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Assessment of Outcomes of Headless Intramedullary Screws versus K-wires Fixation in Metacarpal Fractures

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ABSTRACT

Background: In metacarpal fractures of the hand, intramedullary screw fixation (IMS) has been recognized as an alternate treatment option. **Objective**: This study aimed to compare hand function restoration and pain reduction at postoperative follow-up between intramedullary versus K-wire fixation. **Patients and Methods:** 18 consecutive patients presented by a total of 20 metacarpal fractures were managed by two methods of surgical fixation; percutaneous pinning (PCP), and intramedullary headless compression screws (IMHS). They were followed up for a mean period of 12-24 weeks with an average period of 18 weeks. The study was conducted at Orthopedic Departments, Zagazig University Hospital (ZUH), and Alkhadra Hospital Tripoli (Libya). **Results:** Follow up (months), duration physiotherapy (weeks) and period to return work (days) were significantly shorter in IMHS group. Also, the same group significantly associated with no splint. Favorable outcome was associated more with IMHS group but non-significant (may be due to low number of study groups). **Conclusion**: It's possible to safely and efficiently treat metacarpal fractures with intramedullary screw fixation because of its reduced risk of complications and superior prognosis after surgery. The screws required less casting and allowed workers to return to work more quickly than previously.

Keywords: Intramedullary screws, K-wires Fixation, Metacarpal Fractures.

INTRODUCTION

Metacarpal fractures are widespread, it accounts for the majority of hand fractures, and orthopedic doctors treat it as one of the most prevalent ailments [(1)]. Fractures of the metacarpal bones are generally due to accidental falls and direct blows and between the ages of 15 and 24, the rate is predicted to be more than 250 per 100,000. Metacarpal fractures can affect the proximal base, shaft, neck, or head of the bone [(2)].

Treatment of metacarpal fractures can lead to deformity and stiffness as a result of mistreatment, as well as both deformity and stiffness [(3)]. Metacarpal fractures can be treated non-operatively or operatively, depending on criteria such as the location of the fracture, the degree of angulation, shortening, mal-rotation, and the presence of numerous fractures [(4)].

Currently, Kirschner wires (K-wires), intramedullary screws, plates, and screws are used in the treatment. Metacarpal fractures that leave little or no functional impairment can be treated using these well-established techniques. Intramedullary headless screw fixation may not necessitate the use of splints, allowing patients to return to work sooner than with the use of K-wires [(5)].

There is a growing body of evidence that alternative methods of fixation can reduce tissue dissection and reduce infection, reduce the likelihood of adhesion of the extensor tendon to the bone, and allow early active motion and speedy return to function [(6)]. In metacarpal fractures of the hand, intramedullary screw fixation (IMS) has been recognized as an alternate treatment option [(7)].

It was the goal of this study to compare hand function restoration and pain reduction at postoperative follow-up between intramedullary versus K-wire fixation.

PATIENTS AND METHODS

18 consecutive patients presented by a total of 20 metacarpals shaft fractures were managed by two methods of surgical fixation; percutaneous pinning (PCP), and intra medullary headless compression screws (IMHS). The study was conducted at Orthopedic Departments of Zagazig University Hospital (ZUH), and Alkhadra Hospital Tripoli (Libya).

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee (ZU-IRB#8083). 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.

Inclusion criteria: Skeletal mature patient, fractures of the metacarpals (single, multiple) and closed fracture.

Exclusion criteria:

Skeletal immature, fracture dislocation**,** pathological fractures, neglected cases, associated injuries (tendon, nerve, vessels and soft tissue), failed previous fixation, need for open reduction, and presence of infection.

All patients had gone through:

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1. Full personal history: Name, age, sex, occupation, and dominant side.
2. Past medical history: Details of previous disease or injury to the affected side.
3. Clinical examination: Thorough out examination of head, neck, initial deformity and the rest of the hand skeleton.

Radiological Assessment:

All patients had anteroposterior (AP) and oblique pictures of the hand taken as part of the standard procedure. Additional lateral images were taken in situations with phalangeal injuries.

