

## Bouquet Technique in Management of Unstable Metacarpal Fractures

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### Abstract

**Background:** Several methods of fixing unstable metacarpal shaft fractures have been described; the aim of the study was to assess the clinical and radiological results of bouquet technique in management of unstable metacarpals fractures. **Patients and Methods.** A prospective study held between 2017 and 2019 at Benha University Hospital on 20 patients (15 males and 5 females) had unstable metacarpal fractures affecting second to fifth metacarpals treated with bouquet technique. The patient's mean age was 31.6 years. The dominant hand was affected in 15 patients while in 5 patients the non-dominant hand was affected. Under fluoroscopy, closed reduction and percutaneous bouquet pinning fixation was done using two or three K-wires. The mean operative time was 26.5 minutes. The inclusion criteria included patients with acute metacarpal shaft fracture with unaccepted shortening, angulation and rotation. **Results** The mean follow-up period

was 11.6 weeks. Bony union achieved at an average of 7.4 weeks. At the final follow-up, all patients had almost full ROM with a mean total active range of motion  $260.5^{\circ}$  ( $245^{\circ}$ -  $270^{\circ}$ ). None of the patients had any clinically detectable rotational deformity, functional outcome was satisfactory with mean grip strength of the injured hand 96% in comparison to the non-injured side, average Quick Dash score was  $1.45 (\pm 1.2)$  ranging from zero to 4 points. The mean VAS for pain was  $0.85 (\pm 0.8)$ . All patients returned to their ordinary jobs and were cosmetically and functionally satisfied with the results of their surgery. One patient presented with stiffness and improved gradually with physiotherapy. one patient united with  $10^{\circ}$  angulation of the 5<sup>th</sup> metacarpal without any functional affection or extension lag. No other complications reported. **Conclusion** Bouquet technique is an effective, easy and safe method for treating unstable metacarpal fractures, without significant complications.

**Keywords** Unstable metacarpal, Displaced metacarpal fractures, metacarpal fractures, bouquet technique.

## **Introduction**

Hand injuries are very common resulting frequently in metacarpal and phalangeal fractures (1). Metacarpal fractures comprise between 18–44 % of all hand fractures. Non-thumb metacarpals account for around 88 % of all metacarpal fractures, with the fifth finger most commonly involved. (2)

Most hand fractures are stable either before or after closed reduction and can be effectively treated by closed means. Operative treatment may be indicated in the setting of multiple fractures, excessive shortening, rotational deformity, or excessive angular deformity. Fixation choices depend on the fracture pattern, surgeon preference, and associated injuries. (3)

Shortening and malunion of the metacarpal fractures can cause significant limitation of the hand range of motion. Every 2 mm of shortening up to 10 mm creates a 7° extensor lag. Grip strength is also affected by the amount of shortening; at the full flexion of the digit, shortening more than 5 mm results in a significant decrease in flexion force (1). While less than 10° of rotation could be accepted, angulation of metacarpal shaft fracture has a

lot of debate, and the indication for surgical intervention is highly variable with some of the authors accepting up to 70 degrees of angulation. Due to the compensatory movement of the 4th and 5<sup>th</sup> carpometacarpal joints, the acceptable degree of angulation increases for the more ulnar digits. Fewer angulations of the second and third metacarpals can be tolerated as their CMC joints are much less mobile (2).

Many surgical options have been described to treat metacarpal shaft fractures with no consensus on optimal technique. Options include open reduction internal fixation, Kirschner (K-) wire fixation, suture fixation, and cerclage wiring.(4)

Bouquet osteosynthesis is an attractive option, as extensive surgical dissection soft tissue devitalisation at the fracture site can be avoided. It also limits the potential complication of extensor irritation by a dorsal plate, lessening the chance of extensor tenosynovitis.

The aim of this prospective study was to assess the functional outcome after bouquet

technique in management of unstable metacarpals fractures.

