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Comparing The Efficiency and Outcome of Syringe External Fixators and K-Wire Fixation in Unstable Hand Fractures

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ABSTRACT

Background: Hand fractures are common in surgical practice, with treatment goals focused on achieving maximum bony union, maintaining proper length and alignment, and ensuring normal hand function. The ideal fixation method should also be cost-effective.

Objective: To compare the efficiency and outcomes of syringe external fixators with K-wire fixation in managing unstable metacarpal and phalangeal fractures.

Patients and Methods: This study included 42 patients with hand fractures (metacarpal or phalangeal), treated at Helwan University Hospital between October 2022 and April 2023. Patients were randomly assigned into two groups: 21 treated with syringe external fixators (Group A) and 21 treated with K-wire fixation (Group B). Range of motion (ROM), total active motion (TAM), and quick DASH (qDASH) scores were measured.

Results: Group A had a mean ROM of 201.58° ± 43.78° and TAM of 78.82 ± 16.50%, while group B had a mean ROM of 193.42° ± 35.16° and TAM of 75.76 ± 13.54%. The mean quick DASH score was 7.14 ± 13.20 for group A and 9.74 ± 13.18 for group B. Complications included pin tract infections, pin loosening, and deformities, but no significant differences were found between the groups in terms of functional outcomes.

Conclusions: Syringe external fixators offer a cost-effective, easy-to-apply method for managing unstable hand fractures, with comparable outcomes to K-wire fixation and fewer complications.

Keywords: Syringe external fixator; K-wire; Hand; Fractures.

INTRODUCTION

One of the most frequent bony injuries in the surgical practice is hand fractures. Over the last 50 years, surgical treatment has become more popular as it allows to avoid the complications that may result from prolonged immobilization such as stiffness [1].

The goals of treatment of hand fractures are achieving maximum bony union, maintaining appropriate length and alignment, and confirming the return of normal hand function. The optimal stabilization and fixation approach should also have affordable cost [2].

One of the most frequently used techniques for hand fracture fixation is Kirchner wires, or K-wires. The use of this method offers several benefits, including low cost, little dissection, easy technique, and broad availability of the wire material. However, there are also some drawbacks, including pin tract infection, loosening of pins, damage to nerves or vessels during insertion, and migration or malposition of the wire [3].

External fixation is another technique that can be used for fixation. It provides proper range of motion (ROM) at joints both proximal and distal to the fracture and allows the fracture to be reduced while maintaining normal bone length. This is achieved through a hard support provided by an external fixator equipment [4].

The majority of external fixation devices that are now on the market have significant drawbacks. Commercially available types are usually too expensive, and their sizes might be too big for what is required in the hand [5].

Owing to these disadvantages, a number of creative, new external fixators for hand fractures have been experienced. One of these is the syringe external fixator, whose materials are widely available in almost all hospitals and healthcare institutions. The technique is also easy to use, and reasonably priced. It may be used for a wide range of injury types [6].

The goal of this study was to compare the efficiency and outcomes of syringe external fixators with K-wire fixation in managing unstable metacarpal and phalangeal fractures.

Patients and Methods

The study included 42 patients suffering from hand fractures (metacarpals and phalangeal) presented to Helwan University Hospital in Badr City from October 2022 to April 2023. **Inclusion criteria:** All unstable recent closed fractures involving metacarpal or phalangeal shafts. **Exclusion criteria:** Fractures older than one-week, stable fractures indicated for conservative treatment, associated soft tissue injuries or bone loss, severe osteoporosis or fractures in either ends of the bone, which allow only minimal space for application of pins.

Patients were allocated randomly into 2 groups according to fixation methods, group (A), 21 patients, were managed using syringe external fixator and group (B), 21 patients, were managed by K-wire fixation. The fixator apparatus consisted of 10 ml syringe for metacarpal fractures, or 3 ml or insulin syringes for phalangeal fractures and K-wires were inserted proximal and distal to the fracture line.

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In group (A) patients, reduction of the fracture was achieved under C-Arm by traction and manipulation. then the first K-wire was inserted into the bony fragment proximal to the fracture line after being passed through the syringe barrel **(Figure1)**.

The second K-wire was then inserted into the bony fragment distal to the fracture line **(Figure 2)**. After checking the alignment under C-Arm, the fixation was then augmented by another two K-wires, one proximal and one distal to the fracture site **(Figure 3)**.

