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Comparative Study Between Results of Fixation of Unstable Metacarpal Fractures Using Bouquet Technique Versus Mini-plate and Screws

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Abstract

Metacarpal fractures are difficult to treat since there is no clear evidence on the optimal course of action. The goal of this research was to compare the clinical and radiological outcomes of displaced metacarpal fractures treated with an antegrade intramedullary nail (Bouquet procedure) vs a low-profile micro plate. Methods: A total of 20 metacarpal fractures were deemed surgically fixable, and 10 were treated using the Bouquet approach (antegrade intramedullary nailing) (group I), whereas the other 10 were treated using the low profile micro plate (group II). For one year, all patients were followed up on subjective and objective criteria (PVAS, Q-DASH, grip strength TAM, blesky score radiography (union and residual deformity), complications, operational time, and time to union) to evaluate the success of the procedure. Time to radiological union was not significantly different between PVAS, Q-DASH, and TAM. Remaining malformations or grip strength blesky score In the k-wire group, operative time and time off work were dramatically reduced. It was found that antegrade intramedullary K-wire nailing (Bouquet technique) was superior for the management of unstable metacarpal fractures because it required less operative time and anaesthesia. A low-cost, low-tech solution that does not upset the fractured biosphere.

Key words: Metacarpal, Bouquet, Mini-plate.

1. Introduction

About 18–44% of all hand fractures [1–2] are metacarpal fractures. Most metacarpal fractures are caused by non-thumb metacarpals, with the fifth finger accounting for around 88 percent of all metacarpal fractures.

[2–3] The majority of metacarpal fractures are seen in the active and working population, notably teenagers and young adults.

Although closed reduction and immobilisation may handle the majority of metacarpal fractures, certain unstable fractures will need surgical stabilisation. Fracture pattern shape and placement may guide surgical fixation. Kirschner wire fixation (transverse, crossing, or intramedullary), cerclage or intraosseous wiring, mini-plate or screw fixation, and external fixation [4] are the mainstays of therapy.

Many forms of metacarpal fractures do not have an agreed-upon, evidence-based therapy. It is important to keep in mind that even though one method is plainly superior, there are important aspects of each method to consider [5].

Even if a precise reduction and fixation is achieved, there are several aspects that contribute to optimal mobility, including meticulous treatment of tissues, maintenance of glide planes for tendons and avoidance of infection [6-7].

In this research, we will compare the use of closed reduction and percutaneous fixation by intramedullary Kirschner wires "Bouquet method" versus open reduction & internal fixation (ORIF) using micro plates to treat metacarpal fractures.

First developed by Foucher, Bouquet osteosyntesis (multiple flexible wires fixing for metacarpal fractures) has had excellent results over the last two decades. Pre-curved Kirschner wires (K-wires) are introduced into the decreased metacarpal head in three divergent directions using a closed approach anterograde intramedullary fixation [8]. An easy, safe, and less intrusive procedure for treating soft tissue injuries is the Bouquet technique [9]. "Bouquet method" may be used to treat metacarpal fractures, including neck and head fractures, without damaging the MP joint. Several biomechanical research [10-11] have shown that bending or rotational stability is adequate.

Because substantial surgical dissection and devitalization of the soft tissue at the fracture site may be avoided, minimally invasive procedures utilising Kirschner wires are an interesting choice. Extensor tenosynovitis is less likely with K-wire fixation, although extensor irritation by a dorsal plate is still a concern with this fixation technique [12].

Despite this, dorsal plate structures have shown to be more stable than previous approaches. ORIF with plates offers a stiff and biomechanically robust fixation, suitable for early mobility, letting the patient to return to their daily routines sooner. [13-14-15]. Extensor tendon gliding may be prevented by such implants, however the bone behind the plate might be stressed and metallosis can occur [16-17-18]. Often, further surgery is necessary to remove the plates, which may be especially challenging in certain circumstances. The low-profile plate has been shown to be successful in overcoming these drawbacks in recent studies [19-20].

