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ORIGINAL ARTICLE

Reoperations and postoperative complications after osteosynthesis of phalangeal fractures: a retrospective cohort study

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ABSTRACT

Objectives: The aim of the study was to describe the reoperation rates and postoperative complications associated with different methods of osteosynthesis in all extra-articular, closed fractures of the proximal and middle phalanges operated on in the Department of Hand Surgery at Södersjukhuset beween 2010–2014, and to describe the associated patient demographics.

Patients and methods: This study included all the relevant operations, which comprised operations on 181 fractures in 159 patients (82 male, 77 female), median and mean age = 43 (range = 14–88 years). The clinical records and radiographs were examined retrospectively. A logistic regression analysis was performed on the reoperation data to determine which method of osteosynthesis was the most important descriptor for reoperation, and whether the fracture type was a significant confounder.

Results: Forty-seven patients (26%) were reoperated on, mainly due to finger stiffness. The reoperation rates were 25% after K-wire, 15% after screws, and 42% after plate fixation. The unadjusted reoperation rate after plate fixation was significantly higher than for the other methods, but not after adjustment for fracture complexity. The proximal phalanx was affected in 88% of the fractures, and 77% were located in the fourth or fifth finger. Falls, animal-related, and sports injuries were the most frequent causes of injuries.

Conclusion: Open reduction with plate fixation was associated with a higher reoperation rate, but this method was also used for the more complex fractures. Plate fixation for phalangeal fractures often entails a need for later tenolysis and plate removal. More aggressive mobilisation regimes might be indicated to prevent adhesion problems.

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Finger; fracture; reoperation; internal fixation; phalanx

Introduction

Finger fractures are common, particularly in the proximal phalanges [1,2]. Many of these fractures are stable, not dislocated, and heal well without surgical intervention [3]. However, dislocated and comminuted fractures may require reduction and fixation [4]. Open or closed reduction may be followed by fixation with K-wires or screws. Other options are open reduction and internal fixation (ORIF) with mini plates and screws, external fixation, intramedullar screw fixation, or combined methods [4]. There is no clear consensus in the literature concerning the superiority of any of these fixation methods. Some authors report excellent results of ORIF using plates, while others report substantial problems with this technique [5–8]. The most common problem described in the literature after ORIF is finger stiffness due to adhesion formation between the plate and the soft tissues [9]. Even the newer mini-implants specifically designed for finger phalangeal fractures have been reported to cause adhesion problems, and placement of the plate seems to have an impact on results [10,11].

K-wire fixation is cheaper and often less technically demanding than ORIF. It is, however, biomechanically less stable, which limits the use of early mobilisation regimes [12–14]. Furthermore, protruding pins may hinder interphalangeal joint motion and may cause stiffness. K-wires in combination with early mobilisation may also cause skin irritation and pin-track infection [15]. How the wires are placed has a great effect on rigidity and, when combined with tension bands, K-wires have shown better stability [16,17]. Good results and very few complications have been shown for K-wire fixation in several studies [18,19].

Using screws for spiral or oblique fractures by employing a minimally invasive technique seems to be the only method not surrounded by much controversy [15,20].

Since 1 February 2010, all operations at our department have been registered in the national healthcare quality register HAKIR [21]. The annual report of HAKIR for 2014 showed that adhesion problems or joint contracture was the cause of 15% of all reoperations for postoperative problems after hand surgery in Stockholm, and many of these cases were related to fracture surgery [22]. This raised the question of whether the increasing trend of using plates and screws for ORIF might be responsible for the high incidence of reoperations.

The primary aim of the present study was to analyse the rate of reoperations and complications after surgery for phalangeal fractures. We wanted to examine whether fractures treated by ORIF were over-represented regarding

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reoperations and, if so, whether fracture type was a confounder. The second aim was to describe fracture localisation and fracture type, mechanism of injury, and surgical techniques for all extra-articular and closed fractures of the proximal and middle phalanges of the fingers operated on at our department.

Patients and methods

Our department is the regional centre for hand surgery in the Stockholm area, with ~two million inhabitants. The vast majority of dislocated phalangeal fractures requiring surgical treatment are referred to our department, and the sample size can be regarded as being representative of the total population. This is a retrospective cohort study including all phalangeal fractures operated on at our department between 1 February 2010 and 31 December 2014. Patients with diagnosis codes for phalangeal fracture (ICD 10 codes S626 and S627) and surgical codes for closed or open reduction and osteosynthesis (NDJ09, NDJ19, NDJ49, NDJ69, NDJ79, NDJ89) were identified in the quality register HAKIR. In total, operations for phalangeal fractures in 775 patients were registered during this time period. The data collection took place between February 2014 and August 2015. Inclusion criteria for the study were extra-articular fractures of the proximal or middle phalanx of digits II–V. Exclusion criteria were immature skeleton with open physes, open fractures, and patients who had moved to another region during the study period. Finally, 181 fractures in 159 patients were included in this study (Figure 1). One patient was excluded from the statistical analysis owing to reoperation caused by a new trauma. This patient is, however, included in the background data. There was a fairly even distribution between men ($n = 82$) and women ($n = 77$), and both median and mean age at the time of injury was 43 years (range = 14–88 years).

