

Outcomes of mini-open retrograde intramedullary headless screw fixation of metacarpal fractures

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Background

Metacarpal fractures accounting around one-third of hand fractures, which account for ten percent of all fractures and happen predominantly between the ages of 30 and 40. This research objected to examine the radiological, functional, and complication-reduction effects of closed reduction and internal fixation utilizing headless compression screws in metacarpal fractures cases.

Patients and methods

This prospective one-arm research involved 24 subjects with a total of 25 unstable metacarpal neck and shaft fractures surgically treated at Menoufia university hospital and Sheikh-Zayed Specialized, Egypt. They were controlled with intramedullary headless compression screws (IMHS).

Results

Complications were reported in 5 (20.8%) patients, Union of fracture was reported in 23 (95.8%) patients. The mean TAM score was 250.63 ± 19.58 ranging between 180 and 260 with a median of 260. The mean dash score was 1.75 ± 2.91 ranging between 0 and 11.36 with a median of 0.00.

Conclusion

The metacarpal fractures IMHS fixation is an effective, safe, and complication-free treatment and looked to need less imposing and restore function more quickly.

Keywords:

headless compression screw, intramedullary fixation, metacarpal fracture

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Introduction

The metacarpal bones are considered the longest and closest bones to the hand, and they provide solid foundations for the phalanges. Its head is cam-shaped and articulates with the base of the proximal phalanx as a condylar joint to provide flexion, extension, as well as radial and ulnar deviation. It articulates with the distal carpal row at its base [1]. Hand fractures, which constitute 10% of all fractures and are highest prevalent between the ages of 30 and 40, accounting around $\frac{1}{3}$ of metacarpal fractures. It is usually caused by a direct strike to the hand's dorsum, like an attack, fall, boxing fight, crush injury, vehicle accident, or occupational trauma. Little finger neck fractures (Boxer's fractures) and ring-finger shaft were the most common metacarpal fractures [2]. The highest frequent results of metacarpal fractures are carpometacarpal and metacarpophalangeal joints stiffness and malunion; effective therapy for malunion, which involves rotation, angulation, and shortening, is surgery [3]. Numerous metacarpal fractures have the potential to short, that might result in instabilities. because the transverse metacarpal ligaments are connected to the metacarpal head's both sides of third and fourth metacarpals,

they are more commonly stable than the second and fifth metacarpals. Soft tissue injury often accompanies several metacarpal fractures, in contrast to a single metacarpal fracture [4,5]. Metacarpal fractures IMHS fixation offers numerous benefits, as they may be put percutaneously with little incision, hence reducing the risk of infection, and they also provide solid fixation. They may be inserted via the articular surface and due to the tiny size and lack of a head, can be buried subchondrally without impeding joint mobility. Beck *et al.* [6] reported all cases had full range of motion (ROM), radiological union with minimal incidence of complications, and returned to work early with grip strength averaging 96% [7,8]. This research objected to examine the radiological, functional, and complication-reduction effects of closed reduction and internal fixation utilizing headless compression screws in metacarpal fractures cases.

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Patients and methods

This prospective one-arm research involved 24 subjects with a total of 25 unstable metacarpal neck and shaft fractures surgically treated at Menoufia university hospital and Sheikh-Zayed Specialized, Egypt. They were treated with intramedullary headless compression screws (IMHS).

Inclusion criteria

Unstable transverse and oblique metacarpal fractures, No associated fractures in the same limb and Fracture from day one to 3 weeks after trauma.

Exclusion criteria included

Pathological fracture, Fractures with bone loss, Stable undisplaced fractures, Metacarpal fractures in children less than 18 years or patients > 60 years old, Old fractures and recent on top of old fractures, Associated vascular or tendon injuries, Fractures associated with soft tissue infection.

Preoperative

Routine plain radiography pictures of the hand were taken, including oblique and anteroposterior (AP) hand views. All patients had a comprehensive history and physical examination. Extra lateral pictures were obtained in cases with phalangeal injury. X-ray pictures were utilized to determine the location and geometry of fractures, as well as their displacement and angle. The classification of metacarpal fractures was based on their morphological characteristics.

