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Impact of metacarpal shortening on finger strength following non-surgical treatment of spiral and oblique metacarpal shaft fractures

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Abstract

Background Treatment options for spiral/oblique metacarpal shaft fractures (MSFs) include both operative and non-operative approaches. Non-operative treatment with early mobilization has been shown to reduce treatment costs and sick leave, while maintaining grip strength despite metacarpal shortening. However, the impact of metacarpal shortening on strength at the metacarpophalangeal (MCP) or proximal interphalangeal (PIP) joints remains unclear. This study aimed to evaluate whether a shortening of more than 2 mm in spiral/oblique MSFs affects the strength of a single finger.

Methods A total of 23 patients with metacarpal shortening greater than 2 mm following a spiral/oblique MSF were included. The primary outcomes were flexion and extension strength in the MCP and PIP joints, compared to the uninjured hand. Secondary outcomes included range of motion, grip strength, metacarpal shortening, DASH score, patient satisfaction, pain levels, and return to work.

Results There were no differences observed in grip strength, range of motion, or MCP joint extension. However, PIP joint flexion and extension, as well as MCP joint flexion, were significantly reduced. The DASH scores were generally low (mean 4, range 0–23), with patients reporting no pain and high satisfaction.

Conclusions In conclusion, finger strength was statistically significantly reduced, but its clinical relevance remains unclear. Despite these findings, the low DASH scores and high patient satisfaction suggest that the functional impact of these changes may be minimal for most patients. We recommend discussing these findings with individuals who heavily rely on dexterity, such as professional musicians or other precision skill workers.

Level of evidence IV.

Keywords Hand, Metacarpal, Fracture, Displaced, Non-operative, Conservative, Free mobilization

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Background

Metacarpal fractures are a common injury, accounting for approximately 19% of all fractures, with metacarpal shaft fractures (MSFs) constituting about 32% of these cases [1]. While distal radius fractures are the most prevalent across all age groups, metacarpal fractures are the most common upper extremity fractures among individuals aged 18 to 34 years in the United States [2].

Fracture patterns vary, and spiral/oblique fractures are especially prone to causing bone shortening. A key concern is that metacarpal shortening may result in an imbalance between bone and tendon length in the hand, leading to extension and flexion lag in the finger and reduced grip strength [3–5]. Historically, operative treatment aimed at restoring bone length and correcting malrotation has been the standard approach for displaced MSFs. However, surgery carries risks such as infection, complications related to osteosynthesis materials, and scarring. Additionally, surgical interventions are expensive and often result in prolonged rehabilitation and extended sick leave, generating significant socioeconomic costs, particularly given the typically young age of affected patients.

Recent studies have demonstrated that non-operative treatment, with or without immobilization, can yield positive outcomes. These include good grip strength recovery, no malunion or scissoring, reduced sick leave, and high patient satisfaction [6, 7].

Previous research primarily assessed overall grip strength as the main outcome and measured shortening only on radiographs of the fractured hand. However, no studies have directly compared radiographs of both hands to evaluate shortening and its effects on strength of a single finger.

It remains unclear whether shortening after a spiral/oblique MSF affects the strength of individual fingers. This study aims to investigate the impact of metacarpal shortening on both flexion and extension strength at the level of the metacarpophalangeal- (MCP) and proximal interphalangeal (PIP) joints, with these measures as the primary outcomes.

Materials and methods

This study was approved by the Ethical Review Board of Region Dalarna (Dnr 2021–04218, dated October 19, 2021). All participants provided written informed consent, and the study adhered to the principles outlined in the Declaration of Helsinki.

Study design and participants

This study was designed as a retrospective cohort study. We identified all patients diagnosed with a metacarpal fracture (ICD code S62.30) at a regional hospital in Sweden. The study period ranged from January 1, 2016, to December 31, 2020. Patients who met all inclusion criteria were contacted and invited to participate. See Fig. 1, Flow Chart.

