HAND

A systematic review of treatment Interventions for metacarpal shaft fractures in adults

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Abstract:	Metacarpal shaft fractures are common hand injuries which predominantly affect younger patients. There is wide variability in their treatment with no consensus on best practice. We performed a systematic review to assess the breadth and quality of available evidence supporting different treatment modalities for metacarpal shaft fractures of the finger digits in adults. A comprehensive search was conducted across multiple databases, in line with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 1600 records were identified; seven studies fulfilled eligibility criteria and were included. No randomised controlled trials directly comparing surgery to non-surgical treatment were found. One retrospective study compared non-surgical to surgical treatment, while six compared surgical or non-surgical treatments. Considerable heterogeneity between studies along with high or critical risk of bias restricts direct comparison and conclusions. There is a lack of high quality evidence to guide treatment, supporting the need for well-designed, multi-centre trials to identify the most effective and cost-efficient treatment for metacarpal shaft fractures in adults.

A SYSTEMATIC REVIEW OF TREATMENT INTERVENTIONS FOR METACARPAL SHAFT FRACTURES IN ADULTS

ABSTRACT

Metacarpal shaft fractures are common hand injuries which predominantly affect younger patients. There is wide variability in their treatment with no consensus on best practice. We performed a systematic review to assess the breadth and quality of available evidence supporting different treatment modalities for metacarpal shaft fractures of the finger digits in adults. A comprehensive search was conducted across multiple databases, in line with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 1600 records were identified; seven studies fulfilled eligibility criteria and were included. No randomised controlled trials directly comparing surgery to non-surgical treatment were found. One retrospective study compared non-surgical to surgical treatment, while six compared surgical or non-surgical treatments. Considerable heterogeneity between studies along with a high or critical risk of bias restricts direct comparison and conclusions. There is a lack of high quality evidence to guide treatment, supporting the need for well-designed, multi-centre trials to identify the most effective and cost-efficient treatment for metacarpal shaft fractures in adults.

INTRODUCTION

Metacarpal shaft fractures (MSF) are common injuries, accounting for 10-31% of all hand fractures.[1-6] They place a significant burden on healthcare resources and society, commonly affecting young economically active patients.

Despite their prevalence, acceptable parameters of deformity vary widely in the literature [7-9] and there is no consensus on the best practice management approach. Non-surgical treatment includes closed reduction, various different casting techniques and splints or free mobilisation. Surgical techniques include Kirchner wires (K-wires) fixation, intraosseous wires, interfragmentary compression screws, plates or external fixators.

Both non-surgical and surgical treatment require significant resources and a period of rehabilitation of weeks to months, during which use of the hand is restricted. Surgical treatment is perceived to be more costly due to the need for specialist resources, additional equipment and theatre use.

Whilst the majority of patients have excellent outcomes, if not appropriately treated, MSF can limit range of motion and grip strength, lead to an extensor lag from shortening, and (rarely) rotational deformity of the digit.[10,11] This may impair hand function and affect ability to work and live at the preinjury level. As they predominantly affect those of working age, reduced ability to work during hand recovery may lead to substantial societal costs, increasing the cumulative morbidity of MSF. Therefore, establishing the most effective treatment for MSF will lead to optimal patient care and has the potential to provide economic value to the National Health Service.

We report the findings of a systematic review of the treatment of MSF. This review was undertaken to establish the benefits and risks of surgical and non-surgical treatments and to assess the quality and strength of evidence supporting each treatment modality. In analysing the available literature, we hope to highlight areas of uncertainty and identify learning points for the design of future studies.

MATERIALS AND METHODS

We developed a protocol in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [12] and prospectively registered the review on PROSPERO (CRD42018106950).

Eligibility criteria

The eligibility criteria are detailed in Table 1. We included studies if they compared any form of treatment, either surgical or non-surgical, for an acute fracture(s) of the metacarpal shaft of the finger digits in adult patients, however defined.

Search strategy and study selection

A comprehensive search strategy was compiled by an information specialist (DG) that included a comprehensive list of search terms and synonyms for the concepts; metacarpal bones, fractures and shaft/diaphysis (Supplemental Material). The following bibliographic databases were searched on 16th September 2019: PubMed, Ovid MEDLINE, Ovid Embase, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, Web of Science and PEDro (Supplemental Table S1). We devised a strategy specific to each database, ensuring use of the relevant subject headings where available. We screened the reference list of included studies for further eligible studies and searched the grey literature at the time of the primary search via Google Scholar. No date or language limits were applied.

Study selection is reported in a PRISMA flow diagram. Two authors (RT and DG) independently screened titles and abstracts for eligibility. Full text articles were reviewed where abstracts were unclear. Disagreements were resolved by discussion with a third author (AK). EndNote version X8 (Thomas Reuters, New York City, NY, USA) was used to manage search results and filter duplicate articles.

Data management and risk of bias assessment

Data extraction and assessment of methodological quality was performed in duplicate using a piloted data collection form (RT & SD). Risk of bias was assessed using the Cochrane Risk of Bias Tool for Randomised Controlled Trials and quasi-random studies [13] and the Risk of Bias in Non-Randomised Studies of Interventions (ROBINS-I) for comparative non-randomised studies.[14,15]

Data synthesis

Data collected included information on study design, population, intervention, outcomes, including use of clinical and patient reported outcome measures (PROMs) and results. A meta-analysis was planned, if appropriate, but not performed due to study heterogeneity and risk of bias in included studies; a narrative synthesis is therefore presented.

