

1 **TITLE**2 **Treatment interventions for hand fractures and joint injuries: a scoping review of randomized controlled**
3 **trials**

4

5 **ABSTRACT**

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7 The aim of this study was to identify and assess all existing randomized studies on treatment interventions
8 for hand fractures and joint injuries, to inform practice and plan future research. PubMed, Cochrane
9 CENTRAL, MEDLINE and Embase were searched. We identified 78 randomized controlled trials published
10 over 35 years, covering seven anatomical areas of the hand. We report on sources of bias, sample size,
11 follow-up length and retention, outcome measures and reporting. In terms of interventions studied, the
12 trials were extremely heterogeneous, so it is difficult to draw conclusions on individual treatments. The
13 published randomized controlled clinical trial (RCT) evidence for hand fractures and joint injuries is narrow
14 in scope and of generally low methodological quality. Mapping provides a useful resource and stepping
15 stone for planning further research. There is a need for high-quality, collaborative research to guide
16 management of a much wider breadth of common hand injuries.

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19 **INTRODUCTION**

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21 The wide variety of hand injuries treated by different methods, and the lack of consistency in outcome
22 reporting and research methodological standards make existing evidence difficult to interpret and apply to
23 clinical decision making.

24 The importance of studying hand injuries and the gap in the evidence base was recently highlighted by the
25 James Lind Alliance Priority Setting Partnership on common hand and wrist conditions, a priority-setting
26 national consensus exercise involving patients and those providing hand surgery care (James Lind Alliance,
27 2017). Two of the top ten research priorities highlighted the treatment of bony or ligamentous injuries of
28 the hand. Further work is needed to inform clinical practice and help plan future high quality clinical trials
29 (James Lind Alliance, 2017).

30 A scoping review is a type of systematic review which identifies the nature and the extent of research
31 evidence on a topic. It is the assessment of available published research with the aim of identifying the
32 breadth of relevant evidence, as opposed to trying to answer a specific question (Grant and Booth, 2009).

33 The aim of this scoping review was to identify and assess existing randomized controlled trial (RCT)
34 evidence on treatment interventions for hand fracture and joint injuries in order to inform practice and
35 help plan future trials. The objectives were to collate and map existing RCT evidence to the anatomical
36 sites of hand fractures or joint injuries, appraise the quality of studies using a recognized risk of bias
37 assessment tool, summarize outcomes used and assess the length of follow-up and retention rates in
38 published RCTs.

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41 **METHODS**

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43 The study was prospectively registered on PROSPERO

44 (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=102845). Preferred Reporting Items

45 for Systematic Reviews and Meta-Analyses, Extension for Scoping Reviews (PRISMA-ScR) were followed
46 (Tricco et al., 2018).

47 **Scope and eligibility criteria**

48 For the purposes of this review, hand fractures and joint injuries were defined as carpal fractures of the
49 scaphoid, hamate, lunate and pisiform and others; metacarpal fractures; phalangeal fractures; fractures at
50 the base of the thumb; any joint injuries, such as dislocations or fracture- dislocations; avulsion tendon and
51 joint ligament injuries which can be associated with a small fracture; and other ligament injuries to the
52 hand, carpus or wrist. Distal radial fractures were not included in this review which was focussed on the
53 hand and carpus.

54 Inclusion and exclusion criteria are outlined in Table 1. Interventions included primary treatment (e.g.
55 plaster or surgery for a scaphoid fracture), secondary treatment (e.g. treatment for scaphoid non-union or
56 deformity secondary to the injury) and/or associated therapy interventions (e.g. physiotherapy). Trials were
57 included without restrictions on publication time or language.

58 **Search strategy**

59 The search strategies were compiled with guidance from an information specialist with hand surgery
60 expertise. The search strategy was constructed in four parts:

61 (1) names of bones, joints and ligaments of the hand (e.g. phalanx, scaphoid, collateral),

62 (2) general terms for fractures and joint injuries (e.g. fracture, dislocation),

63 (3) specific terms about hand fractures and joint injuries (e.g. boxer's, Stener, gamekeeper's thumb), and

64 (4) the sensitivity-maximizing version of the Cochrane RCT filter;

65 (1) and (2) were combined using the Boolean 'AND' which was then combined with (3) using the Boolean

66 'OR'. The findings were then combined with the RCT filter (4) using the Boolean 'AND'. The search terms are
67 detailed in Appendix 1 (available online).

68 The databases searched were PubMed, Cochrane CENTRAL, Ovid MEDLINE, and Ovid Embase. The details of
69 coverage and the interfaces used are shown in Table 2. The search was carried out on 27 of December
70 2017.

71 **Data management, quality assessment and data extraction**

72 Records identified via the searches were imported into EndNote X7 (Thompson Reuters, New York, NY) and
73 duplicates removed. Two review authors (CM and DG) independently screened all titles and abstracts for
74 potentially eligible studies, for which full-text reports were obtained where appropriate. The quality (risk of
75 bias) of included studies was assessed independently by two assessors (CM and SD) using the Cochrane
76 Risk of Bias tool for randomized controlled trials and quasi-random studies (Higgins et al., 2017).
77 Disagreements were resolved by consulting a third review author (AK) and discussion. One review author
78 (CM) extracted the data, using a pre-piloted standard data collection form. Data extraction included details
79 of the population, intervention, comparator and outcomes (PICO) for all included trials, external funding
80 source, registration with a trial repository, sample size, sample size calculation, method of randomization,
81 RCT study design (single or multi-centre), and whether intention-to-treat analysis was performed. Length of
82 follow up, losses to follow-up and the outcomes (primary, secondary) were also extracted.

83 **Mapping and data synthesis**

84 The studies were mapped according to the anatomical site of the fracture or joint injury. A narrative
85 descriptive synthesis of the findings, structured around the anatomical site of the hand fracture or joint
86 injury, is presented. Descriptive statistics (proportions, median with range, mean with standard deviation)
87 were used to report study characteristics. Linear regression was used to test the association between
88 length of study follow-up and study retention rates.

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91 **RESULTS**

92 The study selection process is demonstrated via a Preferred Reporting Items for Systematic Reviews and
93 Meta-Analyses (PRISMA) flowchart (Moher et al., 2009) (Figure 1). Seventy eight RCTs fulfilled the eligibility
94 criteria and were included. The authors of three studies were contacted as it was unclear whether they
95 were randomized. One confirmed that the study was an RCT (Sourmelis et al., 1995), one that the study
96 was a cohort study (Gabler et al., 2001) and no reply was received from the third (Toker et al., 2015), so
97 the study was excluded. Details of the included studies, mapped by anatomical region, are presented in
98 Appendix 2 (Tables A-H) (available online), including report identifiers and the PICO outline for each trial.
99 Trial publication dates ranged from 1982 to 2017 (Figure 2). Most trials were from European institutions
100 [51/78, 65%], with fewer studies from North America (USA and Canada) [9/78 (12%)] and the rest from
101 other parts of the world [18/78 (23%)]. The five countries which reported the highest number of trials were
102 the United Kingdom [14/78 (18%)], the United States [8/78 (10%)], Denmark [7/78, (9%)], Netherlands
103 [5/78 (6%)] and Sweden [6/78 (8%)]. Of the included trials, 46 (59%) were published after 1 July 2005,
104 when the registration requirement for trials was implemented by the International Committee of Medical
105 Journal Editors (ICMJE) (De Angelis et al., 2004); of those, only 8/46 (17%) indicated compliance by
106 reporting registration in a clinical trial repository. Few trials reported a sample size calculation or intention-
107 to-treat analysis, studies were generally small (under 100 participants) and single-centre (Table 3); median
108 sample size was 54 (range 8-352). Only 14 of 33 (42%) trials that looked at operative treatment
109 interventions reported the training/experience of surgeons.

110 **Mapping**

111 The trials were mapped according to the anatomical site of injury treated; this is presented visually in
112 Figure 3. The four most common injuries studied were scaphoid fractures (28 trials), followed by
113 metacarpal (23 trials), mallet fingers (ten trials) and proximal phalangeal fracture (five trials). One trial
114 reported a mixed population of 'closed hand bone fractures'.

115 RCTs investigated the effects of a wide range of treatments, including Kirschner-wires, different types of
116 splints, casts, or orthoses and exercise/ rehabilitation programmes. An equal number of studies compared
117 two different types of surgical treatment, and a type of surgical treatment compared to a type of

118 conservative treatment, with the remaining comparing two conservative treatments (Table 3). Of the
119 conservative treatments compared, 35/78 (45%) studies assessed different splints/casts/orthoses, 2/78
120 (3%) studies compared rehabilitation regimes, 4/78 (5%) electrical stimulation to no treatment, 2/78 (3%)
121 ultrasound therapy to no therapy, 1/78 (1%), laser therapy to no therapy, and 2/78 (3%) studies compared
122 pharmacological interventions. Appendix 2 (available online) presents details of all included RCT
123 intervention comparisons, mapped by anatomical site of injury.

124 **Quality assessment**

125 The quality assessment of included trials is visually summarized in the risk of bias graph (Figure 4). Figure 5
126 (Supplementary Material, available online) details the quality assessment for each individual study. A
127 common finding was that most of the studies which claimed to be “randomised” did not actually specify
128 how the randomization was done (i.e. coin toss, sealed envelopes, computer generated sequence or other)
129 or whether or how the allocation sequence was concealed. Only 24/78 (31%) scored “low risk of bias” for
130 random sequence generation and 14/78 (18%) for allocation concealment.

131 Only a small proportion of studies reported blinding, with 8/78 (10%) studies blinding the participants
132 and/or the study personnel and 20/78 (26%) blinding the outcome assessors. Most studies did not report
133 on ‘blinding’ status. Very few studies [5/78 (6%)] referenced a study protocol. Studies published before
134 2003 generally tended to score “unclear” for many risk of bias domains, whereas those published after
135 2003 tended to report more of the information required for bias assessment, therefore scoring either “low”
136 or “high” more often in the domains (Figure 4).

137 **Outcomes and follow-up**

138 Only 13/78 (17%) trials specified the primary outcome measure in full, including what was measured and
139 when. The median time point for the assessment of the primary outcome out of 13 studies was 6 weeks
140 (range 1-16). A further 4/78 (5%) trials specified the primary outcome, but this was incomplete, i.e. they
141 did not report the time point of interest. The primary outcome was “blinded” in 10/78 (13%) trials. Only
142 two trials selected a recognized standardized Patient Reported Outcome Measure (PROM) as primary
143 outcome measure (the QuickDASH). Table 4 shows the outcomes assessed in included trials.

144 The maximum length of individual study follow-up was highly variable (median 24 weeks, range 1 to 624
145 weeks). Twenty-two studies (28%) had a maximum follow-up of 1 year or more. Follow-up (retention) data
146 were reported in 50/78 (64%) of trials; in these trials retention was over 80% in 37/50 (74%) at the end of
147 the study. This translates to reported follow-up over 80% for only 37/78 (47%) of trials. Retention rates of
148 70-80% were reported by 6/78 (8%) and 50-69% by 7/78 (9%) trials, with the rest providing no retention
149 information at all. The median follow-up retention was 89% (range 55-100%) at the end of each study.
150 Retention did not show an association with the maximum length of study follow-up (regression coefficient
151 -0.008; $p=0.63$; 95% CI: -0.39 to 0.023).