- Pronation oblique views were helpful to interpret fractures of radial sided metacarpals including second and third metacarpals. While supination oblique views were helpful in-patient of ulnar-sided metacarpals including fourth and fifth metacarpals.
- Images captured by X-ray machines were utilised to locate and characterise fractures, as well as to quantify their displacement and angular inclination.

Surgical technique:

- **Position:** All of the patients were operated on in the supine position, with the hand that was involved on a side table.
- **Anesthesia:** Surgical operations in this study were carried out for 14 patients (77.8%) under general anesthesia and 4 patients (22.2%) had regional anesthesia by suprascapular nerve block
- **Tourniquet:** Used in all patients.
- **Intraoperative Fluoroscopy:** Fluoroscopy was used in all surgical procedures in this study to ensure that the fractures were properly reduced and stabilized.
- **Operative steps:** *Two main methods of fixation were used in fixation of fractures in this study:*
  - **Percutaneous pinning by Kirschner wire (k-wire) antegrade techniques.**
  - **Retrograde Intramedullary headless screws.**

1) Antegrade intramedullary pinning (the main technique used):

Using an antegrade intramedullary Kirschner wire stabilization approach, all of the patients were successfully operated on.

Steps adopted in this wiring technique was as follows:

- Patient preparation by adequate shaving of the hand and cleaning.
- Scrubbing and surgical draping was put, and antiseptic solution (povidone Iodine) was put on the skin.
- The hand of the patient was put on the operating side-table for fracture manipulation and reduction under fluoroscopy (C-Arm).
- Most fractures of the metacarpal shaft were angulated dorsally by the effect of the intrinsic muscles with the distal fragment displaced volarly in the palm of the hand. So, these fractures were reduced under fluoroscopy by traction and complete metacarpo-phalangeal joint flexion as a strut for reduction with reversing of the fracture mechanism of injury.
- To open the canal, two Kirschner wires are bent at one end, and two 1.2 mm Kirschner wires are inserted through one of the metacarpal's cortical layers, with the wires pointing in the same direction as the canal to avoid perforation of the contralateral cortex. Finally, the fracture has been minimized and Kirschner wires have been inserted longitudinally from base of metacarpal to head. An image intensifier was used to regulate intraoperative hardware location.
- Reduction is confirmed under image intensifier and rotation was corrected if present and confirmed clinically by making a fist by the patient's hand to assure that the finger tips were pointing to the scaphoid tubercle.
- After confirmed reduction and rotation, the Kirschner wires was bent, and cut near its end without tethering the skin or the surrounding soft tissues.
- A sterile gauze was put on the bent wire for dressing.
- A below-elbow slab was done in the intrinsic plus position (functional position of the hand) to avoid post-operative hand stiffness.