RESULTS

The study selection process is demonstrated via a PRISMA flow diagram (Figure 1). A total of 1600 records were identified through database searches; seven studies fulfilled the eligibility criteria and were included.

Two discontinued and four ongoing trials were identified via the World Health Organisation International Clinical Trials Registry Platform (WHO ISCTRP) portal and a further six records were identified on searching the grey literature and reference lists of included studies (Supplemental Table S2).

Study design characteristics

There were no published randomised controlled trials (RCT) directly comparing surgical to non-surgical treatment for MSF in adult patients. One observational study compared non-surgical to surgical treatment. This was a retrospective, two-centre cohort study of metacarpal neck and shaft fractures.[16]

Six studies made comparisons between either surgical or non-surgical treatments, as summarised in Table 2. These included two RCTs,[17,18] one multi-centre retrospective study,[19] one dual-centre retrospective study and three single-centre retrospective cohort studies, as defined by the literature.[20,21] [16,22-24] Of these, three compared two forms of surgical treatment,[19,22,23] and three compared non-surgical treatments.[17,18,24] Two studies assessed MSF only,[18,23] with the remainder being mixed population studies, which reported results for MSF as separate subgroups.

Risk of bias assessment

All studies were assessed to be at critical risk of bias in at least one domain, or serious risk of bias in two or more domains (Tables 2-4). Supplementary material detailing the quality assessment for each individual study is available on request.

As the majority of studies are retrospective, allocation of treatment may be influenced by multiple confounding factors including clinician preference, injury pattern and severity of fracture. Of the two RCTs, one used an inadequate method of randomisation (sequentially-numbered sealed envelopes [18]) and the second did not specify the method used.[17] Only one study provided a prior sample size calculation,[18] therefore studies may lack the power required to detect meaningful differences between interventions.

Studies had variable length of follow-up, ranging from 3 weeks to 65 months, with wide inter-participant variability within individual studies, ranging from 3 weeks to 15-65 months,[18,23] as well as a disproportionate loss to follow-up between intervention groups.[16,19]

Insufficient information regarding blinding of outcome measurements was provided,[19] or assessment of outcomes occurred at variable time points.[16,22,23] Outcome measurements were unblinded in all studies bar one [24] and intervention groups were therefore identifiable (either due to presence of surgical scars or the use of cast/splints in non-surgical interventions), thus risk of bias was assessed as ‘serious’ for all subjectively reported outcomes.

In some studies, there was a disparity between planned methods described and reported results, thus leading to bias in selection of reported results. Furthermore, no protocols were published a priori for any of the included studies, further potentiating the risk of selective reporting.

The majority of studies did not provide sufficient information to assess bias due to deviations from intended interventions [16-19,22-24] or missing data.[24] Therefore, bias in these domains was not demonstrably measured.

Participant and fracture characteristics

A total of 438 participants with MSF were included in the seven studies. All studies had a small sample size, mean of 63 (range 26-139).

Participants varied widely with some studies defining age restrictions while others did not. Gender was not documented in three studies, two studies had higher proportions of male participants [19,22] and one contained no female participants.[23]

Eligibility criteria varied markedly between studies, particularly in definition of displacement, affected digits, multiplicity of fingers fractured, inclusion criterion and indications for surgery. One study defined displacement as dorsal angulation >30° or shortening >3mm,[22] while two did not specify minimum parameters of deformity or indications for surgery.[19,23] All three comparative studies of surgical treatments excluded open fractures and two excluded high-energy/polytrauma or patients with multiple fractures.

One RCT included only closed stable MSF of the fingers, defined as <50% displacement of the width of the shaft, <40° angulation and displaying an angle of >60° between the plane of the fracture and the axis of the shaft,[18] while the second RCT did not specify any exclusion criteria, simply recruiting 100 consecutive patients.[17] Information regarding inclusion criterion, selection of participants, indications for treatment and choice of intervention were not provided in two studies.[17,24]

Interventions and rehabilitation

Surgical interventions, time to surgery, surgical technique and choice of metalwork varied considerably amongst studies, with some including the addition of crossed K-wires as well as intramedullary fixation [23] and variability in surgical pates, including dynamic compression, locking plates or unspecified types. One study compared closed reduction and K-wire fixation to open reduction and internal fixation (ORIF) using locking plates and screws.[23] Another compared intramedullary K-wire fixation to interfragmentary screw fixation [22] whilst the third compared percutaneous K-wire fixation to ORIF using plate-screw fixation or interfragmentary lag screws.[19]

There was a lack of consistency in mode of immobilisation, position, material used (plaster, thermoplastic or other) and period of immobilisation amongst the three comparative studies of non-surgical treatments (Table 2).[17,18,24]

Outcome measures

A combination of outcome measurements were used at varying time-points. Five studies reported radiographic parameters, such as antero-posterior angulation, shortening or presence of bridging callus.[16,17,22-24] Total active motion was reported in three studies [18,19,23] and grip strength in three.[16,22,23]