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154 **DISCUSSION**

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156 This comprehensive scoping review identified and assessed published RCTs on the treatment of hand
157 fractures and joint injuries. It was guided by a search of publications developed with support from an
158 experienced information specialist and used sound methodology informed by the PRISMA-SCR guidelines
159 (Tricco et al., 2018). It has highlighted issues with design and reporting, informed by a recognized
160 assessment tool (Cochrane Methods, 2018). It provides a reference for the planning of future studies as
161 well a repository of the included trials, mapped by topic (Appendix 2). It highlights the paucity of high-level
162 evidence to guide the clinical management of people with hand injuries.

163 The review identified 78 trials published over a period of 35 years, which is a surprisingly small number. To
164 put this number into context, a systematic review on the treatment of distal radial fractures identified 90
165 RCTs published over 5 years from 2010 to 2015 (Lee et al., 2018). The trials identified in the present
166 review covered only seven anatomical areas of the hand. This may be because the injuries studied are
167 common or have potential for poor outcomes. For example, metacarpal fractures are common and
168 scaphoid fractures can have poor outcomes if not properly treated. In terms of the interventions studied,
169 the trials were extremely heterogeneous, and compared various types of operative and non-operative
170 treatments, so it is difficult to draw any conclusions on individual treatments. There are further issues with
171 the design, conduct and reporting of these trials, suggesting potential for bias.

172 Mandatory prospective trial registration came into effect in July 2005 (De Angelis et al., 2004). Of the RCTs
173 published after this time, very few studies had been registered with a trial registry. Only a few studies
174 referenced a study protocol and for the rest it is unknown whether a study protocol was available, but not
175 reported. It was therefore not possible to assess for selective outcome reporting in studies without a
176 protocol. In terms of quality assessment, most assessed bias domains were graded as unclear, reflecting
177 the pressing need for greater clarity in trial reporting via the enforcement of adherence to CONSORT
178 guidelines by researchers and journals (Nagendran et al., 2013).

179 Selection bias refers to systematic baseline differences between the two groups (Cochrane Methods, 2018).
180 Randomization helps to control for known and unknown confounders and minimizes selection bias. Even

181 though all studies were reported as randomized trials, the randomization and allocation concealment
182 methods were not described in many trials.

183 Very few studies were blinded, which introduces performance and detection biases. Performance bias
184 refers to the introduction of differences between the two groups other than the intervention (Cochrane
185 Methods, 2018). Knowing which intervention a patient has received can affect the care provided by
186 clinicians and the perception of recovery by the patients. Detection bias refers to systematic differences
187 between groups in how outcomes are determined (Cochrane Methods, 2018). Knowing which intervention
188 a patient has received can affect outcome assessment, especially of subjective outcomes such as pain.

189 Though it is impossible to achieve blinding in many surgical trials, assessors should be independent and
190 blinded whenever possible. When it is not possible to blind, this should be stated. Most of the included
191 trials did not discuss the blinding, or explained why they did not blind.

192 Though most trials assessed outcomes likely to be reported directly by patients, such as pain and measures
193 of satisfaction, only a small proportion of trials measured this in a standardized way that can be compared
194 across studies, such as a standardized scale or patient-reported questionnaire. Only 24% used Patient
195 Reported Outcome Measures (PROMs). The most frequently used PROMs were the DASH and QuickDASH,
196 reflecting their prominence in orthopaedic publications. Furthermore, very few trials in this review
197 specified their primary outcome, whereas they measured a wide range of heterogeneous secondary
198 outcomes at differing time points (Table 4), precluding future meta-analysis in systematic reviews. Most
199 studies also failed to report a sample size calculation and had a sample size of less than 100 participants,
200 which is likely to be too low to draw meaningful conclusions with narrow confidence intervals (Corty and
201 Corty, 2011).

202 Length of follow-up was variable and participant retention at the final follow-up point was often not
203 reported. Only 22/78 (28%) of trials had duration of follow-up of 1 year or more. Participant retention did
204 not show an association with follow-up length, suggesting that either most studies reporting the
205 percentages of follow-up at the last attendance were relatively short (median follow-up 24 weeks) or
206 possibly that those which had high percentages of losses failed to report it.

207 Few trials of operative treatments reported the training/experience of surgeons. Those that did said that
208 the authors carried out the surgery. The authors were senior, likely to be enthusiasts with specialist
209 knowledge, which would make the results less generalizable.

210 The low number of multi-centre studies and the lack of external funding shows that hand surgery needs to
211 follow other specialties in conducting larger, collaborative studies.

212 There needs to be consistency by better design. A core outcome set for trials relating to the treatment of
213 hand injuries would substantially increase the transparency and consistency of reporting (Williamson et al.,
214 2012). A core outcome set is a consensus minimum set of outcomes that should be measured and reported
215 in all trials relating to a specific condition and is developed with the input of all relevant stakeholders,
216 including patients, researchers, clinicians, and policy-makers (COMET, 2018). Furthermore, issues with
217 poor design are important to highlight and address because a solution will require the endorsement and
218 cooperation of researchers, funders, reviewers, journal editors, and the wider clinical community.

219 The results of this review are compatible with other reports. Post et al. (2013) carried out an analysis of two
220 major hand surgery journals for the level of evidence of RCTs. They found that the lack of quality may be for
221 a number of reasons, such as economic (i.e. trials in surgery lack comparable budgets to those trials funded
222 by pharmaceutical companies), the relatively small and heterogeneous patient populations and the
223 inability to blind surgeons and patients. They suggested that there is a need for high-quality publications,
224 which could be achieved by the use of the CONSORT statement as a guideline to improve the quality of RCT
225 reporting. A systematic review of all hand surgery articles published in six journals over a 20-year period
226 found that the number of hand surgery articles has progressively increased over the last 20 years (Sugrue et
227 al., 2016).

228 This is not a systematic review of the effectiveness of specific interventions, so we cannot draw clinically
229 relevant conclusions about the effectiveness of treatments for a particular injury. The comparatively low
230 number of studies, heterogeneity of interventions, deficiencies in trial design and inconsistencies in
231 outcome assessment make this very difficult, which is why so many systematic reviews in the field of hand
232 surgery rely on lower levels of evidence by including non-randomized studies (Sugrue et al., 2016).

233 .

234 **Funding:**

235 There was no external funding for this study.

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238 **REFERENCES**

239

- 240 Cochrane Methods. Assessing risk of bias in included studies 2018.
241 <http://methods.cochrane.org/bias/assessing-risk-bias-included-studies> (29 June 2018).
242 COMET. Core outcome set (cos). 2018. <http://www.comet-initiative.org/glossary/cos/> (20 July 2018).
243 Corty E, Corty R. Setting sample size to ensure narrow confidence intervals for precise estimation of
244 population values. *Nurs Res.* 2011, 60: 148-53.
245 De Angelis C, Drazen J, Frizelle F et al. Clinical trial registration: A statement from the international committee
246 of medical journal editors. . *N Engl J Med.* 2004, 351: 1250-1.
247 Gabler C, Kukla C, Breitenseher M, Trattng S, Vecsei V. Diagnosis of occult scaphoid fractures and other wrist
248 injuries. Are repeated clinical examinations and plain radiographs still state of the art? *Langenbecks Arch*
249 *Surg.* 2001, 386: 150-4.
250 Grant M, Booth A. A typology of reviews: An analysis of 14 review types and associated methodologies. .
251 *Health Information and Libraries Journal.* 2009, 26: 91-108.
252 Higgins J, Altman D, Sterne J. Chapter 8: Assessing risk of bias in included studies. In: Higgins J, Churchill R,
253 Chandler J, Cumpston M (Eds.) *Cochrane Handbook for Systematic Reviews of Interventions version 520*,
254 Cochrane 2017.
255 James Lind Alliance. Common conditions affecting the hand and wrist, priority setting partnership. . 2017.
256 <https://www.bssh.ac.uk/userfiles/pages/files/Patients/James%20Lind/JLA%20Final%20Summary.pdf> (29
257 November 2017).
258 Lee S, Khan T, Grindlay D, Karantana A. Registration and outcome-reporting bias in randomized controlled
259 trials of distal radial fracture treatment. *JB JS Open Access.* 2018, 3: e0065.
260 Moher D, Liberati A, Tetzlaff J, Altman D. Preferred reporting items for systematic reviews and meta-analyses:
261 The prisma statement. *BMJ.* 2009, 339: b2535.
262 Nagendran M, Harding D, Teo W et al. Poor adherence of randomised trials in surgery to consort guidelines
263 for non-pharmacological treatments (npt): A cross-sectional study. *BMJ Open.* 2013, 3: e003898.
264 Sourmelis S, Platanitis G, Korakis T, Daras A, Schinas N, Papakostas C. Static splinting vs. Functional treatment
265 in extra-articular fractures of the proximal phalanges. *Orthopaedic transactions.* 1995, 19: 210.
266 Sugrue C, Joyce C, Sugrue R, Carroll S. Trends in the level of evidence in clinical hand surgery research. . *Hand*
267 *2016*, 11: 211-5.
268 Toker S, Turkmen F, Pekince O, Korucu I, Karalezli N. Extension block pinning versus hook plate fixation for
269 treatment of mallet fractures. *The Journal of hand surgery.* 2015, 40: 1591-6.
270 Tricco A, Lillie E, Zarin W et al. Prisma extension for scoping reviews (prisma-scr): Checklist and explanation.
271 . *Ann Intern Med.* 2018, 169: 467-73.
272 Williamson P, Altman D, Blazeby J, Clarke M, Gargon E. Driving up the quality and relevance of research
273 through the use of agreed core outcomes. *J Health Serv Res Policy.* 2012, 17: 1-2.

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278 **Figure legends**

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280 Figure 1. Review PRISMA flow diagram.

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282 Figure 2. Distribution of trials per year of publication.

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284 Figure 3. Mapping of the included randomized trials according to the anatomical site.

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286 Figure 4. Risk of bias graph: authors' judgements about each risk of bias item presented as percentages

287 across all included studies.

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289 Figure 5. Risk of bias summary: author's' judgements about each risk of bias item for each included study.

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305 **Table 1.** Inclusion and exclusion criteria for the scoping review.

Criteria
Inclusion criteria
Study design
<ul style="list-style-type: none">• Randomized controlled trials• Studies stated to be ‘randomized’ but for which there is inadequate information about sequence generation and/or allocation concealment• Quasi randomized studies
Population
<ul style="list-style-type: none">• Adults with acute hand fracture(s) and/or joint injury(ies) of the hand• In studies of mixed populations (e.g. adults and children) a randomized controlled trial is included if 90% or more of the population meet the eligibility criteria
Intervention
<ul style="list-style-type: none">• Any intervention for the treatment of hand fractures and joint injuries. This includes primary , secondary treatment and/or associated therapy interventions
Comparator
<ul style="list-style-type: none">• Any other intervention for the treatment of hand fractures and joint injuries as described above• Placebo or no intervention
Study report characteristics
<ul style="list-style-type: none">• Full study reports published in peer review journals• Abstracts of completed studies, if the full study report is not yet available• No timeframe restrictions for trial report publication• Studies in any language
Exclusion criteria
<ul style="list-style-type: none">• Separate publications of economic evaluation of the primary trial• Studies of treatment for distal radial fractures

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- Studies where the primary injury is trauma of nerve, vessel, tendon and/or soft tissue deficits
 - Review articles, unpublished and ongoing trials
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Table 2. Databases searched

Database	Interface	Coverage
PubMed	PubMed	1946-present
Cochrane Central Register of Controlled Trials (Cochrane CENTRAL)	Wiley	1999-present
Embase	OVID	1980-present
MEDLINE	OVID	1946-present
	(In process and non-indexed)	

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Table 3. Study characteristics.