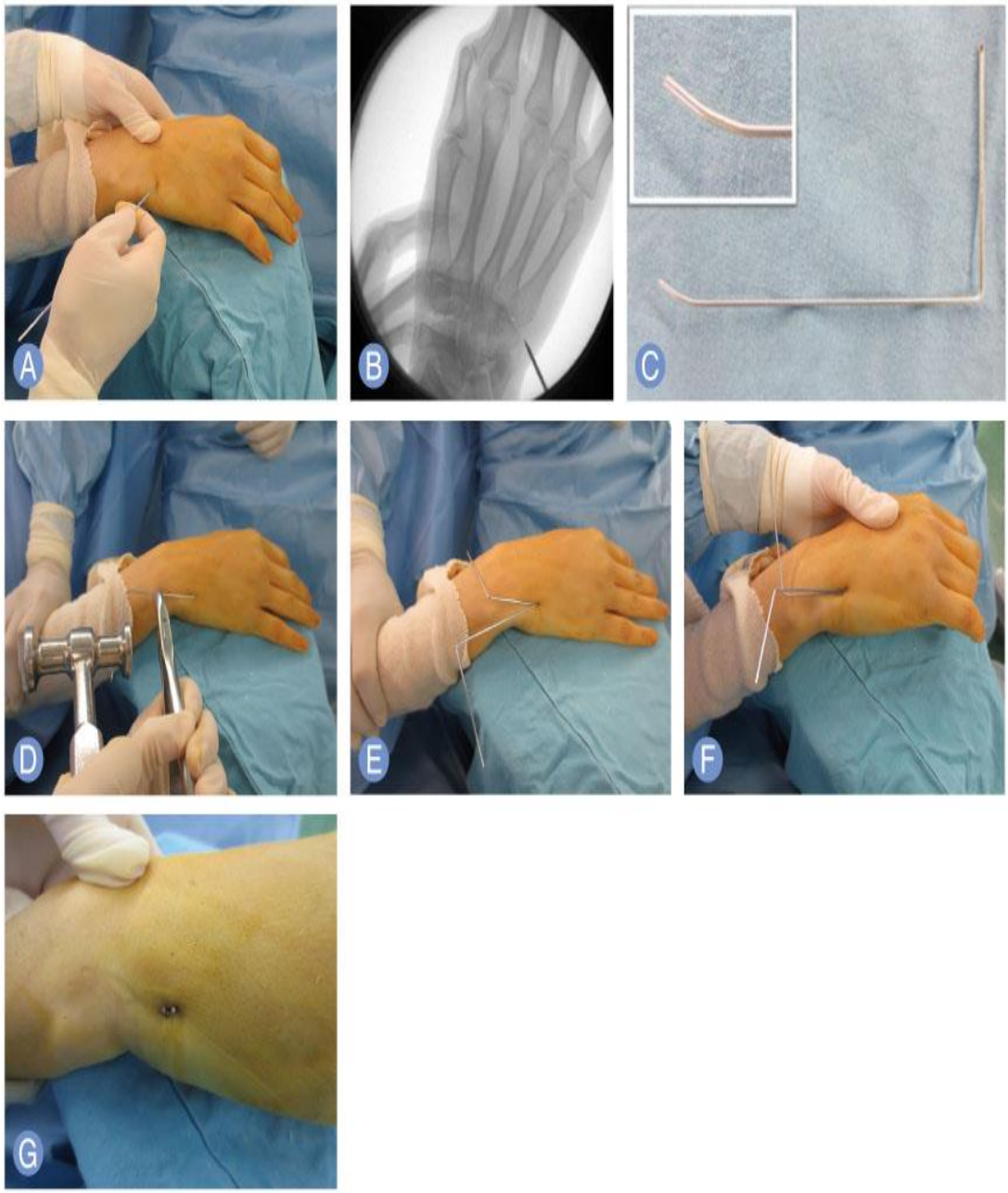

Fig. (1): Steps of surgery

2) Retrograde Intramedullary headless screws:

Steps adopted in this IMHS technique was as follows:

- Patient preparation by adequate shaving and cleaning of the hand.
- Scrubbing and surgical draping was put, and antiseptic solution (povidone Iodine) was put on the skin.
- The hand of the patient was put on the operating side-table for fracture manipulation and reduction under image intensifier (C-Arm) was carried out.
- After the preparation stage is complete, attempts are made at closed reduction using fluoroscopy.
- A #15 blade was used to make a 1.5-cm transverse incision over the metacarpal head and neck.
- Proximal metacarpal heads were exposed by dissecting and separating the extensor tendon longitudinally.
- It was necessary to use fluoroscopy to ensure the correct sizing of the screw before it was driven into place with the guide wire. An acceptable length and width were also taken into account.
- The suitable guide wire was then selected and inserted into the dorsal third of the metacarpal head under fluoroscopic supervision before being advanced retrograde to the fracture level. Following reduction and confirmation by fluoroscopy, the K-wire was advanced over the site of breakage to the base of the metacarpal. Any malrotation that may have occurred during the evaluation of the flexion cascade was corrected.