Surgical technique

All cases were on supine position with the affected hand resting on a side table. Twenty cases had surgery under general anesthesia, while the remaining four received regional anesthetic. All surgical procedures employed intraoperative fluoroscopy (C-arm) (image intensifier-guided) to confirm the reduction and fixation of fractures. A retrograde IMHS was utilized for fracture fixation. Under fluoroscopic supervision, closed reduction with no fracture site disturbance was verified.

- (1) To accomplish temporary fixation, a 1.1- or 1.4-mm guide wire was introduced under direct observation into the alignment of the metacarpal head dorsal canal with the medullary canal. Passive metacarpophalangeal (MCP) joint flexion, dorsal capsulotomy, and the dorsal-central starting point were clearly discernible after fracture reduction.
- (2) Countersinking of the subchondral bone with the cannulated countersink.
- (3) We recorded the measurement at the end of the guide wire using a direct measuring instrument

to estimate the depth of the guide wire in the bone. Using this depth, calculate the length of the appropriate screw.

- (4) A 2.4 mm, 3.0 mm, or 4.0 mm cannulated IMHS was implanted depending on preoperative and intraoperative measurement of the intramedullary canal's isthmus.

Figure 1

- (1) After wound closure, a compression dressing, and limb elevation were performed.
- (2) Tourniquet was removed and postoperative neurovascular examination was done.
- (3) All cases were supported for two weeks with an extended posterior slab.

Postoperative follow-up

- (1) The incision was routinely evaluated, stitches were removed if the wound healed, and physiotherapy was started. As soon as the postoperative splint was removed, the whole hand was urged to move actively.
- (2) All cases were observed weekly for the first month.
- (3) The use of the injured hand in activities of daily living was encouraged within the limits of pain. Heavy work was avoided until progress toward union was sufficient by radiological evidence.

Radiological evaluation

- (1) At one week, 2 weeks, 4 weeks, 6 weeks and 3 months postoperative.
- (2) Plain radiographs included: AP view, oblique and lateral views.
- (3) Typically, radiographic evidence of nonunion alone is inadequate, since radiographic fracture lines may be evident up to 14 months following injury. Combining radiological and clinical indicators is the ideal method for diagnosing nonunion.
- (4) Delayed union is usually considered when there is no evidence of bony union at 3-6 months postoperative.

TAM SCORE (total active motion score)

TAM score is described as the total ROM accomplished when all three joints (MCP, proximal interphalangeal (PIP) and distal interphalangeal (DIP)) of a finger are actively flexed or simultaneously extended, minus any extension deficiency at any of them (Table 1).

ROM was measured utilizing a goniometer 6 weeks postoperative and at the last follow-up appointment (Fig. 2).

Figure 1



Operative technique of 5th metacarpal fracture treated by closed reduction and fixation by retrograde IMHS.

Table 1 American Society for Surgery of the Hand (ASSH) Total Active Flexion (TAF score system) [9]

Degree of flexion TAF from MCPJ to DIPJ:	Rating
>220	Excellent
200–219	Good
180–199	Fair
<180	Poor

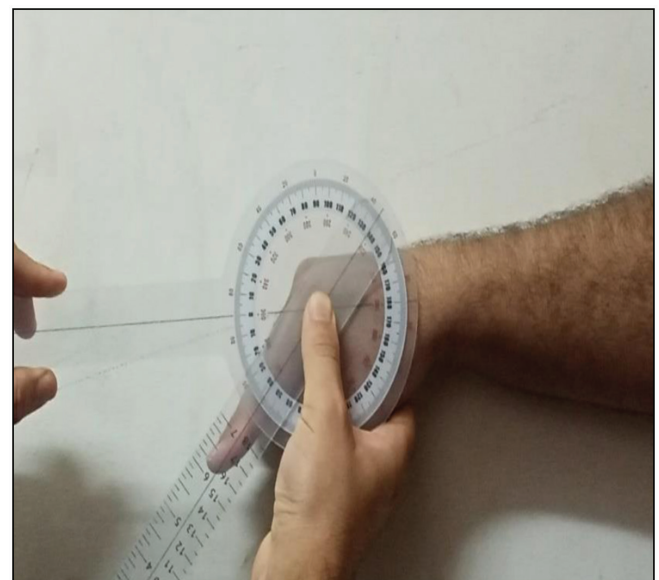
Quick DASH score

Utilizing a questionnaire, the functional outcome of the study group was evaluated 12 weeks postoperative and at the last follow-up. A score out of five is calculated by summing and averaging the values provided to all completed replies. This value is then transformed to a score out of 100 by eliminating one and multiplying by 25. This modification is performed to increase the score’s comparability with other 0–100 scaled metrics. An elevated score reflects a greater degree of disability [10].