A PROM was reported in four of the seven studies, with the MAYO,[22] QuickDASH [16,19] and DASH most frequently used.[16,22,23] Other clinical parameters reported included hand volume and finger circumference as surrogate markers of oedema, [18] while post-operative rehabilitation and therapy use was only reported in one study.[19] Though return to work was recorded by Konradsen et al., it was not separately reported for MSF.[17]

Results of included studies

Only one study directly compared surgical to non-surgical treatment, assessing outcomes of metacarpal fractures at 2 years or more post injury.[16] Though baseline demographics were similar between the groups, there was significant disparity in the number of patients per intervention, 113 treated non-surgically versus 26 surgically, as well as greater palmar angulation at presentation in the surgically treated group. No significant differences in grip strength were reported, though improved DASH scores and aesthetic outcome were noted in those managed non-surgically, along with a worse sportsDASH score.[16] The reported findings suggest non-surgical treatment might be preferable to surgical fixation in the treatment of a single MSF.

Two of the three studies of surgical treatments found no evidence of any difference in either functional or PROMs between treatment groups. Biz and Iacobellis found no evidence of difference when comparing intramedullary fixation to interfragmentary screw fixation at a mean follow-up of 28.4 months.[22] These findings were supported by Vasilakis et al. who found no difference in functional outcomes, outpatient follow-up or hand therapy referral rates between ORIF and percutaneous pinning using K-wires. They noted that both interfragmentary screws and plate-screw fixation resulted in earlier splint removal and mobilisation compared to closed reduction and percutaneous pinning.[19] Only one paper reported improved outcomes in grip strength, range of motion and DASH scores with plate-screw fixation over percutaneous K-wire fixation, which they attributed to the use of low-profile locking plates and screws that allowed for aggressive mobilisation post-surgery.[23] One study reported reduced immobilisation time with ORIF (plate-screw fixation or screw fixation only) [19] whilst another reported a higher incidence of malunion in those treated with intramedullary wire fixation over interfragmentary screw fixation.[22] Given the variability in surgical interventions and lack of clearly reported indications for surgery within studies, comparisons between type of fixation and functional outcomes are not appropriate.

Of the comparative studies of non-surgical treatments, few reported subgroup results for MSF. Konradsen et al. described good outcomes following their “functional cast”, however rotation, pain, cast inconvenience, length of time before returning to work, range of motion (ROM) and grip strength were not separately reported for MSF.[17] McMahon et al. demonstrated improved ROM with immediate mobilisation and a compression glove in the first 3 weeks post-injury, though this improvement was not sustained at 4 weeks.[18] Braakman concluded that near anatomical reduction of MSF resulted in reduced residual angulation at 4 weeks.[24] However, these clinical improvements were not correlated with functional assessments or PROMS, therefore extrapolating these conclusions to guide patient treatment may not be appropriate.

DISCUSSION

This review highlights the paucity of high quality evidence demonstrating superiority of any one form of treatment over another for the management of MSF of the finger digits. Despite their prevalence, there is considerable variability in the management of MSF with no agreement in the literature as to acceptable parameters of deformity nor a consensus on treatment strategies. The limited studies identified lacked consistency of endpoints, surgical techniques, rehabilitation regimens and outcome measures utilised. This makes meaningful comparison difficult due to the considerable heterogeneity.

Only one retrospective study directly compared surgical to non-surgical treatment for MSF.[16] As intervention and comparator groups were defined some time following injury, any differences identified may be due to confounding of either patient or fracture characteristics. The low follow-up rate, imbalance in numbers per intervention and variable length of follow-up, challenges the conclusions drawn that outcomes are favourable following either form of treatment.[16] There was also differential attrition in the treatment groups, which is likely due to systematic differences between the two groups.

Despite increasing trends towards surgical fixation in current practice, no single technique has been demonstrated to be superior in the treatment of MSF. Only one retrospective study reported improved outcomes with plate-screw fixation over percutaneous pinning with K-wires.[23] However, the small sample size (59 patients), significant disparity in length of follow-up between groups and serious overall risk of bias impedes the use of this study in drawing conclusions about the superiority of either form of treatment. A recent meta-analysis of plate fixation versus percutaneous pinning for unstable metacarpal fractures concluded that whilst percutaneous pinning resulted in higher motion scores, there were no differences in functional scores, grip strength, radiographic parameters, time-to-union or complications.[25] However, this review was limited by the small number of eligible studies (only four comparative studies, of which only three reported total active motion and two reported DASH), a lack of standard reporting and limited use of functional outcome scores or PROMs.[25]

Given the heterogeneity in data and inconsistency in reporting throughout the literature, there is no evidence to support any one treatment over another for MSF. Furthermore, the following inconsistencies compounded analysis of the literature:

1. There is no clear definition of the metacarpal “shaft”, with the majority of studies containing a heterogeneous group of neck and shaft fractures. One suggested definition may be that described by the Arbeitsgemeinschaft für Osteosynthesefragen Foundation/Orthopaedic Trauma Association (AO/OTA) as that part of the bone between the two end segments, with the end-segment defined by “a square whose sides are the same length as the widest part of the epiphysis/metaphysis in question (Heim’s system of squares)”.[26] However, only one study defined the shaft using this method.[23] Accurate denotation of the metacarpal shaft is required to differentiate

mixed-population studies that include subcapital/neck fractures, which most agree tolerate far greater angulation than MSF.

