zealand (New Zealand social welfare services).

3.5 Discussion

This study provides new insights into patient perspectives of thumb CMC OA as a unique disease entity and the impact of a hand OA condition. Five key inter-related levels of impact were identified. Also identified were personal and environmental factors that influence the impact of thumb CMC OA, some of which are modifiable.

Key concerns important to participants were constant pain and pain that interrupts sleep; limited performance of power grip and precision tasks; and limited participation in work, caregiving, recreational and physical activities, and ADLs. Negative thoughts and feelings included frustration, anger, worry, concern about the future and the burden of medication. An altered sense of self was related to ageing. Impact was greater where the dominant hand was involved.

The impact of pain was associated with impact at all levels and a major concern for participants, similar to previous findings in general hand (MacDermid, 2008; Siviero et al., 2016) and hip and knee OA (Hawker et al., 2008; Zambon et al., 2016). As with previous hand OA findings (Marshall et al., 2009), constant aching pain was of greater concern to participants in the current study, in contrast to large joint OA where intense, unpredictable pain has been found to be more distressing (Hawker et al., 2008).

Hand weakness was frequently described in this study, also matching previous findings in hand OA (Lee et al., 2012; MacDermid, 2008; Zhang, 2002). The pain commonly accompanying weakness and loss of dexterity suggests these symptoms are closely linked.

This study reported limitations in a wide variety of functional activities and life roles similar to previous hand OA studies (Bijsterbosch, Haugen, et al., 2011; Bromann Bukhave et al., 2014; Calfee et al., 2015; Dziedzic et al., 2007; Leung, Li, & Thumboo, 2017; Leung et al., 2015; Slatkowsky-Christensen et al., 2010; Slatkowsky-Christensen, Mowinckel, Loge, & Kvien, 2007; Spacek et al., 2004; Stamm et al., 2009; Zhang, 2002), but several differences were evident. Whereas cell phone use has been raised as a concern in general hand OA (Stamm et al., 2009), this was not an issue for participants in the current study except for holding the device, possibly because many participants

were ‘one-finger texters’. Furthermore, impact relating to computer use was specific to the computer mouse.

Although manual tasks were a primary concern for participants in the current study, there was also a pattern of reduced general physical activity due to limited hand function. A previous study of patients with hand OA found reduced levels of lower limb as well as upper limb functioning (Moe et al., 2013) and their suggestion that hand OA impairments may contribute to reduced levels of general activity is supported by this study’s findings.

The mental and emotional impact identified in this study concurs with previous studies in thumb CMC (Calfee et al., 2015), hand (Hill et al., 2010; Leung et al., 2015; Moe et al., 2013; Stamm et al., 2009), and general OA (Baird, 2000; Gignac et al., 2006; Harris, Byles, Sibbritt, & Loxton, 2015; Rosemann et al., 2006). However, aesthetic appearance, previously identified as an area of impact in hand OA (Dziedzic et al., 2007; Hill et al., 2010; Hodkinson, Maheu, Michon, Carrat, & Berenbaum, 2012; Leung et al., 2017; Leung et al., 2015; Stamm et al., 2009), was not a major concern in the present study. It may be that the interphalangeal joints (IPJs) are more visible or prone to disfigurement and that pain and function are bigger concerns when the thumb CMC is involved, or that aesthetic comfort is not a priority for people in the southern parts of New Zealand. In contrast to previous authors (Hill et al., 2010), the current study found no embarrassment due to disability, only high levels of frustration and anger.

Participants experienced a negative impact on their sense of self, linked to the perception that their thumb CMC OA was a marker of ageing. This may be related to a view previously reported in a cohort of older people in the United Kingdom, that one’s dignity is jeopardised by ageing (Woolhead, Calnan, Dieppe, & Tadd, 2004). Negative perceptions of OA as an indicator of ageing have previously been described in general OA populations, with OA symptoms similarly often minimised or ignored by health workers, and those with the condition themselves, resulting for example in postponing or avoiding of treatment (Gignac et al., 2006)

As in the current study, environmental support and strategies to continue performing valued activities have previously been identified as important influencing factors in the impact of OA generally (Bromann Bukhave et al., 2014; Gooberman-Hill et al., 2007; Hill et al., 2010). In addition to pain and functional limitations, potential targets for intervention identified in this study are beliefs about ageing; financial and other barriers to accessing services; understanding about the condition and interventions that may halt progression and enable function; and emotional impact. The presence of other health conditions was also identified as a barrier to accessing care for thumb CMC OA. Whereas maintaining physical activity helps control comorbid conditions such as heart disease or diabetes untreated thumb CMC OA may contribute to overall decline in activity levels and, consequently, health status.

The fact that a substantial number of those who would benefit do not access health care has recently been confirmed in thumb CMC OA (Gravas et al., 2019) and previously in hand (Dziedzic et al., 2007) and general OA (Gignac et al., 2006) studies. The findings of previous studies that there is a need to dispel the belief of both patients and clinicians that OA problems are an inevitable part of ageing (Dziedzic et al., 2007; Harris et al., 2015) is endorsed by the work of the current findings. The development of a conceptual model of thumb CMC OA that enables people to understand what is happening and how they can influence it would be extremely helpful.

Education and access to information is a core guideline recommendation (NICE, 2014) but the findings of the present study and those of a previous study in hand OA (Hill et al., 2011) indicate that neither education nor information are readily available. In hand OA this unmet need has been linked to clinical uncertainty and a lack of high-quality evidence for therapeutic options (Hill et al., 2011). Earlier access to evidence-based information, advice, and non-pharmacological and non-surgical interventions in primary care or via public information platforms and agencies would help address this need (Gravas et al., 2019).

Several functional limitations identified in this study, as well as impact at other levels important to participants are not assessed by the FIHOA or AUSCAN instruments (Table 3.5).

Table 3.5 Items from OARSI-recommended outcome instruments (AUSCAN and FIHOA) and the impact of thumb carpometacarpal osteoarthritis from this study not included in these instruments.

AUSCAN	FIHOA	Impact not included
Pain subscale	1. Can you turn a key in a lock? 2. Can you cut meat with a knife? 3. Can you cut fabric or paper with a pair of scissors? 4. Can you lift a full bottle with your hand? 5. Can you make a fist completely? 6. Can you tie a knot? 7. For women: can you sew? For men: can you use a screwdriver? 8. Can you button up a garment? 6. Can you write for a long time (without interruption)? 10. Do you accept to shake hands without reservation?	Functional limitations
1. At rest 2. Gripping 3. Lifting 4. Turning 5. Squeezing		Dropping things Time tasks take to do Vibration or impact tasks Holding media devices Sleep interruption Household tasks
Stiffness subscale		Negative thoughts and feelings
6. After first wakening in the morning		Mental and emotional impact Medication burden
Physical function subscale		Restrictions in social activities and roles
7. Turning taps/faucets on 8. Turning a round doorknob or handle 9. Doing up buttons 10. Fastening jewellery 11. Opening a new jar 12. Carrying a full pot with one hand 13. Peeling vegetables/ fruits 14. Picking up large heavy objects 15. Wringing out wash cloths		Interaction with children and grandchildren Work roles Recreational activities
		Negative impact on sense of self
		Negative indicator of ageing

Development of measurement tools that better capture both the specific and broader impact of thumb CMC OA is needed. The empirical evidence gathered in the present study can be used as the basis of a conceptual framework to underpin the development of valid patient-reported outcomes for thumb CMC OA.

For treatment to be patient-centred it is important to consider the impact of health conditions in different cultural contexts (Napier et al., 2014). The present study contributes new information from the New Zealand context that will broaden and diversify knowledge about the specific needs of people with thumb CMC OA globally. Although some of the findings may relate to the local culture and environment in which the study was conducted, many are comparable with previous studies of OA conducted

elsewhere with differences reflecting the specific focus on thumb CMC OA versus hand or large joint OA. Most participants in the current study were New Zealanders of European descent many of whose social circumstances are not dissimilar to people living in Western European countries. Therefore, findings will have relevance for people with this diagnosis generally.

3.5.1 Strengths and weaknesses

A strength of this study is the use of qualitative methods to yield rich and varied data. The explanatory nature of findings is useful since, in the case of patient's perspectives of thumb CMC OA, little is known about which variables are important to examine, and what factors influence outcomes in studies investigating interventions for this condition. Furthermore, the use of solicited diaries helped to engage participants with self-observation in their everyday life and contributed to richer interview data by the thoughtfulness and attention participants gave to compiling them.

The inclusion of participants who had not sought care is a second strength of this study and supports knowledge generation that includes those who access health services less often. The recruitment rate of participants of Māori descent (10%) was modest, exceeding the proportion of population in the primary centre (6.2%), but not that in the second centre (13.3%) or nationally (16.5%) (Statistics New Zealand, 2013).

This study has some potential weaknesses. First, inclusion criteria were based on self-report of either clinician diagnosis or a history suggestive of thumb CMC OA and did not include radiographic confirmation. However, a thorough screening process by a trained research assistant and the application of inclusion criteria by an experienced physiotherapist and hand therapist gives reasonable certainty that participants were symptomatic for thumb CMC OA. The low mean FIHOA score of participants in the current study could suggest relatively low severity of thumb CMC OA disease. However, the mean pain score and disease duration are comparable to those in a previous large qualitative study of hip and knee OA (Hawker et al., 2008). Low FIHOA scores may instead reflect poor validity of the outcome measure for thumb CMC OA, or alternatively an attitude of stoicism leading to a greater reluctance to reporting problems. This has been found to be common in community-dwelling older people with chronic pain

(Cornally & McCarthy, 2011). It may also be a local cultural difference with a similar general OA cohort from the southern parts of New Zealand recording significantly lower functional disability on the Health Assessment Questionnaire (HAQ) than counterparts in Birmingham in the United Kingdom (Treharne et al., 2008).

It may be that findings of the present study are influenced by the experience and impact of OA at joints other than the thumb CMC. Although involvement of IPJs is known to exacerbate impact in the presence of thumb CMC OA (Gravas et al., 2019), only a small number of participants in the current study reported involvement of other hand joints and the interview schedule guided participants to focus on the impact relating specifically to their thumb CMC OA. Therefore, there can be confidence that the findings of the present study substantially reflect the impact of thumb CMC OA rather than that of other joints, including IPJs, although it is accepted that some impact is shared.

3.6 Conclusion

The present study indicates that thumb CMC OA, as a unique disease entity, has a significant impact, largely associated with the impact of pain, on many aspects of a person's health and well-being. Key areas of impact were identified which may serve as important treatment targets and assessment outcomes. An important novel finding was the common reporting of pain at night. There is a need for clinical practice and research to account for hand dominance; cold climate; people's financial, family and community resources; and attitudes to thumb CMC OA. A current gap which needs to be addressed is the availability and provision of high-quality information about self-management and effective treatments. Development of a thumb CMC OA-specific instrument relevant to contemporary modes of living is also indicated. These findings from the New Zealand context hold relevance for populations with thumb CMC OA generally.

3.7 Implications for the related studies in the thesis

- People with thumb CMC OA desire better access to non-pharmacological and non-surgical interventions. In this regard, splinting may be an acceptable intervention for patients and study participants.
- People with thumb CMC OA desire access to good information about the condition and how they can help themselves. Education and advice about self-

management and joint care principles are core recommendations for managing hand OA and thumb CMC OA and should be available to all people with the condition. Good quality education and advice should form part of the standardised best practice usual care in an intervention study and is likely to be acceptable to participants.

- Pain at night should be included as an outcome measure in intervention studies for thumb CMC OA
- The FIHOA poorly reflects the impact of thumb CMC for people in contemporary society. Alternative functional outcome measures need to be explored and developed. A list of 10 additional functional items tabled in the current study could be trialled in an intervention study. However, although indicated, the development of a new, thumb CMC OA specific instrument is outside the scope of this thesis.
- Quality of life is a mandatory outcome measure for studies investigating treatment effectiveness in thumb CMC OA, particularly given the broader impact of the condition identified in the current study.
- Impact is greater where the dominant hand is involved. Therefore, a feasibility study for a comparative intervention trial should stratify randomisation by hand dominance as differences in this variable between groups at baseline could cause confounding in clinical outcomes particularly in a small study.

The findings of the present study support splint interventions as the focus of a systematic review in Chapter 4 and will inform the design of a feasibility study for a future full-scale trial to investigate a splint intervention in Chapter 5.

Chapter 4

Effectiveness of splinting for pain, function, and quality of life in people with thumb CMC OA: A systematic review with meta-analysis

4.1 Introduction

As outlined in Chapter 1, a diverse range of treatments is suggested to manage thumb CMC OA. However, there remains a paucity of evidence for non-surgical, non-pharmacological interventions, including splinting (Hochberg et al., 2012; NICE, 2014). Interventions that target biomechanical factors in thumb CMC OA are indicated by the anatomical and aetiological literature reviewed in Chapter 2. Moreover, people with thumb CMC OA desire easily accessible non-pharmacological and non-surgical treatments, as voiced by participants in the study in the previous chapter. Splinting is one such intervention which may be well placed to address the biomedical problem of thumb CMC OA and to achieve outcomes important to patients, i.e. reduced need for medication and surgery and improvements in pain, function, participation in life roles, and overall well-being. Further investigation of the effectiveness of splinting for thumb CMC OA is therefore warranted.

Systematic review of the literature supports decision-making in evidence-based practice and clinical research by providing a current, comprehensive understanding of the knowledge of a topic and identifying research gaps (Moher, Liberati, Tetzlaff, Altman, & Grp, 2009; Portney, 2015). Systematic review entails rigorous searching, appraising, and summarising of existing evidence in a way that is trustworthy and reproducible and makes clear the strengths and limitations of the body of evidence (Moher et al., 2009; Portney, 2015). This chapter reports a systematic review of studies which have previously investigated the effectiveness of splinting for improving pain, function, and quality of life in people with thumb CMC OA. The purpose of this chapter is two-fold. Firstly to examine the state of the existing literature, hence addressing the second thesis aim: to investigate the effectiveness of orthotic (splinting) interventions for the management of thumb CMC OA. Secondly, to identify features of splint use and

design, and to review outcome measures and study design needed to inform a future study to evaluate the comparative effectiveness of splinting to manage thumb CMC OA.

The first background section of this chapter provides an operational definition for splint interventions, outlines knowledge of their mechanism of effect, and examines previous systematic reviews on the topic to situate the aims of the present review. The second and third sections report the methods and results respectively. In the final section, findings are discussed in relation to previous literature and conclusions drawn for clinical practice and research including implications for the design of the feasibility study reported in Chapter 5.

4.2 Background

4.2.1 Splinting for thumb CMC OA – an operational definition

A splint or orthotic device is defined by the Australian Orthotic Prosthetic Association as:

> "…an externally applied device that is designed and fitted to the body to achieve one or more of the following goals: control biomechanical alignment, correct or accommodate deformity, protect and support an injury, assist rehabilitation, reduce pain, increase mobility, increase independence." (Australian Orthotic Prosthetic Association, 2020)

An orthotic device, or splint, is classified as a 'medical device' by the World Health Organisation (WHO) (Berumen, 2017). The WHO highlights that the performance of a device depends not just on the device itself but on how it is used, that is, it has to be safe and correct (Berumen, 2017).

A thumb orthotic device may be soft or rigid, include the thumb CMC joint and optionally the thumb MCP joint or wrist or both, may be 'off the shelf' (prefabricated) or custom made, and may be worn for short or long periods during the day or night, or both, for a prescribed period of time or on an ongoing or self-regulated basis. The goals of an orthotic device in thumb CMC OA may include, for example, providing external support; reducing inflammation from arthritis; controlling pain; providing external

support; substituting for absent, weak or imbalanced muscles; evaluating for potential surgery; or increasing or maintaining joint motion (Colditz, 2000; Poole & Pellegrini, 2000). Thumb orthotic devices are commonly prescribed and fitted by physiotherapists, occupational therapists and hand therapists (Davenport, 2009; O'Brien & McGaha, 2014). The devices may also be prescribed by orthopaedic surgeons, rheumatologists, or GPs and fitted by orthotists or purchased independently by individuals, for example, from pharmacies or medical suppliers.

4.2.2 Mechanisms of effect of thumb CMC splinting

Splinting for thumb CMC OA has been shown to have biomechanical and neuromotor mechanisms, with immobilisation of more or fewer joints having consequent advantages and disadvantages (Colditz, 2000). Mechanical effects have been demonstrated (Grenier, Mendonca, & Dalley, 2016; Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Brüggemann, 2014; Weiss, LaStayo, Mills, & Bramlet, 2000, 2004) and more recently thermal and compressive effects have also been shown (Davis, Loyley, Worsley, & Adams, 2019). However, there has been little empirical study of proposed mechanisms for the therapeutic effect of splinting.

In a retrospective thumb CMC OA cohort, a comparison of three splints of varying lengths found that pinch strength increased the most when the greatest number of joints were immobilised (Grenier et al., 2016). While the study had a high risk of bias and confounding, a similar observation was made in a small study by Hamann et. al. comparing four splints for their effect on thumb stabilisation and on function (Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Brüggemann, 2014). In this study, stability, quantified by 3-dimensional thumb motion analysis, was greatest with the most supportive splint encompassing the wrist and the CMC, MCP, and IP joints of the thumb (Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Brüggemann, 2014). On the other hand, function, measured on a physical performance test, was greatest with the least supportive splint (including only the CMC joint) (Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Brüggemann, 2014). The splint producing the greatest stabilisation resulted in the lowest hand functionality, i.e. a trade-off occurred between greater stabilisation and greater function (Hamann, Heidemann, Heinrich, Wu, Bleuel, Gonska, & Brüggemann, 2014). A compromise between the goals of stability and

function may be necessary or splint types may need to be matched to individual problems, for example, pain or weakness versus function. However, the findings of the qualitative study in Chapter 3 indicate that people with thumb CMC OA often experience problems of pain as well as function or strength, or both. Systematic review of the literature and the rationales for splinting therein may provide additional insight into which splints may be more effective for which patients and the potential mechanisms by which splints have effect.

4.2.3 Evidence for effectiveness

Clinicians commonly prescribe splints (Davenport, 2009; O'Brien & McGaha, 2014) and clinical studies have shown positive results with significant reductions in pain and reduced demand for surgery (Berggren et al., 2001; Gomes Carreira et al., 2010; Rannou et al., 2009). Interventions combining splinting with other non-surgical interventions have also demonstrated positive effects (Robbins et al., 2019; Wouters et al., 2019). International treatment guidelines conditionally recommend the use of splints for thumb CMC OA (Hochberg et al., 2012; Zhang et al., 2007) but the strength and quality of the evidence is variable. Furthermore, splints are made from a variety of materials and are of varied designs and evidence is lacking as to which are the most effective (NICE, 2014).

Previous systematic reviews examining the effectiveness of splinting for thumb CMC OA have provided mixed results. In seven prior systematic reviews four made no recommendations due to methodological limitations of the included studies (Lue et al., 2017; Mahendira & Towheed, 2009; Spaans et al., 2015; Towheed, 2005), two concluded there was high to moderate level of evidence for use of splints (Valdes & Marik, 2010; Ye et al., 2011), and one concluded 'fair' level of evidence for the use of splints (Egan & Broisseau, 2007). In two prior meta-analyses, one found splints reduced pain at short- and long-term follow-up although long-term was anything beyond 3 months) (Kjeken et al., 2011), while a recent meta-analysis found no effect on pain or function at ≤ 45 days or ≥3 months (Bertozzi et al., 2015).

The inconsistent findings of these reviews reflect the small number and heterogeneity of the original studies, the small sample size of included studies and, in the older

reviews, outdated and now considered flawed methods for determining study quality and judging the overall strength of evidence. Recently, new primary studies have been published which may strengthen the evidence on which to base clinical recommendations. An attempt at resolving previous inconsistencies using current best practice methodology is needed.

4.2.4 Study aims

Considering this background the primary aim of this present study is to perform a systematic review to investigate the effectiveness of splinting for reducing pain and increasing function and HR-QoL in people with thumb CMC OA. A secondary aim is to examine the comparative effectiveness of different splint types.

4.3 Methods

The recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement guidelines were followed (Moher et al., 2009) and the PRISMA Checklist completed (Appendix J). The study protocol is available in the public domain (PROSPERO registration: CRD42016032612).

4.3.1 Search strategy

Seven electronic databases were searched from inception to 17 March 2018: Cochrane Central Register of Controlled Trials, MEDLINE (OVID), Embase (OVID), CINAHL, ISI Web of Science, Scopus and Google Scholar. The following were screened to identify ongoing or recently completed trials: trial registries, viz. WHO International Clinical Trials Registry Platform, ClinicalTrials.gov, and Australia New Zealand Clinical Trials Registry; and conference proceedings, viz. OARSI, British Society for Rheumatology, European League Against Rheumatism, and ACR. Grey literature directories were also searched including TRIP and OpenDOAR.

A comprehensive search strategy was developed using the PICOS (Population, Intervention, Comparison, Outcome and Study design) framework. Medical subject headings and text terms describing thumb CMC OA were combined with terms describing the interventions. An example search strategy is given in Appendix K; this was adapted for each information source. No study type or language restriction was

applied. Each database was searched independently by the PhD researcher and a second researcher. A manual search of reference lists of previous systematic reviews and included studies supplemented the electronic searches.

Studies were included if they investigated the effect of splinting for pain, function or HR-QoL in participants age ≥18 years with a diagnosis of thumb CMC OA (as defined by the authors of the included trials). Splinting was defined as a thumb orthotic intervention, that is an orthosis, splint, or brace with or without standardised co-interventions, provided co-interventions were given to both experimental and control groups.

Studies combining a variety of conditions or joint involvement were accepted if data for participants with thumb CMC OA could be extracted separately. Excluded were participants with rheumatoid arthritis only, or where the intervention was applied after surgery for thumb CMC OA. Control or comparator interventions included any other surgical or non-surgical intervention including an alternate splint, no intervention, or sham intervention. Randomised controlled trials and quasi-experimental studies were eligible for inclusion. No restriction was applied to study setting. The primary outcome variable of interest was pain. The primary safety outcome was withdrawal due to adverse events.

Secondary outcome variables of interest were measures of physical function or disability, both self-reported or performance measure, and measures of HR-QoL. Where multiple measures of pain were reported in the same study, the primary outcome data were extracted according to the following pre-specified hierarchy: pain overall, e.g. visual analogue scale [VAS] pain; pain on hand usage; AUSCAN pain sub-scale; other algofunctional scale validated for use in hand OA; and patient's global assessment, physician's global assessment. Where more than one measure of physical function or disability was reported, decisions about which outcome data to extract were made according to the following pre-specified hierarchy: FIHOA score, AUSCAN physical function sub-scale, other algofunctional scale validated for use in hand OA, performance-based tests of hand function (e.g. grip strength, pinch strength), and global disability score. Where more than one QoL measure was reported, the following pre-specified hierarchy was adhered to: SF-36, EuroQol, other measures of quality of life.

The main time point of interest was the first assessment after completion of splint-wearing intervention. Longer term follow-up, where available, was categorised as short-term (<3 months), medium-term (3-12 months), and long-term (>12 months) from time of group allocation.

Randomised controlled trials, quasi-experimental studies, before and after studies, interrupted time series studies, non-randomised controlled trials and prospective cohort studies were included. Journal publications, theses and conference abstracts were eligible where these had adequate data to determine whether they met the inclusion criteria. Excluded were case studies, retrospective studies, systematic reviews, and feasibility studies.

4.3.2 Study selection

All citations from database searching were exported to bibliographic software (EndNote X7, Clarivate Analytics [previously by Thomson Reuters], Philadelphia) and duplicates removed. Citations were then uploaded to online systematic review management software (Covidence, www.covidence.org) from where the PhD researcher and a second researcher independently screened titles and abstracts for possible inclusion. Potentially eligible studies were obtained in full text and independently assessed for inclusion. Any disagreement was resolved in the first instance by discussion and, where required, in consultation with a third reviewer. Consultation occurred in five cases and all disagreements were resolved.

4.3.3 Data extraction

Data were extracted using the Cochrane Effective Practice and Organisation of Care Group (EPOC) Data Abstraction Form tailored and piloted for purpose (Appendix L). Data were extracted by the PhD researcher and cross-checked by a second researcher. Data extracted were the following: type of study; recruitment method; population characteristics including total number of participants, severity at baseline including number and location of symptomatic hand joints, duration of symptoms, age, gender, work status, ethnicity, setting, country, and inclusion and exclusion criteria; interventions used in the intervention group including number of follow up clinician contacts; splint characteristics including materials, design, and wearing instructions,

along with the theoretical basis or rationale); comparator or control group interventions including number of follow up clinician contacts; thumb CMC OA case definition or classification criteria; details of the study required for assessments of quality and risk of bias; data pertaining to primary and secondary outcomes, including type and timing; unit of allocation (thumb or individual); unit of analysis (thumb or individual); funding source; and key conclusions.

Authors were contacted to obtain or clarify missing or unclear data. Data available only in graph form were extracted using a freely available web-based tool: http://arohatgi.info/WebPlotDigitizer. Missing statistics were calculated from available data. In the case of failure, participant attrition was treated by intention-to-treat analysis.

4.3.4 Critical appraisal of risk of methodologic bias

Critical appraisal of risk of methodologic bias in each study was undertaken independently by the PhD researcher and a second researcher, using the Cochrane Collaboration's 7-item Risk of Bias Tool to rate each item for each outcome as Yes/No/Unclear (Higgins, Altman, & Sterne, 2011). Risk of detection bias was scored for each outcome; subjective self-reported outcomes completed by unblinded participants were deemed at high risk of detection bias. Judgements were compared for discrepancy and any disagreement resolved by discussion with a third experienced reviewer.

In order to supplement the risk of bias appraisal and thereby gain a fuller understanding of the strengths and weaknesses of the cumulative evidence, both reviewers independently narratively assessed the overall quality of each study for RCTs, using the van Tulder scale (Furlan, Pennick, Bombardier, van Tulder, & Editorial Board Cochrane Back, 2009), and for quasi-experimental design, using the MINORS instrument (Slim et al., 2003). Each criterion in the quality tool was considered; and themes were collated and reported as overall observations rather than calculating a summary score. Any discrepancy or disagreement was resolved first by discussion and with a third reviewer if required.

4.3.5 Data synthesis and analysis

Data analysis and interpretation were performed by the PhD researcher and cross-checked by a second reviewer. Presentation of descriptive and inferential statistical information was made for each study. Study design, population characteristics, intervention parameters, outcome measures, and main findings were summarised. Narrative synthesis of all included studies was undertaken in the first instance.

Studies were to have been included for quantitative synthesis where these met the minimum threshold for risk of methodologic bias. However, due to the few number of studies identified, the published protocol was amended to include all studies in meta-analysis in the first instance, followed by sensitivity analysis based on risk of bias threshold. Owing to the inherent difficulty of blinding participants and providers in rehabilitation research and the frequent use of subjective outcome measures, risk of bias threshold was amended so that only those studies judged to be at high or unclear risk of selection bias pertaining to randomisation, allocation concealment, or both were excluded. Risk of selection bias has been shown to have the biggest impact on direction and magnitude of bias in studies of intervention effect (Higgins et al., 2011).

Clinical heterogeneity was assessed in the narrative synthesis to identify any major differences between trials in study populations, interventions, or outcome measures. Statistical heterogeneity was evaluated using the Chi-square test (with statistical significance set at $P < 0.10$), and the I^2 statistic computed and interpreted such that ≥50% represented substantial heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003).

Quantitative synthesis was undertaken in Review Manager (RevMan) software (version 5.3, Cochrane Collaboration) using the inverse variance method. Standardised mean differences (SMD) and 95% confidence intervals (CI) were calculated to synthesise continuous outcomes. The random-effects model was used as heterogeneity was anticipated to be present. To aid interpretation 95% prediction intervals (PI) were calculated for analyses including three or more studies that met the minimum threshold for risk of methodologic bias (Riley, Higgins, & Deeks, 2011). Stata Version 15.1

statistical package (StataCorp LLC, College Station, TX) was used with the Hedges' g option selected.

Effect sizes were interpreted as 0.2 (small), 0.5 (medium) or 0.8 (large) (Cohen, 1988). The quality of the body of evidence was judged to be 'High', 'Moderate', 'Low' or 'Very Low' for each outcome following the Grades of Recommendation Assessment, Development and Evaluation (GRADE) approach (Balshem et al., 2011). Quantitative synthesis was undertaken by the PhD researcher and checked by a second reviewer with any uncertainties regarding data preparation and computation resolved by a consultant health-sciences biostatistician.

If adequate data were available, subgroup analyses were planned to explore any differences between types of splints (soft, rigid) and across specific population characteristics, including age (<65 years, >65 years) and disease severity (radiographic grade 1, 2, 3 or 4).

4.4 Results

4.4.1 Study selection

After removal of duplicates 1353 records were identified with 12 studies meeting eligibility criteria for inclusion in quantitative synthesis (Figure 4.1), four comparing splint versus no splint and eight comparing different types of splints. Of the included studies, nine authors provided additional information about study characteristics or result data (Becker, Bot, Curley, Jupiter, & Ring, 2013; Cantero-Téllez et al., 2017; Cantero-Tellez, Villafane, Valdes, & Berjano, 2018; Gomes Carreira et al., 2010; Hermann et al., 2014; McKee & Eason-Klatt, 2006; Rannou et al., 2009; Weiss et al., 2000, 2004).

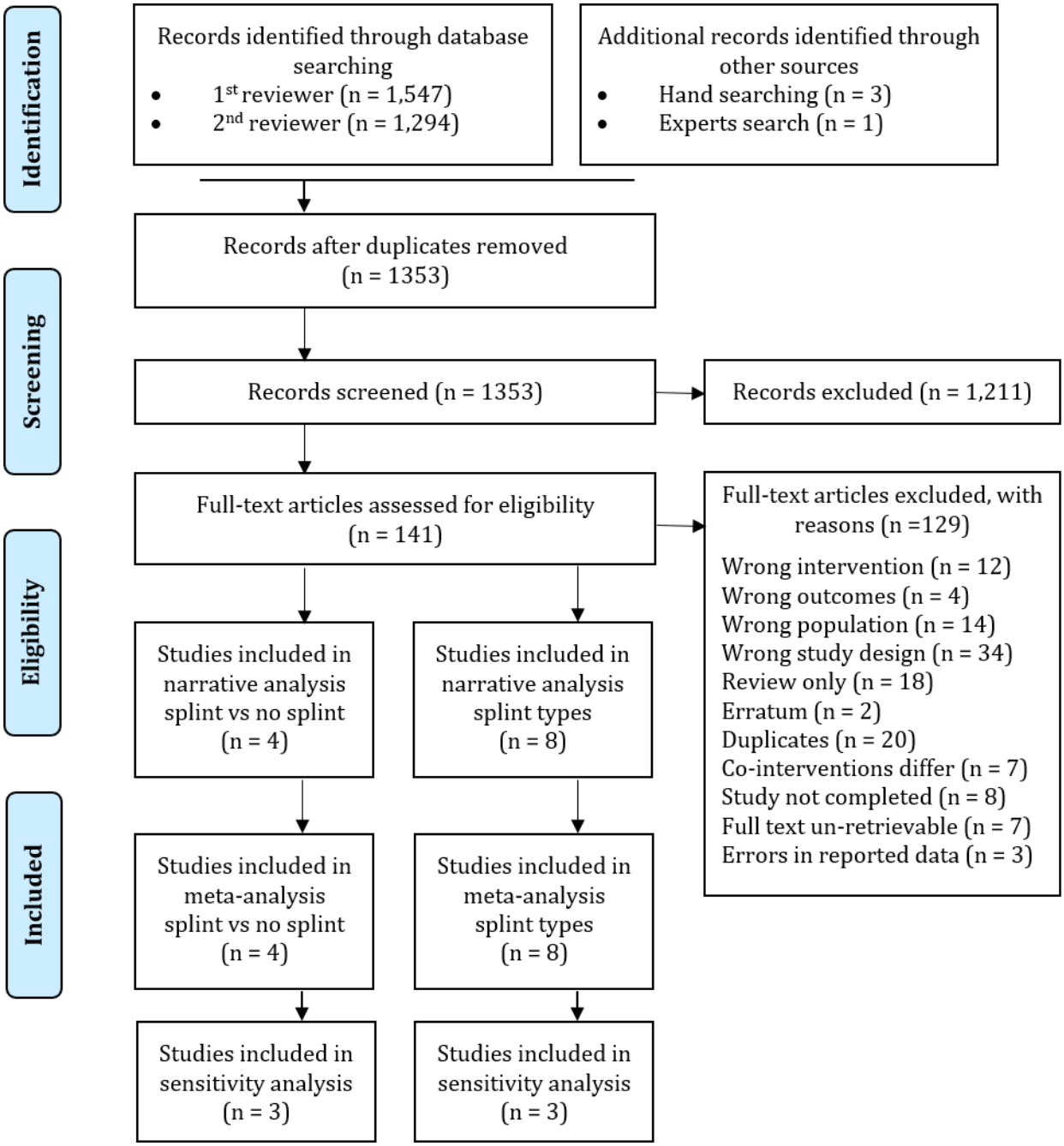


Figure 4.1 Flowchart of study selection process

Designs of the included studies are listed in Table 4.1. Of the four cross-over design trials, two used paired-t tests to assess the effect of splint wearing (Sillem, Backman, Miller, & Li, 2011; van der Vegt et al., 2017) and two used repeated-measures analysis of variance (ANOVA) (Weiss et al., 2000, 2004). Funding was not received in three studies (Arazpour et al., 2017; Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018); four studies received institutional or national health organisation grants (Gomes Carreira et

al., 2010; Hermann et al., 2014; Rannou et al., 2009; Weiss et al., 2004); two studies received complimentary splint materials from the manufacturer (McKee & Eason-Klatt, 2006; van der Vegt et al., 2017) – the latter study stated specifically that there was no influence on the study design, conduct or outcome (van der Vegt et al., 2017). In three studies funding sources were not stated (Sillem et al., 2011; Weiss et al., 2000) or unclear (Becker et al., 2013).

4.4.2 Study characteristics

Characteristics of the included studies are reported in Table 4.1. Study settings were outpatient therapy clinics. Participant ethnicity was reported in one study in which 32.5% were reported as "non-white" [sic] (Gomes Carreira et al., 2010). In three of five studies where it was reported a majority of participants were in employment (Rannou et al., 2009; van der Vegt et al., 2017; Weiss et al., 2004) and in two studies smaller proportions (20% to 30%) were in work (Hermann et al., 2014; Sillem et al., 2011). The remaining studies did not report work status.

Interventions comprised a range of splint designs and materials (Table 4.1). Rationales proposed for splint interventions included to stabilise the CMC joint (Arazpour et al., 2017; Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018; McKee & Eason-Klatt, 2006; Sillem et al., 2011; van der Vegt et al., 2017; Weiss et al., 2000, 2004); to prevent adjacent MCP joint hyperextension (Cantero-Tellez et al., 2018; Gomes Carreira et al., 2010; McKee & Eason-Klatt, 2006; Rannou et al., 2009); to leave adjacent joints free for unhindered function (Arazpour et al., 2017; Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018; McKee & Eason-Klatt, 2006; Sillem et al., 2011); to maintain length of the first web space (Gomes Carreira et al., 2010; Rannou et al., 2009); to reduce CMC joint synovitis or inflammation (Cantero-Tellez et al., 2018; Hermann et al., 2014; van der Vegt et al., 2017); to reduce local muscle spasm (van der Vegt et al., 2017); and, for patient preference (Hermann et al., 2014). One study reported telephone follow-up at 1-week (van der Vegt et al., 2017); remaining studies reported follow-up, 'only if need adjusting' or not specified.

Table 4.1 Characteristics of the studies selected for inclusion

First author, year, country	Study purpose (setting)	Study design N allocated (N analysed)	Outcomes	Time points	Population		
					Entry criteria (actual disease severity and duration, mean ± SD years*)	Baseline pain and function, mean ± SD*	Age, mean ± SD years* (women, %)
Arazpour 2017, Iran	Compare splint vs no splint: rigid CMC splint, provider NA, *"Wear during ADLS, remove when sleeping"* for 4 weeks; control – usual medical care. (University hospital orthopaedic clinic)	Randomised controlled parallel 25 (25)	Pain: on using pen (splint group) or average in last week (control) (VAS, 0-10) Function: (MHQ, 0-100)	0, 4 weeks	Clinical criteria, radiographic criteria (grade I or II) (symptoms 13.08 ± 2.39)	4.48 ± 1.55† 58.58 ± 15.22†	50.95 ± 5.92 (87.6)
Becker 2013, United States	Compare soft CMC/MCP splint vs rigid CMC/MCP splint: both provided by study-trained occupational therapist, *"Wear whenever symptoms day or night"* for 5-15 weeks. (Tertiary hospital outpatient clinic)	Randomised controlled parallel 119 (62)	Pain (ordinal scale, 0-10) Function (DASH, 0-100)	0, 5-15 weeks	Clinical criteria (NA)	5.0 ± 2.19 28.18 ± 17.23	63 ± 8.1 (77.4)
Cantero-Tellez 2017, Spain	Compare rigid CMC/MCP splint vs rigid CMC splint: provided by hand therapy clinician experienced in orthopaedic cases, *"Use orthosis during the nighttime and also during daytime ADL for 3 to 4 hours per day"*, for 3 months. (Hand centre clinic)	Randomised controlled parallel 66 (66)	Pain on activity (VAS, 0-100) Function (QuickDASH, 0-100)	0, 1 week	Clinical criteria, pain VAS >40/100, radiographic criteria (Eaton-Littler grade II or III) (NA)	77 ± 7.5†‡ 40.95 ± 6.84†‡	63.75 ± 9.55 (83.3)
Cantero-Tellez 2018, Spain	Compare rigid CMC/MCP splint vs rigid CMC splint: both provided by experienced hand therapy clinician, *"Use during the night & during daytime ADLs for 3-4 hours"*, 3 months. (Hand rehabilitation clinic)	Quasi-randomised controlled parallel 84 (84)	Pain on activity (VAS, 0-100) Function (DASH, 0-100)	0, 3 months	Clinical & radiographic criteria (NA)	76.91 ± 10.84† 50.12 ± 6.46†	63.95 ± 9.3 (91.7)
Gomes Carreira 2010, Brazil	Compare splint vs no splint: rigid CMC/MCP provided by occupational rheumatology specialist, *"Wear during activity only"*, for 3 months; control – usual care. (NA)	Randomised controlled parallel 40 (40)	Pain in past week, when splint is off (VAS, 0-10) Function (DASH, 0-100)	0, 45 days, 3 months	ACR clinical criteria, pain VAS 3≤7, ACR radiographic criteria (Grade II 97.5%, 7 ± 4.9)	5.1 ± 1.24† 40.55 ± 17.5†	63.95 ± 9.3 (100)

First author, year, country	Study purpose (setting)	Study design N allocated (N analysed)	Outcomes	Time points	Population		
					Entry criteria (actual disease severity and duration, mean ± SD years*)	Baseline pain and function, mean ± SD*	Age, mean ± SD years* (women, %)
Hermann 2014, Norway	Compare splint vs no splint: soft CMC/MCP/wrist splint, provider NA, *"Wear whenever symptoms day or night"*, + exercises + usual medical care, 2 months; control – exercises + usual medical care. (Hospital rheumatology department)	Randomised controlled parallel 59 (55)	Pain (right hand) (NRS, 0-10) Function (AUSCAN function subscale, 1-5)	0, 2 months	ACR hand OA clinical criteria, pain on palpation CMC joint (15.2, range 36)	Median 4 (0, 9) 4.8 (1.9)	70.5 ± 6.7 (98.3)
McKee 2006, Canada	Compare rigid CMC/MCP vs rigid CMC splint: both provided by study-trained therapist, *"Wear whenever symptoms day or night"*, 4 weeks. (Hand therapy, physiotherapy, occupational therapy clinic)	Non-randomised controlled parallel 27 (20)	Pain (PRWHE pain subscale, 0-50) Function (PRWHE function subscale, 0-50)	0, 4 weeks	Clinical criteria +/- radiographic criteria (NA)	28.09 ± 8.52†§ 38.13 ± 19.79†§	59 ± 7.1 (87)
Rannou 2009, France	Compare splint vs no splint: rigid CMC/MCP/wrist splint provided by study-trained occupational therapist, *"Wear at night only"*, + usual medical care, 1 year; control – usual medical care. (Hospital or private rheumatology clinic)	Randomised controlled parallel 112 (101)	Pain in previous 48 hours (VAS, 0-100) Function (Cochin, 0-90)	0, 1 month, 1 year	Clinical criteria, radiographic criteria – Kallman (1.41 ± 2.07)	46.52 ± 19.5† 18.73 ± 12.63†	63.25 ± 7.72 (90.2)
Sillem 2011, Canada	Soft CMC/MCP/wrist splint vs rigid CMC splint: both provided by study-trained therapist, *"Wear whenever symptoms day or night"*, 4 weeks. (Outpatient hand therapy departments – 3 sites)	Randomised controlled cross-over 56 (56)	Pain (AUSCAN pain subscale, 0-50) Function (AUSCAN function subscale, 0-90)	0, 4 weeks	Clinical criteria (2.99 ± 4.68)	27.76 (SD NA)† 52.88 (SD NA)†	64.05 ± 8.61 (91)
Van der Vegt 2017, Netherlands	Rigid CMC/MCP splint vs semi-rigid CMC splint: both provided by 1 of 14 study-trained experienced hand therapy clinicians, instructions NA, 2 weeks. (Hospital and medical centre orthopaedic, plastics, rheumatology and hand therapy clinics – 3 sites)	Randomised controlled cross-over 63 (59)	Pain recorded in daily dairy over 3 days (VAS, 0-10) Function (FIHOA, 0-30)	0, 2 weeks	Clinical criteria, radiographic criteria – Eaton-Glickel (Grade I or II 43%; grade III or IV 57%, >1 year 49%)	3.7 ± 2.05† 9.65 ± 6.03†	60.1 ± 8.2 (70)

First author, year, country	Study purpose (setting)	Study design N allocated (N analysed)	Outcomes	Time points	Population		
					Entry criteria (actual disease severity and duration, mean ± SD years*)	Baseline pain and function, mean ± SD*	Age, mean ± SD years* (women, %)
Weiss 2000, United States	Rigid CMC/MCP/wrist splint vs rigid CMC splint: both provided by study-trained certified hand therapist, *"Wear whenever symptoms day or night"*, 1 week. (Hand clinic)	Randomised controlled cross-over 26 (26)	Pain currently, after functional use (VAS, 0-10) Function (pinch grip strength, Kg)	0, 1 week	Clinical criteria, radiographic criteria – Eaton-Littler (<6 months to >5)	6.23 ± 2.01§ 3.30 ± 1.02§	57, range 36 – 88 (81)
Weiss 2004, United States	Soft CMC/MCP splint vs rigid CMC splint: provider NA, *"Wear whenever symptoms day or night"*, 1 week. (Hand clinic)	Randomised controlled cross-over 25 (25)	Pain currently, after functional use (VAS, 0-10) Function (pinch grip strength, Kg)	0, 1 week	Radiographic criteria – Eaton-Littler stage I or II +/- clinical criteria (Grade I or II, <6 months up to 5 years)	5.42 ± 2.4 3.40 ± 1.8	NA (84)

CMC, carpometacarpal joint; ADLs, activities of daily living; NA, not available; VAS, visual analogue scale; MHQ, Michigan Hand Questionnaire; MCP, metacarpophalangeal joint; DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; NS, not specified; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand questionnaire; ACR, American College of Rheumatology; AUSCAN, Australian-Canadian Hand Osteoarthritis Index; PRWHE, Patient-Rated Wrist and Hand Evaluation; FIHOA, Functional Index for Hand Osteoarthritis; Kg, kilogram

* Unless otherwise stated

† Values calculated from group-level data for study-level means and SD using a freely available online software (https://www.statstodo.com/CombineMeansSDs_Pgm.php)

‡ Data extracted from table II only, in Cantero-Tellez 2017

§ Data extracted from graph

Pain was assessed using a variety of numerical scales (Table 4.1). Function was measured by various self-report outcomes except for two studies in which a performance measure, pinch grip strength, was used (Weiss et al., 2000, 2004). Pain and function outcomes were not reported beyond one year. Quality of life was not assessed in any of the studies, either at baseline or follow up.

4.4.3 Risk of bias and quality assessment

Five studies were judged to be at high or unclear risk of selection bias: one of four studies comparing splint with no splint (Arazpour et al., 2017) and five of eight studies comparing different types of splints (Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018; McKee & Eason-Klatt, 2006; Weiss et al., 2000, 2004). All outcomes reported in this review were judged to be at high risk of detection bias primarily due to self-reported outcomes being completed by unblinded participants. Risk of selective outcome reporting was judged unclear or high for seven studies because study protocols were neither registered a priori nor published (Arazpour et al., 2017; Cantero-Téllez et al., 2017; McKee & Eason-Klatt, 2006; Weiss et al., 2000, 2004), stated outcomes or time points were not reported (Hermann et al., 2014; Rannou et al., 2009), or splint materials were provided by industry with unclear risk of influence (McKee & Eason-Klatt, 2006).

Risk of other bias was judged unclear or high in 10 studies relating to four main areas: short or no washout period in cross-over design trials (Sillem et al., 2011; van der Vegt et al., 2017; Weiss et al., 2000, 2004); potential for contamination between groups where participants in the control group were fitted with the intervention splint during assessment (Gomes Carreira et al., 2010); inconsistency in unit of allocation vs analysis (individual vs hand) (Hermann et al., 2014); and poor quality of data reporting or outcome ambiguity or both (Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018; McKee & Eason-Klatt, 2006; Weiss et al., 2000). The researchers' judgements are summarised for all included studies in the risk of bias graph (Figure 4.2).

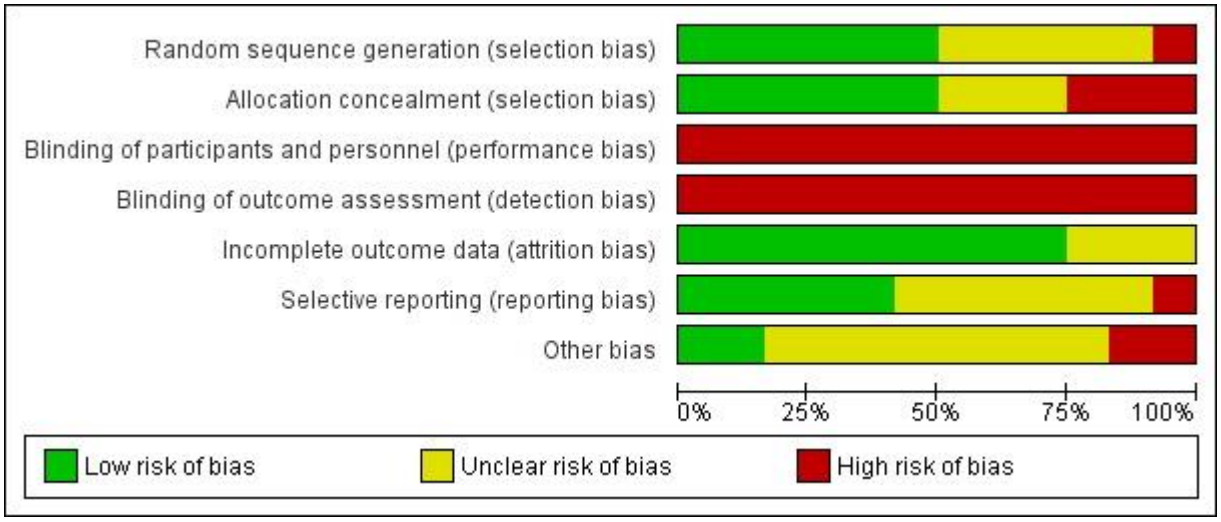


Figure 4.2 Risk of bias graph: summary of each risk of bias item presented as percentages across all included studies.

Further assessment of study quality identified that six studies did not state an intention-to-treat analysis or did not state or did not meet sample size calculations (Arazpour et al., 2017; Cantero-Téllez et al., 2017; McKee & Eason-Klatt, 2006; van der Vegt et al., 2017; Weiss et al., 2000, 2004). In seven of the twelve included studies it was unclear if co-interventions were avoided or similar (Arazpour et al., 2017; Becker et al., 2013; Hermann et al., 2014; McKee & Eason-Klatt, 2006; van der Vegt et al., 2017; Weiss et al., 2000, 2004). Acceptable adherence to interventions was reported in five studies (Arazpour et al., 2017; Cantero-Tellez et al., 2018; Rannou et al., 2009; van der Vegt et al., 2017; Weiss et al., 2004) and variable adherence reported in two studies (Hermann et al., 2014; Sillem et al., 2011). Adherence was not reported in the remaining five studies. Participant drop-out was ≤15% in all but two studies (Becker et al., 2013; McKee & Eason-Klatt, 2006).

4.4.4 Narrative synthesis

Results of the individual studies are summarised in Table 4.2. In all studies splints were associated with a reduction in pain scores over the course of the study. In some studies, function worsened in the short-term (Arazpour et al., 2017; Rannou et al., 2009; Weiss et al., 2000, 2004) or remained unchanged (van der Vegt et al., 2017).

Heterogeneity was present between studies in control over potential sources of bias and in some study characteristics. Major differences were the wide range of outcome

measures used and the variations in intervention implementation. Other differences included time to follow-up and symptom severity (Table 4.1). Insufficient data were available to conduct subgroup analyses.

No major adverse events were reported; one minor adverse event of skin irritation resulted in discontinuation of splint treatment (van der Vegt et al., 2017).

Table 4.2 Summary of results of included studies

First author, year	Outcome	Time point	Change in score (mean ± SD)*	Mean difference (95% CI)
Arazpour 2017	Pain	Short-term	Rigid CMC splint: -1.0 ± 1.99 Control group: 0.11 ± 1.34	-1.11 (-1.31, 0.35)
	Function	Short-term	Rigid CMC splint: 0.85 ± 20.20 Control group: -4.11 ± 17.98	4.96 (-10.40, 20.32)
Becker 2013	Pain	Short-term	Soft CMC/MCP splint: -0.81 ± 2.9 Rigid CMC/MCP splint: -0.9 ± 2.2	0.09 (-1.2, 1.4)
	Function	Short-term	Soft CMC/MCP splint: - 2.5 ± 17.4 Rigid CMC/MCP splint: -3.8 ± 13.2	1.3 (-9.8, 5.9)
Cantero-Tellez 2017	Pain	Short-term	Rigid CMC/MCP splint: -31 ± 1.8† Rigid CMC splint: -29 ± 1.8†	-2.0 (-2.87, -1.13)
	Function	Short-term	Rigid CMC/MCP splint: -4.1 ± 0.8† Rigid CMC splint: -6.0 ± 0.8†	1.9 (1.51, 2.29)
Cantero-Tellez 2018	Pain	Medium-term	Rigid CMC/MCP splint: -25.6 ± 1.7 Rigid CMC splint: -25.0 ± 1.8	-0.6 (-1.35, 0.15)‡
	Function	Medium-term	Rigid CMC/MCPsplint: -10.3 ± 1.0 Rigid CMC splint: -12.0 ± 1.0	1.7 (1.27, 2.13)‡
Gomes Carreira 2010	Pain	Short-term	Rigid CMC/MCP splint: -2.0 ± 2.37 Control group: -0.3 ± 2.36	-1.7 (-3.17, -0.23)‡
		Medium-term	Rigid CMC/MCP splint: -2.2 ± 2.46 Control group: 0.1 ± 2.44	-2.3 (-3.82, -0.78)‡
	Function	Short-term	Rigid CMC/MCP splint: -7.3 ± 24.40 Control group: -7.6 ± 23.43	0.3 (7.56, -14.53)‡
		Medium-term	Rigid CMC/MCP splint: -10.5 ± 24.69 Control group: -6.7 ± 22.65	-3.8 (-18.48, 10.88)‡
Hermann 2014	Pain	Short-term	Soft CMC/MCP splint: -0.3 ± 2.56 Control group: -0.2 ± 2.98	-0.09 (-1.4, 1.2)
	Function	Short-term	Soft CMC/MCP splint: -0.2 ± 1.29§ Control group: -0.3 ± 1.26§	0.06 (-0.7, 0.8)§
McKee 2006	Pain	Short-term	Rigid CMC/MCP splint: -10.24 ± 12.47‖	2.8 (-8.19, 13.69)‡
	Function	Short-term	Rigid CMC splint: -12.99 ± 11.77‖ Rigid CMC/MCP splint: -7.13 ± 23.34‖ Rigid CMC splint: -18.45 ± 28.11‖	11.3 (-11.33, 33.97)‡
Rannou 2009	Pain	Short-term	Rigid CMC/MCP splint: -10.1 ± 22.25 Control group: -10.7 ± 22.38	0.6 (-7.9, 9.1)
		Medium-term	Rigid CMC/MCP splint: -22.2 ± 23.08 Control group: -7.9 ± 23.48	-14.3 (-23.0, -5.2)
	Function	Short-term	Rigid CMC/MCP splint: 1.3 ± 10.29 Control group: -0.3 ± 10.29	1.6 (-2.3, 5.5)
		Medium-term	Rigid CMC/MCP splint: -1.9 ± 11.20 Control group: 4.3 ± 11.53	-6.3 (-10.9, 1.7)
Sillem 2011	Pain	Short-term	Soft CMC/MCP splint: -2.05 ± 9.54 Rigid CMC splint: -5.69 ± 11.08	3.7 (0.68, 6.76)
	Function	Short-term	Soft CMC/MCP splint: -2.69 ± 16.33 Rigid CMC splint: -5.54 ± 17.37	3.1 (-1.12, 7.38)

First author, year	Outcome	Time point	Change in score (mean ± SD)*	Mean difference (95% CI)
Van der Vegt 2017	Pain	Short-term	Rigid CMC/MCP splint: -0.3 ± 2.97 Semi-rigid CMC splint: -0.3 ± 2.83	0.0 (-1.05, 1.05)‡
	Function	Short-term	Rigid CMC/MCP splint: 0.0 ± 8.56 Semi-rigid CMC splint: -0.9 ± 8.34	0.9 (-2.15, 3.95)‡
Weiss 2000	Pain	Short-term	Rigid CMC/MCP: -2.65 ± 2.88‖ Rigid CMC splint: -2.27 ± 3.62‖	-0.4 (-2.16, 1.40)‡
	Function	Short-term	Rigid CMC/MCP splint: 0.25 ± 1.67‖ Rigid CMC splint: -0.07 ± 1.75‖	0.3 (-0.61, 1.25)‡
Weiss 2004	Pain	Short-term	Soft CMC/MCP splint: -3.13 ± 2.91 Rigid CMC splint: -1.83 ± 3.26	-1.3 (-3.01, 0.41)‡
	Function	Short-term	Soft CMC/MCP splint: -0.3 ± 2.55 Rigid CMC splint: 0.3 ± 2.48	0.0 (-1.39, 1.39)‡

CMC, carpometacarpal joint; MCP, metacarpophalangeal joint
* Negative value indicates improvement
† Data extracted from table II only, in Cantero-Tellez 2017
‡ Calculated in RevMan
§ Unpublished data
‖ Data extracted from graph

4.4.5 Quantitative synthesis

4.4.5.1 Effectiveness of splinting on pain and function

Figure 4.3 presents the synthesis of the four studies reporting on the effectiveness of splints for pain and function. No significant effect was found for either outcome in the short-term (0-3 months); this result did not alter with sensitivity analyses (Figure 4.4). GRADE: Very low (serious risk of bias, very serious imprecision).

