TITLE

Treatment interventions for hand fractures and joint injuries: a scoping review of randomized controlled trials

ABSTRACT

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

INTRODUCTION

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

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

A scoping review is a type of systematic review which identifies the nature and the extent of research evidence on a topic. It is the assessment of available published research with the aim of identifying the breadth of relevant evidence, as opposed to trying to answer a specific question (Grant and Booth, 2009). The aim of this scoping review was to identify and assess existing randomized controlled trial (RCT) evidence on treatment interventions for hand fracture and joint injuries in order to inform practice and help plan future trials. The objectives were to collate and map existing RCT evidence to the anatomical sites of hand fractures or joint injuries, appraise the quality of studies using a recognized risk of bias assessment tool, summarize outcomes used and assess the length of follow-up and retention rates in published RCTs.

METHODS

The study was prospectively registered on PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=102845). Preferred Reporting Items

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

Scope and eligibility criteria

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

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

Search strategy

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

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

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

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

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

(1) and (2) were combined using the Boolean 'AND' which was then combined with (3) using the Boolean 'OR'. The findings were then combined with the RCT filer (4) using the Boolean 'AND'. The search terms are detailed in Appendix 1 (available online).

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

Data management, quality assessment and data extraction

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

Mapping and data synthesis

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

RESULTS

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

Mapping

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

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

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

Quality assessment

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

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

Outcomes and follow-up

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

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

DISCUSSION

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

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

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

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

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

Very few studies were blinded, which introduces performance and detection biases. Performance bias refers to the introduction of differences between the two groups other than the intervention (Cochrane Methods, 2018). Knowing which intervention a patient has received can affect the care provided by clinicians and the perception of recovery by the patients. Detection bias refers to systematic differences between groups in how outcomes are determined (Cochrane Methods, 2018). Knowing which intervention a patient has received can affect outcome assessment, especially of subjective outcomes such as pain. Though it is impossible to achieve blinding in many surgical trials, assessors should be independent and blinded whenever possible. When it is not possible to blind, this should be stated. Most of the included trials did not discuss the blinding, or explained why they did not blind.

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

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

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

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

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

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

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

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Figure legends

Figure 1. Review PRISMA flow diagram.

Figure 2. Distribution of trials per year of publication.

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

Figure 4. Risk of bias graph: authors' judgements about each risk of bias item presented as percentages across all included studies.

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

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

Criteria
Inclusion criteria
Study design
• 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
• 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
• Any intervention for the treatment of hand fractures and joint injuries. This includes primary , secondary treatment and/or associated therapy interventions
Comparator
• Any other intervention for the treatment of hand fractures and joint injuries as described above
• Placebo or no intervention
Study report characteristics
• 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
• Separate publications of economic evaluation of the primary trial
• Studies of treatment for distal radial fractures

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

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 (In process and non-indexed)	1946-present

350 **Table 3**. Study characteristics.

	n /*N* (%)
Studies published after 1^{t} 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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355 **Table 4.** Outcome assessed in included trials.

Outcomes	*n/N* (%)
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

Search strategies for the scoping review

1. Hand terms

a. ("Hand bones"[MeSH] OR "Hand joints"[MeSH]
b. OR "Carpal bones"[MeSH] OR carpals OR carpo OR carpus[tw] OR carpocarpal OR intracarpal OR mediocarpal OR mesocarpal OR midcarpal OR transcarpal
c. OR carpometacarpal OR CMC
d. OR "Metacarpal bones"[MeSH] OR metacarpus OR metacarpal OR metacarpals OR metacarpo* OR midmetacarpal OR transmetacarpal
e. OR thumb OR thumbs OR thenar
f. OR "Scaphoid bone"[MeSH] OR scaphoid OR scaphoids OR scaphoidal OR hemiscaphoid OR medioscaphoid OR mesoscaphoid OR midscaphoid OR periscaphoid OR transcaphoid OR transcaphoidal
g. OR "Lunate bone"[MeSH] OR lunate OR lunates OR hemilunate OR mediolunate OR mesolunate OR midlunate OR perilunate OR perilunar OR "semilunar bone" OR translunate
h. OR "Pisiform bone"[MeSH] OR pisiform OR hemipisiform OR mediopisiform OR mesopisiform OR midpisiform OR peripisiform OR transpisiform
i. OR "Triquetrum bone"[MeSH] OR triquetrum OR triquetral OR hemitriquetral OR mediotriquetral OR mesotriquetral OR midtriquetral OR peritriquetral OR transtriquetrum OR transtriquetral
j. OR "Trapezium bone"[MeSH] OR trapezium OR trapeziums OR trapezial OR hemitrapezium OR mediotrapezium OR mesotrapezium OR midtrapezium OR pantrapezial OR peritrapezium OR peritrapezial OR transtrapezium OR transtrapezial

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

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

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

n. OR sesamoid OR sesamoids OR sesamoidal

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

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

q. OR ((Ligaments[MeSH] Or ligament OR ligaments) AND (beak OR capitohamate OR capitolunate OR "central slip" OR "central slips" OR "extensor expansion" OR "extensor expansions" OR "extensor hood" OR "expansion hood" OR "extensor retinaculum" OR "deep transverse metacarpal" OR "dorsal intercarpal" OR "lateral band" OR "lateral bands" " OR lunotriquetral OR "lunotriquetral interosseous" OR natatory OR pisohamate OR pisometacarpal OR radiocapitate OR radiocarpal OR radiolunate OR radiolunotriquetral OR radioscaphoid OR radioscaphocapitate OR radioscapholunate OR radiotriquetral OR "radial collateral" OR retinacular " OR "ulnar collateral" OR radiopalmar OR "sagittal band" OR "sagittal bands" OR scaphocapitate OR scapholunate OR "scapholunate interosseous" OR scaphotrapezial OR scaphotrapezoid OR scaphotrapeziotrapezoid OR "superficial transverse metacarpal" OR trapeziocapitate OR trapeziotrapezoid OR triquetralcapitate OR triquetralhamate OR triquetrocapitate OR ulnocarpal OR ulnocapitate OR ulnolunate OR ulnotriquetral))

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

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

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

2. Fracture and ligament injury terms

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

3. Specific hand fracture/injury terms.

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

4. 1 AND 2

5. 3 OR 4

APPENDIX 2

RCTs included in the scoping review

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, 28, 52 weeks	17	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) Sweden	Adults (median age 30, range 16-63) with acute scaphoid fracture	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, 52 weeks and then every 52 weeks	31	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) Sweden	Adults (median age 30, range 16-63) with scaphoid waist fracture	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) UK	Adults (mean age 29.5, range 16-61) with a fracture of the waist of the scaphoid	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, Radiological evidence of union	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) South Korea	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) Denmark	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) Finland	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.
(Statius Muller et al., 2003) Netherlands	Adults (mean age 29, range 15-74) with a fracture of the subcapital 5th 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.

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) Australia	Adults (mean age 34, standard deviation 11) following 1 week of open reduction and internal fixation of proximal phalangeal fractures	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) Greece	Adults (age of participants not reported) with proximal phalangeal fracture	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

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) Denmark	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) Denmark	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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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

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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