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FIXATION OF NON-THUMB METACARPAL FRACTURES USING THREE-POINT FIXATION PRINCIPLE WITH MULTIPLE PRE-BENT K-WIRES: SURGICAL TECHNIQUE AND CLINICAL RESULTS STUDY

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ABSTRACT

Background: Metacarpal fractures are among the most common hand injuries, accounting for 18–44% of all hand fractures, with non-thumb metacarpals being the most frequently involved. While many fractures can be managed conservatively, unstable, displaced, or rotational deformities often require surgical fixation. Various fixation techniques exist, with Kirschner wire (K-wire) fixation being widely used due to its simplicity and minimal soft tissue disruption. This study evaluates a modified technique using two pre-bent K-wires based on the principle of three-point fixation.
To assess the functional and clinical outcomes of non-thumb metacarpal fractures treated with two pre-bent intramedullary K-wires.
Materials and Methods: A prospective study was conducted on 18 hands of 17 adult patients with 35 non-thumb metacarpal fractures treated between July 2018 and December 2019 at a tertiary care center. Inclusion criteria included extra-articular fractures with operative indications such as angulation and rotational deformity. Patients were treated using a technique involving two or occasionally three pre-bent K-wires inserted through separate entry points. Postoperative immobilization was followed by early mobilization. Functional outcomes were assessed using the Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH) score and Total Active Motion (TAM) at 6 weeks, 3 months, and 6 months.
Results: The mean age of patients was 41.6 years, with a male predominance (70%). The fifth metacarpal was most commonly affected. Significant improvement in functional outcomes was observed over time. Mean Q-DASH scores improved from 44.56 at 6 weeks to 20.08 at 3 months and 8.07 at 6 months ($p < 0.05$). Most patients achieved good to excellent range of motion by 3 months and near-normal grip strength by 6 months. Complications were minimal, with only two cases of superficial pin tract infection managed conservatively.
Conclusion: The use of two pre-bent intramedullary K-wires provides a simple, minimally invasive, and effective method for stabilizing non-thumb metacarpal fractures. The technique offers good functional outcomes, low complication rates, and allows early mobilization, making it a viable alternative to conventional fixation methods.
Keywords: Metacarpal fractures, non-thumb metacarpal fractures, three-point fixation, Kirschner wires, intramedullary fixation.

INTRODUCTION

Metacarpal fractures comprise between 18–44 % of all hand fractures.[1,2] Non-thumb metacarpals account for around 88 % of all metacarpal fractures, with the fifth finger most commonly involved.[2] The majority of metacarpal fractures are isolated injuries, simple, closed, and stable.[3-6]

Displaced fractures of the metacarpal shafts and necks can be treated with a variety of techniques, ranging from conservative treatment to open reduction and internal fixation. However, operative intervention is recommended for open, irreducible, or unstable (rotational and angular)metacarpal fractures to preserve hand function.[7]

Most metacarpal fractures occur in the active and working population, particularly adolescents and young adults and usually result from a direct blow, crush, or missile injury.[8] Studies in the literature conclude that 30degrees is the upper limit for acceptable final angulation. However, any rotation deformity is poorly tolerated and needs correction.[9]

Indications for surgery of metacarpal fractures include greater than 10° of angulation in the index or middle finger metacarpal, or greater than 30°–40° of angulation in the ringor small finger. Any rotational malalignment must be corrected as it often leads toscissoring or overlap of the fingers in flexion.[10]

The functional outcomes of fractures of thering and little finger metacarpal shaft and neckthat unite with severe malunion are usually good,but severe malunion does cause cosmetic deformity, particularly if the fracture is in the shaftrather than at the neck. Thus controversy existsregarding indications for fixation, particularly oflittle finger metacarpal neck fractures, which arethe most commonly encountered in hand fractureclinics.[11]

Various fixation techniques in use are percutaneouspinning, cerclage wiring, plating, lag screws, tension band wires and external fixators.[12-15] Of theseKirschner wire (K-wire) fixation is a popular choice due to the simplicity of the procedure and the minimal softtissue interference.[16]

Foucher described in the French literature a techniqueof using multiple (three, occasionally two) fine (0.8 mm)blunt‑ended Kirchner wires (K‑ wires) to stabilize fractures of the metacarpal neck. The divergent tips of the wires in the metacarpal head resemble the stems of flowers and thus the term 'bouquet' osteosynthesis wascoined for this technique.[16] A variety of modifications of Foucher's technique have been published withsuccessful outcomes.[16] In addition, some surgeons use a singlelarge (1.6 mm) wire,[18,19] whereas others use multiplesmall (0.8–1 mm) intramedullary wires.[16] All the possible treatmentoptions have advantages and disadvantages, and there is no one treatment that is always the best.[20,21]

