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Review

Systematic review and meta-analysis of mobilisation following open reduction and internal fixation of hand fractures

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Summary Delayed mobilisation following open reduction and internal fixation (ORIF) of hand fractures may contribute to stiffness and poor functional recovery. The aim of this systematic review and meta-analysis was to evaluate whether timing of mobilisation post-ORIF impacts patient-reported and clinical post-operative outcomes.

The review was conducted according to the Cochrane Handbook and was reported in concordance with PRISMA guidelines. All studies reporting mobilisation regimens following ORIF performed within two weeks of metacarpal or phalangeal fractures were included. Of 794 abstracts screened, 53 studies were included, evaluating 1822 hand fractures treated with ORIF.

We found differences between mobilisation timing in patient-reported outcome measures (PROMs), adverse events and time to radiological fracture union. Immediate mobilisation ($\leq$1 day of ORIF) had the shortest mean bone healing time of 38.7 days (95% CI 34.3, 42.3) compared to early mobilisation ($\leq$7 days) (49.6 days [95% CI 42.8, 56.5]). Delayed mobilisation (> 7 days) had the lowest rate of adverse events at 9.3% [95% CI 5.6, 15.2] compared to early mobilisation

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at 25.0% [95% CI 17.1, 35.0]. However, variable outcome reporting and inconsistent diagnostic criteria limited definitive conclusions.

The current literature on post-ORIF mobilisation is heterogeneous. Our meta-analysis demonstrated wide variability in outcomes across different regimens, with overlapping confidence intervals across most summary estimates. A definitive, multi-centre RCT comparing time to mobilisation post-ORIF, including comprehensive outcome reporting and cost-effectiveness analysis, is warranted to inform clinical practice.

Contents

Hand fractures result in a high number of emergency department presentations and can be debilitating, sometimes irreversibly.[1] They usually occur because of sporting accidents, road traffic accidents, falls, and punching injuries.[2] One UK-based study found that the yearly incidence of hand fractures was 3.7 per 1000 for men, occurring mostly in the young, working population with an average age of 33 years old. By contrast, yearly fracture incidence in women was 1.3 per 1000.[3]

Optimising postoperative rehabilitation after stable fracture fixation is vital to minimise risk of adverse events and to regain hand function. The British Society for Surgery of the Hand (BSSH) advise that “early mobilisation should be the default plan and instructions for early mobilisation of the fracture should be given to the patient pre-operatively so they can start moving whilst waiting for their first therapy appointment, which should take place 5-7 days after surgery before adhesions become established”.[4] Delayed or missed hand therapy appointments can lead to unintentionally prolonged splint use, resulting in poor outcomes and delayed return to work.[5] Immobilisation may lead to reduced range of motion due to increased swelling, scarring between tendons and surrounding structures, and joint ligament contraction.[6] However, some studies suggest that postoperative immobilisation may facilitate improved tissue healing, reduce the risk of malunion and minimise pain.[7] Immediate mobilisation in hand-adjacent fractures, such as the distal radius, has previously been studied, demonstrating benefit of this approach.[8-10]

In this systematic review and meta-analysis, we evaluate the existing literature supporting immediate mobilisation (IM) with or without protective orthosis within 1 day of ORIF, early mobilisation (EM) with a period of immobilisation of ≤7 days and delayed mobilisation (DM) with a period of immobilisation of > 7 days following hand fracture ORIF. We assessed whether IM was associated with improved functional outcomes compared to early and delayed strategies and quantified postoperative adverse events.

Methods

We performed a systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidance. The study protocol was prospectively registered on PROSPERO (CRD42023493340). The review was conducted in accordance with the Cochrane Handbook for Systematic Review of Interventions.

Search strategy

KS individually searched Embase, MEDLINE (both via Ovid), Cochrane Central Database of Controlled Trials (via Wiley), WHO ICTRP and ClinicalTrials.gov on 12th January 2024 with no date restriction. Searches included subject heading and free text search terms. Full search strategies for all databases and registries are available (Fig. S7). Two reviewers (JK, JY) independently screened the identified articles against a pre-specified checklist of the inclusion criteria (Fig. S8), any disputes were resolved by discussion and involvement of a third independent reviewer (JCRW).