Two patients included in this study, which focuses on finger strength as the primary outcome, were also enrolled in a separate clinical study assessing grip strength of the entire hand. This second study represents an extended follow-up of a randomized controlled trial in which grip strength was the primary outcome and is currently under review. This overlap was acknowledged, and appropriate measures were implemented to ensure that it did not affect the analysis of either study's outcomes. Specifically, different clinicians conducted the evaluations for each study, using separate measurement protocols administered at distinct time points to minimize any potential cross-study influence.

Inclusion criteria are shown in Table 1.

Primary outcome

The primary outcome was the strength in flexion and extension at the level of the MCP and PIP joints. In total, four strength measurements were taken: flexion at the MCP joint, extension at the MCP joint, flexion at the PIP joint, extension at the PIP joint. The Rotterdam Intrinsic Hand Myometer (RIHM) was used, and a standardized protocol was implemented [8]. See appendix 1. Each measurement was performed three times, and the average was used for analysis. The percentage difference in strength between the injured and uninjured fingers was calculated and evaluated.

Secondary outcomes

Secondary outcomes were assessed through various measurements for both hands. These included bilateral hand radiographs to assess metacarpal length. Range of motion (ROM) was evaluated with a goniometer according to a standardized protocol [9], and whole hand grip strength was measured using the Jamar dynamometer, with the elbow held at a 90-degree angle. Patient-reported outcome measures (PROM) were also collected, including the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, patient satisfaction (ranging from "very pleased" to "very displeased"), pain assessed on a numeric rating scale (NRS) from 0 to 10 (with 0 indicating no pain), and return-to-work status. In addition, any complications and reoperations were recorded.

Treatment algorithm

All patients in this study were mobilized immediately, with unrestricted use of the injured hand. Initially, they received guidance from an occupational therapist, who introduced an early mobilization regimen and provided an optional resting splint. No additional casts or splints for further immobilization were used. Follow-up was

