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Pressing fixation of mallet finger fractures with the end of a K-wire (a new fixation technique for mallet fractures)☆

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ABSTRACT

Aim: The aim of this study was to describe and evaluate a surgical technique for the treatment of mallet finger fractures using a K-wire stabilization of the distal interphalangeal (DIP) joint and another K-wire pressing the bone fragment.

Methods: Between June 2007 and March 2014, 41 patients (28 men, 13 women) with isolated closed mallet finger fracture were treated using two K-wires. In the cohort, the mean joint surface involvement was 44.3% (range: 28–62%). With a mean period of 23.6 months, patient follow-up lasted 13–34 months. The fingers were evaluated for loss of extension and flexion of the (DIP) joints. The results were graded using Crawford's criteria.

Results: Union of all fractures took place at an average of 5.5 weeks after the surgical procedure. Average extension lag was 4°, and active flexion 71°. According to the Crawford rating scale, 35 fingers were excellent, four were good, one was fair, and one was poor.

Conclusions: Pressing fixation of the bone fragment with the end of a K-wire was a useful technique in the treatment of mallet finger fractures.

Type of study/level of evidence: Therapeutic IV.

Introduction

In general, mallet finger fracture is a work or sport-related injury, which is an avulsion of the extensor tendon from the base of the distal phalanx with a bony fragment [1]. If untreated, the distal phalanx may gradually assume a fixed flexed position, and the proximal phalangeal joints may gradually hyperextend [2]. Various treatments have been proposed, but the optimal treatment choice is controversial.

Conservative treatment of mallet finger fracture has been extensively reported, such as continuous rigid aluminium splinting, prefabricated splints, plaster casting, and custom-made orthosis [3–6]. However, nonsurgical treatment provides less than satisfactory results in those cases in which there is a fracture avulsion of more than one-fourth of the base of the distal phalanx [1]. Various surgical techniques have been described including open reduction and K-wire fixation, pin fixation alone, tension band wire, and pull-out steel wires [7]. According to the type of surgery, major complications are pin migrations, loss of reduction, and avascular necrosis of the fragment [8].

The aim of this study is to describe a surgical technique for pressing fixation of the dorsal fragment with the end of a K-wire after stabilization of the distal interphalangeal joint (DIP) joint with another K-wire and evaluate the efficacy of the use of this technique.

Materials and methods

Between June 2007 and March 2014, 41 patients with mallet finger fractures were treated in our hospitals. The series comprised 28 men and 13 women with an average age of 37 years (range: 17–53 years). The injury occurred in the right hand in 29 patients and in the left hand in 14. The ring finger was the most commonly injured digit (17 cases), followed by the little finger (14 cases), long (seven cases), and index (three cases). The injuries occurred during sports ($n = 21$), working ($n = 12$), daily activities ($n = 5$), and fighting ($n = 3$). The mean time between the injury and operation was 4.5 days (range: 1–22 days).

☆ No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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Preoperative radiographs were obtained in all cases. On the lateral view, the articular surface of the fragment was measured as a percentage of the entire joint surface. The average articular surface of the fragment was measured at 44.3% (range: 28–62%) of the joint surface, and mean fragment displacement was measured at 3.6 mm (range: 2–5 mm) (Figs. 1–3). On the lateral view, 19 injured fingers had DIP joint subluxation.

The patients recruited for this study met the following standards: (1) joint unstable during active flexion appearing subluxation of the DIP joint; (2) size of the fracture fragment involving one-fourth or more of the joint surface; and (3) complete occurrence of ossification involving the base of the distal phalanx. The exclusion criteria were as follows: (1) if the fracture was comminuted; (2) if the size of the avulsed dorsal fragment involved less than one-fourth of the joint surface; (3) if the fragment was present with no displacement; and (4) if the injury was a tendinous mallet finger injury.

The data of the postoperative results were collected from office visits or home follow-up visits. This study was approved by the institutional review boards of the participating hospitals. Health Insurance Portability and Accountability Act consents were obtained from each patient. In addition, all patients gave their consent for purposes of this study before surgery.

Surgical technique

Surgery was performed under local anaesthesia with finger tourniquet control. An H-shaped incision was made over the dorsal aspect of the DIP joint. The fracture was then exposed clearly.