2. There is no consensus on definition of instability or acceptable parameters of deformity in MSF. One study defined displacement,[22] while others did not specify minimum parameters of deformity or indications for surgical treatment.[19,23] Diao suggested up to 10° angulation was acceptable in the index and middle fingers and 20° to 30° in the ring and little finger, while some authors accept up to 50° angulation in the little and 30° to 35° in the ring ringer.[27] Others are more conservative accepting 60°of angulation in the little finger and 45°in the ring finger.[28] Similarly, while some authors opine that finger metacarpals may tolerate 3 to 4mm of shortening,[29] sometimes more [23,27,28] with minimal clinical deformity and functional loss, cadaveric studies demonstrate that every 2mm of metacarpal shortening may result in as much as 8% loss of grip strength.[30] The inconsistency in reporting of fracture characteristics and deformity increases the risk of selection bias when comparing treatments for MSF and highlights the uncertainties within the hand surgery community regarding acceptable parameters of deformity in MSF. Future studies should use clear definitions of deformity alongside standardised methods of assessment to allow head-to-head comparison of treatments.
3. Though angulation and shortening were assessed in the majority of studies, precise methods of measuring deformity in MSF are not described in the literature, with some remaining as vague as stating radiographs were “scanned for metacarpal angulation and shortening”.[23] Angulation is often measured on lateral radiographs of the hand using mid-medullary measurement, however this method has only been validated in the assessment of metacarpal neck fractures .[31] Furthermore, normal reference values for angulation are only documented for the ring and little finger metacarpal.[32] An accurate and reliable method of measuring angulation and shortening in MSF is required to ensure consistency in assessment across studies. Furthermore, there is no clear evidence that radiographic outcomes directly correlate with function.

Standardising radiographic assessment alongside collection of PROMs would aid our understanding of this.

4. The majority of studies did not examine rehabilitation/therapy regimens or other key variables such as the time from injury to surgery or length of immobilisation, which may also have a prognostic impact on outcomes following MSF.
5. Where cosmesis or inconvenience of treatment has been assessed, arbitrary measures selected by study authors were used.[16,17,22] Patients may have widely differing views to clinicians and acceptability to patients may vary significantly from the parameters selected by clinicians, therefore future studies must address the views of patients.
6. There is incongruity in outcomes assessed, with studies measuring a variety of outcomes at varying time-points. All studies focused on clinical and radiographic outcomes, with no study reporting a PROM as the primary outcome of interest. The lack of standardised reporting and assessment is compounded by the fact that there is no core outcome set for trials/studies in hand surgery. Consensus on a minimum dataset in future trials is required to ensure consistency in reporting and allow future meta-analysis.
7. Low recruitment and retention are inherent issues in studies of metacarpal fractures and have led to the termination of several RCTs, including a multi-centre RCT of intramedullary wiring and conservative treatment for subcapital and shaft fractures of the little finger metacarpal.[33] This limits the pool of available clinical trials and reduces the robustness of evidence available for synthesis of meaningful conclusions regarding treatments for MSF. Future studies must minimise attrition using novel techniques, remote data collection, timely, focused follow-up and reducing research burden.
8. Studies rarely examined the socioeconomic impact of time off work, lost productivity or need for additional support/care whilst undergoing treatment for MSF. There is no evaluation of cost-effectiveness of treatments for MSF, with utilisation of resources

rarely recorded in studies. Only one study recorded length of surgery and hospital stay.[22] Such evidence is required to inform healthcare allocation.

Our conclusions must be considered in lieu of the study limitations. Our review is limited by the small number of eligible studies, which provide mostly level IV evidence. Whilst a comprehensive search strategy was devised, it is possible that relevant publications may not have been identified. As with any review, reporting bias, both within individual studies and in relation to published findings, limits the available data from which to pool results. This is compounded by the small sample size in individual studies. Furthermore, the high risk of bias and associated limitations of included studies impedes any meaningful assessment of specific intervention types and associated outcomes. We recommend that future researchers address the deficiencies of prior studies, so that direct comparisons can be made between treatments (Table 5).

This review highlights the need for large, well designed randomised studies to inform current practice and guide management of these common injuries. Although RCTs are difficult to implement, identifying the most beneficial and cost-effective treatment for MSF will aid clinicians and patients to make informed treatment choices, whilst maximising value for health service providers.

STATEMENTS

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Conflict of Interests

The authors declare that they have no conflict of interest.

Statement of Human and Animal Rights

This is not applicable to this systematic review article.

Statement of Informed Consent

This is not applicable to this systematic review article.