Figure (2) Guidewire placed along dorsal 1/3 and full length of metacarpal

- The final screw length was calculated by subtracting 4–6 mm from the K-wire readings (for partially threaded screws, measurements must accommodate for the distal threads to be placed past the fracture line). Before reaming, the K-wire was advanced through the carpometacarpal joint to prevent the wire from being accidentally removed.
- To accommodate the screw threads, a reamer was used to ream the narrowest section of the metacarpal canal. To guarantee that the screw head was seated in the subchondral bone, a countersink was used.
- A proper flexion cascade and prevention of malrotation were ensured by flexing all of the fingers into the palm during screw placement to avoid rotational deformities.
- It was then driven by hand with the fingers bent. The threads of the screw should penetrate the intramedullary cortical bone and should be buried just below the subchondral bone to ensure a good grip on the canal.
- After then, the guidewire was yanked out. The skin and tendons of the extensor tendon were sealed.
- To allow for early range of motion, a thick, soft dressing was applied immediately after surgery and removed in three to five days.
- If good purchase had been made, there was no need for a rigorous immobilization. To begin strengthening and heavier exercises, the patient should be able to do so within the first four to eight weeks. 8 weeks later, the recommendation was made for unrestricted use.

Functional assessment and outcome: All patients were functionally assessed on the basis of using the Mayo Wrist Score (MMWS), the ability of the patient to use the affected hand in normal daily activity by the Quick DASH score.

Statistical analysis

The Statistical Package of Social Services, version 20, was used to execute analyses on the data collected (SPSS). In order to convey the findings, tables and graphs were employed. The mean, median, standard deviation, and 95% confidence range were used to summarize the quantitative data. Qualitative data, such as the frequency and proportions, were used to illustrate the points made. Quantitative data were examined using the student t test (T) and the Kolmogorov-Smirnov statistic. Researchers used the Pearson Chi-Square test and the Chi-Square for linear trend (X^2) to assess qualitatively independent data. Significant results were defined as those with a p value of 0.05 or lower.

RESULTS

Age was distributed as 34.88 ± 11.31 and 35.11 ± 10.25 years respectively without significant difference between groups. Regard sex distribution males were majority in both groups without any difference between groups. Also, there was no significant difference or association regarding smoking or comorbidity **(Table 1).**

Table (1): Characteristics among studied group

			IMHS Group	K-Wires Group	t/ X^2	P
Age (years)			34.88 ± 11.31	35.11 ± 10.25	0.039	0.969
Sex	Female	N	2	2		
		%	22.2%	22.2%		
	Male	N	7	7	0.0	1.0
		%	77.8%	77.8%		
Smoking	No	N	4	5		
		%	44.4%	55.6%		
	Yes	N	5	4	0.22	0.63
		%	55.6%	44.4%		
Comorbidity	No	N	9	8	1.05	0.303
		%	100.0%	88.9%		
	DM	N	0	1		
		%	0.0%	11.1%		
Total		N	9	9		
		%	100.0%	100.0%		

Regarding the IMHS group, the mean trauma surgery interval was 1.33 ± 0.45 days, the median quick DASH score was 2.81, and MAYO score was 92.33 ± 7.9.

5 cases had right hand fractures, while 4 cases had left hand fractures. 77.8% of fractures were in the dominant hand. As for the site of metacarpal bone, 2 cases for each 2nd and 4th metacarpus, one case with 3rd, 3 cases with 5th, and one case had fracture in the 2nd, 3rd, and 4th. So, 8 cases had single bone fracture, and one case had three bones fracture. With respect to the type of fracture, 55.6% of cases had transverse fractures, and both oblique and spiral were represented equally in 22.2%. Respecting the cause of trauma, 4 cases had direct trauma, 3 cases had fall down, 2 cases had RTA. All cases did not have other skeletal injury. With respect of the K-wires group, the mean trauma surgery interval was 1.74 ± 0.49 days, the median quick DASH was 4.2, and MAYO score was 84.88 ± 12.16. 7 cases had right hand fractures, while 2 cases had left hand fractures.