	<i>n /N (%)</i>
Studies published after 1 st July 2005	46/78 (59%)
Study report indicating registration in a trial repository	8/46 (17%)
Sample size > 100	12/78 (15%)
Studies reporting a sample size calculation	26/78 (33%)
Randomized controlled trial study design	
• Single-centre	49/78 (63%)
• Multi-centre	11/78 (14%)
• Inadequate information	18/78 (23%)
Randomisation	
• Randomized controlled trials	73/78 (94%)
• Quasi Randomized trials	5/78 (6%)
Study report indicating intention-to-treat analysis	14/78 (18%)
External funding source	13/78 (17%)
Comparison type	
• Two different types of surgical treatment	16/78 (21%)
• A type of surgical treatment compared to a type of conservative treatment Two different types of conservative treatment	16/78 (21%)
	46/78 (59%)

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Table 4. Outcome assessed in included trials.

Outcomes	<i>n/N (%)</i>
Clinical measurements	64/78 (82%)
• Range of motion	45/78 (58%)
• Grip strength	33/78 (42%)
Radiological	32/78 (41%)
Pain	28/78 (36%)
Patient reported outcome measures (PROMs)	19/78 (24%)
• Disabilities of the Arm, Shoulder and Hand (DASH)	10/78 (13%)
• QuickDASH	7/78 (9%)
• Patient Evaluation Measure (PEM)	2/78 (3%)
• Patient-Related Wrist Evaluation questionnaire (PRWE)	2/78 (3%)
• Michigan Hand Outcomes questionnaire (MHQ)	1/78 (1%)
Return to previous occupation	15/78 (19%)
Overall satisfaction with the result	15/78 (19%)
Complications	12/78 (15%)
Physician-reported and/or composite outcome scores	5/78 (6%)
• Mayo Modified Risk score	2/78 (3%)
• Green/O'Brien score	2/78 (3%)
• Modified Scaphoid Outcome Scoring System	1/78 (1%)
Satisfaction with cosmetic appearance	4/78 (5%)
Quality of life (EQ-5D)	1/78 (1%)

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APPENDIX 1

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363 Search strategies for the scoping review

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365 1. Hand terms

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a. ("Hand bones"[MeSH] OR "Hand joints"[MeSH]

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b. OR "Carpal bones"[MeSH] OR carpals OR carpo OR carpus[tw] OR carpocarpal OR intracarpal

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OR mediocarpal OR mesocarpal OR midcarpal OR transcarpal

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c. OR carpometacarpal OR CMC

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d. OR "Metacarpal bones"[MeSH] OR metacarpus OR metacarpal OR metacarpals OR

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metacarpo* OR midmetacarpal OR transmetacarpal

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e. OR thumb OR thumbs OR thenar

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f. OR "Scaphoid bone"[MeSH] OR scaphoid OR scaphoids OR scaphoidal OR hemiscaphoid OR

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medioscaphoid OR mesoscaphoid OR midscaphoid OR periscaphoid OR transscaphoid OR

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transscaphoidal

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g. OR "Lunate bone"[MeSH] OR lunate OR lunates OR hemilunate OR mediolunate OR

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mesolunate OR midlunate OR perilunate OR perilunar OR "semilunar bone" OR translunate

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h. OR "Pisiform bone"[MeSH] OR pisiform OR hemipisiform OR mediopisiform OR mesopisiform

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OR midpisiform OR peripisiform OR transpisiform

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i. OR "Triquetrum bone"[MeSH] OR triquetrum OR triquetral OR hemitriquetral OR

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mediotriquetral OR mesotriquetral OR midtriquetral OR peritriquetral OR transtriquetrum

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OR transtriquetral

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j. OR "Trapezium bone"[MeSH] OR trapezium OR trapeziums OR trapezial OR hemitrapezium

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OR mediotrapezium OR mesotrapezium OR midtrapezium OR pantrapezial OR peritrapezium

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OR peritrapezial OR trantrapezium OR trantrapezial

386 k. OR "Trapezoid bone"[MeSH] OR trapezoid OR trapezoids OR hemitrapezoid OR
387 mediotrapezoid OR mesotrapezoid OR midtrapezoid OR pantrapezoid OR peritrapezoid OR
388 peritrapezoidal OR transtrapezoid

389 l. OR "Capitate bone"[MeSH] OR capitate OR hemicapitate OR mediocapitate OR mesocapitate
390 OR midcapitate OR pericapitate OR transcapitate

391 m. OR "Hamate bone"[MeSH] OR hamate OR hamates OR hemihamate OR mediohamate OR
392 mesohamate OR midhamate OR perihamate OR transhamate

393 n. OR sesamoid OR sesamoids OR sesamoidal

394 o. OR "Finger phalanges"[MeSH] OR finger OR fingers OR phalanx OR phalangeal OR phalanxes
395 OR phalanges OR midphalangeal OR transphalangeal

396 p. OR ((Joints[MeSH] OR joint OR joints) AND (carpometacarpal OR metacarpophalangeal OR
397 interphalangeal))

398 q. OR ((Ligaments[MeSH] Or ligament OR ligaments) AND (beak OR capitoamate OR
399 capitolute OR "central slip" OR "central slips" OR "extensor expansion" OR "extensor
400 expansions" OR "extensor hood" OR "expansion hood" OR "extensor retinaculum" OR "deep
401 transverse metacarpal" OR "dorsal intercarpal" OR "lateral band" OR "lateral bands" " OR
402 lunotriquetral OR "lunotriquetral interosseous" OR natatory OR pisohamate OR
403 pisometacarpal OR radiocapitate OR radiocarpal OR radiolunate OR radiolunotriquetral OR
404 radiosaphoid OR radiosaphocapitate OR radiosapholunate OR radiotriquetral OR "radial
405 collateral" OR retinacular " OR "ulnar collateral" OR radiopalmar OR "sagittal band" OR
406 "sagittal bands" OR scaphocapitate OR scapholunate OR "scapholunate interosseous" OR
407 scaphotrapezial OR scaphotrapezoid OR scaphotrapeziotrapezoid OR "superficial transverse
408 metacarpal" OR trapeziocapitate OR trapeziotrapezoid OR triquetralcapitate OR
409 triquetralhamate OR triquetrocipitate OR ulnocarpal OR ulnocapitate OR ulnolunate OR
410 ulnotriquetral))

411 r. OR "Collateral ligament, ulnar" [MeSH]

412 s. OR Testut[tw] OR Kuentz[tw] OR "Space of Poirier" OR "volar plate"

413 t. OR Barton[tw] OR Barton's OR Bennett[tw] or Bennett's OR Boxer OR Boxer's OR
414 Chauffeur[tw] OR Chauffeur's OR Colles[tw] OR Colles' OR Colles's OR diepunch OR "die-
415 punch" OR FOOSH OR "Jersey finger" OR Mallet OR Rolando[tw] OR Rolando's OR Smith[tw]
416 OR Smith's)

417 **2. Fracture and ligament injury terms**

418 a. (dislocation OR dislocations OR extraarticular OR "extra-articular" OR fracture[tw] OR
419 fractures[tw] OR "Fractures, bone" [MeSH] OR "Fractures, cartilage" [MeSH] OR "Fracture
420 healing" [MeSH] OR injury OR injuries OR injuries[subheading] OR intraarticular OR "intra-
421 articular" OR rupture OR ruptures OR sprain OR sprains)

422 **3. Specific hand fracture/injury terms.**

423 a. ("wrist fracture" OR "wrist fractures" OR "hand fracture" OR "hand fractures" OR
424 (carpometacarpal AND dislocation) OR "digital fracture" OR "digital fractures" OR "carpal
425 fractures" OR "carpal fractures" OR "carpal dislocation" OR "carpal dislocations" OR
426 "gamekeepers thumb" OR "gamekeeper's thumb" OR ("proximal interphalangeal" AND
427 dislocation) OR (("radius fracture" OR "radial fracture" OR "radius fractures" OR "radial
428 fractures") AND distal) OR "skier's injury" OR "skier's thumb" OR "stener's lesion" OR "stener
429 lesion" OR (stener AND lesion))

430 4. 1 AND 2

431 5. 3 OR 4

432

433

APPENDIX 2434 **RCTs included in the scoping review**435 **Table A.** Table of RCTs for interventions for the treatment of scaphoid fractures

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Scaphoid fractures						
(Adolfsson et al., 2001) Sweden	Adults (mean age 31, range 15-75) with undisplaced fracture of the waist of the scaphoid.	Percutaneous Acutrak screw fixation was compared to immobilisation in a below elbow plaster cast for 10 weeks	ROM, Grip strength, Active flexion/extension, Radial/ulnar deviation, time to union.	16 and 24 weeks	53	No statistically significant differences with regard to the time to union. Patients who underwent surgery had a significantly better range of movement (ROM), but there were no significant differences for grip strength at 16 weeks.
(Bond et al., 2001) USA	Adults (mean age 24, range 18-44) with an acute nondisplaced	Percutaneous cannulated screw fixation was compared to cast immobilization	Grip strength, ROM, Radiographic	1 week and then at 2-week	25	Percutaneous cannulated screw fixation of nondisplaced scaphoid fractures resulted in faster radiographic union and

	fracture of the scaphoid waist		union, Snuffbox tenderness, complications, Patient satisfaction, time to return to military duty	intervals until union. Every 12 weeks up to 104 weeks		return to military duty compared with cast immobilization.
(Bilic et al., 2006)	Croatia Adults (average age 21, standard deviation 5) with symptomatic scaphoid non-union with no evidence of progressive healing	There were three treatment groups: (1) autologous iliac graft, (2) autologous iliac graft and osteogenic protein-1, and (3) allogenic iliac graft	Pain (VAS), Movements, Grip strength, Radiographic union.	4, 8, 12, 16, 17, 28, 52 weeks		Osteogenic protein-1 resulted in an accelerated radiological and clinical repair of scaphoid avascular and necrotic proximal pole non-unions.
(Braga-Silva et al., 2008)	Brazil Adults (mean age 31, range 17-52) with symptomatic scaphoid non-union of a single wrist	Surgery including distal radius vascularised bone grafting compared to surgery including non-vascularised iliac crest bone grafting.	Wrist ROM, Grip strength, Radiographic union	145 weeks	80	Similar functional results were obtained with the two techniques

(Buijze et al., 2014) Netherlands	Adults (mean age 37.5, standard deviation 16) with acute nondisplaced or minimally displaced fracture of the scaphoid waist	Treatment in a below-elbow cast including the thumb was compared to treatment in a below-elbow cast excluding the thumb	Wrist motion, Grip strength, The Mayo Modified Wrist Score, DASH, Pain (VAS), Radiographic union	10 and 24 weeks	62	There was a significant difference in the average extent of union on CT at 10 weeks favouring treatment with a cast excluding the thumb
(Caporrino et al., 2014) Brazil	Adults (mean age 27.7, range 18-56) with lack of scaphoid union for 3 months of conservative treatment.	Vascularised bone grafting (VBG) using the 1,2 intercompartmental suprareticular artery was compared to distal radius nonvascularised bone graft.	Union rate, Functional outcomes (pain, functional status, ROM, wrist strength)	Every two weeks until bone healing and at discharge.	27	Although the VBG group attained earlier union, this may not be clinically meaningful, nor justify the greater technical difficulty and use of resources associated with this intervention.
(Clay et al., 1991) UK	Adults (mean age 29.7, range 16-71) with radiologically proven scaphoid fractures	A forearm gauntlet (Colles') cast, leaving the thumb free was compared to a conventional 'scaphoid' plaster incorporating the thumb as far as its interphalangeal joint.	Radiological union, Tolerance of casts, Functional recovery	2, 4, 8 24 weeks	352	For acute, undisplaced fractures of the waist of the scaphoid, the simpler Colles' plaster appears to be equally effective.

