A new technique of locked, flexible intramedullary nailing of spiral and comminuted fractures of the metacarpals: a series of 21 cases

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Abstract

Background Spiral and comminuted fractures of the metacarpals are rotationally and axially unstable fractures with a tendency to shorten, which in turn causes significant extensor lag and loss of grip strength. We have designed a new, cheap and locally developed method of locked intramedullary nailing of these metacarpal fractures. We are presenting the results of our first 21 patients with 22 fractures treated by closed, fluoroscopically assisted, intramedullary K-wiring with proximal locking done by a specially designed locking pin.

Materials and Methods This was a retrospective, observational cohort study of all patients with spiral and comminuted fractures of metacarpals with minimum of 1 year of follow-up and average follow-up of 14 months (range, 12 to 26 months). The patients were evaluated clinico-radiologically using range of motion, extensor lag, time to healing, amount of collapse, angulation and rotation and complications.

Results All fractures had healed uneventfully with average time to union being 8 weeks. Average metacarpal shortening was 2.04 ± 0.95 mm, while the average post-operative angulation of the fracture was $4.81^\circ \pm 1.7$. The metacarpophalangeal range-of-motion recovered almost fully with the average extensor lag being only $5.22^\circ \pm 2.42$. Other than extensor tendinitis in two patients, there were no other complications.

Conclusions This method is cosmetically appealing, provides stable fixation, avoids periosteal stripping associated with open reduction and is associated with very low complication rate, and thus can be safely and effectively used for the treatment of these difficult fractures.

Keywords Metacarpal · Spiral fracture · Locked nailing

Introduction

Spiral and comminuted fractures of the metacarpals are rotationally unstable fractures with a tendency to shorten, which in turn causes significant extensor lag and loss of grip strength [9, 15]. The recommended treatment of these fractures has been open reduction and internal fixation with inter-fragmentary fixation or plate fixation [3, 4]. However, due to the complications of open reduction, safer and effective methods of closed reduction and fixation of these fractures are being preferred. While percutaneously inserted intramedullary wires are widely accepted for minimally invasive treatment of transverse fractures of the metacarpals [7], their use alone is not effective in the treatment of spiral and comminuted metacarpal fractures. This is because both these varieties of fractures tend to collapse along the axis of the intramedullary Kirschner wires causing shortening, rotation and angulation either alone or in combination leading to considerable deformity and disability [14]. The possibility of using a proximal locking pin to prevent such an occurrence was first discussed by Orbay et al. [14]. However, that particular technique required special instrumentation as well was not economically viable for patients in our setup. Therefore, the use of a new and locally designed proximal locking (device) needle for the intramedullary Kirschner wire was initiated by the authors

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3 years ago, as an alternative, to prevent the inadvertent collapse and its associated complications. We are presenting the results of the first 21 patients thus treated by us at our institutes.

Material and Methods

The data of 21 adult male patients with 22 spiral and comminuted metacarpal fractures treated between 2006 and 2009 were reviewed retrospectively. The average age of the patients was 30 years (range 18–56 years). The metacarpal of the index alone was fractured in 12, middle finger in seven, ring in one and index and middle finger together were fractured in one patient. Of the 22 fractures, 12 were spiral or long oblique fractures and ten were comminuted. All patients had closed fractures. The mode of injury was domestic fall in ten, road traffic accident in eight and fall of heavy weight in three patients. All patients were operated on by a single surgeon (HP) on the same day of presentation.

Surgical Procedure

With the patient under regional or local anaesthesia, reduction of the fracture was achieved under fluoroscopic guidance. It

was confirmed that closed reduction was possible under image intensifier guidance. A small transverse incision was placed over the base of the metacarpal at the level of the carpometacarpal joint. Blunt dissection of the soft tissues was done and deepened till the bone surface. Careful spreading of the soft tissues was done to identify the extensor tendons. The third and fourth extensor tendons tend to pass over the nail insertion site; while in case of the second and fifth metacarpals, they could be easily retracted medially and laterally, respectively. However, it was always better to enter the metacarpal intramedullary canal slightly off-centre to prevent damage to the extensor tendons. The dorsal cortex of the metacarpal was perforated with a 1.5-mm K-wire about 5–8 mm distal to the carpometacarpal joint and driven across so as to perforate the volar cortex. This is essential in order to seat the locking device—i.e. the needle.

