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Original Research Paper

Orthopaedics

SIMPLE AND EFFECTIVE METHOD FOR MANAGEMENT OF FRACTURES OF BASE OF 1ST METACARPAL USING LIGAMENTOTAXIS AND MINI EXTERNAL FIXATOR FRAME

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ABSTRACT

Background- Fractures of the base of first metacarpal include intra-articular fractures like Rolando fracture and Benette fracture. The ideal management modality of these fractures remains elusive. Management varies from conservative therapy, k wire fixations, external fixators to formal open reduction and plate fixation. Open reduction and anatomic fixation though lucrative, is frought with complications like stiffness, implant failure etc due to excessive dissection and soft tissue stripping that is required. Conservative therapy is usually insufficient to allow the fracture to heal in appropriate position as there are numerous muscle forces acting at the base of first metacarpal which make maintaining the reduction difficult. K wires allow to keep the fracture reduced but obtaining reduction is not an easy task. Here we describe a minimally invasive technique using mini external fixator-JESS(Joshi external stabilization system) which requires minimum soft tissue dissection **Results-** In this prospective study a total of 8 patients were included who underwent fracture fixation using mini external fixator frame. The average time to union was 4 weeks. None of the patients had iatrogenic injury to superficial branch of radial nerve. All of the patients had excellent post fixator frame removal hand function. **Methods-** A prospective analysis was carried out over 8 months. A total of 8 patients met the inclusion criteria and were operated with mini external fixator. Regular follow up was done till 8 weeks. At each postoperative visit patients were evaluated for hand function using Kapandji Score Radiographs were taken at each visit to evaluate for fracture alignment and union. **Conclusion-** Mini external fixator is a simple, minimally invasive surgical technique with excellent functional outcomes for management of Fractures of first metacarpal

KEYWORDS : Thumb fractures, external fixation, JESS Fixator, Minimally invasive technique

INTRODUCTION

Fractures of the base of 1st metacarpal account for 4% of all hand fractures.(Stanton et al., 2007). The complex intra-articular fractures are caused by compressive forces acting along the shaft of the metacarpal usually during a fall on an outstretched hand. Two named fractures of the region are Rolando fracture and Benette fracture. Rolando fracture was described by Silvio Rolando in 1910(Rolando et al., 1996). It has since been used to refer to any comminuted intra-articular fracture of the base of first metacarpal.(Gelberman et al., 1979)(GRIFFITHS, 1964). Another named fracture at the base of the first metacarpal is called Benettes 's fracture(Carlsen & Moran, 2009). This fracture is an intra-articular fracture which separates the palmar ulnar aspect of the first metacarpal base from the rest of the metacarpal (Edmunds, 2006)These intra-articular fractures are inherently unstable and although it is easy to achieve the anatomic reduction, the maintenance of this reduction is the main challenge(Houshian & Jing, 2013). Various treatment modalities varying from conservative management to K wire fixation, modified Suzuki frame application, open reduction and plate fixation etc have been described. Often, despite the anatomic reduction and maintenance of articular surface, contractures and adhesions of surrounding soft tissues can result in stiffness and secondary osteoarthritis.Various external fixator methods have been described including a quadrilateral frame between the first and the second metacarpal.(Buchler et al., 1991), or uniplanar frame consisting of 2 pins in the first metacarpal and 1 pin proximally in trapezium(Salter, 1994) Many types of external fixators have been used to reduce intra-articular fractures by ligamentotaxis and early moblisation as force couple system(Agee, 1987) rubber and pin system(Keramidas & Miller, 2005), Spring devices (Allison, 1996) etc.Here we describe a simple, easy to do and effective technique of using a mini- external fixation system(JESS-Joshi's external stabilization system) for the management of Intra-articular fractures of the base of first metacarpal

Objective of the study-

The questions we seek to answer are-

1. Is Mini external fixator(JESS system) able to achieve acceptable reduction ?
2. Does it maintain reduction till fracture union ?
3. Does it allow adequate hand therapy to reduce stiffness without compromising fracture alignment and reduction

METHODS

This prospective interventional study was carried out at a **tertiary care hospital in Central India**. Patients who presented to the institution with injury/trauma to mid-shaft clavicle were evaluated in detail, clinically and radiographically. This study was carried out over a period **8 months from June 2021 to Jan 2022**

Study Design- Prospective Interventional Study

Sample Size-Estimated sample size considering the outcome with respect to Kapandji Score with following assumption-96.4 % Percent of patients had excellent functional outcome with respect to the Kapandji Score with absolute precision of 7% and 95% confidence interval. Sample size required for study was 8

Ethical Clearance was taken from Institutional Ethical Committee as per the institutional requirements.