Using a 0.039- or 0.047-inch-diameter K-wire from the tip of the distal phalanx and across the DIP joint to the middle phalanx in a retrograde manner, the DIP joint of the injured finger was stabilized in slight hyperextension. The end of this K-wire was left out of the skin (2–3 mm). The fragment was reduced by rotating and placing it into the trough. In the lateral plane, an oblique line was marked which formed an angle of about 30° with the longitudinal axis of the middle phalanx. The entry point was located at the distal one-third of the middle phalanx (Fig. 4). Another 0.039-inch-diameter K-wire was inserted from the entry point towards the base of the middle phalanx at an angle of 30° and passed through the dorsal and volar cortex, respectively. The end of this K-wire was bent at an angle of 90–120° at the level of 5 mm distal to the entry point (Fig. 5). The excessive wire was then cut off leaving a 3-mm-long hook. The hook was rotated 180° to press the dorsum of the fragment (Fig. 6). The pressure at the end of the hook should be moderate so as to provide better control and reduction of the dorsal fragment. X-ray photographs were then taken to confirm the achievement of complete reduction. Finally, the wound was closed (Figs. 7–12).

Fig. 2. The mode pattern of the mallet finger fracture.

During the procedure, the oblique K-wire was drilled onto the middle phalanx at the distal one-third and passed through the dorsal and volar cortex at an angle of 30°. Thus, the fragment was buttoned and pressed into the reduced position. Based on visual estimation, the K-wire was passed through the middle phalanx at an angle of 30°. The fragment being buttoned and pressed would be difficult if the angle was <30°. If the angle was too large, the presenting distance between the end of the K-wire and the fragment would be longer. The hook would then be obvious under the skin. According to our experience, the end of the K-wire hook should press the centre of the fragment. If the hook pressed the far end or near end of the fragment, it would shift or even overturn under the tension.

Postoperative management

A small splint over the metacarpophalangeal joint was used for 2 weeks followed by a finger plaster cast applied directly over the DIP joint that allowed active motion of the proximal interphalangeal and metacarpophalangeal joints. The suture line was removed 2 weeks after the surgery. On radiographic examination, the cortices of the fragment appeared to be joined confirming the

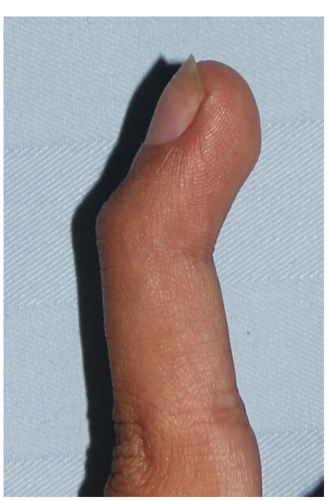

Fig. 1. The mallet finger deformity.

Fig. 3. The actinogram of the mallet finger fracture.

Fig. 4. The sketch map of the technique. The mallet finger deformity – the red arrow was the point of the second K-wire inserted.

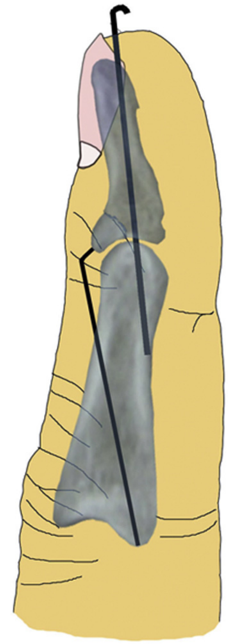

Fig. 6. The hook was rotated 180° to press the fragment.

union of the fracture (mean: 5.7 weeks; range: 6–8 weeks in this series). Both pins were then removed under a digital nerve block performed in the office. The hook could be felt under the skin. A dorsal 2–5-mm longitudinal incision was performed for the easy removal of the hook pin and without the need for suture. Active motion of the finger was allowed after 48 h.

Evaluation of outcomes

At 2 weeks after surgery, the digits were evaluated for skin necrosis, skin breakdown, and pin-track infection.

At the final follow-up, the digits were evaluated for nail deformity. Any dorsal prominence was assessed based on the method described by Kalainov et al. [9] in a qualitative fashion as none, minimal, moderate, and large. Using the visual analogue scale, the pain at the DIP joint was rated by the patients. The visual analogue scale consisted of a 10-cm line that was grouped into mild (1–3 cm), moderate (4–6 cm), and severe (7–10 cm). The active range of motion (ROM) and extension lag of the DIP joint were measured with a goniometer. Full flexion was considered when the angle of the injured side reached that of the opposite side. The results were graded by Crawford's criteria [10], which rank patients from excellent to poor according to flexion/extension movement loss of the DIP joint and possible ongoing pain.