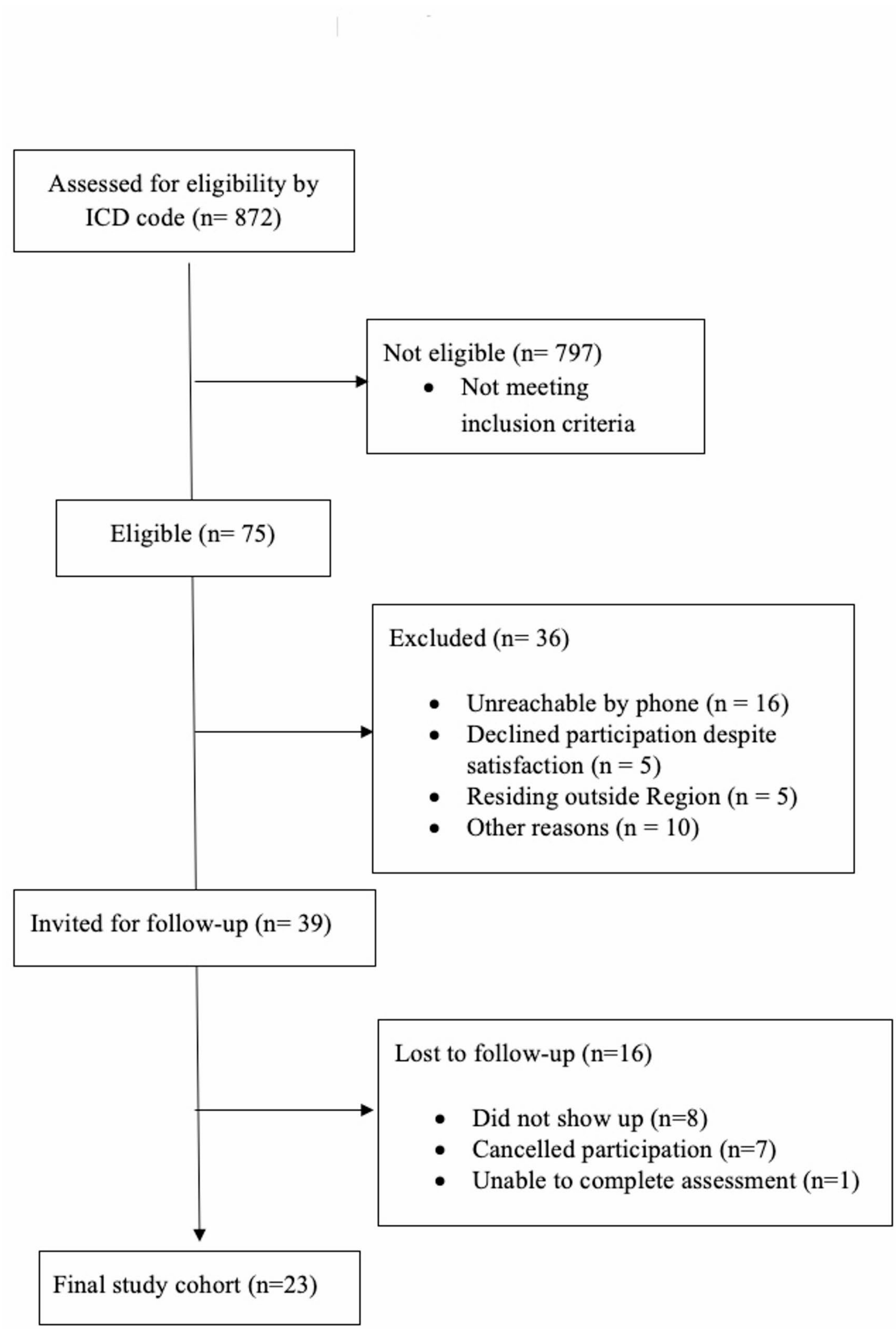

Fig. 1 Enrollment of the study cohort

Table 1 Inclusion/exclusion criteria

Inclusion Criteria	Exclusion Criteria
• Diaphyseal, single spiral and obliques fractures of the index to little finger metacarpals • fracture line at least twice the length of the diameter of the bone at the level of the fracture • non-operative treatment • at least 2 mm displacement/shortening of the fracture and/or malrotation • normal hand function before the injury	• multiple metacarpal fractures • open fractures • inability to comply • fracture line not twice the length of the diameter of the bone at the level of the fracture • abnormal hand function before the injury • previous hand fractures • operatively treated fractures

Table 2 Baseline characteristics

	N = 23
Mean age in years (range)	47.0 (33.5–54.5)
Female (percentage)	8 (35%)
Follow-up in month (range)	48.0 (33.5–57.0)
Injured to the dominant hand (percentage)	10 (43.5%)
Mean radiological shortening at inclusion in mm (range)	4.0 (3.0–5.0)
Injury from falling trauma (percentage)	11 (48%)
Sports injury (percentage)	12 (52%)
Manual worker (percentage)	17 (73.9%)
Injured finger	
3	3 (13%)
4	11 (48%)
5	9 (39%)
(percentage)	
Smoker	
Active smoker	1 (4%)
Previous smoker	0
(percentage)	

Table 3 Finger Joint Strength and Total Grip Strength

	N = 23		
	Estimate	CI (95%)	*p*
Flexion MCP difference (%)	-6.90	-12.69– -1.12	0.022*
Extension MCP difference (%)	-6.34	-13.38–0.70	0.075
Flexion PIP difference (%)	-8.83	-15.78– -1.88	0.015*
Extension PIP difference (%)	-11.93	-22.10– -1.76	0.024*
Full hand grip difference (%)	0.84	-3.42–5.10	0.686

Continuous data are given as median and range.

Model 1 was used.

Estimated percental difference in strength between injured and controlfinger/hand, with 95%

confidence intervals and a p-value for null hypothesis (H0) that the difference equals zero.

Full hand grip: measured using JAMAR dynamometer.

CI confidence interval

*Statistically significant

conducted solely by the occupational therapist and tailored to each patient's individual needs. The minimum requirement for each patient was to perform five repetitions of a full fist exercise, five times a day. No further restrictions were applied.

