BENHA MEDICAL JOURNAL bmj

Print ISSN 1110-208X

Online ISSN 2357-0016

Original article

Comparative Study between Results of Fixation of Metacarpal Fractures Using Bouquet Technique versus Transverse Pinning

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Received:

Accepted:

Abstract

Background: Metacarpal fractures represent a significant portion of hand injuries, affecting predominantly the active working population. The choice of fixation technique can influence recovery outcomes, balancing the need for rapid rehabilitation with minimal complications. **This study aimed to** compare the functional, clinical, and radiological outcomes of metacarpal fracture fixation using the Bouquet technique versus transverse pinning. **Methods:** This prospective cohort study conducted on 40 patients who were candidate for operative treatment of metacarpal fractures at Benha University Hospitals during the period from November 2022 to November 2023. Patients were divided into two groups; group I: 20 patients treated using Bouquet technique and group II: 20 patients treated using transverse K wire. **Results**: No significant difference was observed between the two groups in terms of total active motion (TAM) with Group A (Bouquet) having a mean TAM of 215.4±13.1° versus Group B (transverse pinning) at 213.5±13.2° (p=0.166). Hand grip strength also showed no significant difference (Group A: 225.2±42 mmHg, Group B: 223.3±41.8 mmHg; p=0.457). The time to union and complication rates was similar across groups. **Conclusion:** Both the Bouquet technique and transverse pinning are effective methods for the fixation of metacarpal fractures. The Bouquet technique showed a slight advantage in terms of pain relief and range of motion, but overall, both techniques showed comparable outcomes in fracture healing, alignment, and complications.

Keywords: Fixation; Metacarpal Fractures; Bouquet Technique; Transverse Pinning.

Introduction

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 which is the most commonly involved (1).

Most metacarpal fractures occur in the active and working population, particularly adolescents and adults. Incidence of trauma to the hand has increased for the years, frequently that resulting in metacarpal fractures (2).

Many factors, such as delicate handling of tissues, preservation of gliding planes for tendons, prevention of infection and early and appropriate physiotherapy other than accurate reduction and fixation affect recovery of good mobility (3).

Metacarpal fractures can be complicated by deformity from no treatment, stiffness from over treatment and both deformity and stiffness from poor treatment (4).

Bouquet osteosynthesis, introduced by Foucher, employs flexible wires for minimally invasive metacarpal fracture repair. This technique preserves the metacarpophalangeal (MP) joint and has been validated for stability in biomechanical studies. It's effective for fixing fractures, including those of the neck and head, without soft tissue violation (5).

Intramedullary K-wire fixation is mainly used in sub capital fractures of the metacarpals, especially the fifth metacarpal (“Boxer's fracture”). With this technique, impairment of tendon gliding over a distally placed implant on the bone is avoided. Minimally invasive techniques with Kirschner wires is an attractive option, as extensive surgical dissection soft tissue devitalization 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, although this complication has still been reported with K-wire fixation (6).

The purpose of this study was to evaluate and compare the functional, clinical and radiological outcome of Fixation of metacarpal fractures using closed reduction and fixation by multiple intramedullary flexible wires (Bouquet technique) versus fixation by transverse K wire.

Patients and methods

This prospective cohort study conducted on 40 patients who were candidate for operative treatment of metacarpal fractures at Benha University Hospitals during the period from November 2022 to November 2023. Patients were divided into two groups; group I: 20 patients treated using Bouquet technique and group II: 20 patients treated using transverse K wire.

Inclusion criteria were patients with isolated or multiple metacarpal fractures, irreducible or unstable fracture,

angulation of the fracture greater than 30 degrees, rotational deformity greater than 10 degrees and gross (>5mm) shorting of the metacarpal.

Exclusion criteria were patient with old fracture, non-united metacarpal fractures, intra-articular metacarpal fracture, comminuted metacarpal fracture, non-displaced metacarpal fracture, stable metacarpal fracture and neurovascular injury.