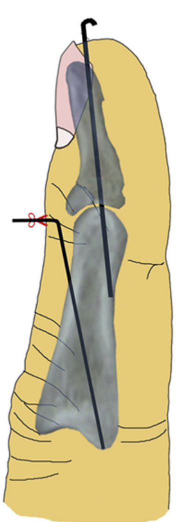

Fig. 5. The oblique K-wire was bent at an angle of 90–120° at a level about 5 mm distal to the entry point, the red arrow was the point of the excessive wire was cut off.

Statistical analysis

Quantitative variables were described as means and standard deviations (for symmetric distribution) or medians and interquartile range (for asymmetric distribution). The *t*-test (symmetric distribution) or the Mann–Whitney test (asymmetric distribution) was applied to compare the two groups in relation to the quantitative outcomes. The level of significance was set at 5%, where $p < 0.05$ was considered statistically significant.

Fig. 7. Mallet finger deformity.

Fig. 8. A similar H-shaped incision was designed.

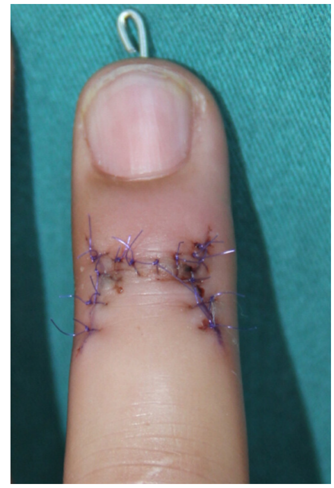

Fig. 10. The wound was closed.

Results

All patients returned for follow-up. The follow-up period was 23.6 months (range: 13–34 months). There was no skin necrosis, skin breakdown, or infection (Fig. 13). The preoperative fracture gap ranged between 2 and 5 mm (average: 3.6 mm). All fractures demonstrated evidence of radiographic healing within an average healing time of 5.7 weeks (range: 4–8 weeks).

Joint motion

In this cohort, the mean preoperative extension lag was 37° (range: 19–58°). At the final follow-up, the mean extension lag was observed to be 6° (range: 0–28°). The mean extension loss of the joint was <10° in 35 digits and 10–25° (mean: 14°) in four digits. The mean extension loss of the joint was >25° in one digit. Except one (the finger had a flexion contracture), all patients exhibited passive extension of the DIP joint to 0°. The mean flexion of the injured DIP joints was 71° (range: 52–86°). There was no difference with the uninjured DIP joints (p 0.05) (Figs. 14 and 15). Based on Crawford's criteria (Table 1), in total, 35 digits were excellent, four were good, one was fair, and one was poor.

Complications

Based on the visual analogue scale, 40 patients reported no pain with one reporting persistent pain in the DIP on excessive usage. Based on the method used by Kalainov et al. to evaluate nail deformity, 34 patients reported none, with four and two experiencing minimal and moderate dorsal prominence, respectively. Mild swan-neck deformity was seen only in one finger. Mild and moderate arthritis were seen in two and one fingers, respectively.

Discussion

To obtain precise reduction while avoiding osteoarthritis and stiffness, mallet finger is shown to be due to intra-articular fractures of the base of the distal phalanx involving >30% of the joint surface requiring surgical fixation [11–13]. Nevertheless, the perfect technique remains controversial. We found that it was not simple to keep the fragment stable and prevent the fragment from breaking. This article introduces the use of a K-wire to press fixation of mallet finger fractures, which can be an optional solution. We find that pressing fixation of the bone fragment with the end of a K-wire is a useful technique for the treatment of mallet finger fractures.

Fig. 9. The fragment was reduced and buttoned.

Fig. 11. The X-ray photograph preoperative.

Fig. 12. The X-ray photograph postoperative.

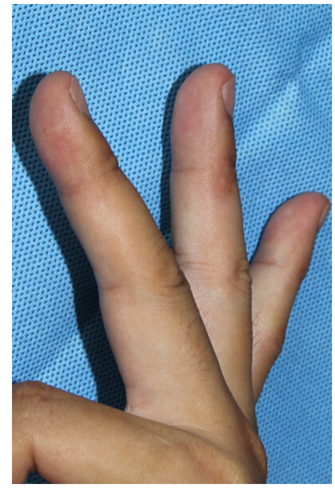

Fig. 14. The finger can extend normally 16 months after operation.