### Patients and Methods

A prospective study, held between 2017 and 2019 at Benha University hospital including 20 patients; 15 males and 5 females, with unstable 2nd to 5th metacarpal fractures were fixed by percutaneous bouquet technique. The patient's mean age was 31.6 years ( $\pm 10.6$ ) ranging from 15 years to 50 years. The inclusion criteria included acute metacarpal fracture with unaccepted shortening, angulation and rotation. Exclusion criteria were Patient with old, Non-united metacarpal fractures, Intra-articular metacarpal fracture.

The mechanism of injury was punch trauma in 10 patients, fall on the ground in 5 patients, direct trauma in 3 patients and RTA in 2 patients (**Table 1**). The dominant hand was affected in 15 patients while in 5 patients the non-dominant hand was affected. All patients were evaluated preoperative clinically and radiologically. At least 3 views of the hand anteroposterior, oblique and lateral views were obtained. The fracture pattern was transverse in 8 patients, spiral in 4 patients, and oblique in 6 patients and comminuted in 2 patients (**Table 2**). The commonest finger affected was the fifth followed by the fourth metacarpals (**Table 3**).

**Table (1):** Different Mechanisms of Injury among the study group

Mechanism of Injury	No. of patient
RTA	2
Punch	10
Falling down	5
Direct	3
Total	20

**Table (2):** Fracture Pattern.

Fracture pattern	No. of patients
Transverse	8
Spiral	4
Oblique	6
Comminuted	2

**Table (3):** Distribution of Metacarpal Fractures.

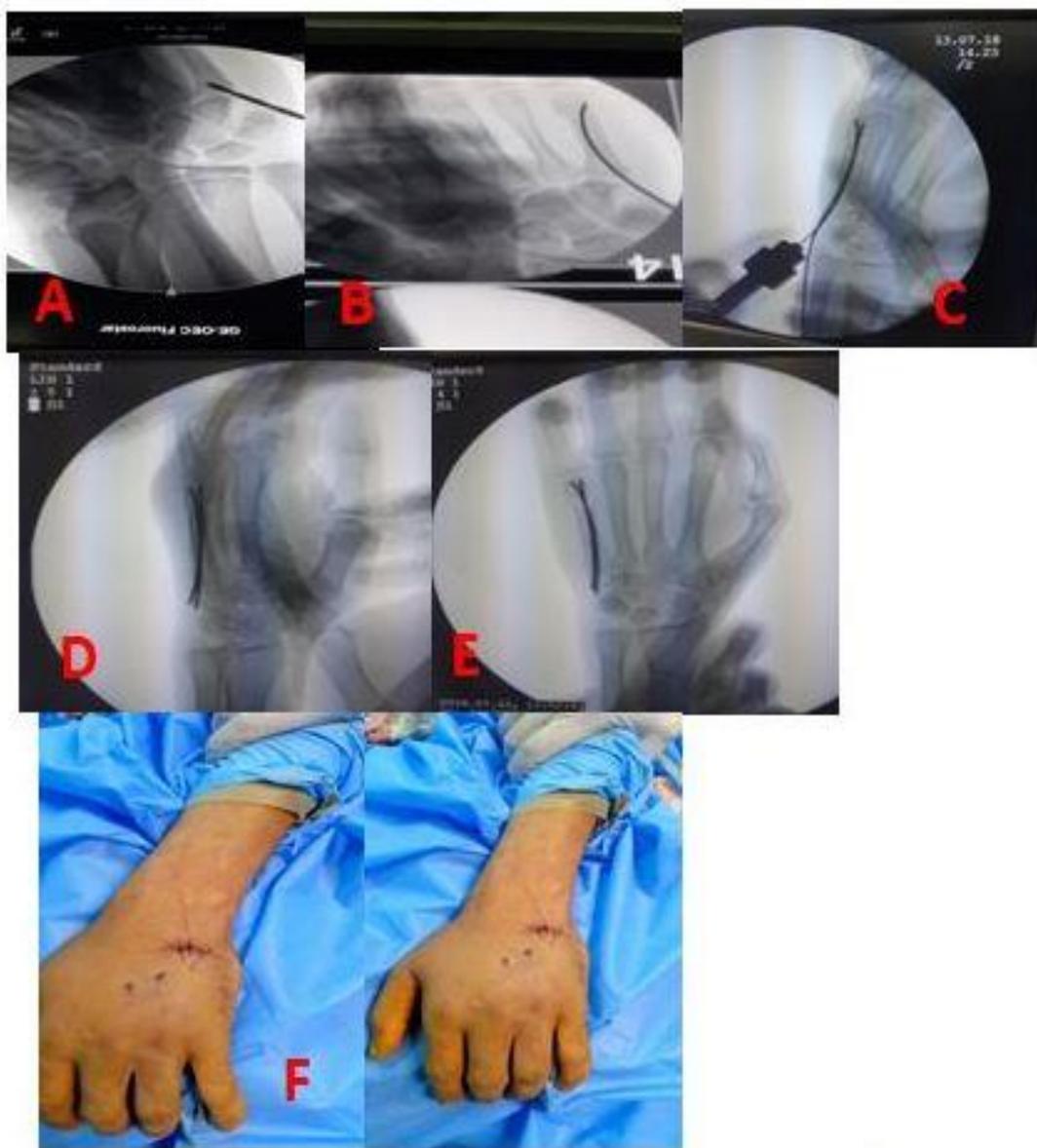
Fractured MCP	No. of patients
5 <sup>th</sup>	11
4 <sup>th</sup>	4
3 <sup>rd</sup>	3
2 <sup>nd</sup>	2