Study eligibility

Study selection was defined by the following inclusion and exclusion criteria. Reasons for exclusion are available for all studies excluded during full-text screening (Fig. S9). Papers reporting post-ORIF rehabilitation regimens for treatment of metacarpal or phalangeal fractures were included (Fig. S10). We also included fracture-dislocation and carpo-metacarpal fracture combinations. Randomised control trials (RCTs), cohort studies, and case-control studies were included, as were case series and conference abstracts with sufficient data. No limitation on study size was imposed. No restrictions on country or language were imposed. Any non-English articles were translated using Google Translate.

Studies involving carpal fractures, distal radius fractures, mallet fractures, avulsion fractures, or combined hand and distal radius fractures were excluded. Studies involving closed reduction, external fixation, or unstable fixation were also excluded. Studies concerned with use of K-wires without specifying procedure type were excluded; however, papers specifying use of K-wires in an ORIF operation were included. We excluded studies where ORIF took place more than two weeks post-injury, as well as studies that did not report the timing and method of postoperative mobilisation. Case reports, letters, opinion pieces, and literature reviews were excluded (Fig. S8).

Data extraction

Data were extracted using a predefined electric form (Microsoft Excel). Accuracy of the data extraction was cross-checked within the group of authors. Where data was not available for extraction, study authors were contacted by email requesting unpublished data. Where no response was received following the second email, the study was excluded.

Outcome measures

The primary outcome for this review was patient reported outcome of hand function, measured via PROMs as per each study (e.g. Disability of the Arm Shoulder and Hand [DASH], QuickDASH, Visual analogue scale [VAS], Hand20, Patient Rated Wrist/Hand Evaluation [PRWHE], Steel's criteria, Patient Evaluation Measure [PEM]).

The secondary outcomes were total rate of adverse events, grip strength, pinch strength, range of motion, total active motion and mean bone healing time. The risk of specific adverse events was separately recorded (return to theatre, stiffness, bone complications [malunion, nonunion, delayed union], surgical site infection, metalwork extrusion, extensor tendon lag, tendon adhesion, tenosynovitis, tenolysis, delayed wound healing, deformity, osteoarthritis, scar adhesion, complex regional pain syndrome [CRPS], implant tenderness).

Data analysis

A narrative analysis of included studies was performed initially. Descriptive statistics were generated for the included studies to allow for basic evidence synthesis. Meta-analysis of proportions was then performed to determine adverse events across study populations.[11] This method allows generation of pooled risk statistics that are weighted according to the size of the individual study populations, giving more weight to larger studies and less to smaller studies. Subgroup analysis of adverse event incidence was performed for immediate (≤1 day), early (≤7 days) and delayed mobilisation (> 7 days) post-ORIF. Statistical heterogeneity was assessed using the chi-squared test ($p < 0.10$ as statistically significant heterogeneity) and the I^2 measure. There was statistical heterogeneity across studies, as shown by the high I^2 statistics (Fig. S1).

Risk of bias

The quality of all RCTs was assessed using the Cochrane Risk of Bias 2 tool (RoB 2). Each RCT was then classified as having either low, moderate or high risk of bias (Fig. S14). The risk of bias for cohort studies, case series and case-control studies was assessed using the National Institute of Health (NIH) National Heart, Lung & Blood Institute (NHLBI) Study Assessment Tools. This was converted to a rating of low, moderate or high risk to be consistent with the Cochrane RoB 2 tool (Fig. S14).

Results

Two reviewers (JK, JY) evaluated 122 full text articles, with 53 deemed eligible for inclusion (11 IM, 23 EM, 19 DM) (Figure 1).

Characteristics of included studies

There were 2277 study participants across all included studies with 2472 hand fractures, 1822 of which were