Various methods have been described for the management of bone mallet injuries. Hofmeister et al. [14] treated displaced mallet fractures with an extension block pin, and transarticular fixation of the DIP joint, and obtained fracture union. However, this method may result in extension lag of up to 20°. The reported complications included pin-track infections, nail deformity, spur formation, and loss of the fracture reduction. Although the use of hook plate may limit its use in some locations, Kang et al. [15] recommended a hook plate technique as an alternative for manipulating a small, avulsed bone fragment. In addition, the plate is very palpable just under the skin and requires subsequent removal by open surgical technique. In these techniques, the fragment was placed into the trough entirely, pressed, and fixed. So the fragment displacement rarely occurs, and the fracture can heal quickly. In this cohort, all fractures demonstrated evidence of radiographic healing within an average healing time of 5.7 weeks. The hook could be felt under the skin and could be removed easily in the office.

Open surgical techniques for mallet fractures may be applicable to cases presenting late such as direct internal fixation of the fragment. At all events, this can be technically challenging owing to the small size of the fragment, and placement of implants into the small proximal fragment may result in further fragmentation of bone. In our experience of the treatment of mallet fracture, we found that strong fixation of the fracture and protection of the blood supply of the dorsal fragment was not simple. Therefore, a trial was carried out on the use of K-wire to stabilize the DIP joint and another K-wire to press the bone fragment with satisfactory result.

Konishiike et al. [16] classified mallet fracture based on the shape of dorsal fragment on lateral view. They proposed that a fragment with small dorsal cortex is caused mainly by traction force of extensor tendon, and a fragment with a large dorsal cortex is caused by longitudinal force. The large fragment was difficult to reduce. However, this technique can press the large fragment more steadily. We think that control of dorsal rotation of the fragment is important for earlier union, because it increases the contact area of the fracture and enables earlier active motion to prevent tendon adhesion.

Use of a K-wire as an internal splint is common in clinical practice [17–20]. In our technique, the longitudinal K-wire can provide both intra-articular and extra-articular alignment; the second oblique K-wire can press the dorsal fragment. In this manner, a satisfactory reduction can be achieved through the end of the hook. The oblique K-wire was passed through both the dorsal and volar cortex, which provided sufficient stability to prevent its rotation and removal.

Weber and Segmüller [21], in their study, considered that most mallet finger fractures could be treated conservatively, despite the

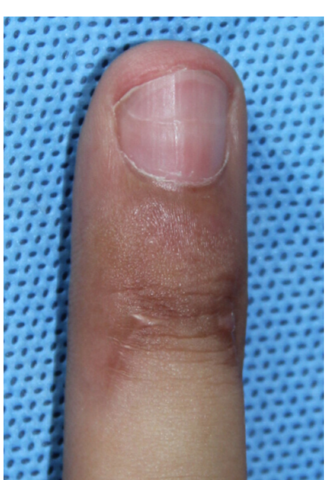

Fig. 13. The wound healed well.

Fig. 15. The finger can flex normally 16 months after operation.

Table 1
Clinical assessment of DIP joint outcomes.

Grade	Postoperative active	Case	%
Excellent	Loss of extension <10° Full flexion No pain	35	85.4
Good	Loss of extension 10–25° Full flexion No pain	4	9.8
Fair	Loss of extension >25° Any loss of flexion No pain	1	2.4
Poor	Any loss of flexion Persistent pain	1	2.4

Results are graded by Crawford's criteria.

size and amount of displacement of the bone fragment. Therefore, operative stabilization should be discussed only in the presence of palmar subluxation. Our experience indicated that the cases involving more than one-fourth of the articular surface were often associated with the subluxation of the DIP joint. Fragments involving one-fourth or more of the articular surface can be considered as a criterion for surgery.

This technique had an advantage of the oblique K-wire hook being pressed to the dorsal fragment offering constant pressure on the fragment. In addition, there was no K-wire or stainless steel wire drilling through the fragment, thus avoiding the fragment breaking into pieces.

The disadvantage of the technique was that it required a second procedure for K-wire removal under local anaesthesia. The limitation of the study was the lack of a comparison group. Future studies ideally will be prospective, randomized, and blinded to better ascertain the efficacy of this technique.

Conflict of interest

None.

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