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Functional outcome of osteosynthesis of closed metacarpal fractures with mini-plates and screws: A prospective study

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Abstract
Background: Metacarpal fractures are not uncommon injuries of the human skeleton. Earlier studies suggest the management of metacarpal fractures is closed reduction with "K" wire fixation. Aim of the study is to assess the functional outcome and duration of union in closed metacarpal fractures with Mini plates and screws.
Materials and Methods: In Thirty-five patients with closed meta-carpal fractures managed with open reduction and internal fixation using mini fragment plate, the functional outcome was obtained using the American Society for Surgery of the Hand (ASSH) Total Active Flexion (TAF) score and the Disabilities of the Arm, Shoulder, and Hand (DASH) scoring system.
Results: A Union rate of 100% was achieved. Functional outcome was excellent in 91.40% (32 of 35), good in 2.8% (1 of 35) of patients and fair in 5% (2 of 35). One case with infection (superficial) which subsided with dressings and antibiotics and two cases with stiffness were reported, which improved with physiotherapy and exercises.
Conclusions: Miniplate fixation is an effective treatment option for closed metacarpal fractures because it provides rigid fixation that allows early mobilization and a favorable functional outcome.

Keywords: Metacarpal fracture, mini fragment plate, internal fixation

Introduction
The hand is a specialized structure that interacts with its environment and is particularly vulnerable to functional damage. One of the most commonly injured parts of the body is the hand [1]. The functional outcome of fractures of small bones of the hand depends upon injury severity and management [2]. In Humans, one of the most common bones to be fractured are the bones of the hand, and their management also varies widely in discrete regions of the world. The final functional outcome is of greater importance than just healing of fractures in hand [3]. Most fractures of the hand can be treated by nonoperative methods with good results [4, 5]. In recent years, the therapy of choice for maintaining good hand function has switched mostly from conservative methods to more surgical operations. The most common method of fixation used for both closed and open metacarpal fractures was with Kirschner wires. However, this kind of treatment has resulted in stiff hand, pin tract infection and pin migration. In a small percentage of unstable hand fractures, results of closed management remain unsatisfactory. Closed multiple metacarpal fractures are considered highly unstable and are more prone to poor functional outcomes compared with open single metacarpal fracture [6–9]. Recent studies show that in comparison to conservative treatment or K-wire fixation, surgical treatment of metacarpal fractures using miniplates and screws resulted in an excellent functional outcome. The goal of the study is to assess the functional metacarpal fractures are treated with mini plates and screws.

Materials and Methods
A prospective study was conducted from November 2019 to March 2021. Thirty-five consecutive patients with closed metacarpal fractures admitted to our institution were enrolled in the study. A total of thirty-five patients were included as a part of this study. The minimum age of the patients in this series was 20 years, and the maximum was 70 years, with a median age of 45 years.

Of all 35 cases, the majority (50%) were either in the second or fifth decade of life, with the maximum bulk of patients in the 20–29 year-old age group, accounting for 47% of total patients. 25 patients were male, and 10 patients were female. The right hands were involved in 19 patients and left in 15 patients. Roadside accidents with high-energy trauma were the mode of injury in most cases (18 patients). The next most common cause of these fractures were assault (13 patients), self-fall (4 patients). Plates of different sizes are available to fix metacarpal fractures (1.5mm screws and titanium mini plates, 2.0mm screws and stainless-steel AO mini plates, and 2.7-mm screws and stainless-steel AO mini plates). Ultra-low-profile plates are available too. We use 2.0mm stainless steel AO mini plates with 2.0-mm screws. However, we achieved a satisfactory purchase with 2.0mm screws in our cases. The DASH score and the American Society for Surgery of the Hand (ASSH) Total Active Flexion (TAF) score (Table 1) were used to assess and grade results. The ASSH TAF score grades result as excellent, good or poor (Table 2).

Table 1: TAF from MCPJ to DIPJ": 2 to 5 digits

Degree of flexion	Result
220 to 260^0	Excellent
180 to 220^0	Good
130 to 180^0	Fair
< 130^0	Poor

Table 2: TAF from MCPJ and IJP": Thumb

Degree of flexion	Result
120 to 140^0	Excellent
100 to 120^0	Good
70 to 100^0	Fair
< 70^0	Poor

Clinical Assessment Committee: Total Active Flexion (TAF) scale, American Society for Surgery of the Hand (ASSH) report. New Orleans, 1976. TAF, total active flexion; MCPJ, metacarpophalangeal joint; DIP, distal interphalangeal joint; IJP, interphalangeal joint

