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FUNCTIONAL AND CLINICAL OUTCOME OF FRACTURES OF THE HAND MANAGED BY MINI EXTERNAL FIXATOR

Orthopaedics

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ABSTRACT

Introduction: Hand fractures can be worsened by deformity caused by insufficient management, stiffness caused by excessive treatment, and both deformity and stiffness caused by inadequate treatment. Therefore, this study aimed to evaluate the functional and clinical outcome of mini external fixator-treated hand fractures. **Methodology:** Fifty patients suffering from hand fractures were enrolled in the trial. All the patients underwent a comprehensive history and clinical and radiological assessment, including demographic information such as age, gender, occupation, x-ray, etc. The functional outcome was calculated using the American society for surgery of the hand and total active flexion (ASSH TAF)/Duncan's criteria and clinically evaluated. **Results:** Most enrolled patients were between 35-44 years (34.0%). Male predominance was seen, and RTA caused 70% of injuries. Fractures of type 2 Gustilo-Anderson were prevalent among patients, with the majority occurring in the right hand. The majority of patients had a transverse shaft x-ray [8(16.00%)], followed by a comminuted p. p. [6(12.00%)] and a comminuted mid shaft [6(12.00%)]. The most prevalent problem (44.00%) was stiffness. 46.00% had a good outcome, 34.00% had an excellent outcome, 12.00% had a fair outcome, and 8.00% had a poor outcome based on Duncan's criterion. **Conclusion:** The findings demonstrate the efficacy of MEFs in establishing union and correct alignment of hand skeletons with minimal tissue trauma while retaining a good clinical outcome even in the most complex injuries. MEFs can be considered for all hand fractures requiring surgical treatment, especially in intra-articular and comminuted fractures.

KEYWORDS

Hand fracture, Mini external fixator, Duncan's criteria, Gustilo-Anderson.

INTRODUCTION

The hand is both valuable and vulnerable. As a result, the hand is commonly wounded. Despite its mechanical sophistication, the hand is exceptionally resistant to fractures, and damaged digits can often be repaired without surgery. Nevertheless, surgery has a place in the management of carefully selected patients. [1-3] Hand fractures are typically more forgiving than soft tissue injuries. Even without cutting the skin, it is easy for the treating doctor to cause more harm than benefit. Hand surgeons have exclusive authority over only the most difficult injuries; various clinicians can treat many hand fractures. Emergency physicians, primary care physicians, general orthopaedic and plastic surgeons treat most hand fractures appropriately. [4,5] 10% to 30% of all fractures are hand fractures, making them the second most prevalent type after forearm fractures. The unique properties of each hand bone and the increased necessity for hand motion frequently confound the selection of the most suited treatment. Closed, Un-displaced, or minimally displaced fractures have traditionally been managed non-surgically, but open, comminuted, intra-articular, unstable, and irreducible fractures have required surgical intervention. [6] Depending on the fracture pattern and local tissue circumstances, numerous surgical procedures with fixation implants and devices such as K-wires, bone wires and sutures, [7,8] expandable miniature nails, plates, screws, and mini-external fixators have been utilised. [9] Mini-external fixation devices, either manufactured or custom-made, were utilised in most reports for the treatment of open fractures with soft tissue injury or bone loss, as well as for severely displaced comminuted intra-articular fractures, based on the ligamentotaxis principle. External fixation devices are positioned so as not to damage the tendons, preserving early motion. The fracture was exposed by means of a longitudinal incision in the extensor tendon, which provided excellent exposure; this stable construct permitted early protected motion. The importance of the aftercare and supervised rehabilitation programme in achieving maximum recovery and function cannot be overstated. External dynamic fixation methods have been developed to treat complex articular fractures, particularly those involving the PIP joint. These procedures are technically difficult. Fluoroscopy equipment in the operating room is helpful for reducing and positioning fixation devices. [10] The present study focused on evaluating the functional and clinical outcome of fractures of the hand managed by a mini external fixator.