(Clementson et al., 2015)	Adults (median age 30, range 16-63) with acute scaphoid fracture	Sweden	Surgical treatment consisted of wrist arthroscopy and percutaneous antegrade screw fixation compared to conservative treatment consisted of a below-elbow thumb spica cast until radiological signs of union appeared	DASH, VAS score, ROM, grip strength, Radiographic (CT scan)	6, 10, 14, 26, 31 52 weeks and then every 52 weeks	Non- and minimally displaced scaphoid waist fractures are best treated conservatively. Operative treatment may provide an improved functional outcome in the short term but at the price of a possible increased risk of arthritis in the long term
(Clementson et al., 2015)	Adults (median age 30, range 16-63) with scaphoid waist fracture	Sweden	Arthroscopically assisted screw fixation was compared to conservative treatment	Time to union	10, 14, 24 and 52 weeks	35 Screw fixation does not reduce time to fracture union compared with conservative treatment
(Dias et al., 2005)	Adults (mean age 29.5, range 16-61) with a fracture of the waist of the scaphoid	UK	Early fixation was compared to non-operative treatment.	Clinical assessment: pain, swelling, tenderness, ROM, Grip strength, PEM	2, 8, 12, 26, 52 weeks.	88 This study did not demonstrate a clear overall, benefit of early fixation of acute scaphoid fractures.

(Dias et al., 2008) UK	Adults (mean age 30, standard deviation 16-61) with a scaphoid fracture	Operative treatment (open reduction and internal fixation through the volar approach using a Herbert screw or a cannulated Whipple screw, with an additional Kirschner wire, or two Kirschner wires only) was compared to non-operative treatment (immobilisation of the wrist in a below-elbow cast for eight weeks with the thumb left free).	PRWE, Grip strength, Pinch strength, ROM, Radiological union	Seen 416 weeks after treatment	88	Our study revealed that the outcome of early fixation is comparable to that of initial non-operative treatment.
(Drac et al., 2014) Czech Republic	Adults (mean age 30) with acute nondisplaced or minimally displaced scaphoid waist fracture	Palmar percutaneous approach (surgical) was compared to dorsal limited approach (surgical).	Flexion, Extension, Radial deviation, Ulnar deviation, Grip strength, Pain, Complaints, DASH	4, 8, 12 weeks	76	We found no advantage to the palmar percutaneous approach in the treatment of nondisplaced and minimally displaced scaphoid fractures compared to dorsal limited approach.

			score, Patient satisfaction			
(Gaebler et al., 2002) Austria	Adults (age of participants not reported) with acute undisplaced scaphoid fractures	Percutaneous screw fixation was compared to non-operative treatment.	Radiological union, ROM, Grip strength, Pinch grip, Green/O'Brien score, Time to return to work and sports	8, 12, 16, 26, 52 weeks.	41	This study suggests that percutaneous stabilisation of scaphoid fractures is a safe and reasonable approach, especially in younger patients who want and need to get back to work and sports early.
(Gellman et al., 1989) USA	Adults (age of participants not reported) with acute non-displaced fractures of the carpal scaphoid	Long thumb-spica cast for 6 weeks, followed by application of a short thumb-spica cast until union was compared to short thumb-spica cast as a sole form of treatment.	Radiographs (Time to union, Delayed union, Non-union)	Every 3-4 weeks, until union.	51	We recommend an initial period of six weeks of immobilisation in a long thumb-spica cast, followed by use of a short thumb-spica cast.
(Goyal et al., 2013) India	Adults (mean age 34.7) with scaphoid non-union	Iliac crest bone graft compared to distal radius bone graft in surgery of nonunion of scaphoid fractures	Residual pain, Complications, Pinch strength,	Minimum 156 weeks	100	The results of our study show that the fusion rates and functional results of the two techniques are equivalent.

			Grip strength, ROM. QDASH, Mayo' scoring system, Pain (VAS)			
(Hambidge et al., 1995) UK	Adults (age of participants not reported) with acute scaphoid fracture	Plaster immobilisation in 20 degrees of flexion was compared to immobilisation in 20 degrees of extension.	Comfort in plaster, ROM, Union	24 weeks	146	The authors recommend that a colles' type cast in slight extension be used for immobilization of the acute un-displaced scaphoid fracture.
(Hannemann et al., 2012) Netherlands	Adults (mean age 41, range 16-84) with acute scaphoid fracture	Pulsed electromagnetic field treatment compared to placebo	Grip strength, range of active extension, flexion, radial and ulnar deviation, Radiological healing, Tenderness, Pain	4,6,9, 12, 24 and 52 weeks after diagnosis of the fracture	53	We conclude that stimulation of bone growth by PEMF has no additional value in the conservative treatment of acute scaphoid fractures

(Hannemann et al., 2014)	Netherlands	Adults (mean age 35, range 18-77) with acute scaphoid fracture	Active PEMF (pulsed electromagnetic fields) compared to placebo. All fractures were treated with immobilisation in a forearm cast with the first metacarpal and both phalanges immobilised	Range of active extension, flexion, radial and ulnar deviation, Grip strength, Tenderness in the anatomical snuffbox, Radiological healing, Pain	6, 9, 12, 24 and 52 weeks	102	We concluded that the addition of PEMF bone growth stimulation to the conservative treatment of acute scaphoid fractures does not accelerate bone healing
(Lawton et al., 2007)	USA	Adults (age range 24-35) with acute non displaced scaphoid fracture	Munster thumb-spica cast was compared to a long arm thumb-spica cast	Forearm pronation and supination, elbow ROM.	Not reported	10	A Munster thumb-spica cast may play a role in the conservative treatment of non-displaced scaphoid fractures by allowing some elbow motion during the long immobilization period.
(Lyons et al., 2017)	UK	Adults (age of participants not reported) with acute	Standard fiberglass resin cast was compared to thermoplastic removable splint	Union of fracture, Patient satisfaction, QDASH	Not reported	25	Treatment with a thermoplastic polymer based removable splint resulted in comparable outcomes and patient

	non-displaced scaphoid fractures					satisfaction compared to the use of traditional resin casts.
(Mayr et al., 2000) Germany	Adults (mean age 37, standard deviation 14) with fresh, stable scaphoid fractures	Low intensity, pulsed ultrasound with immobilisation was compared to immobilisation only.	Not reported.	CT scan every 2 weeks	28	The low-intensity, pulsed ultrasound therapy is suitable for accelerating the healing of fresh scaphoid fractures
(McQueen et al., 2008) UK	Adults (mean age 29.4, range 17-65) with acute scaphoid fracture	Percutaneous fixation with a cannulated Acutrak was compared to immobilisation in a cast	ROM, Grip and pinch strength, Modified Green/O'Brien functional score, Return to work and sports,	8, 12, 26, 52 weeks	60	We recommend that all active patients should be offered percutaneous stabilisation for fractures of the waist of the scaphoid.
(Raju and Kini, 2011) Singapore	Adults (mean age 28, range 20-48) with non-union of the scaphoid involving	The Herbert screw fixation, the Matti Russe bone grafting, or the Kohlman modification of	Scapholunate and radiolunate angles, ROM, Functional	24 weeks	33	The time to union was earliest in the Kohlman modification of vascularised muscle pedicle graft procedure, which is recommended for patients with old non-

	the proximal pole, waist, and distal pole.	vascularised muscle pedicle graft procedure.	outcomes, Modified scaphoid outcome scoring system, Hardware failure or any iatrogenic fracture during pedicle dissection			union (>1 year) or proximal pole fractures.
(Ribak et al., 2010) Brazil	Adults (age of participants not reported) with scaphoid non-union	Treatment using a vascularised bone graft from the dorsal and distal aspect of the radius was compared to treatment with a conventional non-vascularised bone graft from the distal radius.	Radiographic evaluation, Active range of flexion, extension, radial deviation, ulnar deviation, scaphoid-lunate angle, Pain, Grip strength, Joint	Not reported	86	We conclude that vascularised bone grafting yields superior results and is more efficient in patients in scaphoid nonunion.

			mobility, Global outcome score			
(Ricardo, 2006) Cuba	Adults (mean age 26.7, range 17-62) with fractures of the scaphoid with established non-unions treated with vascularised pedicle bone graft	Low-intensity ultrasound was compared to placebo. The placebo units were adjusted to give no ultrasound signal output across the transducer.	Pain, Active range of motion of the wrist, carpal height index, and scapholunate-capitolunate angles, Radiographic evidence of union, Time to healed non-union	Not reported	21	Our data analysis suggests that ultrasound therapy may be beneficial to the healing of non-union of the scaphoid after treatment by vascularised pedicle bone graft.
(Saeden et al., 2001) Sweden	Adults (mean age 33, standard deviation 17) with acute scaphoid fracture visible at the first	Operatively using a Herbert screw was compared to conservatively by a short-arm cast	Tenderness, ROM, strength, Radiological union, Duration of sick leave, Symptoms (VAS),	Not reported	61	Operative treatment of an acute fracture of the scaphoid allows early return of function and should be regarded as an alternative to conservative treatment in patients in whom immobilisation in a cast for three

	radiological examination.		Grip strength, Range of flexion/extension			months is not acceptable for reasons related to sports, social life or work.
(Sjolin and Andersen, 1988) Denmark	Adults (mean age 27, range 9-75) with symptoms of a fractured carpal scaphoid, but without radiological evidence of fracture	Dorsal plaster cast was compared to supportive bandage	Radiographs (fractures, avulsion), Sick leave	Not reported	108	We conclude that patients presenting with the clinical picture of a fracture of the carpal scaphoid should be treated as having a soft-tissue injury if the four standard radiographs do not show a fracture. A cast may still be offered to patients with much pain.
(Vinnars et al., 2008) Sweden	Adults (mean age 31, standard deviation 12) with an isolated scaphoid fracture that was nondisplaced or minimally displaced	Immobilization in a below-the-elbow scaphoid cast with the thumb held in palmar abduction, the interphalangeal joint free, and the wrist in neutral or slight extension for a planned period of six weeks was compared to a standard Herbert screw or a	DASH, PRWE, Radiographic, Complications	520 weeks	83	This study did not demonstrate a true long-term benefit of internal fixation, compared with nonoperative treatment.

cannulated Herbert-Whipple
stabilisation.