Based on the overall pooled effect estimate from two studies totalling 137 participants, splinting was found to result in a statistically significant reduction in pain at medium-term (3-12 months) compared to no splinting (SMD -0.7 [95% CI -1.0 to -0.35], $p < .0001$), representing a moderate to large effect size (Figure 4.3). GRADE: Low (serious risk of bias, serious imprecision).

The overall pooled effect estimate, from two studies totalling 135 participants, also suggested that splinting resulted in a statistically significant improvement in function at medium-term (3-12 months), (-0.42 [-0.77 to -0.08], $p = .02$), representing a small to moderate effect size. GRADE: Low (serious risk of bias, serious imprecision).

Outcomes at medium-term did not alter with sensitivity analysis (Figure 4.4).

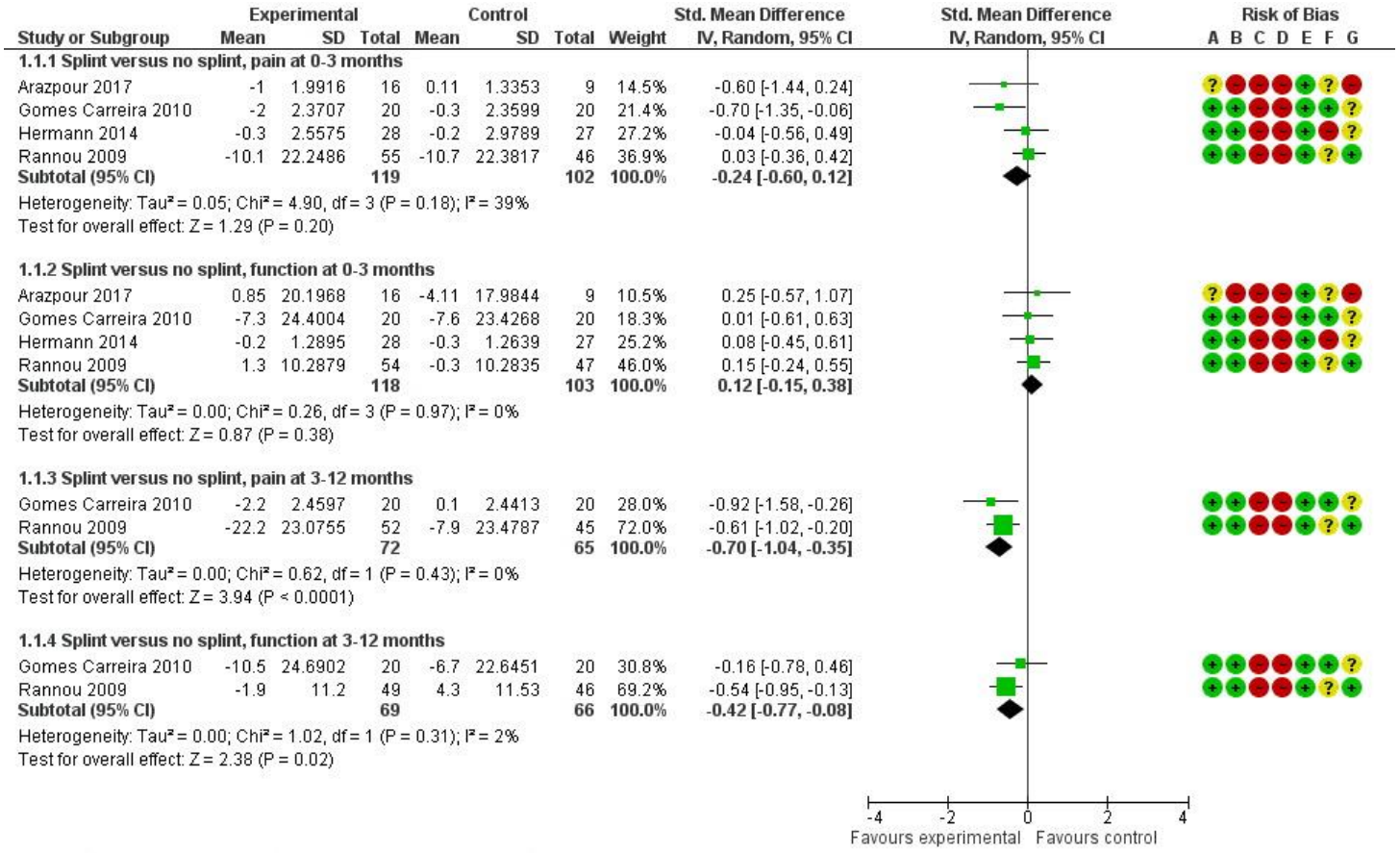


Figure 4.3 Forest plot: effectiveness of splint versus no splint for pain and function forest plot, at short-term (0-3 months) and medium-term (3-12 months).

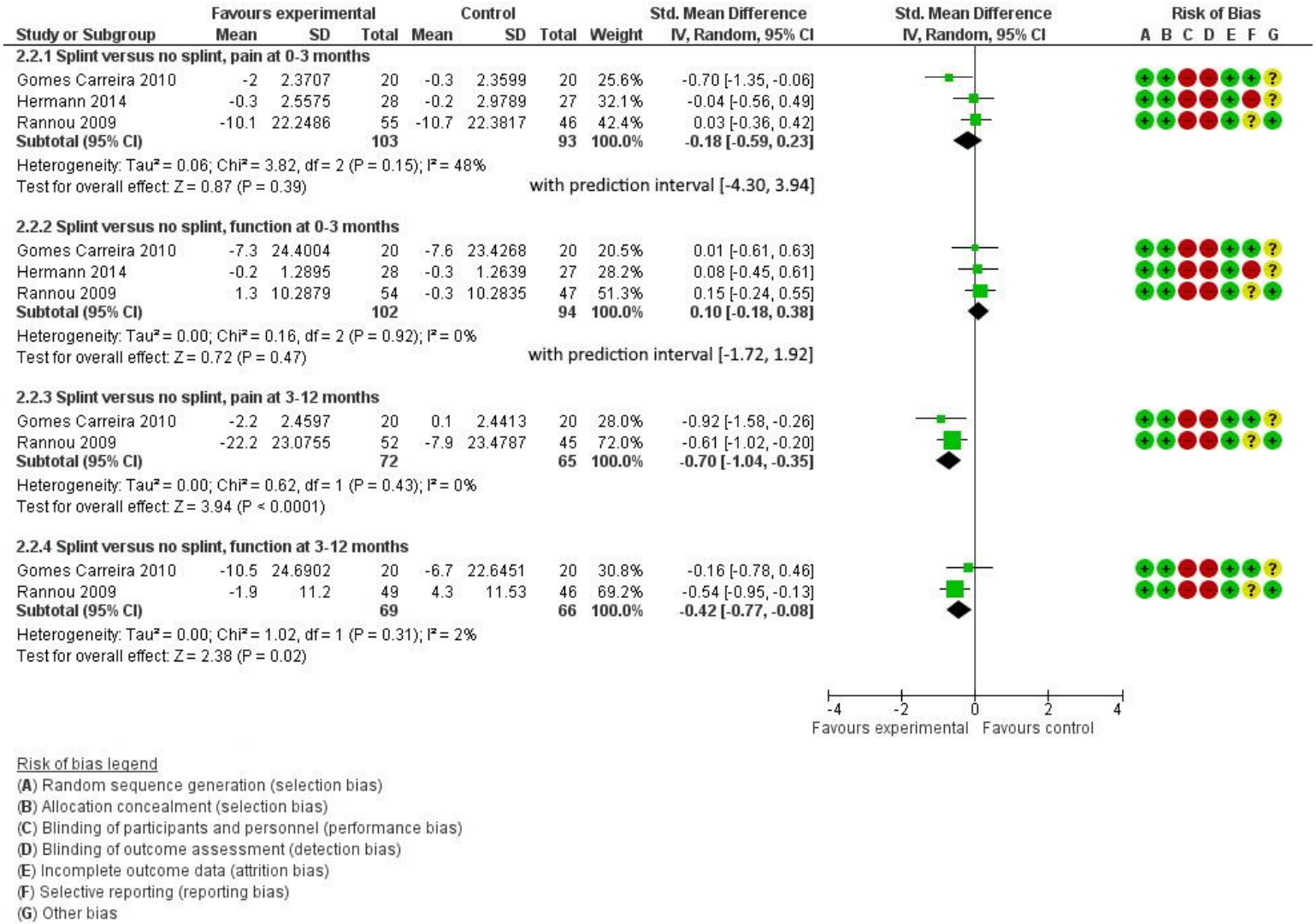


Figure 4.4 Forest plot: effectiveness of splint versus no splint for pain and function forest plot, at short-term (0-3 months) (studies with low risk of selection bias).

4.4.5.2 Effectiveness of different splint types on pain and function

The effect estimate based on one study totalling 84 participants suggested that splints not including the MCP joint compared to splints including the MCP joint resulted in statistically significant improvement in function at medium-term (3-12 months) (1.68 [1.18 to 2.19]) (Figure 4.5). GRADE: very low (very serious risk of bias, very serious imprecision).

All other comparisons showed no significant effect (Figure 4.6). GRADE: Very low (very serious risk of bias, very serious imprecision). Sensitivity analyses showed no significant effect for comparisons of splint type (GRADE: very low) (Figure 4.6).

Predication intervals were calculated for comparison of effectiveness of splints in the short-term for pain (PI -4.30 to 3.94) and function (PI -1.72 to 1.92) (Figure 4.4). No other comparisons met criteria for calculating prediction interval.

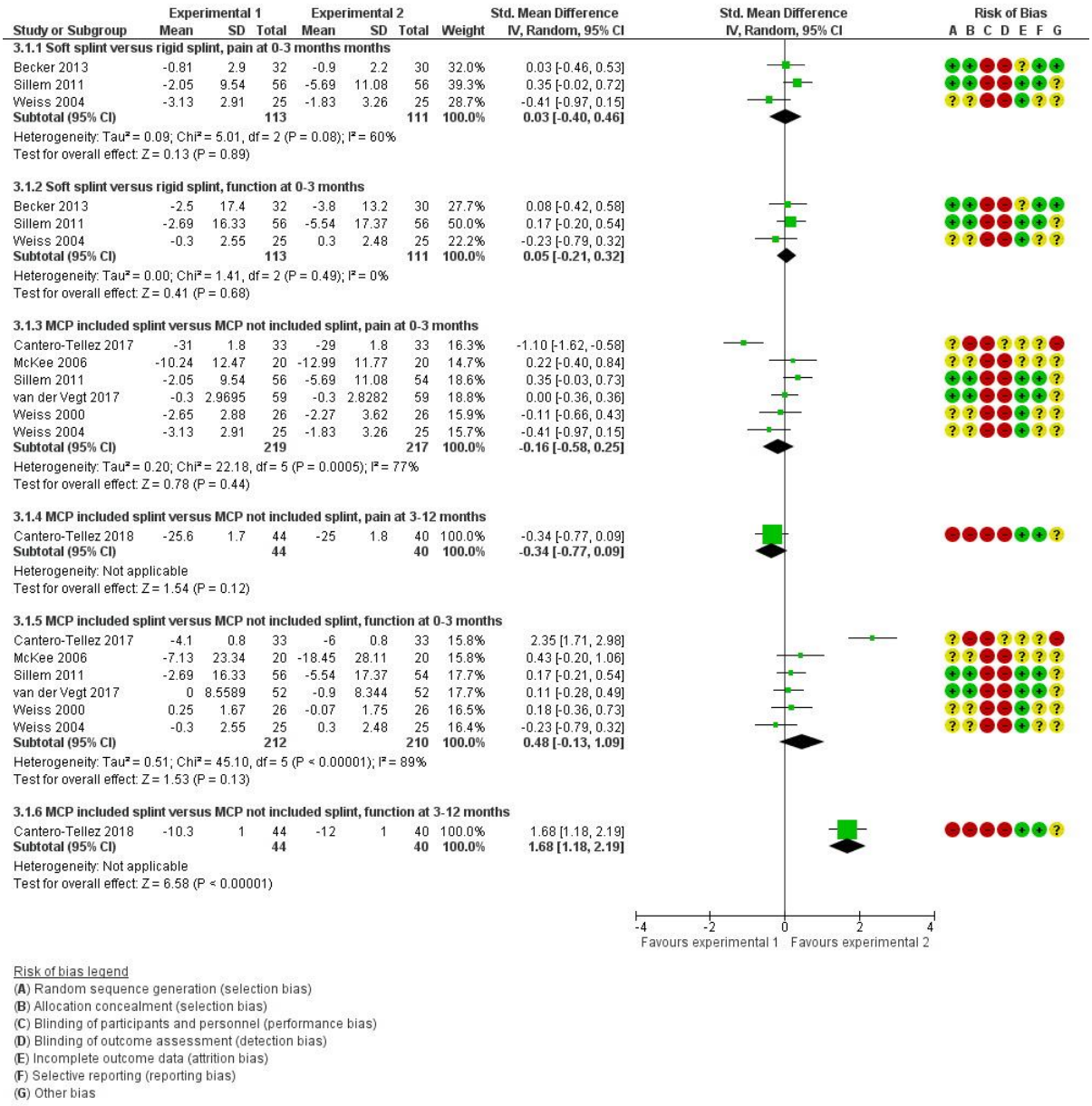


Figure 4.5 Forest plot: effectiveness of soft versus rigid splint for pain and function at short-term (0-3 months), and MCP included versus MCP not included splint for pain and function at short-term (0-3 months) and medium-term (3-12 months).

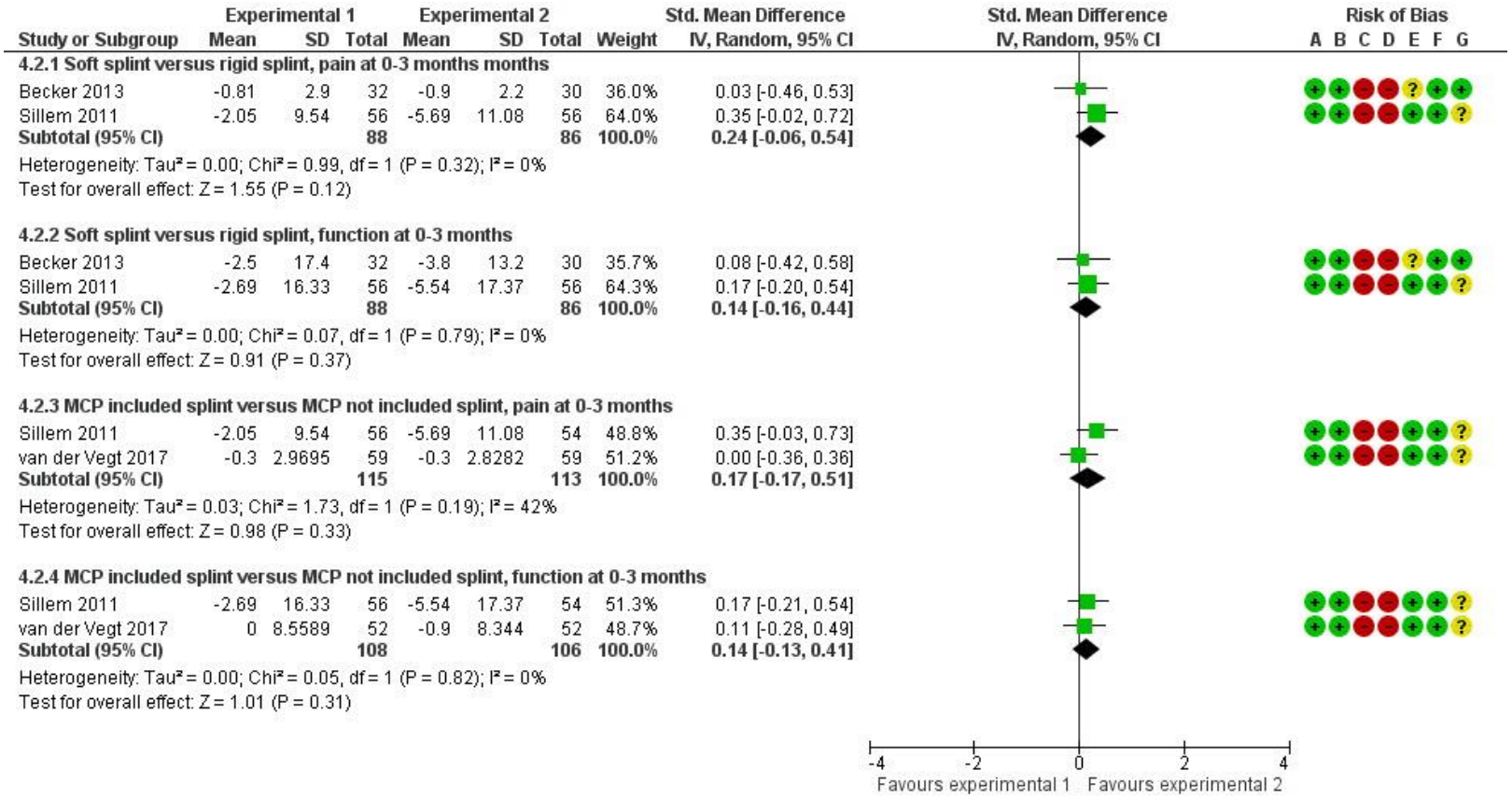


Figure 4.6 Forest plot: effectiveness of soft versus rigid splint for pain and function, and MCP included versus MCP not included splint for pain and function, at short-term (0-3 months) (studies with low risk of selection bias).

4.5 Discussion

This systematic review examined the effectiveness of splinting for pain and function in thumb CMC OA and compared different splint materials and design. Meta-analysis of studies without selection bias found that splints cause a moderate to large reduction in pain and a small to moderate improvement in function in the medium-term (3-12 months) but not short-term (<3 months) (low quality of evidence). Meta-analysis of studies without selection bias also found no difference between rigid and soft splints or between splints including or not including the MCP joint (very low quality of evidence). The effect of splints on quality of life in people with thumb CMC OA is unknown. There was no evidence found that splints cause significant harm.

Findings of a moderate to large effect for pain and a small to moderate effect for function in the medium-term (3-12 months) are comparable to those of a previous systematic review with meta-analysis by Kjeken et al. (Kjeken et al., 2011). However, this review differs from another previous systematic review with meta-analysis which concluded there was no significant effect of splinting on pain levels at ≥3 months (Bertozzi et al., 2015). These conflicting conclusions may be partly explained by the earlier Kjeken et al. review's inclusion of one study with multiple co-interventions which did not meet inclusion criteria for this review.

In contrast, this review found no effect of splinting for pain in the short-term (<3 months), concurring with findings in the earlier review (Bertozzi et al., 2015) but conflicting with the first review which found a significant small-to-moderate effect (Kjeken et al., 2011). This difference from Kjeken et al. may be explained by the inclusion in this review of a more recent study investigating a soft splint and reporting relatively poor adherence to splint wearing (Hermann et al., 2014). The finding of no significant difference between splint material or design concurs with that of a further previous systematic review (Aebischer, Elsig, & Taeymans, 2016).

This systematic review provides a robust updated appraisal of the evidence for splinting in people with thumb CMC OA and examines characteristics of the study designs and splint interventions. Splinting is a promising non-invasive intervention for thumb CMC OA which is an extremely prevalent condition. From current evidence conditional

recommendations can be made for the benefits of splinting and the lack of harm in clinical practice.

4.5.1 Study limitations

The small number of original studies and the small sample size of each included study represent significant limitations of the present and previous reviews. Meta-analysis with such small sample sizes may be at risk of 'small sample bias' (Nuesch et al., 2010). In other words issues of lower methodological quality along with reporting biases combine to result in the reporting of larger effect sizes than those in larger trials (Nuesch et al., 2010). These issues are evident in the present review by the high rate of selective outcome reporting, the ubiquitous risk of detection and performance bias, and by the smaller effect sizes seen on sensitivity analysis. While publication bias is likely to be present to some extent it is not strongly suspected as most of the included studies are not, nor likely to be, industry-sponsored (Guyatt et al., 2011). The use of funnel plots was not warranted given the small number of included studies (Sterne et al., 2011).

In the present study these methodological issues are also apparent in the statistical heterogeneity found in the comparison of splint versus no splint for pain (Figure 4.3, Figure 4.4) and substantially in comparisons between splint types (Figure 4.5) at the short-term. Although heterogeneity relating to risk of bias will tend to have overestimated the effect sizes, the impact of heterogeneity in other study parameters (outcome measures, intervention implementation and population characteristics), is underestimation.

Prediction intervals calculated for the comparison of splint vs no splint outcomes at short-term indicate that it is probable that 95% of exchangeable studies in the future can be expected to produce effects within these intervals (PI -4.30 to 3.94) and (PI -1.72 to 1.92), for pain and function, respectively, which both span the null (Figure 4.4). Clearly, further new studies are likely to add significantly to the current evidence base, if performed to a high standard using Cochrane supported methodology and following the PREPARE trial guidelines (Bandholm, Christensen, Thorborg, Treweek, & Henriksen, 2017). Symptom type and severity may be potential subgroupings for future primary studies or meta-analysis or both.

The study design best suited to provide further evidence for the effectiveness of splints is one which includes a control group and is randomised but without a cross-over design. Only three of the studies in this review included a control group (Gomes Carreira et al., 2010; Hermann et al., 2014; Rannou et al., 2009). The cross-over randomised-trial design was used by four of the studies in this review, with data from two included in sensitivity analysis in the comparisons of splint material (Sillem et al., 2011) and splint design (Sillem et al., 2011; van der Vegt et al., 2017). The use of cross-over design is problematic in studies of thumb CMC OA since it is a chronic condition; if splint interventions are to be worth-while they need to be effective over a prolonged period of follow-up. The cross-over designs included in this review required the treatment effect to be lost after a short washout period: 1-2 weeks. Furthermore, statistical checking of carry-over effect is considered imperfect (Nolan, Hambleton, & Dwan, 2016) and possible bias due to carry-over effect remains a concern. The inclusion of data from both periods in each of the two studies using cross-over design will tend to have under-estimated the overall treatment effect.

Blinding of participants and clinicians to group allocation did not occur in any of the included studies. These are prevalent issues in trials of rehabilitation interventions (Fregni et al., 2010). The impact of not blinding participants is that the effect size of the intervention may be over-estimated, mainly due to non-specific placebo effect (Fregni et al., 2010). This issue is compounded by the subjective nature of the primary outcome measures, the physical characteristic of the intervention (Bannuru et al., 2015), therapist involvement in its delivery (Fregni et al., 2010), and the context of chronic condition and chronic pain (Felson et al., 2016). Study design elements which could have minimised risk of performance and detection bias were not applied in the included trials, in particular: blinding participants to the research hypothesis; ensuring equal treatment across groups, for example, number and duration of sessions, quantity and quality of participant materials; and cluster randomisation, for example, by therapist (Bandholm et al., 2017; Fitzgerald et al., 2015).

The ability to detect an effect for splints or between types of splints may be enhanced by implementing standardised usual care across groups and employing strategies to promote and identify adherence (Felson et al., 2016; Fitzgerald et al., 2015), all of which

were under-utilised in the studies included in this review. However, in most of the included studies participant drop-out was low, strengthening the statistical power and validity of study findings and suggesting that long-term follow up (> 1 year) is feasible.

A core set of outcome domains for investigating interventions for hand OA has been recommended, that is, pain, physical function, HR-QoL, joint activity, and hand strength (Kloppenburg, Maheu, et al., 2015), but it was apparent from the multiple different outcomes measures used by studies in this review that there is no consensus about which specific tools are best suited. Furthermore, no studies included in the review reported HR-QoL and several of the measures used to assess function were ones which face criticism for being outmoded (Stamm et al., 2009). Outcomes that differentiate thumb CMC from hand OA are likely to better detect change where interventions target thumb CMC OA, but no gold standard is currently available.

The studies included in this systematic review were lacking in demographic information about participant ethnicity, body mass index (BMI) and co-morbidity as well as additional disease characteristics. Imaging, where used, was poorly described. Entry criteria were highly variable, reflecting the lack of specific classification criteria for thumb CMC OA. Medication burden, emotional impact, and sense of self were not specifically considered, representing a limitation of the systematic review.

4.5.2 Conclusions

The present review supports the conclusion that splinting has medium to large effects for pain and small to medium effects for function in the medium-term and further supports the conditional recommendation of international guidelines that splinting is an effective intervention for thumb CMC OA. Current evidence, however, derives from a small number of studies with small sample sizes and short periods of follow-up. Thus the overall quality of the existing evidence is low and it is not possible to draw firm conclusions as to the effectiveness of splinting as an intervention. Significant challenges for future studies are the lack of diagnostic criteria and the absence of a gold standard outcome measure for thumb CMC OA. Future research into the effectiveness of splinting for thumb CMC OA should ensure that appropriate sample size requirements are met,

usual care is standardised, study design is appropriate, and follow-up extends beyond one year.

These recommendations are considered in the following chapter in the design and conduct of a feasibility study for a future clinical trial to investigate the effectiveness of splinting for thumb CMC OA.

Chapter 5

Splinting for thumb CMC OA: A feasibility randomised controlled trial

5.1 Introduction

The study reported in this chapter sets out to determine the feasibility of study elements for a future fully-powered trial investigating the effectiveness of splinting for outcomes in people with thumb CMC OA. The chapter opens with an introduction and background that draws on previous chapters and concludes with a discussion of the results of the feasibility study.

5.2 Background

This chapter takes its direction from the patient experience of thumb CMC OA and the treatment targets and outcomes which were identified as of importance to this population. The chapter is also informed by the findings of the systematic review in Chapter 4 and the background literature outlined in Chapters 1 and 2.

As discussed in Chapter 2, the multifactorial aetiology of thumb CMC OA is recognised: genetic factors, age, and likely, metabolic factors all play a role in the development and progression of the condition. However, the inherent instability of the first CMC joint is arguably the most important factor in the onset of OA at this location since, considering the demands associated with human hand functions, this instability places the joint at a critical disadvantage. Therefore, interventions that can address thumb CMC OA from an anatomical and biomechanical approach have a sound theoretical basis. The mechanisms of effect of splinting in this regard were outlined in Chapter 4. Furthermore, the role of biomechanical interventions such as splints has been highlighted as a key area of OA management that needs more research (NICE, 2014).

The qualitative study described in Chapter 3, which investigated the perspectives of people with thumb CMC OA, found that pain was the main symptom of concern, particularly pain that interrupts sleep. Other key problems were: impaired power precision grip; a diverse range of functional limitations, broader than those items

included in the FIHOA instrument, and not included in gender classifications; negative thoughts and feelings including the use and burden of medication; an altered sense of self related to ageing, and, quality of life. These problems serve as key treatment targets and should be evaluated for their candidacy as primary or secondary outcomes for investigating treatment effectiveness in thumb CMC OA. These findings collectively provide a clear direction from the patient perspective about what treatment targets and outcomes are important and meaningful for this population.

The previous work in this thesis also gives direction on which interventions are indicated for people with thumb CMC OA. The findings reported in Chapter 3 indicated that people with thumb CMC OA desire management approaches that delay, reduce, or obviate the need for pharmacological or surgical interventions. In this regard, splinting has potential as an acceptable management approach. As outlined in Chapter 1, this patient preference accords with the lack of evidence for the effectiveness of pharmacological interventions, excepting topical NSAIDs (Kroon et al., 2018), and the less extensive surgical options (NICE, 2014; Thillemann et al., 2016).

The qualitative work also identified a strong desire for information about the condition and its management. This accords with international guideline recommendations for hand OA conditions, i.e. education and advice for self-management as core components of treatment (Hochberg, 2011; NICE, 2014; Zhang et al., 2007). Chapter 1 highlighted that exercise is also part of international guideline recommendations although what constitutes an effective exercise programme for thumb CMC OA has yet to be determined (Hochberg, 2011; NICE, 2014; Osteras et al., 2017; Zhang et al., 2007). Exercise is also a non-surgical, non-pharmacological intervention that is likely to be acceptable to patients. Based on international guidelines therefore, exercise, education, and advice are the current best practice usual care with which a splint intervention must be compared. To this end, a feasibility study needs to include the development of a standardised package of best practice usual care, which includes the development of an exercise programme. Consultation with expert clinician stakeholders can help to deal with some of the unresolved questions around exercise prescription for thumb CMC OA. Furthermore, expert clinicians together with people with thumb CMC OA are uniquely placed to inform the feasibility and acceptability of a given package of care in the real-

world health service and personal life context. Therefore, stakeholder consultation and piloting should form part of defining a standardised best practice usual care package for a feasibility study.

The decision about which splint should be investigated rests again on patient preference and previously cited literature. Results of the systematic review, reported in Chapter 4, found splints to be a safe intervention, even though adverse events were not routinely reported; however, only low-quality evidence supports their use, and only in the medium-term (3-12 months). Furthermore, splints in these studies were made from a variety of materials and designs, were prescribed with a wide range of wearing schedules and dosage, and had no consistent rationale for use. Currently there appears to be no difference between splint types although this is based on very low-quality evidence (Donnelly & Carswell, 2002; Kloppenburg, Maheu, et al., 2015).

Of the many splinting solutions available, a soft neoprene splint available off–the-shelf and easily fitted, is a cheaper and more accessible option than other splints, and one often preferred by patients (Becker et al., 2013; Sillem et al., 2011). The systematic review in Chapter 4 found that no study comparing a soft, off-the shelf splint with a no-splint control has been reported. Furthermore, clear dosage parameters for splint interventions have not yet been determined. Therefore, investigation is necessary into the effectiveness of a soft neoprene splint prescribed with clear dosage parameters and a well-described standardised best practice usual care package, compared with standardised best practice usual care package alone. Stakeholder consultation should also inform development of the splint intervention including dosage parameters.

Randomised clinical trials are the gold standard in providing information about comparative effectiveness in health research because they can deliver unbiased head-to-head evaluations of alternative treatment options (Holbrook, Kempen, Prusakowski, Altaweel, & Jabs, 2011; Portney, 2015). The cost of interventions, particularly clinicians' time, and limited health services' resource require that clinical trials produce results that can be generalised and applied in real-life settings (Patsopoulos, 2011). Therefore, it is preferable that the investigation of effectiveness versus efficacy, following a pragmatic approach, evaluates the effect of an intervention in a real-world rather than

in an ideal or laboratory context (Patsopoulos, 2011). This has implications for the study design in terms of inclusion criteria (condition classification identifiable by practising clinicians); interventions that are deliverable and scalable for real world health services and accessible and achievable for real world patients; and outcomes that are relevant to patients' concerns and practical for real world health service quality audit (Patsopoulos, 2011; Williams, Burden-Teh, & Nunn, 2015).

In addition to centring on outcomes that are important and meaningful to patients, the primary endpoint of an RCT must also meet five key measurement criteria (Holbrook et al., 2011). Firstly, the outcome can be measured for all participants (Holbrook et al., 2011). Secondly, the outcome has sound psychometric properties in terms of reliability, that is, the degree to which test scores are free from measurement error (Donnelly & Carswell, 2002) and validity, that is, it measures what it claims to measure (Donnelly & Carswell, 2002; Portney, 2015). Thirdly, the outcome is responsive and can detect minimal change over time (Donnelly & Carswell, 2002; Holbrook et al., 2011; Portney, 2015). Fourthly, the outcome has good utility in terms of acceptability of format, time required to complete and score, and ease of interpretation (Donnelly & Carswell, 2002). The fifth criterion is to be able to detect change that is clinically meaningful to participants: that is, a known minimal difference which signifies that a patient has improved, the minimal clinically important difference (MCID) (Holbrook et al., 2011; Jaeschke, Singer, & Guyatt, 1989; Losina, Ranstam, Collins, Schnitzer, & Katz, 2015; Portney, 2015; Wright, Cook, Baxter, Dockerty, & Abbott, 2011). While most studies reviewed in Chapter 4 included OARSI-recommended core outcomes of pain and physical function (Kloppenburg, Maheu, et al., 2015), there was no consensus about which instruments should be used, and no studies assessed QoL, joint activity, or number or ratio of OMERACT-OARSI responders, also recommended in OA trials (Fitzgerald et al., 2015; Kloppenburg, Maheu, et al., 2015). Determining which outcomes should serve as primary and secondary endpoints for a comparative effectiveness trial is a further goal to be achieved.

Effectiveness trials require large sample sizes and are costly to conduct. In order, therefore, to conduct an effectiveness trial to a high standard with minimal research waste and optimal quality of findings, study elements are best assessed first through a

feasibility study (Abbott, 2014; Bandholm et al., 2017). This chapter describes the development and conduct of a study with the primary aim of determining the feasibility of conducting a future fully-powered RCT to compare soft splint and best practice usual care versus best practice usual care comparator intervention for thumb CMC OA.

The primary objectives of this feasibility study were:

1) Recruitment of 30 participants in a 4-month period;
2) Retention >85% at 6 months;
3) >90% of participants finding the interventions acceptable; and,
4) Determination of the rate and type of adverse events.

Part of the overall intent of the methods which follow was to develop a splint intervention and a standardised best practice usual care package, and to consider which clinical outcome measures satisfy the research needs outlined above.

5.3 Methods

The study was conducted according to the principles of good clinical practice, which protect the rights, safety, and well-being of study participants, in compliance with the Declaration of Helsinki. Consultation was completed with the University of Otago Ngāi Tahu Māori consultation committee (Appendix M), and received ethical approval from the New Zealand Northern B Health and Disability Ethics Committee Ref 18/NTB/240 (Appendix N).

5.3.1 Study design

This study was designed as a pragmatic, assessor-blinded and partial participant-blinded, 2-arm parallel-group feasibility RCT with randomisation stratified by hand dominance. The study was undertaken to establish the feasibility of conducting a full-scale future trial designed to assess the superiority of a soft, prefabricated splint intervention vs no splint intervention at 4-weeks and 6-months follow-up.

The study adhered to the SPIRIT 2013 Statement (Chan et al., 2013) which defines standard protocol items for clinical trials. The study was also informed by the CONSORT 2010 Statement extension for randomised pilot and feasibility trials (Elridge et al.,

2016), the Medical Research Council Guidance for Developing and Evaluating Complex Interventions (Craig et al., 2008), the Template for Intervention Description and Replication (TIDieR) guide and checklist (Hoffmann et al., 2014), and the PRECIS-2 toolkit (Loudon et al., 2015). A sample size of 30 participants was considered appropriate for a feasibility study. Samples of 24 to 30 participants have been recommended as meeting feasibility study aims (Julious, 2005; Lancaster, Dodd, & Williamson, 2004) and enabling estimates of the location of the mean and variability of parameters for future sample size calculations, when more robust data are unavailable (Abbott, 2014; Cook et al., 2018; Julious, 2005; Lancaster et al., 2004).

This trial was registered with the Australian New Zealand Clinical Trials Registry (ANZCTR): ACTRN12618001639213.

5.3.2 Setting

The study was conducted in two health settings in two centres (Dunedin and Invercargill) in the South Island of New Zealand: a university-based school of physiotherapy and a public hospital outpatient department, respectively. A research administrator at the hosting research centre managed the recruitment process and provided administrative support for the study. To avoid any potential perception of coercion, the PhD researcher, a supervisor, and an advisor, who were all clinician employees of the local District Health Board, were not involved in gaining consent from potential participants.

Three independent research assistants (RA), blinded to participants' study group allocation, conducted the baseline, 4-week, and 6-month assessments (a practicing physiotherapist and two PhD students: one a trained kinesiologist, the other a trained physiotherapist). The assessors were trained according to an assessor manual (Appendix O). All assessments for each participant were made by the same assessor.

Pre-enrolment clinical screening tests, conducted as part of the in-person eligibility screening, were carried out for participants at the Dunedin site by the PhD researcher and in Invercargill by the RA who was a practicing clinician. The PhD researcher, a registered hand therapist and physiotherapist with 17 years' clinical experience, delivered the interventions.

5.3.3 Participants

This study recruited those aged 40 years and over with symptomatic CMC OA who were either physician diagnosed or whose history suggested a diagnosis of thumb CMC OA; met stipulated minimum symptom severity: pain ≥4/10 and FIHOA score ≥6/30 (recommended by OARSI clinical trials group for entry into OA clinical trials(Kloppenburg, Maheu, et al., 2015)); no other specific diagnosis; and fulfilled the inclusion criteria (Table 5.1). A more conservative approach was taken to selecting the age criteria compared to that of the qualitative study which used the criteria of 30 years, to add confidence that those included had the condition targeted by the intervention. A 40-year minimum age is part of validated classification criteria for general OA (Hawker et al., 2008) and 40- or 45-years has tended to be selected for inclusion criteria in previous clinical trials conducted in people with thumb CMC OA (Gomes Carreira et al., 2010; Rannou et al., 2009). Exclusion criteria are also listed in the table. Potential participants were screened initially by telephone and then in-person prior to baseline assessment, according to a screening schedule (Appendix P). The stipulated symptom severity thresholds were not advertised to potential participants to avoid inauthentic reporting of pain and function status (McAlindon et al., 2015).

Since no specific clinical classification criteria for thumb CMC OA have currently been agreed, a method for identifying a history suggestive of hip and knee OA (Hawker et al., 2008) was adapted for use in the thumb (Table 5.1), as was used in the qualitative study (Chapter 3). In addition, a clinical assessment adapted from the ACR criteria for generalised hand OA was performed (Altman et al., 1990). This followed an inclusive approach whereby one or more of four clinical tests were required to be positive. If an eligible participant presented with bi-lateral thumb pain, only the self-nominated 'worst' thumb was included.

Table 5.1 Inclusion and exclusion – Feasibility study

Inclusion criteria	Exclusion criteria

• Aged 40+ years
• Physician diagnosis of thumb CMC OA *or* answer "yes" to the question, "Have you experienced aching, discomfort, pain and/or stiffness in or around the joint at the base of either thumb on most days for at least 1 month (15 or more days of the month) during the past year?" and have no other specific diagnosis.
• Minimum severity pain NRS 4/10
• Minimum score FIHOA 6/30
• One or more clinical sign(s) of 1st CMC joint involvement
  ○ Joint tenderness on palpation
  ○ Grind test
  ○ Pressure-shear test
  ○ 'Step-off' sign
• Give written informed consent
	• Thumb non-symptomatic for the past month
	• Previous surgery of the symptomatic joint
	• Steroid injection in the past 6 months
	• Concurrent rheumatoid arthritis or any other significant inflammatory or autoimmune conditions affecting the hand such as scleroderma, systemic lupus erythematosus and psoriatic arthritis, or another kind of chronic pain syndrome or metabolic disorder, such as fibromyalgia, diabetic neuropathy, or gout.
	• Injury to thumb/wrist in past 6 months
	• Unable to comprehend instructions and outcome measure instruments in English.

CMC, carpometacarpal joint; NRS, numeric rating scale; FIHOA, Functional Index for Hand Osteoarthritis.

Participants were recruited between April and August 2019 from community and health settings, including secondary public health services in the two centres. Recruitment was by way of advertisement (Appendix Q) or clinician invitation (Appendix R). The recruitment strategy aimed to optimise the number of participants of Māori descent, following the same pathway outlined for the qualitative study in Chapter 3. Potential participants contacted the research administrator for a participant information sheet or downloaded this from the study website (Appendix S). A $20 petrol voucher reimbursed participants for their costs incurred in attending each of the three assessments; other benefits of involvement in the study included education and advice about thumb base OA. The consent process was completed by the study assessor, per the consent form (Appendix T).

5.3.4 Intervention development

The splint intervention and the standardised best practice usual care package were developed based on literature review and through stakeholder consultation.

5.3.4.1 Literature review

Based on findings of the systematic review reported in Chapter 5, the optimal duration and schedule for splint wearing is not currently known. The larger of the two studies included in the meta-analysis at the medium-term prescribed splint-wearing over-night for 12 months (Rannou et al., 2009), whereas the smaller study prescribed splint-wearing in the day (Gomes Carreira et al., 2010). Other studies included in the systematic review described variable combinations of over-night or day-time wearing, or left wearing to participants. These showed positive but not significant results (Becker et al., 2013; Cantero-Téllez et al., 2017; Cantero-Tellez et al., 2018; Hermann et al., 2014; McKee & Eason-Klatt, 2006; Sillem et al., 2011; Weiss et al., 2000, 2004); in most cases the actual wear time was not reported. On the other hand, in the clinical literature, full-time splint wearing in the initial treatment period (2- to 4-weeks) has been advocated by some United States authors for more than two decades (Colditz, 2000; Weiss & Falkenstein, 2005) although this has not been systematically investigated.

Since a sufficient intervention dosage is needed to produce therapeutic effects, it is hypothesized, therefore, that insufficient intervention time may be a reason for the lack of short-term effect described in the previous literature. Prescription overnight in addition to daytime use is one way in which wearing time can be increased without interfering in daily activities. Therefore, stakeholder consultation was intended to achieve the highest dosage of splint wearing likely to be feasible and acceptable to patients and clinicians.

Development of the standardised best practice usual care package was based on key recommendations from international guidelines for management of hand OA (Hochberg et al., 2012; NICE, 2014; Zhang et al., 2007), and informed by best available evidence on exercise and joint protection in thumb CMC and hand OA (Dziedzic et al., 2015; Kjeken et al., 2013; O'Brien & Giveans, 2013; Scott, 2018; Shankland et al., 2017; Stamm et al., 2002), expert opinion (Colditz, 2013; Taylor, 2000), and a clinical practice resource (Albrecht, 2015).

Measures to optimise adherence to the splint intervention and standardised best practice usual care included: ensuring the splint was comfortable, well-fitted and

aesthetically acceptable; advising how to successfully adapt activities without compromising the splint regime (O'Brien, 2012); establishing a trusting relationship by providing education and rationale for treatments (Smith-Forbes et al., 2016); catering for different learning styles (Harte & Law, 2017); and implementing a simple behavioural intervention (Cole, Robinson, Romero, & O'Brien, 2017).

5.3.4.2 Stakeholder consultation

From August to September 2018 the PhD researcher conducted stakeholder consultations with two focus groups (n=6, n=2) and a single one-to-one interview (n=1), which included experienced Hand Therapy New Zealand-registered hand therapists, both physiotherapists and occupational therapists, working in public and private practice settings in New Zealand. The consultation schedule included an introduction to the stakeholder discussion (Appendix U); a short presentation of the study and relevant literature (Appendix U.1); and a schedule of questions (Appendix U.2). Data were summarised under key points (Appendix U.3). The stakeholder process gave careful consideration to utility in a usual-care setting and identified the specific splint type and wearing schedule. Typical scenarios were outlined where a patient would be unable to wear the splint as instructed. These scenarios informed the instructions provided to participants concerning when not to wear the splint, or suggested potential solutions to issues with the splint.

Written resources were compiled based on the literature reviews and stakeholder input for 1) the splint intervention and 2) the standardised best practice usual care. The written resources and instructions were pilot-tested with two lay people with thumb CMC OA. The splint intervention and best practice usual care package were acceptable; and changes were made to clarify concepts where necessary.

5.3.5 The splint intervention

Participants randomised to the intervention group were fitted with a soft neoprene hand-based splint (Procool T/R Splint Bound, @Therapy), issued a second (to have one to wash and one to wear) and instructed to wear a splint 20 hours out of 24 for 4 weeks. An explanation of the rationale and wearing schedule for the splints was given.

A simple behavioural intervention accompanied the splint prescription comprising dedicated time for skill acquisition and practice within the treatment session for donning and doffing the splint, providing feedback and encouragement, and fostering self-efficacy through problem-solving to incorporate the splint in everyday life (Cole et al., 2017). Minor modifications were made to the splint as required for optimal fitting while maintaining splint aesthetic and integrity: for example, shortening or altering the shape of the thumb exit space by cutting, or altering the length of the strap through the web space or wrist using NRX Strap (@Therapy) or OneStrap (Mitre10 Mega). The splint intervention procedure comprised a single face-to-face consultation, occurring immediately after delivery of the standardised package of best practice usual care, and took a maximum 20 minutes per participant. The written resource, a single-sided A4 information sheet specific to the left (Figure 5.1) or right hand (Appendix V) was also provided. The 4-week time point marked the end of the intervention period. Thereafter, participants were invited to keep the splints that had been issued and to use them at their discretion.

How to wear your thumb base splint

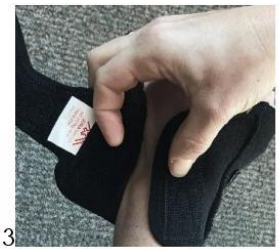
What is a thumb base splint?

Your thumb base splint is a soft support made of neoprene.

How do I put my splint on?


1


2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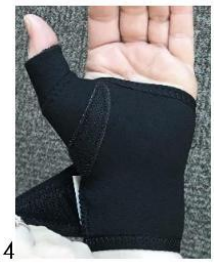
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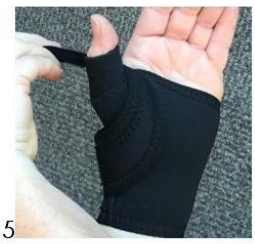

5


6

How does my thumb base splint help?

Your thumb base splint lessens the stress and strain at your thumb base joint by keeping the joint surfaces in the best possible place, and by giving the joint extra support.

Your splint gives your thumb base joint extra warmth and compression, both of which may ease pain and inflammation.

When should I wear my thumb base splint?

Wear your splint at **night**, and **during the day**, both when you are doing things and when you are resting. **Take your splint off** when having a **shower** and if your hands are **getting wet**. Take it off to do the exercises.

Aim to wear your splint 20 out of 24 hours.

How do I look after my splint?

You have two splints – one to wash and one to wear. Wash each splint regularly – at least once a week.

To wash it, soak in a bucket of warm water with washing powder for half an hour, rinse well, and let sit to dry. Do not put it through the washing machine.

RECORD THE TIME YOU WEAR YOUR SPLINT, AND WHEN AND WHY YOU TAKE IT OFF, IN THE DIARY

Left thumb

Figure 5.1 Splint intervention for left thumb

5.3.6 The standardised best practice usual care package

Both groups received a standardised package of recommended best-practice usual care. This was delivered by the PhD researcher at a single face-to-face consultation taking approximately 25 minutes. The package comprised verbal and written education about thumb CMC OA and joint care principles, simple hand exercises, and advice to increase general activity levels, for example, walking or pool (NICE, 2014), together with advice to continue with usual physician care. Also included was the written resource, a 2-sided A4 information sheet specific to the left (Figure 5.2 and Figure 5.3) or right hand (Appendix W), and additional verbal cues (Appendix W.1). The same behavioural approach was taken as for the splint intervention.

Participants in either group who required assistance during the 4-week treatment period were able to contact the research administrator to ask the treating therapist to make an arranged call to the participant. If any issue could not be resolved by telephone consultation, a follow-up treatment session was arranged. Participants were not offered additional treatment after completion of the 4-week intervention period; participants randomised to the comparator intervention group were not offered the splint intervention on completion of the intervention as there was insufficient evidence to demonstrate that the intervention would be effective.

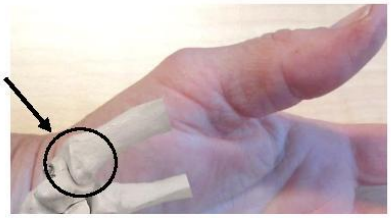
At the end of the 4-week intervention period and following the 4-week follow-up assessment, the treating therapist counselled the participant regarding intervention received by the other group, reiterated that the treatment period was complete but to advise that, at the participant's discretion, the best practice usual care or splint intervention or both might be continued.

How to care for your thumb base osteoarthritis

What is thumb base osteoarthritis?

The thumb gives humans an amazing ability to use tools and create our world. The thumb base joint is a small joint that we put under a lot of force. It has two shallow, saddle-shaped bone ends shaped like a rider on a saddle.

The shallow, saddle-shaped bone ends of the thumb base joint.

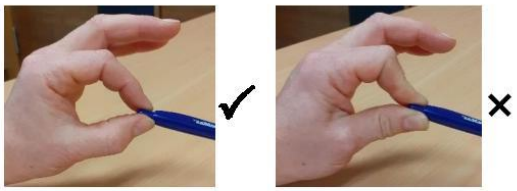


This allows for great movement, which is good when the joint is healthy but a problem if the joint surfaces are not well aligned. Poor alignment means more force through a smaller area, with excess stress and strain on the joint.

Osteoarthritis describes the injury to ligaments, cartilage and bone that occur when stress and strain are more than the joint can handle. This creates inflammation and pain. Recovery is limited by repeated stress and strain and other factors such as age.

What can I do to lessen stress and strain at my thumb base joint?

1. Use your thumb in ways that keep the joint surfaces in the best possible place - use your thumb in a "C" position, where the joint surfaces are in most contact. In doing things, keep your thumb more out to the side. More contact area means less force. Use your finger to grip rather than your thumb.



2. Increase the size and "grip" of the handle of tools or equipment you use, for example a pen or kitchen knife.
3. Use two hands instead of one or use bigger joints such as your elbow or shoulder.
4. Take mini breaks to let your joint recover, but don't stop using your hand.
5. Use gadgets to make the job easier in your kitchen, at work, at your computer, in your garden, or caring for children and others. E.g. non-slip mat to open a jar or use different containers instead of a jar. Spring-loaded scissors, tap turner, slip-on pegs, or hand-shaped computer mouse may ease everyday activities. More gadgets can be found at kitchen or hardware stores, at specialist shops, or online. *For online resources go to* *www.otago.ac.nz/thumb-base-oa*

6. **What about the pain?**

Pain interferes with how the muscles work to support your joint. Less pain is better. Try gentle heat or cold. Take your pain relief as prescribed.

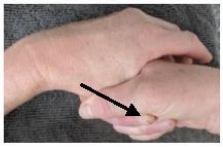
Left thumb

Figure 5.2 Standardised best practice usual care for left thumb, page 1

Perform Exercises 2 times Daily for 5 Minutes - the exercises should not be painful.