Surgical technique

All patients were given tourniquets before surgery. The patient is supine, with one hand on the side table. A dorsal incision on the radial border is used for the 1st and 2nd metacarpal fracture. Making a dorsal longitudinal incision between the 3rd and 4th metacarpals is the approach for the 3rd and 4th metacarpals. For the 5th metacarpal, an incision was performed above the ulnar border. Without undercutting the edges, the skin and subcutaneous tissue were dissected. The tendons of the extensor muscles were retracted. The fascia and periosteum overlaying the bone were then dissected. The bony ends were liberated from the tissue that surrounded them. Did a tiny amount of dissection for soft tissue and periosteum. We have reduced the fracture parts anatomically. Point reduction forceps or stabilizing K wires are employed to maintain the reduction in place. We used interfragmentary lag screws in long spiral and oblique fractures. The following plate layouts were chosen and fixed with screws based on the fracture pattern. Shaft fractures are treated with straight plates, while periarticular fractures are treated with T or L plates. Under fluoroscopy, the reduction is verified. Did soft tissue coverage with caution, and enough soft tissue coverage (periosteum) was provided over the plate to prevent extensor tendon irritation. After careful wound cleansing and precise hemostasis, the surgical wound was closed in layers. A sterile dressing was applied. After ensuring that the patient's vitals were stable, the patient was transferred to the recovery room. We elevated hands for 24–48 hours before actively mobilizing to control pain and swelling. Serial radiographs were used to monitor fracture union during fortnightly follow-up visits. At each outpatient appointment, clinical progress was recorded until the fractures healed. After fracture union, measured the final range of motion of the operated finger in degrees. The average period of follow-up was one year. (Figure 1, 2, 3, 4, 5)

Fig 1: Pre-Operative X-ray of Metacarpal Shaft fracture

Fig 2: Post-Operative X-ray of 4th Metacarpal shaft fracture with Miniplate

Fig 3: Post-Operative Grip Strength

Fig 4: Post-Operative Extension

Fig 5: Post-Operative Flexion

Results

Our study involved 35 patients. Multiple metacarpal fractures were in 4 patients (11.5%). The right hand was affected in 19 of the individuals (54 percent). Out of 35 cases, 10 were female (28.5 percent). All 35 patients who underwent surgery for unstable metacarpal fractures had a union (100 percent). Bony union occurred in most instances between 6 and 8 weeks, with an average of 7.2 weeks (range 6-12 weeks). Spiral and oblique fractures fused after six weeks, but transverse and comminuted fractures united at eight weeks. The American society for surgery of the hand and Total active flexion score for the functional result was outstanding in 32 patients (91.4%), fair in two patients (5%), and good in one patient (2.8 percent). The overall results are satisfactory. Two patients with multiple metacarpal fractures developed stiffness in their small joints the hand. Continued Physiotherapy for both patients and their range of motion improved. One patient developed a superficial wound infection; he had multiple open metacarpal fractures. The external wound settled with daily dressing and antibiotics. As the plate was carefully covered with soft tissue to allow the underlying extensor tendon to move freely, none of the patients in our study had tendon discomfort. There were no fractures with angular or rotational displacement in any instances. There was no implant breakage in any of the cases.

Discussion

We can successfully handle most metacarpal fractures with conservative splinting. Only a tiny fraction of metacarpal fractures are unstable, and traditional treatment results in poor functional outcomes. In these instances, ORIF was advised, which added less than FIVE percent of all hand fractures [10]. According to James *et al*., who utilized a closed technique to treat unstable fractures, 77 percent of the fingers lost function. One of the therapeutic alternatives for these unstable fractures is ORIF with K wire [11]. However, it gives less rigid fixation and is rotationally unstable; there is a risk of pin tract infection, and there are substantial worries about protruding k wires. Although the technique is only beneficial in selected situations, interosseous wiring with K-wire gives proper stabilization than plating in transverse shaft fractures. Transverse and short oblique fractures were treated with intramedullary fixation using pre-bent K-wires. With plate and screw fixation, they provide a functionally equivalent outcome. However, there is a risk of loss of reduction and hardware penetration of the metacarpophalangeal joint, making it necessary for a second surgery to remove the hardware. Metacarpal fractures can be treated with external fixators. Shehadi *et al*. regained full range of motion in up to 100 percent of metacarpal fractures managed with an external fixator [12]. This form of stabilization is beneficial in complex fractures with bone loss. However, regular use of an external fixator is discouraged since the construct loosens after a pin tract infection, causing fixation loss.

In numerous investigations, AO miniplate and screws have shown to be effective in treating unstable metacarpal and phalangeal fractures [13-16]. In a study by Souer *et al*., 18 of 19 patients with closed unstable metacarpal fractures who had plate fixation had a favorable functional outcome with total active motion of more than 230 degrees [17]. In another study, Gupta *et al*. found that patients managed with plate fixation had excellent functional outcomes with total active motions of more than 230 degrees. For various reasons, plate fixation is a better option in unstable metacarpal fractures [18] as

1. As they provide stable fixation, allowing for early finger mobilization.
2. Shortening of the interossei muscle, which is present in many metacarpal fractures that are treated with plating, allows the hand to keep its grip strength. Severe soft tissue injury is usually associated with multiple metacarpal fractures.

All of the cases in our study treated with plate osteosynthesis had a Union of bone (100 percent). In 91.4 percent of instances (32 out of 35), the functional outcome was outstanding, good in 2.9 percent of cases (1 out of 35), and fair in 5.7 percent of cases, according to the scoring system used. Mini plates and screws offered a stable and robust attachment that permitted early finger motion, avoiding stiffness and attaining excellent functional outcomes. Although there were two cases of superficial infection, they completely cleared without compromising the functional outcome with daily treatment.

In conclusion, plate fixation is a suitable alternative for treating closed multiple metacarpal fractures. It provides firm fixation that allows for early mobilization and a favorable functional outcome.

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