Surgical Treatment Options for Unstable Mallet Fractures

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Unstable mallet fractures: a comparison between three different techniques in a multicenter study

Stefano Lucchina, Alejandro Badia, Vlad Dornean, and Cesare Fusetti*

【**Abstract**】**Objective:** Management of mallet fractures is still a matter of discussion throughout the literature. For some authors, mallet fractures involving more than 1/3 of the articular surface and palmar subluxation of the distal phalanx require surgical treatment. In this study we retrospectively compared three different techniques for mallet fractures: Kirschner wire fixation with extension block pinning of the distal interphalangeal joint (EBP), Kirschner wires used as joysticks (KWJ) and interfragmentary mini-screws for open reduction and internal fixation (ORIF).

Methods: Fifty-eight mallet fractures with palmar subluxation in 58 patients were treated with the aforementioned surgical techniques. Twenty mallet fractures in 20 patients 18 to 70 years old (average 42 years) were operated upon by EBP, 16 patients 22 to 56 years old (average 56 years) were operated upon using KWJ and 22 patients 22 to 54 years old (average 36 years) received ORIF. Follow-up time was 6 to 58 months (average 21 months). The following intraoperative parameters were considered: intraoperative time, number of Kirschner wires/screws and technical problems. Postoperative parameters included work absence and complications. The radiological evaluation was based on A-P and lateral views preoperatively and interviews at follow-up time. Bone union was defined by radiological evidence of bone trabeculae crossing the fracture site on at least one view. Clinical evaluation involved range of motion (ROM) test with a goniometer. Based on these measurements a functional Crawford score was established.

Results: All fractures healed. In the KWJ group intraoperative time was shorter and total ROM was wider (72° vs 58° and 54 °); in the ORIF group return to work was faster (2.7 weeks vs 7.2 weeks) but a little higher complication rate due to screw positioning has been found. Functional results as to total ROM, distal interphalangeal lag extension and Crawford classification were similar.

Conclusions: We demonstrate the advantages of the use of the three techniques and bone consolidation in all cases with no signs of osteoarthritis. Screw fixation is more technically demanding (longer intraoperative time and more complications) but allows earlier mobilization and faster returning to work. EBP and KWJ techniques are faster to perform with no complications but require a careful management of the pin tracts. There is no statistically significant difference as to functional results.

Key words: ***Fractures, bone; Finger injuries; Fracture fixation, internal; Internal fixators; Bone wires***

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The definition of mallet fracture includes both the deformity secondary to extensor tendon rupture and due to distal phalangeal fracture pull-off of the tendon. The latter has previously been defined as mallet fracture. Mallet fractures involving more than one third of the articular surface of the distal phalanx can be treated conservatively with splinting, [1-3] or may require surgical treatment.[4-7] Historically many surgical solutions have been found to provide precise reduction of the subluxation of the distal phalanx and prevent secondary volar dislocation. Moreover for many authors, precise fracture reduction and proper buttressing of the dorsal fragment to obtain satisfactory remodelling and to prevent further deformity, stiffness, arthritis and other complications are recommended. Previous reports show the effectiveness of various surgical techniques to treat mallet fractures including distal interphalangeal joint (DIP) pinning alone,[8] tenodermodesis,[9] open reduction and K-wire fixation,[10] tension band wiring,[11] pull-out steel wires,[12] single Kirschner wire compression,[13] "Umbrella handle" technique[14] and the hook plate approach.[15] Previous isolated studies showed the effectiveness of three frequently

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used techniques: Kirschner wires extension block pinning (EBP) of the DIP joint,[16] K-wires as joysticks (KWJ),[17] open reduction and internal fixation with interfragmentary mini-screws (ORIF)[18] for bone fixation. In this retrospective, multicenter study we compare the aforementioned techniques and discuss their advantages and potential complications trying to identify the most effective, safe and easy to be performed technique.

METHODS

Over a period of three years 58 acute mallet fractures in 58 patients were randomly treated with one of the three surgical techniques by three surgeons.

Our study included fractures which involved more than one third of the articular surface, fractures associated with palmar subluxation of the distal phalanx that could not be corrected by closed reduction, and mallet fragments which had migrated proximally with more than a 1-mm gap after positioning the body of the distal phalanx in extension. In all cases, time from injury was less than 3 weeks.

