Original Article

DOI: 10.7860/JCDR/2022/56686.16739

Orthopaedics Section

Comparison of Antegrade Percutaneous Intramedullary K-wire Fixation and Transverse Pinning for Treatment of Unstable Displaced Metacarpal Neck and Shaft Fractures: A Prospective Interventional Study

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ABSTRACT

Introduction: Metacarpal fractures account for upto 10% of all body fractures and 36% of all hand fractures in adolescents, young adults, and active adults. Among metacarpal fractures, fracture of the metacarpal shaft and neck are most common after direct trauma, roadside accidents, or sports injuries. The ratio of the shaft to the neck is 1:2. Closed reduction and plaster of paris cast can be used to treat the majority of these fractures conservatively. Unstable and comminuted fractures necessitate surgery.

Aim: To compare the clinical, functional and radiological outcomes in antegrade intramedullary fixation and transverse pinning of metacarpal fractures in patients of unstable and displaced metacarpal shaft and neck fractures.

Materials and Methods: A single-institutional prospective interventional study identified 60 cases of metacarpal fractures between November 2019 to August 2021 in the Maharishi Markandeshwar Medical college and Hospital, Kumarhatti, Himachal Pradesh, India. Each of the cases met the inclusion criteria for closed extra-articular fractures, displaced and unstable fractures of the metacarpal bone. The patients were divided into two groups having 30 subjects each, randomly allotted to two groups (Antegrade intramedullary K-wiring and Transverse Pinning). Outcomes were compared for range of movement by the American Society of Hand Surgeons Total Active Motion score (ASSH TAM), Visual Analog Scale (VAS), and radiological parameters (Angulation). Patients were followed-up for 12 weeks. Complications were listed in terms of pin site infection.

Results: Most of the patients were found to be in the third decade of life. The fracture union was achieved at 8±2 weeks. Clinical evaluation done by VAS score which was found to be statistically insignificant between two groups (p-value=0.243). Radiological assessment evaluated by measuring postoperative angulation between two groups was found to be statistically insignificant (p-value=0.248). Difference in functional evaluation between the two groups done by ASSH TAM was found to statistically significant between the groups (p-value=0.036).

Conclusion: Both antegrade intramedullary K-wiring and transverse pinning demonstrate good and comparable results for extra-articular neck and shaft metacarpal fractures. However, the former is superior in terms of final range of motion as per ASSH TAM score.

Keywords: Antegrade intramedullary K-wiring, Closed reduction, Metacarpal fractures

INTRODUCTION

Metacarpal fractures constitute up to 10% of all fractures throughout the body and 36% of all hand fractures in young adults [1]. Metacarpal fractures are most common in men between the ages of 10-29 years [2]. Across the life span, males have a higher incidence of fracture than females. Female ratios for those aged 60 and above exceed male ratios [3]. Fractures of the metacarpal bones in the hand account for 14-28% of all hospital visits following trauma induced by a variety of sources, including assault, traffic accidents, industrial accidents and agricultural accidents [4]. The most common types of injury appear to be driving and an accidental fall. Accidental falls are the leading cause of fractures in the lower age groups as well as in those aged 50 and above. Now high percentage of transport accidents in all age groups resulting in metacarpal fractures is observed [3,5]. The 5th metacarpal fracture is the most common of all metacarpal fractures. Fracture of the fifth metacarpal neck, commonly known as boxer's fracture, is one of the most common hand injuries. They account for 20% of all hand fractures [6]. Closed Reduction and Plaster of Paris cast can be used to treat the majority of these fractures conservatively. Unstable and comminuted fractures necessitate surgery [1].

Open fractures, any angulation of the fracture >30°, rotational deformity of fracture more than 10°, and extensive (>5 mm) shortening of the metacarpal are all indications for surgery. Similarly, irreducible or unstable fractures and multiple digit involvement necessitate surgical intervention [7-9]. The majority of shaft and neck fractures can be treated without surgery if an adequate reduction has been achieved. Displaced fractures can be treated with fracture reduction and K-wire fixation [10]. K-wiring in metacarpal fractures is a minimally invasive method used now-a-days for the fixation of metacarpal after closed reduction and remains the mainstay of treatment [11]. Multiple techniques with K-wires are documented: antegrade intramedullary K-wire, retrograde intramedullary K-wire, retrograde cross pinning with K-wire, transverse pinning with K-wire external fixation, intraosseous wiring, and plate fixation have all been used to treat displaced and unstable metacarpal neck and shaft fractures [12].