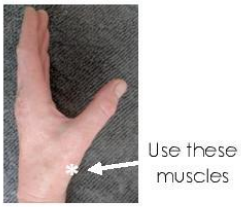
1. Massage your thumb webspace using your other thumb webspace, 30 seconds

2. Gently pull the length of your thumb away from your hand for 5 seconds, then relax.
Repeat 2 times



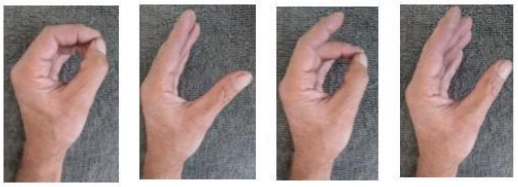
3. Gently stretch your thumb out to the side – grasp the base of your thumb and stretch your fingers back. Hold 5 seconds, then relax.
Repeat 2 times

4. Teach the muscles: Spread your thumb out to the side as if grasping a large jar – keep your thumb long and curved like the arch of a bridge. Hold 3 seconds, then relax back.
Repeat 10 times



5. Butterfly stretch: Place your sore hand on your chest, reach over with your other hand and grasp the base of your thumb. Gently stretch back, hold 5 seconds, then relax. **Repeat 2 times**

6. Touch your thumb to your index and then your middle finger, spread your thumb out in between each movement.
Repeat 5 times



General exercise for example walking or in the pool is recommended for your general health and for reducing the impact of osteoarthritis in any joint. Exercise should be comfortable. Do little bits often, e.g. 10-20 minutes twice daily.

RECORD THE ADVICE YOU FOLLOW AND HOW MANY EXERCISES YOU DO AND WHEN IN THE DIARY

Left thumb

Figure 5.3 Standardised best practice usual care for left thumb, page 2

5.3.7 Primary feasibility outcomes and criteria

The following specific criteria were pre-determined to assess feasibility:

5.3.7.1 Recruitment

Recruitment was evaluated based on the number of participants recruited in 4 months. The number who responded to advertisements, the outcome of screening, and the number enrolled were recorded, by location, on an Excel spreadsheet and reviewed weekly by the research administrator and the researcher. The feasibility criterion was recruitment of 30 participants in a 4-month period.

5.3.7.2 Retention

Retention was defined as the number who completed assessments at the 4-week and 6-month time points. The feasibility criterion was retention >85% at 6-months.

5.3.7.3 Intervention acceptability

Interviews were conducted by the researcher following the 4-week and 6-month assessments to obtain participants' views on acceptability of the interventions and the assessment procedures, according to interview schedules (Appendix X, Appendix Y). The feasibility criterion was acceptability >90%.

5.3.7.4 Notification of adverse events

Participants were asked to notify the research administrator of any adverse events. These were forwarded to the study-treating therapist who addressed any concerns with the participants by telephone in the first instance and in person if necessary. Referral for further care could be made if required. All adverse events were recorded and, if significant, brought to the study-monitoring committee. Splinting is a low-risk intervention and few adverse events were anticipated. The feasibility criterion was no significant adverse events.

5.3.8 Secondary outcomes – feasibility

Secondary aims were to 1) confirm the time needed for study procedures to be undertaken by the assessor and clinician; 2) achieve intervention implementation in over 80% of prescribed instances (days of the week); 3) maintain satisfactory quality-control audit of the intervention and assessments; 4) determine the degree of success of

recruitment and randomisation; 5) explore the potential role of imaging (x-ray and ultrasound) in evaluating participant characteristics at baseline, and the feasibility of using imaging to identify a subgroup of participants who might be more responsive to treatment; 6) explore whether treatment outcomes are consistent with expectations based on previous literature.

5.3.8.1 Intervention fidelity

Adherence to either the splint or best practice usual care interventions, or both, was assessed by a daily log completed by the participants according to a template form specific to each group (Appendix Z, Appendix Z.1). Participants in the splint group recorded the number of hours the splint was worn and any reasons for not wearing the splint. Participants in both groups recorded exercises completed, any reasons for not completing exercises, any concerns or problems, and the advice followed. The clinical research administrator telephoned, texted, or emailed reminders (as preferred) on a weekly basis to remind participants to complete the daily log.

5.3.8.2 Quality audit

The quality of intervention delivery and outcome assessment was audited on two occasions each by the PhD primary supervisor using pre-defined quality audit tools based on those used in the U.K. Osteoarthritis Thumb Therapy (OTTER) trial [Adams, Personal Communication[2]] (Appendix AA, Appendix BB). The quality of the intervention delivery and outcome assessment was also monitored by the PhD researcher and in consultation with the assessors.

5.3.8.3 Imaging

Imaging at baseline was performed as recommended for studies investigating effectiveness of treatment for symptoms or disease status in hand OA (Hunter et al., 2015). X-ray imaging was obtained for each participant to characterise, at baseline, the radiological involvement of the CMC joint, unless a recent good quality x-ray (< 6 months) was available. A consultant orthopaedic surgeon interpreted the x-rays according to the OARSI-atlas (Altman & Gold, 2007) and the modified E-L grade (Eaton, Lane, Littler, & Keyser, 1984). The E-L stages were defined as follows: 1 – slight joint

[2] Email communications 28.09.2018 and 29.09.2018 with Prof Jo Adams on behalf the OTTER trial group

space widening, normal articular contours; 2 - mild JSN, spurs or debris ≤2mm, early erosion trapezium; 3 – marked JSN, spurs or debris ≥2mm, subchondral sclerosis; 4 - marked JSN and articular destruction, involving S-T joint (Eaton et al., 1984). The OARSI-atlas grades for individual features of osteophytes and JSN were defined as: 0 – normal; 1 – mild change; 2 – moderate change; 3 – severe change (Altman & Gold, 2007). Scores were reported directly into an Excel spreadsheet according to a standardised reporting form (Appendix CC). A Professor of Radiology undertook a second independent interpretation and both readings were compared to assess inter-rater reliability of the x-ray scores.

Ultrasound imaging was performed in a convenience sample of seven participants at the Dunedin site. This was undertaken and interpreted independently by two consultant rheumatologists, experienced and trained in musculoskeletal ultrasound, according to a recommended scanning protocols and atlases (Hammer et al., 2011; Mathiessen et al., 2013). Ultrasound was performed using a using a NextGen LOGIQ model e machine (GE Healthcare, Chicago, IL) with a 12L RS 4.2 – 13.0 MHz linear array transducer (optimized for power Doppler for each individual). Grey scale images were graded for osteophytes, and scored as follows: 0 – no osteophytes, i.e. a smooth cortical surface; 1 – small and distinct cortical protrusion(s) of the bony surface; 2 – larger protrusion(s) which may have broad base(s); 3 – very large protrusion(s) which may have very broad base(s) (Mathiessen et al., 2013). Grey scale and power Doppler images were interpreted for presence of joint fluid and vascularisation, and together graded for synovitis as follows: 0 – none; 1 – minor presence of ultrasonographic pathology; 2 – moderate presence of ultrasonographic pathology; 3 – major presence of ultrasonographic pathology (Hammer et al., 2011). Each participant was scanned by both clinicians and scoring reported on a standardised form (Appendix DD). After scanning the first three participants the two rheumatologists completed a consensus exercise conferring on scores that differed, repeating the ultrasound scanning, and coming to agreement about the scores.

Clinicians involved in the acquisition, or reading, or both, of x-ray or ultrasound images were blinded to group allocation.

5.3.9 Secondary outcomes – clinical outcomes

Data were collected and analysed to investigate the impact of the splint versus no splint on pain, self-reported function, QoL, global rating of change (GROC), OMERACT-OARSI responder criteria, use of other treatments including medication, and physical performance variables (Table 5.2). The clinical assessments were chosen for their potential to be primary or secondary outcomes in a future full clinical trial. These measures were based on core outcome sets recommended for hand OA (Kloppenburg, Maheu, et al., 2015) and OA generally (Fitzgerald et al., 2015), and impact identified as important and meaningful to people with the condition, as outlined in Chapter 3. Due to the small sample size, these preliminary data were not collected in anticipation of reaching significance, but rather to identify areas of interest which may inform future studies. The data were also collected to inform, but not be the sole basis for, specification of an effect size for sample size calculation for a future full trial.

Clinical assessments were collected at baseline, then at 4-weeks and 6-months according to pro-forma schedules of assessments (Appendix EE, Appendix EE.1, Appendix EE.2). These time points were chosen to provide 1) a time-frame relevant to the long-term nature of thumb CMC OA (6-months), and 2) short-term assessment (4-weeks) for participant retention and engagement, as well as assessing adverse events and evaluating the immediate impact of the intervention.

5.3.9.1 Pain

Pain on average and pain at night were rated on 11-point NRS, anchored by the statements, 'No pain', and 'Extreme pain' (Hawker, Mian, Kendzerska, & French, 2011) (Appendix FF). The definitions and time frame for recall were "…what your pain at the base of your thumb has usually been like **on average** during the past week" and "what your pain at the base of your thumb has usually been like **at night** during the past week". A minimal detectable change (MDC) of 1.3 has been estimated for pain NRS, derived from a knee OA population (Alghadir, Anwer, Iqbal, & Iqbal, 2018). An MCID of 2-points has been estimated, derived from cohorts with chronic conditions including OA (Farrar, Young Jr, LaMoreaux, Werth, & Poole, 2001; Hawker, Mian, et al., 2011). An MCID specifically for pain in thumb CMC OA has yet to be determined.

Table 5.2 Secondary clinical outcome measures

Assessment – secondary outcomes:	Measurement scale:	Time*:
Pain numeric rating scale (NRS) for pain at base of thumb, on average in past week	0 – 10	0, 4, 26
Pain at night (NRS), on average in past week	0 – 10	0, 4, 26
Functional Index for Hand Osteoarthritis (FIHOA) (10 questions relating to function, rated 0-3; low score is better)	0 – 30	0, 4, 26
Additional Functional Questionnaire (AFQ)	0 – 3	0, 4, 26
Quick Disability of the Arm, Hand and Shoulder (QuickDASH) (11-item questionnaire, rated 0-4; low score is better) (Aasheim & Finsen, 2014; Beaton, Wright, Katz, & Upper Extremity Collaborative, 2005)(Aasheim & Finsen, 2014; Beaton et al., 2005)	0 – 100	0, 4, 26
Global Rating of Change (GROC)	-5 to +5	4, 26
Patient-reported health status (EQ-5D-5L Index score and EQ-5D-5L VAS score)	0.0 – 1.0 0 – 100	0, 4, 26
NSAID Equivalent score (+/- other medications)		0, 4
Other interventions sought (including surgery)		4, 26
Power grip strength, dynamometer (best of three)	kilogram-force	0, 4, 26
Pinch grip strength, dynamometer (best of three)	kilogram-force	0, 4, 26
Inter-digit distance (IDD) (length of 1st web space, ruler)	millimetres	0, 4, 26
CMC joint palmar abduction (Pollexograph – purpose-built box with protractor printed on top)	degrees	0, 4, 26
Grip Ability Test (GAT) (test of functional performance, timed)	seconds	0, 4, 26
OMERACT-OARSI responder	yes / no	4, 26

EQ-5D-5L, EuroQuol 5-Dimension, 5-Level; VAS, visual analogue scale; NSAID, non-steroidal anti-inflammatory; CMC, carpometacarpal; OMERACT-OARSI, Clinical Trials Response Criteria Initiative and Outcome Measures in Rheumatology and Osteoarthritis Research Society International.
* 0 = baseline, 4 = 4-weeks, 26 = 26-weeks (6-months)

5.3.9.2 Self-reported function

Three self-report measures of function were used: the FIHOA, the QuickDASH, and an Additional Functional Questionnaire (AFQ).

The FIHOA, validated in hand OA populations, contains 10 items relating to function, scored on 0-3 scale (total score 0 to 30, lower is better) (Dreiser, Maheu, & Guillou, 2000; Dreiser et al., 1995). The FIHOA was chosen because it is the foremost self-report

functional measure recommended by the OARSI clinical trials group (Kloppenburg, Maheu, et al., 2015) and OMERACT hand OA working group (Kloppenburg, Boyesen, et al., 2015) and is freely available. As described in Chapters 1 and 3, the FIHOA has faults including clinician-centric development and lack of modern-day relevance, and it poorly represents the functional impact for people with thumb CMC OA. Therefore, the QuickDASH was chosen as an additional measure. No studies have previously defined a MCID for the FIHOA. An MDC has been calculated to be 5.6 points (Moe et al., 2010); although previous studies have claimed as MDC an arbitrarily determined 3 points, or 1 scale point (a reported minimal potential detectable change (MPDC) (Bellamy, Carr, Dougados, Shea, & Wells, 2001)) for sample size calculation and interpretation of results (Damman et al., 2018; Deveza et al., 2017).

The QuickDASH is widely used and recommended in the surgical setting for thumb CMC OA (Martou, Veltri, & Thoma, 2004; Wajon et al., 2015). The 11-item QuickDASH is a validated shortened version of the original 30-item DASH (Aasheim & Finsen, 2014; Beaton et al., 2005). The 30-item DASH has existing evidence for reliability in a range of populations (Beaton et al., 2005; Franchignoni et al., 2014; Sorensen, Howard, Tan, Ketchersid, & Calfee, 2013). It contains items relevant to the functional impact and participation restrictions experienced by people with thumb CMC OA (Chapter 3). Scores range from 0 to 100 where 0 = no disability and 100 = maximum disability (Beaton et al., 2005). In relation to the QuickDASH an MCID of 15 points has been suggested (Franchignoni et al., 2014; Sorensen et al., 2013). Smaller MCIDs of 7 to 8 points have also been calculated but these lower values were derived using less robust methods, that is, based on a generous interpretation of using a 1-point change on 7-point GROC scale for an anchor (Kazmers et al., 2020). Estimates of MDC for the QuickDASH range from 11.2 points to 13 points (Franchignoni et al., 2014; Mintken, Glynn, & Cleland, 2009; Sorensen et al., 2013).

While the QuickDASH contains more items relevant to people with thumb CMC OA than the FIHOA, including impact on work, social interactions, and sleep interference (Chapter 3), the instrument is a region-specific rather than condition-specific measure and this may have implications for sensitivity to change in thumb CMC OA (Donnelly & Carswell, 2002; MacDermid, Wessel, Humphrey, Ross, & Roth, 2007; Polson, 2007). For

example, the inclusion of paraesthesia is not directly relevant to the condition of thumb CMC OA.

The third self-report measure of function was an additional set of 10 functional items based on findings from Chapter 3 These were formulated into an 'Additional Functional Questionnaire' (AFQ) for exploratory use and scored as per the FIHOA (Appendix GG).

5.3.9.3 Health-related quality of life

Health-related QoL was evaluated using the newer 5-Level EQ-5D-5L version of the EQ-5D (Herdman et al., 2011; The EuroQol Group, 1990). The cumulative 'health state' which lists scores of each of the five levels was converted to an index value (van Reenen & Janssen, 2015) using the EQ-5D-5L Crosswalk Index Value Calculator, and the published value set from the United Kingdom (EuroQol Research Foundation, 2020; The EuroQol Group, 1990; van Hout et al., 2012) (0.0 to 1.0, higher is better). The EQ-5D-5L index score has an MDC of 0.03 to 0.12 derived from populations of people with diabetes (McClure, Sayah, Ohinmaa, & Johnson, 2018) and cancer (Pickard, Neary, & Cella, 2007).

5.3.9.4 Global rating of change

The global nature of the Global Rating of Change (GROC) scale is presumed to allow participants to focus their response to those things that matter the most to them (Kamper, Maher, & Mackay, 2009). Therefore, the self-reported pain and function instruments were supplemented with the 11-point GROC scale at 4-weeks and at 6-months (Kamper et al., 2009). The question was formulated with respect to participants' 'thumb base problem' (Appendix HH). An MDC of 0.45 points and MCID of 2 points have been suggested for the 11-point GROC scale (Kamper et al., 2009).

5.3.9.5 Responder criteria

The OMERACT–OARSI responder criteria combine pain, function, and patients' global assessment to provide a standardised assessment of whether a patient has responded to an intervention or not (Fitzgerald et al., 2015). This approach takes into account the patient perspective and is recommended for clinical trials in OA (Fitzgerald et al., 2015). Furthermore, since results are easy to interpret, findings are more likely to be translated into practice (McGlothlin & Lewis, 2014). The high threshold for clinically

important change set by this measure provides assurance that measured change is indeed meaningful (McGlothlin & Lewis, 2014; Pham et al., 2004). However, a limitation is that criteria were drawn from data and expert-clinician opinion based on studies of hip and knee OA only (Pham et al., 2004) and no criteria yet exist for hand OA conditions (Kloppenburg, Maheu, et al., 2015).

Nevertheless, these responder criteria have been usefully employed across a wide range of OA trials and interventions, including in hand OA (Dziedzic et al., 2015; Hennig, Hæhre, et al., 2015; Osteras et al., 2014). Therefore, this measure is explored for its use in splinting for thumb CMC OA. Responders were defined as 1) improvement in pain or physical function ≥50% and an absolute change ≥20 on 0-100 scale; or 2) improvement ≥20% and an absolute change ≥10 in at least two of the following three categories: pain, physical function, and GROC (Pham et al., 2004).

5.3.9.6 Medication use

Participants' usual use of medication, including dosage of NSAIDs, where available, was self-reported by participants at the first and second assessments; change in medication use during the 4-week intervention period was recorded by participants in their daily log. Other pharmacological or surgical interventions were similarly recorded. Non-steroidal anti-inflammatory drug use was transformed into an NSAID Equivalent Score based on comparable dosage parameters (Dougados et al., 2012; Dougados et al., 2011), assuming stable use for 7 days prior to baseline assessment.

5.3.9.7 Physical performance

Performance measures included the following: thumb palmar abduction ROM measured using the Pollexograph (de Kraker, Selles, Schreuders, Hovius, & Stam, 2009; de Kraker, Selles, Schreuders, Stam, & Hovius, 2009), as well as a novel modification of the inter-metacarpal distance (de Kraker, Selles, Schreuders, Stam, et al., 2009; Murugkar, Brandsma, Anderson, Gurung, & Pun, 2004) – characterised as the 'inter-digit distance' (IDD) (Figure 5.4) – calculating the mean of three measures; maximum grip and pinch strength using dynamometers, recording the best of three attempts (Buhler, 2007; Mathiowetz, 1990); and the timed Grip Ability Test (GAT) functional performance test (Bircan, 2014; Dellhag & Bjelle, 1995; Poole, 2011).

Measures of palmar abduction were selected because it has been hypothesised that increased first web space may be a mechanism of effect of splinting for thumb CMC OA (Rannou et al., 2009). Although this was not demonstrated in a previous study of night-time splinting (Rannou et al., 2009), a more recent study of exercise in general hand OA did find a significant increase in first web space length in the intervention group compared associated with reduced pain (Osteras et al., 2014). Another study has used a measure of 'hand span' which measured the linear distance from tip of thumb to tip of little finger with the fingers fully-spread. This measure, similar to the IDD, was found to correlate significantly with improved self-reported function of a post-arthroplasty thumb CMC OA population even though most other physical measures recorded in the study, including strength, did not (MacDermid et al., 2007). For the present study, IDD landmarks were chosen for their proximity to the thumb CMC, easy identification and anecdotally, the PhD researcher has usefully employed them in clinical practice for over 10 years.

The Pollexograph is a portable 21 cm x 13 cm x 7 cm cardboard box upon which was printed a 180 degree reversible scale, constructed according to published specifications (de Kraker, Selles, Schreuders, Hovius, et al., 2009). Thumb palmar abduction is measured with the hand stabilised against the box and using a ruler to align skin markings identifying CMC motion to the degree attained on the scale. There is some evidence of reliability of the Pollexograph in healthy adults (de Kraker, Selles, Schreuders, Stam, et al., 2009), and it has shown superior reliability compared to a goniometer in assessment of hypoplastic thumbs (de Kraker, Selles, Schreuders, Hovius, et al., 2009). However, reliability has not been assessed in populations with thumb CMC OA.

Previous estimates of MCID for grip strength are 6.0 KgF to 6.5 KgF (Benaim, Blaser, Leger, Vuistiner, & Luthi, 2019; Bohannon, 2019) derived from a 1-year post-distal radius fracture population (mean age 55 years) (Kim, Park, & Shin, 2014) and a study in adults with chronic musculoskeletal conditions (not including hand OA) (Benaim et al., 2019). Markedly smaller MCIDs for grip strength, of 0.84 KgF to 1.12 KgF, have also been suggested (Villafañe, Valdes, Bertozzi, & Negrini, 2017). These values should be interpreted with caution because, while derived from a large population with thumb

CMC OA, they were calculated using a distribution-based approach in a cross-sectional cohort matched with healthy controls. Although they may not be true MCIDs, these values may serve as interim MDCs. These same authors reported the only published values (also judged to be MDC rather than MCID, for the same reasons as above) for pinch strength, 0.23 KgF to 0.33 KgF (Villafañe et al., 2017),

The GAT was chosen for use in this study for its brevity, low cost, and inclusion of tasks involving the thumb in gross grasp, power pinch, and fine pinch (Dellhag & Bjelle, 1995; Poole, 2011). It is a shortened version of Sollerman's Grip Function Test (Dellhag & Bjelle, 1995). The three key functions in particular were identified as important from the patient perspective in the qualitative interviews in Chapter 3. Furthermore, in Chapter 2 these functions were reported as of significance anatomically in thumb CMC OA aetiology. The GAT has demonstrated excellent reliability, good internal consistency and discriminate validity, sensitivity to change, and an estimated MCID of 8 seconds in an RA population (Dellhag & Bjelle, 1995). Little literature exists for the GAT's measurement properties in other populations, including CMC OA.

All measures were described in detail in the Assessor Manual (Appendix O). Grip and pinch strength were measured using the same dynamometer and pinch grip meter, respectively, for all assessments of each participant.

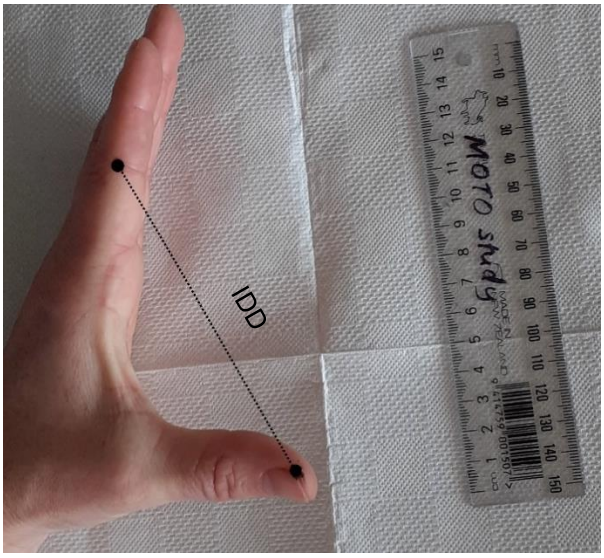


Figure 5.4 Active thumb palmar abduction inter-digit distance (IDD) measurement, measured from the intersection between the volar and dorsal skin creases on the radial aspect of the proximal interphalangeal joint of the index finger and where the thumbnail exists the nail bed (at the ulna border of the junction of the nail bed and the hyponychium) on the distal-ulna aspect of the thumb.

5.3.10 Baseline characteristics

Patient characteristic variables were collected at baseline (Table 5.3) using a tailored and pre-tested data collection form, slightly modified from the qualitative study questionnaire (Appendix II)

5.3.11 Randomisation and allocation concealment

The randomisation schedule was prepared by the research administrator using computerised sequence generation and allocations concealed in series of opaque envelopes according to three randomisation blocks (dominant vs nondominant vs ambidextrous), in block sizes of six. Following the consent process and baseline assessment, the next envelope in sequence in the relevant block was opened by the clinician to reveal group allocation.

Table 5.3 Participant baseline characteristics

Participant characteristic variable:	Measurement scale:
Age	years
Sex	male / female
Ethnicity	
Descent	
Work status	Full time / part time / not working / student / in the home / unemployed or seeking work / age retired / disability pension / sick leave
Dominant hand	Left / Right / Ambidextrous
Hand with thumb CMC OA	Left / Right / Both
Thumb CMC OA diagnosed by health care provider?	Yes / No
If yes, which health care provider?	GP, physio/hand therapy, rheumatologist, surgeon
How long have you had your thumb CMC problem(s)?	years
Other joints with OA (besides your hands):	
Other medical conditions	(e.g. diabetes, heart problems)
Current medications	
Current and previous treatments for thumb CMC problem	Yes / No / When, for: topical cream (type); injections; physio (exercise, advice, splint); other
Thumb MCP hyperextension at rest	degrees
Joint tenderness on palpation*	Present / absent
Grind test*	Positive / negative
Pressure-shear test*	Positive / negative
'Step-off' sign*	Present / absent
BMI	
X-ray: standard PA view, OARSI-atlas grade for individual features (osteophytes, JSN); Eaton-Littler grade	0-3 0-4
Ultrasound: grade for synovitis and osteophytes	0-3 semi-quantitative scale, and dichotomous "Present / Not present"

CMC, carpometacarpal joint; OA, osteoarthritis; MCP, metacarpophalangeal joint; BMI, Body Mass Index; PA, posterior-anterior; OARSI, Osteoarthritis Research Society International; JSN, joint space narrowing.
* Clinical tests for 1st CMC joint involvement: one or more are positive for inclusion (Table 5.1)

5.3.12 Blinding

It was not possible to fully blind the participants or the treating clinicians to group allocation due to the nature of the study intervention. However, to provide partial blinding, the study hypothesis was not revealed to participants until after their 4-week follow-up visit. Information provided to participants at recruitment explained that the nature of the treatments offered to the other trial group would be concealed from them until after the 4-week follow-up, in order that their perceptions about the intervention did not influence the study findings at this time point. Instruction was given to the treating therapist, assessors, and all health professionals and administration staff involved in participants' care to keep this information concealed until after the 4-week follow-up. Outcome assessors were not involved in participant care and were blinded to group allocation. Participants' splints were removed prior to follow-up assessments and participants were instructed not to disclose information about their treatment to maintain assessor blinding.

Data were analysed by the researcher, who was also the study clinician. The researcher was not blinded to participant group allocation.

5.3.13 Data analysis

Planned data analysis of primary outcomes was documented a priori, published in a protocol paper in an academic journal, and adhered to.

Data analysis comprised descriptive analysis of the primary and secondary feasibility outcomes and appraisal against the feasibility criteria. Baseline and adherence-related participant characteristics were presented using descriptive statistics: mean, SD, 95% CI for scale and ordinal self-reported outcomes data, and case number and percentage for nominal data.

To examine individual variation in treatment response across time, modified Brinley plots (Blampied, 2017) were used to show change in the dependent variables considered as candidates for primary outcome in a future full trial (pain on average NRS, pain at night NRS, FIHOA, and QuickDASH). Each individual participant's scores on the same dependent variable at different time points were plotted on a scatter plot about orthogonal axes with the same origin and scale values. Data points lying on or

close to the diagonal (45°) represented no change. Parallel lines depicting the minimal reliable change, that is change beyond measurement error or MDC (Lin et al., 2009; Portney, 2015) and MCID, where available, aided interpretation of the reliability and clinical importance of individual improvement or deterioration (Blampied, 2017). The proportion for whom change in the dependent variable exceeded MDC or MCID was calculated for each group at each time-point. This approach takes the individual as the unit of analysis, enhancing the ecological validity of the construct (Asenlof, Denison, & Lindberg, 2006).

Within-group differences in secondary outcome measures (scale and ordinal data) at different time points were described using paired *t*-tests and between-group differences using independent sample *t*-tests; both were compared to available MDC and MCID, to further inform selection of outcome measures for a future full-size trial. The number and ratio of responders were presented for each group (Fitzgerald et al., 2015). Inter-rater reliability of imaging scores was assessed using Cohen's Kappa.

All data were entered into Excel spreadsheets along with a full data dictionary, and checked by an independent assistant. Data were then imported into IPM SPSS Statistics version 25.0 for analyses. Advanced statistical analyses, including hypothesis testing were not undertaken due to the small sample size and the study's primary aim of testing feasibility. Patient-reported outcomes were treated as scale data while imaging scores were treated as nominal data. Analysis followed the intention-to-treat principle. Complete case analysis was applied where more than one item was missing for an outcome or the outcome was missing in entirety. A missing item on the QuickDASH was dealt with by adjusting the calculation as per instrument instructions (Beaton et al., 2005). The FIHOA has no prescribed rules for missing items so the approach taken was to compute the mean based on the number of items completed.

5.4 Results

Recruitment took place between April and August 2019 and data collection from April 2019 to March 2020. Recruitment ceased once the target of 30 eligible participants was reached. Fifteen participants were randomised to each group (Figure 5.5). One

participant allocated to the splint group withdrew prior to implementation of the intervention.

Of note, in the early phase of recruitment four potential participants recruited and randomised in error resulted in an additional four baseline assessments completed including x-rays; these were also three of the seven who underwent ultrasound imaging. The allocation error was due to misinterpretation of inclusion criteria whereby a score of 6 or more on the AFQ was incorrectly understood to have met the inclusion criteria for functional outcome when the FIHOA score had not reached 6/30. Although clinical baseline measures of these four participants were not included in the data presented as part of the present study, their imaging data are included but only for the purpose of evaluating inter-rater reliability of the x-ray scoring method. The three potential participants randomised in error for whom ultrasound data were available were those in whom the ultrasound imaging consensus process was undertaken; therefore, these were not included in inter-rater reliability analysis of ultrasound.

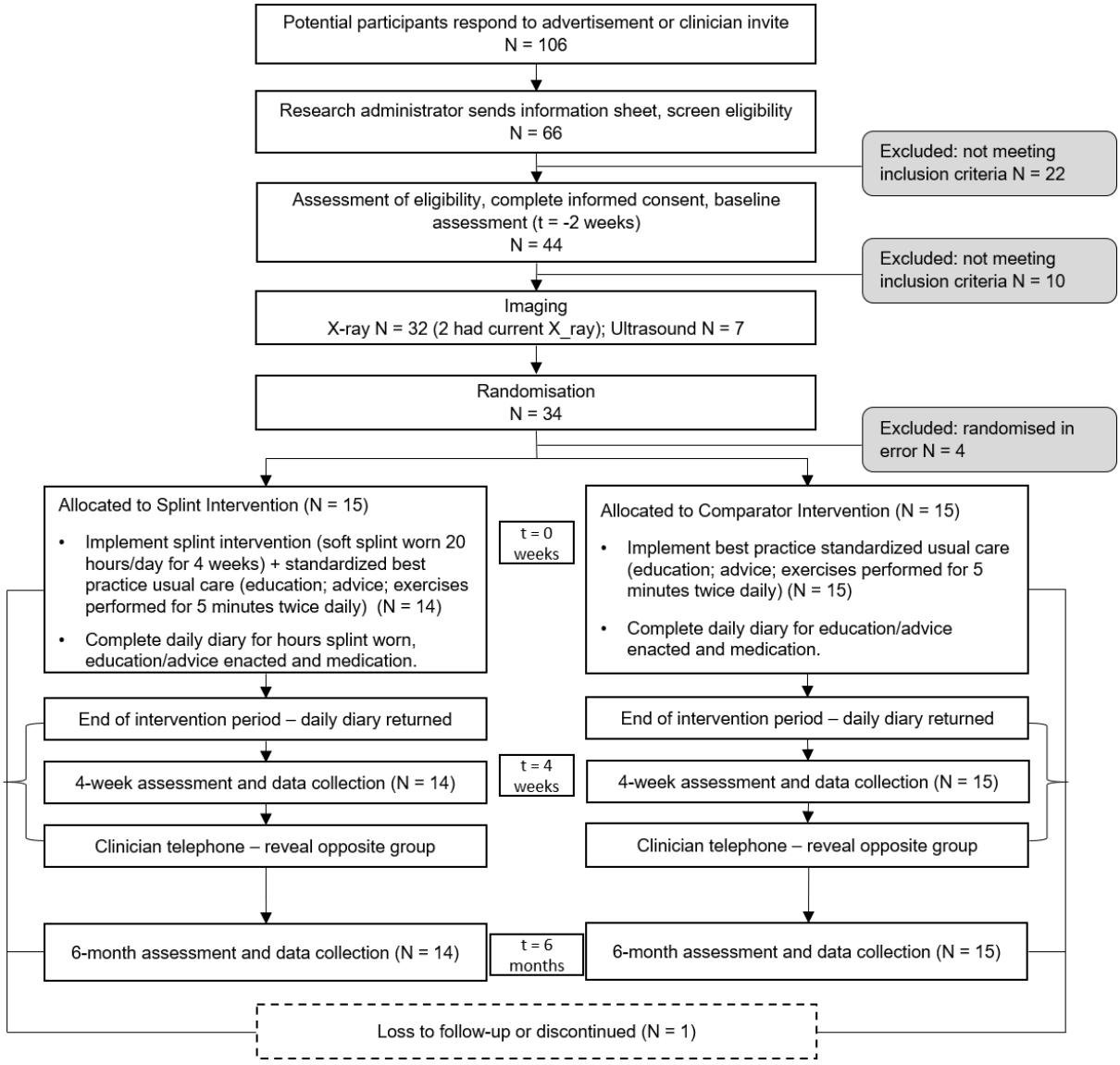


Figure 5.5 Participant flow diagram

5.4.1 Baseline characteristics

Just under two-thirds of participants were female, mean age 66.9 (SD 10.2) years, and just over two-thirds were in paid employment part- or full-time. The two groups were similar in most baseline characteristics including number of dominant hands enrolled and self-report outcome scores (Table 5.4). Few participants reported using medications.

Table 5.4 Baseline characteristics of study participants by group

Variables	Splint group N=15 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)
Recruitment, N (%)		
Centre 1	10 (66.7)	7 (46.7)
Centre 2	5 (33.3)	8 (53.3)
Age (years)	68.33 (11.88)	65.40 (8.28)
Sex, female (%)	6 (40)	13 (86.7)
Descent		
NZ/other European (%)	13 (86.7)	14 (93.3)
NZ Māori (%)	1 (6.7)	1 (6.7)
Missing	1 (6.7)	-
Paid employment		
Full or part-time (%)	12 (80)	9 (60)
Age-retired (%)	3 (20)	5 (33.3)
Dominant hand enrolled (%)	8 (53.3)	9 (60)
Clinician diagnosed thumb CMC OA (%)	6 (40)	10 (66.7)
Duration of symptoms (years)	5.47 (7.11)	6.31 (9.93)
Other joint involvement (%)	15 (100)	11 (73.3)
Contralateral thumb CMC (%)	8 (53.3)	9 (60)
Other finger joint(s) (%)	5 (33.3)	2 (13.3)
Other hand joints (wrist) (%)	-	1 (6.7)
Knee(s) (%)	5 (33.3)	3 (20)
Hip(s) (%)	1 (6.7)	4 (26.7)
Spine (neck or lower back) (%)	3 (20)	1 (6.7)
Feet or ankle(s) (%)	1 (6.7)	2 (13.3)
Shoulder(s) (%)	2 (13.3)	-
Co-morbidities	6 (40)	8 (53.3)
Diabetes or pre-diabetes	3 (20)	2 (13.3)
Heart condition	1 (6.7)	-
High blood pressure	-	3 (20.0)
Epilepsy	-	1 (6.7)
Low back pain or spinal pathology	1 (6.7)	1 (6.7)
Migraines	-	1 (6.7)
Osteoporosis	-	1 (6.7)

Variables	Splint group N=15 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)
Thyroid	-	1 (6.7)
Cancer	1 (6.7)	1 (6.7)
Sleep apnoea	-	1 (6.7)
Asthma	1 (6.7)	-
Medications for pain relief		
Paracetamol (%)	3 (20)	5 (33.3)
NSAID (%)	6 (26.7)*	3 (20)
NSAID Equivalent score	31.91 (65.08)*	23.35 (52.18)
Codeine (%)	2 (13.3)	1 (6.7)
Other pain relief (%)	-	1 (6.7)
Positive clinical tests		
Step-off appearance (%)	15 (100)	13 (86.7)
Tender on palpation (%)	14 (93.3)	15 (100)
Grind test (%)	11 (73.3)	12 (80)
Pressure-shear test (%)	13 (86.7)	12 (85.7)*
BMI	27.3 (5.00)	29.8 (7.90)
MCP hyperextension		
At rest (deg)	2.5 (10.03)	6.1 (8.46)
Active (deg)	15.5 (12.26)	13.1 (7.89)
Pain on average (0-10)	5.7 (1.58)	5.8 (1.48)
Pain on average at night (0-10)	5.3 (2.34)	5.2 (2.76)
FIHOA (0-30)	12.2 (5.79)	10.3 (4.23)
Additional Functional Questionnaire (0-30)	11.7 (5.28)	10.7 (4.13)
QuickDASH (0-100)	32.8 (15.57)	33.9 (16.60)
EQ-5D-5L Index score (0.0-1.0)	0.682 (0.169)	0.656 (0.169)
EQ-5D VAS (0-100)	81.47 (13.56)	82.67 (10.18)
Pollexograph	43.5 (10.53)	45.8 (8.59)
Inter-digit distance (mm)	101.3 (18.18)	95.2 (17.60)
Grip Ability Test (seconds)	22.3 (9.36)	17.6 (5.73)
Grip strength dynamometer		
Contralateral (KgF)	32.1 (11.62)	24.7 (8.66)*
Study hand (KgF)	30.2 (11.41)	21.9 (6.88)*
Pinch strength dynamometer		

Variables	Splint group N=15 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)
Contralateral (KgF)	6.7 (2.44)	6.6 (1.92)
Study hand (KgF)	6.2 (2.32)	5.5 (1.73)

NZ, New Zealand; CMC, carpometacarpal joint; NSAID, non-steroidal anti-inflammatory; BMI, Body Mass Index; MCP, metacarpophalangeal joint; FIHOA, Functional Index for Hand Osteoarthritis; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand Questionnaire; EQ-5D-5L, EuroQuol 5-Dimension, 5-Level; VAS, visual analogue scale; KgF, kilogram-force.
* N=14 due to one missing item

The intervention group had a higher proportion of male and employed, and fewer with clinician-diagnosed CMC1 OA. This group also had a higher proportion with other joint involvement, greater grip strength, and less MCP hyperextension at rest compared with the comparator intervention group. The GAT was 4.7 seconds faster in the comparator intervention group. The NSAID Equivalent score was also higher in the comparator intervention group than in the splint group.

The baseline measures for the withdrawn participant in the splint group did not differ from those of the remaining participants.

X-ray scoring predominantly classified disease as mild or moderate, i.e. OARSI or Eaton grades 2 or 3. Four to six participants were classified as having early OA, i.e. Eaton grade 1. A similar number were classified to have severe OA (Table 5.5).

Four of the 30 study participants underwent US imaging, two from the comparator intervention group and two from splint group. Synovitis was visualised in two participants of the two in the comparator intervention group and in one participant of the two in the splint group (Table 5.5). Examples of grading for synovitis on ultrasound imaging are presented in Figure 5.6. Structural changes were also identified on ultrasound imaging in three of four participants. Examples of grading for osteophytes on ultrasound imaging are presented in Figure 5.7.

Table 5.5 Baseline imaging scores of study participants by group

Variable	Splint group N=15 N (%) or mean (SD)		Comparator group N=15 N (%) or mean (SD)	
X-ray imaging scores	Reader 1	Reader 2	Reader 1	Reader 2
Eaton-Littler (1-4)				
Grade 1	4 (26.7)	2 (13.3)	1 (6.7)	1 (6.7)
Grade 2	3 (20)	6 (40)	6 (40)	7 (46.7)
Grade 3	6 (40)	6 (35.7)	5 (33.3)	6 (40)
Grade 4	2 (13.3)	1 (6.7)	3 (20)	1 (6.7)
OARSI Osteophyte (0-3)				
Grade 0	3 (20)	4 (26.7)	0 (0)	2 (13.3)
Grade 1	3 (20)	5 (33.3)	7 (46.7)	8 (53.3)
Grade 2	5 (33.3)	4 (26.7)	4 (26.7)	3 (20)
Grade 3	4 (26.7)	2 (13.3)	4 (26.7)	2 (13.3)
OARSI JSN (0-3)				
Grade 0	1 (6.7)	2 (13.3)	0 (0)	1 (6.7)
Grade 1	5 (33.3)	8 (53.3)	7 (46.7)	8 (53.3)
Grade 2	5 (33.3)	5 (33.3)	3 (20.0)	5 (33.3)
Grade 3	4 (26.7)	0 (0)	5 (33.3)	1 (6.7)
Ultrasound imaging scores	*(N=2)*		*(N=2)*	
Osteophyte score (0-3)				
Grade 0	1 (50)	1 (50)	0 (0)	0 (0)
Grade 1	1 (50)	0 (0)	0 (0)	0 (0)
Grade 2	0 (0)	1 (50)	1 (50)	2 (100)
Grade 3	0 (0)	0 (0)	1 (50)	0 (0)
Synovitis score (0-3)				
Grade 0	2 (100)	1 (50)	0 (0)	0 (0)
Grade 1	0 (0)	0 (0)	0 (0)	1 (50)
Grade 2	0 (0)	1 (50)	1 (50)	0 (0)
Grade 3	0 (0)	0 (0)	1 (50)	1 (50)
Dichotomous				
Osteophytes present	1 (50)	1 (50)	2 (100)	2 (100)
Synovitis present	1 (50)	1 (50)	2 (100)	2 (100)

OARSI, Osteoarthritis Research Society International [x-ray imaging atlas]; JSN, joint space narrowing

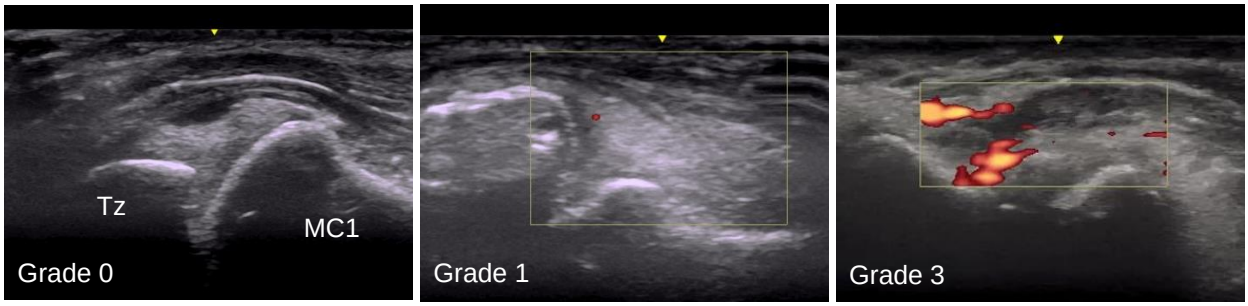


Figure 5.6 Ultrasound images of the thumb CMC joint with examples of synovitis grade (power Doppler and greyscale). Tz, trapezium; MC1, first metacarpal.

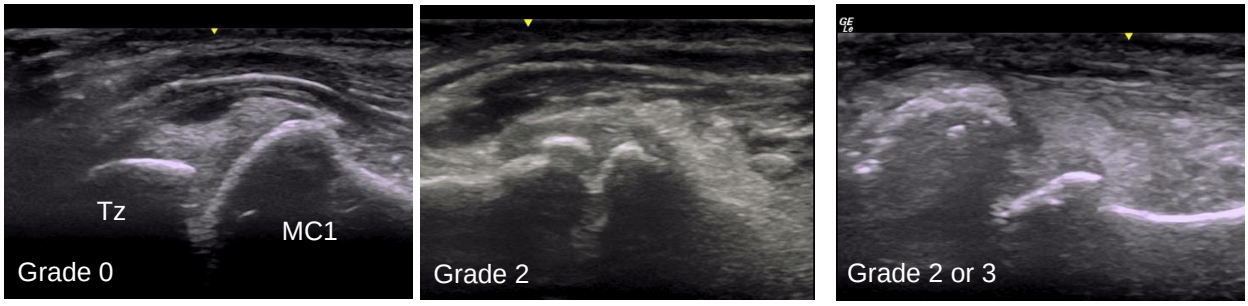


Figure 5.7 Ultrasound images of the thumb CMC joint with examples of osteophyte grade. Tz, trapezium; MC1, first metacarpal.

5.4.2 Primary feasibility outcomes

5.4.2.1 Recruitment-related feasibility

Of the 112 people who responded to advertisements and invitations, 66 were screened by telephone of whom 44 potential participants were booked for screening in-person (one did not attend) before recruiting the targeted 30 participants (Figure 5.5). The 30 enrolled participants represented 45.5% of those screened by telephone and 68.2% of those screened in-person. Reasons for ineligibility at in-person screening were: FIHOA score < 6/30 (N=8); pain NRS score < 4/10 (N=6), or previous clinician-prescribed splint treatment (late declaration, N=1). No potential participants declined to be randomised.

5.4.2.2 Retention-related feasibility

Retention was 96.7% for all outcomes at 4 weeks; 96.7% and 93.3% at 6 months for self-report and physical outcomes respectively. The single withdrawal occurred prior to commencing the intervention due to misunderstanding in the location of the treatment session and was unavailable to rebook. Retention-related feasibility outcomes are summarised in Table 5.6.

5.4.2.3 Intervention-related feasibility: acceptability

The splint intervention was acceptable to all participants who received this intervention, although some reported issues requiring them to remove the splint for a time, either due to minor adverse events (Table 5.6) reported below, or incompatibility with daily tasks. Recommendations for modifications to overcome some of the barriers to routine splint wearing were made and are reported in the final table of this results section.

The standardised best practice usual care package was acceptable to all participants. While some discomfort was experienced doing some of the exercises, most participants found this acceptable: for example, an excerpt from a participant's daily log during intervention week 1: *"discomfort after exercises for an hour. Thumb feeling great!!"*. In some instances other activities interacted with the exercises creating more discomfort; for example, another participant at intervention week 4: "*the more I do exercises the worse my thumb area feels"…, "when thumb not used a lot e.g. no work [then] exercises are easier"*. The same participant ended with the following final comment, *"Thanks for giving me this opportunity. To get some relief and better understanding of this condition."*.

5.4.2.4 Intervention-related feasibility: adverse events

No serious adverse events were recorded. 13 minor adverse events occurred, 5 splint-related and 7 exercise-related (Table 5.6). One prompted a participant to contact the researcher for advice on exercise modification. None required health service input. The types and rates of minor adverse events resulting from the splint intervention, as recorded from post-assessment interview data, were: a welt with skin intact (N=1 [7.1%]), a welt resulting in open wound (N=1 [7.1%]), and pain related to wearing the splint (N=3 [21.4%]). Both participants with a skin event ceased wearing the splint for

3 days until the skin healed and then resumed splint wearing with no further problems. The pain associated with splint wearing was transient. Pain was relieved by removing the splint for 1 or 2 days and the participants then continued to wear the splint.

Table 5.6 Primary feasibility outcomes and summary

Outcome	Splint group N=14 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)	Summary
1. Number of participants recruited in 4-month period	15*	15	N=30
2. Retention at 6 months	14 (93.3)	15 (100)	96.7%
3. Found intervention acceptable	14 (100)	15 (100)	100%
Found assessments acceptable	14 (100)	15 (100)	
4. Rate of adverse events			
Major adverse events	0 (0)	0 (0)	
Splint-related minor adverse events	5 (35.7)	-	
Skin irritation (welt) requiring splint removal	2 (14.3)	-	
Broken skin	1 (7.1)	-	
Pain requiring splint removal up to 1 day	3 (21.4)	-	
Exercise-related minor adverse events	2 (14.3)	5 (33.3)	Splint-related N=5 Exercise-related N=6 Adverse events were transient
Pain requiring exercise cessation on one or more occasion	2 (14.3)	5 (33.3)	
Exercise 1	-	1 (6.7)	
Exercise 2	1 (7.1)	1 (6.7)	
Exercise 3	1 (7.1)	2 (13.3)	
Exercise 4	2 (14.3)	4 (26.7)	
Exercise 5	1 (7.1)	4 (26.7)	
Exercise 6	1 (7.1)	4 (26.7)	

* 15 participants were randomised; one withdrew prior to beginning the intervention

As reported by participants in their daily logs and in mid-way interviews, the exercises caused minor or moderate discomfort in some instances and participants altered performance or stopped for some time as required. Exercise 4, active palmar abduction, caused discomfort most frequently; an alternate technique for carrying out this exercise is suggested for addition to the exercise instructions in the final table of this section. There were no withdrawals or dropouts due to adverse events.

5.4.3 Secondary outcomes – feasibility

The secondary feasibility outcomes are presented in Table 5.7.

5.4.3.1 Assessor-related feasibility: time and quality

The time required to undertake the in-person screening and baseline assessment was confirmed to be 45 minutes' maximum, and for follow-up assessments 30 minutes' maximum.

Observations from the quality audits and PhD researcher's reflections are summarised in Table 5.7. The missing self-report outcome items were primarily attributed to incomplete checking for missed items by the assessors; these were few.

Observations regarding study procedures made by the assessors, the researcher, and participants included difficulty with consistency for the GAT, i.e. whether the clip went on the envelope or in the envelope, lack of clarity about whether grip strength assessments should be carried out 'through pain' or 'to pain', uncertainty about elbow position for grip and pinch strength assessments, uncertainty about which fingers should be involved with the pinch strength test, and failure to record which assessor a participant was assessed by. One set of baseline grip strength data was missing due to faulty equipment; the equipment was replaced as soon as identified and before the next participant was assessed.

5.4.3.2 Clinician-related feasibility: time and quality

The clinician time required for the intervention session was confirmed to be 25-45 minutes, the session taking 15-20 minutes longer in the splint intervention group than in the comparator intervention group. Three follow-up phone calls were conducted, two in the splint group and one in the comparator group, to clarify an aspect of the

intervention or to provide advice on exercise modification. Follow-up phone calls lasted a maximum of 10 minutes each. A fourth telephone call led to one additional 20 minutes' clinic session to modify the splint intervention; the Velcro strap had failed and required some maintenance. Therefore, one in five of splint group participants and one in 15 comparator intervention participants required additional clinician time of 10-30 minutes.

The information resource with exercise instructions together with the verbal prompt sheet were effective in achieving consistent delivery of the standardised best practice usual care package. Quality-control audit of the interventions carried out on two occasions, one in-person and one recorded with the participant's consent, identified full compliance with protocols for the delivery of the splint intervention and the standardised best practice usual care package.

5.4.3.3 Intervention-related feasibility: fidelity

On average the splint intervention was adhered to fully on 68.4% of days during the 4-week intervention period (Table 5.7). On average across participants, splints were worn 94.4% of the total hours prescribed, equivalent to an average of 18.9 hours per day. However, some participants wore their splints for more than the prescribed 20 hours per day. Therefore, these higher values do not accurately reflect average dosage across participants. The first measure, i.e. the proportion of instances on which splints were worn as prescribed, is the key outcome relating to the fidelity of the splint intervention.

The best practice usual care exercise intervention was completed on ≥80% of days for all exercises on all weeks for both groups (Table 5.7). No significant differences were seen in adherence to exercises between groups. Advice was followed in the splint group by half the number who followed the advice in the comparator intervention group.