2. Method

A prospective study was held in Benha university hospital including twenty patients who are candidate for operative treatment of metacarpal fractures. These patients were divided to two groups. Each group contained ten patients. One group is treated using Bouquet technique and the other group is treated using open reduction and internal fixation by mini plate.

Inclusion criteria

- Isolated or multiple shaft metacarpal fractures
- Irreducible or unstable fracture
- Angulation of the fracture greater than 30 degrees
- Rotational deformity greater than 10 degrees
- Gross (>5mm) shorting of the metacarpal

Exclusion criteria

- Patient with old fracture
- Non-united metacarpal fractures.
- Intra-articular metacarpal fracture.

Statistical methods

Data management and statistical analysis were done using SPSS version 28 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Shapiro Wilk test and direct data visualization methods. According to normality testing, quantitative data were summarized as means and standard deviations or medians and ranges for normally and non-normally distributed numerical variables, respectively. Categorical data were summarized as numbers and percentages. Quantitative data were compared between the study groups using independent t-test or Mann-Whitney U test for normally and non-normally distributed numerical variables, respectively. Categorical data were compared using Fisher's exact test. All statistical tests were two-sided. P values less than 0.05 were considered significant.

Surgical technique

The patients are placed in supine position with hand on a side hand table or directly on fluoroscopic device (C-arm). General anesthesia or regional nerve block was used .A pneumatic tourniquet was applied above the elbow of the involved limb.

In the (Bouquet technique) Antegrade Intramedullary Nailing (AIN) group 1:

A longitudinal 2-cm incision was made over dorsal aspect of the base of the involved the sensory nerve branches and longitudinal veins were protected along with the extensor tendon on site. A uni cortical hole was made through the dorso-ulnar cortex of the base of fifth or the dorsal cortex of the other metacarpals initially with a 2mm kirschner wire directed Perpendicular to open the cortex, avoiding perforation of the oppisite cortex. Then a 2.7 drill bit was used afterwards in a distal direction to widen the hole and open up the medulla. A drill sleeve was used to protect the relevant sensory nerve branches, the extensor tendons and to avoid slippage and damage to the carpo-metacarpal joint or volar structures. Two or three blunt ending K-wires of 0.8mm, or 1mm diameter were pre-bent Length-wise to achieve the 3-point fixation principle. The distal tips were bent upwards with pliers by about 20 degrees. Primary reduction was attempted by the "Jhass maneuver"

The primarily achieved reduction is checked under fluoroscopy and manually held in place.Wires were advanced manually into the head in a gentle manner to not perforate the thin cortex. Image intensifier was used to ensure the correct position (**Fig.1)**. Wires were then rotated in divergent directions so that they separate in the metacarpal head as a "flower bouquet". Meanwhile, malrotation was addressed and clinically rectified by carefully monitoring the parallelism of the planes of the fingernails in extension, whilst in flexion, all fingers were to be oriented pointing towards the scaphoid tubercle.

The K-wires were then bent at the level of the entry portal and cut, leaving sufficient length to allow easy secondary removal. The skin incision was closed and a light dressing was wrapped around the hand and a plaster of paris splint in the intrinsic functional position was applied(**Fig.2)**

Fig. (1) a pre bent k wire is inserted to the fracture border then Jahss maneuver is attempted to get reduction for further advancement of the blunt ended wire in to the head in reduced position. “note the dorsal cutenous branch of ulner nerve identified and protect by nylon sheath.