In group (B) patients, the fractures were reduced by flexing the proximal interphalangeal and metacarpophalangeal joints to a 90-degree angle under C-Arm guidance. After achieving good reduction, K-wires were then inserted, either antegrade approach with an entrance site on the dorsal aspect of the bone or retrograde approach from the MCP, PIP, or DIP joint aiming to protect the articular surface. We used either a single intramedullary K-wire fixation in certain situations, such as little finger metacarpal fractures (we usually use adequate size of K-wire that fills the intramedullary cavity and ensures adequate stability) **(Figure 4), or** 2 K-wires crossing each other proximal or distal to the fracture line **(Figure 5)**.

Care was given not to violate the joint during K-wire fixation, though this needs some orthopedic experience and sometimes joint affection occurred.

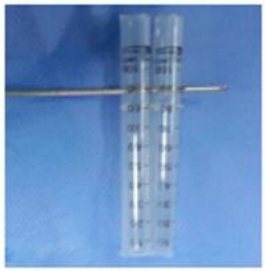

Fig 1: Insertion of 1st K-wire (proximal to fracture)

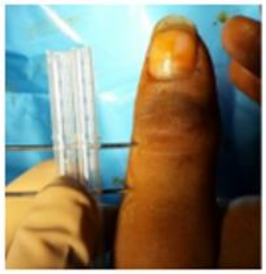

Fig 2: insertion of 2nd K-wire (distal to fracture)

Fig 3: Augmenting the fixation with of another 2 wires (one proximal and one distal)

Fig 4: intramedullary fixation in fifth metacarpal fracture

Fig 5: crossed pins k-wire fixation

In all cases, bulky dressing was done postoperatively, and the wrist was maintained in a splint into a safe position (Wrist: extended 20°, ulnarly deviated 10°. Digits 2 through 5: MP joints flexed 70-90°, PIP 10-20° and DIP 0-10°. Thumb: first carpometacarpal joint partially abducted and opposed, MP joint flexed 10°, IP joint flexed 5°. This position is designed to prevent joint contractures by maintaining the MCP joint collateral ligaments on stretch and preventing volar plate contraction). Hand elevation and anti-oedematous measures were ordered. Postoperative X-rays were done and patients were instructed to follow physiotherapy protocols.

Patients were observed for pain, oedema, apparent deformity or rotation, stiffness, numbness, tingling, or pin tract infection. Follow up visits of the patients were scheduled at 2, 4, 6, 8 weeks and 3 months. If there was no pain or tenderness reported after 6 weeks, the fixator or K-wires were removed. Calcium, phosphorus and vitamin D levels were checked preoperatively and 6 weeks postoperative.

The main outcome measurements of the study were range of motion (ROM), total active motion (TAM) and quick DASH (qDASH) score. Total active motion (TAM) was calculated according to the American Society for Surgery of the Hand (ASSH) as the sum of the degrees of active flexion of MP, PIP, and DIP joints minus the degrees from full extension divided by the norm (either contralateral total or 260 degrees), and the result is the percentage of normal **(Table 1)** [7].

Table (1) TAM evaluation system of the ASSH[7]

Score	Finger	Thumb
Excellent	85 – 100% (220 – 260)	119 to 140
Good	70 – 84% (181 – 219)	98 to 118
Fair	50 – 69% (130 – 180)	70 to 97
Poor	< 50 (0 – 129)	0 to 69

Quick dash score: It consists of 11 items; each one is graded from 1 to 5 points. The higher the score, the greater the disability resulting from the injury [8].

Ethical considerations:

The acceptance from Research Ethics Committee, Faculty of Medicine Helwan University (REC-FMHU) was gained on 16-10-2023, with serial number: (104-2022). All patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. 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.

Statistical analysis

Data management and statistical analysis were done using SPSS version 26 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Kolmogorov–Smirnov test, the Shapiro-Wilk test, and direct data visualization methods. According to normality, quantitative data were summarized as ranges, means, and standard deviations or medians and interquartile ranges. Categorical data were summarized as numbers and percentages. Quantitative data were compared between the studied groups using the independent t-test or Mann-Whitney U test for normally and non-normally distributed quantitative variables, respectively. Categorical data were compared using chi^2 test. P value <0.05 was considered significant.

