

Transverse Metacarpal Fractures; Is It Better to Do Intramedullary Pinning Using K-wires or Internal Fixation Using Mini-plates?

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Abstract

Introduction

Metacarpal fractures represent the third most common fracture of the upper extremity, representing approximately 40% of all hand injuries. Fractures of the metacarpals have a major impact on hand functions. Different mechanisms of injury can lead to different patterns of fracture and different grades of soft tissue injury. There are different fixation methods including Kirschner wires, mini-plates, and interfragmentary screws. The choice of the best method of treatment is dependent on many factors related to the fracture pattern, associated soft tissue injury, patient's age, and level of activity.

Patients and methods

This study included 60 patients with transverse metacarpal fractures; 46 of them were males and the other 14 were females. The average age of patients included in the study was 30 years. They were allocated randomly into 2 equal groups according to fixation methods; Group (A) fixed with intramedullary K-wires, and Group (B) fixed with mini-plates and screws (30 patients in each group). The times of operation, union, and immobilization after surgery were assessed. All the fractures were evaluated both clinically using the Total Active Motion (TAM), Total Active Flexion (TAF), and the quick DASH scores, and radiologically using three views of the hand (antero-posterior, oblique, and lateral) at 3 months, and 6 months. The follow-up period ranged from 6 to 8 months.

Results

Overall, comparison of time till union, total active motion, and total active flexion scores revealed comparable results between both techniques. Quick DASH score mean value was 8.13 in the K-wires group and 5.71 in the ORIF group (p-value = 0.008).

Conclusion

While both techniques; fixation using mini-plates and pinning using K-wires are effective for the treatment of closed, extra-articular transverse metacarpal fractures with good functional outcomes, but mini-plate fixation is associated with early mobilization when compared with K-wires intramedullary pinning.

Level of Evidence: Therapeutic study, level IV

Keywords

Metacarpal fracture, K-wires, Mini-plates.

Introduction

Metacarpal fractures are associated with marked disability and disruption in the mechanism of action of flexor and extensor tendons lever system [1]. These fractures may be the result of direct trauma to the dorsum of the hand or axial loading which may result in transverse comminuted fractures or oblique fractures respectively [2].

Metacarpal fractures represent the third most common fracture of the upper extremity, representing approximately 40% of all hand injuries. They are the most common hand injury among patients between the age of 18 to 34 years old [3].

There are various treatment options for metacarpal fractures. Non-operative treatment is preserved for patients with stable fractures and acceptable alignment. Unstable and displaced fractures need stabilization which can be achieved with the use of K-wires, mini-plates, or interfragmentary screws [4].

Being a less invasive, easy, and short procedure, pinning with K-wires is a more commonly used option for extra-articular metacarpal fractures with displacement or instability. While the invasiveness associated with internal fixation using mini-plates may be associated with a higher risk of wound infection, adhesions, and scarring [4]. Mini-plate removal, if indicated, will need a second surgical setting while K-wires removal can be done on an outpatient basis. On

the other hand, mini-plate fixation has the advantage of being a more biomechanically rigid method and offering early mobilization of the hand [5].

This work aims to assess the clinical and functional outcomes in both intramedullary pinning with K-wires and ORIF with mini-plates and screws in the treatment of displaced extra-articular transverse metacarpal fractures.

Patients and Methods

This prospective comparative randomized controlled study was conducted on 60 patients who presented to the emergency department of a tertiary trauma center from August 2019 to October 2020 and included skeletally mature subjects with displaced extra-articular transverse metacarpal fractures. Displacement was considered when there was angulation $> 30^\circ$ or shortening > 2 mm. We excluded patients with open fractures, associated neurovascular injuries, oblique and spiral fractures, and patients presenting late after 3 weeks. Forty-six patients were males (90%) and fourteen (10%) were females.

The patients were randomized by the even/odd numbers technique. Group A (even numbers) included 30 patients fixed with percutaneous K-wires, and group B (odd numbers) included 30 patients fixed with mini-plates and screws.

The patients' age ranged from 16 to 55 years. Patients in the K-wire group had an average age of 34 years old. While the patients in the mini-plate group had an average age of 30 years old.

Surgical technique:

After proper clinical assessment including NV assessment, preoperative radiological evaluation was done using three views of the hand (antero-posterior, oblique, and lateral).