All patients were subjected to comprehensive clinical evaluation including personal history, history of present illness, past history and medical comorbidities including any prior injuries or surgeries that might impact the fracture healing process were noted and finally, local and neurovascular assessment to evaluate its current condition and signs of swelling, tenderness, deformity, or other local anomalies and to ensure proper nerve function and blood circulation in the affected limb.

Radiological Evaluation: X-ray imaging was employed to capture detailed views of the hand and wrist, specifically focusing on the metacarpal fracture site. Standard anteroposterior (AP) views of the hand and wrist were taken for each patient. Oblique views of the hand and wrist were also obtained to provide additional perspectives on the fracture.

Operative Intervention: Patient received Anesthesia according to patient status and compliance. They were positioned supine with the affected arm on a radiolucent table for optimal access and imaging. Intraoperative imaging was facilitated by a C-arm fluoroscopy system, offering real-time X-ray visuals to assist in accurately placing fixation devices and visualizing the fracture site.

Surgical technique:

Transverse pinning technique: In the preparation phase, both the ventral and dorsal sides of the hand and forearm were sterilized and draped, exposing only the necessary surgical area. The treatment involved reducing a displaced fifth metacarpal shaft fracture through traction, followed by the precise insertion of a smooth K-wire under fluoroscopic guidance to stabilize the fracture by connecting the fifth and fourth metacarpals. Additional K-wires were placed as needed for optimal stabilization. The procedure was meticulously monitored using fluoroscopy to ensure accurate positioning of the wires and fracture reduction. Post-operation, the patient's hand was secured in an extended below-elbow dorsal splint to maintain a functional position, with the K-wires positioned for easy removal at a later stage (7).

Bouquet technique: patients were placed in a supine position with their affected limb on a radiolucent table, and anesthesia was administered via general, nerve block, or brachial plexus block methods. A 2-cm arciform incision was

made near the metacarpal base, followed by drilling through the ulnar cortex to access the canal. Metacarpal fractures were then reduced using traditional traction, manipulation, or Jahss maneuver techniques, with a reduction clamp for anatomical alignment in specific cases like spiral fractures, emphasizing correction of rotational deformity.

The reduction's accuracy was confirmed using an image intensifier. Percutaneous fixation was achieved with two curved, round-tip K-wires, introduced through the medullary canal in divergent directions to form a "flower bouquet" arrangement, ensuring stable fixation (8). Final fluoroscopic checks for the adequacy of fracture fixation and clinical check for rotational position of the finger in extended and semi flexed position were carried out then the K-wires were cut and buried under the skin. A short arm splint was applied in an intrinsic plus position (9).

Post-operative follow up and rehabilitation: Post-surgery, patients were monitored and followed up to track healing. A rehabilitation plan was tailored for each, starting with a splint for two weeks to aid soft tissue recovery, followed by discharge on the same day. At one week, the wound was checked; after two weeks, a shorter splint was used to encourage finger movements for another two weeks.

Upon splint removal, active exercises continued until bone union, checked radiologically every 2 weeks, with wire removal at 6 to 8 weeks. Recovery assessment included pain (Visual Analogue Scale), activity limitations (Quick DASH score), joint movement (measured with a goniometer), and grip strength (tested using a blood pressure cuff).

Assessment of results: Postoperative radiological assessment of fracture healing and alignment of metacarpals. Delayed union and nonunion were evaluated according to new Non-Union Scoring System (NUSS). Clinical assessment was based on **Belsky's criteria**; these criteria depend on pain, bone union, angular or rotatory deformity, and total active movement (TAM). Total active motion (TAM) is the sum of the active metacarpophalangeal (MP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) arc of motion in degrees of an individual digit. The normal range of TAM is 250 to 280 degrees (10).

Approval code: MS 10-2-2022

Statistical analysis

The study's data were analyzed using IBM SPSS Statistics for Windows, Version 25.0, through processes of revision, coding, and tabulation. The Shapiro-Wilk test checked data normality. Descriptive statistics included mean, standard deviation, median, and range for numerical data, and frequency and percentage for non-numerical data.