RESULTS

After 6 weeks, postoperative **total range of motion (ROM)** in group A ranged from 90° – 250°, while in group B it ranged from 125° – 235°. P value was 0.223 (Table 2) (Figure 6). **TAM%** in group A ranged from 34.62% to 96.15%, while TAM% in group B ranged from 48% to 90%. P value was 0.203 (Table 3) (Figure 7).

The most common **TAM score** was "excellent" in both groups. In group A, it was in 12 patients (57.1%), and in group B it was in 9 patients (42.9%) (Table 4) (Figure 8). The mean **quick DASH score** in group A was insignificantly lower (P value was 0.319) than in group B (Table 5) (Figure 9).

In group A, managed with external fixator, 10 patients, out of 21, passed uncomplicated. Loosening of pins was observed in 4 fractures, while one patient suffered from pin tract infection, treated with proper antibiotics. 3 comminuted fractures of the phalanges had angulation (deviation) deformity after (which correlated with non-proper alignment on final radiographs). 3 fractures had non-union, revision with bone graft was done in one patient and the other 2 refused to undergo corrective surgery.

In group B, managed with K-wires, also 10 patients, out of 21, passed uncomplicated, while complications were observed in 11 patients. During the operation, one patient had the K-wire broken inside the bone, which required ORIF after removal of the broken wire. Loosening of pins was observed in one fracture, while 4 patients suffered from pin tract infection, which was treated with antibiotics. 5 fractures (2 comminuted, and 3 simple) had deformities (2 rotational deformities and 3 finger angulation/deviation) after K-wire removal (which correlated with non-proper alignment on final radiographs). No non-union was observed (Table 6) (Figure 10).

Regarding TROM, TAM%, TAM score, qDASH score, and complications, there was no statistically significant difference between the two groups in the study.

Total ROM	Group I (n = 19)	Group II (n = 19)
Mean ± SD.	201.58 ± 43.78	193.42 ± 35.16
Median (IQR)	225.0 (185.0 – 227.5)	205.0(165.0 – 220.0)

SD: standard deviation, IQR: interquartile range.

Table (2): Comparing the two groups regarding total ROM.

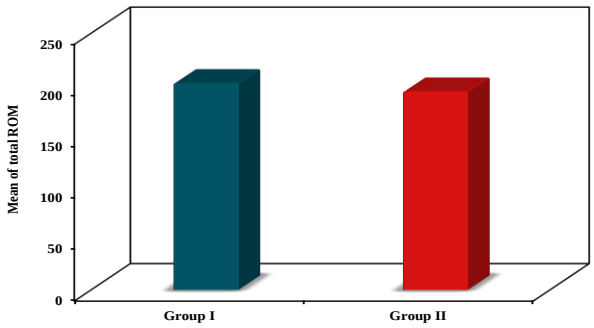

Fig (6): Comparing the two groups regarding total ROM

TAM (%)	Group I (n = 21)	Group II (n = 21)
Mean ± SD.	78.82 ± 16.50	75.76 ± 13.54
Median (IQR)	86.54 (71.15–89.29)	81.0 (64.0–86.0)

SD: standard deviation, IQR: interquartile range.

Table (3): Comparing the two groups regarding TAM%

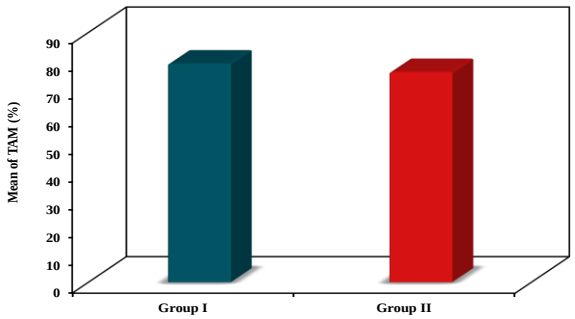

Fig (7): Comparing the two groups regarding TAM%.