Berkman EF and Miles GH described transverse pinning in 1943. It is a relatively quick to perform technique which can be utilised in majority of the metacarpal fractures. It is beneficial as the K-wires does not penetrate the joint and the native range of motion can be started as soon as the fracture fixation is done. Though it has some disadvantages as it may injure the neuromuscular structures which are lying between the web spaces, it still remains one of the commonly used technique [13,14].

Equally popular is antegrade intramedullary pinning described by Foucher G in 1976. In it K-wires are inserted from the base of the metacarpal. This technique also spares the joints which are proximal and distal to the fracture site. But in this K-wires has a chance of damaging the joints if proper caution is not taken while inserting and trajectory of K-wires is not visualised under C Arm [15,16].

A skilled Orthopaedic Surgeon can utilise both these techniques as per his preference. But in literature there is study which actually compare these two techniques [8]. The main purpose of present study was to bridge this gap and to see whether recommendations given by this study can be applied to the population in our country. Hence the present study was conducted with an aim to compare the clinical, functional and radiological outcomes in antegrade intramedullary fixation and transverse pinning of metacarpal fractures in patients of unstable and displaced metacarpal shaft and neck fractures.

MATERIALS AND METHODS

A single-centre prospective interventional study was carried out after taking approval from the Institutional Ethics Committee (IEC) (MMMCH/IEC/20/337) in the Maharishi Markandeshwar Medical College and Hospital, Kumarhatti, Solan, Himachal Pradesh, India, from November 2019 to August 2021. Informed written consent was taken from the patients before surgery and the patients were explained about the rehabilitation program after the procedure and also for possible complications if any.

Sample size calculation: The sample size was calculated; taking standard deviation of 24.2 based on the prior literature with a mean difference of 18 between the samples [17]. Assuming α-error (significance) of 0.05 and power (1- ß) of 80%, the effective sample size on the basis of TAM came out to be 28 in each group for the comparison. This number has been increased to 30 per group (a total of 60) to allow for a predicted dropout from treatment.

Inclusion criteria:

1. Apex dorsal angulation greater than 30° on a pronated oblique view of plain radiographs of hand.
2. Rotational deformities.

Exclusion criteria:

1. Undisplaced metacarpal neck and shaft fractures.
2. Previous deformity at Metacarpo-phalangeal Joint.
3. Rheumatoid arthritis.
4. Associated ligament or tendon injury.
5. Traumatic arthritis.
6. Diabetes.
7. Open fractures.

A total of 60 patients were included in this study, of metacarpal neck and shaft fractures from Outpatient Department (OPD) and Inpatient Department (IPD) and divided into two groups of 30 each.

Group A- Treated by using antegrade intramedullary K-wiring.

Group B- Treated with transverse pinning of K-wires through metacarpals.

Baseline characteristics (including age, gender, mechanism of injury), VAS, and angulation of displacement were calculated and noted preoperatively and on postoperative follow-up. The patients were followed-up for 12 weeks postoperatively, and the result was interpreted by comparison of both groups in terms of functional, clinical and radiological outcome.

Surgical Procedures

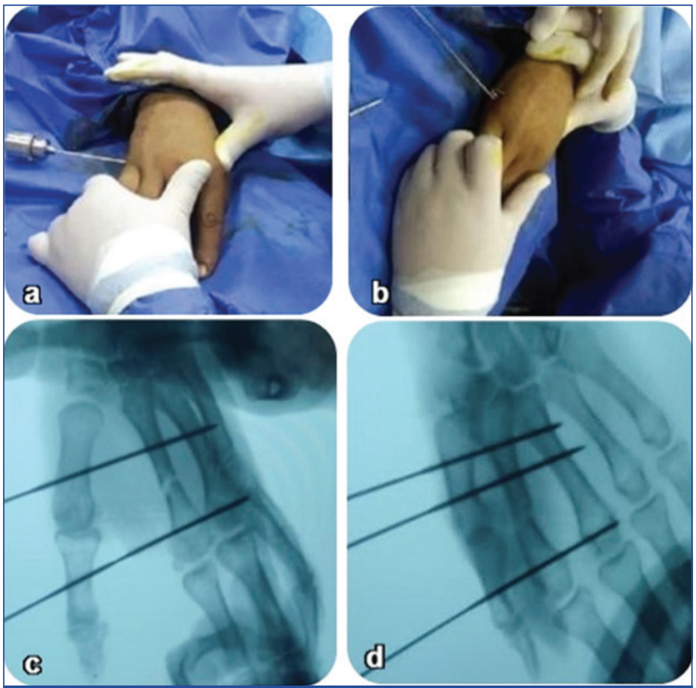
At the commencement of the procedure, closed reduction was attempted, as per the Jahss maneuver [18]. Under the C-arm, the alignment and reduction were checked.