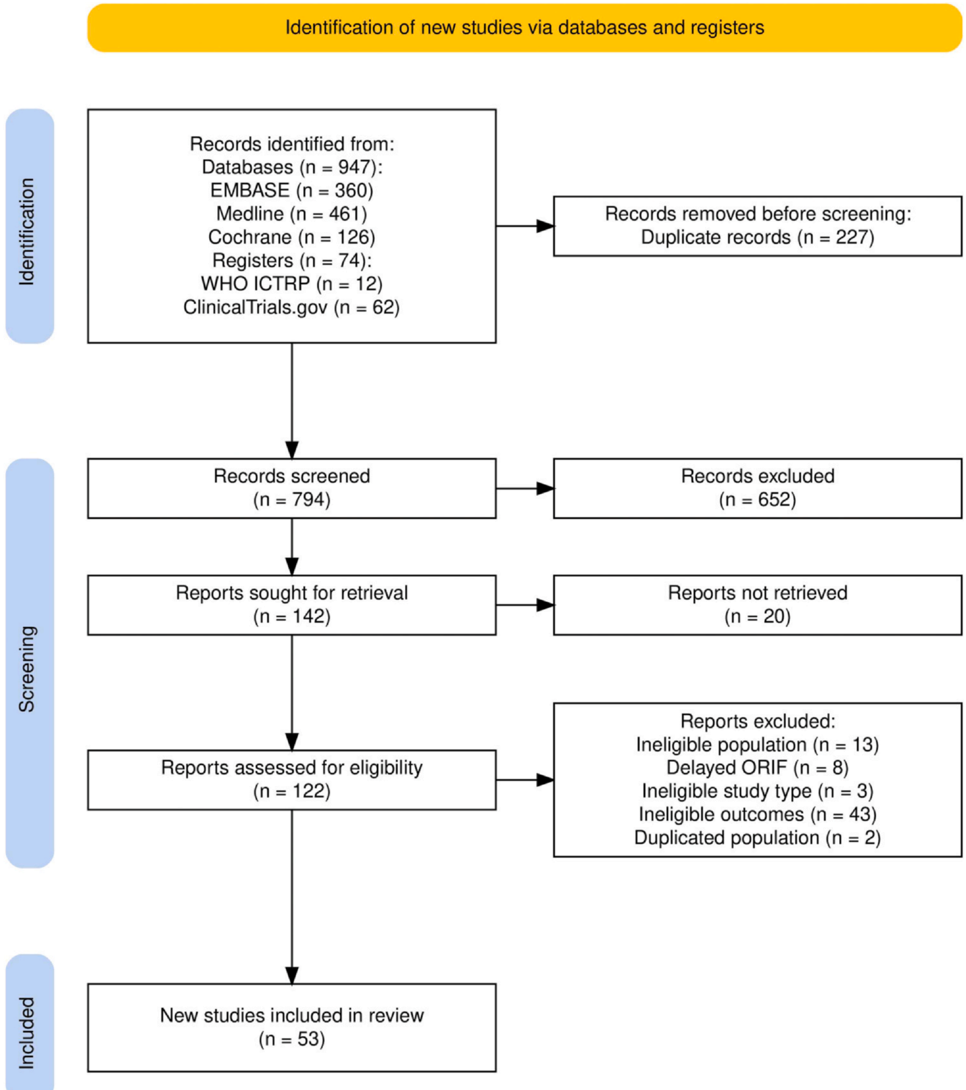


Figure 1 PRISMA flow chart.

treated with ORIF within 2 weeks from date of injury (Table 1, Table S11, Table S12).

Patient-reported outcome measures (PROMs)

The reporting of PROMs was heterogeneous with nine studies reporting QuickDASH, seven reporting DASH, 11 reporting pain on visual analogue scale (VAS) and Hand20, PRWHE, Steel's criteria and PEM being reported once each (Fig. S13). Studies also varied regarding when PROMs were recorded, ranging from less than 6 weeks to more than three years after ORIF. This limited data synthesis between studies (Table S13).

QuickDASH scores tended to be lower in the IM and EM group; however, they were also reported at later time points post-ORIF than in the DM group, which may explain the improvement in scores. For example, some studies reported QuickDASH scores at two time points, demonstrating an improvement in function at later time points post-operatively.[12,13] DASH reporting showed no obvious trend and was mainly reported in the DM group, limiting comparison between groups. Pain VAS scores were lower in the DM group compared to EM (not reported in IM group) (Table S13).

Bone healing

The choice and follow-up duration of objective measures of hand function also varied (Table 1, Table S11, Table S12). Fifteen studies reported mean bone healing time, defined by time between operation and radiological evidence of fracture union. This was quickest in the IM group at 38.7 days [95% CI 34.3, 42.3] compared to EM at 49.6 days [95% CI 42.8, 56.5]. The DM group had a mean bone healing time of 48.8 days [95% CI 29.3, 87.0] (non-weighted data). This difference was not statistically significant, with broad and overlapping confidence intervals. There was one significant outlier in the DM group explaining the large upper confidence interval; a sensitivity analysis without this data point did not result in a statistically significant summary statistic.