Score	Group I (n = 21)		Group II (n = 21)	
	No.	%	No.	%
Poor	2	9.5	2	9.5
Fair	2	9.5	4	19.0
Good	5	23.8	6	28.6
Excellent	12	57.1	9	42.9

Table (4): Comparing the two groups regarding TAM score

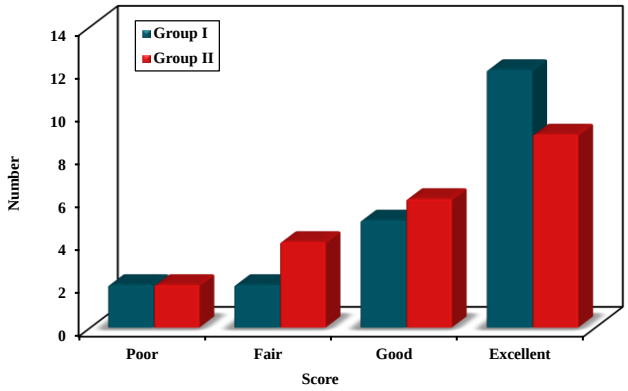

Fig (8): Comparing the two groups regarding TAM score

qDASH	Group I (n = 21)	Group II (n = 21)
Mean ± SD.	7.14 ± 13.20	9.74 ± 13.18
Median (IQR)	0.0 (0.0 – 4.55)	2.27 (0.0 – 15.91)

SD: standard deviation, IQR: interquartile range.

Table (5): Comparing the two groups regarding qDASH score

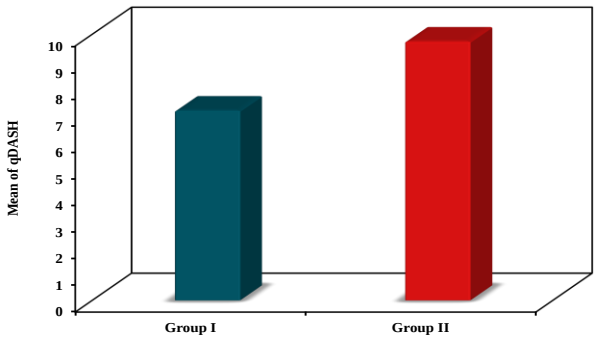

Fig (9): Comparing the two groups regarding qDASH score

	Group I (n = 21)		Group II (n = 21)	
	No.	%	No.	%
Infection	1	4.8	4	19.0
Deformity	3	14.3	5	23.8
Non-union	3	14.3	0	0.0
Broken wires	0	0.0	1	4.8
Loosening of pins	4	19.0	1	4.8

Table (6): Comparing the two groups regarding complications

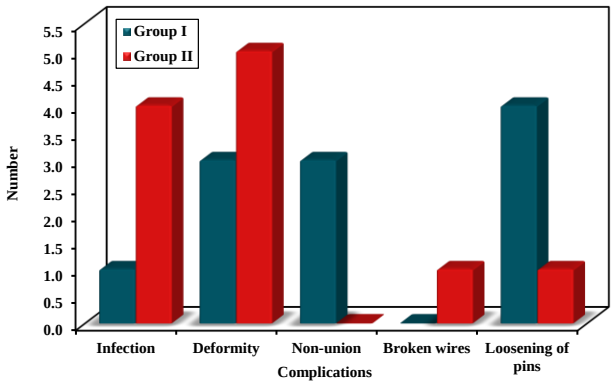

Figure (10): Comparing the two groups regarding complications.

DISCUSSION

One of the most frequent bony injuries in the surgical practice is hand fractures. The goals of treatment are achieving maximum bony union, maintaining appropriate length and alignment, and confirming the return of normal hand function. The optimal stabilization and fixation approach should also have affordable cost [9].

We conducted this study to determine efficiency and outcomes of using syringe external fixators as a management of unstable metacarpal and phalangeal fractures compared to K-wire fixation.

The difference in the functional outcomes, including TROM, TAM% and qDASH score between the two groups in our study may be attributed to the less probability of external fixator to violate the joint, as it is fixed to bony fragments proximal and distal to the shaft fracture, allowing to maintain joint movement while adequately fixing the fractures at the same time.

In accordance with our results, **Rashed *et. al.*** [10] managed 20 patients with phalangeal fractures by closed reduction and external fixation using a syringe external fixator. The study showed a mean ROM of 214°. Twelve digits (60%) showed "excellent" TAM score, 4 digits (20%) were "good", 2 digits (10%) were "fair" and 2 digits (10%) were "poor."