## Surgical Technique

All patients were operated upon while lying in a supine position with the injured upper limb placed on a radiolucent table position perpendicular to the patient's body. General anesthesia, nerve blocked or brachial plexus block all had been used. A 2-cm arciform incision is made proximal to the base of the metacarpal a hole is made through the ulnar cortex with the drill directed distally to open the canal (**Fig. 1A**), Closed reduction of the metacarpal fracture was done using the conventional methods of reductions by traction and fracture manipulation or Jahss maneuver for neck fractures, reduction clamp may be used percutaneously in some fractures as spiral fractures to reduce the fracture anatomically, the most important step is to correct the rotational deformity.

After reduction is checked under image intensifier percutaneous fixation using two round-tip K-wires (0.8 mm), the first K-wire is bent at one end to control the direction of introduction and are gently curved lengthwise and is driven in the medulla using the T handle then the 2nd one is introduced (**Fig 1B, C**).After the two wires are successively driven through the medullary canal, they placed in divergent directions so that they separate in the metacarpal head as a "flower bouquet".

Final fluoroscopic checks for the adequacy of fracture fixation (**Fig. 1D, E**) and clinical check for rotational position of the finger in extended and semi flexed position were carried out (**Fig. 1F**) then the K-wires were cut and buried under the skin. A short arm splint was applied in an intrinsic plus position



**Fig. 1:** surgical technique: (A) a hole is made through the ulnar cortex with the drill directed distally to open the canal at the base of the 5th metacarpal, (B,C) ) steps of wires insertion. B: insertion of the 1<sup>st</sup> wire C: insertion of the 2<sup>nd</sup> wire, (D,E,) final intra-operative fluoroscopic images, (F) clinical photo showing correction of rotational deformity

### **Postoperative care**

The splint is applied for two weeks in order to assist healing of the soft tissues. Patients were discharged on the same day from the hospital. The wound was reexamined after 1 week and splint changed after two weeks to short below elbow splint down to the

MCP joint and patients encouraged to start active fingers flexion and extension while in short splint for 2 weeks (**Fig. 2**). Then splint was removed, patients continued active ROM with wires in place till union achieved (**Fig. 3**)



**Fig. 2:** ROM in short splint after 2 weeks with corrected rotational deformity of the 5<sup>th</sup> finger



**Fig. 3:** functional outcome of the patient at 4 weeks post-operative. The patient had near full range of motion in the metacarpophalangeal and interphalangeal joints.