Also, some authors believe that the wide medullary canal at the metacarpal neck level reduces the effectiveness of the technique and increases the risk of redisplacement of the fracture after fixation, particularly if the fracture fixation is not protected by a splint or plaster cast postoperatively.[11]

We describe the technique and results of using 2 pre-bent k wires with the principle of three-point fixation for diaphyseal or metaphyseal fractures of metacarpals. This technique differs from the existing technique in the literature with bouquet osteosynthesis having similar principle.

MATERIALS AND METHODS

A total of 18 hands of 17 patients with metacarpal fractures including greater than 10 degrees angulation in index or middle finger, or greater than 30 degrees angulation in ring or little finger and any rotational malalignment in any of the fingers, were included in the study from July 2018 to December 2019 at a tertiary care centre. Ethical committee clearance was achieved as per the institutional protocols.

Inclusion Criteria

1. All non-thumb extra-articular head, metaphyseal or diaphyseal metacarpal fractures with relevant operative indications.
2. Fractures involving unilateral hand or bilateral hand
3. All adult patients of either sex

Exclusion Criteria

1. First metacarpal fracture involvement
2. Associated lower end radius or ulna fractures, TFCC injury, carpal fractures or inter-carpal instability in the ipsilateral hand.
3. Intra-articular fractures of head of metacarpals.
4. Pre-existing deformity in the hand, previously low grip strength or history of previous hand surgery.
5. Pathological fractures.
6. Grade 3 or higher compound fracture according to Gustillo Anderson classification of compound fractures.
7. High risk patients with ASA grading 3 or greater.

All patients willing for operative management were taken written informed consent and included in the study. All patients were operated by a single surgeon using the same technique under short general anesthesia or regional anesthesia as per the decision by the anesthetist in the operating room equipped with C-arm.

Author's surgical technique: Fixation of all the metacarpals is recommended using one single technique with minor variation depending on the fracture location.

The technique is different from bouquet technique a way where in bouquet technique, multiple k wires are stuffed in different directions/planes using a single entry point, in this technique, we insert two k wires or occasionally three using two different entry points from both sides of the metacarpal resembling a construct similar to TENS nailing in paediatric long bone fractures.

In case of metacarpal base fractures, small nick incisions are made on both sides of the metacarpal head from dorsal aspect of hand after flexion at metacarpo-phalangeal joint. Entry point is created on the extra-articular portion of the head using a 1.5mm k-wire or a pre-fabricated bone awlfor metacarpal fractures which is thinner in dimensions as compared to routine Radius/Ulna awl used for nailng.A thin

1mm or 1.2mm k wire is pre-bent at around 1cm from the tip at an angle of around 30 degree and the rest of the k wire is given a gentle curve [Figure 1a and 1b]. Fracture is reduced by traction, counter-traction and manipulation. The k wire is then inserted using a T-handle through the entry point and progressed further through the fracture site into the proximal fragment and then the tip is engaged into the far cortex of the bone taking care not to cross the bone and enter the joint. Similarly, another k wire is inserted through another entry point created on the other side of that metacarpal. The directions of the k wires should be such that it should be touching the opposite lateral cortices at the fracture site.For metacarpal head fractures, entry points can be created at the base of metacarpals and k wires are inserted in the similar fashion. [Figure 2 and 3]

For diaphyseal fractures, entry can be created from either end of the metacarpal depending on the surgeon's comfort, however, working lengths should also be taken into consideration prior to choosing between proximal entry or distal entry.

After satisfactory reduction and retainment of the reduction, the k wires are bent and cut leaving the tips of the wires outside the skin or they can be buried subcutaneously.

Post operatively, hand and wrist is immobilized with a splint for three to four weeks. However, active finger movements are encouraged.

After three weeks, a radiograph is taken and in patients showing evidence of callus formation, are encouraged active wrist and finger movements gradually with k wires in situ. If in case, adequate callus formation is not evident, movements are restricted.

After 4-6 weeks, k wires are removed on an outpatient basis under local anesthesia and complete hand function is initiated gradually except heavy weight lifting. Patients are encouraged physiotherapy for grip strengthening and range of motion exercises.

