Compound fractures of the hand metacarpals and phalanges treated by using mini-external fixator

Amer G. Aboud M.B.Ch.B, Sadeq A. Al-Mukhtar, F.I.C.M.S. **, Mohammed S. Al- Iedani F.I.C.M.S. **, Hazim Abdul Razzak F.I.C.M.S. ***, Tarek K. Al-Assadi, F.I.C.M.S.*****

ABSTRACT

Background: A review of articles of method in treating compound phalangeal fractures by using mini-external fixator, elaborating the anatomy, mechanics, modalities of treatment, and complications of these types of fractures. Also, it compares between different studies regarding the functional results and final outcome. External fixation of phalangeal fractures is a good method for osteo synthesis in certain situations. The simplicity of the surgical procedure and the minimal disruption of the normal bone architecture also make it appealing.

Objectives: Evaluating the functional results of the use of mini-external fixator for the treatment of compound fractures of phalangeal bones of the hand.

Method: Our study consists of 15 patients, 12 were male and 3 was female, treated with external fixator for sever open hand fractures at Al-Kindy teaching hospital during the period from June 2011 – June 2013, using 2 K-wires bonded by IV needle cover, or 2 K-wires bonded by bone cement.

Results: In comparison between different studies, external fixation offers several advantages. It allows preservation of the bone architecture, union of the fracture, facilitating healing of the disrupted area, and good functional results. External fixation is versatile, adapting to a wide range of clinical situations. This method of fixation provides good stability and adequate control of comminuted fractures, allowing not only anatomic restoration but also early active motion.

Conclusion: External fixators are appropriate in cases of open, comminuted, unstable fractures. Other appropriate settings for external fixation include temporal management of fractures and length preservation of a functional digit.

Keywords: Phalangeal fractures, mini-external fixator, union

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** Al-Kindy teaching hospital.*
***Department of surgery, AL-Kindy Medical College, Baghdad University*
**** Orthopedic surgeon specialist.*
*****Consultant orthopedic surgeon, Arabic board for medical specialization*
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Corresponding author: Amer Ghreeb Aboud.

The hand is the medium of introduction to the outside world, over 75 % of work injuries affect the hands and inadequate treatment costs the patient and society due to functional disability [1].

In hand fractures, tissue other than bone is always damaged, and early motion is needed to prevent disabling adhesions of tendons, ligaments, and capsules [2, 3]. Soft tissue mobilization, however, means adding dynamic forces to the static forces already acting at the fracture site, and, therefore, motion will occur between the bone ends which prohibits capillary ingrowth and a delayed union or even non-union will occur [2].

Functional restoration also demands correct length, alignment, and rotation of bone, which can be achieved by careful reposition either through closed or open manipulation, and again this reposition must be maintained with splint or an implant[2].

The successful use of external fixation to stabilize severe open fractures elsewhere in the body has led to its adaptation in the hand; it is particularly useful when extensive wounds prohibit internal fixation and when comminution and bone loss render the fracture difficult to control by other methods.

External fixation permits simultaneous wound access and fracture management; it can be used alone or adjunctively with other methods of fixation such as K-wires, or screws for definitive fracture management. Alternatively, it can be used for provisional fracture management until wound conditions permit the application of other means of osteosynthesis [4].

Methods. Our study consists of 15 patients, 12 (80%) were male and 3 (20%) was female, treated with external fixator for fifteen sever open hand fractures at Al-Kindy teaching hospital during the period from June 2011 – June 2013.

The external fixator were applied within 24 hours post injury after a through washing and debridement of the wound using 2 K-wires bonded by IV needle cover, or 2 K-wires bonded by bone cement, figures 1 and 2.

All patients receive injectable antibiotic (3rd generation cephalosporine) for the first 72 hours. All patients were follow-up after 1 week to assess the fracture by x-ray and soft tissue status, then after 3 weeks to take an x-ray, and another visit after 6-8 weeks to remove the external fixator under local anesthesia. Active range of motion was started at the 7th day post operatively.

Two factors are chosen to compare the results of different studies:

The range of motion (ROM): The flexion and extension of the proximal and distal interphalangeal and metacarpophalangeal joints and finally the return to work. Results were graded as: 1. Excellent (completely normal function, 90° of flexion, 100%), 2. Very good (15° deficit of total ROM, 84% - 99%), 3. Good (30° deficit of total ROM, can flex the fingers to the palm, 66% - 84%), 4. Poor (more than30° deficit of total ROM, < 66%). The total ROM is defined between 0 degree (extension) to 90 degree (flexion). Recovery was scored on the basis of the total active range of movement of each injured finger separately,

Figure 1: Showing pre- and post-operative external fixation of compound fractures of proximal phalanx of one of our patients by K-wires bonded by bone cement.