Statistical analyses

A baseline table was created to summarize the data, presenting continuous variables as median and interquartile range (IQR) and categorical variables as counts and frequencies. The analysis was conducted using three linear regression models. The first was a null model used to estimate the mean difference, comparable to a paired t-test. The second model included dominant hand as a factor to assess whether strength reduction differed depending on which hand was analyzed. The third model incorporated both dominant hand and finger shortening to determine whether strength reduction varied based on the extent of finger shortening in addition to hand dominance. To evaluate the robustness of the first model, a sensitivity analysis was performed using Wilcoxon's paired signed-rank test. Additionally, the standard deviation (SD) and coefficient of variation (CV%) were calculated across all three measurements for each patient. These variations were then plotted against the mean measurement, and pooled variation was calculated. All statistical analyses were performed using R version 4.4.1.

Results

In this study 23 patients could be included with a mean follow-up of 48.0 month (33.5–57.0) and a mean shortening of 4.0 mm (3.0–5.0). Characteristics of the study population are presented in Table 2.

Primary outcome

Strength at the level of the finger joints showed a statistically significant difference in MCP joint flexion, as well as both flexion and extension of the PIP joint. In contrast, MCP joint extension did not show a significant difference. Detailed results are presented in Table 3.

Secondary outcomes

There were no significant differences in overall grip strength of the hand. The median metacarpal shortening was 3.76 mm compared to the contralateral uninjured hand. Range of motion was normal in both hands, with no statistically significant differences between them. Patient satisfaction was high, with 20 out of 23 patients reporting being either very satisfied or satisfied with the outcome. Additionally, 20 out of 23 patients reported being very satisfied or satisfied with the strength of the injured finger. The DASH scores had a mean value of 4 (range 0–23), indicating minimal functional impairment. No complications or secondary operations were reported. The variation between the three replicates were around or slightly over 10 CV% for flexion MCP and PIP and extension PIP, similar for both measurements on control and injured fingers. Extension PIP has slightly higher variations while the variations for the full hand grip is lower. Regressions analysis for hand dominance showed no differences in outcomes. A secondary analysis showed no correlation between shortening and strength in either finger joint or grip strength. See Table 4 for secondary outcomes.

Table 4 Secondary outcomes

	***N*=23**
Rotational deformity at injury	0
Rotational deformity at follow-up	1
Cosmesis*	4.7 (3–5)
Strength*	4.4 (1–5)
Motion*	4.3 (1–5)
Pain at rest**	0.3 (0–4)
Pain at heavy activity**	0.9 (0–5)
DASH score (0-100)	4 (0–23)
Secondary surgery	0
Time off work in days (mean and range)	10 (0–49)

Continuous data are given as median and range.

* reported on a scale 1–5 (1=Very dissatisfied, 2=Somewhat dissatisfied, 3=Neutral, 4=Quite satisfied, 5=Very satisfied)

**Pain reported on a scale 0 (pain free) to 10 (most possible pain).

DASH: Disability of arm, shoulder and hand outcome measure.

Discussion

This study aimed to evaluate metacarpal shortening greater than 2 mm following non-surgical treatment of spiral and oblique MSFs and its impact on finger strength. Our results indicate that MCP flexion, as well as both PIP flexion and extension, were significantly reduced. However, there were no significant differences in MCP extension. Range of motion and grip strength of the hand showed no differences.

When compared to previous studies on metacarpal shortening, the findings of this study both align with and challenge certain conclusions. A cadaver study by Mejia et al. (2023) found that metacarpal shortening greater than 2 mm following non-operative treatment led to a noticeable reduction in grip strength and range of motion, particularly in the metacarpophalangeal joint, and emphasized the need for surgical intervention to restore function [5]. Other studies supporting these findings have also been exclusively cadaver-based [3, 4]. However, the current study contradicts these results, showing no significant impact on full hand grip strength, patient satisfaction or range of motion despite a similar degree of shortening. Additionally, a study by Al-Qattan et al. demonstrated that non-surgical treatment of metacarpal fractures with up to 5 mm shortening could still preserve hand function with proper rehabilitation [10]. Other clinical studies have also failed to find any clinically relevant effects of shortening on grip strength or range of motion, including a randomized controlled trial (RCT) published in 2023, which showed non-inferiority despite shortening [7]. Despite overall high patient satisfaction and low DASH scores, our data revealed two patients who reported being very dissatisfied with both range of motion and strength in their hand. These results were not associated with any rotational deformity or higher metacarpal shortening. The lowest DASH score recorded was 23, and this patient had a comorbidity of myasthenia gravis, which may have influenced the DASH score.