On the other hand, the functional outcomes in our study were less favourable compared to **Abdallah *et al.*** [11], who conducted a study including 86 patients with hand fractures managed by syringe Ex Fix. The mean final TROM was 221°. TAM score was "excellent" in 68 (83%), "good" in one (1.2 %), "fair" in six (7.3%), and "poor" in seven (8.5%) of the cases.

Taking into consideration the probable non-compliance of our patients, mostly being manual workers, they were maintained in a splint and instructed to begin hand therapy with active ROM after 1-3 weeks, while in **Abdallah's study,** no splintage was applied and patients were instructed to immediately begin hand ROM exercises. **Abdallah et al.** also noted that elderly and uncooperative patients were noncompliant with postoperative physiotherapy and always achieved "poor" and "fair" results. This can explain less favourable clinical outcomes achieved in our study compared to their patients, denoting that syringe fixators provide adequate fixation of the fracture sufficient for bone healing while maintaining joint movements [11].

Our study included only unstable recent closed fractures, involving the shaft of metacarpal or phalangeal bones, in contrast to **Shah *et. al.*** [6], who conducted a study on 20 patients, including only complex (comminuted or open, unstable) phalangeal fractures, which were treated by syringe fixator. Eight patients (40%) had total ROM ≥ 200°, and 10 patients (50%) between 180 and 200°. TAM score was "excellent" in 30% of the cases and "good" in 60%. The relatively similar functional outcomes denote that syringe external fixators are also effective in complex phalangeal fractures.

Many studies were conducted using other traditional types of external fixators, which had similar functional outcomes compared with our study, but the syringe eternal fixators have the advantage of lower cost, widespread availability in all operating rooms, and more easy technique. **Lenehan *et al.*,** [12] used closed reduction and mini-Hoffman Ex Fix method to treat 25 patients with phalangeal fractures. The mean TROM was 205°, with a mean TAM% of 80% [11]. In addition, **Gupta *et al.*,** [13] studied 45 cases which were managed using universal mini external fixator (UMEX). The functional outcomes were "excellent" in 36%, "good" in 38%, "fair" in 13%, and "poor" in 13% of cases.

K-wire group in our study showed more disability and less favourable functional outcomes compared to **Afifi *et al.*** [14], whose study included 20 patients with hand fractures that were manged by fixation with interosseous wiring. Thirteen cases had "excellent" TAM score and 7 were "good". The mean quick DASH score was 2.72. This difference may be operator-dependent, and due to more violation to the joints during fixation [14].

Many surgeons who used syringe Ex Fix method considered it more preferrable than K-wires especially in

border metacarpal fractures (as first, second and fifth metacarpals), as it is easier to apply and remove, even by surgeons with minimal orthopaedic experience, it has a faster learning curve, and it is less liable to complications such as broken wires.

Other advantages include wide availability in almost all operative theatres, with a low cost, usually affordable by all patients and healthcare facilities, and enabling adequate lateral view due to radiolucency of the syringe barrel in contrast with many other Ex Fix commercial devices. The syringe external fixators also have a smaller size, suitable for what is needed for hand fixation [12-14].

Being inserted from side (lateral) direction, external fixator application may carry the risk of injury to the digital neurovascular structure. Care must be taken to insert the pins more dorsally to avoid such complication [12-14].

The limitations of this study include a relatively small sample size, which may affect the generalizability of the results. Additionally, the study's short follow-up period may not fully capture long-term complications or functional outcomes. Patient non-compliance with postoperative physiotherapy, particularly among manual laborers, could have influenced the functional results. Finally, the study did not evaluate other external fixation methods for comparison, which could provide a broader perspective on the relative efficacy of syringe fixators and K-wires.

CONCLUSION

The study concluded that syringe external fixator can be used to fix the unstable metacarpals and phalangeal fractures. Although they do not have rigid fixation, they provide adequate fixation sufficient for limited fracture segment mobilization while maintaining joint movement at the same time. Compared to K-wires, it is easier to apply and remove, has faster learning curve, and less liable to complications such as broken wires. It is also more cost effective than other traditional external fixator devices.

RECOMMENDATIONS

Further studies are needed to compare syringe ex fix with other traditional external fixator devices. Separate studies are also recommended to compare the different types of fixation in comminuted fractures.

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Conflict of Interest: Nil.

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