The study authors personally analysed all patients' charts and radiological examinations before and after the operation. Information about fracture type, method of osteosynthesis, postoperative complications and reoperations, patient's age, injury mechanism, number of hospital visits, and length of sick leave was recorded.

Reoperation was defined as a procedure that was not planned at the original surgery according to clinical records.

Fracture types were divided into three groups: transverse, spiral/oblique, and comminuted.

Fixation techniques used were K-wires (diameter = 1.0–1.2 mm), screws (Synthes Compact hand 1.5®, Oberdorf, Switzerland), and plates (Synthes Compact hand 1.5®, or Stryker VariAx plating system®, Selzach, Switzerland). In cases where a combination of implants was used, for instance an extra screw in addition to a plate, the fracture was placed in the plate group.

All patients followed the standardised rehabilitation programme available at the department for each type of osteosynthesis.

Statistics

The collected data was described as mean and median (range) values. Logistic regression analysis using SPSS was used to explore whether the osteosynthesis was the most important factor for reoperation, and whether the fracture type was a significant confounder. The K-wire group served as reference, being the always available alternative. The outcome was a 'yes/no' response with respect to reoperation. p-values $<.05$ were considered statistically significant.

Ethics

Ethical approval for the study was granted from the regional ethics committee in Stockholm (Dnr: 2014/1934–31/12), and the study was conducted in accordance with the Helsinki declaration.

Results

In total, 47 fractures in 36 patients (26%) were reoperated on in the study period. The causes for reoperation are presented

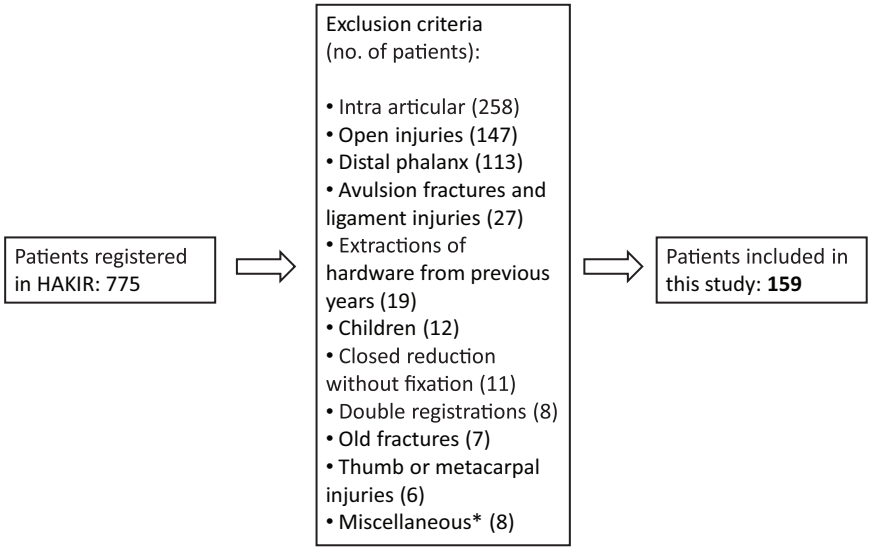

Figure 1. Flowchart of inclusions. *Inaccurate diagnoses and misregistrations.

in Table 1. The most common reason was adhesion problems/finger stiffness. Thirty-two of 47 reoperated on fractures were attributed to this cause. In 26 of the 32 fractures reoperated on because of adhesion, the patient's charts contained information about the range of motion of the proximal interphalangeal (PIP) joint prior to reoperation. The mean active range of motion was 30 degrees. The mean extension deficit was 34 degrees, and the mean active flexion was 66 degrees.

Only one patient, who had previously received surgery with screw fixation, needed to be reoperated on because of redislocation of the fracture. Further, one fracture was reoperated on twice and four fractures thrice.

The risk for reoperation for different surgical methods was examined using logistic regression analysis (Table 2). The analysis showed that plate fixation had an odds ratio (OR) of 2.249 (1.009–5.012, $p = .047$), but it was no longer significant after adjusting for fracture type as a confounder (OR = 2.194 (0.881–5.461), $p = .091$).