Analytically, the Student T Test, Chi-Square test, and Mann Whitney Test evaluated differences between groups and relationships between variables. A p-value of less than 0.05 was deemed significant at a 95% confidence interval, guiding the statistical significance of the findings.

Results

The current study was carried on 40 patients with metacarpal fractures, they were divided according to type of intervention into two groups: **Group I (n=20):** treated using Bouquet technique, **Group II (n=20):** treated using transverse k wire.

The mean age of group A was 35.7±8 years, while the mean age of group B was 34.7±8 years. Males represented 85% of group A and 80% of group B. No significant difference between the two studied groups according to age and gender. According to cause of injury, in group A (60%) had a mechanism of injury that involved a punch, (20%) had a fall, (10%) had a road traffic accident (RTA), and (10%) had a direct injury.

For group B, (50%) had a mechanism of injury that involved a punch, (30%) had a fall, (15%) had an RTA, and (5%) had a direct injury. No significant difference between the studied groups according to cause of injury. For group A, (60%) had a transverse fracture, and (40%) had an oblique fracture. For group B, (60%) had a transverse fracture, (35%) had an oblique fracture, with no significant difference between the studied groups. **Table 1**

Postoperative assessment revealed no significant difference between both groups according to total active motion (TAM). Mean TAM in group A was slightly higher (215.4±13.1°) compared to Group B (213.5±13.2°). **Table 2**

Postoperative assessment revealed no significant difference between both groups according to hand grip strength. Mean hand grip in group A was slightly higher in Group A (225.2±42 mmHg) compared to Group B (223.3±41.8 mmHg). **Table 3**

The results based on Belsky score was excellent, good and poor among 80.0%, 15% and 5% in group A respectively, compared to 75%, 20% and 5% in group B with the same order. **Table 4**

The mean time to union for group A was 9.7±2 weeks, while for Group B, the mean time was 9.3±2.5 weeks with no significant difference between the two groups. The majority of cases in both groups had no complications. In Group A one patient had non-union, and 2 had pin site infection. For Group B, 3 patients had pin site infection, and 1 had stiffness. **Table 5**

Case Presentation:

A 40-year-old male worker underwent surgical intervention for a closed fracture of the 5th metacarpal bone neck using the intramedullary K-wires retrograde technique three days post-injury. The

procedure was successful without any post-operative complications. After 12 weeks, the patient achieved an excellent Total Active Motion (TAM) score of 255 and hand grip strength of 90 mm Hg, indicating a strong recovery. **Figure 1, 2 and 3**

Table 1. Demographic data, mechanism of injury and fracture type of the studied groups.

Variable		Group A (n=20)	Group B (n=20)	Test	p
Age (years)	Mean ± SD	35.7±8	34.7±8	t=0.397	0.694
	Median (Range)	38(20-49)	37(19-48)		
Gender, n (%)	Female	3 (15%)	4 (20%)	X^2=0.173	0.677
	Male	17 (85%)	16 (80%)		
Mechanism of injury, n (%)	Punch	12 (60%)	10 (50%)	1.115	0.773
	Fall	4 (20%)	6 (30%)		
	RTA	2 (10%)	3 (15%)		
	Direct	2 (10%)	1 (5%)		
Type of fracture, n (%)	Transverse	12 (60%)	12 (60%)	1.067	0.587
	Oblique	8 (40%)	7 (35%)		

t= independent t test; X^2=Chi square test, RTA: Road traffic accident; Chi square test.

Table 2. Total active motion 6 months post operation

Variable		Group A (n=20)	Group B (n=20)	Test	p
TAM (°)	Mean ± SD	215.4±13.1	213.5±13.2	1.386	0.166
	Median (Range)	221(220-223)	219(219-222)		

Test: Mann Whitney test

Table 3. Hand grip strength in the studied groups

Variable		Group A (n=20)	Group B (n=20)	Test	p
Hand grip strength (mmHg)	Mean ± SD	225.2±42	223.3±41.8	0.744	0.457
	Median (Range)	250(206-254)	248(203-253)		

Test: Mann Whitney test.