Table 1 Characteristics of included immediate mobilisation studies.

Immediate Mobilisation																
Author Year	Study Design	Popul-ation	Location	N	ORIF < 2 weeks	Age	% Men	% DH	Fracture Type	Internal Fixation	Immobilisation	PROMs	Objective Clinical Parameters	Total AE	Follow Up	Risk of Bias
Al-Qattan 2008	Prospective cohort	Mixed	Saudi Arabia	15	15	32	1.00	-	Phalangeal	Cerclage wire	None	-	TAM	1	3	High
Soni 2011	Prospective cohort	Mixed	India	21	55	49.5	0.86	-	Metacarpal	Plate	Elevation	DASH	TAM, bone healing	1	12	High
Pavic 2013	Prospective cohort	Adults	Croatia	89	89	33	0.82	-	Metacarpal	Mixed	None	-	-	26	24	High
Kamath 2016	Prospective cohort	Mixed	India	34	30	32	0.85	0.40	Mixed	K-wire	Buddy tape	-	Grip strength, TAM	1	12	High
Miller 2016	Prospective RCT	Adults	Australia	66	66	34	0.71	0.90	Phalangeal	Mixed	None	PRWHE	Grip strength, TAM	0	3	Low
Zhang Z. 2024	Retrospectiv-e cohort	Mixed	China	60	30	54.6	0.40		Metacarpal	Plate	None	-	-	-	-	High
Al-Qattan 2010	Retrospectiv-e cohort	Adults	Saudi Arabia	9	1	30	1.00	-	Phalangeal	K-wire	None	-	TAM	1	5	High
Wong 2010	Retrospectiv-e cohort	Adults	China	6	6	32.8	1.00	-	Mixed	Plate	None	-	Grip strength, TAM	3	9	High
Rubin 2016	Retrospectiv-e cohort	Mixed	Israel	5	2	16.4	0.80	0.40	Metacarpal	Screws	None	Quick-DASH	Grip strength, TAM	2	-	Moderate
Poggetti 2021	Retrospectiv-e cohort	Adults	Italy	15-2	173	34	0.88	0.69	Mixed	Mixed	Buddy tape	-	Grip strength, TAM, bone healing	15	49	Moderate
Murayama 2022	Retrospectiv-e cohort	Mixed	Japan	31	12	30	0.92	-	Phalangeal	Plate	None	Han-d20	Grip strength, bone healing	1	35	Moderate

RCT: randomised control trial; N: total participants in study population; DH: dominant hand; IM: immediate mobilisation; EM: early mobilisation; DM: delayed mobilisation; PROM: patient reported outcome measures; PRWHE: patient rated wrist/hand evaluation; cast: non-removable moulded support; splint: removable support; DASH: Disability of the Arm Shoulder and Hand; QuickDASH: Disability of the Arm Shoulder and Hand, TAM: total active motion; AE: adverse events; SSI: surgical site infection; Follow up time (months).

We grouped analysis of bone complications by nonunion, malunion and delayed union outcomes and compared the composite events. Proportion of bone complications were 4.4% [95% CI 2.9; 6.8] in EM compared to 1.7% [95% CI 0.7; 3.8] in IM and 2.1% [95% CI 1.1; 3.8] in DM (Fig. S4). All confidence intervals overlapped, indicating no statistically significant differences in bone complications across groups.

Adverse events

Most papers reported adverse events (49/53), with the total rate of adverse events being 15.5% [95% CI 11.4; 20.6] across all included studies (Figure 2). This composite measure included any listed adverse event reported in the study report. However, reporting of individual adverse events was variable between studies. The proportion of adverse events in DM was 9.3% [95% CI 5.5; 15.2] and for IM was 11.7% [95% CI 5.7; 22.5]. EM had a higher proportion of adverse events at 25.0% [95% CI 17.1; 35.0] (Fig. S1). Although there was a statistically significant difference seen between DM and EM groups, the reporting was variable and most of the studies were at high risk of bias so this must be interpreted with caution.

Stiffness

Stiffness was reported as 5.0% [95% CI 1.0; 21.4] in IM, 4.4% [95% CI 1.1; 15.9] in EM and 1.8% [95% CI 0.6; 5.5] in DM (Fig. S2). These differences were not statistically significant. The definition of stiffness varied across studies and included reduced range of motion, and tendon adhesion with secondary joint contracture. Most studies did not specify definitive criteria for stiffness.