Exclusion criteria included patients with preoperative osteoarthritis or preexisting mallet deformity of the DIP joint.

Twenty mallet fractures in 20 patients 18 to 70 years old (average 42 years) were treated with EBP technique; 16 patients 22 to 56 years old (average 36 years) were treated using the KWJ technique and 22 patients 22 to 54 years old (average 36 years) received interfragmentary mini-screws. The most affected digit was generally the little finger (Table 1). Follow-up time was from 6 to 58 months (average 21 months). The following intraoperative parameters were considered: procedure duration (time from the administration of anesthesia to the removal of the patient from the operating room), number of Kirschner wires/screws and technical problems incurred.

EBP technique

Under axillary block the distal phalanx of the traumatized finger was maximally flexed and a 1.25 mm K-wire was introduced into the head of the middle phalanx at a 45 degree angle. The wire creates an extension block for the bony fragment. Occasionally, manipulation of the distal phalanx against the wire was required to achieve an anatomic reduction. Once the fragment was reduced, a second wire was placed longitudinally from distal to proximal part across the DIP joint to maintain extension and reduction. If the fracture fragment was large enough and if it was needed to gain a better reduction, a 0.8 mm K-wire may be placed through the fragment perpendicular to the fracture line from dorsal to palmar side. The wires were cut short under the skin at the fingertip and protrude out of the skin at the DIP joint. A splint was applied leaving the proximal interphalangeal (PIP) joint free. The digit was kept dry. Pins were cleaned and treated with antiseptic solutions once a day. The pins were removed in the office under a digital block after bone consolidation had been achieved, usually after 6 weeks.

KWJ technique

Under digital block a 1.4 mm K-wire was driven from the tip of the distal phalanx and across the DIP joint to hold it in extension. The distal end of the wire was left out of the skin (2-3 mm). The second wire (diameter depending on the fragment size) was then placed from the dorsal aspect of the distal phalanx to affix the avulsed dorsal fragment. Fragment derotation and placement into the trough was then achieved using the wire as a joystick. Once acceptable reduction of the joint surface was confirmed with fluoroscopy, the K-wire was driven through the base of the distal phalanx and pulp. At this point the end of the second wire was bent and pulled with heavy pliers from the volar aspect. A small dorsal skin incision was performed to allow the hook at the dorsal end of the wire to sit subcutaneously on the dorsal cortex thereby securing it, maintaining the reduction, and preventing further dorsal displacement of this fragment. The volar end of this wire was left out of the skin (2-3 mm). A small splint was used for 1 week followed by a finger plaster splint applied over the DIP joint, yet allowing active motion of the PIP and metacarpophalangeal (MP) joint. Pins were cleaned and treated with antiseptic solutions once a day and removed after 6 weeks in the office under a digital block.

ORIF technique

Under axillary block a 15 mm “H” incision was made on the dorsal side of the DIP joint. Dorsal veins were cauterized to maintain hemostasis. The distal insertion of the extensor tendon at the base of the distal phalanx was then exposed. Blood clots from the fracture site were carefully removed. Anatomic reduction was achieved with the use of a small towel clamp and

subsequent temporary fixation with a 0.8 mm K-wire was recommended. The small fragment was fixed with one or two 1.0 mm self-tapering miniscrews (Synthes, GmbH, Oberdorf, Switzerland). By means of a magnifying fluoroscope the appropriate screw length was checked. The temporary K-wire was removed. A "custom-made" molded plastic splint was used for 4 weeks, and then mobilization was allowed under control of a hand therapist.

Postoperative outcome evaluation

Postoperative parameters considered in our study included work absence and complications. All the authors participated in the radiological review. Radiological evaluation was based on A-P and lateral views preoperatively to define involvement of more than one-third of the articular surface, volar subluxation and fragment diastasis and at follow-up to show congruency of the DIP joint and healing of the fractures. Bone union was defined by radiological evidence of bone trabeculae crossing the fracture site on at least one view. Assessment of the functional outcome was made using the total active motion (TAM) system for the DIP joint defined as the total active joint flexion minus the extension lag measured with a goniometer. By the use of a goniometer, DIP lag extension was defined as the maximum extension measurement when performing active motion testing of the involved joint. Based on these measurements a functional Crawford score was established, comparing any flexion loss in degrees to the same digit on the controlateral side (Table 2).[19] Our patients was asked whether persistant pain was present or not in performing most usual working activities.