When comparing only the sub-group transverse fractures to be able to disregard fracture type confounding we found that four out of 16 (25%) of the plate fixation and six out of 47 (12.8%) of the K-wire fixation transverse fractures had been reoperated on.

Fracture locations and types are listed in Table 3. Fractures of the proximal phalanges constituted 88%, and middle phalanx fractures 12%. Sixteen patients had fractures in more than one finger. None of the patients had more than one fracture of the same ray. Fractures of the proximal phalanges of the fourth and fifth finger constituted the majority of fractures (77%). Injury mechanisms are shown in Figure 2. There was no difference in trauma type or trauma energy between fracture types, except for dog- and horse-related injuries, which were over-represented among spiral/oblique fractures.

Osteosynthesis techniques in relation to fracture types are shown in Table 4. K-wire fixation was dominant for transverse fractures (64%), screw fixation for spiral/oblique fractures (81%), and plate fixation for comminuted fractures (72%).

In total, 121 patients were employed at the time of injury, and the median time for absence from work was 49 days (range = 0–300 days). Reoperated on patients were absent from work for a median of 85 days (range = 0–300 days), as compared to those that did not undergo reoperation (39 days (range = 0–207 days)).

No postoperative infections requiring reoperation were reported in any of the 181 fractures. Three patients received short-term antibiotic treatment owing to superficial pin-track infections around protruding K-wires.

Discussion

The major finding in the present study was the high rate of reoperations (42%) after osteosynthesis with mini plates. The most common reason for reoperation, regardless of operation technique, was adhesion/finger stiffness. The reoperation rate in our study is very similar to that reported by Brei-Thoma et al. [10] (44%). Page and Stern [8] described complications of plate fixation in hand fractures and found a significantly higher complication rate for plate fixation of the proximal phalanges than for the metacarpals. In a study of only phalangeal fractures, including open injuries, Kurzen et al. [9] reported a complication rate of 52% for plate fixated fractures.

The higher rate of reoperations after plate fixation than K-wire fixation in our study can be explained by the more comminuted and complex fractures in the first group. After adjusting for fracture type, the difference in reoperation rates was not statistically significant. Interestingly, Page and Stern [8] did not report a pattern of higher reoperation rate for the more complex fractures in their study, but the inclusion criteria were not similar to ours.

In a recent review on the treatment of hand fractures, it is stated that finger stiffness is the most common complication after phalangeal fractures, and our study supports this opinion [23].

Patients at our department operated on with plate and screw fixation of a finger fracture undergo early active hand rehabilitation starting 2–5 days postoperatively. Nevertheless, finger stiffness due to adhesions is common. This might

Table 1. Reasons for reoperation.

	K-wires	Screws	Plate	Total
Local problems of osteosynthesis material	8	4	1	13
Adhesions/joint stiffness	7	5	20	32
Redislocation of the fracture	0	1	0	1
Rotational malunion	0	0	1	1
Total	15	10	22	47

Table 3. Fracture location and type.

Location and type	Dig II	Dig III	Dig IV	Dig V	Total
Proximal phalanx					
Comminuted	2	10	21	11	44
Spiral/Oblique	3	10	26	18	57
Transverse	4	8	11	35	58
Middle phalanx					
Comminuted	0	0	2	—	2
Spiral/Oblique	0	3	8	2	13
Transverse	0	1	3	3	7
Total	9	32	71	69	181

Table 2. Reoperations logistic regression analysis (odds ratios, 95% CI).

		Reoperated *n*	Total *n*	Crude OR	*p*	Adj. OR	*p*
Fracture type	Transverse	19 (29.2%)	65	Ref	.029	Ref	.574
	Spiral/obliqueblique	11 (15.7%)	70	0.451 (0.196–1.042)	.062	0.613 (0.186–2.020)	.421
	Comminuted	17 (37.8%)	45	1.470 (0.657–3.289)	.349	1.111 (0.434–2.840)	.827
Osteosynthesis method	K-wires	15 (24.6%)	61	Ref	.004	Ref	.088
	Screws	10 (14.9%)	67	0.538 (0.221–1.309)	.172	0.772 (0.222–2.686)	.684
	Plate	22 (42.3%)	52	2.249 (1.009–5.012)	.047[a]	2.194 (0.881–5.461)	.091

n: number; OR: odds ratio; CI: confidence interval.
[a]significant value ($p < .05$).