Limitations and strengths

A major limitation of this study is that the measurement used for finger strength, the RHIM, has not been validated for this specific application. The RHIM is established and validated for measuring abduction of the fifth finger and thumb, and based on these methods, we developed a protocol to assess strength in the interphalangeal joints, which demonstrated high reproducibility [8]. The variation between the three replicates was approximately 10% CV or slightly higher for MCP flexion, PIP flexion, and PIP extension, with similar results for both control and injured fingers. Variation in PIP extension was slightly greater, while variation in full hand grip was lower. This might indicate that RIHM measuremnt for finger strength might not be as accurate as JAMAR for grip strength. Further studies are needed to determine whether this method is effective in this context. Another limitation is the lack of knowledge regarding the minimal clinically important difference for finger strength. While the differences observed at the finger joint level were statistically significant, the clinical impact remains unclear. The low DASH scores and generally high patient satisfaction suggest that these findings may fall below the threshold of clinical relevance for individual patients. Another limitation is the relatively small sample size. Despite several attempts, we were unable to reach all patients who would have been ideal candidates for inclusion. Many patients declined participation, primarily due to the lack of monetary compensation or reimbursement for travel expenses.

The strength of this study lies in its specific evaluation of strength and range of motion in a single finger, a focus that has not been explored in previous studies. Additionally, we performed a regression analysis to account for differences between dominant and non-dominant hands, which could have introduced bias, as it is well-established that grip strength tends to be higher in the dominant hand.

One of the key findings of this study is the potential cost-saving associated with non-surgical treatment. As previous research has shown, the operating room (OR) is one of the most expensive departments in a hospital [11]. Therefore, affirming the efficacy of non-surgical treatment can not only reduce costs but also help free up OR resources for other cases.

Conclusion

In conclusion, finger strength was statistically significantly reduced, but its clinical relevance remains unclear. Despite these findings, the low DASH scores and high patient satisfaction suggest that the functional impact of these changes may be minimal for most patients. We recommend discussing these findings with individuals who heavily rely on dexterity, such as professional musicians or other precision skill workers.

Abbreviations

MSF	Metacrapal Shaft Fractures
MCP	Metacarpophalangeal
PIP	Proximal Interphalangeal
ICD	International Classification of Diseases
RIHM	Rotterdam Intrinsic Hand Myometer
ROM	Range Of Motion
HAKIR	Handkirurgisk Kvalitets Register (Swedish Register for Hand Surgery)
PROM	Patient Reported Outcome Measure
DASH	Disabilities of the Arm, Shoulder, and Hand
NRS	Numeric Rating Scale
IQR	Inter Quartile Range
SD	Standard Deviation
CV%	coefficient of variation
RCT	Randomized Controlled Trial

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12891-025-08776-9.

Supplementary Material 1

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Not applicable.

Author contributions

MN: Conceptualization, data acquisition, methodology development, and manuscript writing.DM: Conceptualization, study design, methodology development, statistical analysis, data interpretation, manuscript writing, and funding acquisition.All authors contributed to the critical revision of the manuscript and approved the final version for submission.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethical Review Board of Region Dalarna (Dnr 2021–04218, dated October 19, 2021). All participants provided written informed consent, and the study adhered to the principles outlined in the Declaration of Helsinki.

Consent for publication

A written, signed informed consent to publish all data and any accompanying images was obtained from each patient.

Competing interests

The authors declare no competing interests.

Clinical trial registration

Ethical Review Board of Region Dalarna, Dnr 2021–04218, dated October 19, 2021.

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