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439 **Table B.** Table of RCTs for interventions for the treatment metacarpal fractures

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Metacarpal fractures						
(Anand et al., 1999) USA	Adults (mean age 24, range 11-48) with Boxer's fracture (fracture of the neck of the fifth metacarpal)	Immediate mobilisation was compared to attempted reduction and splint immobilization.	Cosmetic satisfaction, Return to pre-injury status, Radiological union, Dorsal and ulnar angulation,	1, 3, 6, and 12 weeks	60	The results of our study would suggest that these fractures could be treated with immediate mobilization with good functional results. We feel that reduction and splintage seem unnecessary for these fractures

			Extensor lag, Grip strength, ROM.			
(Braakman et al., 1998) Netherlands	Adults (mean age 26, range 14-44) with fracture of the 5th metacarpal.	Functional tape for four weeks was compared to ulnar gutter plaster-cast for four weeks.	Power grip, static pulling strength of little finger, maximum torque force, fracture angulation, power grip, Radiographic union, Residual symptoms at 6 months	1, 4, 12, and 24 weeks	50	We advise treating fractures of the 5th metacarpal with a functional tape rather than with cast immobilisation
(Cepni et al., 2016) Turkey	Adults (mean age 28, range 18-46) with an acute (0–15 days), closed, and simple fracture of the fifth metacarpal neck	Operative treatment was compared to splinting (U-shaped ulnar gutter)	Palmar angulation, ROM, Metacarpal shortening,	4 and 7 weeks	24	We recommend antegrade intramedullary K-wire fixation as a reliable method, which minimizes the functional loss and allows for early return to daily activities in office

			QDASH, Return to work, Radiological union			workers who sustained a fracture of the fifth metacarpal neck.
(Galal and Safwat, 2017) Egypt	Adults (mean age 32, standard deviation 6) with a closed 5th metacarpal fracture with angulation more than 30	Surgical treatment using transverse pinning was compared to surgical treatment using intramedullary pinning.	Total Active ROM, Total Active Range of Flexion, QDASH, Radiological union	2, 6, 12, and 24 weeks	80	Both techniques are equally safe and effective. The only difference was shorter operative time & less incidence of complications in transverse pinning group.
(Garramone, 1996) USA	Adults (age of participants not reported) with small finger metacarpal neck fractures.	Volar splint was compared to dorsal hood short arm cast	Grip strength, ROM, Subjective patient satisfaction	8-10 weeks	33	Volar splinting was shown to provide significantly increased grip strength along with improved range of motion, and decreased complaints of post treatment pain
(Gulke et al., 2017) Germany	Adults (mean age 32, range 18-60) with postoperative management of metacarpal fractures	A home exercise (HE) program was compared to a traditional physical therapy (PT) program.	ROM, Grip strength, DASH	2, 6, 12 weeks	60	Study results show that both HE program and traditional PT are effective in the postoperative management of metacarpal fractures

(Hansen and Hansen, 1998) Denmark	Adults (age of participants not reported) with fractures of the necks of the ring or little metacarpals.	Ulnar plaster-of-Paris from proximal interphalangeal joint to the ring and little finger was compared to a functional brace made of Hexalite and to an elastic bandage alone.	Fracture tenderness, ROM, Patient satisfaction	4, and 12 weeks	105	We recommend the functional brace for treatment of fractures of the neck of the ring and little metacarpals.
(Harding et al., 2001) UK	Adults (mean age 27, range 12-57) with fractures of the neck of the little finger metacarpal	Treatment with a moulded metacarpal brace was compared to treatment with neighbour strapping.	ROM, Tenderness, Overall satisfaction, Back to work	3 weeks	73	Patients treated with the metacarpal brace had significantly less pain than those treated with neighbour strapping, and this facilitated an early return to work.
(Hofmeister et al., 2008) USA	Adults (age of participants not reported) with isolated fracture of the fifth metacarpal neck.	Short-arm cast with volar outriggers (SAC-VOR) was compared to a short-arm cast extended to the proximal interphalangeal joint with a 3-point mold (MCP-ext).	Radiographic union, cast durability, complications. DASH. ROM, grip strengths	1, 4 and 12 weeks	81	Advantages of the MCP-ext cast include quicker application and, to a much lesser degree, better tolerability, range of motion, and final grip strength

(Kim and Kim, 2015)	Adults (mean age 27, range 18-53) with a surgical indication for a fifth metacarpal neck fracture	An antegrade intramedullary K-wire was compared to a percutaneous retrograde intramedullary K-wire	DASH, Pain (VAS), Radiographic union, ROM	3, 24 weeks	46	Antegrade intramedullary pinning has some clinical advantages during the early recovery period, but the advantages are not evident at 6 months postoperatively.
(Konradsen et al., 1990)	Adults (age of participants not reported) with a shaft or neck fracture of the second through the fifth meta-carpal bone	Immobilization by a plaster cast (immobilizing the wrist and the joints of the involved digits) was compared to immobilisation by a functional cast (allowing the wrist and the digits a free range of motion)	Pain, Cast inconvenience, Time to return to work, Rotation, Ulnar/radial angulation, ROM, Grip strength, Radiographic union	1, 3, and 12 weeks.	100	Functional casting reduced volar angulation by two thirds for metacarpal shaft fractures and by one third for metacarpal neck fractures when compared with plaster cast immobilization. Sick leave was reduced by two thirds after functional casting compared with the plaster cast group.
(Kuokkanen et al., 1999)	Adults (median age 28, range 11-68) with subcapital fractures of the fifth metacarpal bone	Closed reduction and splinting was compared to functional treatment	ROM, Grip force, Hand grip strength	4, and 12 weeks	29	Subcapital fractures of the fifth metacarpal bone can successfully be treated without closed reduction and splinting.

(McMahon et al., 1994) UK	Adults (mean age 31) with a unilateral fresh closed stable fracture of the shaft of a single finger metacarpal.	Compression glove and early mobilization was compared to immobilization in a plaster splint.	Hand volume, Finger circumference, ROM, Loss of flexion, Pain and functional limitations.	Not reported	42	Use of a compression glove relieved pain and avoided the loss of function imposed by splintage and was associated with a greater range of movement during the second and third weeks.
(Rafique et al., 2006) Pakistan	Adults (age of participants not reported) with isolated hand fractures (of metacarpals and phalanges). Both open and closed fractures were included.	Percutaneous K wires were compared to a buried placement of K wires.	Infection rate, Time to remove K wires	Not reported	60	Percutaneous K wires had significantly greater infection rate than wires which were buried deep to skin.

(Randall et al., 1992) USA	Adults (mean age 29, range 19-46) following treatment of a metacarpal fracture and whose hand had been immobilized for least 2 weeks.	Traction and palmar/dorsal glide techniques were used to perform the joint mobilization treatment and they were compared to no treatment.	Active ROM, Torque ROM, Excursion.	Three appointments over a 1 week period	18	The joint mobilization treatment given to the subjects in this study resulted in a significant gain in AROM and decrease in joint stiffness within a treatment session when compared to the control group.
(Sletten et al., 2015) Norway	Adults (mean age 27, range 18-68) with little finger metacarpal neck fractures.	Operative treatment (closed reduction and internal fixation) was compared to conservative treatment (no attempt of reduction, plaster-of-Paris for 1 week, buddy strapping and active exercises)	QDASH, Pain (VAS), Patient satisfaction, QoL EQ-5D-3L, Active flexion/extension, Flexion/extension deficit, TAM, Grip strength	1, 6, 12 and 52 week	85	We recommend conservative treatment with early mobilization for fractures up to 45–50° palmar angulation in the lateral view.
(Sorensen et al., 1993) Denmark	Adults (age of participants not reported) with	A functional brace (the Galveston metacarpal brace) was compared to a dorsal/ulnar plaster cast	Complications, Fracture angulation,	1, 4 and 12 weeks	113	We found that the benefits did not outweigh the risks of the functional fracture bracing, and we cannot

	fractures of the second through the fifth metacarpal bones		Satisfaction with bandage			recommend the tested version of the Galveston metacarpal brace.
(Stadius Muller et al., 2003) Netherlands	Adults (mean age 29, range 15-74) with a fracture of the subcapital 5 th metacarpal	Treatment with an ulnar gutter plaster cast for a period of 3weeks followed by mobilization was compared to pressure bandage for 1 week and immediate mobilization within limits imposed by pain	ROM, Patient satisfaction, Pain perception, Return to work and hobby, Need for physiotherapy.	6 and 12 weeks	40	A pressure bandage for 1 week and immediate mobilization is a sufficient alternative treatment of a boxer's fracture, if this is not angulated greater than 70° and not rotated.
(Strub et al., 2010) Switzerland	Adults (mean age 30, range 20-70) with acute, closed fractures of the little finger metacarpal neck with a palmar displacement of	Closed reduction and intramedullary splinting was compared to conservative treatment without reduction	Flexion / extension of the MCP joint, Grip strength, Radiological union, Pain (VAS), Patient satisfaction, Time	2, 6, 12, 24, and 52 weeks	40	We conclude that intramedullary splinting for displaced fractures of the little finger metacarpal neck offers an aesthetic, but not a functional advantage.

	between 30o and 70o.		off work, Complications			
(van Aaken et al., 2016) Switzerland	Adults (mean age 29, standard deviation 12) with fifth metacarpal (MC) neck fractures (Boxer's fracture)	Soft wrap and buddy taping (SW) was compared to reduction and cast (RC)	Pain (VAS), Patient Satisfaction, ROM, Power grip, Radiographic union	1, 4 and 16 weeks	68	This study supports the use of soft wrap and buddy taping for treatment of boxer's fracture with palmar angulation </=70 degrees and no rotational deformity.
(Winter et al., 2007) France	Adults (mean age 32, range 18-65) with fractures of the little finger metacarpal neck, or "Boxer's" fractures.	Transverse pinning (operative) was compared to intramedullary pinning (operative). A palmar splint was applied for 1 week. Patients began physiotherapy three times per week for 30 days	Pain (VAS), Patient satisfaction, ROM, Grip strength, Radiographic union, Complications	Evaluated clinically six times after surgery, up to the 12 weeks	36	Intramedullary pinning gave better functional outcomes than transverse pinning, although the former was more technically demanding
(Xia, 2015) China	Adults (mean age 27.5, range 18-50)	Mini-plate fixation was compared to Kirschner wire	TAFS score for hand function, total active	Not reported	76	The mini-plate fixation for metacarpal and phalangeal fractures can obviously

	with metacarpal or phalangeal fracture		flexion degree, length of hospital stay, delayed healing of bone, incidence of infection, healing time			improve hand function, shorten length of hospital stay and healing time
(Zyluk and Budzynski, 2009) Poland	Adults (mean age 34, range 16-75) with isolated, displaced and extra-articular metacarpal fractures.	Operative (by fixation with K-wires) treatment was compared to conservative treatment.	Active ROM, Grip strength, Radiological union, DASH	8 and 24 weeks	74	The results of this study indicate the equal effectiveness of both the operative by K-wiring, and conservative treatment of fractures of the metacarpals.