MATERIAL AND METHODS

The present descriptive prospective study was conducted at the Department of Orthopaedics at the Hind Institute of Medical Sciences in Barabanki, Uttar Pradesh, from October 2021 to November 2022. Total 50 individuals aged above 18 with a hand fracture were included in the study. Patients with pathological fractures, crushed hands with numerous compound grade 3(b, c), fractures of the hand with peripheral vascular illness, painful injuries, neurovascular damage, and patients who had not provided written informed consent for the surgery were excluded. Following previous informed consent, preoperative evaluation, and preoperative planning, surgery was performed. Under anaesthesia (brachial block, wrist block, ring block), fractures were reduced under c-arm guidance. Initially, the proximal fragment was implanted with a k-wire, and the distal fragment received a k-wire. These k-wires were fixated with Mini external fixator clamps before joining with connecting rods. In cases of open fractures, daily dressings are applied. Active and passive motion of the fractured finger's proximal and distal joints began the day after surgery. Discharge on the day of surgery or, in the case of an open fracture, the following day. Assessments were performed at regular intervals on days 2 and 5, and patients were summoned for periodic evaluations at 2 weeks, 4 weeks, 6 weeks, 8 weeks, and 6 months on an outpatient basis. At each follow-up, patients were clinically and radiologically examined. In addition, complications were noted. After 4-6 weeks of the interval, a mini external fixator was removed,

followed by quick, aggressive mobilisation of the hand and wrist joints. The functional outcome was assessed using the American society for surgery of the hand and total active flexion (ASSH TAF) / Duncan criteria.

Statistical Analysis:
Data were entered in Microsoft Excel and analyzed using statistical software SPSS version 26 (SPSS Inc., Chicago, IL, USA). The continuous variables were evaluated by mean (standard deviation) or range value when required. The dichotomous variables were presented in number/frequency and were analyzed using the Chi-square test. A p-value of <0.05 or 0.001 was regarded as significant.

RESULTS

Most patients were between the ages of 35 and 44 (34.0%), followed by those aged 15 to 24 (32.0%). Patients were predominantly male (52.0%), with 30% of them being students. The most prevalent causes of injury were RTA (70%), trauma (22%), and assault (8%). [TABLE-1] The majority of patients had Gustilo-Anderson type 2 right middle finger M P fractures. On X-ray, no significant differences were observed. [TABLE-2; FIGURE-1 and 2] The mean time between injury and trauma and union was determined to be 4.09±4.51 hours and 4.85±0.96 weeks, respectively. The mean number of weeks of follow-up was 24.34 ±1.99, and the mean duration for MEF removal was 4.96 ±1.06 weeks. [TABLE-3] It was shown that stiffness was the most prevalent complication, followed by pin tract infection. [TABLE-4] 46.00% of patients had good outcomes, whereas 8.00% had poor outcomes. [TABLE-5; FIGURE-3] The average range of motion was determined to be [191.70±40.44] degrees. The majority of patients' range of motion was outstanding [218.82±4.71], followed by good [198.26±8.16]. [TABLE-6; FIGURE-4]