Antegrade K-wiring technique: Patient was positioned in a supine posture with the arm pronated on a sidearm extension table. On the dorsal part of the hand, a tiny incision was made at the base of the injured metacarpal- ulnar side for the 4th and 5th metacarpals, radial side for the 2nd and radial or ulnar side for the 3rd metacarpal- followed by using a 2.0 mm drill for opening the bony cortex of the metaphysis. After that, a 1.0-1.8 mm K-wire was inserted into the intramedullary cavity through the hole drilled in the metacarpal bone and was passed through the fracture under the C-arm after fracture reduction. Under the C-arm, the K-wire's stability and location were evaluated. A second K-wire was put through the same cortical incision if the first failed to provide adequate stability. A second drill hole was produced if necessary for the insertion of the second K-wire. All of the K-wires were bent and left outside the skin, and the pin entry site was covered with a sterile dressing [Table/Fig-1] [15,19].

[Table/Fig-1]: Antegrade percutaneous intramedullary K-wire technique; a) Insertion of 1st K-wire; b) Insertion of 2nd K-wire; c) Intraoperative fluoroscopy hand anteroposterior view; d) Intraoperative fluoroscopy hand oblique view.

Transverse pinning technique: Patient positioned in a supine position on operation theatre table with the arm pronated on a sidearm extension table. Manipulation and internal fixation with 2-3 K-wires of 1.0-1.8 mm thickness were used to close the fracture. The first K-wire was placed percutaneously near the fracture, perpendicular to the ulnar border of the hand, and fixed with the next metacarpal, resulting in a four cortical purchase. The 2nd and 3rd K-wires were then percutaneously inserted parallel to the first wire and distally or proximally to the fracture site depending on site of the fracture site. The K-wires were bent and cut outside the skin after confirming the sufficiency and stability of the fracture fixation, while the pins were bent and left outside the skin with pin entry site to be covered with a sterile dressing piece [Table/Fig-2] [13,14].

Patients received volar slab for two weeks after either procedure. X-rays were taken postoperatively [Table/Fig-3]. At the two-week follow-up, the pin sites were checked for infection, and the patient was allowed active digit mobilisation. At four weeks, the same was done to check for any pin site infection if any, and they were referred to the physiotherapy department for guided passive and active mobilisation of the same. After six weeks full active functioning was advised in patients of both groups, some were referred to the physiotherapy department to aid in rehabilitation. The pins were removed in the procedure room of the OPD after the fracture had united, with all aseptic measures used.



[Table/Fig-2]: Transverse pinning technique; a) Insertion of 1st K-wire; b) Insertion of 2nd K-wire; c) Intraoperative fluoroscopy hand AP view; d) Intraoperative fluoroscopy hand oblique view [13,14].

[Table/Fig-3]: X-rays; a) Preoperative X-ray; b) Antegrade percutaneous intramedullary K-wire postoperative X-ray; c) Preoperative X-ray; d) Transverse pinning postoperative X-ray.

After a full recovery, patients were released from OPD follow-up. Each patient was clinically observed for a minimum of 12 weeks.

Evaluation of Outcome

Range of movement: Calculated by ASSH TAM [8,20]. Functional Assessment was done by ASSH TAM score. The ASSH TAM is the sum of flexion at metacarpophalangeal joints and interphalangeal joints minus the extensor deficit and is quantified in degrees [8,20,21].

TAM=Total active flexion (MP+PIP+DIP)-lack of active extension (MP+PIP+DIP) (MP- Metacarpophalangeal, PIP-Proximal Interphalangeal, DIP-Distal Interphalangeal).

For digits (2-5), this system considers the degree of flexion at the metacarpophalangeal joint (0-85°), the proximal interphalangeal (0-110°) and distal interphalangeal joints (0-65°) total of 260°, and the degree of extension lag at the metacarpophalangeal and proximal and distal interphalangeal joints [8]. Based on this grading ASSH TAM was calculated and the results were compiled.

Finger Goniometer was used to assess active range of motion of the hand through Metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints were noted down preoperatively and postoperatively for comparison.

Clinical evaluation: Independent Clinical Evaluation was done utilising VAS [22]. This contains VAS for pain in the injured metacarpophalangeal joint during daily activities, with 0 indicating no pain and 10 indicating the most severe pain.

