Comparison of Clinical Outcomes of Phalangeal Fracture Treated with Dorsolateral Approach or Post-middle Approach Using AO Mini Titanium Plate

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Abstract The aim of this study is to investigate the clinical outcomes of various fixation methods for proximal phalangeal fractures with *Arbeitsgemeinschaft für Osteosynthesefragen* (AO) mini titanium plate by dorsolateral approach or post-middle approach. Clinical results of 62 fingers of 53 patients with proximal phalangeal fracture were evaluated. For dorsolateral approach, the lateral bundle of the extensor tendon was drawn away to expose the fracture part of the bone. After reduction, the plate was located at the dorsolateral side of the bone. For post-middle approach, the extensor tendon was split to expose the fracture part of the bone. After reduction, the plate was fixed to the proximal phalangeal side of the bone, and the extensor tendon was repaired with 3-0 nonabsorbable silk sutures. We found low overall complication rates in both groups. The mean total active motion (TAM) for the dorsolateral group and post-middle group was $234.60^{\circ} \pm 22.63^{\circ}$ and $221.08^{\circ} \pm 25.69^{\circ}$, respectively. There was a statistical significance between the two groups ($P=0.037<0.05$), indicating that TAM was notably affected by various fixation methods. With AO mini titanium plate, movement in dorsolateral approach group was significantly higher than in post-middle

approach group. Dorsolateral approach is an acceptable technique of incision for proximal phalangeal fractures.

Keywords AO mini titanium plate · Proximal phalangeal fractures · Dorsolateral approach · Post-middle approach

Introduction

The hands are one of the most frequently injured parts of the human body [1]. Functional outcome in case of fractures of small bones of the hand mainly depends on injury severity and management [2]. Although most hand fractures can be treated by nonoperative methods with good outcome, there is still a small percentage of unstable hand fractures because of unsatisfactory closed treatment [3, 4].

Currently, the nonsurgical treatment, mainly including plaster and finger rest immobilization, is easy to perform and makes less injury to patients, but its drawbacks are also serious, including poor stability, long recovery time, fracture displacement, and stiff joints. Literature offers five main techniques of treating displaced long oblique/spiral fractures of the shaft of the proximal phalanx of the fingers, viz. external fixation, closed reduction and percutaneous oblique Kirschner wire (K-wire) fixation, and open reduction and internal fixation using lag screws, composite wiring, or plates/screws [5–7]. Surgical operation of single K-wire fixation is simple, but cannot prevent rotation of both ends and exerts no pressure on both ends of the fracture, thus slowing down the fracture healing. Moreover, K-wire fixation needs plaster immobilization, which limits early functional exercise [8–10]. In contrast, plate fixation can avoid fracture displacement and improve early functional exercise, with no damage to the articular

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surface [11]. Although plate fixation of proximal phalanx fractures promotes anatomic reduction and bone healing, the harmful effect of the steel plate on the extensor tendon is one of the frequently encountered problems.

A small number of prospective studies have been published on the treatment of unstable metacarpal and phalangeal fractures using miniature plate (mini plate) and screws [12, 13]. However, after thorough literature review, we did not find any prospective studies in which proximal phalangeal fractures were treated with a different surgical approach by plating systems. The current report is a prospective study on 53 patients with proximal phalanx of the finger treated by dorsolateral approach or post-middle approach with *Arbeitsgemeinschaft für Osteosynthesefragen* (AO) mini titanium plate.

Patients and Methods

Patients with displaced proximal phalangeal fractures, operated on through dorsolateral approach or post-middle approach by using AO mini titanium plate, at our hospital between March 2008 and October 2010, and followed up for more than 3 months, were included in our study. Patients with two or more proximal phalanx fractures were included, but patients with preoperative tendons, blood vessels, or nerve injury were excluded. Finally, a total of 53 patients with 62 fractures were included in our study. Twenty-two cases were treated with dorsolateral AO mini titanium plate, and 31 cases were treated with post-middle AO mini titanium plate.