Surgical site infection

There was no statistical difference seen in surgical site infections (SSI): EM at 4.2% [95% CI 2.5; 7.0], IM at 3.4% [95% CI 1.5; 7.4] and DM at 2.1% [95% CI 1.1; 3.9] (Fig. S3).

Return to theatre

Return to theatre for metalwork removal was where metalwork had loosened or needed to be removed due to a complication (e.g. symptomatic, infection). There was no significant difference in overall return to theatre with EM at 18.8% [95% CI 12.1; 28.1], IM at 8.4% [95% CI 3.7; 18.1] and DM at 8.4% [95% CI 4.7; 14.5] (Fig. S5). This was similar for return to theatre for reasons other than metalwork removal, with the EM group being 6.6% [95% CI 4.0; 10.8], compared to IM at 2.1% [95% CI 0.7; 6.1] and DM at 3.1% [95% CI 1.6; 5.9] (Fig. S6).

Discussion

In this systematic review we provide an overview of current practices of mobilisation post hand fracture ORIF, synthesising data from 1822 patients (479 IM, 920 EM, 423 DM). Most studies did not report PROMs and there was substantial variation in the type of PROM reported, prohibiting quantitative meta-analysis of our primary outcome. Including and standardising the choice of PROMs for future hand fracture research will be essential to enable impactful comparisons and conclusions to be drawn.

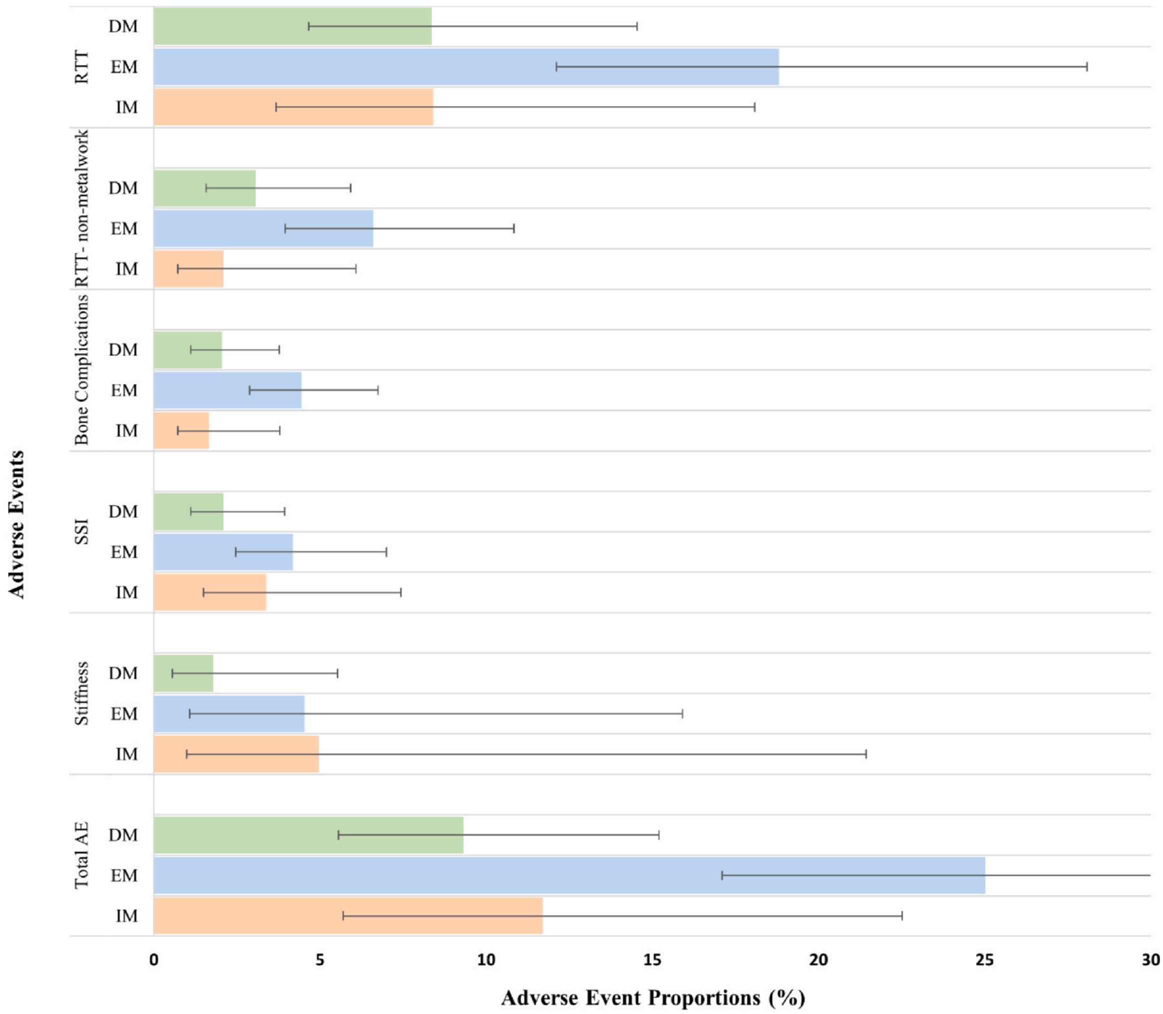
We observed differences in mean bone healing time between interventions. All studies used radiographic evidence of fracture union to define bone healing. However, the number and time interval between radiographs varied, with some studies having more regular follow-ups. Notably, Jun et al. (2021) performed a single radiograph at their final follow-up rather than serial X-Rays which may explain the extended healing time seen in this study.[14] However, even with this value excluded from analysis, the IM group had the fastest fracture healing time. Subjective interpretation of X-rays may have influenced reported time to bone healing, due to the dynamic nature of this process rather than it occurring at a definitive time point. More regular or standardised radiographic assessment with higher resolution imaging could more accurately assess bone healing, in combination with clinical examination.