Hand function is assessed at 6 weeks, 3 months and 6 months using Q-DASH score and range of motion was assessed using TAM score (Total active ROM%).

RESULTS

A total of 18 hands of 17 patients having 35 non-thumb metacarpal fractures were operated using the described technique. Majority of the patients (70.0%) were males. Mean age of patients was 41.6 years (21-63 years). Out of 17 patients, 9 patients had right sided hand involvement, 7 patients had left sided hand involvement and 1 patient had bilateral hands involved. Out of 17 patients, 6 patients had single metacarpal fracture, while 11 had multiple metacarpal fractures. Fifth metacarpal was most commonly fractured, singly or along with other metacarpals. Most common mode of injury was road traffic accident, followed by occupational/industrial accidents followed by assault. In this study, majority (66.6%) of the fractures were closed fractures. Out of 5 compound fractures, 3 patients had GA Grade 1 compound injury and 2 patients had GA Grade 2 compound injury and both were associated with industrial/occupational accident.

In majority (13/17) patients, k wires were removed between 4-5 weeks. In 2 patients, k wires were removed at 3 weeks because of superficial pin tract infection. In remaining 3 hands of 2 patients, k wires were removed at 6 weeks.

At 6 weeks, mean Q-DASH score was 44.56 (31.8-70.5). At 3 months, mean Q-DASH score was 20.08 (6.8-52.3). At 6 months, mean Q-DASH score was 8.07 (0.0-27.3). On statistical analysis of the mean Q-DASH scores at different time intervals, it was observed that Q-DASH scores improved significantly ($p<0.05$) at 3 months as compared to 6 week scores. Also, om further follow- up at 6 months, it was observed that the scores were further improved which were again found to be statistically significant ($p<0.05$)

At the end of 6 months, 2 patients were found to be at their pre-injury state with Q-DASH score of 0 points. [Table 1]

Two patients had superficial pin tract infection, which healed by early pin removal and routine antibiotics. One patient with compound fracture had developed extensive scarring on dorsum of hand limiting its movements.

Majority of the patients had TAM score for range of motion, fair at 6 weeks and good to excellent by 3 months. Majority of patients had excellent range of motion at 6 months.

Grip strength was weak in majority of patients at 6 weeks which was significantly improved at 3 months. 36.6% of patients achieved near normal grip strength at 3 months. Out of 17 patients, 10 (58.88%) patients achieved near-normal grip strength at the end of 6 months.

Table 1: Observations

Sr. no	Age	Sex	Metacarpal no.	Location	Side	QDASH Score		
						6 weeks	3 months	6 months
1	29	M	2,3	B	R	47.7	18.2	9.1
2	45	M	5	N	R	40.9	25	15.9
3	38	F	4,5	S	L	38.6	15.9	4.5
4	33	M	3,4,5	S	R	63.6	25	4.5
5	54	F	2,3,4,5	S	L	47.7	25	11.4
6	39	M	4,5	B	L	34.1	13.6	2.3
7	50	M	4,5	B	R	40.9	20.5	13.6
8	44	F	3,4,5	B	L	70.5	52.3	27.3
9	46	M	5	N	R	43.2	9.1	2.3

10	51	F	4,5	S	R	45.5	11.4	2.3
11	21	M	5	N	R	34.1	20.5	4.5
12	48	M	2	N	L	47.7	20.5	6.8
13	39	F	5	N	R	36.4	9.1	0
14	38	F	4,5	B	L	40.9	6.8	0
15	63	M	2,3,4	S	L	54.5	34.1	15.9
16	54	M	2,3	B	R	43.2	15.9	6.8
17	26	M	4,5	B	R	40.9	20.5	13.6
18	26	M	5	N	L	31.8	18.2	4.5

Table 2: Statistical analysis

(N=18)	6 weeks	3 months	6 months
Mean QDASH Scores	44.56667	20.08889	8.072222
Standard Deviation	9.734532	10.23295	6.87207
P VALUE	0.0001 (p<0.05)		
P VALUE		0.0002 (p<0.05)	

DISCUSSION

Metacarpals are one of the most common fractures in hand,[10] Operative management of non-thumb metacarpals have gained popularity in recent timesVarious techniques for internal fixation of metacarpal fractures have been studied in literature, the principles of treatment include restoration of articular anatomy, stable fixation of fractures, elimination of angular or rotational deformity and rapid restoration of mobility and function.[9] This can be achieved with various techniques using K-wires, screws or plating. Choice of management is, however, more dependent on surgeon's preference and skill.