Statistical analysis

Data were coded and inputted utilizing statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Mean and standard deviation or median were utilized to represent quantitative data and compared by Mann-Whitney test, while frequency (count) and relative frequency (%) were also utilized to represent categorical data and compared by Chi-square (χ^2) test or Exact test. *P* values below 0.05 were deemed significant.

Figure 2



Goniometer used to measure part of range of motion at MCP joint.

Results

This study included 24 patients with 25 unstable metacarpal neck and shaft fractures who were admitted at El-Menofia University hospitals and Sheikh-Zayed specialized hospital. Patients were treated by limited-open retrograde intramedullary headless screw (IMHS). Then the patients were followed up for one year, Thorough clinical and radiological evaluation was

done to verify the criteria of inclusion and exclusion, All patient data were tabulated (age, sex, occupation, mechanism of trauma.....).

According to demographic data of study population

Eighteen (75.0%) cases were male, and 6 (25.0%) patients were female. The mean age among this study population was 38.75 ± 13.56 years ranging between 20 and 59 years with a median of 37.50 years. Twenty (83.3%) patients were right-handed, while 4 (16.7%) were left handed. Smoking and diabetes were the main and most common risk factors among studied patients followed by hypertension (Table 2).

According to mode of trauma

Trauma by heavy objects was the most common among our study population in 45.8% of cases) preceded by the fight in 29.2% of cases. While the least common mode of trauma was sport-related injury in 4.2% of patients (Table 3).

Regarding Fracture specifications of study population

Right-sided injuries were reported in 14 (58.3%) patients while left-sided injuries were reported in 10 (41.7%) patients. The 3rd metacarpal was the most common fracture in 10 (41.7%) patients, followed by the 5th metacarpal in 8 (33.3%) patients. Oblique fractures were the most common fractures in 17 (70.8%) patients, followed by transverse fractures in 5 (20.8%) patients Table 4.

Table 2 Demographic data of study population

	Mean±SD (Range)	38.75 ± 13.56 (20.00–59.00)
Age	Median	37.50
Sex Count (%)	Male	18 (75.0%)
	Female	6 (25.0%)
Handedness Count (%)	Right	20 (83.3%)
	Left	4 (16.7%)
Associated risk factors Count (%)	Smoker	8 (33.3%)
	Hypertension	3 (12.5%)
	Diabetes	4 (16.7%)
	Diabetes & hypertension	1 (4.2%)
	Free	8 (33.3%)
Work Count (%)	Teacher	1 (4.2%)
	Student	2 (8.3%)
	Nurse	1 (4.2%)
	Mechanic	1 (4.2%)
	Manual worker	3 (12.5%)
	Housewife	4 (16.7%)
	Farmer	2 (8.3%)
	Engineer	3 (12.5%)
	Employee	1 (4.2%)
	Driver	3 (12.5%)
	Cocker	1 (4.2%)
	Carpenter	1 (4.2%)
Accountant	1 (4.2%)	

Postoperative data and final functional results

The mean interval time before fixation was 6.63 ± 4.01 days ranging between 2 and 18 days with a median of 5.50 days. Mean union time was 9.39 ± 2.29 weeks ranging between 6 and 14 weeks with a median of 8 weeks. The mean TAM score was 250.63 ± 19.58 ranging between 180 and 260 with a median of 260. The mean dash score was 1.75 ± 2.91 ranging between 0 and 11.36 with a median of 0.00. The mean extension lag was 2.29 ± 4.16 degrees ranging between 0 and 15 degrees with a median of 0 degree. The mean duration before patients' return to work was (weeks) 7.17 ± 2.85 weeks ranging between 4 and 14 weeks with a median of 6 weeks (Table 5).

Only five participants in the study group had the following complications (Table 6): superficial infection was reported in 1 (4.2%) patient—stiffness was reported in 1 (4.2%) patient—protrusion of the screw was reported in 1 (4.2%) patient—nonunion & revision was reported in 1 (4.2%) patient—delayed union was reported in 1 (4.2%) patient.