Patients were operated on under general or regional anesthesia (wrist block or supraclavicular block). One gram of 3rd generation cephalosporin (ceftriaxone) was given parenterally before induction of anesthesia and the antibiotic was continued for 24 hours postoperatively. Patients were positioned supine on the operative table with the arm extended on an arm board. A pneumatic tourniquet was inflated on the arm in Group B; the mini-plate group. The entire limb was sterilized and draped into the surgical field (Fig.-1).



Figure 1: Limb sterilization and draping

ORIF technique:

A dorsal approach to metacarpals was done. The extensor tendons were retracted together with the surrounding loose connective tissue. Dorsal interosseous muscles were partially detached from the bone subperiosteally.

After bone exposure, the fracture was opened, and the fracture bone ends were reduced to anatomical position and maintained by reduction clamps or towel forceps.

Then, 2.7 mm or 2.00 mm mini-fragment plates were used (Fig.-2). Choosing the plate shape whether T or L-shaped or straight was determined according to the fracture site. Then the mini-plate was secured to the bone using mini-screws.

Wounds were closed in layers using Vicryl 2/0 for subcutaneous tissues, and prolene or monocryl 2/0 for skin closure.

Intramedullary K-wire fixation

The entry point was dorsally located at the metacarpal base. Opening of the cortex was done with a 2-mm drill bit. Two pre-bent K-wires were inserted manually into the medullary canal with the blunt tip to reduce the risk of perforating the thin cortex of the metacarpal head and advanced into the diaphysis without reaching the fracture zone. The fracture was reduced under fluoroscopic control using the Jahss maneuver. Flexion of both metacarpophalangeal and interphalangeal joints at the right angle was done, followed by pushing up the metacarpal distal fragment from the proximal phalanx.

Then the wires were advanced manually, or with a hammer, across the fracture zone into the head. The

K-wires were bent at their entry point, cut, and then rotated (Fig.-3).

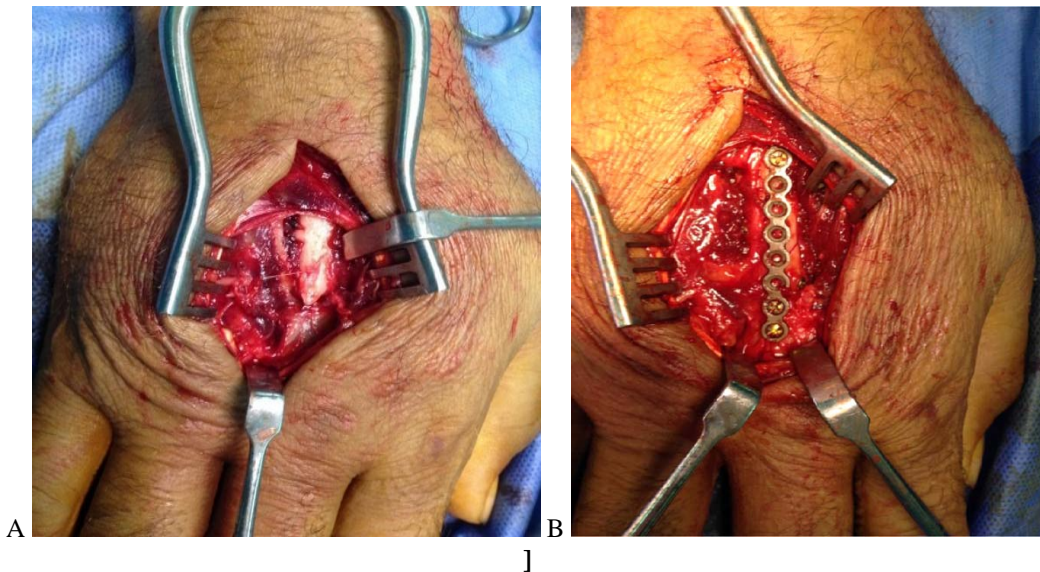


Figure 2: A: Dorsal approach to metacarpal B: Fixation using mini-plate



Figure 3: Intramedullary K-wires fixation of 4th and 5th metacarpals.

Postoperative measures:

In all cases, bulky dressing and below elbow extended back slab were applied postoperatively. Anti-edematous measures were followed; hand elevation, bandage, and medications. A single shot of a 3rd generation cephalosporin (Ceftriaxone 1 gm IV) was given to all patients postoperatively.