All patients were evaluated radiologically every 2 weeks till union, then the wires were removed (usually from 6 to 8 weeks postoperatively) and full motion and

functional activities were allowed. Subjective evaluation consisted of recording pain using (visual analogue scale) and limitation of daily activities using (Quick DASH score). The

range of movement of MCP, PIP, DIP joints were measured with a standard hand goniometer for both hands and the amount of loss was calculated in degrees. Testing grip strength, we pump a blood pressure cuff to 20 mm hg and ask the patient to squeeze it together as tightly as possible.

## Results

The mean operative time was 26.5(±7.797) minutes. The mean follow-up period was 11.6 (±1.31) weeks. Bony union achieved at an average of 7.4(±0.754) weeks ranging from 6 to 8 weeks. At the final follow-up, all patients had almost full extension and 90 degree flexion of the metacarpophalangeal joint and full flexion of the interphalangeal joints with mean total active range of motion 260.5°

(245°- 270°). None of the patients had any clinically detectable rotational deformity, functional outcome was satisfactory with mean grip strength of the injured hand 96% in comparison to the non-injured side, average Quick Dash score was 1.45 (± 1.2) ranging from zero to 4 points. The mean visual analogue score for pain was 0.85 (± 0.8). All patients returned to their ordinary jobs and were cosmetically and functionally satisfied with the results of their surgery. One patient presented with stiffness and improved gradually with physiotherapy. one patient united with 10° angulation of the 5<sup>th</sup> metacarpal without any functional affection or extension lag. No other complications reported.



Fig. 4: 25 y male patient with transverse fracture 4<sup>th</sup> metacarpal A: preoperative x-ray, B: post-operative x-ray, C: ROM after removal of the wires



Fig. 5: 22 y male patient with oblique fracture 5<sup>th</sup> metacarpal A: pre-operative x-ray, B: intra-operative x-ray showing reduction of the fracture neck of the 5<sup>nd</sup> MTC using two intramedullary k-wires 1.2 mm., C: Follow up x-rays (AP, oblique and lateral) views showing fully united fracture in accepted position 10 weeks post-operative.

## Discussion

Selection of the optimal treatment depends on many factors, including fracture location (intra-articular versus extra-articular), fracture geometry (transverse, spiral or oblique, comminuted), deformity (angular, rotational, shortening), whether the fracture is open or closed, whether osseous and soft tissue injuries are associated, and intrinsic fracture stability. Regardless of the preferred mode of treatment, its goal should be full and rapid restoration of function.(5)

. Most cases can be managed with conservative methods after closed reduction; however, surgical intervention is indicated when an unacceptable reduction persists. Metacarpal shortening and malrotation are extremely important factors in the final clinical outcome in any traumatized hand. Shortening of the metacarpal by as much as 2 mm leads to an extensor lag of 7° and a 8% grip strength loss. Also rotational deformity of the metacarpals is poorly tolerated as the rotated finger tends to get impinged or overlapped with the other fingers.(6)

Multiple surgical procedure have been described for treatment of metacarpal shaft fractures including K-wires, circulage wires, intramedullary nail, tension band wires, lag

screws, plating and external fixators. Of these methods K-wires fixation is a popular choice due to its simplicity and minimal soft tissue handling. Therefore, multiple techniques have been described for fixation using K-wires such as crossing wires, intramedullary antegrade and retrograde wires insertion, transverse wiring and Bouquet osteosynthesis.(7)

Plate fixation of metacarpal fractures has high complications rate. Meyer et al reviewed 81 patient with metacarpal fractures treated with plate and screw, Twenty-eight of 81 patients (35%) and 33 of 104 fractures (32%) had one or more complications. 15 of 81 patients (19%) and 20 of 104 fractures (19%) had one or more major complication. Thirteen of 81 patients (16%) and 13 of 104 fractures (13%) had one or more minor complication. Twelve patients (15%) experienced difficulty with fracture healing. There were six delayed unions and six nonunions. Eight patients (10%) experienced functionally important stiffness with a TAM 180 degrees, and five required a second operation to improve range of motion. Plate loosening or breakage occurred in seven patients (8%), and hardware removal was necessary in two patients who were symptomatic.(8)