RESULTS

Follow-up produced similar results for the three techniques. In the KWJ group intraoperative time was shorter (25 minutes vs 28 minutes for EBP technique and 50 minutes for ORIF) and total ROM was larger (72° vs 58° for EBP and 54 ° for ORIF)

All fractures healed completely after 4.2 weeks for the open technique (ORIF) and 6 weeks for the two closed technique (KWJ and EBP).

Functional results as to TAM, DIP lag extension and Crawford classification were similar between the three techniques. According to the Crawford classification, the EBP group (Figure 1) obtained 8 excellent and good results, 4 fair and no poor results. The ORIF group (Figure 2) had 8 excellent and good results, 4 fair and 2 poor results, the poor result being due to a failure in screw positioning. In two cases persistent pain was due to an excessive length of the interfragmentary screw with secondary pulpar pain. The KWJ (Figure 3) group obtained 6 excellent, 8 good, 2 fair and no poor results. Two cases of transient nail dystrophy were found in the EBP group, but resolved by the time of final follow-up.

Table 1. Data related to the patients of three groups

Patients' data		EBP (*n*=20)	ORIF(*n*=22)	KWJ (*n*=16)
Age (years, mean)		18-70 (42)	22-54 (36)	22-56 (36)
M/F		14/6	16/6	7/9
% of affected articulation (mean)		39-100 (64)	30-60 (41)	35-55 (42)
Operation time (minutes, mean)		10-75 (28.3)	42-70 (50.1)	20-30 (25)
Interventions/ digit	Index	2	2	2
	Middle	2	2	3
	Ring	4	6	5
	Little	12	12	6
No. of K-wires/ screws per intervention (mean)		2-3 (2.4)	1-2 (1.8)	2
Consolidation (weeks, mean)		6	4-5 (4.2)	6

Table 2. Crawford's classification for evaluation of mallet fracture treatment

Classification	Criteria
Excellent	Full DIP joint extension, full flexion, no pain
Good	0° to 10° of extension deficit, full flexion, no pain
Fair	10° to 25° of extension deficit, any flexion loss, no pain
Poor	More than 25° of extension deficit, or persistent pain

Table 3. Results for the three techniques

Results	EBP	ORIF	KWJ
Range of motion (° mean)	46-75 (58.2)	35-80 (54.5)	65-80 (72)
DIP lag extension (mean)	5° (0-17)	5° (0-15)	2° (0-20)
Follow up (months, mean)	6-36 (21.3)	6-58 (19.2)	6-36 (22)
Crawford classification			
Excellent	8 (40%)	8 (36%)	6 (37%)
Good	8 (40%)	8 (36%)	8 (50%)
Fair	4 (20%)	4 (18%)	2 (13%)
Poor	0	2 (9%)	0
Fracture healing time (weeks, mean)	6	4-5 (4,2)	6
Complications	2 (nail dystrophy)	2 (screw intolerance)	0
Time away from work (weeks, mean)	2-10 (7.2)	0-7 (2.7)	2-8 (6)

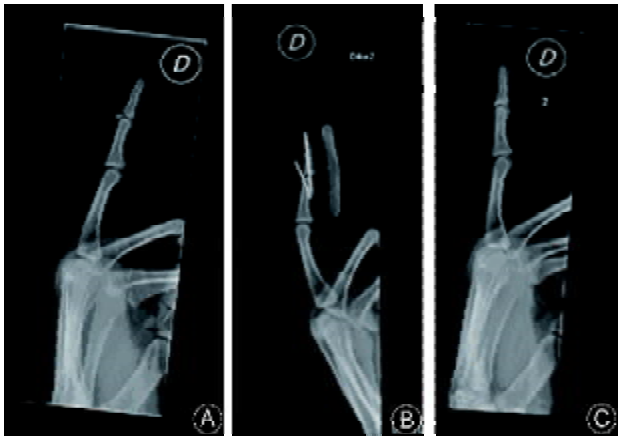

Figure 1. An 18 years old right handed man, treated by EBP. (A) Pre- and (B) post-operative radiographs at 6 weeks and (C) at 36 months. The longitudinal K-wire is positioned in the volar half of the head of the middle phalanx to prevent secondary dislocation of the bone fragment at the base of the distal phalanx.