DISCUSSION

The majority of the patients were aged between 35-44 years [17(34.00%)], followed by 15-24 years [16(32.00%)]. Statistically, a non-significant difference was observed in the age distribution of enrolled patients [p=0.3289]. Similarly, in a study, the patients were 36 years old on average (range 17 to 74). Seventy per cent of the patients were manual labourers, and most accidents happened while doing their jobs. The dominant hand was impaired in 62% of instances. In the follow-up group, 49 patients with 57 fractures remained. The skeleton was always successfully rebuilt, but the clinical results varied depending on the nature of the initial injury: intra-articular fractures performed worse than extra-articular ones (p= 0.035 for grip strength and p=0.0005 for total active motion), and open fractures performed worse than closed ones (p=0.06 for grip strength and p=0.001 for total active motion). The Disabilities of the Arm, Shoulder, and Hand score was <7.9, and the visual analogue scale score was <0.5, all indicating good patient satisfaction. [6] This study observed male preponderance among enrolled patients [26(52.00%)]. Statistically, a non-significant difference was observed in the gender of enrolled patients. Similarly, in another study, out of 17 patients, 10 were male, and 7 were female; agricultural accidents caused the majority of injuries; 76% of patients had good union, and 24% had delayed union; 65% of fractures were open, and 35% were closed; 11 were extra-articular fractures, and 6 were intra-articular fractures. The majority of fractures occurred in the proximal phalanx, followed by the metacarpals; 47% of patients had excellent outcomes, 29% had good outcomes, 18% had average outcomes, and 6% had poor outcomes due to pin tract infection, loosening, fracture collapse, angulation, and side-to-side translation. Due to the rigidity of the joints, the study revealed that extra-articular fractures yielded better results than intra-articular fractures. In addition, the external fixator produced superior results. [11] This study shows the majority of the patients were students [15(30.00%)], followed by housewives [13(26.00%)], farmers [7(14.00%)] and so on. Statistically, a non-significant difference was observed in the occupation of enrolled patients [p=0.0720]. Similarly, a fracture brought on by a relatively low-impact event should elevate the possibility of osteoporosis or enchondroma. Documenting the patient's handedness, functional status, occupation, hobbies, recovery goals, and injury history is crucial. The treating physician faces special challenges while treating a 25-year-old concert pianist and a 65-year-old retiree with the same fracture. [5] In the present study, the majority of the patients had road traffic accidents [35(70.00%)], followed by trauma [11(22.00%)]. Statistically, a significant difference was observed in the mode of injury of enrolled patients. Similarly, these wounds can be treated surgically or conservatively, depending on the type of injury, the fracture pattern, and the stability of the fracture. So, over six months, they conducted a prospective, non-randomized study on 17 patients with phalangeal and metacarpal fractures. They were included in the study after gaining ethical permission and agreement. Connecting rods, link joints, and K-wires were used to stabilise fractures. A decrease was accomplished under the control of C-Arm. Patients were periodically checked for link joint loosening, k wire loosening, and pin tract infection. Only a small number of patients had average or poor outcomes; the vast majority of patients obtained Excellent outcomes. [11] In the present study, the majority of the patients had Gustilo-Anderson type 2 fracture [4(8.00%)], followed by Gustilo-Anderson type 3 fracture [3(6.00%)]. Statistically, a significant difference was observed in compound fractures of enrolled patients. NPWT was applied as a temporary measure for wound coverage in these 8 patients, with NPWT being applied to 7 patients immediately following initial debridement and external fixation application. One patient required soft tissue flap coverage after receiving NPWT following the application of FWF frames during definitive management for a Gustilo-Anderson Type IIIa fracture. For an average of 5.3 (Range: 1-8) days, these 8 patients had NPWT applied as a temporary measure for wound coverage. [12] In this study, the majority of the patients had Right Middle Finger M P [8(16.00%)], followed by Right 3rd Metacarpal [3(6.00%)], Right 5th Metacarpal, Ring P. P [3(6.00%)], Right 4th Metacarpal, 3rd Metacarpal [2(4.00%)], 5th Metacarpal, Ring M. P, Middle P. P [2(4.00%)], Left 2nd Metacarpal [2(4.00%)], and so on. Statistically, a non-significant difference was observed in the side and site of fracture in enrolled patients [p=0.9996]. Similarly, 30 patients with phalanx and metacarpal fractures between 2013 and 2014 received fixation with K wire, external fixation, or hybrid fixation under local anaesthesia. The patients were, on average, 28 years old, with the youngest being 18 and the oldest being 41. This was made up of childcare services. The patient was allowed to continue his regular activities on the first postoperative day. Splinting was applied to the operating region during this course to keep it safe. The findings classified the clinical results as Excellent, Good, Satisfactory, or Poor. [13] In the present study, the majority of the patients had Shaft Transverse x-ray [8(16.00%)], followed by Comminuted P. P [6(12.00%)], Mid Shaft Comminuted [6(12.00%)], Short Oblique [4(8.00%)], Shaft Long Oblique, Shaft Transverse [3(6.00%)], Shaft Short Oblique [3(6.00%)], Shaft Short Oblique, Shaft Transverse [3(6.00%)] and so on. Statistically, a non-significant difference was observed in the x-ray findings of enrolled patients. However, 80 % were shaft fractures, while 36.84 % were proximal phalanx fractures. Within 8–12 weeks, radiological union occurred in 61.4% of patients, and partial stiffness was the most common complication (52.17%). According to Duncan's criteria, 44% of the cases had a positive outcome, 40% had an exceptional case, 10% had a fair one, and 6% had a negative one.