A 1.0-mm K-wire is pre-bent and blunted by cutting its tip. It is advanced through the outer cortical hole in the canal up to the fracture site (Fig. 1a). The fracture is then held reduced under C-arm guidance and the K-wire is advanced across the fracture site and firmly seated in the subchondral bone of the metacarpal head (Fig. 1b). Holding the fracture reduced under traction, the K-wire is bent at the entry site, i.e. the outer cortex up to 90° to the shaft.

A specially designed proximal locking pin made of 16G hypodermic needle was used for locking. The locking

Fig. 1 **a** The procedure of locked nailing: Entry created using a 1.5-mm K-wire which is drilled till the far cortex. Blunt, pre-bent K-wire inserted till fracture site. **b** Wire passed to the distal fragment after reduction and “locked” against the distal subchondral

bone, the tip is then bent to 90°. **c** The “locking pin” advanced till the far cortex and then hammered through it. **d** The tip of the locking pin along with the K-wire cut together just above the level of the extensor tendon

needle was then introduced over the outer end of the K-wire and then advanced over the wire through the outer entrance portal (keeping the bevel facing the fracture site). It was gently passed in the metaphyseal bone, and after encountering some resistance, the needle was gently tapped such that it just penetrates the far cortex (Fig. 1c). Multiple K-wires were used in case of severe instability (as in comminuted fractures or fractures of the neck of the metacarpals).

The K-wire and the locking needle combination were cut below the skin but above the level of the extensor tendon (Fig. 1d). The cutting process caused some crushing of the needle and provided additional snug fit to the K-wire against migration. The small wound was sutured with one or two sutures after careful haemostasis.

Post-operatively, a well-padded plaster slab was given in the “safe” position allowing full inter-phalangeal joint motion. This slab also provided additional support to these rotationally unstable injuries, prevented extension contractures of the metacarpophalangeal joints, supported fixation of the fractures and prevented extensor tendon irritation especially of the third and fourth metacarpal by restricting extensor tendon excursion. This problem was not encoun-

tered in the second and fifth metacarpals as the proximal cut end of the nail was well-separated from the tendons.

The patients were asked to follow-up every 3 weekly for the first 2 months and then every 3 months for a year. The locking pin with its K-wire was routinely removed at 68 weeks to minimize adventitious bursitis. During every follow-up, the patient was assessed clinically and radiologically for union, angulation and shortening. Angulation and shortening were compared to opposite side. The metacarpophalangeal joint range of motion was measured clinically using a goniometer, while rotational deformity was detected by comparing the finger in the flexed position with the contralateral side.

Statistical Analysis

The data about all the patients were entered in Microsoft Excel 2007 and analysed statistically with the help of SPSS version 17. The values of the metacarpal shortening, angulation and extensor lag were presented as mean (standard deviation). The two groups of spiral and comminuted fractures were compared with respect to the

Fig. 2 **a** Clinical example. Pre-operative radiograph of the hand of a 30-year-old man showing comminuted fracture of the second metacarpal. **b** Immediate post-operative radiograph of the same patient showing excellent reduction and fixation done by single blunt pre-bent K-wire locked with locking pin proximally. **c** Post-operative radio-

graph of the patient 12 weeks after surgery showing excellent alignment, union and no shortening. **d** Clinical photograph of the patient showing full range of motion of the metacarpophalangeal joint, with no angulation, rotation and shortening

above mentioned values with the help of independent sample *t* test. A *p* value of <0.05 was taken as significant.

Results

The results of 22 spiral and comminuted fractures of the metacarpals in 21 patients were retrospectively evaluated. The minimum follow-up was 6 months with the mean follow-up being 18 months. All fractures healed with the average time to union being 8 weeks. There were no rotational abnormalities, significant shortening or angulation (Figs. 2a–d, 3a–d and 4a–d). The two groups of spiral and comminuted fractures were compared with each other statistically. The values of the metacarpal shortening, angulation and extensor lag of the two groups are shown in Table 1. According to the independent sample *t* test, there was no statistically significant difference between the two

groups in these three parameters ($p=0.9592$, $p=0.8169$ and $p=0.7030$, respectively). Hence, for all practical purposes, these two groups were considered as a single entity. The average metacarpal shortening of the 22 patients was 2.04 (0.95)mm, while the average post-operative angulation of the fracture was 4.81° (1.7). The metacarpophalangeal range-of-motion recovered almost fully with the average extensor lag being only 5.22° (2.42). Complications included delayed healing (>8 weeks but <12 weeks) in two patients due to distraction and extensor tendinitis in two patients which was treated with early K-wire removal. There were no other complications of infection and stiffness.

