

## Treatment of mallet fractures with a transverse two-hole mini plate

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*To the Editor:* Mallet fracture is a very common hand injury. Although non-surgical treatment for some small fragment cases without distal interphalangeal joint (DIPJ) subluxation is acceptable, many authors have considered restoring the joint surface with accurate reduction to be important to prevent secondary osteoarthritis, loss of movement, and poor cosmetic outcomes.<sup>[1]</sup> To obtain an accurate reduction, several reduction and fixation techniques (such as extension block pinning, hook plate fixation, umbrella handle like K-wire fixation, and so on) have been developed.<sup>[2-4]</sup> But when the fracture fragment is small or comminuted, stable fixation is quite difficult to achieve based on the current techniques. To develop a more universal method to deal with different types of mallet fractures with fewer complications, a transverse two-hole mini plate was used.

Following institutional review ethical board approval, 155 patients (157 fingers) with mallet fractures were treated with open reduction and internal fixation with a transverse two-hole mini plate. With a transverse curved incision, the extensor was explored. The fracture line was explored and the soft tissue or hematoma between the fracture ends was debrided. Then the fracture fragment was reduced and pressed with a two-hole 1.7-mm mini plate (Stryker mini plate system) which was fixed with two screws. Then a 0.9-mm K-wire was inserted across the DIPJ to maintain extension and reduction. The reduction and stability of the fracture fragment were evaluated with a mini C-arm image intensifier [Figure 1]. The K-wire was removed 2 to 6 weeks later according to the stability of the fixation and the follow-up of bone healing. Usually, the smaller the bone fragment was, the later the K-wire was removed. We checked the active range of motion (ROM) including extension lag with a goniometer at each visit after removing the K-wire. Radiographic images were taken immediately after surgery and at 4, 6, and 8 weeks, and then every 3 months after union until the end of follow-up. The pain was assessed with a visual analog scale (VAS).

The series comprised 122 men and 33 women with a mean age of  $33.2 \pm 10.9$  years (range: 16–62 years). The injury occurred in the right hand in 90 patients and in the left hand in 65 patients. The little finger was the most commonly injured digit (66 cases), followed by the ring finger (48 cases), long finger (30 cases), index finger (11 cases), and thumb (2 cases).

Because measured data did not follow the normal distribution (one-sample Kolmogorov-Smirnov test), they were expressed as median (Q1–Q3), the Kruskal-Wallis one-way analysis of variance on ranks was used to compare the differences among multiple groups, and the Mann-Whitney test was used to compare the differences between the two groups. Spearman rank correlation analysis was used to analyze the relationship between age and ROM result with SigmaStat software (version 3.5, Systat Software Inc., Point Richmond, CA, USA). All statistical tests were 2-sided, and *P* values of  $<0.05$  were considered statistically significant.

The average articular surface of the fragment was 39% (range: 12%–67%) of the joint surface. On the lateral view, 31 injured fingers had DIPJ subluxation. The mean follow-up was  $5.0 \pm 3.9$  months. All the patients obtained bone union. Radiography documented union within 6 weeks of surgery. The average final active range of flexion of the DIPJ was  $65^\circ$  ( $55^\circ$ – $75^\circ$ ) and the extensor lag was  $0^\circ$  ( $0^\circ$ – $5^\circ$ ). Significant pain relief was achieved in all cases. According to Crawford criteria,<sup>[5]</sup> 47 out of 157 fingers obtained excellent results, 95 obtained good results, and 15 obtained fair results. In the cases, we found extensor rupture in only 8 fingers which were all acute cases. The rate of the extensor rupture was 6.3% in acute cases and 5.1% in all cases. Complications were found in 1 case with superficial infection, 5 cases with post-operative skin irritation of plate and screws, and 8 cases with a joint step without any clinical discomforts. No skin necrosis or nail deformity was found. For patient with superficial infection, oral administration of antibiotics and wound care achieved good result. For patients with hardware irritation, removal of the plate and screws was performed.