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FIGURE LEGENDS

Figure 1 PRISMA flow diagram detailing study selection

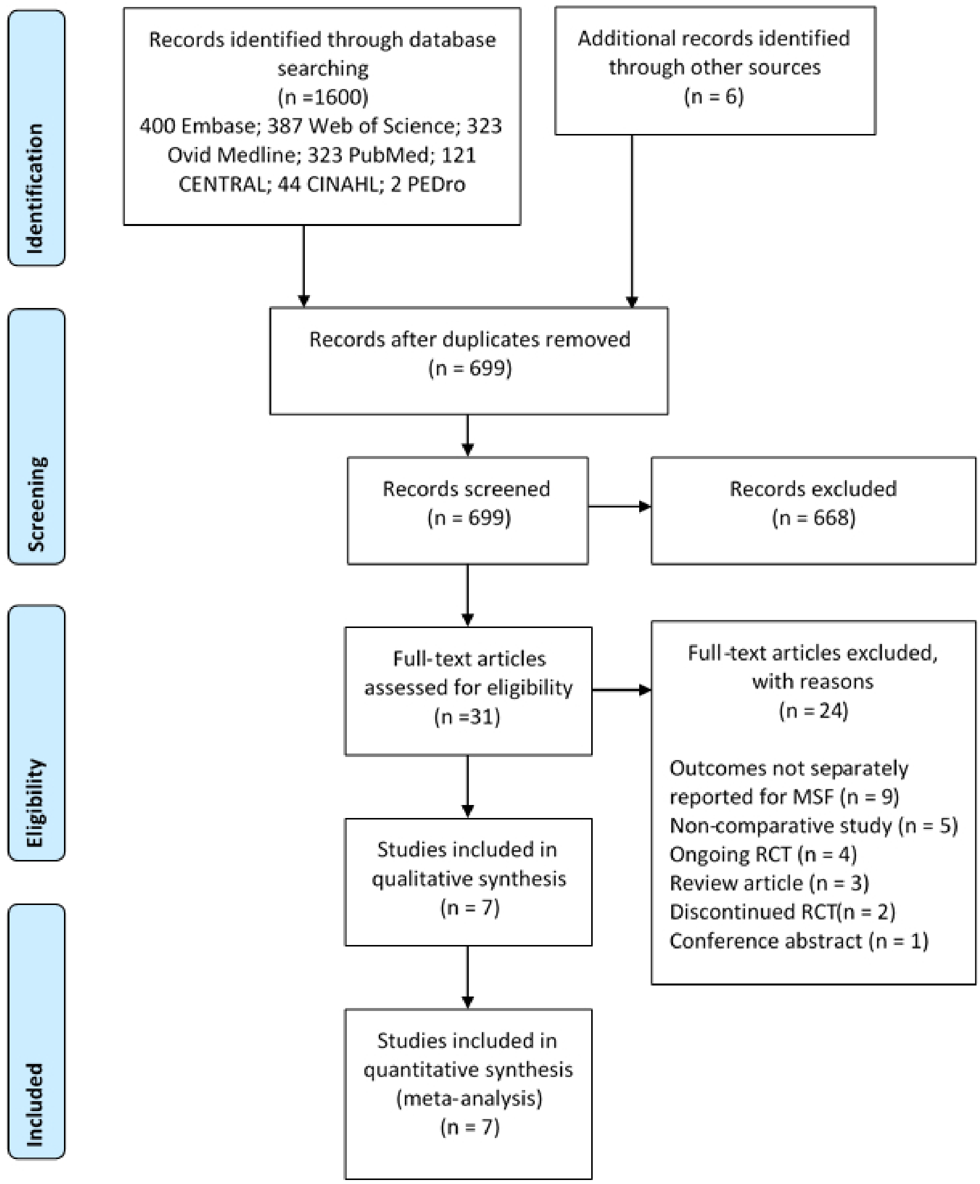

Figure 1 PRISMA flow diagram detailing study selection

Table 1 Eligibility criteria

Inclusion criteria	**Exclusion criteria**
Types of participants	
• Adults, however defined, with one or more fracture(s) of the metacarpal shaft affecting the fingers (index to little)	• Intra-articular fracture(s) • Fracture(s) of the metacarpal neck and/or base • Fracture(s) of the thumb metacarpal • In studies of mixed populations (excluding adults and children) a study will be included if >= 90% of the population meets the review inclusion criteria
Study design	
• Randomised controlled trials • Studies stated to be "randomised" but for which there is inadequate information about sequence generation and/or concealment of allocation • Controlled clinical trials • Quasi-randomised trials, such as those with alternate	• Cadaveric studies • Biomechanical studies • Case series • Case reports • Review articles

allocation or allocation based on day of the week or clinic • Cohort studies	
Publication type	
• Full study reports published in peer review journals • Separate publications of economic evaluation of the primary study • Studies in any language	• Abstracts of completed studies, if full published report is not yet available • Unpublished trials • Ongoing trials/studies

Table 2 Characteristics of included studies

Study	Methods	Participants *n* patients (shaft)	Fracture	Intervention *n* patients (shaft)	Comparator *n* patients (shaft)	Follow-up mean, (range)	Primary outcome of interest (other outcomes assessed)	Risk of bias as per Cochrane assessment tool[a]
Surgical v non-surgical treatment								
Westbrook et al., 2008	Retrospective cohort study	262 (139)	Isolated closed shaft or neck fracture of the little	44 (26)	218 (113) Non-surgical treatment; early	I[b]: 25months (14-79)	Angulation Grip strength DASH	Critical

[a] Revised Cochrane risk-of-bias tool for randomised trials (Rob 2) used for randomised controlled trials. Risk of bias in non-randomised studies of interventions (ROBINS-I) tool was used for non-randomised studies.
[b] Intervention