Ford and colleagues studied 62fractures of the little finger metacarpal neck and concluded that palmar angulation up to 70 degrees resulted in good outcomes when the fracture was,in essence, ignored and the hand was simply mobilized.[21] Other authors have expressed similarviews,[22,23] but Eichenholtz and coworkers,[24] considered that palmar angulation of more than40 degrees required correction. Others recommend operative intervention if there is angulation of 30 degrees.[24]

In contrast to the controversy regarding ringand little metacarpal neck fractures, most surgeons would agree that angulation and shorteningof index and middle finger metacarpal fractures are less well-tolerated and require correction, probably because the carpometacarpal articulations of these radial rays are less mobile.[11]

Plate fixation of metacarpal fractures complication rates varybetween 32–36 %.[26,27] A 1998 review of 66 metacarpalfractures treated with plates and screws revealed a 36 %complication rate.[27]

There havebeen many reports of problems with using plating forthese fractures, mainly in relation to the soft tissue impingement.[26,27] Stiffness was the most commonlyreported complication, with 76 % of patients studied reported to have total activemotion less than 220°.[26,27] More serious complicationsare rare, with nonunion, infection and tendon ruptureeach comprising 1.6%of complications reported in literature. Fusetti et al. reviewed 105 non-thumb metacarpal fractures in 2002, and found a 32 % complication rate.[26] The most common complication was poor healing, with 15 % of patients split evenly between malunion and nonunion . Ten percent of complications were related to stiffness, while 8 % of patientsexperienced hardware failure.[16] Revision surgery due to hardwarecomplication has been reported at rates of 4.6–32 % .[10]

Intramedullary stabilization of metacarpals with K-wire is relatively simple, cost-effective and safe technique with good published outcomes.[11]

For the purpose of intramedullary fixation, many surgeons advocate use of a single larger diameter k wire. Even though it is less prone for angular or translational deformities, it is often less tolerant to rotional stability, which is poorly tolerated and transmits down to entire finger shaft and is exaggerated in flexion which is associated with relatively poorer hand function.[11]

The technique of using multiple K wires for metacarpal fractures was introduced by Foucher.[16] However, the technique described in this article is different from that described in the literature as "Bouquet Osteosynthesis". This technique helps retainment of reduction of diaphyseal fractures in a similar way as principle of TENS does in paediatric long bone fractures. However, for fractures more towards metaphysis which have a wider canal, it is difficult to entirely fill in the medullary cavity. Hence, the technique in this article is more suitable of wider medullary canals and more proximal or distal fractures where canal diameter is greater and hence less tolerant to translational displacement. Also, multiple pins in different planes prevent rotation of the fragments. Two or three pre-bent k wires inserted from different portals gives an elastic three point fixation with adequate stability with minimum soft tissue stripping encouraging early fracture healing. Apart from this, this procedure also gives advantages of reduced operative time, minimum need for usage of anti-biotics, post-operative dressing needs and can be performed as a day care surgery.

In our study, post-operative splint in Intrinsic-plus position was given and active finger movements were initiated on day 1 of surgery to prevent stiffness and to encourage early rehabilitation.

Majority of patients in our study had lower grip strengths and Q-DASH scores at 1st follow-up because majority of the patients were given immobilisation splints for 3-4weeks as well as involvement of soft tissue injury associated with fractures. Hence, at 2nd follow-up (i.e. at 3 months) majority of the patients had improved outcome significantly and were able to resume their work and perform their ADL efficiently. In this study, there were no complications like osteomyelitis, nonunion or delayed union. Infection rates in metacarpal fractures are low and osteomyelitis of hand is rare but serious.[10] In this study, only 2 patients had superficial pin tract infection which was managed by antibiotics and early pin removal.

However, there are certain limitations for using this technique. This method cannot be efficiently used in displaced intraarticular fractures which cannot be reduced by closed manipulation, metacarpals with very narrow medullary cavity, intra-articular fractures of head of metacarpals which often require other methods of management and subluxated or dislocated fractures which need more interventions than the described technique alone.

CONCLUSION

Non-thumb metacarpal fractures are common fractures of hand. Radial rays being less mobile, it requires fixation with least possible chances of malunion. Fixation of metaphyseal fractures of non-thumb metacarpals with multiple pre-bent k wires is a relatively easy and a minimally invasive procedure, which gives a good clinical outcome with minimum complication rates.

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