Table 4. Belsky score 6 months post intervention in the studied groups

Variable		Group A (n=20)	Group B (n=20)	Test	p
Belsky score, n (%)	Excellent	16 (80%)	15 (75%)	0.175	0.916
	Good	3 (15%)	4 (20%)		
	Poor	1 (5%)	1 (5%)		

Test=Chi square test.
For Group A, the mean time

Table 5. Time lapse to union and complications in the studied groups

Variable		Group A (n=20)	Group B (n=20)	Test	p
Time to union (weeks)	Mean ± SD	9.7±2.0	9.3±2.5	0.764	0.445
	Median (Range)	9.5(6-13)	9(6-14)		
Complications, n (%)	No complications	17 (85%)	16 (80%)	2.230	0.526
	Non-union	1 (5%)	0 (0%)		
	Pin site infection	2 (10%)	3 (15%)		
	Stiffness	0 (0%)	1 (5%)		

Mann Whitney test; SD= standard deviation, Chi square test.

Figure 1: Preoperative X-ray.

Figure 2: Postoperative X-ray

Figure 3: Follow-up.

Discussion

Regarding patients' characteristics, our results agreed with a study found that surgical group had 22 patients, 21 males, and one female, with a mean age of 33.4 years (range 16–61 years). The conservative group had 19 patients, seventeen males, and two females, with a mean age of 33.8 years (range 19–58 years) (11).

Another study reported that that both groups were comparable as regard to patient age, gender and occupation, with males and manual workers represents the majority in both groups [males represented 86.7% of group 1 and 80.0% of group 2, while manual workers represented 66.7% and 46.7% of groups 1 and 2 respectively] (12).

According to cause of injury, a recent study supports our findings revealing that most patients had to punch a hard surface as trauma mode (n = 37). There was no significant difference in the side involved between the studied groups (11).

Regarding type of fracture, a study was parallel to our results reporting that the distribution of fracture types was comparable. Specifically, "Transverse" fractures were observed in 53.3% of cases in each group (8 instances each), while "Oblique" fractures were present in 46.7% of group 1 cases (7 instances) and 40.0% of group 2 cases (6 instances). Additionally, "Intra-articular" fractures were absent in group 1 but constitute 6.7% of cases (1 instance) in group 2. There was no significant difference in the distribution of fracture types between the groups (p = 0.58) (12).

Concerning total active motion, a parallel study found that the surgical group showed greater grip strength, with an average of 31.7 kg, compared to the conservative group's grip strength, which averaged at 22.4 kg. Nonetheless, this disparity did not show statistical significance (p = 0.21) (11).

Compatibly, a study found that in Group 1, the TAM score averages at 241.67, with a standard deviation of 24.54, and a range from 170 to 260. Similarly, in Group 2, the average TAM score is 237.67, with a standard deviation of 22.42, and a range between 170 and 260. Statistical analysis indicates no significant difference in TAM scores between the groups (p = 0.64). In group 1, the average strength is 92.00, with a standard deviation of 8.61, and a range from 70 to 100. In group 2, the average strength is slightly lower at 88.67, with a standard deviation of 8.33, and the same range from 70 to 100. Statistical analysis reveals no significant difference in hand grip strength between the two groups (p = 0.29) (12).

Similar results were reported by a study found that the mean TAM score was 250 for transverse group and 257 for intramedullary group in treatment of

closed fractures of metacarpal of little finger. They included 59 patients and follow up was for 24 months (13).

In addition, a study found that the mean of TAM score was 268 for intramedullary fixation of fifth metacarpal fractures and was 266 for intramedullary fixation of shaft of fifth metacarpal fractures with no statistically difference after studying on 56 patients for 3 months (14).