Radiographic evaluation: Independent radiological assessment was done by comparing preoperative and postoperative angulation. Preoperative and postoperative angulation on x-rays of hand was calculated by drawing two lines along the longitudinal axis of proximal and distal fragments and calculating the angle made between them.

STATISTICAL ANALYSIS

Data were described in terms of range; mean±Standard Deviation (±SD), frequencies (number of cases) and relative frequencies (percentages) as appropriate. To determine whether the data were normally distributed, a Kolmogorov-Smirnov test was used. Comparison of quantitative variables between the study groups was done using Student's t-test and within the group; Wilcoxon rank test was used. All statistical calculations were done using Statistical Package for the Social Sciences (SPSS) 21.0 version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows. SPSS generated randomisation file was kept with the author 4 and the patients were allocated to 2 groups according to the sequence in it.

RESULTS

When the patients were divided into different age groups, 41.67% of patients were from the age group between 20-29 years of age, followed by 20% of patients above the age group of 50 years. When coming to gender, out of 60 patients, 39 were males and 21 females, [Table/Fig-4].

Based on the mechanism of injury, three groups were, Road Traffic Accidents (RTA), fall from height, blunt trauma (hit or blow to the hand with a blunt object, household or agricultural injuries, Punch). About 36.67% of patients had an injury from RTA, 36.67% had fall as a mechanism of injury, 26.66% contributed to the group of blunt trauma [Table/Fig-5].

VAS score in all patients at the time of presentation was found to be a mean of 7.53 in group A and 7.67 in group B. VAS score at 12 weeks was 1.23 in group A and 1.4 in group B with the difference between them found to be insignificant with p-value of 0.243.

The mean preoperative angulation in patients on presentation was found to be mean of 47.6° in group A and 48.23° in group B. At the time of 12 weeks follow-up the angulation was found to be of 8.63° in group A and 9.2° in group B, with the difference between them statistically insignificant with p-value of 0.248 [Table/Fig-6].

Groups	Group A				Group B				Total patients	
Age (years)	Male		Female		Male		Female			
10-19	1	5.26%	1	9.09%	1	5.00%	1	10.00%	4	6.67%
20-29	9	47.37%	5	45.46%	7	35.00%	4	40.00%	25	41.67%
30-39	3	15.79%	1	9.09%	6	30.00%	1	10.00%	11	18.33%
40-49	2	10.53%	2	18.18%	4	20.00%	0	0.00%	8	13.33%
>50	4	21.05%	2	18.18%	2	10.00%	4	40.00%	12	20.00%
Total	19	100.00%	11	100.00%	20	100.00%	10	100.00%	60	100.00%

[Table/Fig-4]: Age and gender distribution between groups.

Mechanism of injury	Group A	Percentage	Group B	Percentage	Total cases	Percentage
RTA	16	53.33	6	20	22	36.67
Fall on hand	7	23.33	15	50	22	36.67
Blunt trauma	7	23.33	9	30	16	26.66
Total	30	100	30	100	60	100

[Table/Fig-5]: Mechanism of injury.
The fracture in both the groups achieved union at 8±2 weeks

Variables	N	Group A Mean±SD	Group B Mean±SD	p-value
VAS preoperative	30	7.53±0.82	7.67±0.43	0.411
VAS (12 weeks)	30	1.23±0.61	1.4±0.49	0.243
p-value (Wilcoxon rank test)		0.0001	0.0001	
Angulation- preoperative (in degrees)	30	47.6±13.92	48.23±13.67	0.861
Angulation (12 weeks)	30	8.63±1.09	9.2±2.07	0.248
p-value (Wilcoxon rank test)		0.0001	0.0001	
TAM preoperative (in degrees)	30	106.5±6.45	119±7.36	0.167
TAM (12 weeks)	30	252±8.68	245±8.45	0.036
p-value (Wilcoxon rank test)		0.0001	0.0001	

[Table/Fig-6]: Preoperative and Postoperative VAS, Angulation, ASSH TAM.
Student t-test was used for between the groups

The mean preoperative range of motion was calculated by ASSH TAM across metacarpophalangeal, and both interphalangeal joints were found to be mean of 106.5° in group A and 119° in group B. At 12 weeks follow-up ASSH TAM was found to be mean of 252° in group A and mean of 245° in group B. The difference was found to be statistically significant with a p-value of 0.036 [Table/Fig-6].