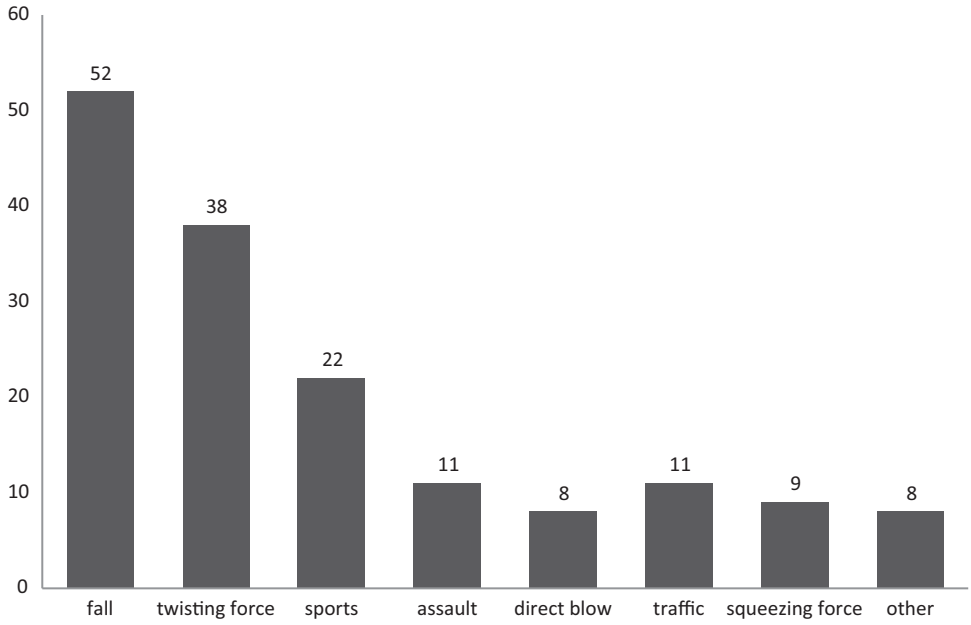

Figure 2. Mechanism of injury in 181 phalangeal fractures. The category 'Horse/dog' was mainly injuries caused by reigns or leash.

Table 4. Techniques of osteosynthesis used in different types of fractures.

	Osteosynthesis method			
Fracture type	K-wires	Screws	Plate	Total
Comminuted	8	8	29	45
Spiral/Oblique	6	57	7	70
Transverse	47	2	16	65
Total	61	67	52	181

indicate that an even more active rehabilitation regime should have been used, especially considering that there was only one case of fracture redislocation. Lateral plate placement has been reported to cause less adhesion problems, but is not technically feasible for all fracture types [5,11]. Comparisons of adhesion problems with other studies are difficult, owing to differences in case collection concerning phalangeal and metacarpal fractures, open and intraarticular fractures [5,7–9,11].

Except for the adhesion problems and a few reports of discomfort from palpable implants, very few other postoperative complications were found in our study. There were only three cases of superficial infections, all from K-wires, and none of them necessitating a reoperation.

In the present study, we also report on injury mechanisms for closed extraarticular phalangeal fractures. The majority of the fractures were caused by accidental falls, interaction with horses and dogs, and sports-related injuries. This pattern of injuries is similar to the findings of De Jonge et al. [2]. However, the sex distribution was different in our study, possibly because we included only closed fractures, excluding machinery injuries associated with soft tissue damage, which are more common among men. In the study by De Jonge et al. [2], the male:female ratio was 1.8:1, whereas in ours it was 1:1.

A limitation of the present study is its retrospective design, and the fact that the choice of fixation techniques was not randomised, and instead depended on the surgeon's choice. The main objective of our study was to analyse rates of, and causes for reoperation, rather than to report postoperative results regarding hand function which would have demanded another study design. The true rate of adhesion problems might well be underestimated, as the only outcome measure was reoperation. Additional patients in all groups may have had considerable finger stiffness without being reoperated on.

Our study's strength, however, is the size and homogeneity of the cohort. We included a fairly large sample size of 181 closed extraarticular phalangeal fractures, representing all consecutive cases at our department during the stated period. Confounding factors such as tissue injury or articular injury were eliminated. All patient records and radiographs were meticulously examined by the authors themselves.

To conclude, this study shows that osteosynthesis of fractures of the proximal and middle finger phalanges still constitute a significant clinical problem. We agree with Markiewitz [24] that the choice of treatment for each individual patient and fracture is crucial, regarding both choices of implant and rehabilitation regimes. When the new low-profile mini plates were introduced to the market it was believed that plate removal was unnecessary. Based on the results of our study, we suggest that patients operated on with mini plate fixation should be informed that additional surgery with tenolysis and plate removal may be needed. It should be further investigated if better results could be achieved by more aggressive postoperative rehabilitation programmes.

To increase the level of evidence for treatment choices, a randomised controlled study comparing plate fixation to K-wire fixation using range of motion as a primary outcome variable on a homogenous fracture type cohort would be required. This study also suggests that there is a need for further technical improvements of implants for phalangeal fracture fixation and methods to prevent adhesions post surgery.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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