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451 **Table C.** Table of RCTs for interventions for the treatment of mallet finger

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Mallet finger						
(Auchincloss, 1982) UK	Adults (mean age 41, range 17-82) with mallet finger. Both open and closed injuries were included.	Percutaneous fixation of the distal interphalangeal joint using a K wire was compared to a Pryor and Howard splint for 6 weeks without radiographic control.	Subjective results (treatment acceptable good result, normal function), Objective results	56, 72 weeks	50	After a mallet finger injury treated within two weeks by either method few patients have significant persistent disability. Both groups of patients were generally satisfied with their treatment and its outcome.

			(Good, improved, unchanged), ROM			
(Batibay et al., 2017) Turkey	Adults (mean age 36, range 17-61) with mallet finger	The new suture anchor technique (operative) compared to conservative management (aluminium orthotic device)	ROM, Extension lag/deficit DIP flexion, VAS score, Return to work, Radiologic union, DIP joint degeneration	12, 24, 52 weeks	29	Our study suggests that the new suture anchor technique is not superior to conservative treatment
(Gruber et al., 2014) USA	Adults (mean age 50, range 24-78) with mallet finger with or without fracture and treatment with a period of continuous splint or cast immobilization for 6 weeks or greater	A night splint for an additional month after 6 to 8 weeks of continuous splinting was compared to no night splint.	DASH	Not reported	51	Supplemental night splinting does not improve the outcome of mallet finger.

(Kinninmonth and Holburn, 1986) UK	Adults (age of participants not reported) with mallet finger	Perforated splint and told to keep it on without restricting their activities compared to standard 'stack' splint with instructions on daily removal for hygiene purpose.	Skin status, Lag, Ability to change splint	2, 6, 52 weeks	54	The perforated mallet finger splint can produce consistently good results even in those patients who would not tolerate a conventional splint.
(O'Brien and Bailey, 2011) Australia	Adults (mean age 38, range 11-86) with mallet finger	A prefabricated stack splint (control), was compared to a dorsal padded aluminum splint, and a custom-made thermoplastic thimble splint. All were worn for 8 weeks continuously, with a 4 week graduated withdrawal and exercise program.	ROM, Compliance, Treatment failure and complications, Pain (VAS), Patient satisfaction	1, 6, 8, 10, 12, 20 weeks	64	In this study, no extensor lag difference was found between the 3 splint types, but custom-made thermoplastic splints were significantly less likely to result in treatment failure.
(Pike et al., 2010) Canada	Adults (mean age 43) with acute mallet finger	3 splint types were compared: volar padded aluminum splint, dorsal padded aluminum splint, and custom thermoplastic. Splints	Clinical lag, Radiographic lag, Complications, MHQ scores	7, 12, 24 weeks.	87	No lag difference was demonstrated between custom thermoplastic, dorsal padded aluminum splint, and volar

		were continued for 6 weeks full-time.				padded aluminum splinting for Doyle I acute mallet fingers.
(Saito and Kihara, 2016) Japan	Adults (mean age 42, range 18-72) with mallet finger.	The 2-step immobilization group underwent initial immobilization using an orthosis, followed by the use of a second orthosis. This was compared to the figure of eight-type orthosis (control) group, which underwent conventional immobilization using an orthosis.	Not reported.	3 and 16 week	44	Our study thus suggested that the initial immobilization involved in new 2-step orthosis and is thus a good immobilization technique.
(Tocco et al., 2013) Italy	Adults (mean age 45, standard deviation 12) with mallet finger	Cast immobilization of closed mallet fingers using Quickcast (QC) was compared to a removable, lever-type thermoplastic orthosis.	Edema, Hand function, Subjective evaluation of the orthosis, Satisfaction with outcome, Grip strength	Once during 3-4, 6-8, 7-9, 8-10, 10-12, 12-14, 24-28 and weeks	57	Cast immobilization seems to be slightly more effective than the traditional approach probably for its greater capacity to reduce edema.

(Warren et al., 1988) UK	Adults (mean age 46.1, range 10-77) with mallet finger	Stack splint was compared to Abouna splint	Extension loss, Success of treatment, Patient satisfaction	Regularly until 10 weeks	116	The Stack splint is more acceptable to the patient than the Abouna splint.
(Zhou et al., 2008) China	Adults (mean age: 27.5, standard deviation 9.5) with mallet finger	Percutaneous pinning with plaster splint was compared to open reduction and pulling out wire	Total active movement (TAM) functional assessment, operation time, flap necrosis and infection, skin ulcer, bone union, pseudoarthrosis	Regularly until 104 weeks	72	Percutaneous pinning with plaster splint is simple in operation and has smaller incisions and fewer complications compared with open reduction and pulling out wires.

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457 **Table D.** Table of RCTs for interventions for the treatment of proximal phalangeal fracture

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Proximal phalangeal fracture						
(Abubeih et al., 2016) Egypt	Adults (mean age 31, range 14-56) with extra-articular proximal phalangeal fractures.	An extensor tendon splitting approach fixed with a nonlocking titanium miniplates and screws was compared to an extensor tendon sparing approach	QDASH, Total active ROM, Grip strength	Not reported	40	Meticulous surgical dissection, anatomical closure of layers, and early active mobilization are the keys to success in fixation of phalangeal fractures, regardless of the approach chosen.
(Franz et al., 2012) Switzerland	Adults (mean age 49, range 16-93) with extra-Articular Fractures of the Proximal Phalanges of the Fingers	Treatment using a functional forearm cast was compared to treatment with LuCa	Clinical and radiographic assessments, ROM	1, 2, 4, 6, and 12 weeks	66	The clinical and radiological results achieved with the Lucerne cast are comparable to those of established treatment.

(Horton et al., 2003) UK	Adults (mean age 26, range 14-79) with an isolated spiral or long oblique fracture of the proximal phalanx	Closed reduction and Kirschner wire group was compared to open reduction and lag screw	Pain (VAS), Functional recovery, Tip-palm distance, loss of extension/flexion grip strength, Radiographic union, Failure of fixation	12, 24 and 52 weeks	32	We feel that surgeons treating displaced spiral and long oblique fractures of the proximal phalanx should favour the method with which they are most familiar and competent, or the technique that utilizes the least health care resources.
(Kappos et al., 2016) Switzerland	Adults (age of participants not reported) with an isolated, closed proximal phalangeal fracture needing plate osteosynthesis	Open reduction and internal fixation with a plate and screws via a dorsal approach with adhesive barrier was compared to no adhesion barrier.	ROM. DASH, ability to work, Need for secondary surgery.	6 and 24 weeks	42	At 6 weeks there was a trend favouring the adhesion barrier that disappeared at 6 months. Overall the results do not support the use of this device

(Miller et al., 2016)	Adults (mean age 34, standard deviation 11) following 1 week of open reduction and internal fixation of proximal phalangeal fractures	Australia	6 weeks of synergistic wrist and finger exercises with the metacarpophalangeal joint constrained were compared to finger exercises with the metacarpophalangeal joint unconstrained, as part of a comprehensive rehabilitation program	Pain, Difficulty with specific and usual hand activity	1, 6 and 12 weeks.	66	Constrained and unconstrained exercises has similar effects after open reduction and internal fixation of proximal phalangeal fracture.
(Sourmelis et al., 1995)	Adults (age of participants not reported) with proximal phalangeal fracture	Greece	Functional treatment was compared to static splinting	Fracture union	4 and 6 weeks	40	We conclude that functional treatment is a safe method for the conservative treatment of the proximal phalangeal fractures

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459 **Table E.** Table of RCTs for interventions for the treatment PIP joint injuries

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
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Fracture/dislocation of PIP joint						
(Arora et al., 2004) Austria	Adults (age of participants not reported) with isolated, acute, closed dorsolateral dislocation of the PIP joint	Dorsal block splinting of the PIP joint following reduction with daily exercises was compared to a closed reduction and immobilisation with a short-arm cast including both interphalangeal joints for 4 weeks	Pain, Radiological (looking for arthritis and bony healing), Active ROM, Pinch power, Circumference of the finger, Stability of the collateral ligament	Not reported	65	Early active motion after dorsolateral dislocation of the PIP joint produces significantly superior results regarding the active range of motion and pinch power than static splinting.
(Boisgontier et al., 2009) France	Adults (mean age 36, standard deviation 12) with sprain of proximal interphalangeal joint	The techniques of both active range of motion (AROM) and of NMES superimposed (superimposed technique [ST]: application of electrical stimulus during a voluntary muscle action) compared to active range of	ROM	Not reported	20	These findings highlighted the superimposed technique as an effective method, which could be integrated in rehabilitation protocols for recovering the proximal interphalangeal joint range of motion following sprain

		motion (AROM) treatment on its own				
(Norregaard et al., 1987)	Adults (mean age 24, standard deviation 11) with hyperextension trauma to the PIP joints of any of the four ulnar fingers	3 weeks of immobilization with a foam-rubber-covered aluminum splint applied to the volar surface with the injured joint flexed was compared to treatment with analgesics and no immobilization. They were advised to start active movements a few days after the trauma.	Pain, Thickened joint, Flexion/extension defect, Swan-neck or Button-hole deformity, Volar-plate tenderness, Stiffness and coldness	24 and 160 weeks	112	We concluded that comfort of the patient and the economic advantages of early motion are obvious.
(Pedersen et al., 1995)	Adults (mean age 37, range 18-79) with dislocation of the PIP joint (volar plate injuries)	Double finger bandage was compared to a Carstam splint	Clinical examination according to Benke and Stableforth, ROM	2 and 24 weeks.	40	The two methods were equally good as treatment for volar plate injuries to the PIP-joint. The advantage of DFB may be a quicker return to full ROM.

(Thomsen et al., 1995) Denmark	Adults (mean age 37, range 18-79) with type I hyperextension injuries to PIP joint, involving avulsion of the volar plate or a minor avulsion fracture	Treatment with an aluminium splint for 2 weeks was compared to treatment conservatively by an elastic double-finger bandage for 2 weeks	ROM, Clinical (joint stiffness, hyperextension). Satisfaction with treatment, Return to work.	2 and 24 weeks.	40	We find that type 1 hyperextension injuries to the PIP joint are well-treated with an aluminium splint or with DFB for 2 weeks.
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471 **Table F.** Table of RCTs for interventions for the treatment of rupture of UCL

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Rupture of UCL						
(Moineau and Boisgontier, 2014) France	Adults (mean age 43, standard deviation 12) with pre-stiff thumbs after operative repair for rupture of the ulnar collateral ligament	In the superimposed electrical stimulation session, they performed 20 min of percutaneous neuromuscular electrical stimulations which were superimposed to voluntary flexion. In the voluntary contraction session, they performed 20 min of repeated	Not reported.	Not reported	8	Superimposing electrical stimulation to voluntary contractions is an efficient technique to improve active range of motion of the pre-stiff metacarpophalangeal joint of the thumb

		active flexions of the impaired metacarpophalangeal joint.				
(Rocchi et al., 2014) Italy	Adults (mean age 39, range 16-64) with an acute tear of the UCL (0-7 days)	Patients received modified spica splint with freedom of motion at the MCP joint, but prevention of the radial and ulnar joint deviation. This was compared to the operated thumb being immobilised for a month using a traditional spica splint.	ROM, Pinch strength, Stability, Time off work, Physiotherapy, Complications	Weekly in the first 4 weeks, and then 8, 24 and 52 weeks.	30	Surgical repair, combined with active metacarpophalangeal motion allowed by the new functional splint, was effective, safe and well tolerated.
(Sollerman et al., 1991) Sweden	Adults (mean age 32, range 11-62) with fresh rupture of the ulnar collateral ligament of the MCP joint of the thumb.	Immobilization in a plaster cast was compared to a functional splint	Clinical examination, Stability tests, ROM, Pinch grip test, Comfort of the bandage, Length of sick leave.	60 weeks	63	We conclude that immobilization of the thumb after a ligamentous injury with a movable splint is strongly preferred by the patients and that the functional results of this technique are equal to plaster cast immobilization after both surgical and nonsurgical treatment.