Postoperative x-rays of the operated hand were done for all patients (antero-posterior, oblique and lateral views). Patients were discharged on the following day post-surgery.

Rehabilitation protocol:

In the ORIF group, the slab was removed after 1 week, and patients were instructed to start tendon gliding exercises. One week later, stitches were removed and patients started blocking exercises followed by active ROM exercises in the 3rd week.

In the K-wires group, the slab and the K-wires were kept for 4-6 weeks. After that, patients were allowed to do passive and active range of motion exercises, and gradual return to daily activities with the operated digit buddy-taped to the next one and avoidance of forced active motion or heavy lifting for another 2-3 weeks.

The follow-up period was at least 6 months. Patients were followed at the outpatient clinic at 2, 4, 6, 8 weeks, 3 months, and 6 months postoperatively. They were followed for persistent pain, edema, radiological union, Total Active Motion (TAM), Total Active Flexion (TAF), and the quick DASH scores.

Results

In the K-wire group, operative time ranged from 22 to 65 minutes with a mean value of 37 minutes. While in the mini-plate group, operative time ranged from 40 to 67 minutes with a mean value of 53 minutes (p-value = 0.02).

Time to union was 9.8 weeks on average in the K-wire group and 10.1 weeks in the mini-plate group (p-value = 0.8). (figure 4,5)



Figure 4: A) A case fixed by intramedullary k-wire, B) After union and k-wire removal



Figure 5: A case fixed by mini-plate after union

In the K-wires group, the mean TAM at 6 months follow-up was 89.1 %. While in the mini-plate group, the mean TAM was 91.2 %.

Total active Flexion at 6 months follow-up was excellent in 74.1 % of cases in the K-wire group and 87.3 % of cases in the mini-plate group. It was good in the rest of the cases in both groups.

Mean Quick DASH score at 6 months follow-up was 6.2 in the K-wire group and 6.9 in the ORIF group.

In the K-wire group, there were 5 cases (16.6%) suffering from pin tract infection while in the mini-plate group there were 3 cases (10 %) with superficial wound infection. Delayed union after 4 months was seen in 6 cases in the K-wire group.

Table 1: Comparison between the two groups

	K-wire group			Mini-plate group			P-value
	Mean	Min.	Max.	Mean	Min.	Max.	
Age (years)	34.3	18	55	30	16	55	0.713
Union time (weeks)	9.8	6	18	10.1	6	15	0.8
Operative time (minutes)	37	22	65	53	40	67	0.02
TAM (%)	89.1	73	100	91.2	74	100	0.4
TAF							
Q-DASH	6.2	0	15	6.9	0	21	0.9

Discussion

Fractures of the metacarpals are mostly stable fractures and can be managed conservatively by protective splinting followed by early mobilization [3]. However, the results of conservative management of displaced metacarpal fractures are unsatisfactory [4].

For those displaced metacarpal fractures, closed reduction and percutaneous pinning using K-wires can be performed but they lack the rigidity and are rotationally unstable. So, internal fixation with mini-plates is an alternative with higher rigidity and allows early mobilization. K-wires use may be associated

with the risk of pin tract infection, and pin migration [4, 5].

Venkatesh R et al conducted a prospective study on 30 cases (24 males and 6 females) who had a mini-plate fixation for their metacarpal shaft fractures. Functional outcomes assessed using TAF were excellent, good, and fair in 70%, 20%, and 10% of the patients respectively [6]. In our study results; TAF was excellent in 87.3 % and good in 12.7 % of the cases.

Başar H et al conducted a study on 43 patients (7 females, 36 males) to assess the clinical and radiographic results of using mini-plates in closed metacarpal fractures. The average follow-up period was 19.76 months. Their mean age was 31.11 years. The results showed insignificant discrepancies in TAM score and grip strength between the fingers of the operated and healthy hands. The TAM score was perfect in 38 patients, good in four patients, and medium in one patient. The mean time to union was 6 weeks (range 5-7 weeks). Return to work was achieved at an average period of 31.6 days following the operation [7].