	Dual centre Nottingham, UK		finger metacarpal bone, sustained at least 2 years previously	Any form of surgical fixation	mobilisation or temporary immobilisation in a plaster	C[c]: 48months (28-76) (median, (range))	SportsDASH Cosmesis	
Surgical v surgical treatment								
Biz & Iacobellis, 2014	Retrospective Single centre Padova, Italy	49 (26)	Closed, unstable metacarpal fracture, with dorsal angulation	31 (6) Percutaneous intramedullary K-wire fixation	22 (20) Interfragmentary screw fixation	28.4months (18-55)	Mayo DASH Radiographic; shortening, antero-	Critical

[c] Comparator

			>30° or shortening >3mm.				posterior and lateral angulation, presence of bridging bone callus Pain Grip strength Sensitivity	
Dreyfuss et al., 2019	Retrospective Single centre Haifa, Israel	59 (59)	Adult patient with metacarpal shaft fracture, fracture line does not	30 (30) Closed reduction and percutaneous	29 (29) Locking plate and screws (PS)	I: 45months (27-65)	ROM Grip strength Rotational deformity	Serious

			extend into proximal or distal end segment square	Kirschner wire pinning		C: 23months (15-32)	DASH Radiographic: angulation, shortening Time to bony union of at least 3 cortices	
Vasilakis et al., 2019	Retrospective Multi-centre New York, US	70 (56)	>16years, isolated, closed, single-digit extra-articular metacarpal fractures	44 (33) Closed reduction and percutaneous pinning	26 (23) Open reduction internal fixation; mini-plate or lag screws	I: 2.9 (SD 2.4) months C: 4.2 (SD 6.8) months	Time from injury to surgery Immobilisation time TAM	Critical

							Complication Reoperation rate OT referral rates Duration of OT QuickDASH	
Non-surgical v non-surgical								
Konradsen et al., 1995	RCT Single centre Hillerød, Denmark	100 (42)	Shaft or neck fracture index to little finger metacarpal	50 (22) Immobilisation in functional cast, allowing	50 (20) Immobilisation in plaster cast, immobilising the	3 months	Angulation	High

				free movement of the wrist and fingers, strapping of injured finger to adjacent digit, for 3 weeks	MCP and PIP joints of the injured and adjacent digit, for 3 weeks			
McMahon et al., 1994	RCT Single centre Oxford, UK	42 (42)	Unilateral, fresh closed stable fractures of the shaft of single finger metacarpal	21 (21) Immobilisation in palmar plaster slab, MCP joints flexed and	21 (21) Application of compression glove and immediate mobilisation	3 weeks	Range of motion Hand volume Finger circumference	High

				PIP joints extended				
Braakman, 1997	Retrospective Single centre Sittard, Netherlands	200 (74)	Conservatively treated primary fracture of fourth or fifth metacarpal	100 (37) Near anatomical reduction (residual angulation <5°) + immobilisation in antebrachial cast, wrist 45° and IP joints 0°-10°	100 (37) Partial reduction (residual angulation >5° + immobilisation in antebrachial cast, wrist 45° and IP joints 0°-10°	4 weeks	Residual fracture angulation at 4 weeks	Critical

Table 3 Consolidated summary of risk of bias for non-randomised studies

Paper	Domain[a]							Overall risk of bias
	1	2	3	4	5	6	7	
Biz & Iacobellis, 2014	Critical	Serious	Low	NI	Low	Serious	Moderate	Critical
Braakman, 1997	Critical	Critical	Serious	NI	NI	Low	Serious	Critical
Dreyfuss et al., 2019	Low	Serious	Low	NI	Moderate	Serious	Moderate	Serious
Vasilakis et al., 2019	Critical	Serious	Low	NI	Serious	NI	Serious	Critical
Westbrook et al., 2008	Critical	Serious	Moderate	NI	Critical	Serious	Moderate	Critical

[a] Domain 1: Bias due to confounding. Domain 2: Bias in selection of participants into the study. Domain 3: Bias in classification of interventions. Domain 4: Bias due to deviations from intended interventions. Domain 5: Bias due to missing data. Domain 6: Bias in measurement of outcomes. Domain 7: Bias in selection of the reported result. NI – No information.

Table 4 Summary of risk of bias assessment for randomised studies

Paper	Domain[a]					Overall risk of bias
	1	2	3	4	5	
Konradsen et al., 1995	Some concerns	High	Low	High	Some	High
McMahon et al., 1994	Some concerns	Some concerns	Low	High	Some	High

[a] Domain 1: Risk of bias arising from the randomisation process. Domain 2: Risk of bias due to deviations from the intended interventions (effect of assignment to intervention). Domain 3: Missing outcome data. Domain 4: Risk of bias in measurement of the outcome. Domain 5: Risk of bias in selection of the reported result.