The mean age of the included patients was 35 years (ranged from 12 to 55 years). All injuries were industrial, including machine crush injuries or traffic accident injuries (Table 1). In dorsolateral group, 15 patients were male, and 7 patients were female. Eighteen cases of 20 fingers are closed fractures, and four cases of 5 fingers are open fractures (Table 2). The mean time from injury to operation is 3.6 days (Table 3). In post-middle group, 18 patients were male, and 13 patients were female. Twenty-eight cases of 32 fingers are closed fractures, and three cases of 5 fingers are open fractures (Table 2). The mean time from injury to operation is 3.4 days (Table 3).

All patients were treated by the senior author, or under his direct supervision, using open reduction and AO mini titanium plate fixation and immediate postoperative mobilization.

Table 1 Injury types of the two groups of patients

Injury types	Dorsolateral (<i>n</i> =22)	Post-middle (<i>n</i> =31)	<i>P</i> value
Machine crush injury	10 cases of 11 fingers	16 cases of 11 fingers	>0.05
Crushing injury	7 cases of 9 fingers	9 cases of 10 fingers	>0.05
Traffic accident injury	5 cases of 5 fingers	6 cases of 8 fingers	>0.05

Table 2 Fracture type of the two groups of patients

Fracture type	Dorsolateral (<i>n</i> =22)	Post-middle (<i>n</i> =31)	<i>P</i> value
Closed	18 cases of 20 fingers	28 cases of 32 fingers	>0.05
Open	4 cases of 5 fingers	3 cases of 5 fingers	>0.05

There are different fingers fractured in patients of both groups, including little finger, middle finger, ring finger, and index finger (Table 4).

Surgical Technique

With the aid of an image intensifier, the procedure was performed on the patients by using brachial plexus block and with the limb positioned on a hand table. All patients have received one prophylactic dose of a cephalosporin before surgery and two doses after surgery.

For dorsolateral approach, the dorsolateral incision was performed on the proximal phalanx, namely the radial dorsal of the index finger and the ulnar dorsal of the little finger. The fracture fragments were exposed by drawing away the extensor tendon. Fractures were then fixed with AO microplates in the dorsolateral of the phalanx. The extensor tendon was repaired by 3-0 nonabsorbable silk sutures (DemeTech, USA). The wound was closed without drainage. For post-middle approach, the incision was located in the dorsal middle of the fingers. The peripheral membrane was cleaved to expose the extensor tendon, which was then longitudinally split in the middle, revealing the fracture fragments. After fracture reduction, AO mini titanium plate was planted in the middle of the dorsal phalanx. The wound was closed after washing.

The same postoperative treatment programs were performed in two surgery groups. Plaster immobilization was applied in patients with unstable internal fixation. Active range of motion (without resistance) was allowed in the next day following surgery. Full-strength mobilization (against resistance) was allowed after 2–3 weeks. Patients were followed up in our hospital every 2 weeks. Clinical progress in terms of range of movement and complications was recorded at each outpatient visit until healing of fractures, and fracture union was noted.

At the final follow-up visit, total active motion (TAM), viz. active flexion of the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints minus the extension deficit in these joints, was used to assess the range

Table 3 Time from fracture to surgery

	Dorsolateral (<i>n</i> =22)	Post-middle (<i>n</i> =31)	<i>P</i> value
Time	3.6 days	3.4 days	>0.05

Table 4 Fracture site of the two groups of patients

Finger	Dorsolateral (<i>n</i> =22)	Post-middle (<i>n</i> =31)	<i>P</i> value
Index	11 cases	16 cases	>0.05
Middle	7 cases	10 cases	>0.05
Ring	5 cases	7 cases	>0.05
Little	2 cases	4 cases	>0.05

of motion [14]. Complications such as fracture re-displacement, nonunion, and infection were recorded [15]. Fracture healing time was recorded until return to work.

All subjects were given informed consent before participating. The study was approved by the local research ethics committee and was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Results

Dorsolateral Approach Group

No cases of fracture re-displacement, skin flap necrosis, or infection occurred in closed fracture surgery. Only one finger of open fracture surgery had superficial infection which was cured later by an anti-infective. Average follow-up was 8.2 months and ranged from 6 to 10 months. The

representative image of X-rays in Fig. 1c showed that all fractures were bone union without rotating and shifting, without loose screws and broken titanium plates compared with preoperative oblique X-rays (Fig. 1a). The healing time ranged from 3 to 6 weeks, with an average of 4.3 weeks. The mean postoperative TAM of the dorsolateral group was $234.60^{\circ} \pm 22.63^{\circ}$, indicating a full range of motion. No patient complained of pain at the final follow-up.