Table 5.7 Secondary feasibility outcomes and summary

Outcome	Splint group N=14 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)	Mean difference (95% CI)	Summary
1. Time (minutes)				
Assessor baseline	45	45	-	
Assessor follow-up	30	30	-	Satisfactory
Clinician intervention	45	30	-	
2. Intervention fidelity				
Number of days per week splint worn (0-7)				
Week 1	4.9 (2.1)	-	-	
Week 2	5.6 (2.1)	-	-	68.4% of instances
Week 3	4.7 (2.8)	-	-	
Week 4	4.2 (3.1)	-	-	
Total	4.8 (2.6)	-	-	
Number of hours per day splint worn (0-24)				94.4% of total hours prescribed
Week 1	19.1 (2.8)	-	-	
Week 2	19.4 (4.4)	-	-	*Splint worn for longer than the prescribed time in some instances.*
Week 3	19.4 (4.3)	-	-	
Week 4	17.7 (4.4)	-	-	
Total	18.9 (3.4)	-	-	
Number of days per week exercises completed (0-7)				
Week 1	6.3 (0.5)	6.0 (1.4)	-0.3 (-1.1, 0.5)	
Week 2	6.2 (1.0)	6.6 (0.7)	0.4 (-0.3, 1.0)	89% of instances
Week 3	6.6 (0.6)	6.7 (0.8)	0.1 (-0.4, -1.3)	No difference between groups
Week 4	6.0 (0.7)	5.6 (1.3)	-0.4 (-1.3, 0.4)	
Total	6.3 (0.5)	6.2 (0.7)	-0.1 (-0.6, 0.4)	

Outcome	Splint group N=14 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)	Mean difference (95% CI)	Summary
Advice and education followed (N)				
Took breaks	1 (7.1)	2 (13.3)		
Rest	0 (0)	3 (20)		
General exercise (walking, cycling, stationary bike, swimming, gym)	2 (14.3)	3 (20)		
Use thumb in 'C' shape	0 (0)	1 (6.7)		
Mindful when gripping (alter thumb posture or direction of pull, use whole hand)	1 (7.1)	4 (26.7)		51.7% followed advice
Heat	0 (0)	2 (13.3)		Difference between groups
Use both hands	0 (0)	4 (26.7)		
Use large pen	0 (0)	1 (6.7)		
Use sharper knives	0 (0)	1 (6.7)		
Modified handles for better grip (pot handles, gear stick knob)	0 (0)	1 (6.7)		
Gloves for gardening	0 (0)	1 (6.7)		
Avoided actions (wringing)	0 (0)	1 (6.7)		
Use fingers more than thumb in pinch	0 (0)	2 (13.3)		
Use larger joints	1 (7.1)	1 (6.7)		
Not specified (ticked OR state 'followed advice')	3 (21.4)	3 (20)		
Total	5 (35.7)	10 (66.7)		
Reasons for non-adherence to splint				
Other exercise, e.g. pool, tennis, golf	5 (35.7)	-		
Food preparation or eating	6 (42.9)	-		
Wet tasks, e.g. dishes, washing	8 (57.1)	-		

Outcome	Splint group N=14 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)	Mean difference (95% CI)	Summary
Toilet	2 (14.3)	-		
Work requirements, e.g. patient contact, hand hygiene, gloves	5 (35.7)	-		
Incompatible with tasks, e.g. computer, sewing	1 (7.1)	-		
Aesthetic reason	1 (7.1)	-		
To avoid splint getting dirty, e.g. painting, garden, outdoor chores, pets	7 (50)	-		
Driving (%)	2 (14.3)	-		
Forgot to put splint on, or left it somewhere	7 (50)	-		
For rest or 'time out'	4 (28.6)	-		
Too hot	1 (7.1)	-		
Too tight/web strap too short	1 (7.1)	-		
Got bored with it	1 (7.1)	-		
Reasons for non-adherence to exercises				
Family events	0 (0)	1 (6.7)		
Difficulty with motivation	0 (0)	1 (6.7)		
3. Quality-control audit				
• Reasons for missing data: o Assessor checking incomplete o Faulty equipment x1 o Participant unable to travel x1 • Corrections for GAT, grip, and pinch strength assessments. • Assessor name and signature added • Interventions met all 11 criteria				Satisfactory with recommendations.
4. Recruitment and randomisation				
• Achieved: o Dominant hands equal between groups o Māori N=6.7% o Not previously sought care N=46.7% • Issues: o Males unequal between groups				Satisfactory with recommendations

Outcome	Splint group N=14 N (%) or mean (SD)	Comparator group N=15 N (%) or mean (SD)	Mean difference (95% CI)	Summary

• Randomisation in error N=4
• Reasons for exclusions:
  ○ FIHOA score < 6/30 (N=8)
  ○ Pain NRS score < 4/10 (N=6)
  ○ Previous clinician-prescribed splint treatment (late declaration) (N=1)				

5. Imaging (x-ray and ultrasound)				

• X-ray imaging
  ○ Referral and image accessing 100%
  ○ Inter-rater reliability k = 0.34 to 0.41
• Ultrasound imaging
  ○ Time per participant: 15 minutes
  ○ Inter-rater reliability
  ▪ Scores (N=4): k = 0.33
  ▪ Dichotomous (N=4): k = 1.0
				Inter-rater reliability for scores: borderline
				
				Inter-rater reliability for dichotomous outcomes: excellent

6. Clinical outcomes were explored				

• Low rate of missing data
• MCID surpassed for pain at night NRS in splint group at 4-weeks and 6-months.
• All other outcomes saw positive within-group change with the following exceptions:
  ○ FIHOA, Pollexograph, GAT no change at 4-weeks in comparator group.
  ○ AFQ, Pollexograph, IDD, GAT no change at 6-months in comparator group
  ○ EQ-5D-5L VAS negative change at 6-months in splint and comparator group
  ○ EQ-5D-5L VAS negative change at 6-months in comparator group
				Pain NRS, including pain at night, is a promising primary outcome

GAT, Grip Ability Test; FIHOA, Functional Index for Hand Osteoarthritis; NRS, numeric rating scale; MCID, minimal clinically important difference; AFQ, Additional Functional Questionnaire; IDD, inter-digit distance; EQ-5D-5L, Euroquol 5-Dimension, 5-Level; VAS, visual analogue scale.

5.4.3.4 Recruitment and randomisation-related feasibility

The recruitment strategy was successful in that those who might not otherwise seek care, that is, those with no health-care provider diagnosis, constituted 46.7% of those included in the study. The strategy to optimise the number of participants of Māori

descent achieved partial success with one person of Māori descent recruited from each centre, i.e. a study proportion of 6.7%, just over the population proportion in the primary centre (6.2%), but lower than that in the secondary centre (13.3%) or nationally (16.5%) (Statistics New Zealand, 2013). Randomisation was successful in allocating similar number of dominant-involved hands to each group (Table 5.4, Table 5.7).

5.4.3.5 Secondary outcomes – feasibility of baseline imaging

Inter-rater reliability for x-ray and ultrasound imaging scores for the two readers for each modality are given in Table 5.8. Inter-rater reliability was *k* 0.34 to 0.41 for x-ray reading (n=30 and n=34). The Eaton-Littler had slightly higher Kappa values than OARSI atlas items. For ultrasound image reading (n=4) *ks* = 0.33 were computed for both the osteophyte and the synovitis scores. Dichotomous scores for presence or absence of osteophytes and of synovitis, had perfect reliability (*k* = 1.00).

Table 5.8 Inter-rater reliability for imaging scores

Score		
X-ray imaging score	Kappa (N=30)	Kappa (N=34)
Eaton-Littler (1-4)	0.41	0.40
OARSI Osteophyte (0-3)	0.38	0.38
OARSI JSN (0-3)	0.34	0.39
Ultrasound imaging scores	Kappa (N=4)	
Osteophyte score (0-3)	0.33	
Synovitis score (0-3)	0.33	
Osteophyte dichotomous (0,1)	1.00	
Synovitis dichotomous (0,1)	1.00	

OARSI, Osteoarthritis Research Society International [x-ray imaging atlas]; JSN, joint space narrowing

5.4.4 Secondary outcomes – clinical outcomes

Clinical outcomes were collected at the three time points as planned. Individual outcomes are reported in Figure 5.8, Figure 5.9, Figure 5.10, Figure 5.11. Within and between group means are reported in Table 5.9 and Table 5.10. Overall, there was a low rate of missing data.

5.4.4.1 Clinical outcomes of individual participants

For pain on average NRS, 7 of 15 participants (47%) in the comparator group and 8 of 14 participants (57%) in the splint group improved reliably and clinically at 4-weeks (Figure 5.8). Two in the comparator group and one in the splint group deteriorated. At 6-months, 7 of 15 (47%) in the comparator group and 7 of 13 (54%) in the splint group were improved reliably and clinically and two in each group deteriorated.

For pain at night NRS, 7 of 15 (47%) in the comparator group and 10 of 14 (71%) in the splint group improved reliably and clinically at 4-weeks (Figure 5.9). One participant in the comparator group and two in the splint group deteriorated. At 6-months, 6 of 15 (40%) in the comparator group and 6 of 13 (46%) in the splint group improved while two in the comparator group and one in the splint group deteriorated.

For the FIHOA, no participants in the comparator group were improved at 4-weeks while 2 of 14 participants (14%) in the splint group improved reliably (Figure 5.10). At 6-months, 2 of 15 participants (13%) in the comparator group and 4 of 14 participants (29%) in the splint group were reliably improved. No participants in either group showed reliable deterioration at either time point.

The QuickDASH outcome saw reliable but not clinically important improvement in 2 of 15 participants (13%) in the comparator group at 4-weeks (Figure 5.11). In the splint group, 4 of 14 participants (29%) saw improvement, 2 (14%) of which were clinically important. No participants in either group showed deterioration at this time-point. At 6-months, 4 of 14 (29%) in the comparator group and 3 of 13 (23%) in the splint group improved reliably and clinically; one participant in the comparator group deteriorated.

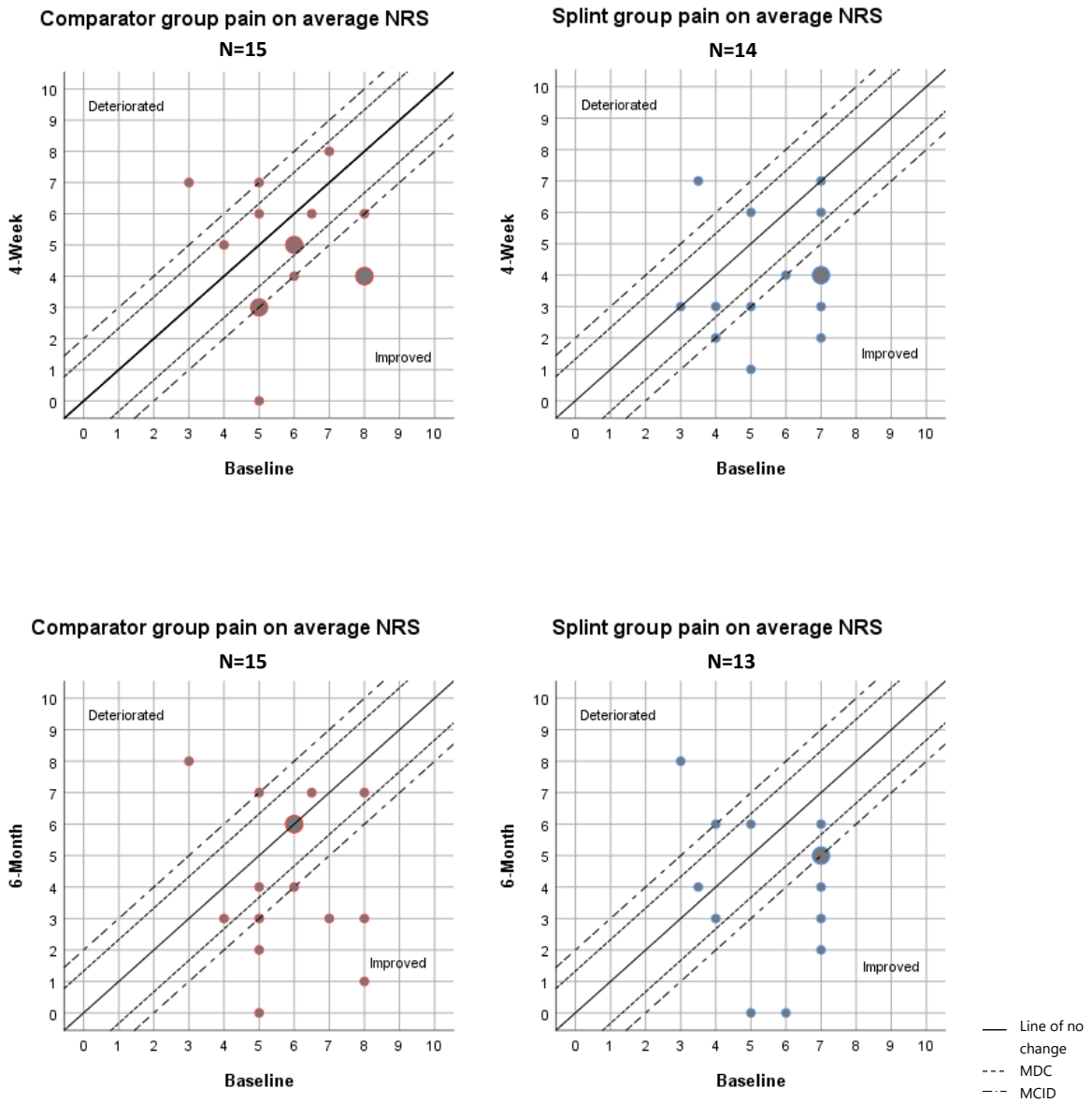


Figure 5.8 Modified Brinley plots depicting individual change in scores for pain on average numeric rating scale (NRS) by group for baseline to 4-weeks and baseline to 6-months. Data points to the right of the small-dashed line (MDC boundaries of 1.33) represent those who showed reliable improvement. Data points to the right of the long-dashed line (MCID boundaries of 2.0) represent those who showed clinically important improvement. Note that larger data points represent two individual values.

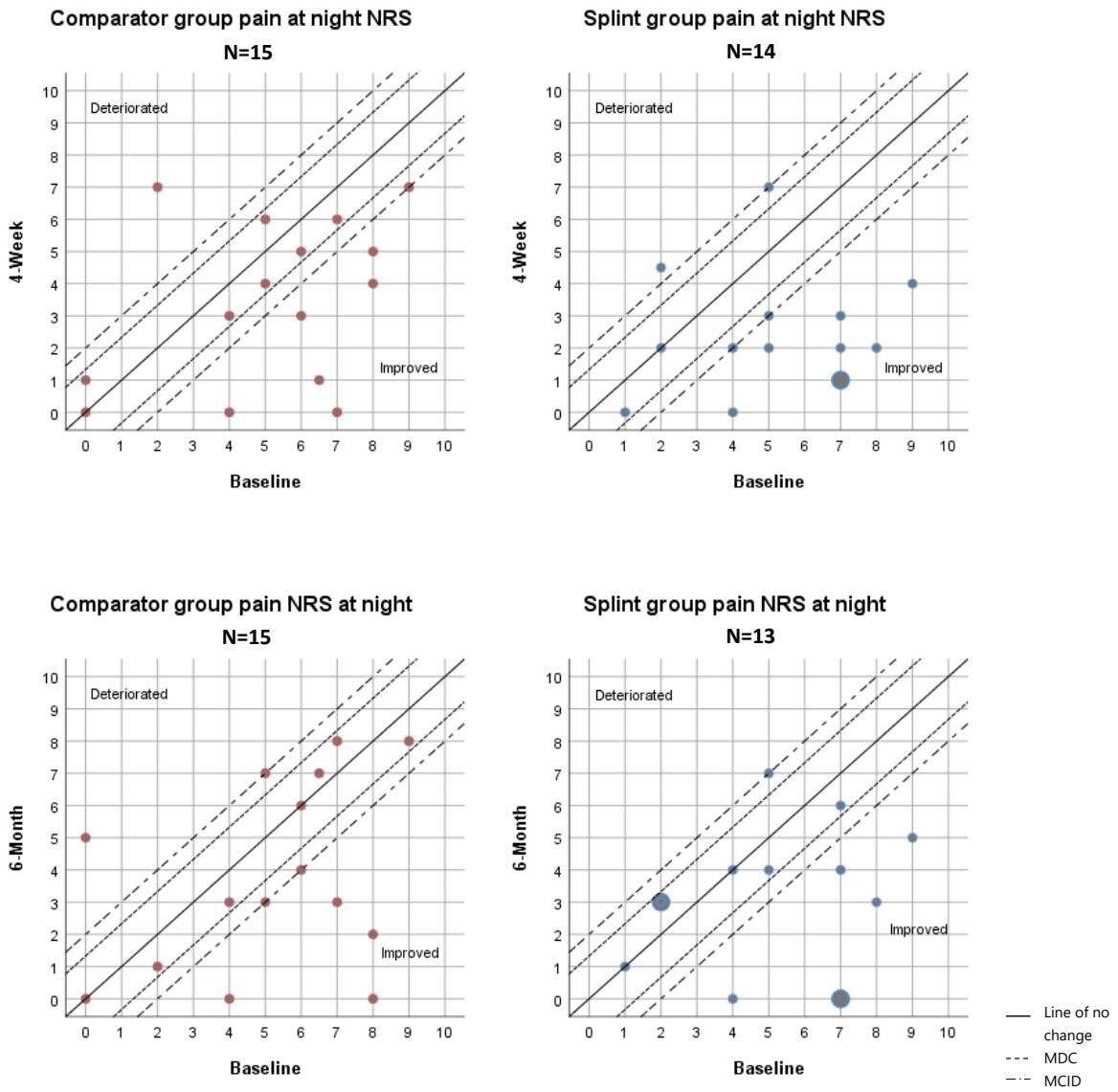


Figure 5.9 Modified Brinley plots depicting individual change in scores for pain at night numeric rating scale (NRS) by group for baseline to 4-weeks and baseline to 6-months. Data points to the right of the small-dashed line (MDC boundaries of 1.33) represent those who showed reliable improvement. Data points to the right of the long-dashed line (MCID boundaries of 2.0) represent those who showed clinically important improvement. Note that larger data points represent two individual values.

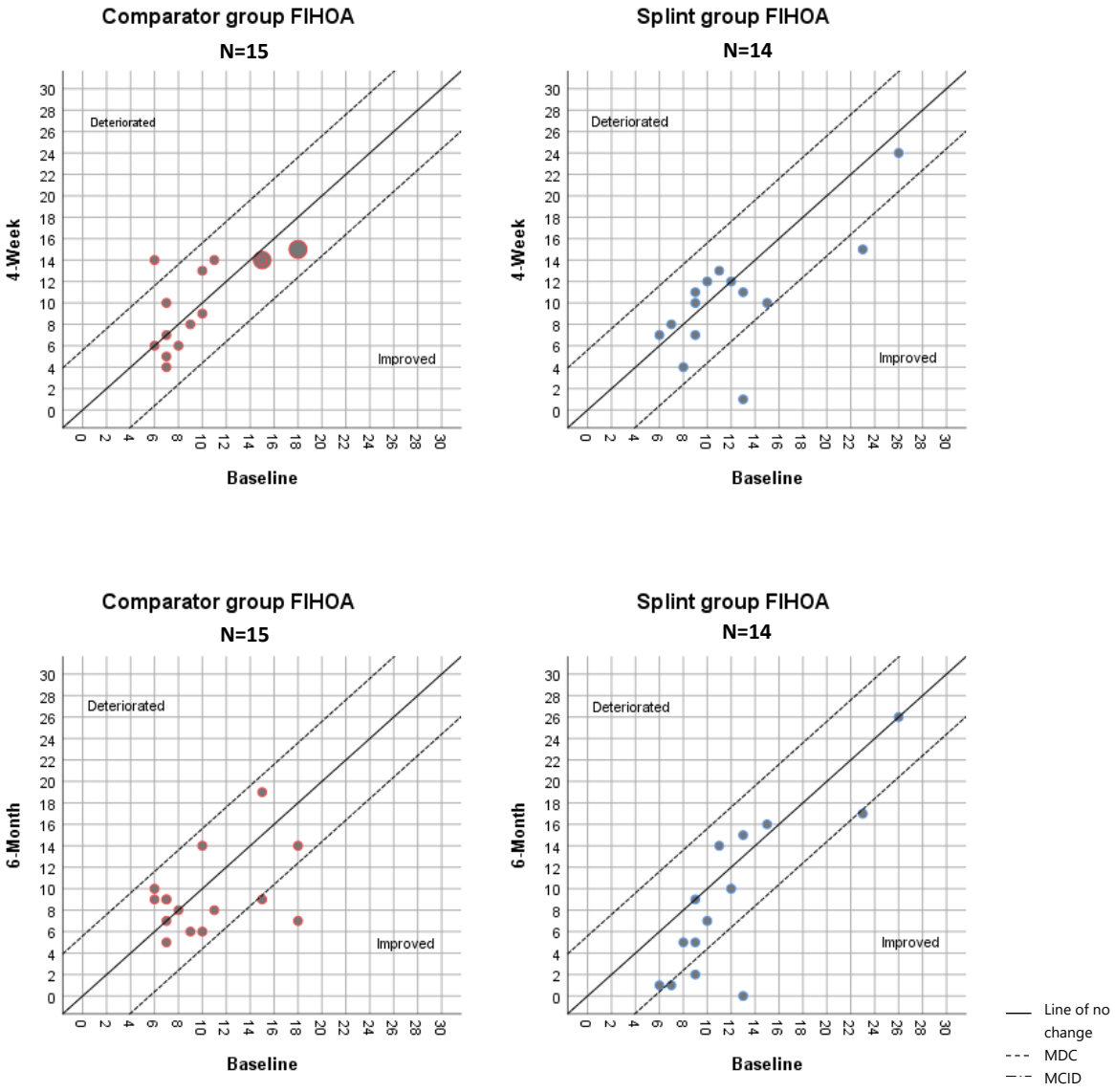


Figure 5.10 Modified Brinley plots depicting individual change in scores for Functional Index of Hand Osteoarthritis (FIHOA) questionnaire by group for baseline to 4-weeks and baseline to 6-months. Data points to the right of the small-dashed line (MDC boundaries of 5.6) represent those who showed reliable improvement. Note that larger data points represent two individual values.

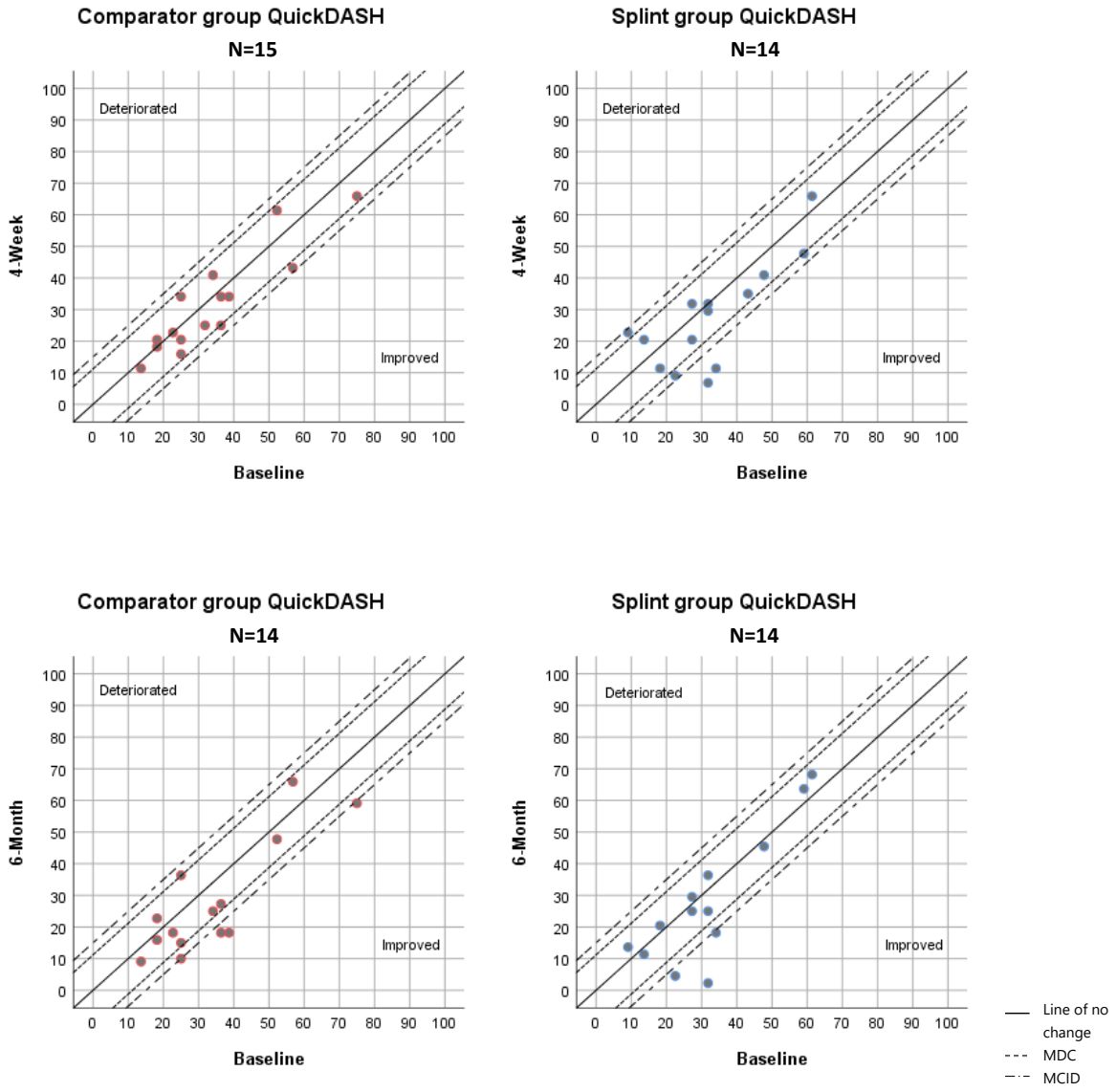


Figure 5.11 Modified Brinley plots depicting individual change in scores for Quick Disabilities of the Arm, Hand, and Shoulder (DASH) questionnaire by group for baseline to 4-weeks and baseline to 6-months. Data points to the right of the small-dashed line (MDC boundaries of 11.2) represent those who showed reliable improvement. Data points to the right of the long-dashed line (MCID boundaries of 15) represent those who showed clinically important improvement.

5.4.4.2 Clinical outcomes and descriptive statistics within- and between groups

At baseline in the splint group one participant was missing data for descent, one was missing one item on the QuickDASH, and one was missing grip strength. At 4-week follow-up in the splint group one participant was missing one item on the FIHOA, one was missing one item on the QuickDASH, one was missing one item on the Additional Functional Questionnaire, and one was missing the EQ-5D index score. At 6-months follow-up two participants, one in each group, were missing full QuickDASH outcome; a further three participants, two in the splint group and one in the comparator intervention group, were missing one item each on the QuickDASH; and one participant in the comparator group was missing physical measures due to a rural domicile and not having time to travel the distance to attend the final assessment..

5.4.4.2.1 Descriptive statistics for clinical outcomes at 4 weeks

Pain on average at night in the past week NRS (0-10) showed reduction in both groups between baseline and 4-weeks with CIs of neither including the null (Table 5.9). Between group difference of -1.1 (95% CI -3.34 to 1.09) appeared to favour splinting. However, the CI for this difference included the null and the CIs for within-group change overlapped substantially (-4.8 to -1.17 and -3.33 to -0.07 for splint and comparator groups, respectively).

Pain on average in the past week NRS, not specifically at night, also reduced in both groups, but to a lesser extent and with a smaller apparent between-group difference, again with a wide CI that included the null (-0.6 [-2.48 to 1.16]). GROC score recorded +1.2 (SD 1.3) on an 11-point scale in the splint group and +0.5 (1.63) in the comparator intervention group, with an apparent between-group difference which also had a wide CI that included the null 0.7 (-0.51 to 1.81). Self-report functional measures (FIHOA, AFQ, and QuickDASH) showed apparent but not substantial positive change in the splint group and less improvement or none at all in the comparator group, all with wide CIs that included the null. QoL measured by the EQ-5D-5L index score appeared to change marginally in a positive direction in both groups, as did the EQ-5D-5L VAS scale score; both had large CIs that included the null.

Palmar abduction ROM measured on the Pollexograph increased by 9.3 (0.80 to 17.82) degrees in the splint group compared to no apparent change in the comparator intervention group (0.2 [-3.75 to 4.06]), with a between-group difference of 9.2 (0.45 to 17.86). The positive change in Pollexograph ROM demonstrated in the splint group although still with a wide CI, excluded the null and overlapped only modestly with that of the comparator group; the CI for the between-group difference also excluded the null. Inter-digit distance also showed apparent increase in the splint group greater than that in the comparator group but with a smaller between-group difference of 3.3 (-2.68, 9.25) millimetres and a wider CI that included the null. The GAT showed apparent positive change of -2.9 (-6.91 to 1.13) seconds in the splint group against -0.3 (-3.28 to 2.79) seconds in the comparator group, although the splint group had a higher baseline time by over 5 seconds. The CIs were wide for both groups and overlapped substantially. Grip strength measures showed small apparent positive change over time of 2.0 (-0.33 to 4.33) KgF in the splint group and 1.5 (-1.48 to 4.41) KgF in the comparator group, both with wide CIs which included the null. Pinch strength showed smaller apparent change (Table 5.9).

No participants required new medication prescription or proceeded to joint injection or surgery. According to OMERACT-OARSI responder criteria, at 4-weeks there were nine (64.3 %) responders in the splint group and four (26.7 %) in the comparator intervention group.

Table 5.9 Clinical outcomes: Comparison of change within and between groups at 4-weeks

	Splint group∞			Comparator group			Between group difference∞	
Variable	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	*t*	Difference
Pain on average NRS	5.5 (1.50)	3.9 (1.90)	-1.6 (-2.91, -0.31)	5.8 (1.48)	4.9 (2.00)	-1.0 (-2.33, 0.39)	-0.73	-0.6 (-2.44, 1.16)
Pain on average at night NRS	5.2 (2.42)	2.4 (1.86)	-2.8 (-4.48, -1.17)	5.2 (2.76)	3.5 (2.56)	-1.7 (-3.33, -0.07)	-1.04	-1.1 (-3.34, 1.09)
GROC	-	1.2 (1.31)	-	-	0.5 (1.63)	-	1.23	0.7 (-0.51, 1.81)
FIHOA	12.2 (5.79)	10.4 (5.39)	-1.9 (-4.27, 0.56)	10.3 (4.23)	10.3 (4.04)	0.0 (-1.69, 1.69)	-1.37	-1.9 (-4.63, 0.92)
Additional Functional Questionnaire	11.7 (5.28)	10.3 (4.68)	-1.4 (-3.03, 0.17)	10.7 (4.13)	10.5 (4.82)	-0.2 (-2.84, 2.44)	-0.84	-1.2 (-4.23, 1.77)
QuickDASH	32.8 (15.57)	27.5 (16.57)	-5.3, (-11.57, 1.02)	33.9 (16.60)	31.5 (15.93)	-2.4 (-6.36, 1.51)	-0.84	-2.9 (-9.82, 4.11)
EQ-5D-5L Index	0.67 (1.727)	0.73 (0.172)	0.05 (-0.081, 0.190)	0.66 (0.169)	0.74 (0.108)	0.09 (0.011, 0.164)	-0.473	-0.03 (-0.180, 0.112)
EQ-5D-5L VAS	85.1 (9.20)*	87.6 (8.64)*	2.5 (-2.76, 7.83)*	82.7 (10.18)	83.4 (7.18)	0.7 (-4.59, 6.06)	0.52	1.8 (-5.39, 9.00)*
NSAID Equivalence Score	19. (7.53)	7.5 (24.30)	-11.5 (-32.65, 9.75)	23.4 (52.18)	17.5 (45.21)	-5.9 (-19.23, 7.56)	-0.24	-5.6 (-51.94, 40.82)
Pollexograph	43.2 (10.80)	52.5 (12.90)	9.3 (0.80, 17.82)	45.8 (8.59)	46.0 (11.36)	0.2 (-3.75, 4.06)	2.16	9.2 (0.45, 17.86)
Inter-digit distance	100.1 (18.18)	104.7 (16.67)	4.6 (0.68, 8.51)	95.2 (17.60)	96.5 (13.50)	1.3 (-3.50, 6.12)	1.13	3.3 (-2.68, 9.25)
Grip ability test	23.1 (9.16)	20.2 (8.09)	-2.9 (-6.91, 1.13)	17.6 (5.73)	17.3 (5.80)	-0.3 (-3.28, 2.79)	-1.14	-2.7 (-7.40, 2.11)
Grip strength	29.5 (11.51)*	315. (11.94)*	2.0 (-0.33, 4.33)*	21.9(6.88)	23.4 (8.99)	1.5 (-1.48, 4.41)	0.30	0.5 (-3.13, 4.19)*
Pinch strength	6.2 (2.41)	6.7 (2.14)	0.5 (-0.64, 1.60)	5.5 (1.73)	5.8 (1.62)	0.4 (-0.07, 0.84)	0.18	0.1 (-1.08, 1.28)

	Splint group∞			Comparator group			Between group difference∞	
Variable	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	*t*	Difference
OMERACT-OARSI responders N (%)	-	-	9 (64.3)	-	-	4 (26.7)	-	

NRS, numeric rating scale; GROC, Global Rating of Change; FIHOA, Functional Index for Hand Osteoarthritis; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand questionnaire; EQ-5D-5L, EuroQuol 5-Dimension, 5-Level; NSAID, non-steroidal anti-inflammatory; OMERACT-OARSI, OMERACT-OARSI, Clinical Trials Response Criteria Initiative and Outcome Measures in Rheumatology and Osteoarthritis Research Society International.
∞ N=14 for all splint group baseline and follow up data, unless otherwise indicated. This table represents those data available for full case analyses for each of the follow up time points.
* N=13

5.4.4.2.2 Descriptive statistics for clinical outcomes at 6 months

At 6-months from baseline, pain on average at night NRS showed apparent positive change in both the splint group and the comparator group (Table 5.10). While the splint group appeared to show greater change (-2.2 [-4.00 to 0.31] and -1.4 [-3.15 to 0.42] for splint and comparator group, respectively), CIs for both groups were wide, included the null, and overlapped substantially. The CI for the between-group difference of -0.8 (-3.24 to 1.66) was also wide and included the null.

Pain on average NRS also showed apparent positive change in both groups but with no apparent difference between groups (-0.0 [-2.41 to 2.39]). The CIs for change over time were again wide and included the null (Table 5.10). The GROC score saw apparent small positive change over time in both groups with no apparent between-group difference. The FIHOA score also showed apparent positive change of -3.1 (-5.53 to 0.62) and -0.9 (-3.33 to 1.47) points in the splint and comparator group respectively, but with wide CIs that included the null and overlapped substantially. An apparent between-group difference of -2.1 (-5.41 to 1.14) also had a wide CI and included the null. The QuickDASH showed apparent positive change at 6-months in both groups, again with wide CIs that included the null and substantially overlapped. An apparent between group difference that appeared to favour the comparator intervention of 2.3 (-5.84, 10.55) had a wide CI that crossed the null.

The EQ-5D-5L Index score showed apparent positive change over time in the comparator group but apparent negative change in the splint group, both with wide CIs that crossed the null; CIs overlapped substantially. The EQ-5D-5L VAS scale scores showed apparent decline in both groups, by -4.5 (-12.45 to 3.45) in the splint group and -4.5 (-13.90 to 4.97) in the usual care group. With an outlier removed from the splint group, the EQ-5D-5L Index score was calculated to be unchanged from that at baseline (0.01 [-0.140 to 0.167]) while the VAS scale score still showed apparent negative change but to a lesser extent (-3.3 [-11.50 to 4.89]).

Palmar abduction again showed apparent positive change on both measures in the splint group, and not in the comparator group, although at this time the CI for change in the splint group on the Pollexograph included the null and that on IDD excluded the null

(Table 5.10). While CIs for change over the time in the splint group were wide, they overlapped with those of the comparator group only modestly. Between group differences on both measures appeared to favour the splint group, of 5.4 (-3.02 to 13.73) degrees for the Pollexograph and 5.6 (-1.06 to 12. 25) mm for the IDD, but with CIs that were wide and included the null.

Grip and pinch strength showed apparent small positive change in both groups while the GAT greater apparent change in the splint group. The number of OMERACT-OARSI responders was similar between the two groups, N=6 (46.2%) in the splint group and N=6 (40%) in the comparator group.

Table 5.10 Clinical outcomes: Comparison of change within and between groups at 6-months

	Splint group∞			Comparator group			Between group difference∞	
Variable	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	*t*	Difference
Pain on average NRS	5.6 (1.55)*	4.0 (2.38)*	-1.6 (-3.48, 0.33)*	5.8 (1.48)	4.3 (2.43)	-1.6 (-3.24, 0.10)	-0.01	-0.0 (-2.41, 2.39)
Pain on average at night NRS	5.2 (2.52)*	3.1 (2.29)*	-2.2 (-4.00, -0.31)*	5.2 (2.76)	3.8 (2.91)	-1.4 (-3.15, 0.42)	-0.66	-0.8 (-3.24, 1.66)
GROC	-	0.9 (1.9)	-	-	0.8 (1.9)	-	0.17	0.1 (-1.6, 1.4)
FIHOA	12.2 (5.79)	9.1 (7.63)	-3.1 (-5.53, -0.62)	10.3 (4.23)	9.3 (3.71)	-0.9 (-3.33, 1.47)	-1.34	-2.1 (-5.41, 1.14)
Additional Functional Questionnaire	11.7 (5.28)	10.0 (7.00)	-1.7 (-3.27, 0.15)	10.7 (4.13)	10.5 (5.45)	-0.3 (-2.26, 1.72)	-1.22	-1.5 (-3.89, 0.99)
QuickDASH	32.0 (15.91)*	28.0 (20.67)*	-4.0 (-10.58, 2.57)*	34.1** (17.22)	27.7** (17.94)	-6.3 (-11.95, 0.71)**	0.59	2.3 (-5.84, 10.55)
EQ-5D-5L Index	0.67 (1.727)	0.65 (0.248)	-0.02 (-0.187, 0.139)	0.66 (0.169)	0.73 (.189)	0.07 (-0.003, 0.152)	-1.20	-0.01 (-0.266, 0.070)
EQ-5D-5L VAS	82.3 (13.68)	77.8 (20.18)	-4.5 (-12.45, 3.45)	82.7 (10.18)	78.2 (17.32)	-4.5 (-13.90, 4.97)	-0.45	-0.0 (-11.89, 11.83)
Pollexograph	43.2 (10.80)	48.3 (11.71)	5.1 (-2.77, 13.06)	46.1 (8.83) **	45.9 (11.47) **	-0.2 (-4.07, 3.65)**	1.32	5.4 (-3.02, 13.73)
Inter-digit distance	100.1 (18.18)	105.1 (20.14)	4.9 (0.02, 9.78)	97.0 (16.73) **	96.3 (11.45)**	-0.7 (-5.70, 4.32)**	1.73	5.6 (-1.06, 12.25)
Grip ability test	23.1 (9.16)	18.6 (10.73)	-4.5 (-8.51, 0.45)	17.8 (5.90)**	18.1 (7.42)**	0.4 (-2.85, 3.56)**	-1.22	-4.8 (-0.06, 9.74)
Grip strength	29.5 (11.51)*	31.4 (11.97)*	1.9 (-0.22, 4.07)*	22.9 (5.92) **	25.1 (6.79)**	2.1 (-0.97, 5.26)**	-0.12	-0.2 (-3.87, 3.43)
Pinch strength	6.2 (2.41)	6.3 (2.87)	0.1 (-0.95, 1.23)	5.5** (1.79)**	5.8 (1.61)	0.3 (-0.61, 1.15)**	0.18	-0.1 (-1.22, 1.02)

	Splint group∞			Comparator group			Between group difference∞	
Variable	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	Baseline mean (SD)	Follow-up	Change (95% CI) or (%)	*t*	Difference
OMERACT-OARSI responders N (%)	-	-	6* (46.1 %)	-	-	6 (40.0)	-	

NRS, numeric rating scale; GROC, Global Rating of Change; FIHOA, Functional Index for Hand Osteoarthritis; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand questionnaire; EQ-5D-5L, EuroQuol 5-Dimension, 5-Level; NSAID, non-steroidal anti-inflammatory; OMERACT-OARSI, OMERACT-OARSI, Clinical Trials Response Criteria Initiative and Outcome Measures in Rheumatology and Osteoarthritis Research Society International.
∞ N=14 for all splint group baseline and follow up data, unless otherwise indicated. This table represents those data available for full case analyses for each of the follow up time points.
* N=13
** N=14

5.4.4.3 Clinical outcomes by group in relation to reliable and clinically important change

The apparent direction of change in each variable at each time point and in relation to known MDC or MCID or both, is presented in Table 5.11.

In both the splint and the comparator groups, at both time points, an MDC of 1.3 for pain NRS was exceeded by the apparent positive change in both pain NRS and pain at night NRS. MCID of 2-points for pain NRS was surpassed by apparent positive change in pain at night NRS in the splint group of both -2.8 (-4.48 to -1.17) at 4-weeks and -2.2 (-4.00 to -0.31) at 6-months.

The apparent positive but negligible change in the splint group shown by FIHOA, QuickDASH, and AFQ, did not exceed known estimates of MCID or MDC. In the comparator intervention group, findings were similar although no change was seen in the FIHOA at 4-weeks, or in the AFQ at 6-months.

Apparent positive change in grip strength in both groups at both time points exceeded smaller previous estimates of MDC values (0.8 KgF to 1.1 KgF) but not MCID (6.0 KgF to 6.5 KgF). Smaller previous estimates of MDC for pinch strength (0.2 KgF to 0.3 KgF) were surpassed by both groups at 4-weeks but not at 6-months.

Regarding the GAT, the estimated MCID (8 seconds) was not exceeded by either group.

Table 5.11 Direction of change in clinical outcomes at 4-weeks and 6-months in relation to minimal detectable change (MDC) or minimal clinically important difference (MCID) where known.

	4-weeks		6-months	
Variable	Splint group	Comparator group	Splint group	Comparator group
Pain on average NRS	+ ***MDC***	+	+ ***MDC***	+ ***MDC***
Pain on average at night NRS	+ ***MCID***	+ ***MDC***	+ ***MCID***	+ ***MDC***
GROC	+ ***MDC***	+ ***MDC***	+ ***MDC***	+ ***MDC***
FIHOA	+	NC	+	+
Additional Functional Questionnaire	+ *NK*	+ *NK*	+ *NK*	NC
QuickDASH	+	+	+	+
EQ-5D-5L Index	+ ***MDC***	+ ***MDC***	–	+ ***MDC***
EQ-5D-5L VAS	+	+	–	–
NSAID Equivalence Score	+	+	NA	NA
Pollexograph#	+ *NK*	NC	+ *NK*	NC
Inter-digit distance#	+ *NK*	+ *NK*	+ *NK*	NC
Grip ability test#	+	NC	+	NC
Grip strength	+ ***MDC***	+ ***MDC***	+ ***MDC***	+ ***MDC***
Pinch strength	+ ***MDC***	+ ***MDC***	+	+

+, positive change; **–**, negative change; ***MDC***, known minimal detectable change exceeded; ***MCID***, minimal clinically important change exceeded; NC, no change; NA, not available; *NK*, no known MDC or MCID; NRS, numeric rating scale; GROC, Global Rating of Change; FIHOA, Functional Index for Hand Osteoarthritis; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand questionnaire; EQ-5D-5L, EuroQuol 5-Dimension, 5-Level; NSAID, non-steroidal anti-inflammatory.
Judged as no change if less than one degree, one millimetre, or one second.

5.5 Discussion

This study investigated the feasibility of study elements with a view to conducting a future full RCT to evaluate the effectiveness of splinting for thumb CMC OA. The study found that the described protocol is feasible and identified some modifications that will optimise the conduct of the full-size study. A summary of the feasibility criteria and recommendations for a future full trial are given in Table 5.12.

5.5.1 Principal findings

All primary outcomes surpassed the a priori feasibility criteria for feasibility. The study RCT protocol was found to be feasible for recruitment, retention, intervention acceptability, and safety. Five participants experienced splint-related problems and seven experienced exercise-related concerns. These were minor short-lived events; their frequency can be interpreted as acceptable. In addition, the factors causing these events are modifiable and can be addressed in a future trial.

The secondary feasibility outcomes were met except for the fidelity of the splint intervention which reached less than the targeted 80% of instances. Measures were identified which could lead to this target being achieved and are outlined in Table 5.12. The remaining five secondary outcomes were met. The time required for study procedures was feasible. Quality-control audit of the intervention and assessments was satisfactory and suggested areas for improvement. Randomisation stratification was successful in evenly allocating enrolled participants by their dominant hand. Clinical outcomes were successfully collected with few missing items and could be explored to ascertain whether treatment effects and outcomes are consistent with expectations based on previous literature. Baseline imaging was feasible with respect to time and process but demonstrated borderline inter-rater reliability. Measures were identified which will improve this.

Table 5.12 Summary table of feasibility criteria and recommendations for full trial

Criteria	Feasibility criteria met?	Recommendations for full-scale trial
Primary feasibility criteria		
1. Recruitment of 30 participants in a 4-month period	Yes	No change needed
2. Retention >85% at 6 months	Yes	No change needed
3. >90% find the intervention acceptable	Yes	No change needed
4. Rate of adverse events	Yes	Splint-related adverse events can be avoided by: 1) instruction not to exceed the prescribed splint-wearing time, 2) splint removal for short periods at regular intervals (e.g. 4-hrly in the day), 3) address splint design modifications with manufacturer – lengthen web space strap, remove binding against 2nd metacarpal, add lining to 1st web space. Exercise-related adverse events can be reduced by reminding participants to contact the researcher should an exercise cause unacceptable pain on two or more consecutive days and by offering alternative techniques for the exercises. Modification is recommended for Exercise 4 (active palmar abduction): e.g. place the palm flat on a table or other firm surface and allow the thumb to palmar abduct by dropping vertically over the edge. Advice regarding exercise discomfort generally should be that some discomfort is acceptable.
Secondary feasibility criteria		
1. Time required for assessor and clinician confirmed	Yes	No change needed
2. Intervention implementation achieved in over 80% of prescribed instances		
Splint	No	In addition to the recommendations for splint intervention modifications above, a tentative recommendation is to reduce the splint-wearing fidelity threshold to 16 hours /24 hours in 80% of instances. This would allow those who need to remove the splint for work purposes to meet intervention fidelity; and reflects the lack of evidence for optimal splint dosage.

Criteria	Feasibility criteria met?	Recommendations for full-scale trial
		Provision of a third splint would allow use of one outdoors for dirty tasks, one indoors or 'clean', and one to wash.
Exercises	Yes	An alternative technique for Exercise 4, and advice regarding exercise discomfort generally, is suggested above. The remaining content and format can remain unchanged.
Advice and education	No	The daily log should be modified to provide more space for the specific advice given to be recorded and for the participant to record which advice was followed and when. Additional instruction should be provided to the participant about recording the advice followed.
3. Satisfactory quality-control audit assessments and interventions	Yes	For assessments: recap on assessor training after first assessment and then 2-weekly; revise assessor manual and training to clarify GAT and grip and pinch strength assessments; test equipment prior to assessment; more robust checking of missing data by assessors and direct audit by researcher of data- checking for first 4 assessments for each assessor (prior to participant leaving the premises). Interventions: more than one clinician will be required for a large-scale trial. Clinician training should be provided and regular audit of intervention implementation. The audit forms in the present study were satisfactory.
4. Successful recruitment and randomisation strategy	Yes	Additional strategies are required for targeted recruitment of participants of Māori descent – recommendations are made in Chapter 6. Enrolment error can be obviated by a two-person check system for the first 10 enrolments to confirm inclusion criteria are adhered to and any inconsistencies clarified. Stratification by hand dominance is feasible in a future full RCT. Removal of the stipulated FIHOA score ≥6/10 for study entry is recommended; discussed in later section.
5. Imaging (x-ray and ultrasound) for characterising participants joint status at baseline	Yes, if cost can be met and expertise and time available	X-ray imaging: recommend pre-reading training and two readers confer for consensus score. Ultrasound imaging: dichotomous outcomes can be used. Pre-reading training and consensus approach should be used for osteophyte and synovitis scores.

Criteria	Feasibility criteria met?	Recommendations for full-scale trial
6. Treatment outcomes explored	Yes	Pain NRS appears to be a suitable primary outcome. Other measures have potential as secondary outcomes; however, additional information of measurement properties in thumb CMC OA is required, including reliability (palmar abduction measures, GAT, grip and pinch strength, MCID (FIHOA). Exploration of the decline in EQ-5D-5L scores at 6-months is needed to understand the role of this measure. Measures to enhance assessment of medication use include: request participants to bring a full list of their medications to assessments; complete a 1-week daily log of medication use prior to the baseline assessment.

NRS, numeric rating scale; FIHOA, Functional Index for Hand Osteoarthritis; CMC, carpometacarpal joint; GAT, Grip Ability Test; MCID, minimal clinically important difference; EQ-5D-5L, EuroQuol 5-Dimension, 5-Level.

5.5.2 Discussion of findings in relation to feasibility and previous literature

5.5.2.1 Recruitment and randomisation

Several differences in baseline characteristics between the groups appeared to be associated with the higher number of males in the splint group, that is: higher grip strength and higher employment status. Although these between-group differences occurred by chance, such differences create potential for confounding if characteristics are associated with differences in treatment response. Female sex has been identified as one of several predictors of success in responses to physical therapy intervention in knee OA (Chapple, 2012) and has shown a similar association in studies of topical NSAIDs for hand OA (Persson et al., 2020). However, neither sex, age, post-menopausal stage, BMI, radiographic stage, nor duration of symptoms has been established as a predictor of disease progression or treatment response in hand OA (Barthel, Peniston, Clark, Gold, & Altman, 2010; Bijsterbosch, Watt, et al., 2011; Botha-Scheepers et al., 2009; Haugen et al., 2011; Kwok, Plevier, Rosendaal, Huizinga, & Kloppenburg, 2013; Marshall et al., 2013; Persson et al., 2020); furthermore, no data exists specifically for thumb CMC OA. Firm evidence for the influence of hand dominance on degree of impact was found by the qualitative study in Chapter 3. This study has shown stratification by hand dominance to be feasible; this is recommended in a future full study.

The systematic review reported in Chapter 4 found that study populations in previous studies have included generally only 10-20% male, compared to the 37% enrolled in the present study. One reason for this is likely due to the success of the present study in recruiting those who might not otherwise seek care – who are commonly men (Yousaf, Grunfeld, & Hunter, 2015).

In considering feasibility outcomes for recruitment, the rates of success in achieving recruitment response, screening (telephonic and in-person), and in identifying eligibility were similar to those in previous general OA studies: for example, Gignac screened n=224 to include 90 participants (with and without OA) in a qualitative study (Gignac et al., 2006). The present study, screening 66 to enrol 30 participants, performed well, given that its inclusion criteria were tighter than Gignac's study and its demands on participants were higher in terms of the number of assessments, commitment to the interventions, and duration of follow-up. No potential participants declined to participate or voiced concern about being randomised to a no-splint comparator intervention group in an RCT. Many reported that they were pleased to have received any care and happy to support research into the condition.

The strategy used in this study to recruit participants of Māori descent was less successful than expected. Additional steps for a future study are outlined in Chapter 6.

5.5.2.2 Intervention implementation findings

Overall, the splint intervention package developed in this study was implemented with a high level of success and some modifications were identified to ensure fidelity criteria can be met in a future full trial. Adherence to the standardised best practice usual care exercises in this study exceeded the fidelity criteria of 80% of prescribed instances. This a high rate of adherence. Poor adherence is a common weakness of exercise interventions for chronic musculoskeletal conditions including OA, and is considered a major reason for lack of effectiveness in research and clinical practice (Jordan, Holden, Mason, & Foster, 2010).

Since no previous studies of splinting for thumb CMC OA have included a best practice standardised usual care package, this is the first study to do so. However, only two-thirds of participants in the comparator intervention group and one-third in the splint

group reported adherence to the advice component of the standardised best practice usual care. It may be that participants did not follow the advice, or it may be that they just did not report it. Daily reporting of the exercises completed, and in the splint group, the hours the splint was worn, may have detracted from reporting on the advice followed; this may also explain the discrepancy in advice followed between groups. A recommendation for a full trial is to modify the daily log for a stronger emphasis on reporting of the advice followed. Alternative approaches to monitoring adherence are discussed in the study strengths and weaknesses section below.

A positive response occurred in participants receiving best practice usual care comparator intervention and so, if this is used for future studies it may necessitate a large sample size since the differences between groups will have to significantly exceed the beneficial effects of the comparator intervention.

In summary, the standardised best practice usual care package developed in this study is fit for use in a future full trial with some modifications to Exercise 4 (active palmar abduction). Furthermore, the package, with recommended modifications, may also have a role in usual clinical practice.

5.5.2.3 *Imaging findings*

To enable better evaluation of participant characteristics at baseline, the feasibility of x-ray and ultrasound imaging was evaluated, with a view to exploring their potential ability to predict a subgroup of participants who might be more responsive to treatment. Process and timing were found to be feasible for the imaging measures. Inter-rater reliability of the x-ray scoring was borderline but comparable to previous reports for Eaton-Littler score (k = 0.11 to 0.56) (Berger et al., 2014) and OARSI Atlas JSN (k = 0.48) (Gossec et al., 2008). Additional measures, namely, pre-study training and a consensus approach to reaching a final score, are likely to provide a satisfactory level of reliability for x-ray scoring to be used in intended future analyses.