Table 5 Our recommended minimum dataset for future metacarpal shaft studies

Definitions	Patient details	Fracture details	Details of fracture diagnosis and treatment	Details of outcome assessment	Economic evaluation
Metacarpal shaft Instability MCID for selected PROM Indication for treatment or surgery	Age Gender Occupation Hand dominance Number of patients identified, recruited and followed-up	Method of assessment of fracture deformity Fracture angulation Shortening Presence of "step-off" deformity	Implants used Cast/splint details Length of immobilisation Rehabilitation	PROM[a] Comparable follow-up between treatment groups TAM[b] Grip strength	Time off-work Treatment costs Personal impact of injury and treatment

[a] Patient Reported Outcome Measure
[b] Total Active Motion

SUPPLEMENTAL MATERIAL

OVID Medline search strategy

1. metacarpal.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

2. metacarpals.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

3. transmetacarpal.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

4. midmetacarpal.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

5. exp Metacarpal Bones/

6. 1 or 2 or 3 or 4 or 5

7. fracture.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

8. fractures.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

9. fractured.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

10. exp Fractures, Bone/

11. 7 or 8 or 9 or 10

12. diaphysis.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

13. diaphyses.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

14. diaphyseal.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

15. shaft.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

16. shafts.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

17. extraarticular.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

18. extra-articular.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

19. exp DIAPHYSES/

20. 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19

21. 6 and 11 and 20

Supplemental Tables

Supplemental Table S1 Summary of databases searched

Database	Platform	Dates covered
PubMed	PubMed	1946 - 2019
MEDLINE(R) ALL	OVID	1946 - 2019
EMBASE	OVID	1974 - 2019
Cochrane Central Register of Controlled Trials (CENTRAL)	Cochrane Library, Wiley	1996 - 2019
CINAHL	EBSCO*host*	1937 - 2019
PEDro	PEDro	1999 - 2019
Web of Science	Web of Science	1900-2019

Supplemental Tables

Supplemental Table S2 Characteristics of ongoing studies (ordered by enrolment date)

NCT02718170	
Trial name or title	Buried intramedullary K-wire fixation compared with plate and screw fixation for metacarpal fractures in unstable extra-articular metacarpal fractures
Methods	**Study design**: parallel RCT **Random sequence generation**: not reported **Allocation concealment**: not reported **Masking**: open-label
Participants	**Location**: Prisma Health-Upstate, Greenville, South Carolina, USA **Target sample size (N)**: 110 participants **Inclusion criteria** • The patient has an unstable extra-articular metacarpal fracture that meets operative indications • Informed consent is obtained from the patient or proxy • Male or female who are 16 years of age or older **Exclusion criteria** • If the patients range of motion was decreased prior to injury (previous upper extremity injury, osteoarthritis, etc.) • Pathological Fracture • Greater than 21 days from fracture to definitive open reduction and internal fixation • If contamination or wounds from open fractures do not permit standardized buried intramedullary fixation or plate and screw fixation • Highly comminuted diaphyseal fractures • Articular fractures • Multiple fractures involving bones other than another metacarpal in the same upper extremity • The patient had a previous upper extremity injury that has limited hand function or finger range of motion
Interventions	**Type of intervention** • Buried Intramedullary K-wire Fixation **Type of comparator** • Plate and Screw Fixation
Outcomes	**Primary outcomes**

	• Disability as measured by Disability of Arm, Shoulder and Hand Score **Secondary outcomes** • Total Active Motion in degrees • Measured by goniometer • Grip Strength • Disability as measured by Disability of Arm, Shoulder and Hand Score **Timing of outcomes measurement**: 3 months, 1 year
Starting date	**Main ID**: NCT02718170 **Date of registration**: 24 March 2016 **Last refreshed on**: 30 May 2019 **Date of 1st enrolment**: March 2015 **Status**: enrolling by invitation **Estimated study completion date**: March 2022
Contact information	**Name**: John Millon, MD **Address**: Prisma Health-Upstate **Telephone**: not reported **Email**: not reported **Affiliation**: Prisma Health-Upstate
ISRCTN18006607	
Trial name or title	Stability of unicortical versus bicortical metacarpal fracture internal fixation trial (SUBMIT):
Methods	**Study design**: parallel RCT **Random sequence generation**: not reported **Allocation concealment**: not reported **Masking**: open-label
Participants	**Location**: University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK **Target sample size (N)**: 290 **Inclusion criteria** • Aged 18 or over • Metacarpal diaphyseal fractures that require plate fixation • Patients undergoing anaesthesia with axillary brachial plexus regional blocks • Acute injury (within 72 hours) **Exclusion criteria** • Under 18 years of age • Deemed not competent to sign the consent forms