The lowest rate of adverse events was in the DM group (Fig. S1). The definition of adverse events varied, as well as the extent to which they were reported. Follow-up duration across studies also differed, with DM having a longer average follow-up period than EM or IM (Table 1, Table S11, Table S12). Many studies also suffered from loss to follow-up, which potentially left adverse events undetected.

Our hypothesis that IM might improve functional outcome is in keeping with existing evidence for distal radius fracture management.[8-10] Multiple RCTs comparing mobilisation of distal radius fracture post-ORIF show improved clinical parameters of hand function and PROMs initially with IM or EM. Watson et al. (2018) performed a parallel-design, assessor-blinded RCT comparing the effect of one, three and six weeks of immobilisation following distal radius fracture ORIF repair in adults, finding that shortened immobilisation periods resulted in earlier improvements in PRWE, pain, and range of motion.[8] Another RCT by Clementsen et al. (2019) showed early mobilisation post extra-articular distal radius fracture ORIF was associated with earlier recovery of range of motion and greater initial QuickDASH scores, concluding immobilisation beyond 3 days post-surgery to be unnecessary for this procedure.[9]

Quadlbauer et al. (2022) performed a prospective randomised parallel-group comparative trial, which showed immediate mobilisation (first day after surgery) of distal radius fractures stabilised by volar locking plate resulted in a better short-term outcome than a five-week period of immobilisation.[7] This manifested as higher range of motion in extension/ flexion, stronger grip strength and Mayo Wrist score in the immediate mobilisation group. PROMs were also improved in the IM group with higher qDASH and pain VAS scores with no significant differences in complications or radiological loss of reduction between groups. However, these did not persist between groups one year after surgery.

Both Watson and Clementsen also found there to be no long-term benefits to early mobilisation - Watson found outcome measures for patients in early and late mobilisation groups converged at 3 months post-surgery; Clementsen found they converged at 1 year. This highlights the need for long-term follow-up in such trials to ensure clinically significant conclusions are drawn. Furthermore, early mobilisation seems



IM: immediate mobilisation; EM: early mobilisation; DM: delayed mobilisation; AE: adverse events; SSI: surgical site infection; RTT: return to theatre, Bone complications: malunion, nonunion, delayed union.

Figure 2 Summary adverse event meta-analysis split by time to mobilisation.

to have diminishing returns, with Watson finding no significant difference in adverse events rate with immobilisation periods shorter than one week.[8] Nevertheless, though long-term benefits may be limited, quicker improvement in hand function and reduction in pain may facilitate faster return to work and improve patient satisfaction post-treatment, offering both economic and psychological benefits. Further cost-benefit analysis is necessary to better quantify this.