Post-middle Approach Group

No cases of fracture re-displacement, skin flap necrosis, or infection occurred in both closed fracture surgery and open fracture surgery. Average follow-up was 7.6 months ranging from 6 to 10 months. The representative image of X-rays in Fig. 1b showed the preoperative fingers of patients treated with anteroposterior approach. The representative image of X-rays in Fig. 1d showed that postoperative recovery was perfect, similar to that of the dorsolateral fixation group. The healing time ranged from 3 to 6 weeks, with an average of 4.5 weeks. The mean postoperative TAM of post-middle fixation group was $221.08^{\circ} \pm 25.69^{\circ}$. Postoperative TAM was statistically significant between dorsolateral group and post-middle group (*t* test, *t*=2.13 and *P*<0.05), indicating that the dorsolateral approach was more effective than the post-middle approach.

Fig. 1 **a** Preoperative X-rays in dorsolateral approach group. **b** Preoperative X-rays in post-middle approach group. **c** Postoperative X-rays in dorsolateral approach group. **d** Postoperative X-rays in post-middle approach group

Discussion

Many authors have suggested that most hand fractures can be treated by nonoperative methods with satisfactory outcomes [3, 4]. For example, Barton noted that about 75 % of phalangeal fractures had little or no displacement, and reduction was unnecessary, and they could be treated satisfactorily by strapping the fractured finger to the neighboring finger and encouraging early movement [16]. However, James reported on a loss of function in 77 % of fingers with unstable phalangeal fracture treated by closed methods [17]. Clinical outcome of closed treatment in small percentage of unstable hand fractures is still disappointing. If an unstable proximal phalangeal fracture cannot be reduced, open reduction may be selected. The fixation with lag screw is a popular technique [18] which is identified as the most rigid technique of fixation of the proximal phalanx. But lag screw fixation has several disadvantages. For example, it demands special technique and special equipment. Moreover, there is no opportunity for second chances if the first fixation is incorrect. The composite wiring technique for fractures of the proximal phalanx are obliquely oriented K-wires that are placed across the fracture line, and the pins are left protruding 2 to 3 mm from the surface of the bone. The fixation was then supplemented with dental wires looped around the protruding ends of the pins [19].

Plate and screw fixation is also used in the fixation of proximal phalangeal fractures, although more generally used for short oblique/transverse fractures. A growing body of literature has reported satisfactory results for unstable metacarpal and phalangeal fractures fixed with AO mini plates and screws [20–22]. Souer et al. evaluated that outcomes of plate fixation were satisfactory in closed ipsilateral multiple metacarpal fractures [10]. However, we did not find any study about the assessment of different fixation approaches in phalangeal fractures.

The current study demonstrates through a comparative study on 53 cases of 62 fractures that dorsolateral fixation is a better method to treat the proximal phalanx by using AO mini titanium plate. After exclusion of the related factors, TAM of dorsolateral approach groups was more desirable than that of post-middle approach groups. According to summary of the literature and clinical experience, we proposed that reasons may be as follows: First, titanium plates are placed through the posterior midline, leading to the split of the extensor tendon and irritation of the tendon [23, 24]. Second, the finger volume is so small that the AO mini titanium plate is placed on top of the extensor tendon, which will increase the stimulation of weak extensor tendon, thus resulting in inflammatory changes of tendon fibrous tissue. Third, Lu et al. [25] found that micro steel plate showed the best strength in compression, bending, and torsional mechanical tests when planted in the side in comparison to commonly used techniques for metacarpal fracture internal fixation. And fourth, during dorsolateral fixation, fracture is revealed along

the side beam of the extensor tendon. The AO mini plate is placed under the extensor tendon beam, thus reducing the frequency of irritation and complications.

In summary, in the same treatment conditions of proximal phalangeal fractures, we proposed that the AO mini plate should be placed in the dorsolateral of the proximal phalanx, which is an ideal method for the treatment of hand fractures with reliable efficacy.

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