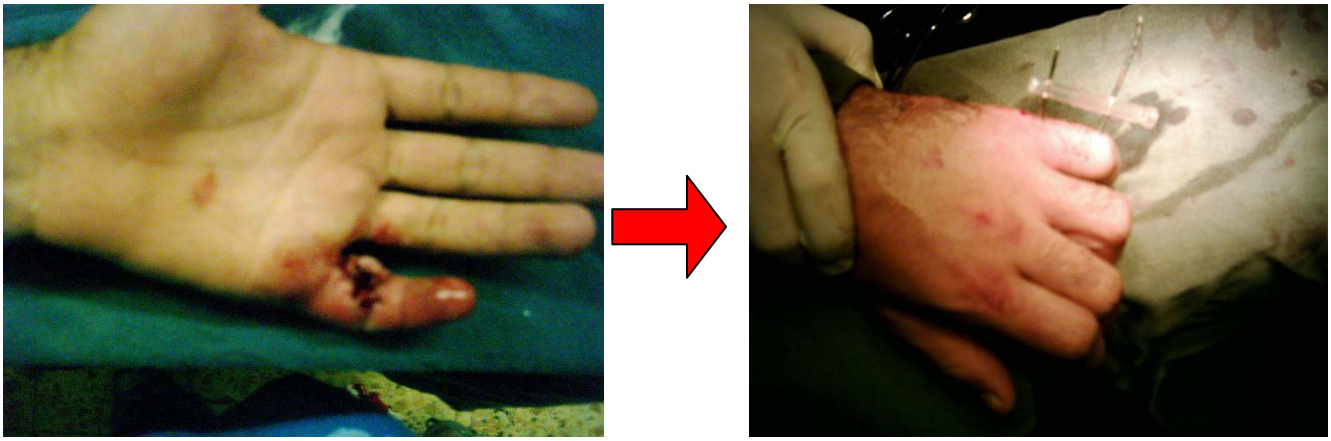

Figure 2: Showing pre- and post-operative external fixation of compound fracture of proximal phalanx of one of our patients by K-wires bonded by IV needle cover.

using the scoring system of Duncan et al for total active movement. This adds the active flexion of the metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints, then subtracts the sum of the extension deficits at these three joints [5].

The degree of union: Bone union was assessed as stable and of appropriate length if stable in active and passive movement, and the length was equal or close to that of the opposite hand. Bone union was achieved in 6-8 weeks. Bony non-union is established when there is considerable movement occurred between the fragments after 6-8 weeks and sclerosis of the fragment ends [6].

In this study, we compare the results of different studies, according to these two characters (ROM, and the bony union).

In the ROM, we select the excellent, very good, and the good results of the study to be compared.

Results. A wide variety of mechanisms of injury were involved. Six (40%) had fracture from gunshot wounds, 6 (40%) had fracture from a fall of heavy object on their hands and 3 (20%) had fracture from road traffic accident (RTA), Table 1. The patient's ages ranged between 15-40 years with mean age (27.5 years).

There were 3 (20%) metacarpal fracture, and 12 (80%) phalangeal fractures. The metacarpal fracture was two in the second metacarpal bone and one in 3rd metacarpal bone and the phalangeal fractures were four in the proximal phalanx of the index finger, four cases in proximal phalanx of the little finger, three in proximal phalanx of the thumb, and one case in middle phalanx of the ring finger. The right hand was involved in 12 patients (80%). Table 2

Nine fractures were comminuted (60%), three fractures were transverse (20%), and three fractures were short oblique. (20%). Of 15 cases, 6were associated with tendon injury (40%), three with flexor tendon (flexor digitorum profundus), and three with extensor expansion injury. Six patients (20%) had both digital neurovascular injuries.

Nine patients were treated by 2 K-wires bonded by IV needle cover, and six patients treated by 2 K-wires bonded by bone cement. Six patients (40%) need bone grafting

from olecranon process of ulna of the same injured side after nonunion.

Regarding ROM, there are three cases were excellent ROM (20%), three cases were very good ROM (20%), Six case were good ROM (40%), and three cases were poor ROM (20%). Table 3 and Figure 3.