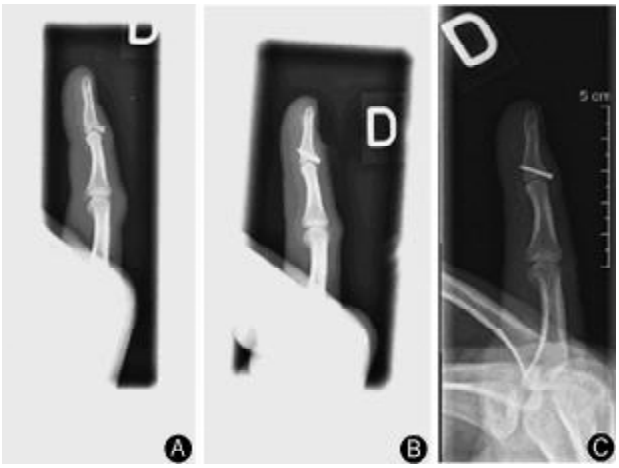

Figure 2. An 18 years old right handed man, treated by ORIF with two screws. (A) Pre-and (B) post-operative radiographs and (C) final result at 58 months.

Figure 3. A 45 years old right handed man, manual worker treated by KWJ technique. (A) Pre-and (B) post-operative and (C) final radiographs after 6 months.

DISCUSSION

Mallet injury is the avulsion of the terminal extensor tendon from the base of the distal phalanx, with or without a bony fragment. The disruption of the terminal extensor mechanism results in a characteristic flexion deformity of the DIP joint.

Management of mallet fractures is still a matter of discussion throughout the literature. For many authors, mallet fractures should be treated conservatively,[1-3] while for others fractures involving more than 1/3 of the articular surface and palmar subluxation of the distal phalanx require surgical treatment.[4-7]

Some authors propose that with either a closed or open surgical procedure a congruent articular arc without subluxation should be achieved,[20] while others[21] argue that accurate anatomical reduction and internal fixation of displaced fragments is necessary to prevent joint deformities, posttraumatic arthritis and stiffness.

Our findings suggest that the three techniques are similarly effective at achieving good anatomic reduction and stable fixation until bone consolidation.

Previous reports show the effectiveness of various techniques to treat mallet fractures, including surgical techniques achieving excellent results in terms of eliminating deformity, stiffness, arthritis, however displaying complication rates ranging widely from 3% to 53%,[12,16,19,22] which include marginal necrosis, loss of surgical reduction, recurrent extension lag, nail deformities, pin track infection and osteomyelitis, implant failure and joint deviation. In contrast, we suggest that complication rates do not differ significantly between the different techniques and composite K-wiring, which is easier and faster, yet not prone to a higher complication rate when not too many pinning attempts are made. The latter issue being critical in drilling the vertical pin in EBP and KWJ.

We found no differences as to bone consolidation amongst all cases with no secondary dislocations. By contrast we confirm previous reports[23] indicating that screw fixation is more technically demanding (with longer intraoperative time) but allows earlier mobilization and an earlier return to work for the patient.

In spite of the medium-term follow-up, we found no differences in terms of cartilage damage leading to secondary osteoarthritis and stiffness.

Unlike Damron et al[12] we found that nail dystrophy is a temporary complication and pin tract care in KWJ and EBP is mandatory to prevent secondary infection. If possible, in both techniques the longitudinal K-wire should be left under the skin leaving only the vertical end protruding out of the skin for an easier hardware removal.

In summary, EBP and KWJ techniques are faster to perform and without complications, but require a careful management of the only pin tract left on the skin.

With no significant differences with respect to functional or aesthetic results between the three techniques, we emphasize that EBP, ORIF and KWJ techniques should be preferred and recommend. The technique selection should be based on individual patient needs in terms of pin care compliance and faster return to work.

Further studies should be performed to ascertain the functional and aesthetic results of the same procedures performed on patients with mallet fractures, presenting for treatment 3 weeks postinjury.

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