77.8% of fractures were in the dominant hand. As for the site of metacarpal bone, 3 cases for 2nd, and 6 cases with 5th. So, all cases had single bone fracture. With respect to the type of fracture, 3 cases had oblique, 5 cases had transverse, and 1 case had spiral. Respecting the cause of trauma, 3 cases had direct trauma, 4 cases had fall down, 2 cases had RTA. All cases did not have other skeletal injury. The present results did not reveal any significant difference or correlation between the groups. No significant difference or association was found between the 2 investigated groups **(Table 2).**

Table (2): Pre OP data distribution between studied groups

			IMHS Group	K-Wires Group	t/ X^2	P
Trauma surgery interval days			1.33 ± 0.45	1.74 ± 0.49	1.633	0.117
Quick DASH			2.81 (0-6.8)	4.2 (0-34.1)	Mann Whitney 1.85	0.068
MAYO Score			92.33±7.9	84.88±12.16	1.941	0.053
Site of fracture	Left	N	4	2		
		%	44.4%	22.2%		
	Right	N	5	7	1.0	0.31
		%	55.6%	77.8%		
Dominant hand	No	N	2	2		
		%	22.2%	22.2%		
	Yes	N	7	7	0.0	1.0
		%	77.8%	77.8%		
Site of metacarpal bone	2	N	2	3		
		%	22.2%	33.3%		
	3	N	1	0		
		%	11.1%	0.0%		
	4	N	2	0	5.22	0.26
		%	22.2%	0.0%		
	5	N	3	6		
		%	33.3%	66.7%		
	2,3,4	N	1	0		
		%	11.1%	0.0%		
Number of bone	1.00	N	8	9		
		%	88.9%	100.0%		
	3.00	N	1	0	1.05	0.303
		%	11.1%	0.0%		
Type of fracture	Oblique	N	2	3		
		%	22.2%	33.3%		
	Spiral	N	2	1	0.53	0.76
		%	22.2%	11.1%		
	Transverse	N	5	5		
		%	55.6%	55.6%		
Cause of trauma	Direct Trauma	N	4	3		
		%	44.4%	33.3%		
	Fall down	N	3	4	0.28	0.86
		%	33.3%	44.4%		
	RTA	N	2	2		
		%	22.2%	22.2%		
Other skeletal injury	No	N	9	9		
		%	100.0%	100.0%		
	Yes	N	0	0		
		%	0.0%	0.0%		
Total		N	9	9		
		%	100.0%	100.0%		

Concerning the IMHS group, 4 cases undergone general anesthesia, and 5 cases had regional anesthesia. While in K-wires groups, the majority of cases had regional anesthesia (77.8%), and only 2 cases had general anesthesia. There was no significant difference between groups regarding the type of anesthesia **(Table 3).**

Table (3): Type of anesthesia distribution between studied groups

			Group		X^2	P
			IMHS Group	K-Wires Group		
Type of anesthesia	General Anesthesia	N	4	2		
		%	44.4%	22.2%		
	Regional Anesthesia	N	5	7	1.0	0.31
		%	55.6%	77.8%		
Total		N	9	9		
		%	100.0%	100.0%		

The IMHS group and K-wires group had mean follow-up of 2.11 ± 0.33 and 3.66 ± 0.86 months respectively, and mean physiotherapy duration of 1.33 ± 0.41 and 3 ± 1 weeks respectively, and mean period for work return was 23.22 ± 3.96, and 42.33 ± 14.63 days respectively. Regarding IMHS group, all cases had union during 6 weeks, and all cases did not have splint age postoperative. While in K-wires group, all cases had union during 6 weeks, and one case had splint age postoperative of 2 weeks, 6 cases had between 3-4 weeks, and 2 cases had splint age postoperative over 4 weeks. There was statistically significant difference and remarkable correlation between the groups regarding follow-up period, physiotherapy duration, period to work return and postoperative splint age (P<0.05) **(Table 4).**