Nine cases good unions were achieved (60%), and in 6 cases non-union were evident (40%) after 8 weeks of injury. Table 4 and Figure 4. External fixator was removed after 6-8 weeks.

Table 1 : Mechanisms of injury**.**

Mechanism of injury	No. of patients	percentage
Gunshot wound	6	40%
Falling heavy object	6	40%
RTA	3	20%

Table 2 : Site of fracture.

Fracture site	No. of patients	percentage
Metacarpal bone	3	20%
2nd MC	2 (67%)	
3rd MC	1 (33%)	
Phalangeal bone	12	80%
*Proximal	11 (91.7%)	
Index finger	4 (36.4%)	
Little finger	4 (36.4%)	
Thumb	3 (27.2%)	
Middle	1(8.3%)	

Table 3 : Range of motion.

ROM	Excellent 100%	Very good 84%-99%	Good	Excellent 100%
Number of patients	3	3	6	3

Table 4: The results of bony union.

	Union	Non-union
Number of patients	9 patients (60%)	6 patients (40%)

Discussion. The method of external fixation widely used in the treatment of fractures of the lower extremities, can now be readily utilized in complex hand injuries. Internal fixation with K-wires or micro plates and micro screws are good methods of stabilizing phalangeal fractures. However, if there is soft tissue compromise or bone loss, internal fixation may not be the preferred method of treatment. The basic principles employed in the management of fractures, either open or closed, include accurate reduction and stabilization, edema control, use of the unaffected joints and early movement of the affected ones [7].

Regarding the ROM (excellent, very good, and good results) ,our result were nearly similar to other studies Shehadi [8] , Drenth [9], and Krunoslav [10] and lower to the result of Ardenghy [7] figure 5. When compare the bony union of the phalangeal fractures after removal of the mini-external fixator after 6-8 weeks , Our results lower as compare with other studies Drenth [9], Fricker [11], , and Mcculley [12] , Figure 6.

In Ardenghy M[7]. et al. study, the reason for good results is the use of early bone graft (3-10 days) for cases of bone loss and severely comminuted fractures and the use of 4 pin external fixator. In Fricker et al. study [11], the reason of high percentage of bony union is the use of new AO mini-external fixator which enables less bulky unilateral fixation, facilitating early mobilization, and the special design of the double clamps that allows preliminary intraoperative stabilization with only one wire in each fragment. Modular fixation makes free placement of the wires possible with accommodation of bone and soft tissue lesions. In our study the cause of non union ,one patient was uncooperative ,and the second patient ,the external fixator was not so rigid.

The technique of external fixation using K-wires bonded with polymethylmethacrylate (PMMA) resin was first described by Crockett in 1974. Several external fixation systems designed specifically for small bone injuries are commercially available. They offer great versatility, and the components are designed so that the fracture can be reduced after the frame is assembled, thus providing a high degree of control over the exact positioning of small bones[7].

Discardable external fixators are commercially available, but are still expensive and not always accessible. Other "alternative" external fixators, using K-wires as a pins held by orthopedic or dental cement (polymethylmethacrylate) as a bar, are well recognized. However, even here a packet of cement is used at relative expense or may not be readily available. Authors have used with success the discardable plastic sheath of an IV cannula or hypodermic needle as the crossbar for external fixator. K-wires are passed through the plastic and into the bone acting as the pins. The plastic sheath is slender yet stable, so is not cumbersome. The method is simple, cheap and effective, and the materials are always available [12].

Compared with other fixation methods, external fixation offers several advantages. It allows preservation of the bone architecture, facilitating healing of the disrupted soft tissue. External fixation is versatile, adapting to a wide range of clinical situations. This method of fixation provides good stability and adequate control of comminuted fractures, allowing not only anatomic restoration but also early active motion [7].

Nevertheless, several disadvantages exist, such as pin tract infection, technical difficulties in the placement of pins if the bony fragments are too small, and the associated cost (most external fixation devices are quite expensive).