The results of the trial show that UMEX is a successful treatment for multiple intra-articular and open fractures. [14] In the present study, the mean time interval between injury and trauma was recorded as [4.09±4.51]. The time of union was noted [4.85±0.96]. Follow-up and MEF removal were [24.34±1.99] and [4.96±1.06], respectively. Similarly, in a study, Patients were monitored for 18 to 55 months while MEFs were taken for an average of six weeks. There were 49 patients in the follow-up group, and they had 57 fractures. Although the skeleton was successfully rebuilt in every case, the clinical outcome varied depending on the type of initial injury: open fractures performed worse than closed fractures (p=0.06 for grip strength and p=0.001 for total active motion), and intra-articular fractures performed worse than extra-articular fractures. The study tells the majority of the patients had stiffness [22(44.00%)], followed by pin tract infection [16(32.00%)]. Non-union was not observed in any of the patients. Statistically, a significant difference was observed in complications of enrolled patients [p=0.0002*]. Similarly, Radiological union occurred in 61.4% of cases within 8-12 weeks, and partial stiffness was the most prevalent consequence (52.17%). 44% had a good outcome, 40% had an exceptional outcome, 10% had a fair outcome, and 6% had a terrible outcome, according to Duncan's criteria. [14] In the present study, the majority of the patients had good outcomes [23(46.00%)], followed by [17(34.00%)]. At the same time, only four patients had poor outcomes. Statistically, a significant difference was observed in the outcomes of enrolled patients. Similarly, another study showed that the average age was 36.31 years and 8.79 months; men made up 73.21% of the population, while women made up the remaining 26.79%. The primary cause of fractures was automobile accidents. Although only one finger was broken, 16.07% and 7.14% of the patients, respectively, had two or three

broken digits. Functional outcomes were outstanding in 66.0% of cases, good in 16.0%, fair in 10.71%, and terrible in 0% of cases. Ninety-one per cent of fractures have healed after six months. According to the study, micro external fixators have a high percentage of functional recovery and union when used to treat open metacarpal or phalangeal fractures of the hand. [15] In the study, the mean range of motion was noted [191.70±40.44]. Most patients had an excellent range of motion [218.82±4.71], followed by a good range of motion [198.26±8.16]. Statistically, a significant difference was observed in the range of motion with outcomes of enrolled patients [p<0.0001*]. Similarly, all patients received mini-external fixators, and at 6 weeks, 12 weeks, and 6 months their fractures were assessed for union and functional assessment based on active range of motion (Excellent, Good, Fair, Poor). The findings showed that the average age was 36.31 years and 8.79 months. Men made up 73.21% of the population, while women made up the remaining 26.79%. The most common reason for finger fractures was a car collision; however, 16.07% and 7.14% of patients also suffered two- or three-digit fractures, respectively. Functional outcomes were outstanding in 66.0% of cases, good in 16.0%, fair in 10.71%, and terrible in 0% of cases. Ninety-one per cent of fractures have healed after six months. According to the study, micro external fixators have a high percentage of functional recovery and union when used to treat the hand's open metacarpal or phalangeal fractures. [15,16] Similarly, Intra-articular to extra-articular and open-to-closed fractures were compared regarding grip strength and TAM. They found that intra-articular fractures had the worst results, which proved to be statistically significant (p=0.0035 for grip strength and p=0.0005 for TAM). [6]