	• Pathologic fracture or a previous fracture of the same metacarpal • Other injury to the same upper limb requiring surgery • Major nerve injury (e.g., median, ulnar or radial) • Multi-trauma or -fractured patient • Revision procedure • Pregnant patient • Current or prior history of malignancy
Interventions	**Type of intervention** • Bicortical fixation (standard practice), in which both the dorsal and palmar cortices of the metacarpal are drilled though **Type of comparator** • Unicortical fixation, in which only the near cortex is drilled
Outcomes	**Primary outcomes** • Fracture union is assessed at 6 weeks and 6 months **Secondary outcomes** • Complication rate is monitored continually throughout study • Fluroscopy exposure is measured during surgery • Implant failure is measured at 6 weeks and 6 months • Post operative stiffness is measured at 6 weeks and 6 months • Surgical time is measured during surgery **Timing of outcomes measurement**: 6 weeks, 6 months
Starting date	**Main ID**: ISRCTN18006607 **Date of registration**: 19 November 2015 **Last refreshed on**: 22 August 2016 **Date of 1st enrolment**: June 2015 **Status**: enrolling by invitation **Estimated study completion date**: not provided
Contact information	**Name**: Mr Mark Foster **Address**: University Hospital Birmingham NHS Foundation Trust, Plastic Surgery Department, Mindelson Way, Edgbaston, B15 2WB, UK **Telephone**: not reported **Email**: not reported **Affiliation**: University Hospitals Birmingham NHS Foundation Trust, Birmingham and Royal Centre for Defence Medicine (UK)
Notes	This trial was due to complete in April 2018 but has been extended due to poor recruitment.
KCT0003863	
Trial name or title	Comparison of low-profile locking plate Fixation versus antegrade Intramedullary nailing of Unstable Metacarpal Shaft Fractures

Methods	**Study design**: parallel RCT **Random sequence generation**: not reported **Allocation concealment**: not reported **Masking**: open-label
Participants	**Location**: Chungnam National University Hospital, Daejeon, Korea **Target sample size (N)**: 46 participants **Inclusion criteria** • Adults older than 20 years • Acute single metacarpal shaft fractures from 2nd to 5th, except thumb metacarpus **Exclusion criteria** • Any concomitant fracture in the ipsilateral hand and wrist. • Multiple metacarpal fractures • Lesion or sequelae around muscle due to trauma or degenerative disease • Patients with unexplained lesions due to rheumatoid disease and degeneration • Open fractures
Interventions	**Type of intervention** • Low profile plate **Type of comparator** • Intramedullary nailing
Outcomes	**Primary outcomes** • Visual analog scale (VAS) for postoperative pain • Disabilities of the Arm, Shoulder, and Hand (DASH) score **Secondary outcomes** • Grip Strength **Timing of outcomes measurement**: 2 years
Starting date	**Main ID**: NCT02718170 **Date of registration**: 29 April 2019 **Last refreshed on**: not reported **Date of 1st enrolment**: 14 February 2019 **Status**: Active, not recruiting **Estimated study completion date**: February 2021
Contact information	**Name**: Soo Min Cha

	Address: Department of Orthopaedic Surgery, Chungnam National University School of Medicine, Regional Rheumatoid and Degenerative Arthritis Center, 640, Daesa-Dong, Jung-Gu, Daejeon, Korea **Telephone**: 82-42-338-2480 **Email**: csm9827@hanmail.net **Affiliation**: Chungnam National University Hospital
NCT04001062	
Trial name or title	Non-operative vs Surgical Treatment of Isolated Non-Thumb Metacarpal Shaft Fractures
Methods	**Study design**: parallel RCT **Random sequence generation**: not reported **Allocation concealment**: not reported **Masking**: open-label
Participants	**Location**: University of Missouri, Columbia, Missouri, United States **Target sample size (N)**: 100 **Inclusion criteria** • Adults 18 and older • Native English-speaker • Non-thumb isolated single metacarpal shaft closed fracture **Exclusion criteria** • Pre-existing condition in the involved hand/wrist, hand contracture or deformity, pre-existing stiffness • Cognitive dysfunction with inability to follow rehabilitation protocol • Subacute/chronic fracture (>4 weeks) • Pregnant Participants • Veteran Affairs (VA) patients
Interventions	**Type of intervention** • Surgical Fixation For both scissoring and non-scissoring injuries surgical fixation by either pinning, dorsal plate, or lag screws will be considered. This will be determined by surgeon expertise at the time of surgical fixation. Postoperative, a volar short arm splint and immediate AROM at full range with buddy taping to adjacent digit will be indicated. Transition to removable short arm splint at week 2 after suture removal. No strengthening until clinical union. **Type of comparator** • Non-operative/conservative management For non-scissoring injuries: Placement of short-arm cast; immediate AROM with buddy taping to adjacent digit. Focus on achieving pulp-to palm distance of <2cm at first visit. Transition to removable short arm splint at week 2 (discontinue at 6 weeks or

	when non-tender). Strengthening after clinical union. For scissoring injuries: Closed reduction in clinic/ER and placement of short-arm cast; immediate full range AROM with buddy taping to adjacent digit. Focus on achieving pulp-to palm distance of <2cm at first visit. Transition to removable short arm splint at week 2 (discontinue at 6 weeks or when non-tender). Strengthening after clinical union
Outcomes	**Primary outcomes** • Vas Pain Score • PROMIS score • DASH score • Grip strength • Extension lag • Finger range of motion • Time to union • Adverse events **Secondary outcomes** • None reported **Timing of outcomes measurement**: 6 months
Starting date	**Main ID**: NCT04001062 **Date of registration**: 27 June 2019 **Last refreshed on**: 25 March 2020 **Date of 1st enrolment**: June 2019 **Status**: enrolling by invitation **Estimated study completion date**: January 2029
Contact information	**Name**: Stacee Clawson **Address**: University of Missouri-Columbia, Missouri, United States **Telephone**: 573-884-9017 **Email**: clawsons@health.missouri.edu **Affiliation**: University of Missouri-Columbia