Table (4): Post-operative data distribution between studied groups

			IMHS Group	K-Wires Group	t/ X^2	P
Follow up (months)			2.11 ± 0.33	3.66 ± 0.86	5.029	0.00**
Duration physiotherapy (Weeks)			1.33 ± 0.41	3.0 ± 1.0	4.472	0.00**
Period to return work (days)			23.22 ± 3.96	42.33 ± 14.63	2.670	0.017*
Union_per_6_weeks	No	N	0	0		
		%	0.0%	0.0%	0.0	1.0
	Yes	N	9	9		
		%	100.0%	100.0%		
Splint age post-operative /weeks	No	N	9	0		
		%	100.0%	0.0%		
	2	N	0	1		
		%	0.0%	11.1%		
	3-4	N	0	6	18.0	0.003*
		%	0.0%	66.6%		
	>4	N	0	2		
		%	0.0%	22.2%		
Total		N	9	9		
		%	100.0%	100.0%		

The current study found that respecting the IMHS, there was no case had infection, or malunion, only 22.2% had stiffness. While in K-wires group, 66.7% had malunion, 44.4% had stiffness, and 22.2% had infection. There was no significant correlation or difference between the groups regarding complications **(Table 5).**

Table (5): Complication distribution between studied groups

			Group		X^2	P
			IMHS Group	K-Wires Group		
Malunion	No	N	9	6		
		%	100.0%	66.7%		
	Yes	N	0	3	3.60	0.058
		%	0.0%	33.3%		
Stiffness	No	N	7	5		
		%	77.8%	55.6%		
	yes	N	2	4	1.00	0.31
		%	22.2%	44.4%		
Infection	No	N	9	7		
		%	100.0%	77.8%		
	Yes	N	0	2	2.25	0.13
		%	0.0%	22.2%		
Total		N	9	9		
		%	100.0%	100.0%		

With regard to IMHS group, 66.7% of cases had excellent satisfaction level, and 33.3% had good level. On the other hand, for the K-wires group one case for the both levels of poor and satisfactory, while 3 cases had good level, and 4 cases had excellent satisfaction outcome. Favorable outcome associated more with IMHS group but not significantly (may be due to low number of study groups) **(Table 6).**

Table (6): Outcome distribution between studied groups

			Group		X^2	P
			IMHS Group	K-Wires Group		
Outcome	Poor	N	0	1		
		%	0.0%	11.1%		
	Satisfactory	N	0	1		
		%	0.0%	11.1%		
	Good	N	3	3	2.40	0.49
		%	33.3%	33.3%		
	Excellent	N	6	4		
		%	66.7%	44.4%		
Total		N	9	9		
		%	100.0%	100.0%		

DISCUSSION

Hand fractures are a big problem for orthopedists since metacarpal fractures account for more than half of all hand fractures **[8].** The incidence of metacarpal fractures in people between the ages of 15 and 24 is estimated to be more than 250 fractures per 100,000 people. They can affect the metacarpal bone's head, shaft, neck, or proximal base, depending on the location **[9-12].**

The current results showed that the mean age was distributed as 34.88 ± 11.31 and 35.11 ± 10.25 years in IMHS group and K-wires group respectively without significant difference between groups. regarding sex distribution, males were majority in both groups without any difference between groups. Also, there was no significant difference or association regarding smoking or comorbidity. **Abdel-hamid *et al.* [13]** in their study using K-wires in fixation of metacarpal fractures reported that the age ranging between 19-58 years, 13 case were males and 2 cases were females. In addition, **Kibar *et al.* [14]** reported in their study, on 34 cases treated by intramedullary headless screws (IMHS) for fixation of metacarpal fractures, that the mean age was 33 years, 28 cases were males, and 6 cases were females.