Discussion

Fractures of the metacarpals are quite common, amounting to about one third of all hand fractures. A majority of these

Fig. 3 **a** Pre-operative radiograph of the hand of a 26-year-old man showing spiral fracture of the third metacarpal. **b** Immediate post-operative radiograph of the same patient showing excellent reduction and fixation done by single blunt pre-bent K-wire locked with locking pin proximally.

c Post-operative radiograph of the patient immediately after implant removal showing excellent alignment, union and no shortening. **d** Clinical photograph of the patient showing full range of motion of the metacarpophalangeal joint, with no angulation, rotation and shortening

Fig. 4 **a** Pre-operative radiograph of the hand of a 38-year-old man showing comminuted fracture of the neck of the second metacarpal. **b** Immediate post-operative radiograph of the same patient showing excellent reduction and fixation done by single blunt pre-bent K-wire locked with locking pin proximally. **c** Post-operative radiograph of the

patient immediately after implant removal showing excellent alignment, union and no shortening. **d** Clinical photograph of the patient showing full range of motion of the metacarpophalangeal joint, with no angulation, rotation and shortening

fractures are closed, simple, transverse, or short oblique and are amenable to protective splintage and early motion [9]. Over the years, a number of hand surgeons had realised the

risk of soft tissue scarring and stiffness following operative treatment of metacarpal fractures, especially in the regions near the extensor tendon sheaths and have suggested against

Table 1 Table showing the comparison of fixation of spiral and comminuted metacarpal fractures in our series

Parameter	Value	Type of fracture		Combined
		Spiral	Comminuted	
Number of fractures		12	10	22
Shortening	Mean	2	2.1	2.04
	S.D.	0.99	0.78	0.95
	<i>p</i> value	0.9592		
Angulation	Mean	4.7	5.1	4.81
	S.D.	1.78	2.02	1.7
	<i>p</i> value	0.8169		
Extensor lag	Mean	5.41	5	5.22
	S.D.	1.44	3.33	2.42
	<i>p</i> value	0.703		

Table 2 Table showing comparison of the present series with various other series describing fixation methods for metacarpal fractures

Sr. No	Authors (year)	Method	No. of patients	Complications	Remarks
1	Faraj and Davis [7]	Single/multiple K-wiring with cortical window	19 (14 with follow-up)	2-angulation > 20° 3-wire backing out	
2	Botte et al. [5]	K-wire fixation	131 K-wires for metacarpal fractures	Complications—18% Loss of fixation—4% Non-union—5%	No details about type of fracture
3	Orbay and Touhami [15]	Locked and unlocked K-wire fixation	95#—locked nailing 55#—non-locked nailing	Shortening—1.6 mm Angulation—8° No extensor lag	Requires special instrumentation (?) difficult to use
4	Fuseti et al. [10]	Open reduction and plate fixation	104 fractures 69 non-oblique #	8 pts (10%)—stiffness 12 pts (15%)—delayed union	
5	Agashe et al. (present series)	Locked K-wire fixation	22 spiral and comminuted fractures	Shortening—2.04 mm Angulation—4.81° Extensor lag—5.22°	Locking done by simple to use instruments

open treatment of most metacarpal fractures [2, 6, 18]. However, the same cannot be said of spiral and comminuted fractures of the metacarpals. These fractures have a remarkable tendency to shorten and angulate and are inherently rotationally unstable [12].

Metacarpal shortening and malrotation are extremely important factors in the final clinical outcome in any traumatised hand. Shortening of the metacarpal by as much as 2 mm leads to an extensor lag of 7° and a 8% grip strength loss [19]. Also rotational deformity of the metacarpals is poorly tolerated as the rotated finger tends to get impinged or overlapped with the other fingers [17]. Thus due to these reasons, the aim is to obtain good anatomical reduction of these difficult fractures than risk the complications of their malunions.

Over the past many years, open reduction and internal fixation with mini-plates and screws have become increasingly used in the management of these difficult fractures [3]. The reasons for this increasing popularity may be better instrumentation for open reduction and internal fixation, better understanding of the principles of biomechanics and fracture healing and also the greater availability of antibiotics [11]. However, this type of fixation always carries the risk associated with exposure of the fracture site namely fragment devascularisation and soft tissue irritation. The scars are often large and unsightly, while stiffness is also a major issue. These plates cause significant osteopenia. Also the Association of Study of Internal Fixation recommends routine removal of these plates at around 6 months after surgery which entails another surgical procedure [11].