CONCLUSION

Our study concluded that the results show how effective versatile (MEFs) mini external fixators are at establishing hand skeleton union and proper alignment of hand skeleton with minimal tissue trauma while retaining good clinical outcomes even in the most complex injuries. Mini external fixator should be taken into consideration for any hand fractures that need surgery, especially for intra-articular and comminuted fractures. However, further to enhance the accuracy of the present findings and bypass the confounders, we recommend a resilient, multicentric study with high large sample size. Additionally, periodic surveys should be done for any change or update in the pattern of results.

Table-1: Clinico-Demographical parameters of enrolled patients (n=50).

		NUMBER	PERCENTAGE	P- VALUE
AGE	15-24	16	32.00%	X=3.438 p=0.3289
	25-34	11	22.00%	
	35-44	17	34.00%	
	45-54	6	12.00%	
GENDER	Female	24	48.00%	X=0.04002 p=0.8414
	Male	26	52.00%	
OCCUPATION	Carpenter	6	12.00%	X=13.01 p=0.0720
	Driver	3	6.00%	
	Farmer	7	14.00%	
	House Wife	13	26.00%	
	Shopkeeper	1	2.00%	
	Student	15	30.00%	
	Teacher	3	6.00%	
	Worker	3	4.00%	
MODE OF INJURY	RTA	35	70.00%	X=15.56 p=0.004*
	Assault	4	8.00%	
	Trauma	11	22.00%	
	Grand Total	50	100.00%	

Table-2: Type, location and X-ray findings of fractures of enrolled patients (n=50).

		NUMBER	PERCENTAGE	P-VALUE
COMPOUND FRACTURE	G A TYPE 1	3	6.00%	X=32.38 p<0.0001 *
	G A TYPE 2	4	8.00%	
	G A TYPE 3A	2	4.00%	
	Nil	41	82.00%	
LOCATION OF FRACTURE	Left 5th Metacarpal	1	2.00%	X=8.889 p=0.9996
	Right 4th Metacarpal, 3th Metacarpal	2	4.00%	
	3rd Metacarpal, Ring M. P	1	2.00%	
	5th Metacarpal, Ring M. P, Middle P. P	2	4.00%	
	Lt 1st Metacarpal	1	2.00%	
	Lt 2nd Metacarpal	2	4.00%	
	Lt 3th Metacarpal, Ring Finger P. P	1	2.00%	
	Lt 4th M. P, 4th Metacarpal	2	4.00%	
	Lt 5th Metacarpal	3	6.00%	
	Lt Index Finger M. P.	1	2.00%	
	Lt Index Finger P. P	2	4.00%	
	Lt Index P. P	1	2.00%	
	Lt Ring Finger P. P	2	4.00%	
	Lt Thumb P. P	2	4.00%	
	Ring Pp, 4th Metacarpal	1	2.00%	
	Rt 3rd Metacarpal	3	6.00%	
	Rt 4 Metacarpal, Ring Finger M. P	1	2.00%	
	Rt 4th Middle P. P	1	2.00%	
	Rt 5th Metacarpal, Ring P. P	3	6.00%	
	RT 5th Metacarpal, 5th M.P,4th M.P,3th M. P	1	2.00%	
	Rt Index Finger M. P.	1	2.00%	
	Rt Little Finger P. P	1	2.00%	
	Rt Middle Finger M P	8	16.00%	
	Rt Middle M P	1	2.00%	
	Rt Ring Finger M. P	2	4.00%	
	Rt Ring Finger M. P. Little Finger P. P	1	2.00%	
	Rt Ring Finger P. P	1	2.00%	
	Rt Thumb P. P	2	4.00%	
XRAY FINDING	Comminuted M. P	1	2.00%	X=12.87 p=0.9131
	Comminuted P. P	6	12.00%	
	Comminuted Proximal Part	2	4.00%	
	Comminuted Proximal Part, Shaft Transverse	1	2.00%	
	Comminuted Ring M.P Rt Hand	1	2.00%	
	Comminuted Shaft	1	2.00%	
	Long Oblique	1	2.00%	
	Mid Shaft Comminuted	6	12.00%	
	Mid Shaft Transverse, Proximal Comminuted	1	2.00%	
	Shaft Comminuted	1	2.00%	
	Shaft Long Oblique, Shaft Transverse	3	6.00%	
	Shaft Short Oblique	3	6.00%	
	Shaft Short Oblique, Shaft Transverse	3	6.00%	
	Shaft Short Oblique	1	2.00%	
	Shaft Transverse	8	16.00%	
	Shaft Transverse, Short Oblique, Mid Shaft Comminuted	1	2.00%	
	Shaft Transverse, Mid Shaft Comminuted	1	2.00%	
	Shaft Transverse, Short Oblique, Mid Shaft Comminuted	1	2.00%	
	Shaft Transverse, Comminuted P. P	1	2.00%	
	Shaft Transverse, Short Oblique	2	4.00%	
	Short Oblique	4	8.00%	
	Transverse Fracture Shaft 5th Metacarpal, Fracture 5th M.P Fracture 4th M.P Rt Hand, Fracture 3rd M. P	1	2.00%	
	Grand Total	50	100.00%	