There may be other, less quantifiable risks associated with longer periods of immobilisation and orthosis wear. Loss of function when wearing an orthosis can have a dramatic adverse effect on patient mood; often related to the patient becoming single-handed and the loss of independence this ensues. For example, loss of financial independence and the routine of going to work, which are both important factors given the higher incidence of hand fractures in the young, working population.[3] In addition, the dependence on others for simple tasks, particularly that of self-care.[15-17] This impact has been demonstrated to be longer-lasting than previously expected. Ammann et al. (2012) report that the impact and change to occupation and task management can last for as long as 14 months. Patients reported feeling vulnerable and anxious once the orthosis had been removed, almost afraid to use the hand due to the perceived loss of protection; and they felt frustrated they were not 'back to normal' once the visible indicator of their injury (the orthosis) had been removed.[16,17] Therefore finding a treatment regimen with the lower duration of orthotic wear could be important in the ability of patients to return to perceived normal function.

Despite the initial benefits of early mobilisation, the risk for later complications has also been shown. Deng et al. (2021) performed a literature review assessing the impact of early mobilisation of distal radius fracture post-ORIF which concluded that although early mobilisation may improve early DASH scores, it was also associated with post-operative complications such as implant loosening, and fracture re-displacement risk.[18]

Moreover, not all studies suggest early mobilisation is associated with earlier recovery. Amadio (2005) states that flexor tendon healing may benefit from an initial short period of post-operative immobilisation (3-5 days) to reduce the risk of fresh bleeding in an already traumatised digit.[6] They reason that acute inflammation may worsen adhesion formation, stiffness and limit hand function, whilst also acknowledging that immobilising for too long also increases tendon gliding resistance and may worsen outcomes. Finding the optimal duration for immobilisation post-operatively, considering the benefits and risks for a variety of hand fracture patterns and soft tissue injuries, is an interesting and unanswered question.

Hand fractures show differences in outcomes with different rehabilitation regimen. This is further confounded by issues of compliance with orthosis and splint wear and mobilisation regimen.[19] The lack of evidence currently available limits the conclusions we can directly draw from our systematic review and meta-analysis. This in itself is an important finding, especially considering how common hand fracture ORIF is within the scope of hand trauma surgery and the economic implications regarding return to work in a largely young, active, working population.[3]

Therefore a definitive RCT comparing mobilisation regimens post-ORIF of both metacarpal and phalangeal fractures is required. The full design of this trial is beyond the scope of this paper, but a multi-centre, adequately powered, pragmatic RCT with robust early outcome measurement (i.e. within the first weeks post-ORIF) and up to 12 months would be able to provide reliable data to guide practice. It should be sufficiently large to handle the natural variability in and between metacarpal and phalangeal fractures and could include both adult and paediatric populations. Cost-effectiveness analysis would be essential to guide practice and inform national guidelines. Although ambitious, similar trials have been performed in other injuries.[10]

Strengths and limitations

We used robust methods to search, extract and analyse current literature, providing a novel insight and summarising outcomes of clinical practice. This work can be used to dependably inform of gaps in existing research and act as a platform to guide future primary research in the field.

There is always a risk of missing studies in our search strategy. Our review was also limited by the low number of RCTs, high risk of bias and small sample sizes of included studies, despite the total pooled patient population being large (Table 1, Table S11, Table S12, Table S14). Furthermore, most included studies were retrospective which limits reliable detection of adverse events, usually reliant on accurate reporting in the medical notes. There was a lack of comparative studies, contrasting postoperative rehabilitation timing directly. Access and interaction with postoperative hand therapy also varied vastly with studies variably reporting specific rehabilitation regimens or not monitoring compliance with them. This paper influences practice by summarising the literature to date, demonstrating variability in both practice and outcomes and as a justification for a robust, definitive trial.

Conclusions

There is substantial variation in the timing and delivery of rehabilitation following ORIF of hand fractures. Our review indicates that different mobilisation regimens may give rise to differences in patient outcomes and adverse events. There is currently insufficient evidence to draw definitive conclusions on functional performance of different mobilisation regimens. A definitive, multi-centre RCT would provide evidence to inform practice and improve patient outcomes following surgery for this common injury.

Ethical approval

Not applicable.

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Data availability

Full dataset available on request.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.bjps.2025.05.006.

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