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**Figure 1:** Treatment of a mallet fracture that involved the little finger with a transverse two-hole mini plate. (A) A transverse curved incision was designed. (B) There was no extensor rupture although there was hematoma around the injury site. (C) The extensor was cut along the fracture line, and the soft tissue or hematoma between the fracture ends was debrided. (D) The fracture was reduced and fixed with a transverse two-hole mini plate. (E) A K-wire was used to hold the distal interphalangeal joint in a hyperextended position, and the incision was sutured. (F) The pre-operative lateral radiograph showed a mallet fracture of the little finger without a distal interphalangeal joint subluxation. (G) The intra-operative fluoroscopic image showed that the mallet fracture was accurately reduced.

After data analysis, we found there was no significant difference ( $P=0.992$ ) of ROMs between the acute ( $65^\circ$ ,  $55^\circ$ – $75^\circ$ ) and chronic cases ( $65^\circ$ ,  $50^\circ$ – $72^\circ$ ). There was also no significant difference ( $P=0.119$ ) of ROMs between male ( $65^\circ$ ,  $55^\circ$ – $75^\circ$ ) and female ( $52.5^\circ$ ,  $47.5^\circ$ – $70.0^\circ$ ). Because there were only two cases of thumb injuries, we only compared 2nd to 5th fingers' results. There were no significant differences of ROMs ( $P=0.781$ ) and extension lags among different fingers ( $P=0.090$ ). As to the extension lag, the middle finger injury obtained the worst result ( $-5^\circ$ ,  $-7.5^\circ$  to  $0.0$ ), but the difference was not significant. Also, we did not find a significant difference ( $P=0.980$ ) of ROM between the right side

( $65^\circ$ ,  $55.00^\circ$ – $73.75^\circ$ ) and the left side ( $65^\circ$ ,  $53.75^\circ$ – $76.25^\circ$ ). As to the extension lag, there were no significant differences between different genders ( $P=0.169$ ), sides ( $P=0.087$ ), and the time from the injury to the surgery ( $P=0.453$ ). However, we found a negative correlation between age and ROM with a coefficient of  $-0.293$  ( $P=0.026$ ). There was no correlation between age and extension lag with a coefficient of  $0.098$  ( $P=0.454$ ). There was a significant difference between pre-operative VAS ( $4.0$ ,  $3.6$ – $4.6$ ) and post-operative VAS ( $0.0$ ,  $0.0$ – $0.1$ ) ( $P < 0.001$ ).

In most of our cases, the mallet fracture was found without an extensor rupture. This means that the fragment of the

mallet fracture was not caused by extensor avulsion. So the mallet fracture is a totally different injury from mallet fingers with extensor laceration. A research showed that the force applied to the joint in extension can lead to a bony dorsal edge fracture with articular involvement while hyperflexion trauma leads to plastic deformation or rupture of the extensor tendon with or without a tiny dorsal bony avulsion with an intact joint line.<sup>[6]</sup> Our clinical observations agreed with those results.

Many techniques have been developed to hold the reduced fragment.<sup>[7,8]</sup> But for small and comminuted fractures, fixation of the fragment is very difficult. We found that transverse two-hole plate fixation is a relatively universal fixation method for different size fragments except for very tiny one. With this method, it is not necessary for the screws to go through the fragments. It is the plate that presses the fragment into a reduced position as a washer. Thus, the insertion of the screws is much easier.

Although we tried to develop a universal fixation method for the mallet fingers, during our clinical practice, we found that the transverse two-hole mini plate fixation was not suitable for the comminuted fracture involved both volar and dorsal sides, and the avulsion fracture with a very tiny fragment, which could not be stably pressed by the plate. Fortunately, such kind of avulsion fracture can get quite good result with conservative treatment. Also, the method cannot be used in an infected or potential infected case. Compared with the extension block pinning, our method is expensive. So it should be used in the cases which are not suitable for the extension block pinning.

#### **Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal.

The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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#### **Conflicts of interest**

None.

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