Page and Stern reviewed 66 metacarpal fractures treated with plates and screws revealed a 36 % complication rate. Stiffness was the most commonly reported complication, with 76 % of patients studied reported to have total active motion less than 220°. Sixteen percent of complications reported involved a minor extensor lag, while 7.9 % had contractures, followed by major extensor lag in 6.3 % of complications. More serious complications are rare, with nonunion, infection and tendon rupture each comprising 1.6 % of complications reported.(9)

In 2018 Lorenzo et al., published their result over 150 patients treated with antegrade intramedullary K-wires for fixation of metacarpal fractures, the mean duration of surgery was 14 min ( range 4 – 33 min), Q-DASH score showed an average value of 12.3 points (range, 0 to 37 points), Bone union was observed in each patient after a mean time of 4.7 weeks (4 to 7 wks). Rotational deformity was observed in 8 patients, A total of 12 patients developed a superficial pin site infection/inflammation, all of which resolved after treatment with oral antibiotics.(10)

In 2013 Potenza et al. used transverse wiring technique in management of 35 case with metacarpal fractures. At 8 weeks post-operative union was achieved in almost all patient. In five cases, a minor local infection

occurred at the site of introduction of the K-wires, and it was treated successfully with antibiotic therapy. In two patients, a slight limitation of the extension of the fifth MP joint of less than 108 was observed, although they did not report any significant impairment of their hand function. residual palmar angulation of the head of the fifth metacarpal was found in three patients, averaging 78 (range 5–138)(21).In 2007 Choi and Song published the results of their study using transverse K-wires for fixation of metacarpal fractures in 34 patients. Three cases united with angulation over 20 degrees; five cases had skin problems around the tips of the K-wires. Three cases had residual rotational deformity. One case was not united and the K-wires were removed and treated by plate and screws. (11)

Bouquet osteosynthesis (multiple intramedullary flexible wires fixation for metacarpal fractures) was first described by Foucher and had very good result over the last two decades. In 1995, Foucher performed his study over 66 patient with unstable metacarpal fractures treated by antegrade intramedullary pinning. All the patient returned to their normal activity with normal strength in 61 patient and decreased by 11% in the remaining cases. Postoperative complications were infrequent. (12)

In the study done in 2014 bouquet pinning was performed in 41 patient with unstable metacarpal fractures. The mean TAM was 260° with grip strength (kg) 49. The overall VAS satisfaction (0-100, 100 best) was 100 and mean Quick DASH score (0 – 100, 0 best) was 0 ranging from (0 - 41). Only two patient developed superficial pin tract infections whom managed with oral antibiotics and 2 cases suffered from pin migration. 4 patients had mild rotational deformity at 1 year follow up but it was not impairing the functional outcome and not required surgical intervention. (13)

In 2007 a prospective randomized controlled trial was performed, which demonstrated that 18 patient operated with antegrade bouquet pinning had a slightly better total active motion (TAM) of the 5<sup>th</sup> finger and better ROM in the 5<sup>th</sup> MP joint than 18 patient treated with transverse pinning at final short follow-up after 3 months. The differences were only 18 and 12° respectively.(13)

In 2018 researchers published their study in which 30 patients with boxer's fracture managed with simplified bouquet technique using single thick K-wire. The mean operative time was 14 min (7-28 min). After 3 months follow up, all fractures healed with mean TAM 264°. No infection, 2ry displacement, K-

wire migration nor injury to sensory branch of ulnar nerve was evidenced(15).