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483 **Table G.** Table of RCTs for the interventions for treatment of distal phalangeal fractures

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Distal phalangeal fractures (open)						

(Sloan et al., 1987) UK	Adults (mean age 37, standard deviation 16) with open fractures of the distal phalanges of less than 6 hours duration treated by conventional surgery.	Short or long courses of antibiotics compared to no antibiotics.	Infection rate	1 week	85	Three different antibiotic regimes were compared, with no difference in the infection rate.
(Stevenson et al., 2003) UK	Adults (range 16-88) with open fractures of the distal phalanges of less than 12 hours old.	Prophylactic flucloxacillin compared to placebo (in addition to meticulous wound toilet)	Infection rate (superficial, deep)	1, 2, and 8 weeks.	193	It is concluded that the addition of prophylactic flucloxacillin to thorough wound toilet and careful soft-tissue repair of open fracture of the distal phalanx confers no benefit

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495 **Table H.** Table of RCTs for interventions for the treatment of closed bone fractures

Study identifier	Population	Intervention and comparator	Outcomes	Follow up at	Sample size	Conclusion
Closed bone fractures						
(Chang et al., 2014) Taiwan	Adults (mean age 33, standard deviation 8) with closed bone fracture (CBF) of wrist and hand.	Low level laser therapy (LLLT) for the healing of CBF five times per week for 2 weeks compared to sham laser treatment	Pain (VAS), Functional disability, QDASH, Grip strength,	2 weeks	50	LLLT can relieve pain and improve the healing process of CBF in the human wrist and hand.

The fracture was in
the phalanges, or the
metacarpal, carpal,
distal ulna, or distal
radial bones. The
patients had not been
treated.

Radiographic
union

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507 **References**

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509 Abubeih H, Saleh W, Thabet M, Ibrahim A-K. Extensor tendon splitting versus extensor tendon sparing approach for miniplate fixation of extraarticular proximal
510 phalangeal fractures. *Current orthopaedic practice*. 2016, 27: 623-32.

511 Adolfsson L, Lindau T, Arner M. Acutrak screw fixation versus cast immobilisation for undisplaced scaphoid waist fractures. *Journal of hand surgery (Edinburgh, Scotland)*. 2001, 26: 192-5.

513 Anand N, Tannoury T, Mey S, Weinstein R. Boxer's fracture: A prospective randomized study comparing immediate mobilization to immobilization. *American academy of orthopaedic surgeons annual meeting; 1999 feb 4-8; anaheim (CA) 1999*.

515 Arora R, Lutz M, Fritz D, Zimmermann R, Gabl M, Pechlaner S. Dorsolateral dislocation of the proximal interphalangeal joint: Closed reduction and early active motion
516 or static splinting; a retrospective study. *Archives of orthopaedic and trauma surgery*. 2004, 124: 486-8.

517 Auchincloss JM. Mallet-finger injuries: A prospective, controlled trial of internal and external splintage. *Hand*. 1982, 14: 168-73.

518 Batibay SG, Akgul T, Bayram S, Ayik O, Durmaz H. Conservative management equally effective to new suture anchor technique for acute mallet finger deformity: A
519 prospective randomized clinical trial. *Journal of hand therapy : official journal of the American Society of Hand Therapists*. 2017.

520 Bilic R, Simic P, Jelic M et al. Osteogenic protein-1 (bmp-7) accelerates healing of scaphoid non-union with proximal pole sclerosis. *International orthopaedics*. 2006,
521 30: 128-34.

522 Boisgontier M, Vuillerme N, Thomas D, Pinsault N, Emprin M, Caillat-Mioussse JL. Effects of neuromuscular electrical stimulation on the range of motion recovery in
523 hand proximal interphalangeal sprain. *Science and Sports*. 2009, 24: 192-5.

524 Bond CD, Shin AY, McBride MT, Dao KD. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. *J Bone Joint Surg Am*. 2001, 83-a:
525 483-8.

526 Braakman M, Oderwald EE, Haentjens MH. Functional taping of fractures of the 5th metacarpal results in a quicker recovery. *Injury*. 1998, 29: 5-9.

527 Braga-Silva J, Peruchi FM, Moschen GM, Gehlen D, Padoin AV. A comparison of the use of distal radius vascularised bone graft and non-vascularised iliac crest bone
528 graft in the treatment of non-union of scaphoid fractures. *J Hand Surg Eur Vol*. 2008, 33: 636-40.

529 Buijze GA, Goslings JC, Rhemrev SJ et al. Cast immobilization with and without immobilization of the thumb for nondisplaced and minimally displaced scaphoid waist
530 fractures: A multicenter, randomized, controlled trial. *The Journal of hand surgery*. 2014, 39: 621-7.

531 Caporrino FA, Dos Santos JB, Penteadó FT, de Moraes VY, Belloti JC, Faloppa F. Dorsal vascularized grafting for scaphoid nonunion: A comparison of two surgical
532 techniques. *Journal of orthopaedic trauma*. 2014, 28: e44-8.

533 Cepni SK, Aykut S, Bekmezci T, Kilic A. A minimally invasive fixation technique for selected patients with fifth metacarpal neck fracture. *Injury*. 2016, 47: 1270-5.

534 Chang W, Wu J, Wang H, Jiang J. Therapeutic outcomes of low-level laser therapy for closed bone fracture in the human wrist and hand. *Photomedicine and laser
535 surgery*. 2014, 32: 212-8.

536 Clay NR, Dias JJ, Costigan PS, Gregg PJ, Barton NJ. Need the thumb be immobilised in scaphoid fractures? A randomised prospective trial. *The Journal of bone and
537 joint surgery British volume*. 1991, 73: 828-32.

538 Clementson M, Jorgsholm P, Besjakov J, Bjorkman A, Thomsen N. Union of scaphoid waist fractures assessed by ct scan. *Journal of wrist surgery*. 2015, 4: 49-55.

539 Clementson M, Jorgsholm P, Besjakov J, Thomsen N, Bjorkman A. Conservative treatment versus arthroscopic-assisted screw fixation of scaphoid waist fractures--a
540 randomized trial with minimum 4-year follow-up. *The Journal of hand surgery*. 2015, 40: 1341-8.

541 Dias JJ, Dhukaram V, Abhinav A, Bhowal B, Wildin CJ. Clinical and radiological outcome of cast immobilisation versus surgical treatment of acute scaphoid fractures
542 at a mean follow-up of 93 months. *The Journal of bone and joint surgery British volume*. 2008, 90: 899-905.

543 Dias JJ, Wildin CJ, Bhowal B, Thompson JR. Should acute scaphoid fractures be fixed? A randomized controlled trial. *J Bone Joint Surg Am*. 2005, 87: 2160-8.

544 Drac P, Cizmar I, Manak P et al. Comparison of the results and complications of palmar and dorsal miniinvasive approaches in the surgery of scaphoid fractures. A
545 prospective randomized study. *Biomedical papers of the Medical Faculty of the University Palacky, Olomouc, Czechoslovakia*. 2014, 158: 277-81.

546 Franz T, von Wartburg U, Schibli-Beer S et al. Extra-articular fractures of the proximal phalanges of the fingers: A comparison of 2 methods of functional, conservative
547 treatment. *The Journal of hand surgery*. 2012, 37: 889-98.

548 Gaebler C, McQueen M, Vecsei V. Percutaneous screw fixation versus conservative treatment in undisplaced scaphoid fractures. *European journal of trauma*. 2002,
549 28: 98.

550 Galal S, Safwat W. Transverse pinning versus intramedullary pinning in fifth metacarpal's neck fractures: A randomized controlled study with patient-reported
551 outcome. *Journal of clinical orthopaedics and trauma*. 2017, 8: 339-43.

552 Garramone J. A functional analysis of short arm cast vs volar splint immobilization in the treatment of small finger metacarpal neck fractures. *Orthopaedic
553 transactions*. 1996, 20.

554 Gellman H, Caputo RJ, Carter V, Aboulaflia A, McKay M. Comparison of short and long thumb-spica casts for non-displaced fractures of the carpal scaphoid. *J Bone
555 Joint Surg Am*. 1989, 71: 354-7.

556 Goyal T, Sankineani SR, Tripathy SK. Local distal radius bone graft versus iliac crest bone graft for scaphoid nonunion: A comparative study. *Musculoskeletal surgery*.
557 2013, 97: 109-14.

558 Gruber JS, Bot AG, Ring D. A prospective randomized controlled trial comparing night splinting with no splinting after treatment of mallet finger. *Hand (New York, NY)*. 2014, 9: 145-50.

560 Gulke J, Leopold B, Grozinger D, Drews B, Paschke S, Wachter NJ. Postoperative treatment of metacarpal fractures-classical physical therapy compared with a home
561 exercise program. *Journal of hand therapy : official journal of the American Society of Hand Therapists*. 2017.

562 Hambidge J, Davis T, Schranz P, Compson J, Barton N. Which position for the wrist when immobilising scaphoid fractures. *Journal of bone and joint surgery - british*
563 *volume*. 1995, 77 Suppl 1: 12.

564 Hannemann PF, Gottgens KW, van Wely BJ et al. The clinical and radiological outcome of pulsed electromagnetic field treatment for acute scaphoid fractures: A
565 randomised double-blind placebo-controlled multicentre trial. *The Journal of bone and joint surgery British volume*. 2012, 94: 1403-8.

566 Hannemann PF, van Wezenbeek MR, Kolkman KA et al. Ct scan-evaluated outcome of pulsed electromagnetic fields in the treatment of acute scaphoid fractures: A
567 randomised, multicentre, double-blind, placebo-controlled trial. *The bone & joint journal*. 2014, 96-b: 1070-6.

568 Hansen PB, Hansen TB. The treatment of fractures of the ring and little metacarpal necks. A prospective randomized study of three different types of treatment.
569 *Journal of hand surgery (Edinburgh, Scotland)*. 1998, 23: 245-7.

570 Harding IJ, Parry D, Barrington RL. The use of a moulded metacarpal brace versus neighbour strapping for fractures of the little finger metacarpal neck. *Journal of*
571 *hand surgery (Edinburgh, Scotland)*. 2001, 26: 261-3.

572 Hofmeister EP, Kim J, Shin AY. Comparison of 2 methods of immobilization of fifth metacarpal neck fractures: A prospective randomized study. *The Journal of hand*
573 *surgery*. 2008, 33: 1362-8.

574 Horton TC, Hatton M, Davis TR. A prospective randomized controlled study of fixation of long oblique and spiral shaft fractures of the proximal phalanx: Closed
575 reduction and percutaneous kirschner wiring versus open reduction and lag screw fixation. *Journal of hand surgery (Edinburgh, Scotland)*. 2003, 28: 5-9.