The ultrasound imaging in the present study served as a pilot for a full study protocol. A consensus approach was taken for the first three scans. Preliminary computations indicated border-line inter-rater reliability for semi-quantitative scoring but excellent reliability for dichotomous outcomes, i.e. presence or absence of OA changes. The small

number of participants (n=4) means this data is purely exploratory. Previous investigation of ultrasound inter-rater reliability in hand OA (including thumb CMC), has found high agreement for osteophytes ($k \geq 0.91$) for both semi-quantitative scale and dichotomous response (Mathiessen et al., 2013). Inter-rater reliability for both detecting synovitis and use of power Doppler in the same cohort has also been found to be high ($k = 0.74$ and >0.93 respectively) (Mathiessen et al., 2016). Therefore, ahead of a future full trial, further work is warranted to refine the protocol and reader training.

If baseline imaging, x-ray or ultrasound, proves able to provide robust characterisations of participants' joint status, a linear regression model could be used to examine the association between imaging findings and treatment outcomes. For example, whether change in pain intensity in response to the splint intervention can be predicted for subgroups with higher grade structural change or presence of synovitis at baseline. Sub-group analysis would require careful preparation as part of the study statistical plan and sample size computation (Losina et al., 2015; Moher et al., 2010). This is particularly important as synovitis is increasingly recognized as an important correlate of pain in OA (Bacon et al., 2020).

5.5.2.4 Clinical findings

Secondary clinical outcomes were collected to explore whether treatment outcomes and effects were consistent with expectations based on previous literature.

On an individual participant basis, pain on average NRS and pain at night NRS saw reliable and clinically meaningful improvement in around half participants in both groups at 4-weeks which was largely maintained at 6-months. Of note, at 4-weeks a substantially greater proportion in the splint group (71%) improved on pain at night NRS compared to that in the comparator group (47%). In contrast, functional PROs saw only a small proportion who reliably and clinically improved in either group at 4-weeks, increasing to around one quarter at 6-months. Few participants deteriorated on any of the four outcomes.

Due to the small sample size group-level clinical findings represent preliminary indicative data only and do not have sufficient statistical power to assess significance. Whilst the apparent direction of change in some variables is described, the CIs of both

change over time and between-group difference, being wide, frequently overlapping, and in the majority of group-comparison CIs including null, indicate a low level of confidence that this suggested change actually occurred.

5.5.2.4.1 Pain

At 4-weeks (short-term) the mean between-group differences in pain in the present study were similar to findings in previous larger studies at low risk of selection bias (Chapter 4) (Table 5.13). However, at 6-months (medium-term) mean between-group differences were lower, or absent. The standardised best practice usual care may have contributed to positive change in both groups; while this may explain the aforementioned observation, earlier apparent positive change seen in the splint group could be attributed to the splint intervention. Given the wide CIs of the between-group difference which included the null, along with the wide and overlapping CIs of the change over time, the confidence with which the observed change might be said to suggest actual change is low.

The positive change over time at both individual participant and group level appeared to be maintained in both groups at 6-months with minimal deterioration towards the baseline. The overall apparent improvement in pain seen with standardized best practice usual care alone might signal that there is little room for other interventions to prove their additional benefit.

Alternate explanations for the observed change are that the improvement was a result of participants' knowledge of their being observed in the context of a clinical study, i.e. the Hawthorne effect (Portney, 2015), or that change reflected the natural fluctuations in the disease state. In studies of knee OA two thirds of patients report pain that remains the same or improves while one third report deterioration (National Collaborating Centre for Chronic Conditions Corporate, 2008). However, studies suggest that the natural trajectory of hand OA is less likely to be associated with improvement in pain over time, with approximately half of patients having stable pain or improving, while the other half deteriorates (Bijsterbosch, Watt, et al., 2011; Botha-Scheepers et al., 2009), although specific information for thumb CMC OA is unavailable.

Table 5.13 Comparison of change in pain outcomes between previous studies at low risk of selection bias (Chapter 4) and the present feasibility study

	Study	N	Variable	Short-term (0 to 3 months)			Medium-term (3-12 months)		
				Splint group (SD)	Comparator group (SD)	Between group difference (95% CI)	Splint group (SD)	Comparator group (SD)	Between group difference (95% CI)
Systematic review (high-quality studies)	Gommes-Carreira 2010	40	Pain past week splint off NRS (0-10)	-2.0 ± 2.37	-0.3 ± 2.36	-1.7 (-3.17, -0.23)	-2.2 ± 2.46	0.1 ± 2.44*	-2.3 (-3.82, -0.78)
	Hermann 2014	59	Pain – NRS (0-10)	-0.3 ± 2.56	-0.2 ± 2.98	-0.1 (-1.4, 1.2)	-	-	-
	Rannou 2009	112	Pain past 48 hours VAS (0-100)	-10.1 ± 22.25	-10.7 ± 22.38	0.6 (-7.9, 9.1)**	-22.2 ± 23.08	-7.9 ± 23.48	-14.3 (-23.0, -5.2)
Feasibility study		30	Pain average past week NRS (0-10)	-1.6 ± 2.25	-0.1 ± 2.46	-0.6 (-2.44, 1.16)	-1.6 ± 3.14	-1.6 ± 3.02	-0.0 (-2.41, 2.39)
		30	Pain at night average past week NRS (0-10)	-2.8 ± 2.88	-1.7 ± 2.94	-1.1 (-3.34, 1.09)	-2.2 ± 3.06	-1.4 ± 3.21	-0.8 (-3.24, 1.66)

NRS, numeric rating scale; VAS, visual analogue scale.
* Negative change within group
** Change in favour of comparator group (versus splint group)

5.5.2.4.2 Self-reported function

In common with previous studies investigating splinting for thumb CMC OA, the feasibility study did not show great change in functional scores, frequently failing to meet previous estimates of MCID. This could be a result either of problems with the outcome measures, such as lack of available MCID and none developed specifically for CMC OA or, potentially but unlikely, no actual change in function.

The between-group differences in the present study were slightly larger in the short-term but smaller in the medium-term compared to findings from previous larger studies at low risk of selection bias (Table 5.14).

An important finding in the present study was that the self-report functional outcomes in the present study (FIHOA and QuickDASH) showed minimal change, consistent with previous studies in thumb CMC OA (Table 5.14). There are several possibilities for why this may have occurred, including that current measures are not sensitive enough for thumb CMC OA, the sample size was too small to be able to detect any true change that may have occurred, resulting in type II error, or that there truly was no change in function to be observed.

On the latter, the domain of function was also assessed by performance measures in the present study which, as discussed in the section below, changed positively but not substantially. The FIHOA correlates moderately with a comprehensive test of hand function performance (Stamm et al., 2007) but its relationship with the GAT is unknown. In RA populations the longer DASH, and another questionnaire similar to, but longer than the FIHOA – the Duruoz Hand Index – as well as the HAQ, have been shown to correlate moderately with the GAT (Bircan, 2014). However, these data are not available for hand OA populations. Grip strength has been shown to have weaker correlation with self-report function than tests of hand function performance (Stamm et al., 2007). Unfortunately, due to insufficient sample size in the present study, it is not possible to undertake any statistical analysis to explore these relationships further.

Table 5.14 Comparison of change in self-report function outcomes between previous studies at low risk of selection bias (Chapter 4) and the present feasibility study

				Short-term (0-3 months)			Medium-term (3-12 months)		
	Study	N	Variable	Splint group (SD or 95% CI)	Comparator group (SD or 95% CI)	Between group difference (95% CI)	Splint group (SD or 95% CI)	Comparator group (SD or 95% CI)	Between group difference (95% CI)
Systematic review (high-quality studies)	Gommes-Carreira 2010	40	DASH (0-100)	-7.3 ± 24.40	-7.6 ± 23.43	0.3 (7.56, -14.53)**	-10.5 ± 24.69	-6.7 ± 22.65	3.8 (-18.48, 10.88)**
	Hermann 2014	59	AUSCAN function subscale (0-5)	-0.2 ± 1.29	-0.3 ± 1.26	0.06 (-0.7, 0.8)**	-	-	-
	Rannou 2009	112	Cochin scale (0-90)	1.3 ± 10.29*	-0.3 ± 10.29	1.6 (-2.3, 5.5)**	-1.9 ± 11.20	4.3 ± 11.53*	-6.3 (-10.9, 1.7)
Feasibility study		30	FIHOA	-1.9 ± 4.17	0.0 ± 3.54	-1.9 (-4.63, 0.92)	-3.1 ±04.26	-0.9 ± 4.33	-2.1 (-5.41, 1.14)
		30	AFQ	-1.4 ± 2.77	-0.2 ± 4.77	-1.2 (-4.23, 1.77)	-1.7 ± 2.70	-0.3 ± 3.59	-1.5 (-3.89, 0.99)
		30	QuickDASH	-5.3 ± 10.89	-2.4 ± 7.11	-2.9 (-9.82, 4.11)	-4.0 ± 10.89	-6.3 ± 9.73	-2.3 (-10.55, 5.84)

DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; AUSCAN, Australian-Canadian Hand Osteoarthritis Index; FIHOA, Functional Index for Hand Osteoarthritis; AFQ, Additional Functional Questionnaire
* Negative change within group
** Change in favour of comparator group (versus splint group)

All things considered, it is reasonable to surmise that current functional outcomes are not adequate for thumb CMC OA because while positive changes in pain were noted, existing self-assessment outcome measures noted in previous and the present studies report limited change in function. Although future data may enable the establishment of an MCID for FIHOA and thus help to understand better the utility and sensitivity of this measure, it seems increasingly clear that other measures also need to be explored or developed to identify a valid and responsive instrument for thumb CMC OA. This is further discussed in Chapter 6.

5.5.2.4.3 Health-related quality of life

While MDC for this outcome was exceeded by positive change for both groups at 4-weeks and in the comparator group at 6-months values unexpectedly showed apparent negative change at 6-months in the splint group. Furthermore, the EQ-5D-5L VAS score showed apparent negative change in both groups at 6-months, suggesting a decline in health-related QoL. Wide and overlapping CIs for change over time and the inclusion of null in CIs of between-group comparison indicates a low level of confidence that this observed change suggests actual change.

The apparent negative change in the splint group was explored for a single outlier for whom a marked reduction in EQ-5D5L- scores at 6-months was due to substantial co-morbidities. Despite exclusion of this outlier value, a secondary analysis still showed return to baseline for the index score at 6-months and apparent decline below baseline of the VAS scale score. It is unclear why this occurred when generally positive apparent change was seen in most other parameters. If reflecting actual decline, this inconsistent finding may be an aberration given the small sample study population, or the role of other health or life events may have a significant bearing. If real, consideration would need to be given to how a decline in HR-QoL can be understood in a full study or how change in QoL specific to thumb CMC OA status can be measured. This is explored further in Chapter 6. Quality of life has not been assessed in previous studies of splint effectiveness but the significant impact on people's emotional, mental, and spiritual well-being indicates that QoL is an essential outcome in investigating the effectiveness of interventions for thumb CMC OA.

5.5.2.4.4 Global rating of change

The MDC was exceeded by positive change in both groups at both time points, indicating that, in general, participants' in both groups perceived positive overall change. However, this did not reach the threshold for clinically meaningful change.

5.5.2.4.5 Responder criteria

The relatively high proportion of responders in the splint group (n = 9 [64.3%]) compared to comparator group (n = 4 [26.7%]) at 4-weeks in the present study, along with evidence from previous fully-powered trials in hand OA, makes OMERACT-OARSI responder criteria a promising candidate for a robust and responsive outcome measure to assess effectiveness of splint interventions for thumb CMC OA.

Significant findings in previous studies include, for example, 33% for joint protection group vs 21% for no joint protection as part of self-management for hand OA (Dziedzic et al., 2015); and, for exercises versus no exercises for hand OA, 43.2% vs 5.9% (Hennig, Hæhre, et al., 2015) and 46% vs 16% (Osteras et al., 2014). The present and previous studies indicate that detecting a significant and meaningful difference using current responder criteria is feasible. Therefore, work is worth carrying out to determine criteria relevant to hand OA and, by extension, thumb CMC OA.

5.5.2.4.6 Medication use

Self-report medication use showed a surprisingly low rate of use at baseline by most participants. This may reflect both the inclusion of a relatively high proportion of participants, nearly half, who had not previously sought care for their thumb CMC OA problem, and the desire expressed in the qualitative study to avoid medication use where possible. Three previous studies included in the systematic review reported simple dichotomous outcomes (yes/no) of participants' medication use on study entry and found half (Sillem et al., 2011; van der Vegt et al., 2017) to three-quarters (Rannou et al., 2009) were using medication. Only one of these studies reported medication type and assessed medication use over the course of a splint intervention, although no analysis of this data was made (Rannou et al., 2009).

The calculation of quantitative measure of NSAID use in the present study is a novel method in studies of splinting for thumb CMC OA and has potential to enable more

robust evaluation of this important outcome. A suggested MCID of 24 points, calculated in a population with axial spondyloarthritis (Dougados et al., 2012; Dougados et al., 2014), was not met in the present study. However, this MCID might not be relevant to thumb CMC OA given the low baseline scores in the present study. Interestingly, low use of NSAIDs has also been reported in a previous similar southern New Zealand cohort of lower limb large joint OA (Stebbings, Gray, Schneiders, & Sansom, 2017) – this may be a local difference for New Zealand.

5.5.2.4.7 Thumb palmar abduction range of motion

Thumb palmar abduction ROM appeared to changed positively in the splint group while the comparator intervention group saw little or no apparent change at both time points. While CIs were wide for these measures, they only modestly overlapped for change over time, and for Pollexograph at 4-weeks excluded the null for between-group comparison. Thus, a low to moderate level of confidence can be had that this observed change suggest actual change. No MDC or MCID values are available for these measures. Furthermore, the IDD is a novel adaptation of another method and requires evidence of its validity and reliability.

Notably, the splint group demonstrated a marked increase in first web space length on measures of both Pollexograph palmar abduction and IDD at 4-weeks and the increase was maintained, to a lesser extent, at 6-months. This contrasts with an earlier study which showed no significant change in first web space length with night-time splint wearing over a 12-month period (Rannou et al., 2009). Since the present study used a different splint worn at a higher dosage, different measurement methods, and included best practice usual care, any or all of these may explain the difference between these two studies. The change in thumb palmar abduction in the splint group but not the comparator intervention group in the present study supports the hypothesis that the splint intervention may have a specific effect on thumb palmar abduction. Whether this could form a useful outcome measure is worthy of further study.

5.5.2.4.8 Grip and pinch strength

The small yet positive change in both grip and pinch strength is interesting given that the best practice usual care exercises did not include any formal strengthening. This

also contrasts with a previous large RCT which found strength decreased, although not significantly, following 12 months of night-time splint wearing (Rannou et al., 2009).

5.5.2.4.9 Grip ability test

In this study, the speed of performance on the GAT improved in the splint group at 4-weeks and even more so at 6-months but not at all in the comparator intervention group. Notably, the baseline speed was around 20% slower in the splint group than the comparator group, leaving much greater room for improvement in the splint group; this may explain the greater change in the splint group. Adjustment for baseline performance could address this in a future trial.

The GAT shows promise in detecting improvement in physical functioning in response to a splint intervention. Further research to determine its measurement properties is indicated.

5.5.3 Strengths and limitations

The strengths of this study included blinding of participants to the study hypothesis, a high dosage of splint intervention, best practice usual care, high adherence to exercise, exploration of outcome measures important to patients, analysis of individual-level data, and inclusion of a representative study population for all of whom thumb CMC OA has an impact. These strengths have resulted in findings that can effectively inform a future full trial and so produce high quality findings that are translatable to practical real-world settings.

A major strength of this study, in addition to the blinding of study assessors, was the blinding of participants to the study hypothesis until after the 4-week follow-up, something not previously reported in studies of splinting for thumb CMC OA. Together, these measures reduce the risk of performance and detection bias, and so reduce the likelihood of over-estimating intervention benefit due to non-specific placebo effect (Fregni et al., 2010), thereby increasing the validity of the results. However, the success of the measures taken to blind participants to both the study hypothesis and the opposite group intervention, and to blind assessors to group allocation, was not assessed. Evaluating the effectiveness of blinding measures should be built into a future full-scale trial and can be done at post-intervention or exit interviews with participants

and at interim periods with assessors. Furthermore, statistician blinding can help to minimise researcher bias; a researcher blinded to group allocation should perform the statistical analysis in a future trial.

Participant knowledge of their group allocation at the 6-month follow-up increases the risk of performance bias and, for self-reported measures, detection bias at this time point. Any new studies should be reviewed in planning for a future trial, as this might permit longer-term participant blinding if uncertainty in longer-term outcomes persists.

Additional strengths of the study included successful recruitment strategy, enrolment, and retention. The low participant attrition rate minimised the issue of missing data. Those data that were missing tended to be items not completed due to inadequate checking rather than due to any characteristics specific to participants or the outcomes themselves, i.e. 'missing completely at random' (Lodder, 2014). The single participant who withdrew did so due to participant characteristic-related factors, namely, work-related time commitments, and thus can be defined as 'missing at random' (Lodder, 2014). No data were missing due to factors related to the outcomes themselves ('missing not at random') (Lodder, 2014). Therefore, the multiple imputations method would be a robust option for dealing with missing data in a future full study that retains statistical power and adherence to the intention-to-treat principle while mitigating to a good extent against loss of validity (Lodder, 2014; Losina et al., 2015).

There were also little missing data from self-report diaries, following reminders to complete diaries, and high intervention implementation. The splint-wearing schedule was prescribed at a dosage much higher than in previous studies; the present study has shown that such higher dosage is feasible and acceptable to participants. It has also shown, for both splint intervention and the standardised best practice usual care package, that clearly described dosage parameters with similar treatments, time, and attention between groups can be implemented in an RCT design. Evaluation of intervention fidelity could be further strengthened by assessing participants' correct donning and doffing of splints and exercise performance at 1 week, or by random audit.

Limitations of the present study include the relatively short length of the follow-up period; assessment at varying times of day; a lack of evaluation of ongoing self-management; reliance on paper methods for screening, informed consent, outcome measures, and fidelity evaluation; a lack of assessment of the success of blinding participants and assessors; a lack of blinding of statistical analysis; the absence of some demographic measures.

Thumb CMC OA is a long-term condition; although follow up occurred at 6-months post-implementation of intervention, long-term evaluation is required to assess whether interventions are effective over longer time periods (Kloppenburg, Maheu, et al., 2015). Follow-up at 12- and 24-months is recommended (Kloppenburg, Maheu, et al., 2015), and should be included in a future large trial. Retention rates in the present study substantiate the findings of the systematic review in Chapter 4 that longer follow-up is likely to be feasible. Evaluation of self-regulated continued splint use or exercise performance beyond the active intervention period should be undertaken for the longer time periods, for example, at 6- and 12-months. The present study's success in evaluating intervention implementation suggests that a similar but more sporadic assessment of ongoing self-management is feasible.

Reliance on paper methods for many elements in the present study is a limitation contributing to researcher burden and cost. Although the use of digital methods to support recruitment, screening, outcome collection, automation of reminders, and intervention implementation may reduce this reliance, the consequent reduction in researcher contact and relationship may come at the cost of increased missing data and lower adherence to intervention prescriptions. Furthermore, age, ethnicity, employment status, and hearing and vision ability may limit study participation for vulnerable or deprived groups, such as Māori and the very elderly, if the study were to go completely digital. Digital sensors could be an alternate option for monitoring splint wearing adherence with low participant burden but are still at the development stage for appendicular devices (Davies et al., 2020). No standardised approach exists for measuring adherence to complex interventions in clinical trials (Davies et al., 2020; Graham et al., 2016). A simple descriptive approach suited to the context has been considered appropriated (Graham et al., 2016). The use of a paper logbook for

measuring device use in rehabilitation intervention trials has been found to be accurate compared to electronic monitoring including in older adults (Jeffrey et al., 2012), although the method appears less valid for other interventions such as walking frequency (Frost, McClurg, Brady, & Williams, 2016). Given the low cost, simplicity, and suitability for devices, a simple logbook is recommended for measuring adherence to thumb splint wearing in a future full trial.

To eliminate unnecessary travel and researcher time for potential but ineligible participants, digital methods to assess remotely baseline eligibility could be used, e.g. to screen demographic, health, and self-report measures. Video consultation might overcome the issue of self-report measures designed to be interviewer-administered, e.g. the FIHOA (Dziedzic, Thomas, & Hay, 2005). Developing a specific self-administered questionnaire would also be helpful for distance or electronic administering, making the FIHOA even less fit for purpose now and in future.

Although assessments in the present study were generally conducted between 11am and 4pm they were not booked at consistent times for each participant. Pain, dexterity, and stiffness in hand OA are known to fluctuate according to daily rhythms with the optimal time being mid-afternoon (Bellamy, Sothern, Campbell, & Buchanan, 2002). Depending on the time of day assessments took place, results could have under- or overestimated change in these outcomes. A future full trial should either ensure assessments occur at consistent times for each participant or use symptom diaries at specific points during the day. Additional baseline characteristics of marital status, living circumstances, and education level are recommended for intervention trials in hand OA (Kloppenburg, Maheu, et al., 2015) and should be collected in a future full-size trial. It would be feasible to add these to the demographic questionnaire as assessments were not time-pressured and participants identified no concerns about questionnaire burden. Robust methods of checking for data completeness at time of assessment was a further area identified as potentially improving a future study.

5.6 Conclusion

The present study provides necessary data to assess the feasibility and to inform the conduct of a future fully-powered RCT to investigate the effectiveness of a splint

intervention for thumb CMC OA. Findings from such a full trial can inform health funding policy on the provision of orthotic devices for people with thumb CMC OA and assist clinicians to be better informed when recommending an appropriate intervention for their patients. The conduct of a future full trial has been shown to be feasible. A subsequent RCT investigating the effectiveness of a soft off-the shelf splint for managing thumb CMC OA should be undertaken using the current protocol. Analysis of the feasibility data suggested a number of protocol adaptations.

This feasibility study represents the final empirical work of this thesis. The final discussion chapter, drawing together the findings of the present study in relation to the findings of the earlier systematic review and qualitative study, reviews each in the context of the thesis as a whole and makes recommendations for future research and for clinical practice in Aotearoa New Zealand and internationally.

Chapter 6

General discussion

6.1 Background

Thumb CMC OA is a common, disabling condition and, from the patient perspective, little has been known about its unique impact. Usually it has been studied as part of the more general condition of hand OA and has received far less attention than lower limb large joint OA. Consequently, thumb CMC OA has been significantly under-investigated. Although international guidelines recommend splinting as a non-surgical, non-pharmacological treatment option for CMC OA, evidence supporting this is sparse and inconsistent. The resultant lack of understanding about which outcomes and treatment targets are of importance to patients has contributed to gaps in outcome measurement, intervention design and, therefore, evidence for practice.

This thesis set out to address these gaps in the research field by exploring the impact of thumb CMC OA from the perspective of people living with the condition and by investigating the effectiveness of splinting interventions for improving outcomes of importance for people with thumb CMC OA. A pragmatic, shared post-positivist and constructivist approach informed the research methodology. Thus, the research involved both qualitative and quantitative methods.

In the pragmatic qualitative study in Chapter 3, 30 participants took part in individual interviews and solicited diaries. Data were analysed by thematic analysis using a primarily inductive approach. The Health Impact Model was employed to aid interpretation of results.

In the systematic review in Chapter 4, existing evidence, that is, from published studies up to 17 March 2018, was investigated using narrative- and meta-analysis to determine the effectiveness of splinting for improving pain, function, and HR-QoL in people with thumb CMC OA.

Informed by these initial studies, a feasibility study in Chapter 5 was conducted to investigate a proposed protocol for a future fully-powered RCT to investigate the effectiveness of a soft splint intervention.

6.2 Overview of thesis findings

An overview of the thesis findings and directions for future research are outlined in Figure 6.1

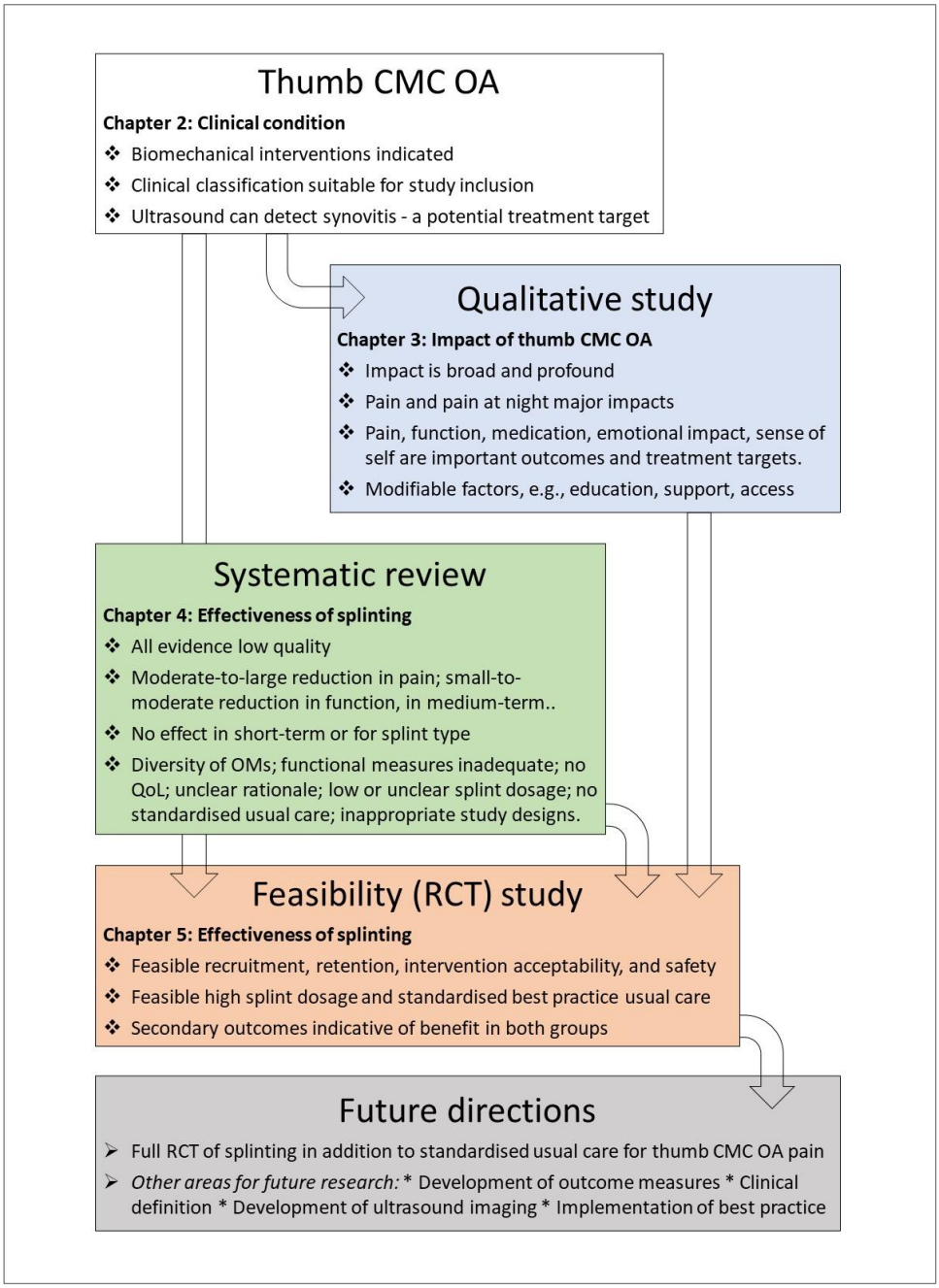


Figure 6.1 Overview of thesis findings and future directions

The qualitative study found that thumb CMC OA has a profound impact, largely associated with pain, on many aspects of a person's health and well-being. Five main themes representing five inter-related levels of health impact were identified: negative experience of symptoms, functional limitations, restricted social activities and roles, negative thoughts and feelings, and altered sense of self. Impact was influenced by dominant hand involvement; cold climate; people's financial, social and societal support; and attitudes to thumb CMC OA. Areas of impact which inform treatment goals and important measurable outcomes were identified, as well as areas requiring targeting of health resources. Pain, including pain at night, was a major concern. There was a strong desire for provision of high-quality information about self-management as well as effective non-surgical, non-pharmacological treatment options. Self-report composite functional questionnaires, currently recommended to measure functional limitations in people with thumb CMC OA, were concluded to be inadequate.

The systematic review included twelve studies (n=1353 participants), four comparing a splint to control and eight to another splint. All evidence for splinting was of low quality. Sensitivity analyses demonstrated that in the medium-term (3-12 months) splints cause a moderate-to-large reduction in pain (SMD -0.7 [95% CI -1.04, -0.35], < 0.0001) and small-to-moderate improvement in function (SMD -0.42 [-0.77, -0.08], p = 0.02). No effect exists in the short-term. The review identified variability in self-reported outcomes, case definitions, and rationale for splinting; low and variable splint dosage; lack of standardised usual care; unassessed QoL; and inappropriate study designs. A need for further high-quality research was clearly established.

The RCT design of the feasibility study was found to be achievable with some modifications. All primary outcomes surpassed the a priori thresholds for feasibility. Thirty participants were enrolled; 29 (96.7%) completed the assessment at 4 weeks. Preliminary indicative data suggest that a positive effect of splinting for pain on average and pain at night may exist in the short-term and for pain at night in the medium-term. The changes in pain – recording both pain on average in the past week and pain on average at night in the past week using NRS – indicated that these measures are appropriate and relevant primary outcomes.

In the following sections of this final chapter key findings of the overall thesis are discussed and their implications for clinical practice and research outlined. These include the significant impact of pain and pain at night; the relationship between pain and physical limitations; the challenges of assessing function; the broader impact of thumb CMC OA; factors that modify impact; and the effectiveness and prescription of splinting. A brief update of literature since the systematic review is then given, and gaps in thumb CMC OA outcome responsiveness literature outlined. Next, the strengths and weaknesses of the overall body of work are reviewed and recommendations for future research are made. The final section draws overall conclusions.

6.3 The significant impact of pain and pain at night

6.3.1 Pain, and pain at night are key outcomes and treatment targets

The qualitative study of Chapter 3 identified that pain, including pain at night, was the major problem experienced by people with thumb CMC OA. This finding, concurring with the work of previous authors who have explored the impact of hip and knee OA (Hawker et al., 2008; Parmelee, Tighe, & Dautovich, 2015; Woolhead, Gooberman-Hill, Dieppe, & Hawker, 2010), including the pain experience, now extends this knowledge to include thumb CMC OA specifically. Pain, constant rather than intermittent or unpredictable, was of greater concern to participants with thumb CMC OA in contrast to those with hip and knee OA (Hawker et al., 2008). This finding aligns with and extends previous reports of pain impact in hand OA (Marshall et al., 2009) although pain on activity was identified as a more prevalent problem in the cohort among whom the AUSCAN outcome instrument was developed (Bellamy, Campbell, et al., 2002). From the perspective of people with thumb CMC OA, pain and pain at night are key treatment targets and outcomes. From a surgeon's perspective, pain is also seen as the primary reason for surgery for thumb CMC OA and its relief the most important outcome (Martou et al., 2004).

6.3.2 Pain at night an important clinical feature

An important and novel finding of this thesis in both the qualitative and feasibility studies is the presence of pain at night as a major problem for participants who had a range of disease stages. While sleep disturbance has been reported for around 30%-40% of hand OA cohorts (Maheu, Michon, Carrat, & Berenbaum, 2008; Steen

Pettersen et al., 2019), pain at night has not previously been established as a prominent feature of thumb CMC OA other than as a symptom that may be present 'in the later stages' (Burkholder, 2000). Although 'pain at rest' is mentioned in some clinical texts (Valdes, Algar, & Weston McGee, 2020), pain at night associated with thumb CMC OA is not generally common in the literature, and clinical texts often describe thumb CMC OA pain as primarily mechanical and associated with demanding, repetitive manual tasks (da Silva & Woolf, 2010).

Pain that occurs at night in hip and knee OA is associated with fatigue, distress, and worse pain levels (Hawker et al., 2008; Parmelee et al., 2015; Woolhead et al., 2010) and this is also likely to be the case in thumb CMC OA. Reducing pain that disturbs sleep may also relieve pain-related emotional distress (Parmelee et al., 2015).

6.3.3 The relationship between pain and inflammation

Osteoarthritis pain that occurs at night or interrupts sleep has been described as suggestive of an active inflammatory process (Sellam & Berenbaum, 2010). Furthermore, the importance of inflammation in OA pathogenesis and symptomatology is being increasingly recognised (Bacon et al., 2020), including in thumb CMC OA (Oo et al., 2019). However, there is no empirical evidence yet for a relationship between pain at night in the thumb CMC and inflammation in the joint; it would be salutary to understand this further. Whether signs of inflammation can predict response to treatments such as splints is also a question to be answered. Some preliminary steps were taken in this thesis to assess the feasibility of incorporating ultrasound evaluation into an RCT and this would appear achievable.

6.3.4 The pain experience

Pain experienced with an osteoarthritic joint may be associated with pathophysiological, molecular, or structural damage but the severity of anatomical joint disease is known to be only weakly related to that of the clinical problem (Dieppe & Lohmander, 2005). A recent study investigating the psychological aspects of pain from thumb CMC OA using cross-sectional survey methods found that 47% of variation in pain levels could be explained by psychological factors including illness distress, pain catastrophising, and illness perceptions, but only 6% of the variance could be explained

by x-ray scores (Hoogendam et al., 2019). Negative illness perceptions have also been associated with short- and long-term disability in hand OA (Damman et al., 2018).

The extent to which psychological factors play a role in outcomes of hand and upper limb disease and injury is poorly understood however; previous studies attempting to explain this relationship suffer from methodological flaws, for example, cross-sectional study design and an unbalanced focus on negative psychological traits (MacDermid, Valdes, Szekeres, Naughton, & Algar, 2018). It is postulated though that the broader impact of thumb CMC OA, as identified in the qualitative study in this thesis, exerts a complex interactional effect on the pain experience of people with this condition. This effect includes anger and frustration about restrictions in life roles, distress about the future, anxiety about continuing independent and in work, loss of enjoyment, negative mood, 'dispiritedness', and altered sense of self.

6.3.5 Pain assessment

The measurement of pain is complex and the variety of instruments and operational definitions identified in the systematic review present a challenge to making valid comparisons across studies. In hip and knee OA the Western Ontario and McMaster Universities Arthritis Index (WOMAC) has become a standardised way of assessing pain and functional loss (Woolacott, Corbett, & Rice, 2012). For all its faults, including fee for use, multiple versions and scoring, the WOMAC has played a significant role in allowing more robust synthesis of findings across studies (Copsey et al., 2019; Woolacott et al., 2012). Future research in thumb CMC OA should aim to decrease diversity in the outcome measures used, for pain particularly.

The nuanced experience of pain has also been recognised and is poorly reflected by a single number recorded on a scale (Portney, 2015). Based on findings in this thesis, the pain profile in thumb CMC OA appears to be different to that in hip and knee OA. For example, although dimensions of impact on mood, sleep, and quality of life in the newly developed Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP) (Hawker, Mian, et al., 2011) will be highly pertinent, the dimension of unpredictability may not be so relevant. Adaptation of the ICOAP for hand and thumb CMC OA has been recommended (Kloppenburg, Boyesen, et al., 2015) and is supported by the findings of

this thesis. The development of a pain question (NRS) that seeks to measure the constancy of pain with for example, present all the time at one anchor and present none of the time as the other anchor, which may incidentally measure night pain, may be a more sensitive measure in people with thumb CMC OA.

Pain and pain at night are significant impacts of thumb CMC OA that should serve as key treatment targets and outcomes in clinical studies. Pain at night is not commonly described as a symptom in this population but was present for most participants in the work of this thesis, including those in early or mid-stage disease. A consistent measure of pain in hand and thumb CMC OA is needed. Pain at night is a symptom deserving of more attention in thumb CMC OA.

6.4 The relationship between thumb CMC OA pain and physical limitations

The qualitative study in Chapter 3 found that physical symptoms experienced by people with thumb CMC OA, including loss of strength and dexterity, were often associated with pain.

The prominent role of pain in reducing strength and motor control in thumb CMC OA is suggested by a recent study employing an experimental model of thumb CMC joint pain. In this study, investigators injected hypertonic saline into the dorsal-radial ligament of human volunteers and isotonic saline on the contralateral hand, demonstrating a greater increase in pain and a concomitant between-group difference of 50% reduction in tip pinch strength compared to baseline (Ooishi et al., 2019). Furthermore, surface electromyography revealed significantly reduced activity of the APB and FDI muscles while activity of the EPL remained unchanged (Ooishi et al., 2019). The differentially greater experimental CMC joint pain induced by the hypertonic saline was hypothesised to reduce tip pinch strength via mechanical provocation of sensitised joint tissues causing inhibition of motor recruitment. Additionally, the loss of balanced dynamic control was hypothesised to increase joint point contact forces, provoking further pain (Ooishi et al., 2019). Such mechanisms are likely to be at play in thumb CMC OA.

Variability in hand dexterity in OA has previously been observed to follow fluctuations in hand joint pain and stiffness, improving when pain and stiffness are less (Bellamy,

Sothern, et al., 2002). In the qualitative study in this thesis participants identified problems such as dropping things, loss of grip, reduced dexterity, and perceived loss of power with pinch and grasp. These may be the consequences of pain-inhibited sensorimotor functioning rather than loss of strength per se. Moreover, in general hand OA, a reduction in pain has been correlated with improved function (Barthel et al., 2010). While limitations in physical function are an important impact for people with thumb CMC OA, many of these limitations are influenced by pain. Since reducing pain has potential to increase hand strength and function, pain is the primary treatment target and outcome of interest. The relationship between pain, function, and strength in thumb CMC OA is also an area worthy of further research.

6.5 The diversity of functional limitations

6.5.1 The diversity of impact

The qualitative study in Chapter 3 highlighted the impact of thumb CMC OA on a remarkably diverse range of functional activities. This reflects and underscores the importance of the thumb and, in particular, its basal joint in every-day human life. However, this diversity presents a challenge to capturing the functional domain adequately.

In the feasibility study self-report functional measures showed a lack of change in the feasibility study and only small effect sizes in the previous studies included in the systematic review. The lack of change in function seen in thumb CMC OA is in contrast to the lower limb OA where, in the short-term, improvements in functional outcomes are greater than those seen in pain (Fransen et al., 2015). Based on the work of this thesis and previous literature, a possible reason for this contrast is that lower limb function is primarily ambulatory, against the remarkable variation in upper limb, especially hand and thumb, function. It is, therefore, more challenging to capture the full breadth of impact in the upper limb with a single standardised instrument. An alternative explanation is that splinting has no effect at all on function in people with thumb CMC OA, in which case no change would be measured even if thumb CMC OA-specific instruments were to be used.

6.5.2 Assessing self-reported function

Both functional limitations and participation in life roles are important outcomes for people with thumb CMC OA. Currently, the FIHOA is the only freely available self-report functional outcome recommended by the OARSI clinical trials group recommendations for hand and, by extension, thumb CMC OA (Kloppenburg, Maheu, et al., 2015). The FIHOA was developed in the early 1990s using clinician-derived items (Dreiser et al., 1995). Several participants in the present qualitative study, both men and women identified some items as inappropriate. In particular, the item "For women: can you sew? For men: can you use a screwdriver?". These issues have also been identified by previous authors (Stamm et al., 2006). Furthermore, the appraisal of findings from the qualitative study found that a range of impact and potential outcome items important to people with thumb CMC OA were missing from the FIHOA, including household tasks, tasks involving impact or vibration, work roles, and interacting with children or grandchildren, among others.

For the feasibility work in this thesis the QuickDASH was considered a good alternative to the FIHOA; it is valid, reliable, and has known MCID (Beaton et al., 2005; Franchignoni et al., 2014; Sorensen et al., 2013; Wong, Fung, Chu, & Chan, 2007). However, the ability of the QuickDASH to detect change in the feasibility study appeared no better than that of the FIHOA. The Additional Functional Questionnaire based on findings in Chapter 3 also showed little change but was not a robustly devised instrument.

In summary, these findings support previous work which concluded that the currently recommended functional measures for hand OA are lacking in specific relevance to thumb CMC OA (Kloppenburg, Maheu, et al., 2015; Stamm et al., 2009). This is an area urgently requiring further research; the inclusion of patient perspectives will be critical to its success.

6.5.3 Instrument development

It would be challenging to develop an instrument to measure patient-reported function specifically for thumb CMC OA. Nevertheless, the qualitative work conducted in this thesis provides findings which may be used as the basis for developing a conceptual

framework for a new or modified instrument (Bredart, Marrel, Abetz-Webb, Lasch, & Acquadro, 2014). A subsequent step would be to conduct cognitive interviews to confirm the concepts selected after which a framework could be elaborated to develop items that assess the key identified concepts, thus establishing face- and content validity (Bredart et al., 2014). The process of building construct validity, i.e. providing the evidence to support or refute the theoretical framework, could then commence (Portney, 2015). This could use a factor analysis approach which analyses scores for factors' fit with the theoretical premise of the instrument and can assess for internal consistency and removal of redundant items (Portney, 2015). Finally, the instrument's ability to detect change would need to be assessed, including testing for reliability, floor and ceiling effects, and responsiveness to change (Portney, 2015).

Alternative directions to assessment of self-reported function include person-specific measures such as the Patient-specific Functional Scale (PSFS), or computer adaptive testing (CAT) such as the dynamic Patient Reported Outcomes Measurement Information System (PROMIS). In contrast to region- or condition-specific measures, patient-specific measures such as the PSFS can be used in diverse client populations and can allow for those items of greatest relevance to the patient to be measured (Donnelly & Carswell, 2002). The PSFS has been found to have good reliability and content validity in thumb CMC OA cohorts although concurrent validity (against the DASH/Quick DASH and grip strength) is low-to-moderate (Rosengren & Brodin, 2013; Wright et al., 2017). This instrument also shows good ability to detect change in the hand OA population (Hennig, Haehre, et al., 2015). However, longstanding debate exists about the validity of using person-specific instruments in cross-participant group-level evaluation, a purpose for which they were not designed (Donnelly & Carswell, 2002; Kyte et al., 2015).

The dynamic PROMIS employs item response theory to establish item difficulty estimates which, when used to select questions in a CAT situation, can increase measurement precision and accuracy (Lehman et al., 2011). The flexibility of this system is more likely to capture the diversity of functional limitations than currently available region- and condition-specific instruments (Lehman et al., 2011). The PROMIS physical function upper limb sub-domain appears to be able to detect differences between thumb CMC OA and other hand conditions and has been shown to have good

construct validity when evaluated against the DASH and QuickDASH (Beleckas, Gerull, Wright, Guattery, & Calfee, 2019). However, limitations include the level of technological capability required to reliably administered the CAT version and the need for additional validation testing (Makhni et al., 2017). Responsiveness to change is also yet to be explored in hand conditions (Brodke, Saltzman, & Brodke, 2016).

In summary, currently available measures are not satisfactory and their adaptation or the development of a new self-report outcome measure for thumb CMC OA is warranted. Findings from this thesis can contribute to future work. More robust, relevant, easy to use instruments are required to assess functional outcomes before splinting effectiveness for function can be determined.

6.6 Impact beyond physical limitations

The qualitative study in Chapter 3 revealed that people with thumb CMC OA experience a range of impact beyond that of hand-specific symptoms and function, including negative emotions, altered sense of self related to negative perceptions of ageing, reduced activity levels, and medication burden. These data highlight the broader patient experience of thumb CMC OA which is fundamental in determining suitable outcomes to evaluate the effectiveness of interventions and to assist clinicians to meet their patients' needs and expectations (Carr, 1999; Hawker, Gignac, et al., 2011; MacDermid, 2005; Wylde, Hewlett, Learmonth, & Cavendish, 2006).

Negative emotions experienced by participants included anger and frustration relating to pain and restrictions in work and life roles. Another negative impact was concern about the future. Maintaining independence was a common concern and has been reported in previous studies of hand OA (Hill et al., 2010); this is unsurprising given the central role of the hand and thumb in daily activities. Such negative mental and emotional impacts are important treatment targets in thumb CMC OA, while they are likely to contribute to the pain experience and are distressing on their own merits, they can also respond to a variety of interventions.

Participants described an altered sense of self, related to a negative perception of their thumb CMC OA, as a signifier of ageing. This may be explained by findings of previous

qualitative work among older people in the United Kingdom that one's dignity can be jeopardised in older age, compared with other age groups, by being associated with loss of identity and loss of value (Woolhead et al., 2010). In New Zealand about 20% of adults aged 50 years or over reported as having felt invisible because of their age and around one third are concerned about becoming a burden on family, even though only 8% of younger people see them in this way (Ministry of Social Development, 2016). In the World Values Survey, 60% of respondents thought that older people were not respected and the lowest levels of respect were found in high income countries (Officer et al., 2016). Ageing in this period of neoliberalism which emphasises qualities of individualism and independence can be a fraught experience (Rubinstein & de Medeiros, 2015). This wider context is liable to be an important factor in the impact of thumb CMC OA experienced by patients.

Another negative impact experienced by participants in the qualitative study was reduced general activity levels. This has potential to contribute not only to a decline in a person's general health but also to co-morbidities including mental health (Callahan & Ambrose, 2015; Kim, 2019). Therefore, maintenance of general activity to avoid decline in overall health is another important target for intervention in those with thumb CMC OA.

Participants in the qualitative study wished, wherever possible, to avoid surgery and the burden of medication, especially in the presence of multi-morbidities. This compares with more mixed views found among cohorts of people with hip and knee OA for whom surgery is often seen as a more mainstream and available option (Papandony et al., 2017).

Along with the impacts of pain and physical limitations described in the previous sections, these data portray in detail the less tangible and less easily measured costs borne by individuals with thumb CMC OA.

6.6.1 Assessing the broader impact

The findings of the qualitative study in Chapter 3 support those authors who now encourage a holistic approach in clinical trials of OA, i.e. monitoring the health of the 'whole person' (Kloppenburg, Maheu, et al., 2015; Lundgren-Nilsson et al., 2018).

However, it is unclear whether the measures available can do this justice (Lundgren-Nilsson et al., 2018; Michon et al., 2011).

Health-related QoL measures such as the EQ-5D-5L capture aspects of emotional and spiritual well-being, as well as perceived physical health status. Notably, however, one of the EQ-5D-5L questions relates to mobility, which is less likely to reflect isolated OA thumb-related QoL, and this forms one fifth of the measure. Its generic scope might account for the negative change seen in the EQ-5D-5L in the feasibility study at 6-months, compared with the positive change seen in all other measures, i.e. by reflecting change in factors not directly related to thumb CMC OA. Other widely used HR-QoL instruments, such as the SF-36, have a similar emphasis on the lower limb. Suitable measures for assessing wider well-being in thumb CMC and hand OA is another area for further research.

In contrast to previous findings in OA of hand joints generally (Hill et al., 2010; Stamm et al., 2009) participants in the qualitative study were minimally concerned about the aesthetic impact of their condition. This concurs with a previous U.K. study in which aesthetic appearance was of lesser concern for thumb CMC than nodal or erosive hand OA (Marshall et al., 2013). While assessment of aesthetic distress is advocated for general hand OA (Michon et al., 2011; Stamm et al., 2009), this domain need not form part of the outcome repertoire for thumb CMC OA.

6.6.2 Management approaches

Management of persistent pain and its attendant social, emotional, and spiritual impacts, requires an holistic approach (Allen et al., 2016; Lundgren-Nilsson et al., 2018). This requirement has been identified by both patients and physicians in primary care of generalised OA (Rosemann et al., 2006). A range of complementary therapies including Yoga and Tai Chi can be ways in which to support a more holistic approach to OA management and are recommended by international guidelines (Bannuru et al., 2019); however, the reasons or justifications for seeking complementary therapies are diverse and health professionals may not be well informed (Kim et al., 2020). Nevertheless, alleviation of OA pain can positively affect coping strategies, sleep, and mood, which then engender further improvements in pain and function (Hutchings et al., 2007). Such

approaches are likely to be of benefit in addressing the broader impact experienced by people with thumb CMC OA.

Given the negative impact of thumb CMC OA on sense of self and quality of life reported in the qualitative study, consideration of the impact of splint use on these aspects is also necessary when investigating splinting as an intervention. Few studies have reported the personal experience of splint wearing generally and only one study could be located that specifically explores the experience of splint wearing for thumb CMC OA (Gruschke, Reinders-Messelink, van der Vegt, & van der Sluis, 2019). This study found that, for two types of rigid splint, central phenomena of splint wearing experience were stabilizer, tool, healer, preventer, and nuisance; these were related to participants' understanding of the disease process and splint mechanism of effect (Gruschke et al., 2019). Thus, optimisation of splint wearing experience should include explanation of thumb CMC OA and the proposed mechanism of effect. The inclusion of these aspects in the best practice usual care intervention in the feasibility study may have contributed to the high levels of adherence and acceptability found in this study. Patient choice in splint types based on lifestyle, priorities, and personal beliefs may deliver an optimal splint experience (McKee & Rivard, 2004; McKee & Rivard, 2011) although evidence for achieving goals such as less pain and improved function is necessary for informed shared decision making (Towle & Godolphin, 1999). Limited narrative accounts suggest that successful patient-centred application of orthotic devices including for thumb CMC OA can make positive contributions to individual's lives (McKee & Rivard, 2004; McKee & Rivard, 2011). Further research that explores the impact of splint wearing on sense of self or quality of life in thumb CMC OA would be valuable to better inform the process of splint prescription in both research and clinical settings.

6.7 Impact-modifying factors

The work of the qualitative study also provides some insights into the ways individual and environmental factors interact to mitigate or amplify the impact of thumb CMC OA. Many of these factors are modifiable. This has implications for research, clinical practice, health services, funders, policy makers, and health worker education.

6.7.1 Personal factors

At a personal level, the impact of thumb CMC OA was found to be greater where the dominant hand was involved. Therefore, in a research setting and depending on a study's objective studies should stratify group allocation by hand dominance or adjust analyses where any baseline between-group differences are identified.

Other person-level modifiers which alleviated the impact included self-efficacy, social supports, and religious faith; those which amplified impact included cold weather and lack of good information about the condition. Interventions that can alter or harness these, for example, to improve self-efficacy or provide quality information, are likely to have a positive effect.

6.7.2 Education

Findings of the qualitative work in this thesis indicate that information and education are highly valued and sought after by patients. Provision of quality information and education to explain a condition and its symptoms is a key intervention and a core recommendation of international guidelines for hand and thumb CMC OA (Bannuru et al., 2019; Kloppenburg et al., 2019; Kolasinski et al., 2020; NICE, 2014). Education can have powerful positive effects. For example, the 'Explain pain' approach for persisting or complex pain uses a range of educational interventions to increase patients' understanding of the biological processes known to underpin pain as a mechanism to reduce pain itself (Moseley & Butler, 2015). Approaches that increase understanding, dispel myths, and allay fears are promoted for hip and knee OA (Darlow et al., 2020; O'Brien, Chapple, Baldwin, & Larmer, 2019). A conceptual model of thumb CMC OA that aids understanding, relieves fear and anxiety, and informs how CMC joint health can be influenced positively is likely to be well received. This could be developed by integrating current scientific knowledge from Chapters 1 and 2 and incorporating patients' perspectives (Chapter 3) alongside clinician stakeholders' views gathered as part of the feasibility study (Chapter 5) to produce a biopsychosocially-informed paper or digital resource. This could then be evaluated using a mixed-methods approach involving survey and focus groups with patients and clinicians, such as that undertaken for a general OA information booklet (Darlow et al., 2020).

6.7.3 Barriers to care

Impact was influenced by barriers to accessing care. Participants experienced barriers for several reasons: 1) attitudes of participants or their health provider towards thumb CMC OA and older age; 2) clinical uncertainty about the effectiveness of treatments for thumb CMC OA; and 3) financial or geographical barriers.

6.7.3.1 Attitudinal barriers

Attribution of thumb CMC OA to older age, by participants or their health providers, was a frequent experience of participants in the qualitative study. This presents a barrier to accessing care for thumb CMC OA because symptoms are often minimised or ignored. Health worker prejudice towards older patients is a recognised phenomenon that influences decision making and impedes equitable quality and quantity of care for older people (Wyman, Shiovitz-Ezra, & Bengel, 2018), including those with OA (Gignac et al., 2006). Age-related biases and assumptions held by adults themselves are also a known phenomenon that can influence interactions with health services (Gignac et al., 2006; Wyman et al., 2018). While thumb CMC OA is more prevalent in older age, well-informed clinicians and patients are able, nevertheless, to make a difference to outcomes and the impact experienced; stronger evidence for treatment effectiveness will help this.