On the other side, a study reported that, the active range of motion of metacarpophalangeal joint was significantly different between the two procedures, with a better result in the intramedullary pinning group. This could be attributed to the fact that they measured their score 12 months postoperatively. Also, grip strength was stronger after intramedullary pinning than after transverse pinning, but the difference was not statistically significant where the mean for intramedullary was 92% of normal side and the mean for transverse group was 83% (15).

Regarding Belsky score, our study was comparable to a study which reported that the average time to union is compared, with the surgical group showing a mean of 9.1 weeks and the conservative group exhibiting a longer mean of 12.2 weeks. However, this difference is not statistically significant ($p = 0.20$) (11).

In consistent with our findings, a study found that in Group 1, the average time is 9.50 weeks, with a standard deviation of 2.62, and a range between 6 and 14 weeks. In Group 2, the average time is 9.53 weeks, with a standard deviation of 1.95, and the same range between 6 and 14 weeks with no statistical difference in time to union between the groups ($p = 0.96$) (12).

Similarly, a study also reported that the radiological union time for intramedullary and transverse group ranged from 6-16 weeks with mean 10 weeks for the two groups (13).

On the other side, a study reported that, the time of union in intramedullary nail group was 5.4 weeks and the time of union in percutaneous k-wires group was 5.2 weeks with no significant difference. Their results support the comparable outcome between both techniques. However, the duration of union is so short when compared to the present study and others in literature (16).

Regarding complications, our study was in harmony with a study reporting that in Group 1, 80.0% of cases have no complications, compared to 66.7% in group 2. Non-union is reported in 6.7% of cases in Group 1 and none in Group 2. Pin site infection is observed in 13.3% of group 1 cases and 26.7% of Group 2 cases. Additionally, stiffness is reported in 6.7% of group 2 cases, while no cases exhibit stiffness in group 1 with no significant difference in the distribution

of complications between the groups (p = 0.41) (12).

A study reported one patient in percutaneous group had stiffness of injured finger, while one patient in intramedullary group had K-wire migration which required early removal and treated with brace (13).

Another study reported that there was no postoperative infection or digital neuropraxia in either group. One patient in the transverse group developed complex regional pain syndrome type 1 after having worn his splint for 4 weeks without coming for review (15).

Of note, previous studies reported comparable results. For example, one reported excellent functional and radiographic outcomes in a series of patients affected by unstable metacarpal fractures treated with percutaneous transverse fixation with K-wires (17). While another one reported that in the boxer's fracture, intramedullary pinning gave better functional outcomes than transverse pinning, although they concluded that intramedullary pinning is technically more demanding than transverse pinning and the surgeon has a more definite learning curve (15).

Furthermore, a study reported that the main advantage of percutaneous transverse K-wire fixation or intramedullary K-wires in treating the Boxer's fracture is the avoidance of the complications occurring after open reduction and internal fixation, including infection, difficulties with fracture healing, stiffness due to extensive soft tissue dissection and later, fibrosis and extensor tendon adhesion, plate loosening or breakage and complex regional pain syndrome (18).

The study is limited by its small sample size and single-center nature, potentially affecting the generalizability of results. The follow-up period might not fully capture long-term outcomes, and the subjective measures used could introduce bias. Further, multicenter studies with larger samples and extended follow-up are needed to confirm these findings.

Conclusion

Both the Bouquet technique and transverse pinning are effective methods for the fixation of metacarpal fractures. The Bouquet technique showed a slight advantage in terms of pain relief and range of motion, but overall, both techniques showed comparable outcomes in fracture healing, alignment, and complications.

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to cite this article: Mohamed G. Montaser, Osama M. Essawy, Mohamed A. Abd Elbaky, Mohammed A. Ahmed. Comparative Study between Results of Fixation of Metacarpal Fractures Using Bouquet Technique versus Transverse Pinning. BMFJ XXX, DOI: 10.21608/bmfj.2024.278264.2046