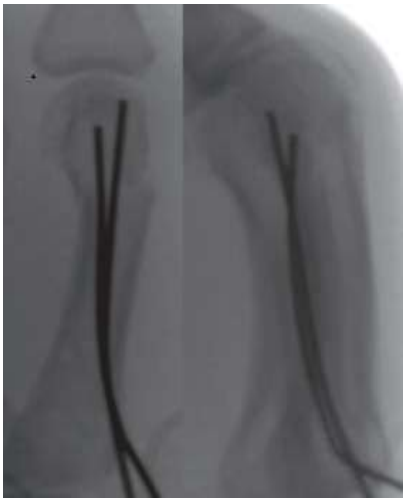

Fig. (2) final installment of kwires with their tips cut close to the bone buried followed by skin closure

In the Low profile mini plate (group 2)

a straight longitudinal dorsal skin incision was done in the interval between adjacent metacarpal bones with oblique distal extension. A dorso-ulnar incision in the same manner was done for the fifth metacarpal. meticulous soft tissue dissection for preservation of the sensory nerve branches imbedded in the subcutaneous tissue, the longitudinal veins, the extensor tendons and intertendinous connections on site **(Fig. 3)**.

The extensor tendons were retracted together with the surrounding loose connective tissue by blunt retractors and the intertendinous connections were divided**.** Partial detachment of the dorsal interosseous muscles from the fracture site and splitting the periosteum to clean fracture hematoma and interposed tissue. Hohmann levers were avoided to preserve volar structures. The same way as group 1 using Jhass technique. Reduction was maintained by introducing a disto-proximal retrograde non threaded 1.4 to 1.6 mm intramedullary Kirschner wire under fluoroscopy to keep the achieved alignment.

Fixation was achieved with plate and screws according to the standard AO technique with minimum of four cortices in each side of fracture using a 4-5 hole 1mm profiled plate. The central hole in the five holed plate was to bridge a comminution. The plate was properly placed on the dorsal surface of the involved metacarpal except for the fifth where plates were placed medial. Postero-anterior and lateral views were checked with fluoroscopy to ensure that the plate was placed exactly on the dorsum of the bone and exactly medial in case of the fifth metacarpal. Rotational alignment was also checked the same manner as in group one.

Then drilling using a 1.5 mm drill bit to the holes adjacent to the fracture line was done. Two 1.7 mm screws were inserted primarily of right length measured by depth gauge. Both are tightened making sure they engage with the far cortex and then the K-wire was removed and the rest of the screws were inserted. The implant was covered with the periosteum, as far as possible to minimize contact with the extensor tendons and the implant. If an intertendinous connection had been cut, it was repaired. No subcutenous sutures were taken to avoid adhesions. Skin was closed primarily

Fig. (3) Dorsoulnar approach to 5th metacarpal with identificatoion of dorsal sensory branch of the ulnar nerve

Fig. (4) Intraoperative figures of pre and post reduction – an dorosomedial comminution was handeled by two interfragmentary mini screws

Clinical evaluation

Patients were routinely evaluated in our clinic once every 4 weeks after surgery. Range of motion of the affected digit was measured by standard goniometer and evaluated as a proportion of total active motion (% TAM) compared with the contralateral side at the follow-up. Other objective assessments included measurement of grip strength and the presence of postsurgical complications. Grip strength was measured using a sphygmomanometer. Patients also evaluated using The Quick-DASH questionnaire , Pain Visual Analogue Scale (PVAS) and Belsky's criteria , this criteria depends on pain, bone union, angular or rotatory deformity, and total active movement

Radiological evaluation

Radiographs were taken preoperatively, and at 4, 8, 12, 16, and 20 weeks postoperatively to assess fracture deformity and healing. Bone union, which was defined as the disappearance of fracture lines,.