Nalbantoglu U et al conducted a retrospective study on 43 patients (37 men, 6 women) with 50 metacarpal fractures treated with mini-plate fixation. Mean age was 31 ± 9 years; ranging from 17 to 52 years. The follow-up period ranged from 12 to 96 months with a mean value of 62.2 months. Quick-DASH score ranged from 0 to 11 with a mean value of 2.0. In most cases (25 out of 43) TAM was excellent (58.1%). While it has been good in 12 cases, fair in five, and poor in one patient. Loss of grip strength was 5.2 as a mean value. There were no reported cases of nonunion or delayed union, but ten cases (23.2%) had tenosynovitis in the extensors and symptomatic plate which required removal in four patients [8].

Van Bussel M retrospectively analyzed 34 metacarpal shaft fractures of 27 patients fixed with antegrade intramedullary K-wires. The mean follow-up period was 11 weeks. No reported cases of nonunion, delayed union, or K-wires migration. One patient had persistent pain and impaired function and he was treated by performing tenolysis. The functional outcome was excellent with an average DASH score of 5 points [9]. In our study; the quick DASH score for the cases treated with K-wires ranged from 0 to 15 with a mean value of 6.2.

Boussakri H et al in 2014 conducted a study of 28 patients with boxer's fracture which is a fracture in the fifth metacarpal neck. They were treated with intramedullary pinning using K-wire which was present in a lazy-S fashion. All fractures proceeded to bony union (range 4-6 weeks). Three cases with su-

perficial wound infection needed antibiotic treatment. K-wires usually were removed with pliers post-operatively at four weeks and a full range was obtained in 97% [10].

Xu J and Zhang C conducted a meta-analysis comparative study between the results of mini-plate fixation and pinning by K-wires for metacarpal and phalangeal fractures. Eighteen studies were included involving 1,375 patients (709 cases and 666 controls). They revealed that mini-plate fixation is superior to K-wire pinning regarding healing time, infection rate, and complication incidence. On the other hand, mini-plates require a longer surgery time than pinning by K-wires [11].

Wutphiriy S also conducted a comparative study between K-wire pinning and mini-plate fixation in the treatment of metacarpal and phalangeal fractures. The study involved 112 patients with 122 fractures either in the metacarpals or phalanges. K-wire pinning was used in sixty-three fractures while the other fifty-nine fractures were treated with mini-plate fixation. There was a significant difference in operative time which was shorter in the K-wire group. But there were no differences in rate of healing, residual pain, and TAM [12].

Kim JY et al conducted a study on 39 cases to compare intramedullary fixation by K-wires (in 15 cases) and internal fixation using mini-plates (in 24 cases) in metacarpal shaft fractures. There was no significant difference in time of bone union between the two groups with an average time of 7.8 and 8 weeks in intramedullary K-wire and mini-plates respectively. Also, there were no significant differences in TAM and Q-DASH scores between both groups. Posterior angulation measured in follow-up x-rays was significantly lower in the mini-plate group. It was 14° on average in the intramedullary K-wire pinning group, and 5° on average in the mini-plate group [13].

In our study, there was no significant difference between the two methods regarding time to union with an average time of 9.8 weeks in the K-wire group and 10.1 weeks in the mini-plate group.

TAM had a mean value of 89.1 % in the K-wire group (73 % to 100%) and 91.2% in the mini-plate group (74 % to 100%). TAF was excellent in 74.1 % of cases fixed by K-wires and in 87.3 % of cases fixed by mini-plates. Quick DASH score mean value was 6.2 in the K-wire group and 6.9 in the mini-plate group.

Pin tract infection was found in 5 patients fixed by k wires. Superficial infection was observed in three patients fixed by mini-plate. All 8 patients were chronic smokers.

There were several limitations to this study including a relatively short period of postoperative follow-up (from 6 to 8 months). Further longer follow-up is planned in a future study to get more data about the hand functions. The small number of cases in each group was another limitation.

But after all, the clinical results of the present series have been encouraging with few complications rates, short time for full union, and good hand functions.

Conclusion

K-wires can be used to fix unstable metacarpal fractures. Although they do not provide rigid fixation, they provide adequate fixation sufficient for limited mobilization.

Mini-plate fixation provides rigid fixation for unstable metacarpal fractures, hence allowing for early mobilization.

Both techniques can be used effectively for the treatment of closed, extra-articular fractures of the metacarpal with good functional outcomes.

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