Statistical analysis :

Collected Data were entered into Microsoft word spreadsheet. Tables and charts were prepared using Microsoft word and excel spreadsheet. Continuous variables (demographic, biochemical and hemodynamic parameters) were presented as Mean ± SD. Categorical variables were expressed in frequency and percentages. Continuous were compared at different follow-up period by performing one-way ANOVA test for non-normalized data and Kruskal Wallis one-way ANOVA for categorical data. Categorical variables were compared by performing chi-square test. For small numbers, Fisher exact test was used wherever applicable. Multiple comparison test was performed by Bonferroni test for continuous parameters

and Dune's test for categorical data. $p<0.05$ was considered as statistical significance. Statistical software STATA version 14.0 was used for statistical analysis

Inclusion Criteria:
1) Patients with Age > 18 years were included in the study
2) Closed fractures
3) Intra articular fractures Base of first metacarpal
4) No medical contraindication for General Anesthesia
5) Both Male and Female patients included

Exclusion Criteria:
1) Patients not willing for study.
2) Extra articular fractures of first metacarpal
3) Pathological fractures
4) Associated Carpal joint dislocation
5) Associated with neuro-vascular injury
6) Compound fractures

Radiographs-
All the patients underwent Antero-posterior, oblique and Gedda view of the thumb to delineate fracture morphology and classify fracture.

PROCEDURE

Operative procedure :
The surgical technique for the application of mini external fixator involved following steps-
1. Patient Positioning- Patient is positioned supine on OT table with hand kept on side arm rest. C-arm is positioned on ipsilateral side from head end of the patient to allow easy fluoroscopy positioning.

2. Closed reduction- Closed reduction of the fracture is done using ligamentotaxis to reverse the pull of the muscles- Abductor pollicis longus and adductor pollicis which pull the shaft proximally and dorsally. The reduction maneuver involves abduction, pronation and longitudinal traction applied to the thumb.

3. Placement of pins- a low speed drill was used to insert 1.5 mm k-wires. Point of insertion were determined using intraoperative fluoroscopy. Surface marking of superficial branch of radial nerve was done to avoid iatrogenic damage to it during k wire insertion. After insertion of k wires reduction of fracture was done using distractor. One pin was inserted into trapezium under fluoroscopic guidance and another pin was inserted in first metacarpal. After appropriate distraction and fracture reduction the distractor was exchanged with a rod and a closed external fixator frame was assembled to keep the fracture was aligned. The decision to make an open or a closed frame was taken depending on the fracture stability.

4. Intra-operative imaging views- Anteroposterior view of the thumb, Gedda's view(Bett's view) taken with hand pronated 30 degrees and C arm beam directed obliquely in a distal to proximal direction.

5. Post-operative dressing- Post operatively pin tract dressing of the external fixator pins was done using betadine soaked gauze pieces.

Post-operative Protocol:
Post operatively the limb was kept elevated Hand Therapy- Post operatively the patients were encouraged to mobilise the thumb as early as pain allowed, usually on day 2 post operatively.

Hand exercises included Thumbs flex, web space stretch, 3-finger pinch, key pinch exercises. Pin Tract Care-Patients were taught about pin tract care. They were taught to clean the pin tracts using spirit solution and then apply a spirit soaked gauze. Twice daily pin tract dressing was encouraged. Patients were taught to do the pin tract dressings at home by themselves thus reducing the frequency of hospital visits

Post-Operative follow up and Rehabilitation:
All patients were followed up clinic-radiographically at 1 week, 2 week, 4 week and 6 week intervals.

At each visit clinical, functional and radiographic assessment was done. Clinical assessment included-pin tract infection, loosening of pins, edema, range of motion in fingers. Functional assessment was done using VAS Score(on a scale of 1-10), Kapandji Score.

Radiographic assessment was done using Antero-posterior, lateral and oblique views to look for fracture alignment and fracture union.

JESS fixator was removed as OPD procedure once bony union was obtained.