3.Results

Time of surgery

Time of surgery was significantly higher in group II (56 ±12 minutes) than group I (28 ±7 minutes) (P < 0.001). **(Table 1 & Fig. 5).**

Table (1) Time of surgery

		Group I (n = 10)	Group II (n = 10)	P-value
Time of surgery (minutes)	**Mean ±SD**	28 ±7	56 ±12	< 0.001*

Independent t-test was used *** Significant**

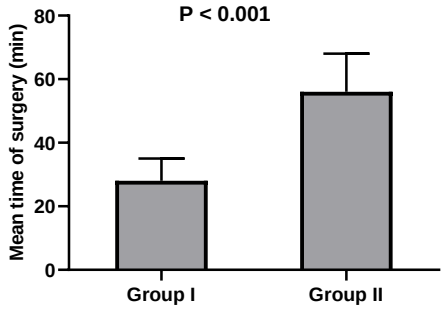

Fig. (5) Time of surgery in the studied groups

Active and passive ROM and total active range of movement

No significant differences were noted between both groups regarding active ROM (P = 0.460), passive ROM (P = 0.570), and TAM (P = 0.606) **(Table 2& Fig. 6).**

Table (2) Active and passive ROM and total active range of movement in the studied groups

		Group I (n = 10)	Group II (n = 10)	P-value
Active ROM %	**Mean ±SD**	0.92 ±0.05	0.94 ±0.04	0.460
Passive ROM	**Mean ±SD**	0.98 ±0.03	0.99 ±0.03	0.570
TAM	**Mean ±SD**	258 ±9	260 ±8	0.606

Independent t-test was used

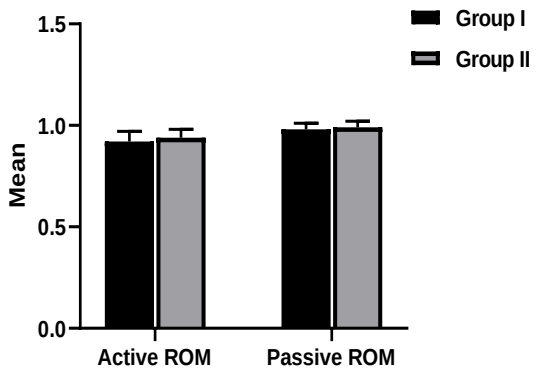

Fig. (6) Active and passive ROM in the studied groups.

Grip strength and dash and pain scores

No significant differences were noted between both groups regarding grip strength (P = 0.922), Dash score (P = 0.912), and pain score (P = 0.796) **(Table 3 & Fig. 7).**

Table (3) Grip strength and dash and pain scores in the studied groups.

		Group I (n = 10)	Group II (n = 10)	P-value
Grip strength (%)	**Mean ±SD**	96 ±5	95±4	0.922
Dash score	**Median (range)**	2 (0 - 4)	2 (0 - 4)	0.912
Pain score	**Median (range)**	1 (0 - 3)	1 (0 - 3)	0.796

Independent t-test was used for grip strength. Mann Whitney U test was used for Dash and pain scores

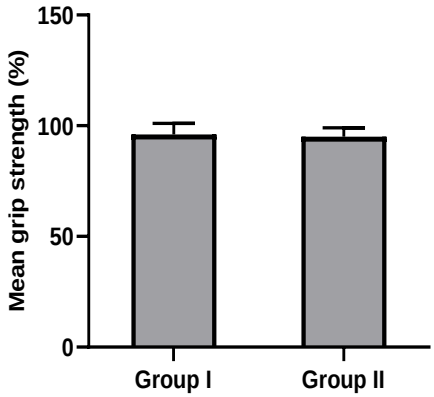

Fig. (7) Grip strength in the studied groups.

Follow up and union time

The mean follow-up time showed no significant difference between the studied groups (12 ±2 weeks in both groups) (P = 0.895). Also, the union time showed no significant difference between the studied groups (7 ±1 weeks in both groups) (P = 0.567) **(Table 4 & Fig. 8).**

Table (4) Follow up and union time in the studied groups.