576 Kappos EA, Esenwein P, Meoli M, Meier R, Grunert J. Implantation of a denaturated cellulose adhesion barrier after plate osteosynthesis of finger proximal phalangeal
577 fractures: Results of a randomized controlled trial. *J Hand Surg Eur Vol*. 2016, 41: 413-20.

578 Kim JK, Kim DJ. Antegrade intramedullary pinning versus retrograde intramedullary pinning for displaced fifth metacarpal neck fractures. *Clinical orthopaedics and*
579 *related research*. 2015, 473: 1747-54.

580 Kinninmonth AW, Holburn F. A comparative controlled trial of a new perforated splint and a traditional splint in the treatment of mallet finger. *Journal of hand*
581 *surgery (Edinburgh, Scotland)*. 1986, 11: 261-2.

582 Konradsen L, Nielsen PT, Albrecht-Beste E. Functional treatment of metacarpal fractures 100 randomized cases with or without fixation. *Acta orthopaedica*
583 *Scandinavica*. 1990, 61: 531-4.

584 Kuokkanen HO, Mulari-Keranen SK, Niskanen RO, Haapala JK, Korkala OL. Treatment of subcapital fractures of the fifth metacarpal bone: A prospective randomised
585 comparison between functional treatment and reposition and splinting. *Scandinavian journal of plastic and reconstructive surgery and hand surgery*. 1999, 33: 315-
586 7.

587 Lawton JN, Nicholls MA, Charoglu CP. Immobilization for scaphoid fracture: Forearm rotation in long arm thumb-spica versus munster thumb-spica casts.
588 *Orthopedics*. 2007, 30: 612-4.

589 Lyons R, Stanley C, McKenna P. Assessment of the use of a synthetic removable polymer splint (fastform polytrextm) for the treatment of non-displaced scaphoid
590 fractures: Prospective randomized trial. *Irish journal of medical science Conference: 42nd sir peter freyer memorial lecture and surgical symposium Ireland*. 2017,
591 186: S330.

592 Mayr E, Rudzki MM, Rudzki M, Borchardt B, Hausser H, Ruter A. [does low intensity, pulsed ultrasound speed healing of scaphoid fractures?]. Handchirurgie,
593 Mikrochirurgie, plastische Chirurgie : Organ der Deutschsprachigen Arbeitsgemeinschaft für Handchirurgie : Organ der Deutschsprachigen Arbeitsgemeinschaft für
594 Mikrochirurgie der Peripheren Nerven und Gefäße 2000, 32: 115-22.

595 McMahon PJ, Woods DA, Burge PD. Initial treatment of closed metacarpal fractures. A controlled comparison of compression glove and splintage. Journal of hand
596 surgery (Edinburgh, Scotland). 1994, 19: 597-600.

597 McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid:
598 A prospective randomised study. The Journal of bone and joint surgery British volume. 2008, 90: 66-71.

599 Miller L, Crosbie J, Wajon A, Ada L. No difference between two types of exercise after proximal phalangeal fracture fixation: A randomised trial. Journal of
600 physiotherapy. 2016, 62: 12-9.

601 Moineau B, Boisgontier MP. Superimposed electrical stimulation improves mobility of pre-stiff thumbs after ulnar collateral ligament injury of the
602 metacarpophalangeal joint: A randomized study. Annals of physical and rehabilitation medicine. 2014, 57: 373-80.

603 Norregaard O, Jakobsen J, Nielsen KK. Hyperextension injuries of the pip finger joint. Comparison of early motion and immobilization. Acta orthopaedica
604 Scandinavica. 1987, 58: 239-40.

605 O'Brien LJ, Bailey MJ. Single blind, prospective, randomized controlled trial comparing dorsal aluminum and custom thermoplastic splints to stack splint for acute
606 mallet finger. Archives of physical medicine and rehabilitation. 2011, 92: 191-8.

607 Pedersen M, Thomsen N, Hovgaard C. Double finger bandage versus carstam splint for the treatment of volar plate injuries of the proximal interphalangeal joint.
608 Acta orthopaedica scandinavica. 1995, 66: 72.

609 Pike J, Mulpuri K, Metzger M, Ng G, Wells N, Goetz T. Blinded, prospective, randomized clinical trial comparing volar, dorsal, and custom thermoplastic splinting in
610 treatment of acute mallet finger. *The Journal of hand surgery*. 2010, 35: 580-8.

611 Rafique A, Ghani S, Sadiq M, Siddiqui IA. Kirschner wire pin tract infection rates between percutaneous and buried wires in treating metacarpal and phalangeal
612 fractures. *Journal of the College of Physicians and Surgeons--Pakistan : JCPSP*. 2006, 16: 518-20.

613 Raju PK, Kini SG. Fixation techniques for non-union of the scaphoid. *Journal of orthopaedic surgery (Hong Kong)*. 2011, 19: 80-4.

614 Randall T, Portney L, Harris BA. Effects of joint mobilization on joint stiffness and active motion of the metacarpal-phalangeal joint. *The Journal of orthopaedic and*
615 *sports physical therapy*. 1992, 16: 30-6.

616 Ribak S, Medina CE, Mattar R, Jr., Ulson HJ, Ulson HJ, Etchebehere M. Treatment of scaphoid nonunion with vascularised and nonvascularised dorsal bone grafting
617 from the distal radius. *International orthopaedics*. 2010, 34: 683-8.

618 Ricardo M. The effect of ultrasound on the healing of muscle-pediculated bone graft in scaphoid non-union. *International orthopaedics*. 2006, 30: 123-7.

619 Rocchi L, Merolli A, Morini A, Monteleone G, Foti C. A modified spica-splint in postoperative early-motion management of skier's thumb lesion: A randomized clinical
620 trial. *European journal of physical and rehabilitation medicine*. 2014, 50: 49-57.

621 Saeden B, Tornkvist H, Ponzer S, Högglund M. Fracture of the carpal scaphoid. A prospective, randomised 12-year follow-up comparing operative and conservative
622 treatment. *The Journal of bone and joint surgery British volume*. 2001, 83: 230-4.

623 Saito K, Kihara H. A randomized controlled trial of the effect of 2-step orthosis treatment for a mallet finger of tendinous origin. *Journal of hand therapy : official*
624 *journal of the American Society of Hand Therapists*. 2016, 29: 433-9.

625 Sjölin SU, Andersen JC. Clinical fracture of the carpal scaphoid--supportive bandage or plaster cast immobilization? *Journal of hand surgery (Edinburgh, Scotland)*.
626 1988, 13: 75-6.

627 Sletten IN, Hellund JC, Olsen B, Clementsen S, Kvernmo HD, Nordsletten L. Conservative treatment has comparable outcome with bouquet pinning of little finger
628 metacarpal neck fractures: A multicentre randomized controlled study of 85 patients. *J Hand Surg Eur Vol.* 2015, 40: 76-83.

629 Sloan JP, Dove AF, Maheson M, Cope AN, Welsh KR. Antibiotics in open fractures of the distal phalanx? *Journal of hand surgery (Edinburgh, Scotland)*. 1987, 12: 123-
630 4.

631 Sollerman C, Abrahamsson SO, Lundborg G, Adalbert K. Functional splinting versus plaster cast for ruptures of the ulnar collateral ligament of the thumb. A
632 prospective randomized study of 63 cases. *Acta orthopaedica Scandinavica*. 1991, 62: 524-6.

633 Sorensen JS, Freund KG, Kejla G. Functional fracture bracing in metacarpal fractures: The galveston metacarpal brace versus a plaster-of-paris bandage in a
634 prospective study. *Journal of hand therapy : official journal of the American Society of Hand Therapists*. 1993, 6: 263-5.

635 Sourmelis S, Platanitis G, Korakis T, Daras A, Schinas N, Papakostas C. Static splinting vs. Functional treatment in extra-articular fractures of the proximal phalanges.
636 *Orthopaedic transactions*. 1995, 19: 210.

637 Stadius Muller MG, Poolman RW, van Hoogstraten MJ, Steller EP. Immediate mobilization gives good results in boxer's fractures with volar angulation up to 70
638 degrees: A prospective randomized trial comparing immediate mobilization with cast immobilization. *Archives of orthopaedic and trauma surgery*. 2003, 123: 534-
639 7.

640 Stevenson J, McNaughton G, Riley J. The use of prophylactic flucloxacillin in treatment of open fractures of the distal phalanx within an accident and emergency
641 department: A double-blind randomized placebo-controlled trial. *Journal of hand surgery (Edinburgh, Scotland)*. 2003, 28: 388-94.

642 Strub B, Schindele S, Sonderegger J, Sproedt J, von Campe A, Gruenert JG. Intramedullary splinting or conservative treatment for displaced fractures of the little
643 finger metacarpal neck? A prospective study. *J Hand Surg Eur Vol.* 2010, 35: 725-9.

644 Thomsen NO, Petersen MS, Hovgaard C. Treatment of hyperextension injuries to the pip joint. *Journal of hand surgery (Edinburgh, Scotland)*. 1995, 20: 383-4.

645 Tocco S, Boccolari P, Landi A et al. Effectiveness of cast immobilization in comparison to the gold-standard self-removal orthotic intervention for closed mallet fingers:
646 A randomized clinical trial. *Journal of hand therapy : official journal of the American Society of Hand Therapists*. 2013, 26: 191-200; quiz 1.

647 van Aaken J, Fusetti C, Luchina S et al. Fifth metacarpal neck fractures treated with soft wrap/buddy taping compared to reduction and casting: Results of a
648 prospective, multicenter, randomized trial. *Archives of orthopaedic and trauma surgery*. 2016, 136: 135-42.

649 Vinnars B, Pietreanu M, Bodestedt A, Ekenstam F, Gerdin B. Nonoperative compared with operative treatment of acute scaphoid fractures. A randomized clinical
650 trial. *J Bone Joint Surg Am*. 2008, 90: 1176-85.

651 Warren RA, Norris SH, Ferguson DG. Mallet finger: A trial of two splints. *Journal of hand surgery (Edinburgh, Scotland)*. 1988, 13: 151-3.

652 Winter M, Balaguer T, Bessiere C, Carles M, Lebreton E. Surgical treatment of the boxer's fracture: Transverse pinning versus intramedullary pinning. *J Hand Surg*
653 *Eur Vol*. 2007, 32: 709-13.

654 Xia X. Kirschner wire and mini-plate fixation in repair of metacarpal and phalangeal fractures: Hand function and adverse reactions. *Chinese journal of tissue*
655 *engineering research*, 2015, Vol. 19: 2741-4.

656 Zhou F, Shen B, Wang R, Fan S, Hu W. [clinical contrast of percutaneous pinning with plaster splint and open reduction and pulling out wire in the treatment of mallet
657 fingers]. *Zhongguo xiu fu chong jian wai ke za zhi = Zhongguo xiufu chongjian waike zazhi = Chinese journal of reparative and reconstructive surgery*. 2008, 22: 1451-
658 4.

659 Zyluk A, Budzynski T. [conservative vs operative treatment of isolated fractures of phalanges: Results of the prospective, randomized study]. *Chirurgia narzadow*
660 *ruchu i ortopedia polska*. 2009, 74: 74-8.

661