6.7.3.2 Clinical uncertainty

Clinical uncertainty was evident in the qualitative study on the part of both participants and participants' reports of their interactions with clinicians. Lack of clarity about which treatments work or do not work leads to people either to avoid seeking care or to seek inappropriate care (Ackerman, Livingston, & Osborne, 2016; Runciman et al., 2012). This has been previously identified as a barrier to care in hand OA (Hill et al., 2011). A scarcity of research, particularly concerning peripheral joint OA such as the thumb CMC and hand, contributes to this problem (Hunter & Bierma-Zeinstra, 2019). The use of non-pharmacological, non-surgical treatments, including physiotherapy and occupational therapy, among people with hand OA and OA at other joints, is surprisingly low internationally (Dziedzic et al., 2007; Dziedzic & Allen, 2018; Gravas et al., 2019; Iversen et al., 2018; Runciman et al., 2012). For example, in Australia about 40% only of those with OA receive care that is appropriate (Runciman et al., 2012), despite these

interventions being recommended as best practice first-line management (Hunter & Bierma-Zeinstra, 2019; Kloppenburg et al., 2019; Kolasinski et al., 2020; NICE, 2014). No data could be located for New Zealand. Whilst New Zealand expert clinician stakeholders nominated the type of advice, education, and exercises that they would offer a patient thumb CMC OA as part of the best practice usual care development for the feasibility study, findings from the qualitative study indicate that, unfortunately, such care is not yet 'usual' in New Zealand.

6.7.3.3 Cost barriers

Findings from the qualitative study indicated that some participants were prevented from accessing care by an inability to pay for health services. In the New Zealand healthcare system access to care for thumb CMC joint OA and OA at other joints is under-resourced (Baldwin, Briggs, Bagg, & Larmer, 2017), a situation common to many countries (Ackerman et al., 2016; Choojaturo, Sindhu, Utriyaprasit, & Viwatwongkasem, 2019). Although New Zealand has a universal secondary-level public health system, primary care general practice is accessed on a subsidised user-pays basis (Goodyear-Smith & Ashton, 2019) and most allied health OA-related primary care services have no subsidy. Therefore, both primary care and second tier services can be out of reach for those unable to pay (Jatrana & Crampton, 2020). Changes to health policy, funding, and provider arrangements that enable subsidised or universal access to care are likely to improve outcomes for people with CMC OA.

Knowledge of the personal, social, and societal factors that modify the impact of thumb CMC OA to enable better understanding of variations in presentations or treatment effect is a target for health resourcing and changes in health worker education and health policy. The work of this thesis, along with ongoing and future research, will increase awareness of the significant impact of OA, including thumb CMC OA, and contribute to stronger evidence that will reduce clinical uncertainty, inform health services and policy, lead to better access and care provision, and improve patient outcomes.

6.7.4 Potential models for implementing best practice care

The implementation of best practice care as usual care in New Zealand and elsewhere requires urgent attention. Modes of delivery such as telehealth or mixed media approaches may help to overcome cost and geographical barriers and make care more directly accessible to patients.

Implementation of best practice care for peripheral joint OA generally in primary care has been investigated in the in the Model Consultation (MOSAICS) study (Dziedzic et al., 2018). In this cluster RCT a well-developed package of care was provided to participants in the intervention group including an enhanced GP consultation, education, advice, pain management, an OA self-management guidebook, and practice nurse follow-ups. Although the intervention resulted in statistically significant higher uptake of best practice care, the primary clinical outcome of SF-12 physical component score was not significantly improved. A small but significant reduction in NSAID use was observed. Possible reasons for the lack of expected benefit included patient or clinician beliefs limiting access to nurse follow-ups, the time frame of 6-months being too short to see benefit in the chronic condition, complexity requiring more specialist input, and insufficient uptake of self-management or exercise intensity or both (Dziedzic et al., 2018). It was concluded that the optimal combination of strategies for implementing best practice care for OA was yet to be discovered. Of note, the study had no severity threshold entry criteria and mean pain scores for the hand at study entry were low, around 2.9 on an 11-point scale. This may have resulted in a potential floor effect for participants with primarily hand OA. Furthermore, the 54-page self-management guidebook was lengthy and relatively generic. Possibly, a more focused approach e.g., for each joint or tailored to the patient, may have had a greater impact particularly where the thumb CMC joint is concerned.

A number of OA management programmes (OAMPs) have had their implementation evaluated in various countries (Eyles et al., 2019). Overall, understanding of the optimal approach to implementation of OAMPs remains in its infancy. An international survey and prioritization exercise generated five top issues recommended for urgent attention: 1) guidelines for implementing OAMPs to enhance consistency of delivery and adherence to best practice guidelines; 2) training and education programmes for health

care professionals (HCPs); 3) develop and evaluate implementation of novel models of OAMPs; 4) develop and evaluate core skill sets and resources for HCPs; and 5) develop a framework for enhancing quality of care provided by OAMPs (Eyles et al., 2019).

Telehealth (remote synchronous or asynchronous patient care including by telephone, video conference, and online materials) is an example of a novel OAMP model. Multi-media telehealth interventions for knee OA have shown a good level of acceptability among both patients (Lawford et al., 2020) and clinicians when well supported (Lawford et al., 2021), and positive outcomes (Hinman et al., 2020). It is postulated a blended model with options for in-person in addition to telehealth may meet the needs of the widest range of patients (Hinman et al., 2020). A process evaluation with programme coordinators involved in leading the Australian secondary-care referred Osteoarthritis Chronic Care Programme identified telehealth as a potential key facilitator for improved implementation by overcoming space and geographical barriers, particularly if primary care input were to be expanded (Eyles et al., 2020).

A preliminary evaluation of telehealth assessment and management of hand impairments and function deficits by occupational therapists concluded that telehealth has potential as a successful model of service delivery that can facilitate implementation of best practice care for a range of hand conditions (Worboys, Brassington, Ward, & Cornwell, 2018). Brief review of the literature reveals that an OAMP model for thumb CMC OA that includes telehealth has not yet been developed or evaluated; this is a key area for future research.

6.8 Splinting effectiveness and prescription

The systematic review reported in Chapter 4 found that splinting has a moderate-to-large effect in the medium-term but not in the short-term; but both findings were of low quality.

The feasibility study in this thesis aimed to implement splint wearing at the highest dosage possible and acceptable. Following consultation with New Zealand expert hand therapists, this was tested for 20 hours of 24, including while sleeping. In contrast to previous large studies this small feasibility study produced findings indicative of an

effect at short-term as well as medium-term. This is encouraging and may be a result of the high splint dosage or the overnight wearing, or both. Importantly, this study demonstrated that splint wearing at a higher dose than reported in previous controlled trials is feasible and acceptable to patients.

The lack of withdrawals or dropouts in the feasibility study concurs with the finding of the systematic review of Chapter 4 and is encouraging for future studies. It provides further support to the existing evidence that there is no significant harm associated with splint interventions. This, together with the high level of acceptability, is an important point for both research and clinical practice since thumb CMC OA is a long-term condition and interventions that can be used frequently, for long or short periods without harm, are of high importance for optimising participants' overall health and QoL.

The mechanisms by which splint interventions influence first CMC joint alignment, motor patterns, synovial inflammation, or pain modulation and whether these are related to changes in patient symptoms are all areas requiring further research. A range of technologies now exist with which living tissues (and the impact of interventions) can be investigated, including biomechanical, EMG, and imaging methods.

Splinting has good indication in all respects, and good potential to address patients' pain concerns and meet patients' desires for non-pharmacological, non-surgical interventions for symptomatic thumb CMC OA. Further investigation of both the efficacy and the effectiveness of splinting is merited.

6.9 Literature update on the effectiveness of splinting for thumb CMC OA

Since the systematic review in this thesis was undertaken, a large multi-centre RCT has been completed investigating the effectiveness and efficacy of active vs placebo thumb splints, in addition to an 8-week self-management programme, for participants with symptomatic thumb CMC OA (Adams et al., 2020). The OTTER study was conducted across 17 U.K. National Health Service (NHS) localities and enrolled 349 patients randomised in 1:1:1 ratio. Loss to follow-up was 16% at the primary endpoint of 8-weeks. On the primary outcome (AUSCAN hand pain, 0-20) there was no evidence of

clinically or statistically significant differences between the intervention groups: active splint vs placebo splint MD -0.4 (95% CI -1.4 to 0.6 p=0.41); active splint vs. self-management -0.5 (-1.4 to 0.4 p=0.26); placebo splint vs. self-management -0.1 (-1.0 to 0.8 p=0.78). This result of no effect for splinting in the short-term concurs with the findings of the systematic review in this thesis. Furthermore, although some imprecision may persist, this was a large, well-conducted study with low risk of most biases and thus would be likely to increase the GRADE rating of the finding to a moderate quality and reduce the likelihood that any future study would change the conclusion.

However, several aspects of the study interventions require further consideration. First, the splint intervention involved some variability; a decision tool was used to determine whether a participant was fitted with a soft, off-the-shelf neoprene splint, or a custom-made rigid thermoplastic splint (Adams et al., 2019). If more targeted intervention is more beneficial, this variability could have increased the effect or it could have reduced the effect if only one splint is more beneficial, or if the decision tool was imperfect to begin with. Second, splints were prescribed to be worn for approximately 6 hours in the day and wearing at night was discouraged (Adams et al., 2019). This dosage may not have been high enough to produce an effect, particularly if wearing a splint at night is a key factor, although this is not yet established. Third, the self-management programme was standardised, developed, and based on best practice comprising education, advice, and exercises (Adams et al., 2019). This represents a well-designed comparator; however, it is also likely to have reduced the effect size detectable for the splint. While including standardised usual care is a necessary development, it does make investigating interventions for thumb CMC OA more challenging, particularly when the effect size of a given 'usual care' remains unknown.

In summary, in any future trial, sufficient dosage of a splint intervention is likely to be a key factor in its effectiveness for improving pain in thumb CMC OA, and the addition of best practice usual care to both the intervention and comparator groups raises the floor and increases the difficulty of detecting a difference between groups. The protocol outlined in the feasibility study in this thesis involves a substantially higher splint dose and could give a different result. An interim step could be a dose-ranging study in which

response to low splint dose such as that in the OTTER study is compared to medium or high splint dose such as that described in the feasibility study. The purpose of this type of study would be to estimate the response compared to dose given to analyse the efficacy of the intervention (Portney, 2015). Findings could further refine the future trial design or further inform whether to proceed with a full trial or both. Knowledge of the effect size of best practice usual care would aid in design of a future trial; however, it is unrealistic that this will ever be possible to study.

An additional consideration regarding the OTTER study is the choice of primary outcome: the AUSCAN hand pain scale. This instrument places little emphasis on pain at night with one question asking about 'pain at rest' while the other four relate to pain on activities. Therefore, this measure may have lacked sensitivity for thumb CMC OA pain and so failed to detect actual change that may have occurred. Evaluation of splinting using pain, and pain at night, on NRS, as described by the feasibility study may be a more appropriate primary outcome.

6.10 Treatment responsiveness

Although most outcomes in the feasibility study demonstrated positive change, all require determination of what represents meaningful change in a thumb CMC OA population. The paucity of robust evidence of MCID for grip and pinch strength is particularly surprising, especially given that these measures are widely used as proxies for general health status in the older population (Bohannon, 2019), in which hand and thumb CMC OA are common. The GAT and the measures of thumb palmar abduction (IDD and Pollexograph) also require determination of validity or MDC, or both. Importantly, MCIDs are not absolutes; rather, they differ for different populations and contexts.

The MCID of outcomes can be established by interpreting the outcome's change (Portney, 2015). This can be done using one of two general approaches: distribution- or anchor-based (Portney, 2015; Wright et al., 2011). However, each method has its weaknesses. The distribution-based approach uses statistical methods and probability sampling (Portney, 2015); the major short-coming of these is that, because the importance of the observed change is not known, they identify the MDC, i.e. the smallest

detectable change beyond random error, rather than the MCID (Wright et al., 2011). By way of contrast, in anchor-based approaches scores are fixed to a reference standard, for example, a question that asks the patient about the level of change since a point in time, such as the GROC provides.

A strength of the anchor-based approach is that the external anchor takes into account an understanding of the patient's perspective of change (Wright, Hannon, Hegedus, & Kavchak, 2012). A limitation of this approach is the intrinsic weaknesses of the GROC which may suffer from recall bias (Portney, 2015; Schmitt & Abbott, 2015; Wright et al., 2011) and uncertainty about what represents meaningful change on this primary measure for a given population and context (Terwee et al., 2010; Wright et al., 2012; Wright et al., 2011). Nevertheless, it is recommended that MCID be based primarily on anchor-based methods. Therefore, this would be an appropriate method to follow for determining MCID for outcomes in thumb CMC OA. It has also been recommended that MCID should exceed the MDC values, and should not rely on one study or one method only (Terwee et al., 2010). A more nuanced approach can be achieved by determining MCIDs relevant to participant demographic details such as baseline severity (Wright et al., 2012).

6.11 Overall strengths and weaknesses of the thesis

6.11.1 Strengths

The strengths of this thesis derive from the pragmatic methodologies used to investigate the research questions, which entailed practical real-world perspectives, resulting in knowledge that translates directly to the needs of patients, clinicians, health services, researchers, and funders.

The qualitative study in this thesis is the first investigation into the unique impact of thumb CMC OA from the patient perspective using interview methods. The pragmatic qualitative methods brought to light the significant and far-reaching impact of thumb CMC OA for patients, an impact which extends beyond that of physical impairments and symptom presentation. As an initial consequence, clinicians will be better informed in their management of the condition; beyond this, health services, researchers, and funders should be spurred on and justified in devoting more attention and resources to

the problem of thumb CMC OA. Furthermore, patients themselves can expect to find benefit from a greater shared understanding of their condition.

The use of qualitative methods ensured inclusion of patient perspectives in a robust way and enabled important insights to be incorporated into the feasibility study early in the research process. The input from stakeholders through focus group and individual interviews and including their clinical practice experience, together with the daily professional practice of the PhD researcher, increases the likelihood that future study findings will be successfully translated into clinical practice.

The pragmatic approach to the qualitative study prompted responses relevant to the clinical presentation and preferred treatment options, as well as identifying barriers to potentially successful interventions. Findings from the study help to explain variation in thumb CMC OA presentation and response to treatments in clinical practice and research, for example, through consideration being given to the presence of other stressors in peoples' lives and the impact on emotional well-being and general health. Furthermore, the qualitative study generated rich information that will inform the future development and refinement of outcome instruments and indicates areas where, for example, educational interventions may have benefit and may be worth the investment of further research and health service resources.

The use of systematic review methods enabled a nuanced appraisal of available evidence as well as the potential pitfalls and difficulties of examining the questions of the benefits of splinting in thumb CMC OA and the difficulties of defining outcomes. The systematic review concluded that splinting is a promising non-invasive intervention for thumb CMC OA, and that the evidence supports the conditional recommendations made for the benefits of splinting.

The methods of the feasibility study overcame several of the limitations identified in the previous studies of splinting for thumb CMC OA. Blinding participants to group allocation, providing similar or equal quantities and quality of participant materials and researcher contact time across groups, all reduce the likelihood of an effect size being over-estimated due to non-specific placebo effect (Bandholm et al., 2017; Fitzgerald et

al., 2015; Fregni et al., 2010). This has not been achieved in any of the previous studies reported in Chapter 4. Novel methods also included using ultrasound to explore its role in characterising structural changes and inflammation, trialling the IDD, a modified method of measuring palmar abduction, and using a quantitative score of NSAID use.

The pragmatic orientation of the feasibility study, including the clinically applicable inclusion criteria and outcome measures, and the acceptability of the interventions to clinicians and patients will make findings of a future full RCT translatable to a broad range of clinical settings and patient presentations.

Another strength of this thesis were the steps embedded in both the qualitative study and the feasibility trial to increase the recruitment of Māori participants. These included early consultation with Māori research advisors; the targeting of populations with a higher proportion of Māori, for example, adding the second centre; including people who might not otherwise seek care; consulting with service providers where possible about how to promote the study and to enable appropriate locations for study activities; and extending the recruitment time to implement strategies specifically aimed at recruiting Māori participants. In both studies the recruitment of participants of Māori descent in proportions that matched or exceeded the percentage in the local population is a positive outcome and is also an improvement on the low rates of recruitment of indigenous populations in much arthritis research (O'Brien et al., 2020; Strait et al., 2019). The recruitment approach taken in this thesis is recommended as a small step towards addressing inequities in health care.

However, Māori remained a small proportion of the total study populations. Steps to improve future recruitment include more extensive consultation with representatives, (Health Research Council of New Zealand, 2010; National Ethics Advisory Council, 2020); seeking advice from Māori health research units, such as the Ngai Tahu Māori Health Research Unit in Dunedin (Health Research Council of New Zealand, 2010). In addition, there are other actions that have demonstrated success previously and could be incorporated in a future trial, namely, extending further the recruitment of Māori participants, e.g. by 6 months after non-Māori recruitment has ended; employing Māori research staff; committing to home- or marae-based assessment and interventions; and

greater use of whakawhanaungatanga (the process of establishing relationships, relating well to others) (Dyall et al., 2013; Selak et al., 2013).

In summary, the methodological strengths of the work in this thesis are likely to make significant contributions to achieving high quality and accessible non-surgical, non-pharmacological care that supports health and well-being for all people with thumb CMC OA.

6.11.2 Weaknesses

Limitations of the work in this thesis relate to the limitations of qualitative research generally, the need for validated classification criteria for thumb CMC OA, and the need for longer timeframes for follow-up.

While valuable for generating rich understandings, the findings of the qualitative work in this thesis are not generalisable to all people with thumb CMC OA. A different researcher will bring different perspectives, experiences, and relationships, and may generate different data and make alternate interpretations (Creswell, 2014; Padgett, 2012). This is a limitation applicable to the qualitative work in this thesis. However, the thesis introduction made clear the intent of the researcher, an experienced clinician and training clinician-researcher, to approach the work from a combined constructivist and post-positivist perspective. Furthermore, the development and conduct of the methods for collecting and interpreting interview data are robustly reported in Chapter 3. Therefore, where findings from the qualitative work are appropriate they can be applied with confidence.

Alternate methods that could also serve the research aims include focus group interviews. A strength of focus groups is the scope that they give for participants to discuss, explore, and compare their experiences, a process which enables clarifications of participants' views (Padgett, 2012). Although focus group data can be influenced by group norms and participants may be less likely to disclose personal accounts of health impacts (Padgett, 2012), focus groups may help in working through the complexity of the impact on function for further understanding of this domain, and in a co-design approach to treatment and health service development. Interview methods proved a good exploratory approach for the study in this thesis.

The inclusion criteria used in the qualitative and feasibility studies seemed successful in identifying people with thumb CMC in the community but require validation. The use of validated classification criteria is recommended for entry into OA clinical trials (Fitzgerald et al., 2015). The feasibility study in Chapter 5 built on the clinical classification criteria used in the qualitative study in Chapter 3; these criteria could be investigated further for wider use in thumb CMC OA studies and clinical practice.

The feasibility study included follow-up at 6-months but because thumb CMC OA is a long-term condition with long-term outcomes, follow-up >12 months is desirable in order to delineate the success of therapeutic approaches (Kloppenburg, Maheu, et al., 2015). Furthermore, acquiring additional interview or questionnaire data, e.g. at 4-weeks and 6-months, may reveal more about whether splint-wearing continues under participants' own volition and more about what enables splint-wearing or what sets up barriers.

6.12 Recommendations for future research

This thesis has focused on the impact of thumb CMC OA from the perspective of people with the condition, and on the effectiveness of splinting based on existing evidence. When findings from these two threads of inquiry established that the lack of high-quality studies investigating splinting constitutes a gap in the current evidence, a feasibility study for a full RCT was designed, informed by the first two studies, to address this problem. The findings of this third study indicate that a full RCT is feasible; recommendations for a full trial are outlined below.

Several other areas requiring further investigation were also outlined in the sections above. These include developing or identifying a consistent measure of pain; the development of outcome instruments for self-reported function and HR-QoL in thumb CMC OA; developing a clinical definition of the condition; refining splinting and best practice usual care interventions; developing and evaluating implementation for best practice care; a dose-ranging study to estimate intervention efficacy; establishing validity for IDD, Pollexograph, and GAT in thumb CMC OA; providing estimates of MCID for outcomes in thumb CMC OA that account for the patient perspective; and refining the use of ultrasound in clinical trials. While the work needing to be done for some

aspects could occur as smaller studies nested within a larger trial, the conduct of a full RCT should be preceded by exploration of splint dose effect and optimisation of outcome measures. The detail of these additional studies is for future consideration. The purpose of this section is to put forward a design for a future fully-powered RCT based on the work to date.

6.12.1 Inclusion criteria

Based on the findings of the feasibility study and the qualitative study reported in Chapter 3, it is recommended that inclusion for studies in thumb CMC OA should not be based on self-report functional score. The inclusion criteria for the present study included stipulated severity thresholds of pain NRS ≥4/10 and FIHOA score ≥6/30 as recommended per the OARSI clinical trials group recommendations for hand OA (Kloppenburg, Maheu, et al., 2015). However, the FIHOA does not adequately capture all those who need and would benefit from treatment. Furthermore, pain is the largest concern to most people with thumb CMC OA and this outcome is more likely to change in response to treatment. This refutes the OARSI clinical trials group recommendations. It suggests rather that for thumb CMC OA clinical trials, a pain score ≥4/10 should be the only stipulated severity threshold criterion.

6.12.2 Primary and secondary outcomes

A clearly delineated rationale for the choice of primary and secondary endpoints is essential for good clinical trial design (Losina et al., 2015). Based on the clinical findings in the feasibility study, the patient perspectives described in Chapter 3 where pain and pain at night were the greatest impact for most participants, and on the findings of the systematic review in Chapter 4, pain NRS is recommended as the primary outcome domain for a future full study recording both pain on average in the past week and pain on average at night. Pain, particularly pain at night, showed potential as the most sensitive measure to detect the effect of the splint intervention, in both the short- and medium-term.

While functional limitations and restrictions in important life roles also have significant impacts on people with thumb CMC OA, these domains did not appear to be adequately assessed by the currently available instruments used in this study. Secondary outcomes

should include a patient-reported functional measure; however, since it is not clear which instrument or instruments should be used, new or adapted measures are likely to be necessary to determine the effectiveness of splint for function in thumb CMC OA.

For pain NRS outcomes and, in a smaller number of participants, functional self-reported outcomes, a proportion of participants in both the splint and comparator groups showed reliable and clinically important responses. Future work should narratively explore these participants to identify any apparent characteristics that may warrant investigation as potential predictors of treatment response, to either splinting or the best practice usual care intervention. The intensive study of the individual known as the idiographic approach (Barlow & Nock, 2009) has high internal validity; it can discover key sources of inter-subject variability and begin to isolate factors responsible for this variability (Barlow & Nock, 2009).

The OMERACT-OARSI responder ratio which captures a combination of pain and function makes it an alternate candidate for primary outcome. At present, instruments designed to measure functional outcomes in the hand are not yet satisfactory for contributing to the primary outcome in thumb CMC OA. Therefore, responder criteria are not the best choice for primary outcome. However, the benefits of this measure and the ability to detect a difference between groups as described in the earlier section, makes it a robust and useful secondary outcome.

The GROC should also be part of the repertoire of secondary outcome measures even though its use is contentious. In musculoskeletal conditions, the GROC has been shown to be strongly biased toward a person's current symptom state with little or no consideration of baseline symptom state and therefore unable to reflect accurately change over time (Norman, Stratford, & Regehr, 1997; Schmitt & Abbott, 2015). However, the GROC can serve as an anchor measure to help build literature of MCID for outcomes in the specific population and contribute to future research (Jaeschke et al., 1989; Wright et al., 2011). It has therefore a useful role in a future trial.

In the feasibility study, QoL measured by the EQ-5D-5L appeared to detect some positive change at 4-weeks. However, the return to baseline or below at 6-months,

irrespective of the maintained improvements in pain, is a possible anomaly relating to the small sample size. Whether another QoL instrument would serve better in the thumb CMC OA population is unclear. However, the EQ-5D-5L is a well-validated measure that can also be used in cost-effectiveness analysis (van Reenen & Janssen, 2015), another dimension that should be added to a future full trial. Evaluation of the relative cost-benefit of a given intervention is necessary to make decisions about health service resources (Ramsey et al., 2015), yet evidence that non-surgical, non-pharmacological interventions are cost effective in hand or thumb CMC OA is rare (Hiligsmann et al., 2013; Tveter et al., 2020). The EQ-5D-5L index score can serve as a QoL utility measure and can be analysed alongside direct health costs, such as health services and medications, and indirect costs, such as lost productivity, both absenteeism and presenteeism, and transport (Hiligsmann et al., 2013; Losina et al., 2015; Ramsey et al., 2015). While a cost effectiveness analysis was not an aim of the present study, the utility and acceptability of the EQ-5D-5L indicates that it is feasible to collect the data required to conduct such an analysis. Therefore, the EQ-5D-5L should be kept as a secondary outcome.

Despite the apparent floor effect of medication use, its importance to patients and its potential to be more informative over longer time periods, qualify this end point as relevant to the outcome set of a future fully-powered study. Additionally, failure to record medication use or to control for it in analyses could mask important effects and could potentially over- or under-estimate responses. Additional analyses can be conducted for the proportions of patients achieving other NSAID-sparing endpoints, for example 50% decrease in NSAID score compared with baseline, NSAID score <10, or NSAID score = 0 (Dougados et al., 2014).

Based on the findings of the feasibility study, the qualitative findings of Chapter 3, and previous literature outlined in the earlier section of this chapter, other secondary outcomes should include grip and pinch strength and measures of thumb palmar abduction. However, establishment of MCID for these measures and confirmation of the validity and reliability of the palmar abduction measures in thumb CMC OA require further research; the same is indicated for the GAT measure of physical function. An additional outcome is to monitor joint activity. While joint activity was recorded in the

feasibility study from participants' verbal reports at baseline, recording at the follow-up points would help to identify whether this is a confounding factor in treatment response in thumb CMC OA. Furthermore, the use of hand diagrams as reported in Chapter 3 would be a feasible and more robust method to monitor local hand joint activity.

The feasibility study demonstrated the feasibility of investigating splinting for thumb CMC OA for outcomes at both 4-weeks and 6-months. Good participant retention for data collection at these time points and over a longer period is also supported by previous studies (Gomes Carreira et al., 2010; Rannou et al., 2009). Given the long-term nature of thumb CMC OA it is recommended that 6-months rather than 4-weeks is a more appropriate primary endpoint. Additionally, 12- and 24-month follow-ups should be included. In summary, it is recommended that pain intensity at 6-months is used as the primary outcome.

6.12.3 Sample size for future trial

Factors affecting a sample size calculation are the precision and variance of measurements within any sample; the magnitude of a clinically important difference; with how much certainty a type 1 error is to be avoided; and the type of statistical test performed (Cook et al., 2018; Portney, 2015).

While the feasibility study was not statistically powered to give precise estimates of effect size and variability, it was the first study conducted in people with thumb CMC OA in which the benefit of a splint in addition to standardised best practice usual care was investigated. Therefore, the findings, alongside those of previous large trials, are important to inform what constitutes a realistic estimate of variability (Sim, 2019).

The size of the target difference to be used for calculation of the sample size for a future trial can be approached in several ways. Reassurance that a target difference can be reliably detected is given by a sample size that is sufficiently powered to do so, in this case, power of 90% (Cook et al., 2018), and by setting the level of statistical significance at that planned for the statistical analysis, i.e. 5% (Cook et al., 2018). Using these data, a priori sample size calculations can be modelled to give a range of sample sizes, using G*Power 3.1.9.7 (Universität Kiel, Germany), for a future randomised controlled two-arm parallel superiority trial with 1:1 allocation ratio and an unadjusted analysis of a

primary endpoint assessed with a two-tailed *t*-test and accounting for loss to follow up of 10%.

One approach is to take the median of the estimates of the change over time for the splint (MD -2.2) and comparator groups (MD -0.5) reported at 6-months in the high-quality studies identified in the systematic review and use the variability of the groups from the feasibility study for pain at night NRS (SD 3.06 and 3.21 for splint and comparator group, respectively) (Table 5.13). With this option, the required sample size is 102 participants.

An alternate approach is to take the previously published MCID for pain NRS in an OA population of 2.0 points as the basis for a target difference and variability from either that reported in previous high-quality studies (estimated at SD 2.39 for both groups) (Table 5.13), or that found in the feasibility study for pain NRS at night (Table 5.13). Using these parameters, total sample size requirements of 86 and 143 are calculated. A caveat is that the MCID for a thumb OA population representative of that in the feasibility study may well differ to the MCID previously published. Furthermore, MCID specifically for pain at night NRS may differ again.

A trial of N=143 would require a third centre to ensure successful recruitment within a reasonable time frame, for example, 1-year. A large urban centre in the North Island of New Zealand is recommended, such as Wellington, Hamilton, or South Auckland. Such urban populations with higher proportions of potential Māori participants would also support a greater rate of recruitment. The smaller sample size of 86 could be conducted across the same two centres as the feasibility study but may benefit from involving a third larger centre for the reasons above. Before proceeding with a full study, consultation with a biostatistician as well as careful consideration of what constitutes a clinically important change in pain on average and pain at night NRS from patient, clinician, and statistical perspectives would be essential to confirm specific values used for the sample size calculation (Sim, 2019). Patient and clinician stakeholder involvement in the study design stage including decisions around sample size calculation would help to ensure the study is capable of detecting change that is meaningful to patients and clinicians.

In summary, the work in Chapter 5 demonstrated the feasibility of conducting a fully-powered RCT of splinting for thumb CMC OA pain. The recommendations detailed in Chapter 5 and above would ensure that the study would be robust and of high quality.

6.13 Conclusions

Thumb CMC OA has a profound impact on a person's health and well-being. Pain, including pain at night, is the major impact and it influences impact at other levels. Physical limitations, for example, loss of dexterity and hand strength, appear to be associated with thumb CMC OA pain.

This thesis highlights the fact that the impact of thumb CMC OA reaches well beyond hand-specific symptoms and physical impairments, imposing significant limitations on a diverse range of functional activities. It restricts people's important life roles including work, caring for others, and recreational activities. Its broader impact gives rise to negative emotions, concerns about the future, and an altered sense of self related to ageing. The findings of the qualitative study suggest that the impact of thumb CMC OA has been underestimated. As a consequence, these findings emphasise the importance of going beyond the physical impairments in order to assess the impact of thumb CMC OA adequately. The immediate benefit would be more appropriate and potentially more successful treatment plans.

The findings of this thesis support the contemporary move towards patient-centred outcome evaluation. However, they also highlight the extensive knowledge gap in this area, as well as limited previous research, for thumb CMC OA.

The qualitative study found that personal, social, and societal factors play important roles in the overall impact of thumb CMC OA. For example, cold weather and involvement of the dominant hand are negative influences while social supports, religious faith, self-efficacy, and access to health services are positive influences. Quality information and advice is highly sought-after by people with thumb CMC OA, and non-pharmacological, non-surgical interventions are preferred.

Splinting is an intervention well-matched to the biomedical problems of CMC OA and to patient preference. This thesis suggests that splinting, supported by best practice usual

care education, advice, and exercises, may play a key role in improving outcomes that are important to people with thumb CMC OA.

The systematic review in this thesis demonstrated low-quality evidence for splinting as an effective treatment for thumb CMC OA with a moderate-to-large effect on pain and a small-to-moderate effect on function in the medium-term and, in the short-term, very low-quality evidence of no effect. Although this showed that splints are a promising treatment for thumb CMC OA, further research is needed because of the present lack of high-quality studies. A high-quality fully-powered trial, robustly informed by patient perspectives and able to address some or all of the challenges identified by the systematic review, would provide much needed evidence for the effectiveness of splinting in thumb CMC OA.

To this end the thesis, in its feasibility study, developed and tested design elements for a trial to investigate the effectiveness of a soft off-the-shelf splint for thumb CMC OA. The study blinded assessors and partially blinded participants, assessed outcomes important to patients including pain at night and QoL, trialled alternate functional outcomes, and explored the role of ultrasound imaging. A splint dosage much higher than reported in earlier studies, including overnight wearing, was found to be feasible and acceptable to participants and a standardised best practice usual care was determined to be acceptable and well adhered to. Modifications to the study design were identified that would optimise the interventions, recruitment, outcome assessment, and the overall conduct of the study.

Change in pain at night NRS exceeded a known estimate of MCID in the splint group at 4-weeks and 6-months, and an apparent between-group difference in favour of the splint group was present at both time points. Calculations were made that estimate a sample size of between 86 and 143 participants may be capable of testing for a clinically meaningful difference in pain at night NRS at 6-months.

In light of the recent OTTER trial, exploration of dose effect and further optimisation of outcome measures should occur before an RCT based on the protocol formulated in this

thesis is conducted. If the routine prescription of splints can be shown to be effective, it will lead to significant improvements in patient care.

In conclusion, this thesis presents clinicians, health services, researchers, and funders with a greater understanding of the patient experience of thumb CMC OA and enables a more nuanced approach to its management. The findings provide the impetus for researchers and funders to take up and support the work required to provide a more robust evidence base for this long-term, high-impact condition. Finally and importantly, the work in this thesis can help patients to feel validated in their experiences of this very over looked area: thumb CMC OA.

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Appendices

Appendix A Copyright permissions report log

Copyright Permissions Report (Thesis, M. Buhler, 2020 – The impact of thumb osteoarthritis and the effectiveness of splinting)

Record of details of permissions requested, and responses received.

Page number in thesis	Details of in-copyright material	Date permission requested	Permission granted for print thesis (Y / N and date)	Permission granted for digital thesis (Y / N and date)	Conditions
Chapter 1	[Fig. 1.2] *Line drawing*: The simple illustration of the thumb CMC joint. "Reprinted from Gray's basic anatomy, Second edition, Ed., Drake, R. L., Figure 7.82 Deep transverse metacarpal ligaments, (Copyright 2018), with permission from Elsevier."	21 April 2021	Y, 21 April 2021	Y, 21 April 2021	Elsevier License Number: 5053590534798 Suitable acknowledgement to the source must be made, either as a footnote or in a reference list at the end of the publication Altering/Modifying Material: Not Permitted. However figures and illustrations may be altered/adapted minimally to serve your work.
Chapter 2	[Fig. 2.1] *Line drawing:* The thumb CMC joint has been hinged open from the dorsum – *bony and ligamentous anatomy of the thumb CMC joint.*	6 Aug 2020	Y, 14 Aug 2020	Y, 14 Aug 2020	That credit be given as follows: "From Bettinger PC, Linscheid RL, Berger RA, et al. An anatomic study of the stabilizing ligaments of the trapezium and trapeziometacarpal joint. J Hand Surg Am. 1999 Jul;24(4):786-98; used with permission of Mayo Foundation for Medical Education and Research, all rights reserved."
Chapter 2	[Fig. 2.4] *Line drawing:* Trapezial cantilever bending – *pattern of collapse of thumb CMC joint*	6 Aug 2020	Y, 14 Aug 2020	Y, 14 Aug 2020	That credit be given as follows: "From Bettinger PC, Linscheid RL, Berger RA, et al. An anatomic study of the stabilizing ligaments of the trapezium and trapeziometacarpal joint. J Hand Surg Am. 1999 Jul;24(4):786-98; used with permission of Mayo Foundation for Medical Education and Research, all rights reserved."

Appendix A Copyright permissions report log

Chapter 2	[Fig. 2.2] *Photograph of dissections:* The volar thumb CMC ligaments.	6 Aug 2020	Y, 7 Aug 2020	*Y, 7 Aug 2020*	Email correspondence with Prof Amy Ladd. No specific conditions. Permission to reproduce in thesis.
Chapter 2	[Fig. 2.3] *Photograph of dissections:* The dorsal thumb CMC ligaments.	6 Aug 2020	Y, 7 Aug 2020	*Y, 7 Aug 2020*	Email correspondence with Prof Amy Ladd. No specific conditions. Permission to reproduce in thesis.

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

Thursday, 09 February 2017.

Dr Catherine Chapple,
School of Physiotherapy,
DUNEDIN.

Tēnā Koe Dr Catherine Chapple,

Thumb osteoarthritis research study: Patients' perceptions of the impact of disease and acceptability of splint interventions.

The Ngāi Tahu Research Consultation Committee (the committee) met on Tuesday, 07 February 2017 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

The Committee notes and commends that ethnicity data is to be collected using the questions on self-identified ethnicity and descent contained in the latest census.

The Committee suggests dissemination of the research findings to relevant Māori health organisations regarding this study, including Taeora Tinana, Māori Physiotherapists within the New Zealand Society of Physiotherapists.

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KAI TAHU

We wish you every success in your research and the committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 07 February 2017 to 7 August 2018.

Nāku noa, nā

Mark Brunton
Kaiwhakahaere Rangahau Māori
Research Manager Māori
Research Division
Te Whare Wānanga o Otāgo
Ph: +64 3 479 8738
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The Ngāi Tahu Research Consultation Committee has membership from:
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Te Rūnanga o Moeraki

Appendix C Ethical approval from University of Otago Human Ethics Committee

H17/032

Academic Services
Manager, Academic Committees, Mr Gary Witte

17 March 2017

Dr C Chapple
School of Physiotherapy

Dear Dr Chapple,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled **"Impact of thumb base osteoarthritis on health and every-day life: a qualitative study of patients' perspectives"**.

As a result of that consideration, the current status of your proposal is:- **Approved**

For your future reference, the Ethics Committee's reference code for this project is:- **H17/032**.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.

Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

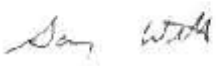
gary.wits@otago.ac.nz

jo.farrondediaz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Yours sincerely,



Mr Gary Wits
Manager, Academic Committees
Tel: 479 8256
Email: gary.wits@otago.ac.nz

c.c. Professor L A Hale Dean School of Physiotherapy

Participant Information Sheet

Study title:	Impact of thumb base osteoarthritis study
Study department:	University of Otago School of Physiotherapy, Te Kura Kōmiri Pai
Principal investigator:	Name Dr Cathy Chapple Position Senior Lecturer
Primary researcher:	Name Miranda Bűhler Position PhD student **Contact phone number:** 0800 687 489 **Or** 027 299 3979

Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part, there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?

Osteoarthritis affecting the joint at the base of the thumb is a very common condition but we don't know much about how it impacts on people's health and everyday life.

We are interested to know from you how your thumb base osteoarthritis impacts on your health and daily life.

The information from this study will help clinicians and researchers to understand the impact of thumb base osteoarthritis from patients' perspectives, and to know what are the important things that should be measured to find out if a treatment works or not.

Who will be doing the study?

The research project will be carried out by Miranda Bűhler as part of her PhD studies. Miranda is a physiotherapist and hand therapist with 13 years' experience working in the health system in New Zealand. Miranda will be carrying out the interviews and analysing all the information.

She is supported in this work by her research supervisors at the University of Otago School of Physiotherapy and Dunedin School of Medicine.

The funding for this study comes from the Physiotherapy New Zealand Scholarship Trust Fund and the University of Otago School of Physiotherapy PhD Fund.

Who can be in this study?

We are looking to recruit people aged 30 years and over who have osteoarthritis in the joint at the base of the thumb.

To be eligible, you have been diagnosed with thumb base osteoarthritis OR you have had pain or problems at the base of your thumb on most days for more at least 1 month in the past year with no other diagnosis. You must also have had some pain or problems with your thumb in the past month.

You do not have rheumatoid arthritis or any other inflammatory or autoimmune condition that affects your hands such as scleroderma, systemic lupus erythematosus or psoriatic arthritis. You do not have any kind of chronic pain syndrome or metabolic disorder such as fibromyalgia, diabetic neuropathy or gout, or a history of thumb surgery.

What will participants be asked to do?

Should you agree to take part in this project, you will be asked to meet for a one-to-one interview at a time that is convenient to you. The interview may take place in a community venue or in your home as you prefer. You are welcome to bring a support person along if you wish. The interview will take around 90 minutes and will be recorded on a digital audio device.

Interviews will be semi-structured with the interviewer (Miranda) asking questions. The questions will stimulate discussion about your experience of thumb base osteoarthritis, including any activities that you have difficulty with and any pain or other symptoms that you experience in relation to your thumb. You will be asked how your thumb base osteoarthritis affects your health in the wider sense including your physical health, thoughts and feelings, spiritual health, and in regard to your family/whānau.

Before the interview takes place, you will also be asked to complete a daily diary for one week. This will help you to notice and remember how your thumb osteoarthritis affects you in your normal day-to-day life. Completing the diary will help bring to mind important points to discuss at the interview. The contents of the diary will also be analysed by the researcher. The diary can be written into a booklet or spoken into a recorder, as you prefer. We will provide you with the equipment you need to do this.

At the end of the interview you will be asked to complete some questionnaires about your age, work history, and about your thumb and your health so that we have an idea of the severity of your thumb osteoarthritis. You will also be asked how you found the interview and what it was like completing the diary. This will help us improve the way we do research.

Miranda will confirm the time and place for the interview with you at least 1 week before the interview. After the diary, interview and questionnaires are completed and you have given feedback on the draft summary of findings, you will have completed your involvement in the study. The total time commitment is 3 hours.

You will be offered a $20 petrol voucher to help cover any costs associated with in taking part in the research. Light refreshments will be provided.

Is there any risk of discomfort or harm if you take part?

If the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question.

What information will be collected, and how will it be used?

The interviews will be recorded on an audio device to help us remember exactly what was said so we can fully understand the information you tell us. We will also collect the written or recorded diaries from you. These recordings and diaries will only be used for this project.

Recordings and diaries will be typed out (transcribed). If you want to see your typed-out transcript or hear the original recording of your focus group/interview you can do this by contacting one of the researchers and they will arrange for a copy to be sent to you.

The transcribed information will be analysed to obtain the main ideas raised in the discussions. We will ask for your permission to use any direct quotes from the interview.

After the interviews and analyses have been completed, a draft summary of findings will be sent to you to review. Later we will telephone or email as you prefer, to find out if you have any comments or feedback.

The data in the transcripts will be anonymous and transcripts will be kept for a period of 10 years **in a locked cabinet in the School of Physiotherapy and on the University's secure** electronic data storage system. Your name or other information that might identify you will not be used in reports about this research. The audio recordings and written diaries will be destroyed.

The people who will view the data are the interviewer (Miranda) and the research supervisors (Cathy, Dave and Simon). Your data will be coded and people other than Miranda will not know who you are.

What will happen if you don't want to be a part of the study later on?

You may withdraw from the study at any time and without any disadvantage to yourself.

Any questions?

If you have any questions now or in the future, please contact either:

Name: Miranda Bühler Position: (Physiotherapist & Hand therapist) and PhD student Department: University of Otago School of Physiotherapy	Contact phone number: 0800 687 489 Or 027 299 3979 Contact email: Miranda.buhler@postgrad.otago.ac.nz
Name: Dr Cathy Chapple Position: Physiotherapist and Senior Lecturer Department: University of Otago School of Physiotherapy	Contact phone number: 03 479 5428 Contact email: Cathy.chapple@otago.ac.nz
Name: Simon Stebbings Position: Consultant Rheumatologist and Associate Professor Department: University of Otago Dunedin School of Medicine and Rheumatology Department, Southern DHB	Contact phone number: 03 470 3888 Contact email: Simon.stebbings@otago.ac.nz

If you want to talk to someone who is not involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050

Free fax: 0800 2 SUPPORT (0800 2787 7678) E-mail: advocacy@hdc.org.nz

If there is a specific Māori issue or concern, please contact: 0800 555 050.

This study has been approved by the University of Otago Human Ethics Committee (Health). Reference H17/032. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

Thumb osteoarthritis research study

Principal Investigator: Dr Cathy Chapple

Primary Researcher: Miranda Buhler

Email Miranda.Buhler@postgrad.otago.ac.nz Tel 0800 687 489 or 027 299 3979

CONSENT FORM FOR PARTICIPANTS

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:.....

1. I have read the Information Sheet about this study and understand the aims of this research project.
2. I have had enough time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. I am happy that all my questions about the project have been answered, and I understand that I am free to ask for more information at any stage.
5. I know that it is entirely my choice to take part in the project, and that I can withdraw without having to give a reason at any time and nothing will happen.
6. I know that because I am taking part I will complete a daily diary for one week, have a one-to-one interview that will be recorded, fill out some questionnaires about myself and my health, and provide feedback on the draft research report.
7. I know that the interview and the diary will explore how my thumb osteoarthritis impacts on my health and daily life.
8. I know that if the line of questioning develops in such a way that I feel hesitant or uncomfortable I can decline to answer any particular question.
9. I know that I may withdraw from the project without disadvantage of any kind.

10. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.
11. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.
12. I understand that the results of the project may be published and be available in the University of Otago Library, but that I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.
13. I know that there is no payment offered for this study other than the $20 petrol voucher to help cover any costs associated with taking part in the research. I know that no commercial use will be made of the data.
14. I would / would not like a copy of the results when the study is completed.
15. I am / am not happy to be informed about future studies

Signature of participant:	Date:

Name of person taking consent	Date:

Appendix E Advertisement for recruitment – Qualitative study

In this study, we want to hear from you about how your thumb base osteoarthritis impacts on your health and daily life.

To be eligible you meet all the following criteria:

- You have been diagnosed with thumb base osteoarthritis OR you have had pain or problems at the base of your thumb on most days for at least 1 month in the past year with no other diagnosis
- You have had some pain or problems in the last 4 weeks
- Must be at least 30 years of age
- You do not have rheumatoid arthritis or any other problems affecting your hands.

You will receive a $20 petrol voucher to help reimburse any costs. Light refreshments will be provided.

You will be asked to complete a daily diary for one week and participate in one 90-minute one-to-one interview.
Total time commitment: max 3 hours.

If you live in Dunedin or Invercargill, please contact the Clinical Research Administrator at the University of Otago School of Physiotherapy.

Email: clinicalresearch.physio@otago.ac.nz
or Tel: 0800 687 489

For more information visit our website
otago.ac.nz/thumb-base-oa

This project has been approved by the University of Otago Human Ethics Committee, (Health). Reference: H17/032.

Appendix F Letter of invitation to clinicians to assist with study recruitment

University of Otago
Centre for Health, Activity, and Rehabilitation Research
School of Physiotherapy

Date: 22 May 2017

To: The Practice Principal

From: Miranda Bűhler PhD Candidate, University of Otago School of Physiotherapy
Miranda.Buhler@postgrad.otago.ac.nz Tel. 03 479 7460 Mob. 027 299 3979

RE: **Impact of Thumb-base Osteoarthritis Study**

Please could I request your assistance in recruiting participants with thumb base osteoarthritis (OA) for a qualitative study that I am conducting as part of my PhD programme. The specific assistance I am requesting is 1) displaying the enclosed poster and flyers in your waiting room, and 2) that clinicians invite patients whom they identify as having thumb base osteoarthritis to consider taking part in the study. The patient would then contact the researcher if they felt they might be interested in participating.

Thumb base OA is a debilitating condition which has a prevalence like hip and knee OA however has received much less attention. This study aims to gain knowledge of patients' perspectives of thumb base OA and what outcomes are most important to them. Participants will be asked to complete a daily diary for one week and participate in a one-to-one interview (60-90-minute duration) to ask them about the impact of their thumb base OA.

Inclusion criteria: Adults with thumb base OA aged 30+ years who have either a physician diagnosis or answer "yes" to the question, "Have you experienced aching, discomfort, pain and/or stiffness in or around the joint at the base of either thumb on most days for at least 1 month (15 or more days of the month) during the past year?", and have no other specific diagnosis. Exclusion criteria: thumb(s) non-symptomatic for the last month; previous surgery of the symptomatic joint; rheumatoid arthritis or any other significant inflammatory or autoimmune conditions affecting the hand such as scleroderma, systemic lupus erythematosus and psoriatic arthritis, or another kind of chronic pain syndrome or metabolic disorder, such as fibromyalgia, diabetic neuropathy, or gout.

Study recruitment is occurring from April-September 2017. Ethical approval has been granted by the University of Otago Human Ethics Committee (Category A). This study is supervised by Dr Cathy Chapple.

If you have any questions about this study please do not hesitate to contact me at the above details. Further information can also be found on the study website, otago.ac.nz/thumb-base-oa.

Thank you,

Miranda Bűhler MPhty, NZ Reg. Hand Therapist

Thumb OA Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

Appendix 5: Participant demographic & health questionnaire

Age:	Gender:
Ethnicity:	Descent:
What is your current occupation? (Please circle): Working full time (*type*:_____) / working part time (*type*:_____) / not working / student (*type*:_____) / working full-time in the home / unemployed or seeking work / age retired / disability pension / sick leave, for how long? _____	
What have been your occupation(s) in the past, and for how long?	
Dominant hand: Left / Right	Hand with thumb osteoarthritis: Left / Right / Both
Thumb osteoarthritis diagnosed by health care provider? Yes / No If yes, which health care provider? (Please circle): GP, physio, rheumatologist, other	
How long have you had your thumb base problem(s)?	
Other joints with osteoarthritis (besides your hands):	
Other medical conditions (e.g. rheumatoid arthritis, other arthritis_____, gout, diabetes, heart problems):	
Current medications (Please circle): Paracetamol / Non-steroidal anti-inflammatory / Codeine Other (Please list): Self prescribed medications (Please list):	

Current treatments for your thumb osteoarthritis? (Please circle and tick as applies)

Type	Current	Previous	Helpful	Not helpful
Injections				
Topical cream (type _____)				
Physiotherapy				
Splint				
Other _____				
Other _____				

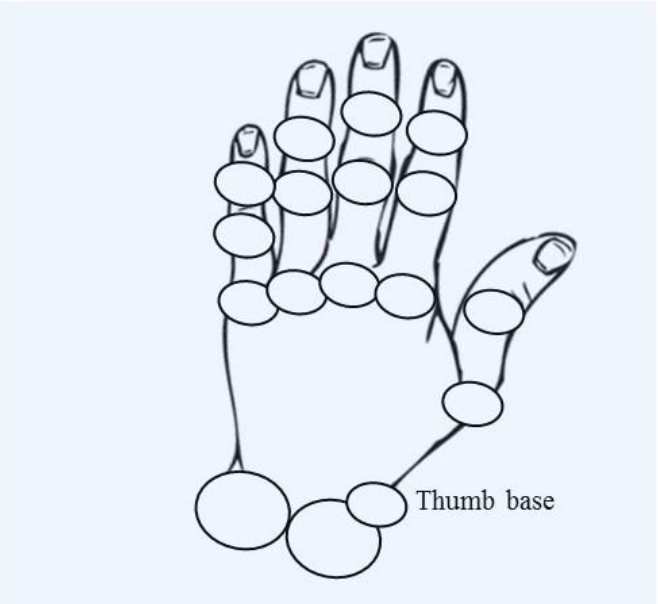
Appendix H Hand diagram – Pain

PAINFUL JOINTS

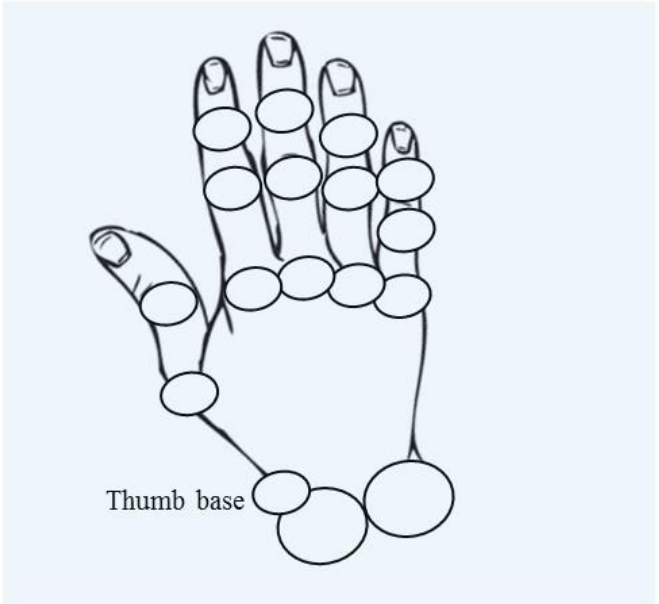
Mark on the chart the areas that you have **pain** by writing a number that best describes what your pain has usually been like during the past month where "0" is no pain and "10" is extreme pain.