External fixators are appropriate in cases of open comminuted, unstable fractures because internal fixators do not provide adequate stabilization and are associated with a

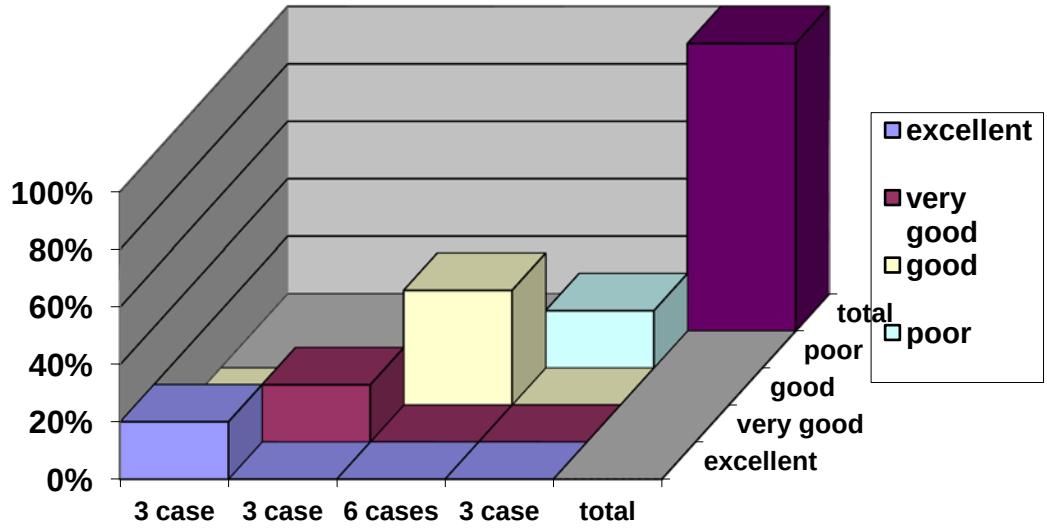

Figure 3: Range of motion.

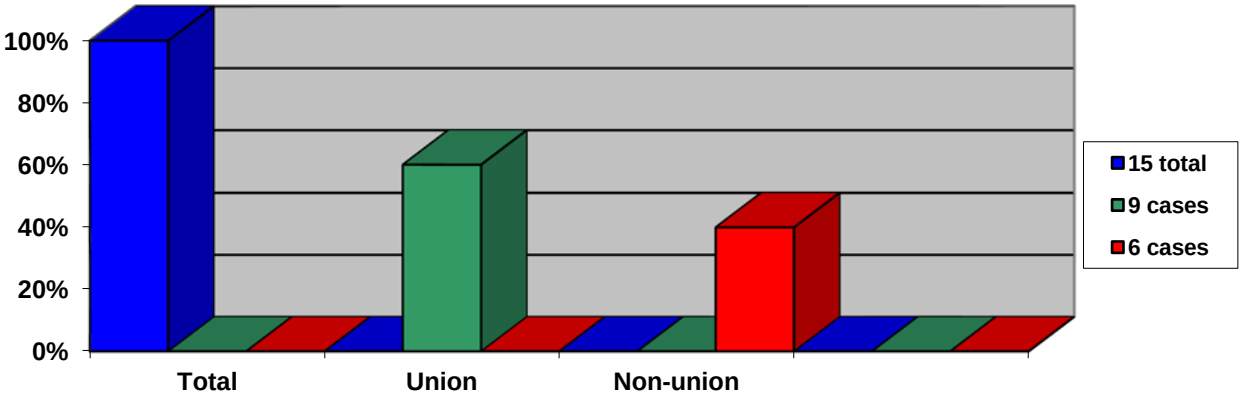

Figure 4: The results of bony union.

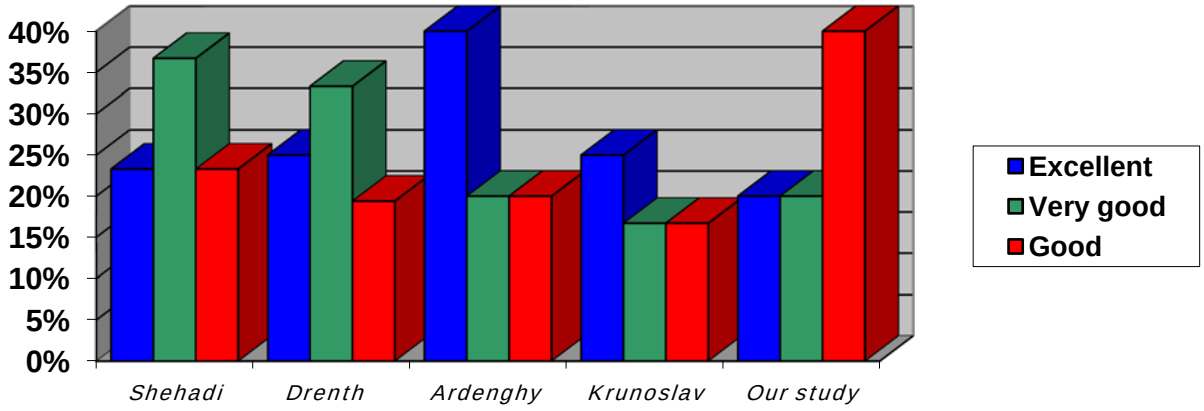

Figure 5: Comparison between different studies regarding the ROM.