The intragroup evaluation of preoperative and postoperative variables in terms of functional, clinical and radiological outcome was highly significant with p-value of 0.0001 [Table/Fig-6]. Two patients in group A and four patients in group B had pin site infection which was treated by oral antibiotics.

DISCUSSION

The influential textbook Rockwood and Green's mentions CRPP (Closed reduction and percutaneous pinning) as the standard management of metacarpal fractures [11]. Out of the various constructs available, antegrade intramedullary k-wiring and transverse pinning have gained popularity over the traditional retrograde technique. Present study was undertaken to know which of these two techniques is advantageous in restoration of hand function in terms of range of motion, VAS, and radiological angulation. The age distribution in present study was similar to those seen by Nakashian MN et al., [2] and De Jonge JJ et al., [3] who found the peak incidence to be in the second and third decade of life. This may be attributed to the active lifestyle of people in this age group with more participation in cultural and sports activities. The gender distribution was found to be similar to that of Nakashian M et al., [2] and De Jonge et al JJ et al., [3] with males accounting most in the 2nd, 3rd decade and male-female ratio equal in patients above 50 years of age. The increased incidence in females after the age of 50 years may be due to the increased prevalence of osteoporosis in females after menopause.

In present study major cause of metacarpal fractures was seen as RTA and fall from height. This may be attributed to our hospital is situated in the lower hilly Himalayan region. This was similar to Gudmunsen T and Borgen L [23] who found falls and hitting a wall to be the main cause of metacarpal fractures but in contrast to De Jonge JJ et al., who found accidental falls to be the leading cause in groups of age <5 and >50 years [3].

VAS in present study was seen to have decreased to the range of 1-2 in both the groups at 12 weeks. This may be attributed to the early passive and active range of motion under the guidance of the physiotherapist and later by the consolidation of the fracture at eight weeks. This finding was consistent with as seen by Wong TC et al., and Sletten IN et al., [24,25]. The mean postoperative angulation in present study at final follow-up was in the range of acceptable limits with resulting matching those seen by Winter M et al., and Moon SJ et al., [17,26]. This may be attributed to proper reduction and application of postoperative Plaster of Paris slab so that the fracture site attains some stability before the physiotherapy is started.

The range of motion as assessed by the ASSH TAM score was found to be 252° in group A and 245° in group B. The difference was found to be statistically significant. This shows functional outcome to be better in group A as compared to group B. This may be attributed to more stability of the intramedullary implant with it acting as load sharing implant. Another factor that could have contributed is that there was no alteration in the range of motion of neighboring metacarpal in contrast to transverse pinning in which the neighbouring metacarpal is fixed to the fractured metacarpal. This was in contrast to that seen by Sletten IN et al., and Moon SJ et al., who have found TAM in both the groups to be comparatively equal with no statistically significant difference between them [25,26].

Both these techniques are minimally invasive techniques for the treatment of metacarpal fractures. Any one of these can be used to treat metacarpal fractures. Though both techniques are relatively easy even then great care has to be taken that the wires do not penetrate and damage the articular surface for this may in itself lead to poor outcome [8]. Also, there are chances of fracture of the metacarpal base while making the entry hole for intramedullary wire and transverse pinning wire may damage the structures between the metacarpals [8]. So, in no way, we can say that these are easy surgeries. A minor complication can lead to serious adverse effects and later on poor outcomes. So, every effort should be made to be cautious about the above concerns.

Infection can be explained as the K-wires were left outside the skin and this may have led to pin site infection. The strengths of present study are the low rate of patients lost to follow-up, and the relatively homogeneous patient material (only neck and shaft fractures, two widely used and similar operative techniques).

Limitation(s)

The weakness of present study was a small sample size and a short follow-up period. It is advised for further studies with a larger sample size, a longer follow-up and better statistical tools to analyse the results.

CONCLUSION(S)

Both antegrade intramedullary pinning and transverse pinning are minimally invasive techniques with the advantage of early postoperative rehabilitation and clinical, functional, and radiological recovery. Although similar results were obtained with both techniques when assessed in terms of clinical and radiological recovery, the functional recovery however in terms of the final range of motion achieved as per ASSH TAM score was found to be superior with antegrade intramedullary pinning.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 05, 2022
- Manual Googling: Jun 07, 2022
- iThenticate Software: Jun 14, 2022 (10%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Mar 27, 2022**
Date of Peer Review: **Apr 27, 2022**
Date of Acceptance: **Jun 09, 2022**
Date of Publishing: **Aug 01, 2022**