Warrender *et al.* [15] in their study on 150 cases undergone intramedullary headless compression screw fixation of metacarpal fractures reported that regarding the metacarpal injury site, 131 cases with the small digit, 25 cases with ring digit, 2 cases with the middle digit, and 2 cases with index digit. 130 cases had fractures in the dominant hand, 121 cases had fractures in the right hand, and 29 cases had fractures in the left hand. Moreover, **Ruchelsman *et al.* [16]** in their study on 39 cases with IMHS treatment of metacarpal fracture reported that 33 cases with the small digit, 3 cases with ring digit, no cases with the middle digit, and 3 cases with index digit. Furthermore, **Abdel-hamid *et al.* [13]** reported that 10 cases had fractures in the dominant hand, 10 cases had fractures in the right hand, while 5 cases had left-hand fractures. 5 cases had fractures in the 2nd, the 3rd and 4th metacarpus were represented each in 3 cases and 4 cases in the 5th. With respect to the type of fracture, 3 cases had oblique, 9 cases had transverse, and 3 case had spiral. The median quick DASH score was 3. Also, **Elmaraghy *et al.* [17]** found that 29.2% of sustained injury were in the dominant hand. 66.7% of cases had single digit to be pinned, 20.8% of cases had two digits to be pinned and 12.5% of cases had three digits to be pinned. The cause of injury was a fall in 50% of cases, direct trauma in 20.8%, a crash in 16.7%, and twisted in 12.5%. The type of fractures was oblique in 20%, transverse in 45.7%, and spiral in 2.9%.

Concerning the IMHS group, 4 cases undergone general anesthesia, and 5 cases had regional anesthesia. While in K-wires group, the majority of cases had regional anesthesia (77.8%), and only 2 cases had general anesthesia. There was no significant difference between groups regarding the type of anesthesia.

Abdel-hamid *et al.* [13] revealed that all cases undergone K-wire treatment had union during 6 weeks. **Kibar *et al.* [14]** revealed that union was achieved in all patients in the IMHS group. **Ruchelsman *et al.* [16]** in their study on 39 cases with IMHS treatment of metacarpal fracture reported that all cases had achieved union by 6 weeks.

Couceiro *et al.* [18] found that he mean return to work time was 0.92 months for the IMHS group (0.5–1.5) and 1.86 for the Kirschner wire group (0.1–3). This difference was statistically significant (p = 0.043). They did find differences in terms of postoperative splinting time. This was not surprising, as they only applied splinting for a very brief time on some of the patients on the screw group for comfort purposes. The mean return to work time or time back to their regular activities appeared to be shorter on the screw group.

Since the screws we used were non-compressive and fully threaded with the same thread pitch along the whole screw, and compression and shortening of the fracture lines were not seen during surgery, we can say that the IMHS acts as an internal splint and can be applied to all fracture patterns.

Abdel-hamid *et al.* [13] found that regarding the complications after K-wires, 6.7% of case had stiffness, and 13.3% of case had infections. **Kibar *et al.* [14]** fount that regarding cases subjected to IMHS for metacarpal fractures fixation, there were no cases reported for

complications during the follow-up period (Infection, loss of fixation, nonunion, malunion, hardware failure, metal allergy and extensor tendon disruption). A recent study on the outcome of K-wires-treated case for fixation of metacarpal fractures showed that 66.7% of cases had excellent satisfactory level, 26.7% of cases had good level, and 6.7% had satisfactory levels [(13)]. As regards other author's opinions about closed reduction and percutaneous fixation by intramedullary Kirschner wire, **Elmaraghy and coworkers** [(17)] reported 76% of cases with satisfactory results, while, **Gingrass *et al.*** [(19)] reported 70% satisfactory results after intraosseous wire fixation. **Tobert *et al.*** [(20)] reported that all patients with total active motion greater than 240 degrees had excellent functional outcomes in their study of 16 instances treated with IMHS for metacarpal fractures. Surgeons began to move patients within a week of the procedure. No additional procedures were required as a result of the IMHS fixation causing complications. According to **Couceiro *et al.*** [(18)]**,** the mean satisfaction score for the screw group was 9.4 (7–10), while the mean Quick DASH score for the Kirschner wire group was 5.2 (0–34.1). These differences were not statistically significant (p values of 0.861 and 0.613, respectively).

CONCLUSION

Metacarpal fractures can be safely and efficiently treated with intramedullary screw treatment, which has a low incidence of complications and a superior prognosis. In this study, we discovered no significant changes in patient outcomes or function between the two procedures used. To my eye, the screws appeared to require less casting and allowed for a faster return to work time. Because there were so few instances, we were unable to draw any conclusions about the relative merits of one strategy over another.

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Author contribution: Authors contributed equally in the study.

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