All these reasons have prompted a number of hand surgeons to investigate and devise new methods of minimally invasive fixation of metacarpal fractures. Closed intramedullary fixation with K-wires has been the simplest

method of fixation of metacarpal fractures. However, this operative ease is offset by the fact that the fixation obtained is less than optimal especially in spiral and comminuted fractures which tend to collapse, rotate and angulate. Lord in 1957 [13] and other surgeons first described the method of retrograde intramedullary K-wiring of metacarpal fractures through the flexed metacarpophalangeal joint. This method had the disadvantage of impaling the MCP joint and damaging the extensor mechanism. Foucher's "bouquet" technique described in 1995 [8] was the most significant development for the management of metacarpal fractures. This technique involved passing multiple flexible antegrade K-wires and had the advantage of being less traumatic to the tissues and avoided tissue devascularisation. However, this technique was quite technically demanding and needed a wider proximal surgical incision [14].

Orbay et al. described a technique of "locked" intramedullary fixation of metacarpal and phalangeal fractures [14]. This procedure had the advantages of minimally invasive fixation namely good cosmesis, less tissue trauma and consequently, less stiffness as well as the benefits of open fixation with screws and plates of stability and early mobilisation. This method entailed passing a flexible intramedullary antegrade wire and "locking" it proximally with the help of a specially designed locking pin fitted with a plastic cap.

Orbay et al. in 2006 [15] performed a retrospective analysis of 150 hand (metacarpal and phalangeal) fractures treated with locked and unlocked intramedullary nailing. In this study, the authors concluded that proximally locked nails may be especially useful in rotationally and longitudinally unstable fractures (spiral and comminuted fractures respectively) and also are helpful in post-operative mobilisation obviating the need for post-operative splintage. The authors showed excellent results with their technique of locked nailing with

the average shortening being 1.6 mm, the average angulation being 8° with no extensor lag.

However, the disadvantages of the abovementioned method in our setup included the use of the required instrumentation which was not routinely available and was prohibitively expensive. Also there have been concerns by some authors about the locking device needed in that technique due to the fact that it is a bit difficult to use and also because of its undue prominence under the skin [1]. Hence, the authors designed this cheap and locally designed method of locked nailing of metacarpal fractures (the approximate cost of the implants with the K-wires was not more than \$5–10). The proximal locking pin here was locally made and was just a modification of the routine 16G hypodermic needle developed into a longer bevel. The length of the bevel was the approximate average width of a metacarpal which was 12 mm. This bevel can be developed easily locally using simple equipment. Also, because of the authors' technique of cutting the wire just below the skin and above the tendons, the need of the plastic cap also was not felt. The routine removal of the locking pin with the K-wire at 6 weeks prevented the formation of adventitious bursitis. With the use of this method, the authors were able to produce satisfactory results for this group of difficult fractures with minimal complications.

This method compares favourably with various other series of metacarpal fracture fixation using a variety of implants. Faraj and Davis [7] described a series of 22 metacarpal fractures treated with single or multiple K-wires with a proximal cortical window to bury the K-wires to prevent backing out. Amongst the 14 patients who followed up, there were five complications—two patients with angulation deformities of 20° and three patients with K-wire back-out and collapse. Botte et al. [5], in a comprehensive review of complications of K-wire fixation for hand and wrist fractures, commented on 131 K-wire fixations in metacarpal fractures. They reported 18% complications, with loss of fixation and collapse, symptomatic and asymptomatic non-unions and pin migrations being the major complications.

On the other hand, the various series describing open reduction and plate fixation for metacarpal fractures also showed a different set of complications. In an article by Page and Stern [16] in 1998, the authors describe a 36% total complication rate for fractures treated with mini-fragment plates. Amongst the 63 metacarpal fractures described, there was extensor lag of more than 15° in 14, contractures more than 15° in six and problems of union in five. In another excellent article by Fusetti et al. [10], the authors describe the results of open reduction and internal fixation with plates of 104 metacarpal fractures of whom 69 were non-transverse (oblique and comminuted). Stiffness developed in eight patients (10%) and delayed

union/non-union developed in 12 patients (15%). The salient features and complications of the important series showing metacarpal fracture fixation are denoted in Table 2.

The advantages of the present study include a fair number of patients treated by a single senior surgeon and with an adequate follow-up. The instrumentation used is locally made, extremely cost-effective and does not require complicated inventory. This can thus be particularly useful in rural and less privileged sectors of the developing world. However, the limitations of this study include its retrospective and non-comparative nature, especially over a period when the technique and instruments were still being developed and the surgical and post-operative algorithm were still evolving. Hence, a prospective, randomised trial would definitely be a very effective way in proving the efficacy of this unique methodology.

Conflict of interest None

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