No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain Example: (3)

Left hand



Right hand



Appendix H.1 Hand diagram – Abnormal joints

JOINTS WITH ABNORMAL APPEARANCE / FEEL

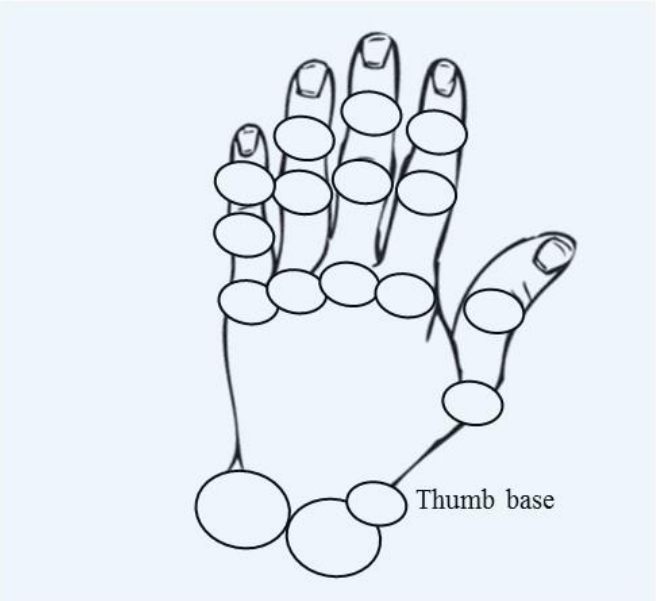
Mark on the chart the areas that look or feel different to you:

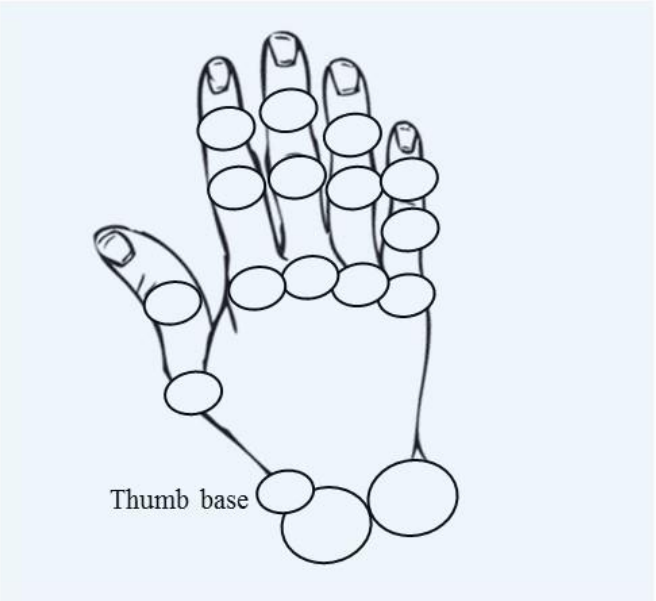
For **nodules or deformity** mark ●

For joints that are more **soft and squishy** than normal **or** there is **obvious visual swelling** mark *

For joints that are stiff mark **S** Example: (●) or (*S)

Left hand *Right hand*





Impact of thumb CMC OA qualitative study – Interview schedule

1. Introduction
    a. Welcome the participant and introduce the interviewer (Miranda). Explain about the research and the purpose of the interview.
    b. Outline the format of the interview including use of visual tool (see p.)
    c. Opportunity for any questions
2. Procedural information
    a. No right or wrong answers
    b. You can change your mind
    c. Can take 'time-out' at any time, without needing to give any reason
    d. The interview will be recorded, are you ok with that?
    e. Any information that could identify you will not be disclosed to anyone other than the researcher (Miranda), so please speak freely and fully.
    f. Opportunity for any further questions
    g. Confirm consent to participate
3. The interview questions

Main questions	**Probing questions**
1) Can you tell me about your thumb osteoarthritis…	Can you tell me more about that? Can you give an example of that? Can you describe a good day… a bad day? How does that make you feel? What about stiffness, does that concern you*?* Are you happy with how your thumb(s) look? *…how do these things impact on your physical, mental, family or spiritual well-being?*
2) What kind of things do you have difficulty with because of your thumb osteoarthritis?	At home… *around the house, in the garden, in the kitchen, with tools, washing and dressing, toileting, getting lids off, getting through doors, doing the groceries?* At work… With driving… *or other means of transport* With writing or using media, technology or communication devices… *computers, cell phones, newspapers?* With recreational activities/hobbies…

	In your social life… *going out for normal social activities… interacting with people socially… do you limit this in anyway?* In your family or community roles… *e.g. caring for others – grandchildren, partner, family or friends, community?* In your personal/intimate relationships? *…how do these things impact on your physical, mental, family or spiritual well-being?*
3) Can you tell me more about the pain... (sensitising question)	Can you describe what it's like? How often do you get the pain? *If the pain comes and goes…* Do you know when the pain is going to come on? Are there specific activities on which your thumb gives you more pain? How is the pain at night time? What bothers you the most about your pain? How does the pain make you feel? *…how do these things impact your physical, mental, family or spiritual well-being?*
4) How has your thumb osteoarthritis impacted on your health and life in general? *Is there anything else you would like to add?*	In your physical/mental/spiritual wellbeing? In the wellbeing of your family, community and relationships? What would be the 3 most significant ways in which your thumb osteoarthritis has impacted on you, in your view?
INTERVIEW ENDED	

4. Complete demographic and disease information (x)
5. Invite participant to share any feedback about their participation in the study, the interview, and completing the diary.

Draw the session to a close and review what happens next (per Participant Information Sheet).

Appendix J Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

PRISMA 2009 Checklist – Splinting for thumb base OA

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	69
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Thesis abstract
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	69-73
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	72,73
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	73
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	73-75
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	73,75,76
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	73, App K
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	73-77
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	75,76
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	74-76
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	76-78
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	77,78
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	76-78

Appendix J Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

PRISMA 2009 Checklist – Splinting for thumb base OA

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	76,77
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	77,78
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	78, Fig 8
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	79-81, Table 6
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	85,86, Fig 10-13
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	86,87, Table 7, Fig 10-13
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	89,90,93 Fig 10-13
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	89,90,93, Fig 9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	93, Fig 12,13
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	96,97
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	97-99
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	99,100
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Acknowledgements

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Search terms for MEDLINE (OVID)

Result: 459

1. Metacarpus/
2. Trapezium Bone/
3. cmc.mp
4. carpometacarpal.mp.
5. tmc.mp.
6. trapeziometacarpal.mp.
7. basal.mp.
8. base.mp.
9. thumb.mp.
10. exp Hand/
11. hand.mp.
12. osteoarthritis.mp.
13. oa.mp.
14. musculoskeletal pain.mp.
15. degenerative.mp.
16. arthritic.mp.
17. Casts, Surgical/
18. Braces/
19. Equipment Design/
20. exp Plastics/
21. Combined Modality Therapy/
22. splint*.mp.
23. brace.mp.
24. orthos*.mp.
25. orthotic.mp.
26. hand therapy.mp.
27. physiotherapy.mp.
28. physical therapy.mp.
29. occupational therapy.mp.
30. neoprene.mp.
31. thermoplastic.mp
32. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11
33. 12 or 13 or 14 or 15 or 16
34. 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
35. 32 and 33 and 34

Appendix L Data abstraction form – Systematic review

Study ID:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 1

Date:_ _/_ _/_ _ Miranda ☐ Bahram ☐

SPLINTING FOR THUMB OA

Data Abstraction and Assessment Form

1. General information

First author:	Year published:
Citation:	
Publication type: Journal article ☐ Abstract ☐ Thesis ☐ Other ☐	
Country of study:	Language of publication:
Funding source:	Potential conflict of interest from funding? Y / N / Unclear

2. Study eligibility

Study characteristics			Page/fig.
Type of study ***2nd Reviewer agree*** ☐	☐ Randomised controlled trial (RCT) ☐ Controlled clinical trial (CCT) (quasi-experimental/non-randomised trial)	☐ Controlled before and after (CBA) study • Contemporaneous data collection • Comparable control site • At least 2 x intervention and 2 x control clusters	
	☐ Interrupted time series (ITS) • At least 3 time point before and 3 after the intervention • Clearly defined intervention point	☐ Prospective cohort study ☐ Other design (specify):	
	Does the study design meet the inclusion criteria? Yes ☐ No ☐ → **Exclude** Unclear ☐ ***2nd Reviewer agree*** ☐		
	Description in text:		

Participants	Describe the participants included:		
	Are the participants adults with a diagnosis of thumb base osteoarthritis as defined by the authors? Yes ☐ No ☐ → **Exclude** Unclear ☐ ***2nd Reviewer agree*** ☐	Do participants have a variety of conditions or joint involvement? Can data for the group with thumb OA be extracted separately? Yes ☐ No ☐ → **Exclude** Unclear ☐ ***2nd Reviewer agree*** ☐	
	Are participants age under 18 years? Yes ☐ → **Exclude** No ☐ Unclear ☐ ***2nd Reviewer agree*** ☐	Is the splint intervention applied after thumb surgery? Yes ☐ → **Exclude** No ☐ Unclear ☐ ***2nd Reviewer agree*** ☐	
	Do the participants meet the criteria for inclusion? Yes ☐ No ☐ → **Exclude** Unclear ☐ ***2nd Reviewer agree*** ☐		

Appendix L Data abstraction form – Systematic review

Interventions *Thumb orthotic device (orthosis, splint, brace) intervention with or without standardised co-interventions*	**Describe the intervention(s):**	
	Are co-interventions provided? Yes ☐ No ☐ Unclear ☐ *2nd Reviewer agree* ☐	**If so, are co-interventions given to both the experimental and control groups?** Yes ☐ No ☐ → **Exclude** Unclear ☐ *2nd Reviewer agree* ☐
	Do the interventions meet the criteria for inclusion? Yes ☐ No ☐ → **Exclude** Unclear ☐ *2nd Reviewer agree* ☐	

Outcomes	**List outcomes:**	
	Is at least one measure of pain reported? Yes ☐ No ☐ → **Exclude** Unclear ☐ *2nd Reviewer agree* ☐	**Is relevant and interpretable data presented or obtainable?** Yes ☐ No ☐ → **Exclude** Unclear ☐ *2nd Reviewer agree* ☐

Summary of assessment for inclusion

Include in review ☐ *2nd Reviewer agree* ☐	**Exclude from review** ☐ *2nd Reviewer agree* ☐
Independently assessed, and then compared? Yes ☐ No ☐	**Differences resolved?** Yes ☐ No ☐
Request further details? Yes ☐ No ☐ *2nd Reviewer agree* ☐	**Contact details of author:**
Notes:	

DO NOT PROCEED IF PAPER EXCLUDED FROM REVIEW

3. Study details

Study intention	**Descriptions as stated in the report/paper** *2nd Reviewer agree* ☐	**Page/fig.**
Aim of intervention	*What was the problem that this intervention was designed to address?* ☐	
Aim of study	*What was the study designed to assess? Are these clearly stated?* ☐	
Start and end date of the study	☐	
Total study duration	☐	

Methods	**Descriptions as stated in the report/paper**	**Page/fig.**
Method/s of recruitment of participants (How were potential participants approached and invited to participate? Where were participants recruited from?)	☐	

Appendix L Data abstraction form – Systematic review

Inclusion/exclusion criteria for participation in study	☐	
Representativeness of sample: Are participants in the study likely to be representative of the target population?	☐	
Total number of intervention groups	☐	
Sample size calculation: What assumptions were made? Were these assumptions appropriate?	☐ Yes ☐ No ☐ Unclear ☐ *2nd Reviewer agree* ☐	
What was the unit of randomisation? E.g. digit, hand, individuals or cluster/groups?	☐	
What was the unit of analysis? Is this the same as the unit of randomisation?	☐ Yes ☐ No ☐ Unclear ☐ *2nd Reviewer agree* ☐	
Statistical methods used and appropriateness of these methods	☐	

Participants	Descriptions as stated in the report/paper	Page/fig.
What percentage of selected individuals agreed to participate?	☐	
Total number randomised (or total pop. at start of study for NRCTs)	☐	
Number allocated to each intervention group (no. of individuals)	☐	
For cluster trials, number of clusters, number of people per cluster	☐	
Were there any significant baseline imbalances?	Yes ☐ No ☐ Unclear ☐ *Details:* ☐	
Number and reason for (and sociodemographic differences of) withdrawals and exclusions for each intervention group	☐	
Were patients who entered the study adequately accounted for?	Yes ☐ No ☐ Unclear ☐ *2nd Reviewer agree* ☐	
What percentage of patients completed the study?	☐	
What percentage of participants received the allocated intervention of interest?	☐	
Is the analysis by intention-to-treat? Attempts to impute missing data?	☐	
Age (mean, SD)	☐	

Appendix L Data abstraction form – Systematic review

Sex (% female)		
Race (descent)/ethnicity (%)		
Description of osteoarthritis diagnosis at baseline (mean, SD) I.e. duration of disease, severity at baseline, no. and location of involved hand joints, other joint involvement		
Diagnostic/classification criteria		
Co-morbidity		
Other socio-demographics e.g. educational level, socio-economic status, first language, work status, hand dominance.		
Any participant subgroups from this paper to be analysed in the review?	*E.g. age, occupation*	
Intervention groups	**Descriptions as stated in the report/paper**	**Page/fig.**
Intervention group 1	*State brief name:*	
Details of intervention or control condition	*(include if relevant in sufficient detail for replication)*	
Setting e.g. multicentre, rural, metropolitan, hospital, community, GP clinic, therapy clinic		
Reimbursement system including funding of intervention		
Content – i.e. splint (orthotic device) characteristics e.g. materials, design, wearing instructions (timing, frequency, duration		
Theoretical basis (include key references/guidelines)		
Was the intervention individualised?	Yes ☐ No ☐ Unclear ☐ *Details:*	
Co-interventions	Yes ☐ No ☐ Unclear ☐ *Details:*	
Providers i.e. who (profession, time since graduation, ethnicity), education/training in intervention delivery, etc.), how many?		
No. of follow up/clinician contacts		
Duration of intervention		
Duration of follow-up		
Resource requirements to replicate intervention e.g. staff numbers, hours of implementation, equipment?		

Intervention group 2	*State brief name:*	
Details of intervention or control condition *(include if relevant in sufficient detail for replication)*		
Setting e.g. multicentre, rural, metropolitan, hospital, community, GP clinic, therapy clinic	❑	
Reimbursement system including funding of intervention	❑	
Content – i.e. splint (orthotic device) characteristics e.g. materials, design, wearing instructions (timing, frequency, duration	❑	
Theoretical basis (include key references/guidelines)	❑	
Was the intervention individualised?	Yes ❑ No ❑ Unclear ❑ *Details:* ❑	
Co-interventions	Yes ❑ No ❑ Unclear ❑ *Details:* ❑	
Providers i.e. who (profession, time since graduation, ethnicity), education/training in intervention delivery, etc.), how many?	❑	
No. of follow up/clinician contacts	❑	
Duration of intervention	❑	
Duration of follow-up	❑	
Resource requirements to replicate intervention e.g. staff numbers, hours of implementation, equipment?	❑	

If more than 2 interventions groups, print and complete additional tables.

Any intervention subgroups from this report to be analysed in the review.	❑	
Was a process/fidelity evaluation conducted? Components included? (e.g. dose, frequency, consistency, compliance/adherence)	❑	

Control/comparison		
What information is provided about what the control or comparison group received?	❑	
Gold standard/clinical guidelines?	Yes ❑ No ❑ Unclear ❑ *References:* ❑	
Sham/placebo?	Yes ❑ No ❑ Unclear ❑ *Details:* ❑	
No. of follow up/clinician contacts	❑	

Appendix L Data abstraction form – Systematic review

Outcomes	Descriptions as stated in the report/paper	Page/Fig.
Outcome 1 - Pain	*Name:*	
Outcome definition	❑	
Time points measured	❑	
Time points reported	❑	
Is there adequate latency for the outcome to be observed?	Yes ❑ No ❑ Unclear ❑ ❑	
Unit of measurement (if relevant)	❑	
For scales – upper and lower limits and indicate whether high or low score is good	❑	
How is the measure applied? (Telephone, post, in person by trained assessor, routinely collected data…)	❑	
How is the outcome reported? (Self or study assessor)	❑	
Is this outcome/tool validated?	Yes ❑ No ❑ Unclear ❑ ❑	
…And has it been used as validated?	Yes ❑ No ❑ Unclear ❑ ❑	
Is it a reliable outcome measure?	Yes ❑ No ❑ Unclear ❑ ❑	
Is there adequate power for this outcome?	Yes ❑ No ❑ Unclear ❑ ❑	

Outcome 2 - Function	*Name:*	
Outcome definition	❑	
Time points measured	❑	
Time points reported	❑	
Is there adequate latency for the outcome to be observed?	Yes ❑ No ❑ Unclear ❑ ❑	
Unit of measurement (if relevant)	❑	
For scales – upper and lower limits and indicate whether high or low score is good	❑	
How is the measure applied? (Telephone, post, in person by trained assessor, routinely collected data…)	❑	
How is the outcome reported? (Self or study assessor)	❑	
Is this outcome/tool validated?	Yes ❑ No ❑ Unclear ❑ ❑	
…And has it been used as validated?	Yes ❑ No ❑ Unclear ❑ ❑	
Is it a reliable outcome measure?	Yes ❑ No ❑ Unclear ❑ ❑	
Is there adequate power for this outcome?	Yes ❑ No ❑ Unclear ❑ ❑	

Outcome 3 – Quality of life (QoL)	*Name:*	
Outcome definition	❑	

Appendix L Data abstraction form – Systematic review

Time points measured	❑	
Time points reported	❑	
Is there adequate latency for the outcome to be observed?	Yes ❑ No ❑ Unclear ❑ ❑	
Unit of measurement (if relevant)	❑	
For scales – upper and lower limits and indicate whether high or low score is good	❑	
How is the measure applied? (Telephone, post, in person by trained assessor, routinely collected data…)	❑	
How is the outcome reported? (Self or study assessor)	❑	
Is this outcome/tool validated?	Yes ❑ No ❑ Unclear ❑ ❑	
…And has it been used as validated?	Yes ❑ No ❑ Unclear ❑ ❑	
Is it a reliable outcome measure?	Yes ❑ No ❑ Unclear ❑ ❑	
Is there adequate power for this outcome?	Yes ❑ No ❑ Unclear ❑ ❑	

Additional outcome measures: ***2nd Reviewer agree ❑***

4. Results

In all cases, report a more favourable provider/patient outcome in the more active intervention group as a positive (+) finding (i.e., where differences in the groups are in the intended direction).

*For **all studies**, state the main results of the main outcome(s), for each study group, in natural units.*

*For **RCTs and CCTs**, for each available comparison, report the baseline and post intervention differences between study and control groups, in natural units. Include statistical significance if reported. Indicate if the unit of randomisation and analysis were different.*

*For **CBAs**, a) for each study group, report baseline and post intervention results and calculate the pre-post intervention difference for each outcome in natural units (i.e. the post-intervention outcome minus the pre-intervention outcome); b) for each available comparison, calculate the difference across study groups of the pre-post intervention change (i.e. where **Δ**E is the pre-post intervention change in the experimental/ intervention group, and **Δ**C is the pre-post intervention change in the control group, this will be **Δ**E-**Δ**C). Include statistical significance if reported.*

*For **ITS**, report a) no. of points pre and post, b) no. of patients or measurement units (e.g. lab tests) in whole series, c) time interval between points, d) pre and post intervention means, e) absolute change in natural units, f) percentage relative change, g) model used and statistical significance.*

Results:	Page/No.
2nd Reviewer agree ☐	

5. Other relevant information

		Page/No.
Were outcomes relating to harms/unintended effects of the intervention described?	Yes ☐ No ☐ Unclear ☐ *Details:* ☐	
Consumer involvement?	Yes ☐ No ☐ Unclear ☐ *Details:* ☐	
Ethical approval?	Yes ☐ No ☐ Unclear ☐ *Details:* ☐	
Potential for author conflict, *i.e. evidence that author or data collectors would benefit if results favoured the intervention under study or the control*	Yes ☐ No ☐ Unclear ☐ *Details:* ☐	
Key conclusions of the study authors	☐	
Could the inclusion of this study potentially bias the generalisability of the review? (NB Equity pointer)	☐	
References to other relevant studies	☐	
Request further details? Yes ☐ No ☐ ☐	Contact details of author:	
Notes: 2nd Reviewer agree ☐		

Appendix L Data abstraction form – Systematic review

Study ID:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 9

Date:_ _/_ _/_ _ Miranda ☐ Bahram ☐

6. Risk of bias assessment

For additional guidance for scoring Yes/No/Unclear, refer to Chapter 8 in the Cochrane Handbook version 5.1.0 for assessing **Risk of bias for studies with a separate control group (RCTs, CCTs, CBAs)**, and to the Cochrane **EPOC Group's guidance** (Appendix 3) for assessing **Risk of bias for interrupted time series studies (ITS)**. Note that the table below includes items from both the Cochrane Risk of Bias tool and the EPOC ITS tool. The EPOC ITS tool has been incorporated into the bottom of the table and all items for ITS studies are denoted by ITS preceding the risk of bias question.

Domain	Reviewers' judgement* 2nd Reviewer	Description	Page/Fig. #
Selection bias			
Random sequence generation (Van Tulder item 1.)	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Describe the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.*	
Allocation concealment (Van Tulder item 2.)	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Describe the method used to conceal the allocation sequence in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrolment.*	
Performance bias			
Blinding of participants and personnel (Van Tulder items 4. & 5.) (MINORS item 5.) *Assessments should be made for each main outcome (or class of outcomes).*	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.*	
Detection bias			
Blinding of outcome assessment (Van Tulder item 6.) (MINORS item 5.) *Assessments should be made for each main outcome (or class of outcomes).*	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Describe all measures used, if any, to blind outcome assessors from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.*	
Attrition bias			
Is outcome data sufficiently complete? *Assessments should be made for each main outcome (or class of outcomes).* (Van Tulder item 9.) (MINORS item 7.)	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors.*	
Reporting bias			
Are reports of the study free of suggestion of selective outcome reporting?	Yes ☐ No ☐ Unclear ☐ Agree ☐	*State how the possibility of selective outcome reporting was examined by the review authors, and what was found. Was there a priori registration or publication of study protocol?*	

Appendix L Data abstraction form – Systematic review

Assessments should be made for each main outcome (or class of outcomes).			
Other bias			
Are reports of the study free of the suggestion of Other sources of bias:	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***State any important concerns about bias not addressed in the other domains in the tool.***	
Interrupted time series studies (ITS)			
ITS: Was the intervention independent of other changes?	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***Describe whether or not the intervention occurred independently of other changes over time and whether or not the outcomes may have been influenced by other confounding variables/historic events during the study period.***	
ITS: Was the shape of the intervention effect pre-specified?	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***State whether or not the point of analysis was the point of intervention. If not, describe whether a rationale for the shape of the intervention effect was given by the study authors.***	
ITS: Was the intervention unlikely to affect data collection?	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***Describe whether or not the intervention was likely to affect data collection and what the potential impact might have been.***	
ITS: Blinding of participants and personnel ***Assessments should be made for each main outcome (or class of outcomes).***	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.***	
ITS: Blinding of outcome assessment **(Van Tulder item 6.)** **(MINORS item 5.)** ***Assessments should be made for each main outcome (or class of outcomes).***	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***Describe all measures used, if any, to blind outcome assessors from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.***	
ITS: Was incomplete outcome data adequately addressed? ***Assessments should be made for each main outcome (or class of outcomes).***	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performe d by the review authors.***	
ITS: Was the study free from selective reporting?	Yes ☐ No ☐ Unclear ☐ ***Agree*** ☐	***State how the possibility of selective outcome reporting was examined by the review authors, and what was found.***	

"Yes' indicates a 'low risk of bias'; 'No' indicates a 'high risk of bias'; 'Unclear' indicates 'an uncertain risk of bias'. When entering data into RevMan, the options to choose from will be 'Low', 'High', and 'Unclear'.

Appendix L Data abstraction form – Systematic review

7. Overall quality assessment

For randomised trials, complete the van Tulder scale items. For non-randomised trials complete the MINORS instrument items.

Van Tulder	Reviewers' judgement	Description	Page/fig. #
1. Randomisation method acceptable	Yes ☐ No ☐ Unclear ☐ Agree ☐	*A random (unpredictable) assignment sequence, e.g. computer-generated random-number table and use of sealed opaque envelopes. Methods using date of birth, date of admission, hospital numbers, or alternation are not appropriate.*	
2. Treatment allocation concealed	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.*	
3. Groups similar at baseline regarding most important prognostic factors	Yes ☐ No ☐ Unclear ☐ Agree ☐	*To receive a "yes," groups have to be similar at baseline regarding demographic factors, duration or severity of symptoms, and value of main outcome measure(s).*	
4. Patient is blind to intervention	Yes ☐ No ☐ Unclear ☐ Agree ☐		
5. Care provider blinded to intervention?	Yes ☐ No ☐ Unclear ☐ Agree ☐		
6. Blinding of outcome assessor	Yes ☐ No ☐ Unclear ☐ Agree ☐		
7. Co-interventions were avoided or similar	Yes ☐ No ☐ Unclear ☐ Agree ☐		
8. Adherence was acceptable in all groups	Yes ☐ No ☐ Unclear ☐ Agree ☐	*The reviewer determines whether adherence to the interventions is acceptable, based on the reported intensity, duration, number, and frequency of sessions for both the index intervention and control intervention(s).*	
9. Dropout rate is described and acceptable (≤ 15%)	Yes ☐ No ☐ Unclear ☐ Agree ☐	*The number of participants who are included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and dropouts does not exceed 15% and does not lead to substantial bias, a "yes" is scored.*	
10. Timing of outcomes assessment similar	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.*	
11. Intention-to-treat analysis	Yes ☐ No ☐ Unclear ☐ Agree ☐	*All randomly assigned patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of nonadherence and co-interventions.*	

Appendix L Data abstraction form – Systematic review

MINORS	Reviewers' judgement	Description	Page/fig. #
1. A clearly stated aim	Yes ☐ No ☐ Unclear ☐ Agree ☐	*The question addressed should be precise and relevant in the light of available literature.*	
2. Inclusion of consecutive patients	Yes ☐ No ☐ Unclear ☐ Agree ☐	*All patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion).*	
3. Prospective collection of data	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Data were collected according to a protocol established before the beginning of the study.*	
4. Endpoints appropriate to the aim of the study	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Unambiguous explanation of the criteria used to evaluate the main outcome which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.*	
5. Unbiased assessment of the study endpoint	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise the reasons for not blinding should be stated.*	
6. Follow-up period appropriate to the aim of the study	Yes ☐ No ☐ Unclear ☐ Agree ☐	*The follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events.*	
7. Loss to follow up less than 5%	Yes ☐ No ☐ Unclear ☐ Agree ☐	*All patients should be included in the follow up. Otherwise, the proportion lost to follow up should not exceed the proportion experiencing the major endpoint.*	
8. Prospective calculation of the study size	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes.*	
9. An adequate control group	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data.*	
10. Contemporary groups	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Control and studied group should be managed during the same time period (no historical comparison)*	
11. Baseline equivalence of groups	Yes ☐ No ☐ Unclear ☐ Agree ☐	*The groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results.*	
12. Adequate statistical analyses	Yes ☐ No ☐ Unclear ☐ Agree ☐	*Whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk.*	

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

Tuesday, 09 October 2018.

Dr Catherine Chapple,
School of Physiotherapy
University of Otago
PO Box 56
Dunedin 9054.

Tēnā Koe Dr Catherine Chapple,

Splinting for thumb carpometacarpal osteoarthritis: a feasibility randomised controlled trial

The Ngāi Tahu Research Consultation Committee (the committee) met on Tuesday, 09 October 2018 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

The Committee notes and commends that ethnicity data is to be collected using the questions on self-identified ethnicity and descent contained in the latest census.

The Committee suggests dissemination of the research findings to Māori health organisations regarding this study.

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

We wish you every success in your research and the committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 09 October 2018 to 9 April 2020.

Nāku noa, nā

Mark Brunton
Kaiwhakahaere Rangahau Māori
Research Manager Māori
Research Division
Te Whare Wānanga o Otāgo
Ph: +64 3 479 8738
Email: mark.brunton@otago.ac.nz
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Appendix N Ethical approval from the New Zealand Northern B Health and Disability Ethics Committee – Feasibility study

Health and Disability Ethics Committees

Health and Disability Ethics Committees
Ministry of Health
133 Molesworth Street
PO Box 5013
Wellington
6011

0800 4 ETHICS
hdecs@moh.govt.nz

14 March 2019

Ms Miranda Buhler
University of Otago School of Physiotherapy
PO Box 56
Dunedin 9054

Dear Ms Buhler,

Re:	Ethics ref:	18/NTB/240
	Study title:	Splinting for thumb carpometacarpal osteoarthritis: a feasibility randomised controlled trial

I am pleased to advise that this application has been *approved* by the Northern B Health and Disability Ethics Committee. This decision was made through the HDEC-Expedited Review pathway.

1. Before the study commences at *any* locality in New Zealand, it must be registered in a clinical trials registry. This should be a WHO-approved registry (such as the Australia New Zealand Clinical Trials Registry, www.anzctr.org.au) or https://clinicaltrials.gov/.

2. Before the study commences at *each given* locality in New Zealand, it must be authorised by that locality in Online Forms. Locality authorisation confirms that the locality is suitable for the safe and effective conduct of the study, and that local research governance issues have been addressed.

Non-standard conditions:

- The Committee has asked that in the Information Sheet, please avoid referring to the intervention as "treatment"

Non-standard conditions must be completed before commencing your study, however, they do not need to be submitted to or reviewed by HDEC.

If you would like an acknowledgement of completion of your non-standard conditions you may submit a post approval form amendment through Online Forms. Please clearly identify in the amendment form that the changes relate to non-standard conditions and ensure that supporting documents (if requested) are tracked/highlighted with changes.

For information on non-standard conditions please see section 128 and 129 of the *Standard Operating Procedures for Health and Disability Ethics Committees* (available on www.ethics.health.govt.nz)

After HDEC review

Please refer to the *Standard Operating Procedures for Health and Disability Ethics Committees* (available on www.ethics.health.govt.nz) for HDEC requirements relating to amendments and other post-approval processes.

Appendix N Ethical approval from the New Zealand Northern B Health and Disability Ethics Committee – Feasibility study

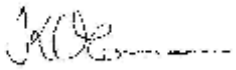
Your next progress report is due by 14 March 2020.

Participant access to ACC

The Northern B Health and Disability Ethics Committee is satisfied that your study is not a clinical trial that is to be conducted principally for the benefit of the manufacturer or distributor of the medicine or item being trialled. Participants injured as a result of treatment received as part of your study may therefore be eligible for publicly-funded compensation through the Accident Compensation Corporation (ACC).

Please don't hesitate to contact the HDEC secretariat for further information. We wish you all the best for your study.

Yours sincerely,



Ms Kate O'Connor
Chairperson
Northern B Health and Disability Ethics Committee

Encl: appendix A: documents submitted
appendix B: statement of compliance and list of members

Management of Thumb Osteoarthritis (MOTO) feasibility study

Assessor Manual

Study contact details:

Miranda Buhler, PhD candidate (Principal Investigator)

University of Otago School of Physiotherapy

Office extn 5694 Mob [redacted] Work [redacted]

Email Miranda.buhler@postgrad.otago.ac.nz

Research Administrator

Ph [redacted]

Email clinicalresearch.physio@otago.ac.nz

School of Physiotherapy Main Reception

03 479 746

Appendix O Assessor Manual

2. Abbreviations

NRS	Numeric Rating Scale
FIHOA	Functional Index of Hand Osteoarthritis – questionnaire
CMC	Carpometacarpal joint
OA	Osteoarthritis
MCP	Metacarpophalangeal joint
ROM	Range of motion
KgF	Kilograms of force

3. Data Collection

Data collection sheets for Baseline, 4-week and 6-months outline the data to be collected at each of the three time-points. Please complete and mark-off all sections. The participant questionnaires to be completed will be compiled in a document wallet in preparation for each assessment. If you find any documents are missing, spare copies are kept in the ring binder folder in the assessment room.

Please take care to check through all data collection sheets that all data sets are complete, and to check through all participant questionnaires that all questions have been answered.

Thank you!

Physical measures – Eligibility screening

Before performing each physical assessment, briefly explain what will be done and seek consent. If the [potential] participant declines an assessment, move to the next test.

- **Observation of thumb CMC joint for 'step-off' sign**
  - **Positive test = observable 'squaring' or 'shouldering' or 'stepping-off' of the thumb CMC joint** in the relaxed hand position.

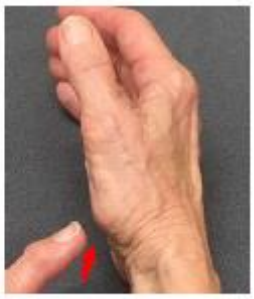


Figure 1 Thumb carpometacarpal joint step off sign.

- **Palpation of thumb CMC joint**
  - Palpate the thumb CMC joint firmly but evenly, starting dorsally and proceed radially around the base of the thumb to the volar joint line.
  - Positive test = any pain or tenderness at base of thumb joint.

Figure 2 Thumb carpometacarpal joint.

Figure 3 Palpation of the thumb carpometacarpal joint.

- **Grind test for thumb CMC joint**
  - The grind test is performed by compressing the joint axially while rotating the thumb metacarpal.
  - Positive test = produces pain with or without crepitus of the thumb base joint.

Figure 4 The grind test for thumb carpometacarpal joint.

- **Pressure-shear test for thumb CMC joint**
  - **The participant's thumb is grasped by the assessor's hand for support on the examination table. The participant's wrist and finger metacarpals are placed in a neutral position. The** assessor then applies pressure over the volar aspect of the thumb CMC joint and creates a shearing force across the joint by rocking the metacarpal across the trapezium.
  - Handling is similar to that of the Grind test.

<u>Physical measures – Baseline only</u>

- **MCP joint hyperextension a) at rest and b) on active extension (degrees)**
  - Measure a) MCP hyperextension at rest and b) on active MCP extension. Place the hand comfortably, palm up. Measure using the small goniometer placed along the 1st metacarpal and thumb proximal phalanx. Measure 3 times, record on the data sheet.

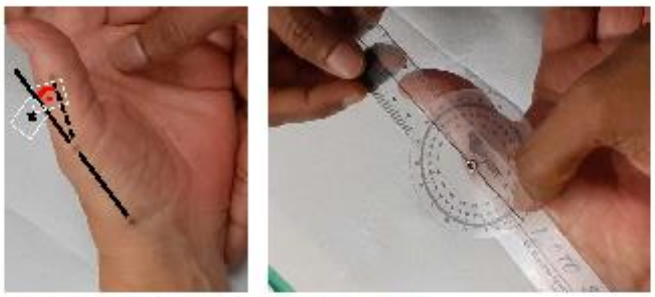


Figure 5 Measure thumb MCP joint hyperextension ROM angle

- **Height (cm)**
  - Measure using standing height metre, record on the data collection sheet
  - Remove shoes
- **Weight (Kg)**
  - Measure using standing scales, record on the data collection sheet
  - Remove shoes

Physical measures – Baseline, 4-weeks and 6-months

- **Pollexograph – thumb palmar abduction active ROM (degrees)**
  - https://www.youtube.com/watch?v=dQK7uZSNf4I

Figure 6 The Pollexograph

Figure 7 The Pollexograph measurement of thumb palmar abduction

  - Measurements are taken using the pollexograph (box-shape measuring device)
  - Participant performs a warm-up of 3 repetitions active palmar abduction
  - To measure, place the palm of the hand to rest against the side of the box
  - The thumb CMC joint should be located at the centre of the protractor diagram
  - Use a ruler to measure the angle aligned to the first metacarpal and CMC joint
  - Repeat measure three times, record on the data collection sheet

- **Inter-digit distance – use a ruler (mm)**
  - On the index finger, at the radial aspect of the proximal interphalangeal joint, mark the intersection between volar and dorsal skin creases.
  - On the thumb, at the distal-ulna aspect of the thumb, mark where the nail exists the nail bed (at the ulna border of the junction of the nail bed and the hyponychium).
  - Ask the participant to rest their hand on the table, on the ulna border
  - Ask the participant to actively palmarly abduct their thumb (90 degrees to from the palm), **"spread your thumb out as far as you can and stretch your fingers back, as if trying to put** your hand round **a large jar."**
  - Using a ruler, measure the distance between the two points
  - Repeat measure three times, record on the data collection sheet

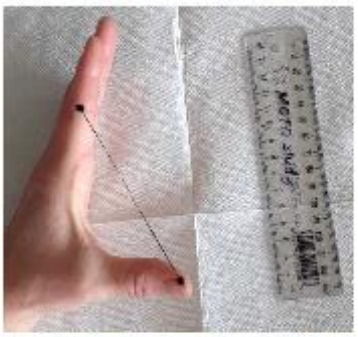


Figure 8 Active thumb palmar abduction ROM inter-digit distance measurement

- **Grip Ability Test – timed (seconds)**
  - This test assesses three functional tasks: putting a sock over one hand, putting a paper clip on an envelope, and pouring water from a jug.
  - Explain the three tasks and to perform as quickly as possible
  - **Give the cue, "Ready, set go!", time** tasks together or individually if stop for instructions
  - Record on assessment chart

Figure 1 The Grip Ability Test: A – put on a sock, B – put a paper clip on an envelope, C – pour water from a jug.

- **Grip strength (KgF)**
  - https://www.youtube.com/watch?v=frcNPiLnWRo
  - Measurements are taken using the hand-held dynamometer following standard protocol
    - Setting 2
    - Arm by side, elbow flexed 90 deg, arm slightly abducted
    - Explain they should squeeze as hard as they can, but the handle will not move.
    - **Give the cue, "Ready, set, go!"**, offer encouragement
    - Record the grip strength on the data collection sheet, then re-set the dial.
  - Measure the non-study arm first, then the study arm
  - Repeat three times in total, alternating sides, or if pain increases **"more than a little"** do not repeat the test.

Figure 9 Grip strength measured using hand-held dynamometer

- **Pinch grip strength (KgF)**
  - Measurements are taken using the mechanical pinch gauge following standard protocol
    - Arm by side, elbow flexed to 70 degrees, arm slightly abducted, hand forward
    - Show the participant how to make a tip pinch – thumb and index digits opposed
    - Ask the participant to pinch as hard as they can, offer encouragement
    - Record the pinch grip strength on the data collection sheet, then re-set the dial
    - Measure the uninvolved (or non-study) arm first, then the involved arm
    - Repeat three times in total, alternating sides, **or if pain increases "by more than a little" do not repeat the test.**

Figure 10 Pinch grip strength measured using mechanical pinch gauge

Self-report measures – Baseline and Follow up assessments

- **Participant demographic and health questionnaire**

Participant demographic & health questionnaire	
Age:	Gender:
Ethnicity:	Descent:
What is your current occupation? (Please circle):	
Working full time (type:_____) / working part time (type:_____) / not working / student (type:) / working full time in the home / unemployed or seeking work / age retired / disability pension / sick leave, for how long?	

  - Definition of **ethnicity**: the group or groups that people identify with or feel they belong to. Ethnicity is a measure of cultural affiliation, as opposed to race, ancestry, nationality or citizenship. **Ask: "*Which cultural group do you affiliate [identify] with?*" *e.g. NZ European/Pākeha, Māori, Pacific Island, Indian etc.***
  - Definition of **descent**, **e.g. for Māori descent, a person has Māori descent if they are of Māori race of New Zealand; this includes any descendent of such a person.** Ask: **"*Who do you descend from – which group are your parents?*" *e.g. NZ European/Pākeha, Māori, Pacific Island, Indian, English, Scottish etc.?***

- **Pain (on average in past week) numeric rating scale – NRS**

1. Pain at base of thumb on average in the past week
Circle a number that best describes what your pain at the base of your thumb has usually been like on average during the past week, where "0" is no pain and "10" is extreme pain No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain

- **Pain (interfering in sleep on average in past week) NRS**

2. Pain at base of thumb on average at night in the past week
Circle a number that best describes what your pain at the base of your thumb has usually been like at night during the past week, where "0" is no pain and "10" is extreme pain No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain

- **Functional Index of Hand Osteoarthritis (FIHOA) questionnaire**
  - **Explain, "this is a questionnaire about your hand function – rate each task as…"**

FIHOA Questionnaire (Dreiser Index)

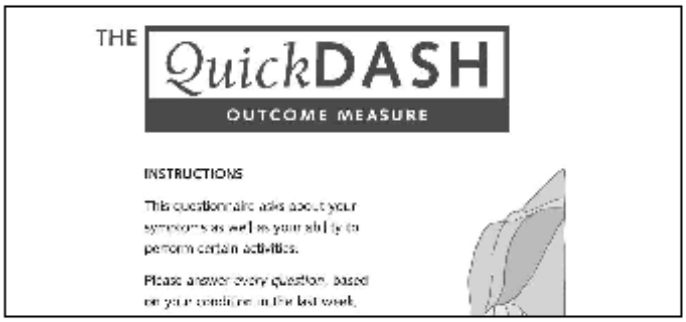
0 – possible without difficulty
1 – possible with slight difficulty
2 – possible with important difficulty
3 – Impossible

- **Additional questions**
  - **Explain these are additional questions – please complete as per the FIHOA**

Questionnaire – additional questions

0 = possible without difficulty
1 = possible with slight difficulty
2 = possible with important difficulty
3 = impossible

- **Quick DASH questionnaire**
  - **Read the front page to the participant and check if they have any questions**


THE QuickDASH OUTCOME MEASURE

INSTRUCTIONS

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer every question, based on your condition in the last week.

- **EQ-5D health status questionnaire**
  - **Read the instructions to the participant and check if they have any questions**

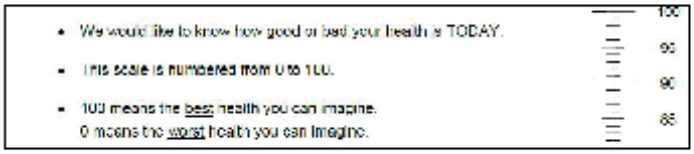

MOTO Study ID:_____
Date __/__/__

EQ-5D-5L

Under each heading, please tick the ONE box that best describes your health TODAY

MOBILITY

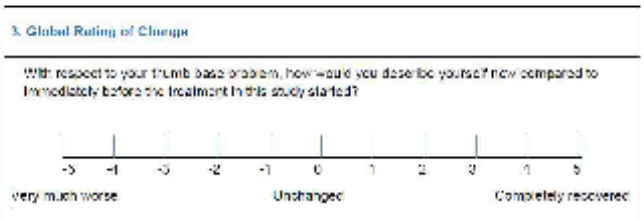
I have no problems in walking about ☐
I have slight problems in walking about ☐


- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.

100
95
90
85

Self-report measures – Follow up (4-week and 6-month) only

- **Global Rate of Change (GROC)**
  - **Read the instructions to the participant and check if they have any questions**



- **Complications or adverse events**
  - **Ask the participant about any complications or adverse events since the last assessment, record on the assessment sheet.**

- **Medications**
  - **Ask the participant about medications taken since the last assessment**
  - **Specifically, ask about non-steroidal anti-inflammatory (NSAIDS) taken over the past week, record on the assessment sheet.**

- **Other interventions sought**
  - **Ask the participant about any other interventions sought (including surgery) during the study intervention and/or follow up period, record on the assessment sheet.**

- **Daily diary**
  - **At 4-week assessment, collect the daily diary from the participant and place in the document folder. Do not open the diary and do not ask or answer any questions about the content – advise the participant that you need to have no knowledge about what treatment the participant has received. Any queries should be directed to the Research Administrator in the first instance.**

Issuing petrol vouchers

On completion of the data collection, please issue the participant with their petrol vouchers. The correct value for the participant will have been calculated beforehand and recorded on the Petrol Voucher Record Sheet along with the date and participant number. Please have the participant sign the Petrol Voucher Record Sheet on issue of the petrol vouchers.

The completed data sheets and questionnaires should be placed in the document wallet and returned to the Research Administrator in Room 210 or to the School of Physiotherapy Reception.

4. Eligibility screening

- Eligibility screening comprises a series of questions (1-7), information derived from the Participant Demographic and Health Questionnaire, the Pain NRS, the FIHOA questionnaire, and physical assessments (palpation, observation, grind test and traction-shift test).
- Partial screening (questions 1-7) will have been undertaken by the Research Administrator.
- Full eligibility screening will be conducted at the Baseline timepoint
- Questions 1-7 should be asked prior to the informed-consent process
- Only those who meet all eligibility criteria can be enrolled into the study
- Full eligibility screening is outlined in detail in the Eligibility Screening Form

5. Informed-consent Complete the informed-consent process:

- Review the Participant Information Sheet
- Allow the potential participant to ask any questions
- Do not reveal the full study hypothesis to the participant
- Sign the Consent Form (participant and researcher)
- Give the [potential] participant the Participant Information Sheet and highlight contact details.

6. Research Assistant role reflections

As this is a feasibility study, you will be asked to reflect on the eligibility screening, informed consent, and assessment procedures, and the overall assessor role, to inform decisions about the design and planning for future full-size trial.

You will **be provided with an 'Research Assistant Diary'. Please take a couple of minutes after each** assessment session to note any comments or reflections about the processes and procedures and overall feasibility.

7. Emergency procedures

- In the case of an emergency event, call 1_111
- Instruct on evacuation procedures specific to site
- Demonstrate defibrillator location specific to site

Appendix P Baseline screening schedule – Feasibility study

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _
Date:_ _/_ _/_ _

MOTO feasibility study – Eligibility Screening Tool

Question	Inclusion Criteria	Met?
1. Are you comfortable speaking, reading and writing in English?	English-speaking adult	☐
2. What is your age?	Aged 40+ years	☐
3. Have you experienced aching, or problems *(e.g. stiffness)* in or around the joint at the base of either thumb on most days for at least 1 month (15 or more days of the month) during the past year?	Answers "yes" to the question	☐
4. Do you have any other diagnosis for your thumb problem?	Answers "no" to the question	☐
5. Have you experienced some problems in your thumb in the past month?	Answers "yes" to the question – i.e., symptomatic	☐
6. Have you had surgery for this joint?	Answers "no" to the question	☐
7. Do you have rheumatoid arthritis or any other inflammatory or autoimmune conditions that affect your hand? *(e.g. scleroderma, systemic lupus erythematosus and psoriatic arthritis, or another kind of chronic pain syndrome or metabolic disorder, such as fibromyalgia, diabetic neuropathy, or gout.)*	Answers "no" to the question	☐
Complete informed consent process before proceeding to next sections		
Participant-reported outcomes		
Participant demographic and health questionnaire: current or previous treatments for thumb base pain	Answers do NOT include injection (in last 6 months) or splint (prescribed by health professional)	☐ ☐
Complete pain (on average in past week) NRS	Minimum severity pain NRS 4/10	☐
Complete FIHOA questionnaire	Minimum score FIHOA 6/30	☐
Physical assessments		
Observable 'step-off' sign Palpate thumb CMC joint for tenderness Perform grind test Perform pressure-shear test	One or more test is positive	☐ ☐ ☐ ☐
Inclusion and Exclusion criteria met?		☐
Enroll participant in study?		☐

Comments

Appendix Q Advertisement for recruitment – Feasibility study

In this research study, we want to test a study design where you are randomly assigned to either standard normal care (education, advice and general exercise) for your thumb base osteoarthritis, or normal standard care plus an additional non-drug, non-surgical treatment.

As part of this study:

You will receive a $20 petrol voucher for each of the 3 assessments you attend, to help reimburse any costs

Light refreshments will be provided.

You will be asked to complete 3 assessment sessions, an X-ray of your hand, ultrasound imaging of your hand (only for first 8 people able to attend specified time slots) and a 4-week treatment programme. Total time commitment: 5 hours, over 6 months.

To be eligible you meet all the following criteria:

- You have been diagnosed with thumb base osteoarthritis OR you have had pain or problems at the base of your thumb on most days for at least 1 month in the past year with no other diagnosis.
- You have had some pain or problems in the last 4 weeks.
- Must be at least 40 years of age.
- You do not have rheumatoid arthritis or any other problems affecting your hands.

If you live in Dunedin or Invercargill, please contact the Clinical Research Administrator at the University of Otago School of Physiotherapy.

Email: clinicalresearch.physio@otago.ac.nz
Phone: 0800 687 489
For more information visit otago.ac.nz/thumb-base-oa

This project has been reviewed and approved by the Northern B Health and Disability Ethics Committee (HDEC). Reference: 18/NTB/240

Appendix R Letter of invitation to clinicians to assist with study recruitment – Feasibility study

University of Otago
Centre for Health, Activity, and Rehabilitation Research
School of Physiotherapy

Date: 8 April 2019

To: The Practice Principal

From: Miranda Bűhler PhD Candidate, University of Otago School of Physiotherapy
Miranda.Buhler@postgrad.otago.ac.nz Tel. 03 479 7460 Mob. 027 299 3979

RE: **Management of Thumb Osteoarthritis – MOTO Study**

Please could I request your assistance in recruiting participants with thumb base osteoarthritis (OA) for a feasibility randomised controlled trial study that I am conducting as part of my PhD programme. This feasibility study aims to test the study design for a future full-sized study investigating the management of thumb base OA. The specific assistance I am requesting is 1) displaying the enclosed poster and flyers in your waiting room, and 2) that clinicians invite patients whom they identify as having thumb base osteoarthritis to consider taking part in the study. The patient would then contact the researcher if they felt they might be interested in participating.

Participants in this study will be randomised to standardised package of usual care (education, advice, general exercise and normal physician care), or standardised usual care plus additional splint intervention, for thumb base OA. Participants will be asked to: attend a one-off treatment session; complete a short daily log for 4 weeks; attend for assessment at baseline, 4 weeks and 6 months; and attend for one-off x-ray imaging of their hand (if no hand X-ray in past 6 months), and for eight participants also ultrasound imaging, at baseline. **The exact nature of the additional intervention will not be revealed to participants until after the 4-week assessment**, to avoid bias in how they perceive the intervention during the treatment period and first follow up assessment, i.e. participants will remain blinded to the study hypothesis for the first 4 weeks. Therefore, **clinicians – please do not reveal the splint intervention to the participant**.

Inclusion criteria: Adults with thumb base OA aged 40+ years who have either a physician diagnosis or answer "yes" to the question, "Have you experienced aching, discomfort, pain and/or stiffness in or around the joint at the base of either thumb on most days for at least 1 month (15 or more days of the month) during the past year?", and have no other specific diagnosis. Exclusion criteria: thumb(s) non-symptomatic for the last month; previous surgery of the symptomatic joint; corticosteroid injection of symptomatic joint in past 6 months; previous referral for splinting for symptomatic joint; rheumatoid arthritis or any other significant inflammatory or autoimmune conditions affecting the hand such as scleroderma, systemic lupus erythematosus and psoriatic arthritis, or another kind of chronic pain syndrome or metabolic disorder, such as fibromyalgia, diabetic neuropathy, or gout.

The GP and/or nominated health provider will be informed of participants' enrolment in the study but will not be informed of the specific intervention received until after the 4-week assessment, after which time a copy of any imaging reports and a summary report from the study clinician will be forwarded.

Appendix R Letter of invitation to clinicians to assist with study recruitment – Feasibility study

University of Otago
Centre for Health, Activity, and Rehabilitation Research
School of Physiotherapy

Study recruitment is occurring from April – June 2019. Ethical approval has been granted by the Northern B Health and Disability Ethics Committee (HDEC). Reference: 18/NTB/240. Locality authorisation has been gained from the Southern DHB Health Research South office. This study is supervised by Dr Cathy Chapple.

If you have any questions about this study please do not hesitate to contact me at the above details. Further information can also be found on the study website, www.otago.ac.nz/thumb-base-oa.

Thank you,

Miranda Böhler MPhty, NZ Reg. Hand Therapist

2

Appendix S Participant information sheet – Feasibility study

Participant Information Sheet

Study title:	Management of thumb osteoarthritis research study
Study department:	University of Otago School of Physiotherapy, Te Kura Kōmiri Pai
Principal investigator:	**Name** Dr Cathy Chapple **Position** Senior Lecturer
Primary researcher:	**Name** Miranda Bühler **Position** PhD student **Contact phone number:** 0800 687 489 **Email:** clinicalresearch.physio@otago.ac.nz

Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate.

If you decide to participate we thank you. If you decide not to take part, there will be no disadvantage to you and we thank you for considering our request.

What is the aim of this research project?

Osteoarthritis affecting the joint at the base of the thumb is a common condition that impacts on people's health and everyday life. There is potential for relief of symptoms with non-pharmacological, non-surgical treatment options. However, there is little evidence for us to know which treatments work, and for whom.

The aim of this research project is to test the practicality of a study design for investigating management of thumb base osteoarthritis with an additional non-medical, non-surgical treatment option over and above best standard usual care.

The information from this study will inform a future full-sized research study, the findings of which will help clinicians, patients and health services to know if the additional treatment (intervention) works.