		Group I (n = 10)	Group II (n = 10)	P-value
Follow up (weeks)	**Mean ±SD**	12 ±2	12 ±2	0.895
Union (weeks)	**Mean ±SD**	7 ±1	7 ±1	0.567

Independent t-test was used

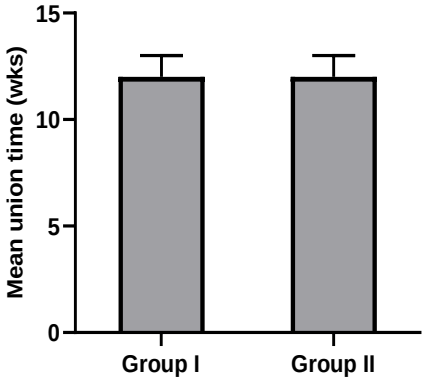

Fig. (8) Union time in the studied groups.

Belsky score and complications

Belsky's score and complications showed no significant differences between the studied groups (P = 1.0 for each) **(Table 5 & Fig. 9).**

Table (5) Belsky score and complications in the studied groups.

			Group I (n = 10)	Group II (n = 10)	P-value
Belsky's score	**Excellent**	**n (%)**	5 (50.0)	6 (60.0)	1.0
	Good	**n (%)**	5 (50.0)	4 (40.0)	
Complications	**Shortening**	**n (%)**	1 (10.0)	0 (0.0)	1.0
	Stiffness	**n (%)**	1 (10.0)	2 (20.0)	
	No	**n (%)**	8 (80.0)	8 (80.0)	

Fisher's exact test was used

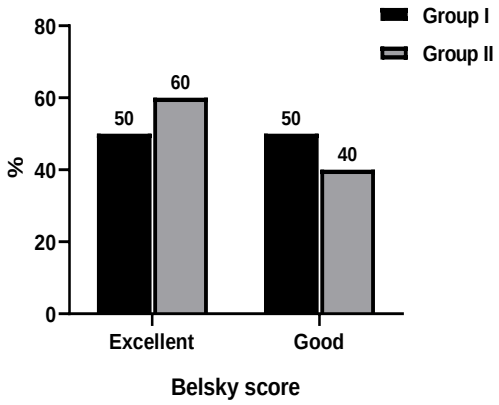

Fig. (9) Belsky score in the studied groups

4.Discussion

The goal of this investigation was to see whether a low-profile plate or an intramedullary nail may provide better clinical and radiographic outcomes for patients with displaced unstable metacarpal fractures. We reasoned that the good anatomical restoration for unstable metacarpal neck fractures and the early postoperative range of motion provided by low profile plate fixation would lead to a superior functional result.

No significant differences were identified in the occurrence of post-operative complications between the two groups (p=1.0). Two patients in the low-profile plate group had their stiffness measured. Stiffnesses were recorded. Shortening in one Bouquet method patient and lengthening in another. The Bouquet group's average operating time was 28 7 minutes, while the low profile plating group's was 56 12 minutes (p 0.001).

There was no statistically significant difference in the time it took for the two groups to get together (P = 0.567).

There was no significant difference in the time to union between the two procedures in many comparative trials [68-83-85]. One year of follow-up found no significant difference between the two groups in terms of subjective pain perception as judged by the PVAS score (p=0.66).

At the end of the study, the total active range of motion (TAM) for the antegrade nailing and plate groups

ranged from satisfactory to outstanding. A p-value of 0.606 indicates no difference between the two groups. A sphygmomanometer is used to monitor the patient's grip strength after a year, and the patient holds a clyndrical cuff, pre-inflated to 20 mmHg in both hands, to record the gauge reading. Grip strength did not vary significantly (P = 0.922) between the two groups.

5. Conclusion

Despite the fact that the research demonstrates PVAS, Q-DASH, TAM, time to radiological union Grip strength blesky score, or residual deformities were shown to be significantly different between the study's two groups. For unstable metacarpal fractures, the Bouquet approach of antegrade intramedullary K-wire nailing (Bouquet technique) was preferable because it required less surgical time and less anaesthetic. A low-cost, low-tech solution that does not upset the fractured biosphere.

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