Table-3: Details of injury and union of enrolled patients (n=50).

INJURY AND UNION DETAILS	MEAN±SD
Time Interval Between Injury and Trauma (Hours)	4.09±4.51
Time Of Union (Weeks)	4.85±0.96
Follow-Up (Weeks)	24.34±1.99
MEF Removal (Weeks)	4.96±1.06

Table-4: Complications of enrolled patients (n=50).

COMPLICATIONS	NUMBER	PERCENTAGE	P-VALUE
Pin Tract Infection	16	32.00%	X=23.77
Pin Loosening	2	4.00%	p=0.0002*
Stiffness	22	44.00%	
Collapse Of Fracture	3	6.00%	
Angulation	5	10.00%	
Non-Union	0	00.00%	

Table-5: Outcomes of enrolled patients (n=50).

OUTCOMES	NUMBER	PERCENTAGE	P-VALUE
Excellent	17	34.00%	X=10.28
Good	23	46.00%	p=0.0163*
Fair	6	12.00%	
Poor	4	8.00%	
Grand Total	50	100.00%	

Table-6: Range of Motion of fractured part of enrolled patients (n=50).

RANGE OF MOTION(DEGREE)			P-VALUE
MEAN±SD		191.70±40.44	X=444.1
OUTCOMES	Excellent	218.82±4.71	p<0.0001*
	Good	198.26±8.16	
	Fair	173.33±9.43	
	Poor	66.25±14.74	