Discussion

Nonoperative treatment of isolated metacarpal injuries might lead to up to six weeks of lost work. Therefore, enhancing the treatment of these injuries may have major effects on these patients' quality of life and ability to back to work. Several procedures as percutaneous Kirschner wires (K-wires), intramedullary devices, and

Table 3 Mode of trauma

	Count (%)
Mode of trauma	
Sport-related injury	1 (4.2%)
Road traffic accident	3 (12.5%)
Heavy object	11 (45.8%)
Fight	7 (29.2%)
Fall to ground	2 (8.3%)

Table 4 Fracture specifications of study population

	Count (%)
Affected side	
Right	14 (58.3%)
Left	10 (41.7%)
Fracture site	
2 nd	2 (8.3%)
3 rd	10 (41.7%)
3 rd & 4 th	1 (4.2%)
4 th	3 (12.5%)
5 th	8 (33.3%)
Fracture pattern	
Transverse	5 (20.8%)
Oblique	17 (70.8%)
Comminuted	2 (8.3%)

Table 5 Postoperative data and final functional results

Union Count (%)	Yes	23 (95.8%)
	No	1 (4.2%)
	Superficial infection	1 (4.2%)
	Stiffness	1 (4.2%)
Complications Count (%)	Protrusion of the screw	1 (4.2%)
	Nonunion and revision	1 (4.2%)
	Delayed union	1 (4.2%)
	No	19 (79.2%)
Interval time before fixation (days)	Mean±SD	6.63±4.01
	(Range)	(2.00–18.00)
	Median	5.50
Union time (weeks)	Mean±SD	9.39±2.29
	(Range)	(6.00–14.00)
	Median	8.00
TAM score	Mean±SD	250.63±19.58
	(Range)	(180.00–260.00)
	Median	260.00
Dash score	Mean±SD	1.75±2.91
	(Range)	(0.00–11.36)
	Median	0.00
Extension lag (degree)	Mean±SD	2.29±4.16
	(Range)	(0.00–15.00)
	Median	0.00
Return to work (weeks)	Mean±SD	7.17±2.85
	(Range)	(4.00–14.00)
	Median	6.00

SD, standard deviation.

Table 6 Incidence of complications among study population

	Count (%)
Complications	
Yes	5 (20.8%)
No	19 (79.2%)

plate-screw structures are commonly used implants [11]. There has been a significant surge in the IMHS usage for the metacarpal neck and shaft fractures repair due to their many benefits and low incidence of reported problems. Percutaneously inserted headless compression screws provide a secure fixation utilizing minimum invasive surgical procedure. They may be inserted via the articular surface and due to the tiny size and lack of a head, can be buried subchondrally without impeding joint mobility [12]. This research was conducted on twenty-four unstable metacarpal fractures cases managed with mini-open retrograde IMHS fixation. This research shown that IMHS is an effective method for treating unstable metacarpal fractures. This surgery is much more appropriate for people who need a little recuperation time before returning to work or normal activities. A thorough attention to the surgical method is required for achieving favorable outcomes and minimizing negative effects. It is essential to comprehend the fracture pattern and attempt to

correct it by obtaining adequate baseline stability and preventing the metacarpal head rotation, shortening, and kneeling. Careful preoperative planning, as well as the selection of the proper screw diameter and length, may avoid these crucial complications. The region of insertion on the metacarpal head must also respect the articular surface loading area, which remains an important consideration. The two primary limitations of this treatment are the challenging screw handling during percutaneous insertion, especially when the screw base becomes entangled in the soft tissue, and the hard withdrawal, which requires likely a more complex operation than installation.

Regarding closed reduction and internal fixation by IMHS

Ruchelsman *et al.*, reported that cases utilized a hand-based orthosis till suture withdrawal started active movement during the first 7 days. Digital goniometry, grip strength and pad-to-distal palmar crease distance were used to evaluate the clinical results. Twenty cases were followed for at least three months. Each patient attained complete composite flexion, and the extensor lag was eliminated. All cases displayed complete active MCP joint extension. 105% of the grip strength of the contralateral hand was assessed. No more operations were conducted. Two instances of shaft re-fracture due to blunt trauma occurred followed indications of complete osseous union with the screw in situ. All cases attained radiographic union within six weeks, and there was no evidence of radiographic arthrosis at the most recent follow-up. One case observed sporadic clicking during MCP joint mobility that did not need additional therapy. They came to the conclusion that restricted open retrograde IMHS fixation was secure and effective for the axially stable shaft and metacarpal neck/subcapital fractures, permitted early postoperative mobility with no union rate reduction, and eliminated immobilization [13].