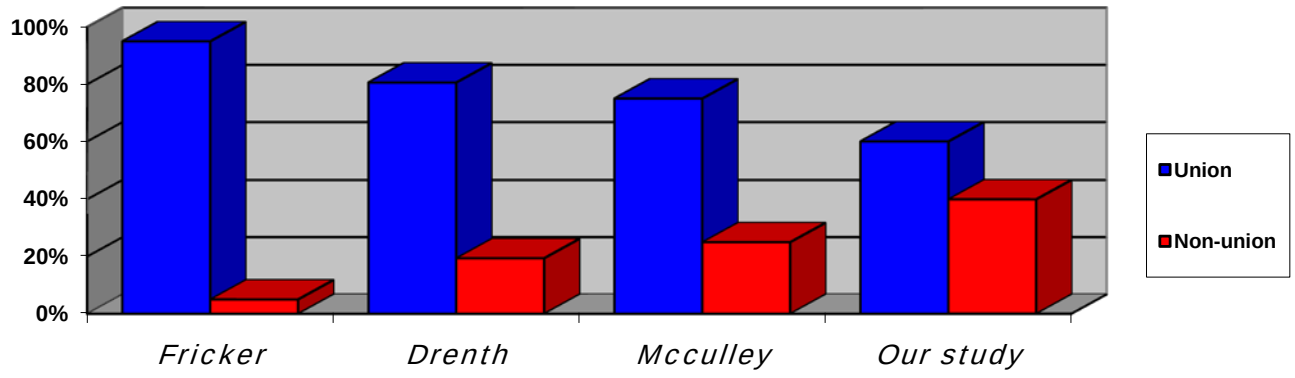

Figure 6: Comparison between different studies regarding bony union.

risk of infection. Other appropriate settings for external fixation include temporal management of fractures, (i.e. until the lesion heals adequately to permit other methods of osteosynthesis), or when trying to preserve the length for a functional digit [7].

External fixators have had good results in complex hand injuries that are at high risk for infection, (i.e. high-energy trauma, industrial or farm accidents, bullet injuries, or in patients with a history of diabetes mellitus or alcohol abuse), and in chronic osteomyelitis, septic arthritis, established infected fractures and nonunion [7]. And provides rigid fixation in sever compound fractures and it is associated with lower infection rate than other fixation methods [13, 14, 15]. Compression, neutralization, or fixed distraction of the fracture fragments is possible with external fixation [4, 14, 16]. And allows direct observation of the affected part and wound status and other methods of treatment, irrigation, dressing, or grafting [13, 14].

Although results of studies employing external fixation are quite good, successful application is dependent upon the surgeon being properly familiarized with the device and its assembly. Training can begin with the use of a skeletal model, where different types of fractures can be reproduced and immobilized with the external fixator. The surgeon using such a device must be familiar with the techniques and follow the established regimens during postoperative care to prevent pin tract infection, pin loosening, and fracture through pin tract [15, 17, 18].

External fixation provides a safe approach to managing fractures in selected cases when other means of fixation are inadequate [7].

In conclusion, The external fixator is ideal for the treatment of compound fractures of the hand especially Gustilo II and III fractures, in which other treatment modalities as conservative measures or internal fixation, are less suitable in the treatment of these compound fractures, particularly when these fractures are displaced, unstable, comminuted or with bone loss. Commercially available external fixator such as mini AO external fixator, Hoffman mini-external fixator provide a solution of these injuries, however, they are bulky, expensive [3], and not readily available. So that some authors used "alternative" external fixators comprising the disposable sheath of an IV cannula, bone or dental cement, or electrical clamps as the cross bar, held by K-wires as the pins. Such basic raw materials are available immediately in all theatres at minimal cost. The use of external fixator in early stabilization of open fractures of hand proved very useful to facilitate soft tissue healing. The stability of fixation resulting from this technique and the almost immediate relive of pain allow early mobilization of the fingers and thus avoiding or minimizing stiffness and allows for early movement and rehabilitation.

In general, this technique can help in solving part of the problems in the treatment of compound fractures of long bones of hand in complaint patient otherwise the patient may disturb the appliance adjustment [15,17].

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