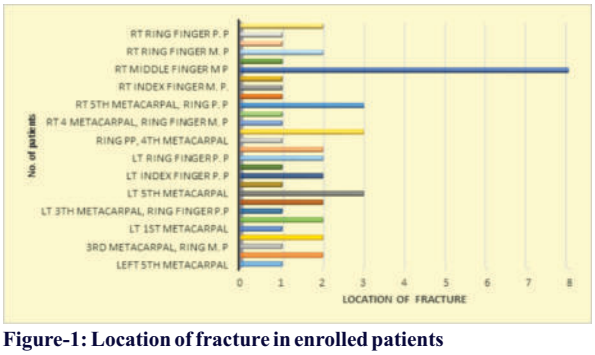

Figure-1: Location of fracture in enrolled patients

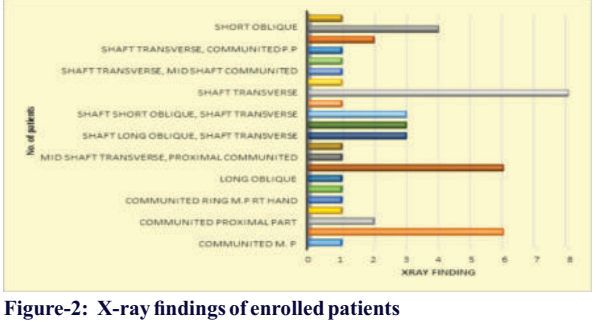

Figure-2: X-ray findings of enrolled patients

Figure-3: Outcomes of enrolled patients

Figure-4: Range of motion of fractured part of enrolled patients

REFERENCES

1. Day C, and Stern P. Fractures of the metacarpals and phalanges. In: Wolfe S, ed. Green's Operative Hand Surgery. 6th ed. Philadelphia: Elsevier Churchill Livingstone; 2011.
2. Calandruccio J,andJobe M. Fractures, dislocations, and ligamentous injuries. In: Canale S, andBeaty J, eds. Campbell's Operative Orthopaedics. 11th ed. Philadelphia: Mosby; 2008.
3. Henry M. Hand fractures and dislocations. In: Bucholz R, Heckman J, Court-Brown C, Tornetta P, eds. Rockwood and Green's Fractures in Adults. 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2010.
4. Jupiter J, Axelrod T, andBelsky M. Fractures and dislocations of the hand. In: Browner B, Jupiter J, eds. Skeletal Trauma: Basic Science, Management, and Reconstruction. 4th ed. Philadelphia: Saunders; 2009.
5. Meals C, Meals R. Hand fractures: a review of current treatment strategies. The Journal of hand surgery. 2013 May 1;38(5):1021-31.
6. Dailiana Z, Agorastakis D, Varitimidis S, Bargiotas K, Roidis N, Malizos KN. Use of a mini-external fixator for the treatment of hand fractures. The Journal of hand surgery. 2009 Apr 1;34(4):630-6.
7. Pennig D, Gausepohl T, Mader K, Wulke A. The use of minimally invasive fixation in fractures of the hand—the minifixator concept. Injury. 2000 Feb 1;31:102-12.
8. Tun S, Sekiya JK, Goldstein SA, Jebson PJ. A comparative study of mini-external fixation systems used to treat unstable metacarpal fractures. American Journal of Orthopedics (Belle Mead, NJ). 2004 Sep 1;33(9):433-8.
9. Ugwonali OF, Jupiter JB. Mini external fixation in the hand. Techniques in hand & upper extremity surgery. 2006 Sep 1;10(3):187-96.
10. Harness NG, Meals RA. The history of fracture fixation of the hand and wrist. Clinical Orthopaedics and Related Research. 2006 Apr 1;445:19-29.
11. Venkatesh V and Maruti CV. Functional outcome of mini- external fixator for hand in a rural tertiary care hospital. International Journal of Orthopaedics Sciences. 2020; 6(3): 49-53.
12. Lim JA, Thahir A, Zhou AK, Girish M, Krkovic M. Definitive management of open pilon fractures with fine wire fixation. Injury. 2020 Nov 1;51(11):2717-22.
13. Salunkhe RM, Joshi H, Pisal TK, Biswas SK, Patel JJ, Singh A. A prospective study of dynamic treatment of fracture phalanx and metacarpals of the hand with Kirschner-wire fixation/external fixator and finger splint: Daycare management (30 cases). Medical Journal of Dr. DY Patil University. 2016 Nov 1;9(6):708.
14. Vijayanand A and Penchalaih A. An assessment of functional outcome and management of metacarpal and phalangeal fractures of hand with universal mini external fixator. International Journal of Research in Orthopaedics. 2020;6(4):682-686.
15. Arunachalam P, Karthicoumaran SM, & Chellappa P. Prospective Study of External Fixators in Fractures of Hand. Indian journal of applied research. 2016; 6(5): 22-31.
16. Aboud AG, Al-Iedani MS, Razzak HA, Al-Assadi TK. Compound fractures of the hand metacarpals and phalanges treated by using mini-external fixator. AL-Kindy College Medical Journal. 2015 Jun 30;11(1):67-72.