Jann *et al.*, found except for one case had a skull fracture of the second metacarpal with 25° extension lag, 17 fingers in 13 patients exhibited complete ROM. All patients had grip strength averaging 93% for the opposite hand. There were no infections, non-unions, or rotational deformities reported in this research. There were no recorded instances of complicated regional pain syndrome. One case required the removal of a screw due to proximal migration [14]. Berg *et al.*, demonstrated that the significance of the screw head volume in the metacarpal head is rather minimal [12]. In contrary, Del Pinal *et al.*, demonstrated a significant articular surface damage via cannulated screws. Yet they did not publish any report on mid-term osteoarthritic degeneration using IMHS [15]. Poggetti *et al.*, revealed that all fractures healed with rotational or axial

abnormalities of fewer than 5 degrees. After surgery, every patient returned to work after 2.38 weeks. There were no recorded instances of complex regional pain syndrome (CRPS), nerve damage, tendon lesions, infection, mobilization, or protruding hardware. IMHS with wide-awake anesthesia for oblique, transverse, and choose comminuted fractures management metacarpal fractures is a dependable alternative for early active mobility recovery and a speedy back to work and daily exercise. Radiologically, fractures were repaired in 4.36 weeks. M2 DASH score, TAM, and Jamar grip strength were used to evaluate functional recovery. At the conclusion of the study, the extension lag of the MCP joint averaging 4 degrees, the PIP joint averaging 7 degrees, and the DIP joint was not examined. There were no instances of insufficient fixation, reduction loss, intra-articular protruding screws, mal-rotation, infection, CRPS, or screw migration. No implant was removed, and there was no evidence of early osteoarthritis at the last follow-up. Additionally, the average back to regular exercise was 2.38 weeks [16]. Tobert *et al.*, described the reasons for surgery included 5 cases with rotational malalignment, 5 cases with multiple metacarpal fractures, 4 cases with angular deformity, and 2 cases with shortening more than 5 mm. The follow-up duration averaging 19.4 weeks.

All cases with TAM more than 240° were deemed to have satisfactory functional outcomes. Active mobility was begun within one week following the surgical technique. No subsequent techniques were conducted as consequences of IMHS fixation. For cases with comminution, mal-rotation, multiple fractures, and those who need quick mobility, IMHS fixation of metacarpal fractures is an effective therapeutic method. With outstanding clinical outcomes, it eliminates requiring immobilization or invasive plate and screw fixing procedures [17].

Complication rate with IMHS, compared to K-wires and plates

Stahl and Schwartz demonstrated a 15.2% incidence of complications (tendon rupture, osteomyelitis, nerve lesion, pin loosening, pin tract infection, or migration) [18]. Fusetti *et al.* revealed 32 percent of complications (fracture healing difficulty, plate loosening or breakage, stiffness, CRPS, and deep infection) [19]. Jann *et al.* described the surgical treatment of 20 unstable metacarpal fractures using compression screws. One patient out of 15 underwent arthrolysis, while another suffered extension lag [14]. Only cases were found to have a significant extension lag at the PIP joint by Del Pinal *et al.* [15]. A month after the procedure, Borbas *et al.* discovered a screw protruding from the MCP joint. The removal of the screw requires a mini-open

procedure of the MCP joint in order to grip the screw's projecting portion and remove it [20].

Conclusion

Intramedullary fixation of metacarpals by headless compression screws constitutes a valid and reliable alternative to the established operative methods for these fractures. It is more preferable in transverse, short oblique fractures with good postoperative functional outcomes while it is not advisable in highly comminuted or spiral fractures especially when the fracture is situated in the distal diaphysis, because of its tendency to displace, rotate and collapse.

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Author contribution

Authors contributed equally in the study.

Ethical consent

An approval of the study was obtained from Menoufia University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Conflicts of interest

There are no conflicts of interest.

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