Who will be doing the study?

The research project will be carried out by Miranda BÖhler as part of her PhD studies. Miranda is a Physiotherapist and Hand Therapist with 15 years' experience working in the health system in New Zealand. She is supported in this work by her research supervisors at the University of Otago School of Physiotherapy and Dunedin School of Medicine.

Miranda will be carrying out treatments that are part of the study and analysing the results. An independent Health Research Assistant will be carrying out the assessments. A Research Administrator will be coordinating the study activities. For some of the research activities, a Co-researcher (Dr Cathy Chapple) will be observing to check that assessments and treatments are done in the same way each time.

The funding for this study comes from Otago Medical Research Foundation Jack Thomson Arthritis Grant.

Who can be in this study?

We are looking to recruit people aged 40 years and over who have osteoarthritis in the joint at the base of the thumb.

To be able to participate in this study you have been diagnosed with thumb base osteoarthritis OR you have had pain or problems at the base of your thumb on most days for at least 1 month in the past year with no other diagnosis. You must also have had some pain or problems with your thumb in the last 4 weeks and have some physical signs of osteoarthritis (as assessed at an initial interview).

You do not have rheumatoid arthritis or any other inflammatory or autoimmune condition that affects your hands such as scleroderma, systemic lupus erythematosus or psoriatic arthritis. You do not have any kind of chronic pain syndrome or metabolic disorder such as fibromyalgia, diabetic neuropathy or gout, or a history of thumb surgery, or thumb steroid injection in the past 6 months

What will participants be asked to do?

In this study, the Physiotherapist/Hand Therapist will see you for a one-off treatment session in which they will provide you with a 4-week package of best standard usual care including education, advice and general exercise for your thumb base osteoarthritis, or best standard usual care plus an additional non-drug, non-surgical intervention. You will also be advised on how to continue with self-management after the 4-week treatment period until the 6-month follow up.

Should you agree to participate in this study, you will be randomly allocated to the usual care group or to the usual care plus additional intervention group. Random allocation makes sure that participants in each of the study groups are similar, and we can be more certain that the

findings of our study are due to the treatment method and not due to some other reason. The Physiotherapist/Hand Therapist will know which group you are in. However, the Research Assistant who assesses your progress to collect information for the study will not know which treatment group you are in. This 'blinding' of the assessor will prevent them from influencing the results due to their personal opinions of the treatments.

Likewise, if you agree to participate you will be partially-blinded to the full purpose of the study for the first 4 weeks – that is, we will only tell you what intervention is offered to the opposite group after the 4-week assessment so that your own opinions do not influence the study findings at the 4-week assessment. After this time the Physiotherapist/Hand Therapist will telephone you to advise you what interventions were offered to the opposite group and you can ask questions of them. However, you will not be offered the additional intervention if you did not receive this already, as there is not yet enough information to know that the additional intervention works. We will ask that you do not tell the Research Assistant who carries out the assessments at 4 weeks and 6 months what intervention you have had as part of the study.

The time involved in participating in this study will be 1) a one-hour initial interview and baseline assessment, 2) a 20-minute attendance for X-ray imaging, 3) a 20-minute attendance for ultrasound imaging (only if you are in Dunedin and able to attend at one of the specified time slots – ultrasound imaging will only occur for the first eight participants who are able to do so, due to resource limitations), 4) a 45-minute treatment session, 5) complete a record of home activity for 3 minutes daily for 4 weeks, 6) a 45-minute assessment at 4 weeks, and 7) a 45-minute assessment at 6 months.

At the initial interview the Research Assistant will first go through this information sheet with you and ask for your written consent to participate in the study. If you agree to participate, they will then ask you about your age, and about your thumb and your health, and perform some physical assessments of your thumb base joint, so that we have an idea of the severity of your thumb osteoarthritis and to confirm you are eligible to participate in the study.

Once your eligibility is confirmed, further assessments will be completed including personal details such as gender and ethnicity; your work history; questionnaires about how well your hand is functioning and your wellbeing; measurements of thumb movement, strength (using a hand-held and thumb-held dynamometer) and function (using a short test of picking up and moving every-day objects), and your height and weight. On some occasions some of the physical measurements may be repeated at the end of the session to test reliability of the measurements.

In the following 2 weeks you will have an X-ray of your thumb base joint at Pacific Radiology, and if the scheduling works for you and you are in Dunedin, an ultrasound at the Dunedin Hospital Rheumatology Department. If you have had an X-ray of your thumb base joint in the last 6 months and it is available and of good quality, then you will not need to have another X-ray.

At the 4-week and 6-month assessments the Research Assistant will again ask you to complete the questionnaires and measurements of thumb movement, strength and function. At the 6-month assessment you will also be asked how you found the study processes including the assessments and the treatment. This will help us improve the way we do research.

The assessments and treatment will take place at the School of Physiotherapy in Dunedin or in the Therapies Department in Southland Hospital, Invercargill. The Research Administrator will confirm the time and place for the study assessments and treatment with you at least 1 week ahead. You are welcome to bring a support person along if you wish.

If you need to contact the Physiotherapist/Hand Therapist during the 4-week treatment period, you can contact the Research Administrator. They will arrange for the Physiotherapist/Hand Therapist to call you. If an issue is unable to be resolved by telephone, then a second treatment session will be arranged.

After the three assessments over 6 months, the X-ray and possible ultrasound imaging, the treatment session, and the daily log for 4 weeks, you will have completed your involvement in the study. The total time commitment is 5 hours.

For each of the three assessments, you will be offered a $20 petrol voucher to help cover any costs associated with your attendance. Light refreshments will be provided.

There is no cost to you for any of the assessments or treatments carried out as part of the study. We will inform your GP of your participation in the study and send a short report about the imaging of your hand.

Is there any risk of discomfort or harm if you take part?

There are no foreseeable risks associated with study participation. There may be some minor discomforts while undertaking the physical assessments of your thumb. You can stop the assessment if you need to. The dose of radiation with hand X-ray is comparable to natural background radiation for 3 hours.

What if something goes wrong?

If you were injured in this study, which is unlikely, you would be eligible for compensation from ACC just as you would be if you were injured in an accident at work or at home. You will have to lodge a claim with ACC, which may take some time to assess. If your claim is accepted, you will receive funding to assist in your recovery.

If you have private health or life insurance, you may wish to check with your insurer that taking part in this study won't affect your cover.

What information will be collected, and how will it be used?

If you agree to participate in the study, you will have the right to access information collected about you as part of the study. A report from the X-ray, and ultrasound imaging if that occurs for you, will be sent to your GP. Your study data will be coded and people other than the research administrator, research assistant and treating therapist will not know who you are. We will tell you of any new information about adverse or beneficial effects related to the study that becomes available during the study that may have an impact on your health.

After the study has been completed, we will communicate findings to clinicians and researchers in New Zealand and internationally by presenting at conferences and by submitting articles to a journal in the field of osteoarthritis and/or hand therapy research. Your name or other information that might identify you will not be used in reports about this research. If you wish, we will inform you of the study findings by a short, written report mailed out.

The study is expected to be completed by 31 March 2020. We will keep the information collected in this study for a period of 10 years in a locked cabinet in the School of Physiotherapy and on the University's secure electronic data storage system.

What will happen if you don't want to be a part of the study later on?

You may withdraw from the study at any time and without any disadvantage to yourself.

Any questions?

If you have any questions now or in the future, please contact either:

Name: Miranda Bühler **Position:** (Physiotherapist & Hand therapist) and PhD student **Department:** University of Otago School of Physiotherapy	Contact phone number: 0800 687 489 Contact email: clinicalresearch.physio@otago.ac.nz
Name: Dr Cathy Chapple **Position:** Physiotherapist and Senior Lecturer **Department:** University of Otago School of Physiotherapy	Contact phone number: 03 479 5428 Contact email: Cathy.chapple@otago.ac.nz

Appendix S Participant information sheet – Feasibility study

Name: Simon Stebbings **Position: Consultant Rheumatologist and Associate Professor** **Department: University of Otago Dunedin School of Medicine and Rheumatology Department, Southern DHB**	Contact phone number: 03 470 3888 Contact email: **Simon.stebbings@otago.ac.nz**

If you want to talk to someone who is not involved with the study, you can contact an Health and Disability Ethics Committee independent health and disability advocate on:

Phone: 0800 555 050 E-mail: advocacy@hdc.org.nz

If there is a specific Māori issue or concern, please contact: Katrina Pōtiki Bryant, Professional Practice Fellow and Kaiārahi Māori – Māori Liaison Officer, University of Otago School of Physiotherapy (phone 03 479 7473 or email katrina.bryant@otago.ac.nz).

This study has been approved by the Northern B Health and Disability Ethics Committee. Reference 18/NTB/240.

Appendix T Participant consent form – Feasibility study

Management of thumb osteoarthritis study

Principal Investigator: Dr Cathy Chapple

Primary Researcher: Miranda Buhler

Email Miranda.Buhler@postgrad.otago.ac.nz Tel 0800 687 489 or 027 299 3979

CONSENT FORM FOR PARTICIPANTS

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant:.....

1. I have read the Information Sheet about this study and understand the aims of this research project.
2. I have had enough time to talk with other people of my choice about participating in the study.
3. I know that because I am taking part I will have an initial interview and baseline assessment where I will fill out some questionnaires about myself and my health and have my hand assessed to confirm my eligibility for the study, and for thumb movement, function and strength; undergo X-ray imaging of my hand if I have not had a hand X-ray in the past 6 months, and possibly ultrasound imaging; have a one-off treatment session with a Physiotherapist/Hand Therapist; complete a daily log everyday for 4 weeks; and then repeat the questionnaires and hand assessments 4 weeks and 6 months later.
4. I know that I will not be told what treatment (intervention) is offered to the opposite group until after the 4-week assessment.
5. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.
6. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data

from the project, and that these will be placed in secure storage and kept for at least ten years.

7. I understand that the results of the project may be published and be available in the University of Otago Library, but that I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.
8. I know that there is no payment offered for this study other than the three $20 petrol vouchers to help cover any costs associated with attending the three assessments. I know that no commercial use will be made of the data.
9. I know that there is no cost to me for any of the assessments or treatments carried out as part of the study.
10. I know that my GP will be informed about my participation in the study and sent a report from the imaging of my hand.
11. I am happy that all my questions about the project have been answered, and I understand that I am free to ask for more information at any stage.
12. I know that it is entirely my choice to take part in the project, and that I can withdraw without having to give a reason at any time and nothing will happen.
13. I would / would not like a copy of the results when the study is completed.
14. I am / am not happy to be informed about future studies

Signature of participant:	Date:

Name of person taking consent	Date:

Appendix U Clinician stakeholder consultation introduction

Dear Hand Therapist,

RE: Stakeholder discussion for "Effectiveness of splinting for thumb base osteoarthritis: a feasibility randomized controlled trial"

Thank you for participating in this stakeholder discussion. This discussion specifically aims to inform the intervention and control components of a study which aims to test the feasibility of study design parameters including the recruitment strategy, assessment battery for time and acceptability, implementation and evaluation of 'usual care', the intervention procedures including evaluation of adherence, and outcome change over time to inform a future full-powered randomized controlled trial (RCT). This feasibility study represents the third and final stage of my PhD programme investigating the impact of thumb base OA and the effectiveness of splinting.

The current study will aim to recruit 30 adults with thumb base OA, randomised to two groups: splint intervention or control group. Both groups will also receive usual care (education and advice, general exercise, and usual GP/physician care). The intervention will occur over 4 weeks. Assessment will occur at baseline, 4 weeks and at 12 weeks. The splint intervention will be an off-the shelf neoprene thumb support provided to the patient with fitting and wearing instructions given by the treating therapist. Both the intervention and control group will also receive 'standardised usual care' – education and advice, general exercises, and continue usual GP or physician care. Questions about the intervention and standardized usual care are outlined below. I particularly wish to know what your expert clinical opinion is on the proposed content and format of each, as well as how acceptable and 'doable' each aspect would be in the real-world clinical setting. I will provide a short presentation on the literature relevant to the discussion points.

Your participation in this discussion is much appreciated and will be recognized by way of acknowledgement in presentations and publications of this work if you consent to this. NB, sometimes written consent from the person being acknowledged is mandatory for their name to be published and therefore if you would be able to write your consent, sign, date and scan or post to me, that will ensure the permission is on file, thank you!

Miranda Buhler, PhD candidate

Supervisors and Co-investigators: Dr Cathy Chapple, Prof Dave Baxter, Assoc Prof Simon Stebbings

Appendix U.1 Clinician stakeholder consultation power point presentation

10/10/2020

Effectiveness of splinting for thumb base OA: a feasibility randomized controlled trial

Stakeholder discussion: splint intervention & standardized usual care

Miranda Buhler, PhD Candidate University of Otago Centre for Health, Activity & Rehabilitation Research

June 2018

1

- Research question:
  - How effective is splinting for thumb base OA?
- Aim of current study:
  - Test feasibility for RCT - recruitment strategy, assessment battery time & acceptability, intervention procedures, adherence, outcome change over time
- Aim of discussion:
  - Inform the intervention and control components of the study

2

1

Appendix U.1 Clinician stakeholder consultation power point presentation

Splint intervention


- Systematic review *(submitted for publication)*
  - The Cochrane Library, MEDLINE, Embase, CINAHL, ISI Web of Science, Scopus and Google Scholar, 3 trial registries and 2 conference proceedings up to 17/3/18.
  - Randomised and non-randomised controlled trials
  - 12 studies, 4 comparing splint to control and 8 to another splint.
  - Moderate to large effect for pain and small to moderate effect for function in the medium-term (3-12 months) (low quality evidence).
  - No significant effect at short-term or for different types of splints (low quality evidence)
- ***"Wear at night only"*** Rannou (2009) Ann Intern Med 150(10):661-9
- ***"Wear during activity only"*** Gomes Carreira (2010) J Rehabil Med 42(5):469-74
- Follow-up: ***"only if need adjusting"*** or not specified

International guidelines: only conditional recommendation for splints

3

Splint intervention


Rationales:

- Stabilise the CMC joint
- Stabilise adjacent joint (prevent thumb MCP joint hyperextension)
- Leave adjacent joints free for unhindered function
- Maintain length of the first web space
- Reduce CMC joint synovitis/inflammation
- Reduce local muscle spasm
- Patient preference

Evidence for mechanisms:

- Reduce CMC joint subluxation Weiss (2004) J Hand Ther 17(4):401-6
- Reduce pain and bone oedema in knee OA Goodman (2013) Medscape Med News /article-813572ced
- No effect on thumb abduction ROM after 1 year Rannou (2009) Annals Internal Med 150:661-669
- MCP flexion effectively unloads the most palmar surface of CMC joint Moulton (2001) JBJS 83(5):709-716

4

Standardised usual care: Education & Advice

- Leaflet & advice for hand OA Dziedzic (2015) Ann Rheum Dis 74(1):108-12
  - http://www.arthritisresearchuk.org/
- Joint protection education Dziedzic (2015) Ann Rheum Dis 74(1):108-12
  - Delivered over 4 group sessions max 1 hour, 1 x weekly
  - **Based on 'Looking After Your Joints** Programme' **for rheumatoid arthritis**
  - At 6 months, statistically significantly more likely to be classified as responders to treatment vs not receiving joint protection (33% vs 21%)
- Intensive group-based multidisciplinary treatment programme incorporating self management, ergonomic principles and exercises not effective Stukstette (2013) Osteoarthritis Cartilage 21:901-10.
- Continue usual GP/physician care

5

Dziedzic (2015) Ann Rheum Dis 74(1):108-12

Core components

- Introduction to the programme
- Education about hand OA and its management
- Managing pain during everyday activities
- How to change habits
- Long-term and short-term goal setting
- Weekly individually negotiated home programmes to practice skills taught
- Weekly review of individually negotiated home programmes
- Workbooks

6

Dziedzic (2015) Ann Rheum Dis 74(1):108-12

Joint care principles

- Distributing the weight of what you lift over several joints (eg, spread the load over two hands)
- Avoiding putting strain on the thumb and repetitive thumb movements
- Avoiding prolonged grips in one position
- Using as large a grip as possible
- Reducing the effort needed to do a task (eg, use labour-saving gadgets; avoid lifting heavy objects, and reduce the weight of what you lift)
- Energy conservation (activity pacing and planning)

7

Standardised usual care: Exercise

- Designed to increase muscle strength, increase mobility and stability
- Recommended by EULAR guidelines Zhang (2007) Ann Rheum Dis 66(3):377-88, but not ACR Hochberg (2012) Arthritis Care Res 64(4):465-74
- Effectiveness of exercise for hand OA Osteras (2017) Cochrane Database of Systematic Reviews
  - Small effect on hand pain and on hand function (low quality evidence)
  - Small-moderate reduction in finger stiffness (low quality evidence)
  - **Optimal exercise programme and dosage for hand OA not yet known**
- Example exercise programme Dziedzic (2015) Ann Rheum Dis 74(1):108-12
  - Delivered over 4 group sessions max 1 hour, 1 x weekly (no significant effect)

8

Appendix U.1 Clinician stakeholder consultation power point presentation

Dziedzic (2015) Ann Rheum Dis 74(1):108-12

Stretching exercises

- Wrist flexion and extension, pronation and supination
- Tendon gliding
- Radial finger walking
- **Making an 'O' with the thumb and index finger**
- Thumb extension, abduction and opposition to the base of the 5th finger

Strengthening exercises

- Using an elastic band to provide resistance to thumb extension, thumb abduction and finger extension
- Using Play-Doh rolling and forming into a ring to provide resistance to thumb and finger extension, squeezing it into a ball, and
- Pinching off pieces between the thumb and index fingers
- Holding a 0.5–0.75 kg weight while doing wrist flexion and extension exercises in pronation then supination

9

5

Appendix U.2 Consultation schedule with questions

STUDY COMPONENT	YOUR THOUGHTS
The intervention: neoprene thumb (CMC) support	
Fitting • Sizing – measure strictly or try on • Cut/trim to fit • Sew on additional strap length	
Wearing schedule • Day and night: 23/24 hours ▪ Remove just for hygiene ▪ Remove for exercises	
Duration ▪ 4 weeks	
Delivery ▪ One-off session • Phone follow up as required • Further sessions?	
Other aspects	
Standardised usual care: Education and advice	
Content ▪ About the condition: anatomy, disease process ▪ CMC joint kinematics – optimal joint congruency ▪ Ergonomics – increase size and grip for reduced joint loads • Joint care principles – use bigger, more proximal joints; micro-pauses/macro-pauses; assistive devices; task modification	
Format • A4 page	

- Pamphlet
- Online?

Delivery

- One-off ca. 10 min
- Discussion of material vs goal setting, problem-solving

Standardised usual care: Exercise

Content

- Generic hand – opposition; open; gentle fisting
- General – walking

Format

- A4
- Pamphlet
- Online

Delivery

- One-off ca. 10 minutes
- Standardised vs individualised

Other aspects

Standardised usual care: GP/Physician care

- Advice
- Medication
- Monitoring

Appendix U.3 Summary of consultation responses

Summary of stakeholder consultation with expert hand therapists

Main points		Conclusions and recommendations for study
Splint intervention		
	Type of splint and fitting	
	□ **Splint type** • The Comfort Cool neoprene splint is a good option for wide range of patients and is not too costly compared to other splints. • In Northland patients are sweating in summer so neoprene may not be so good. • Thermoplastic might be better, or light elastic. Australia would be same problem. In Nelson, the neoprene is well tolerated, although some challenges in height of summer. Look out for skin rash in heat. • Tend to start with thermoplastic splint first – lower cost to DHB as just uses a small piece, vs neoprene splint is more expensive off the shelf. • Neoprene splint sometimes harder to get hold of in DHB (one centre), especially different sizes. • Push Brace is pricier especially in private practice, and harder to fit off the shelf. • Neoprene ok for little old ladies not doing too much, but 'men' need something more supportive because working and greater demand on hands. • The evidence tells us that splinting helps – doesn't matter what splint – let the patient choose. Unless MCP hyperextension in which case aim to control MCP position. • Show patient the options, see what patient thinks will work for them. Find that find that patients often don't like hard rigid thumb spicas. • Have been playing around with soft cast long thumb spica for colleague with hand OA and this has been	The neoprene Comfort Cool splint is suitable for study intervention. Need to consider what time of year (which season) study will take place in. Consider climate generally. Look out for skin irritation with neoprene splint. Neoprene may not work for everyone, or currently be available to all therapists (but most respondents agreed is accessible). Cost of labour to produce thermoplastic splint is further consideration. *Result of future study would help inform resource decisions in DHB and other settings.* A range of splint options are used. Patient choice is part of current practice. *This is an area for future study.*

	successful for tasks such as gardening – offers near full immobilization of the CMC joint. • Little USL splint colleague found good for light tasks e.g. knitting. • Often use "ordinary old thumb-wrist wraps – neoprene (therapist in department makes them). • Orfit – light thermoplastic – is nice material to make thermoplastic splint – has some flexibility, well tolerated, but more support, can include MCP. • Consider Orficast? • These alternate (thermoplastic or casting tape) splints take more skill to fabricate. • Also have Push brace splints. Find these are good in early OA. But they are expensive. Can be good for working people who must do repetitive tasks. • Indicate the season – neoprene may be more beneficial and better tolerated in cooler climate. • Patients like heat – likely the neoprene provides some benefit in this regard. • Neoprene splint a good option because it is the easiest to fit, although some patients have difficulty pulling on and may not wear because of difficulty donning. • Consider USL splint? • In hospital system lucky – can change around to see what works for patient without having to charge.	Tailoring the splint to the individual has perceived benefit however requires a range of splints to be available. *Future study may include algorithm for splint choice, or stepped approach, e.g. where first line not successful, try second line.* May be sex and age difference in splint effectiveness due to different demands on thumb CMC joint. *This is an area to consider for future study.* Check patient donning and doffing during intervention session, record any difficulties.
	□ **Sizing – measure strictly or try on?** • Comfort Cool splint can be a bit narrow • Patients are often between sizes. • Try on rather than measure for sizes. • Fit well if no deformity, but if adduction deformity or big wrist/forearm then poor fit - can't do up proximally or is saggy in the volar web area and not supportive. • A lot of ½ sizing (between sizes) are available • If don't fit properly then no good	Include option of in-between sizes. Have different sizes available for participants to try on. Ensure good fit
	□ **Cut/trim to fit?** • Yes, do snip a bit • Often need to cut off the top of the thumb bit	Have good fabric scissors available to modify.

	• Need to "brutalise" the neoprene splint to get it to fit – often too tight but right size, so man handle to stretch out.	Give splint a good stretch before participant takes away.
	□ **Sew on additional strap length?** • Agree the webspace strap is sometimes too short, good idea to extend when need to. • Recommend use 'OneWrap' to extend the Velcro strap, or NRX strap. • May use rivet. Rarely take to orthotist to adjust. • Don't do any sewing – too firm at wrist end to adjust there.	Have options available to extend webspace strap: 'OneWrap' or 'NRX strap'. These options more feasible than sewing. Rivet is too complex for general practice setting.
	Wearing schedule (dosage)	
	□ **Hours per day and during which parts of day?** • Prescribe for use during day for activity or whenever patient needs to wear. • Usually recommend to patients they "wear when helpful"; wear as much as can first 2-3 weeks, then wean. • Use for rest in the day • Day and night for 23 out of 24 hours would be possible. It is longer than usually prescribed. • 23-24 hours is a lot, perhaps unrealistic. • Maybe 20/24 hours to allow some tasks • Find patients do wear a lot especially if helping • For more frequent wearing, would need two splints – one to wash, one to wear, if wearing long periods for long duration. • Tend not to wear at night if splint is dirty from use in the day e.g. gardening. Patients find splint is good when gardening, so they wear for gardening tasks. One to wash, one to wear is good idea. • Push brace or thermoplastic is well-tolerated in the North, like to wear as working splint. Or little thumb USL splint. • Recommend wear gloves over top for some tasks? But neoprene splint bit bulky – works better e.g. with PushBrace.	Usual splint prescription is variable. Long duration is possible but not usual. Wearing over night as well as during day is acceptable, especially given evidence presented in pre-discussion presentation. 23 hours/24 not acceptable but 20 hours probably would be. Would require two splints, one for wash, one for wear. Concern the splint may cause thumb muscles to become weaker. *This has been demonstrated not to occur – summary of evidence provided verbally and discussed.*

	• Yes, recommend patient wear at night – based on Rannou 2009 study (in presentation to stakeholders). • Often recommend wear at night (one therapist) • If really sore, recommend wear night and day for 1-2 weeks. Then just when doing activities. • Recommend reduce splint wearing to avoid muscles becoming weaker (due to splint wearing causing dis-use). • Agree that higher dosage is better for optimizing effect, especially for study	
	□ **Remove just for hygiene?** • Always need to take off for wet tasks so perhaps stipulate this. • Agree, patients usually take off for dishes etc. • Often also take off for dirty tasks.	Advise participants to remove splint for wet tasks. Leave 'dirty' tasks up to participant, provide two splints.
	□ **Remove for exercises?** • Yes	Do so
	Duration of splint intervention	
	□ **4 weeks?** • Agree 4 weeks is good duration as patients often busy; if 2-3 weeks then things may be happening, they don't have a chance to give it a good go. Allows for ups and downs of life • 8 weeks might be better – based on Rannou study? • 4 weeks sensible. • 1-2 weeks as above – not too long or get weakness	Splint intervention of 4-weeks duration is suitable.
	Delivery	
	□ **Number and timing of clinic appointments?** • Usually initial appointment, then follow-up at 2 weeks to check patient applying splint correctly and if working. • Usually see first to institute splint and give advice/education/exercise, then touch base at 3-4 weeks. • Minimise follow up in private practice because of cost. Or see again at 2 weeks, mainly for one therapist for	One-off session in context of the study aims could work. High quality instruction and support materials, and sufficient time to provide participant feedback, would assist in achieving satisfactory performance of

	whom the exercises are very important and therefore check quality of exercises and check splint. • If custom-made splint, see at 1-2 weeks to check up if needs adjusting. • If off-the-shelf splint, just telephone follow up to see how they get on. If not successful, then follow up to provide alternate splint. If is successful, then may provide second splint. • One-off session could work. Makes sense for study purpose. Patient understanding of splint donning and wearing would need to be good. • One-off may be reasonable, although important to check treatment is being implemented correctly including exercises. In light of evidence from presentation, understand that it is unclear as to the importance of the exercises, or which exercises, so more in favour of one-off session at this point.	exercises and correct adherence to splint wearing. Quality audit important to monitor quality of intervention delivery.
	□ **Phone follow-up?** • No – this often occurs in studies but doesn't translate to practice; clinicians don't want to be receiving phone calls and emails. Rather, patient come into clinic, sort things and that's that. • Follow-up in clinic would better reflect practice.	No formal telephone follow-up scheduled as part of intervention but leave open for participant.
Standardised best practice usual care: Education and advice		
	Content	
	□ **About the condition: anatomy, disease process?** • Don't talk a lot – just very briefly: convex/concave joint, lots of movement, females have more shallow joint surfaces so less stability; aim is to reduce loading and swelling.	Keep concise Cover joint structure, high mobility, low stability, aim of treatment. *Sex-related features not accurate according to current evidence – leave out.*
	□ **CMC joint kinematics – optimal joint congruency?** • Yes – 'C' posture	Include

	□ **Ergonomics – increase size and grip for reduced joint loads?** • Yes	Include
	□ **Joint care principles – use bigger, more proximal joints; micro-pauses/macro-pauses; assistive devices; task modification?** • Yes • Tailor to individual	Include Individualise
	□ **Additional suggestions?** • What about heat? Usually mention this to patients – that they might like to try. • Often issue arthritis gloves • Sometimes piece of non-slip mat for lids etc. • Encourage patient to take Arthritis NZ pamphlet – available in the department. • If stiff fingers then patient uses thumb more to grip with more adduction and MCP hyperextension, in which case more important to increase size of grips to ensure fingers doing the work. Rubbery matting for jars etc. can help here.	Look at evidence for heat treatment *Arthritis gloves are additional device, no specific guideline recommendations.* Given undoing lids and tops was the most common functional difficulty for participants in qualitative study – suggest participant consider nonslip mat as option. *Won't supply as additional device.*
	Format	
	• **A4 page?** • Use 2-sided folded A4 pamphlet. • Provide sheet with info, along with catalogue from local 'mobility' shop	Written information is well utilised. Max 2-sided A4
	□ **On-line information?** • Sometimes refer to e.g. Mayo Clinic resources, but don't know how many patients use. Suggest put information on hand therapy website? • Don't currently routinely use online info (most), but keen to if something good is produced.	Use study website to make available Arthritis NZ pamphlet and information about where to buy adaptive equipment. *Could also be more widely disseminated, e.g. NZ Health Navigator, or HealthPathways.*
	Delivery	

	• **One-off ca. 10 minutes?**
	  • About the amount of time usually spent
	  • Best when supported with written information
		Allocate 10-15 minutes for Education and Advice.

	□ **Discussion of material vs goal setting, problem-solving**
	  • Agree simple discussion of material is fine, as not investigating an education intervention per se.
	  • Agree simple is fine
	  • Agree – does minimal talking, main thing to provide written info, and fit splint.
		Individualise, but not necessary to carry out goal-setting process.

Standardised best practice usual care: Exercises		
	Content	

	□ **Generic hand – opposition; open; gentle fisting?**
	  • Agree reasonable to keep simple/generic. No consensus on what exercise is best.
	  • Thumb palmar abduction exercise *Everyone does this* so should include – either free active movement, or place and hold (isometric), or trace line on tennis ball.
	  • Get patient to "show me what you've done" to check quality of exercise.
	  • "Make an "O" grip" and using fingers to grip rather than thumb to decrease MCP joint hyperextension.
		Include: thumb palmar abduction range of motion and/or isometric exercise; opposition.

	□ **Specific exercise?** • Agree manual techniques in Jan Albrecht often used	Include: self-massage of 1st webspace; self-traction; 1st webspace stretch.
	□ **General exercise, e.g. walking?** • If guidelines recommend this, sure	Include: general exercise such as walking
	Delivery	
	□ **One-off ca. 10 minutes?** • Usual practice (for the patients referred to hand therapists in secondary care) is first session – overview of the condition + splint = rest first to reduce inflammation, and older patients often aren't able to take everything on board at once; so yes, further	Allocate 10-15 minutes to Exercises

	session might be a good idea – for the education side. However, this study not an investigation of education, rather the splint + 'standardised usual care'. Most patients don't get referred to hand therapists so would be acceptable just to provide one session of education.	
Standardised best practice usual care: GP/Physician care		
	Agree this usually comprises advice, monitoring, and medication	Include: continued usual GP/Physician care.

Appendix V Splint intervention information sheet for Right thumb

Centre for Health, Activity, and Rehabilitation Research
School of Physiotherapy

Management of Thumb Osteoarthritis – MOTO study

How to wear your thumb base splint

What is a thumb base splint?

Your thumb base splint is a soft support made of neoprene.

How do I put my splint on?


1


2


3


4


5


6

How does my thumb base splint help?

Your thumb base splint lessens the stress and strain at your thumb base joint by keeping the joint surfaces in the best possible place, and by giving the joint extra support.

Your splint gives your thumb base joint extra warmth and compression, both of which may ease pain and inflammation.

When should I wear my thumb base splint?

Wear your splint at **night**, and **during the day**, both when you are doing things and when you are resting. **Take your splint off** when having a **shower** and if your hands are **getting wet**. Take it off to do the exercises.

Aim to wear your splint 20 out of 24 hours.

How do I look after my splint?

You have two splints – one to wash and one to wear. Wash each splint regularly – at least once a week.

To wash it, soak in a bucket of warm water with washing powder for half an hour, rinse well, and let sit to dry. Do not put it through the washing machine.

RECORD THE TIME YOU WEAR YOUR SPLINT, AND WHEN AND WHY YOU TAKE IT OFF, IN THE DIARY

Right thumb

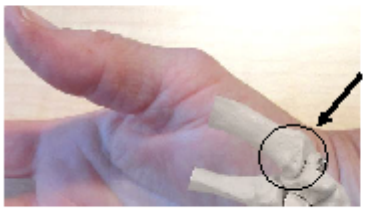
Centre for Health, Activity, and Rehabilitation Research
School of Physiotherapy

Management of Thumb Osteoarthritis – MOTO study

How to care for your thumb base osteoarthritis

What is thumb base osteoarthritis?

The thumb gives humans an amazing ability to use tools and create our world. The thumb base joint is a small joint that we put under a lot of force. It has two shallow, saddle-shaped bone ends shaped like a rider on a saddle.



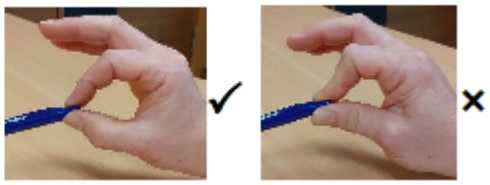
The shallow, saddle-shaped bone ends of the thumb base joint.

This allows for great movement, which is good when the joint is healthy but a problem if the joint surfaces are not well aligned. Poor alignment means more force through a smaller area, with excess stress and strain on the joint.

Osteoarthritis describes the injury to ligaments, cartilage and bone that occur when stress and strain are more than the joint can handle. This creates inflammation and pain. Recovery is limited by repeated stress and strain and other factors such as age.

What can I do to lessen stress and strain at my thumb base joint?

1. Use your thumb in ways that keep the joint surfaces in the best possible place - use your thumb in a "C" position, where the joint surfaces are in most contact. In doing things, keep your thumb more out to the side. More contact area means less force. Use your finger to grip rather than your thumb.



2. Increase the size and "grip" of the handle of tools or equipment you use, for example a pen or kitchen knife.
3. Use two hands instead of one or use bigger joints such as your elbow or shoulder.
4. Take mini breaks to let your joint recover, but don't stop using your hand.
5. Use gadgets to make the job easier in your kitchen, at work, at your computer, in your garden, or caring for children and others. E.g. non-slip mat to open a jar or use different containers instead of a jar. Spring-loaded scissors, tap turner, slip-on pegs, or hand-shaped computer mouse may ease everyday activities. More gadgets can be found at kitchen or hardware stores, at specialist shops, or online. *For online resources go to* www.otago.ac.nz/thumb-base-oa

6. **What about the pain?**

Pain interferes **with how the muscles work to support your** joint. Less pain is better. Try gentle heat or cold. Take your pain relief as prescribed.

Right thumb

Appendix W Standardised package of best practice usual care information sheet for Right thumb

University of Otago | Centre for Health, Activity, and Rehabilitation Research, School of Physiotherapy

Management of Thumb Osteoarthritis – MOTO study

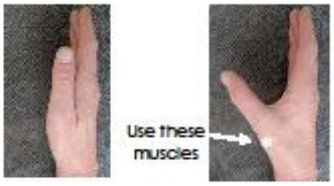
Perform Exercises 2 times Daily for 5 Minutes - the exercises should not be painful.

1. Massage your thumb webspace using your other thumb webspace, 30 seconds

2. Gently pull the length of your thumb away from your hand for 5 seconds, then relax.
Repeat 2 times

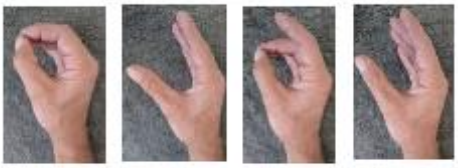
3. Gently stretch your thumb out to the side – grasp the base of your thumb and stretch your fingers back. Hold 5 seconds, then relax.
Repeat 2 times

4. Teach the muscles: Spread your thumb out to the side as if grasping a large jar – keep your thumb long and curved like the arch of a bridge. Hold 3 seconds, then relax back.
Repeat 10 times



5. Butterfly stretch: Place your sore hand on your chest, reach over with your other hand and grasp the base of your thumb. Gently stretch back, hold 5 seconds, then relax. **Repeat 2 times**

6. Touch your thumb to your index and then your middle finger, spread your thumb out in between.
Repeat 5 times



General exercise for example walking or in the pool is recommended for your general health and for reducing the impact of osteoarthritis in any joint. Exercise should be comfortable. Do little bits often, e.g. 10-20 minutes twice daily.

RECORD THE ADVICE YOU FOLLOW AND HOW MANY EXERCISES YOU DO AND WHEN IN THE DIARY

Right thumb

Appendix W.1 Standardised package of best practice usual care additional verbal cues

How to care for your thumb base osteoarthritis

Discussion prompts:

What is thumb base osteoarthritis?

- Illustrate CMC saddle joint using reciprocal hands.
- Illustrate malalignment
- 2 pounds force at tip = 12 pounds force at base – long lever effect.

What can I do to lessen stress and strain at my thumb base joint?

- Use your thumb in ways that keep the joint surfaces in the best possible place
  - Describe 1st CMC joint alignment by positioning in lateral grip – "step off", vs opposition – flush.
  - Length of first webspace important to achieve congruency – exercises
- Applying principles, solving problems
  - Identify barriers/ opportunities/ facilitators
  - "Where do you see this working for you?" – self scanning

Appendix X Researcher schedule 4-week follow-up

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

STUDY CLINICIAN FOLLOW UP

Prior to 6-month assessment:

- Instruct participant not to reveal what treatment received
- Instruct participants issued with splints not to wear to the assessment at 6-months

Study group (circle): Usual care Usual care + splint

After 6-month assessment: Date of 6-mo assessment __ / __ / __

Telephone participant after 6-month assessment: Date of telephone f/u __ / __ / __

- Ask if they found intervention acceptable (yes/no)

.....

.....

- Ask if they found assessment procedures and time acceptable (yes/no)

.....

.....

- Ask about any adverse events related to treatment as part of study

.....

.....

- Encourage participants to continue with their care package as self-management as they find useful.

.....

- Answer any questions from participants

.....

Appendix Y Researcher schedule 6-month exit interview

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

STUDY CLINICIAN FOLLOW UP

Prior to 6-month assessment:

- Instruct participant not to reveal what treatment received
- Instruct participants issued with splints not to wear to the assessment at 6-months

Study group (circle): Usual care Usual care + splint

After 6-month assessment: Date of 6-mo assessment __ / __ / __

Telephone participant after 6-month assessment: Date of telephone f/u __ / __ / __

- Ask if they found intervention acceptable (yes/no)

.....

.....

- Ask if they found assessment procedures and time acceptable (yes/no)

.....

.....

- Ask about any adverse events related to treatment as part of study

.....

.....

- Encourage participants to continue with their care package as self-management as they find useful.

.....

- Answer any questions from participants

.....

Appendix Z Daily log template for splint group

Week_____ Day_____

Advice followed:		
Exercises completed:	No. Repetitions	Occasions
Ex.1		
Ex.2		
Ex.3		
Ex.4		
Ex.5		
Ex.6		
Hours splint worn in 24-hour period:		
Reasons splint not worn:		
Any difficulties or concerns:		
Medication taken for thumb base problem:		

Management of Thumb OA (MOTO) feasibility study – participant daily log (splint group)

Appendix Z.1 Daily log template for comparator intervention group

Week_____ Day_____

Exercises completed:	No. Repetitions	Occasions
Ex.1		
Ex.2		
Ex.3		
Ex.4		
Ex.5		
Ex.6		
Any difficulties or concerns:		
Medication taken for thumb base problem:		

Appendix AA Quality audit form – Intervention delivery

Monitoring quality of standardised usual care and intervention procedures

Trial:	
Site:	**Principal Investigator:**
Visit date:	**Visit Type: Routine**
Monitor name(s):	**Visit Number:**
Clinician observed:	**ID of participant observed:**
Confirm participant has verbally agreed for the clinician to be observed during their appointment: **Yes / No**	

Item	Description	Which participants	Was the step completed fully Y-N	Describe errors or omissions
1	Briefly review MoTO CMC joint and OA information [sheet] with participant	All		
2	Review MoTO joint protection advice [sheet] with participant	All		
3	Review MoTO discussion prompts – applying joint protection principles	All		
4	Review MoTO exercise programme with Participant and complete training /instructions on how to do exercises.	All		
5	Review the daily log and explain how to complete it – for advice and exercises	All		
6	Review the splint information [sheet] and wearing instructions with participant	Splint only		
7	Splint fitted correctly and comfort checked	Splint only		
8	Review the daily log and explain how to complete it – for splint wearing	Splint only		

Appendix AA Quality audit form – Intervention delivery

Checklist of materials patient should have to take home				
9	MoTO 'How to care for your thumb base OA' [sheet]	All		
10	MoTO 'How to wear your thumb base splint' [sheet]	Splint only		
11	Daily log diary - with ID number added	All		

Comments:

For completion by trial team after the visit:

Site feedback:

Actions:

Serious concerns:

Overall outcome:

Appendix BB Quality audit form – Assessment

Monitoring quality of assessment procedures

Trial:	
Site:	**Principal Investigator:**
Visit date:	**Visit Type: Routine**
Monitor name(s):	**Visit Number:**
Assessor observed:	**ID of participant observed:**
Confirm participant has verbally agreed for the clinician to be observed during their appointment: **Yes / No**	
Appointment Observed: **Baseline / 4 week follow up**	
Comments:	

Appendix BB Quality audit form – Assessment

For completion by trial team after the visit:

Site feedback:

Actions:

Serious concerns:

Overall outcome:

Appendix CC Standardised reporting form for x-ray image scoring

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

X-ray imaging report CMC joint:

Circle/highlight: Left thumb Right thumb

Grade for osteophytes (Altman 2007 – OARSI Atlas)

- ☐ Grade 0: normal
- ☐ Grade 1: mild change
- ☐ Grade 2: moderate change
- ☐ Grade 3: severe change

Comments:

Grade for joint space narrowing (Altman 2007 – OARSI Atlas)

- ☐ Grade 0: normal
- ☐ Grade 1: mild change
- ☐ Grade 2: moderate change
- ☐ Grade 3: severe change

Comments:

Modified Eaton-Littler Grade (Eaton 1984)

- ☐ Stage I: slight joint space widening, normal articular contours
- ☐ Stage II: mild joint space narrowing, spurs or debris ≤2mm, early erosion trapezium
- ☐ Stage III: marked joint space narrowing, spurs or debris ≥2mm, subchondral sclerosis
- ☐ Stage IV: marked joint space narrowing and articular destruction, involving S-T joint

Comments:

Appendix DD Standardised reporting form for ultrasound image

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

Ultrasound imaging report:

Circle: Left thumb Right thumb

Grade for osteophytes (Mathiessen 2013)

- ☐ Grade 0: no osteophytes, i.e. a smooth cortical surface.
- ☐ Grade 1: small and distinct cortical protrusion(s) of the bony surface.
- ☐ Grade 2: larger protrusion(s) which may have broad base(s).
- ☐ Grade 3: very large protrusion(s) which may have very broad base(s).

Comments:

Dichotomous

- ☐ Present
- ☐ Not present

Grade for synovitis

Grey scale (GS) and vascularisation assessed by the use of power Doppler (PD) (Hammer 2011).
Semiquantitative scores for the presence of GS (combined score for synovitis and joint fluid) and PD

- ☐ 0 = none presence of ultrasonographic pathology
- ☐ 1 = minor presence of ultrasonographic pathology
- ☐ 2 = moderate presence of ultrasonographic pathology
- ☐ 3 = major presence of ultrasonographic pathology

Comments:

Dichotomous

- ☐ Present
- ☐ Not present

Assessor:..... Signature.....

Appendix EE Clinical assessments schedule – Baseline

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

DATA COLLECTION SHEET – BASELINE

1. **Eligibility tool** Complete ☐

2. **Informed consent** Complete ☐

3. **Enrolment** Complete ☐
   Participant GP/health provider contact details:

   _____

4. **FIHOA additional questionnaire** Complete ☐

5. **QuickDASH questionnaire** Complete ☐

6. **EQ-5D-5L questionnaire** Complete ☐

7. **MCP joint hyperextension ROM – goniometer (degrees)** Complete ☐

a. At rest	b. On active extension
1.	1.
2.	2.
3.	3.

8. **Pollexograph – active thumb palmar abd ROM (degrees)** Complete ☐
   Warm up movements x 3, then measure:

1.
2.
3.

9. **Inter-digit distance (mm)** Complete ☐

1.
2.
3.

Assessor:_____ Sign:_____ Date:_____

Appendix EE Clinical assessments schedule – Baseline

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

10. Grip Ability Test – timed (seconds) Complete ☐

Pull tubigrip over hand			
Paper clip on envelope			
Pour a glass of water		Total	

11. Grip strength (KgF) Complete ☐

Test #	Non-involved hand L / R		Test #	Involved hand L / R
1			1	
2			2	
3			3	

12. Pinch grip strength (KgF) Complete ☐

Test #	Non-involved hand L / R		Test #	Involved hand L / R
1			1	
2			2	
3			3	

13. Height (shoes off) Complete ☐

_____cm

14. Weight (shoes off) Complete ☐

_____Kg

Check all questionnaires and assessments are complete Complete ☐

Issue slip of paper informing participant on how to get hand X-ray Complete ☐

Issue petrol voucher and have participant sign for it Complete ☐

Assessor:_____ Sign:_____ Date:_____

Appendix EE.1 Clinical assessments scheulde – 4-week

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

DATA COLLECTION SHEET – 4 Weeks (circle) Left thumb Right thumb

NB. Ask that the participant does not tell you about treatment received as part of the study

1. **NRS pain, NRS pain at night, and GROC** Complete ☐
2. **FIHOA questionnaire** Complete ☐
3. **FIHOA additional questionnaire** Complete ☐
4. **QuickDASH questionnaire** Complete ☐
5. **EQ-5D-5L questionnaire** Complete ☐

6. *Please ask the participant about any additional treatments sought or received for their thumb base osteoarthritis in the past 4 weeks, other than that received in the study.*

.....

.....

.....

7. *Please ask the participant about any new or changed (increase or decrease) medication they have taken for their thumb base osteoarthritis in the past 4 weeks.*

.....

.....

If NSAID: *Name*..... *Av daily intake (mg)*..... *Days/week* .....

Name..... *Av daily intake (mg)*..... *Days/week* .....

Assessor:_____ Sign:_____ Date:_____

Appendix EE.1 Clinical assessments scheulde – 4-week

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

8. Pollexograph – active thumb palmar abd ROM (degrees) Complete ☐

	left thumb	right thumb
1.		
2.		
3.		

9. Inter-digit distance (mm) Complete ☐

	left thumb	right thumb
1.		
2.		
3.		

10. Grip Ability Test – timed (seconds) Complete ☐

Use: left hand right hand

Pull tubigrip over hand			
Paper clip on envelope			
Pour glass of water		Total	

11. Grip strength (KgF) *alternate hands* Complete ☐

Test #	Non-involved hand L / R		Test #	Involved hand L / R
1			1	
2			2	
3			3	

12. Pinch grip strength (KgF) *alternate hands* Complete ☐

Test #	Non-involved hand L / R	Test #	Involved hand L / R
1		1	
2		2	
3		3	

Check all questionnaires and assessments are complete Complete ☐

Issue petrol voucher and have participant sign for it Complete ☐

Assessor:_____ Sign:_____ Date:_____

Appendix EE.2 Clinical assessments schedule – 6-month

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

DATA COLLECTION SHEET – 6 Months (circle) Left thumb Right thumb

NB. Ask that the participant does not tell you about treatment received as part of the study

1. **NRS pain, NRS pain at night, and GROC** Complete ☐
2. **FIHOA questionnaire** Complete ☐
3. **FIHOA additional questionnaire** Complete ☐
4. **QuickDASH questionnaire** Complete ☐
5. **EQ-5D-5L questionnaire** Complete ☐

6. *Please ask the participant about any additional treatments sought or received for their thumb base osteoarthritis in the past 5 months, other than that received in the study.*

.....

.....

.....

7. *Please ask the participant about any new or changed (increase or decrease) medication they have taken for their thumb base osteoarthritis in the past 5 months.*

.....

.....

If NSAID: *Name*..... *Av daily intake (mg)*..... *Days/week* .....

Name..... *Av daily intake (mg)*..... *Days/week* .....

Assessor:_____ Sign:_____ Date:_____

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

8. Pollexograph – active thumb palmar abd ROM (degrees) Complete ☐

	left thumb	right thumb
1.		
2.		
3.		

9. Inter-digit distance (mm) Complete ☐

	left thumb	right thumb
1.		
2.		
3.		

10. Grip Ability Test – timed (seconds) Complete ☐

Use: left hand right hand

Pull tubigrip over hand			
Paper clip on envelope			
Pour glass of water		Total	

11. Grip strength (KgF) *alternate hands* Complete ☐

Test #	Non-involved hand L / R		Test #	Involved hand L / R
1			1	
2			2	
3			3	

12. Pinch grip strength (KgF) *alternate hands* Complete ☐

Test #	Non-involved hand L / R		Test #	Involved hand L / R
1			1	
2			2	
3			3	

Check all questionnaires and assessments are complete Complete ☐

Issue petrol voucher and have participant sign for it Complete ☐

Assessor:_____ Sign:_____ Date:_____

Appendix FF Pain numeric rating scale (NRS) – pain

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _

Date:_ _/_ _/_ _

Thumb base Pain score

1. Pain at base of thumb on average in the past week
Circle a number that best describes what your pain at the base of your thumb has usually been like **on average during the past week**, where "0" is no pain and "10" is extreme pain No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain
2. Pain at base of thumb on average at night in the past week
Circle a number that best describes what your pain at the base of your thumb has usually been like **at night during the past week**, where "0" is no pain and "10" is extreme pain No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain

Appendix GG Additional Functional Questionnaire (AFQ)

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/_ _

Additional Functional Questionnaire

0 = possible without difficulty

1 = possible with slight difficulty

2 = possible with important difficulty

3 = impossible

	Please circle:			
1. Can you unscrew a lid?	0	1	2	3
2. Can you hold and use a media device (e.g. cell phone or tablet)?	0	1	2	3
3. Can you do activities in which your hand takes impact or vibration?	0	1	2	3
4. Can you complete tasks without taking extra time?	0	1	2	3
5. Can you complete tasks without dropping things?	0	1	2	3
6. Can you interact with children/grandchildren?	0	1	2	3
7. Can you do your normal recreational activities?	0	1	2	3
8. Can you do your normal work or household activities?	0	1	2	3
9. Can you sleep without interruption from your hand?	0	1	2	3
10. Can you manage without medication?	0	1	2	3

Appendix HH Global rating of change (GROC) scale

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _
Date:_ _/_ _/_ _

Thumb base Pain score and Global Rate of Change

1. Pain at base of thumb on average in the past week

Circle a number that best describes what your pain at the base of your thumb has usually been like **on average during the past week**, where "0" is no pain and "10" is extreme pain

No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain

2. Pain at base of thumb on average at night in the past week

Circle a number that best describes what your pain at the base of your thumb has usually been like **at night during the past week**, where "0" is no pain and "10" is extreme pain

No pain 0 1 2 3 4 5 6 7 8 9 10 Extreme pain

3. Global Rating of Change

With respect to your thumb base problem, how would you describe yourself now compared to immediately before the treatment in this study started?

-5 -4 -3 -2 -1 0 1 2 3 4 5

Very much worse — Unchanged — Completely recovered

Appendix II Demographic and disease characteristics data collection form

Centre for Health, Activity, and Rehabilitation Research

MOTO Study ID:_ _ _ _ _ _ _ _
Date:_ _/_ _/__

Participant demographic & health questionnaire

Age:	Gender:
Ethnicity:	Descent:
What is your current occupation? (Please circle): Working full time (*type:*_____) / working part time (*type:*_____) / not working / student (*type:*_____) / working full-time in the home / unemployed or seeking work / age retired / disability pension / sick leave / other	
Dominant hand: Left / Right / Ambidextrous	Hand with thumb osteoarthritis: Left / Right / Both
Thumb osteoarthritis diagnosed by health care provider? Yes / No If yes, which health care provider? (Please circle): GP, physio, rheumatologist, surgeon	
How long have you had your thumb base problem(s)?	
Other joints with osteoarthritis (including in your hands):	
Other medical conditions (e.g. rheumatoid arthritis, other arthritis_____, gout, diabetes, heart problems, other):	
Current medications (Please circle): Paracetamol / Non-steroidal anti-inflammatory-NSAID / Codeine If NSAID: *Name*..... *Av daily intake (mg)*..... *Days/week intake*..... *Name*..... *Av daily intake (mg)*..... *Days/week intake*..... Other medications (Please list): Self-prescribed medications (Please list):	

Current or previous treatments for your thumb osteoarthritis?

(Please circle and tick as applies):

	Yes	No	When
Topical cream (type):			
Injections			
Physiotherapy • *Exercise* • *Advice/Education* • *Splints*			
Other:			