A comparative study between intramedullary (Bouquets) pinning and low profile plate fixation of metacarpal fractures in 30 patients was made in 2012. Fifteen patients managed with intramedullary pinning and 15 patients managed with open reduction and plate fixation. Bone union was achieved successfully in all patients. Average periods to bone union were 2.3 months in the intramedullary fixation and 2.0 months in the plate fixation. There was no significant difference between the two groups. Patients with intramedullary nails acquired better postoperative range of finger motion. % TAM at the 3 months follow-up in the patients with intramedullary nails showed a significant increase compared to plate fixation group. Regarding range of motion at the metacarpophalangeal joint, % MP joint at 6 and 12 months of postoperative periods showed a significant increase in the patients with intramedullary nails compared to plate fixation. On the other hand, Postoperative grip strength was better in low-profile plate group. At 6 and 12 months postoperatively, there was a trend to be superior in grip strength after plate fixation, with no significant difference between the two groups. The reported complications however for ORIF and K-wire

fixation in the treatment of single, closed metacarpal shaft fracture were unremarkably different for the two types of fixation. ORIF was associated with a considerable number of functional restricting complications as stiffness, adhesions, and consequent reoperation with lower TAM than Bouquet pinning K-wire group, whereas, K-wire fixation resulting in superficial infection treated conservatively. The significance of these reported complication suggested that ORIF might be less preferable technique in comparison with intramedullary pinning in the treatment of metacarpal shaft fractures.(16)

In the current study, the mean total active motion (TAM) was 260.6° (245°-270°). None of the patient had any clinically detectable rotational deformity, which was in line with another study (13) with TAM 262°. In bouquet pinning group and 264° in transverse wiring group, and better than TAM in Moon et al. comparative study (17) with the intramedullary pinning group that was 250° and 245° in the transverse wiring group. While in another study .(15), single thick

intramedullary K-wire (modified bouquet) was used and reported mean TAM 264° when compared with the healthy side. While when they used plate and screws for fixation, lower TAM of 180°, (8) was reported. Other researchers (9) reported 76% of patients to have TAM with less than 220° while some other study (18) reported TAM of 225°. **(Table 4).**

The average Quick DASH score of the current study was 1.45 (±1.23) ranging from zero to 4 points which again was in line with the study done in 2015 (13) in both groups which had Quick DASH score of 0 point (0-41) and was like the results of the recent study done in 2018 (10) with antegrade intramedullary wiring which showed a score of 12.3 points (range, 0 to 37 points). In 2013 it was shown that the average DASH score of 8.7 with modified retrograde percutaneous intramedullary K-wire (20). When plate and screws were used, it was reported (18 & 19) that the mean DASH score 8.07 and 5 points respectively.

**Table (4):** Functional outcome of different studies with different surgical technique

	Surgical technique	TAM	Quick DASH
<b>Current study</b>	Bouquet pinning	260.6°	1.45
<b>Amsallem et al.(15)</b>	Modified Bouquet	265	N/A*
<b>Lorenzo et al.(10)</b>	Antegrade intramedullary K-wires	N/A*	12.3
<b>Sletten et al.(13)</b>	Bouquet pinning	262°	1
	Ts. Pinning group	264°	1
<b>Moon et al.(17)</b>	Intramedullary pinning group	250°	N/A*
	Ts. Pinning group	245°	N/A*
<b>Ozer et al.(18)</b>	Plate and screws	225°	8.07 DASH
<b>Meyer et al.(8)</b>	Plate and screws	180°	N/A*
<b>Page and Stern.( 9)</b>	Plate and screws	< 220°	N/A*
<b>Westbrook et al.(19)</b>	Plate and screws	N/A*	5 DASH

\*N/A: *not available in the study*

The complication rete was low in the 20 patient of the current study when compared to the other studies (**Table 5**) with only one patient had stiffness and improved gradually with physiotherapy and another patient united with 10° angulation of the 5<sup>th</sup> metacarpal without any functional affection or extension lag. In the other studies using Bouquet pinning, it was found that 2/41 patient pin tract infection, 2/41 patient had pin migration and 4/41 patient had mild rotational deformity (13). One fracture was revised for failed fixation and reported three cases with superficial wound infection with surrounding cellulitis and two patients had mild extensor lag of about 15°. (1)

In other studies using different techniques, Lee et al reported 4/56 patients developed

extensor tendon irritation during follow-up, 3/56 patients developed a superficial pin site infection, 5/56 patients had some stiffness after fixation of metacarpal fractures using multiple retrograde K-wires(20). In the study done using antegrade intramedullary K-wire for fixation of metacarpal fractures reported 8/150 patients had rotational deformity and 12/150 patients developed pin tract infection. (10)

Using transverse wiring technique, a group of researchers found 3/22 patient pin tract infection(17), others found 8/45 patient pin tract infection (13). Also, some reported 5/35 a minor local infection occurred at the site of introduction of the K-wires, 2/35 patients a slight limitation of the extension of the fifth

MP joint and 3/35 patients residual palmar angulation of the head of the fifth metacarpal (21).Choi and Song found three cases united with angulation of over 20° and five cases had pin tract infection <sup>(53)</sup>. While in the study done previously there was 5/25 patients with skin irritation at the site of K-wire insertion.(11)

When the plate and screws for fixation of metacarpal shaft fractures were used, it was found that 5 cases with stiffness and adhesions requiring reoperation for tenolysis (18,19) while in the study done 1998, (9) it was reported that there was a 36% complication rate with plate and screws fixation (**Table 5**)

**Table (5):** complication of current study compared with other studies.

	Surgical technique	Cases No.	Complications
<b>Current study</b>	Bouquet pinning	20	No major complications 1 superficial infection 1 mild stiffness
<b>stletten et al.(13)</b>	Bouquet pinning	41	2 PTF* 2 pin migration 4 mild rotational deformity
<b>Mohammed et al.(1)</b>	Modified Bouquet pinning	20	3 PTF* 2 mild extensor lag of 15° 1 revised for failed fixation
<b>Lee et al.(20)</b>	Retrograde multiple K-wire	56	3 PTF* 6 temporary stiffness 1 palsy of sensory branch of ulnar nerve
<b>Lorinzo et al.(10)</b>	antegrade intramedullary K-wire	150	12 PTF* 8 rotational deformity
<b>Moon et al.(17)</b>	Ts. Wiring	22	3 PTF*
<b>Choi and Song.(11)</b>	Ts. Wiring	34	3 united with angulation of over 20° 5 PTF*
<b>Ozer et al.(18)</b>	Plate and screws	14	5 stiffness & adhesions
<b>Page and Stern.( 9)</b>	Plate and screws	66	36% of cases
<b>Westbrook et al.(19)</b>	Plate and screws	22	5 stiffness & adhesions

*\*PTF: pin tract infection*

The current study confirms that functional and radiological results using transverse K wires technique was excellent and statistically comparable to other techniques. We believe in this because it is relatively simple and rapid to perform (28 minutes average) with no soft

tissue dissection, more biological avoiding damage to the periosteal blood supply which allows predictable bony union in metacarpal shaft fracture. While in metacarpal neck fractures, Placement of the wire away from the MP joint had very good results.

In our study 20 patients most of them were men, average age of 30 years old had trauma mostly to their dominant hand resulting in unstable metacarpal fracture and were treated by transverse k wires technique resulting in 100% bony union within 6.8 weeks average with maximum 2 weeks duration of immobilization. We encouraged patients to start early active range of motion in IP joints, which result in almost normal range of motion within 3 months, and almost normal grip strength allowing early return to work for manual workers or return to school for students. Clinical and radiologic results were excellent without any major complications. The limitations of this study were the number of cases that was relatively small, and the short period of follow-up and lack of direct comparison with another fixation method.

## Conclusion

Despite the availability of many options for fixation, percutaneous fixation using Bouquet technique is a good method for treatment of unstable ulnar four metacarpal fractures. We recommended this technique, which is more biological, technically easier, safe, cheap and rapid to perform with good functional outcome.

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