Functional outcome assessment tools:
1.Kapandji Score
2. VAS Score

Implants Used- Joshi's External Stabilisation system

RESULTS
A total of 8 patients were included in the study with 5 patients in 30-40 age group; 2 patients in 40-50 age group and 1 patient in 20-30 age group. There were a total of 6 male and 2 females. Most common mode of injury was road traffic accident followed by fall. None of the patient had any incidence of pin tract infection. No patient had loosening of pins during follow up. Average time to union was 4 weeks. Average VAS score was 2. Average kapandji score was 8. Fixator removal was done for all patients by 8 weeks. None of the patients had sensory deficit over the area of distribution of superficial branch of radial nerve.

DISCUSSION
The comminuted fractures of the base of first metacarpal are relatively common fractures. Comminuted fractures of the base are frequently displaced due to deforming forces acting at the base of the metacarpal(Byrne et al., 2008). Significant comminution makes it difficult to obtain and maintain the reduction. Prognosis of these fractures is poor when treated in either cast or with skin traction.(Rolando et al., 1996) (GRIFFITHS, 1964) The deforming forces acting on these fractures include forces of extensor pollicis longus, abductor pollicis longus and adductor pollicis. These forces have to be neutralized to achieve a congruent reduction. Langhoff et al in 1991 showed that closed reduction and fixation was ineffective while open reduction and interfragmentary k wires led to better joint congruity.(Langhoff et al., 1991) Despite this, osteoarthritic changes in trapeziometacarpal joint was a significant problem.(Langhoff et al., 1991) Thus the main aim of surgical treatment of these fractures is to achieve stable fixation, allow early mobilization, prevent stiffness of first carpometacarpal joint.(Giesen et al., 2017) Superficial branch of radial nerve is the structure at risk during pin insertion. SBRN passes along the front of the radial side of the forearm to the commencement of its lower third. It lies at slightly lateral to the radial artery, beneath the brachioradialis. It quits the artery about 7 cm above the wrist, passes beneath the tendon of brachioradialis and by piercing the deep fascia divides into two branches- lateral and medial. The lateral smaller branch supplies the radial side of the thumb while the medial branch divides into four digital nerves which supply radial three and half digits. Slow and careful insertion of the k wires is the key to avoid injury to SBRN.(Giesen et al., 2017) Various external fixation options

have been described by various authors ranging from simple, unilateral constructs, a quadrilateral fixator to constructs based on K-wires. Here we used a simple minimally invasive JESS fixator utilizing ligamentotaxis for intra-articular fractures of the base of first metacarpal. This technique has the ability to neutralize deforming forces using traction and ligamentotaxis. This minimally invasive procedure has several advantages including- ease of insertion, no dissection, minimal soft tissue trauma, minimal devascularization of the tissues and bone and preservation of bone length. This construct is stable and rigid enough to allow immediate and early mobilization of the thumb. Lack of any metal hardware at the articular surface reduces the risk of stiffness and any hardware impingement. Risk of damage to superficial sensory branch of radial nerve limits the use of percutaneous k-wires.(Giesen et al., 2017)

Limitations of the Study-

A concern in the present study is the low number of cases and the lack of conservatively managed control group. To make meaningful treatment recommendations a larger multi centric case control study needs to be undertaken

CONCLUSIONS-

The JESS fixator aided in achieving reduction by closed methods. No open reduction was required. There was no loss of fracture alignment till fracture union. Hand therapy could be started concurrently without the risk of loss of alignment at fracture ends

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Declaration

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Conflict of Interest-None declared

Ethical approval-Taken from Institutional Ethics committee (IEC)

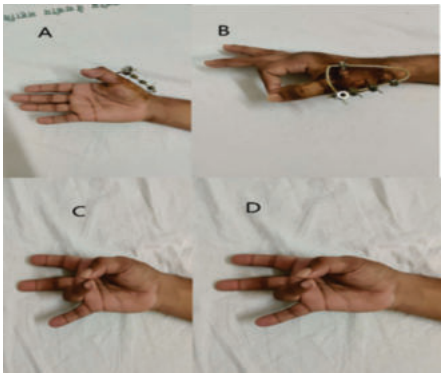

Fig 1-clinical photograph of range of motion

A,B- Range of motion with external fixator frame in situ

C,D- Range of motion after the removal of external fixator frame

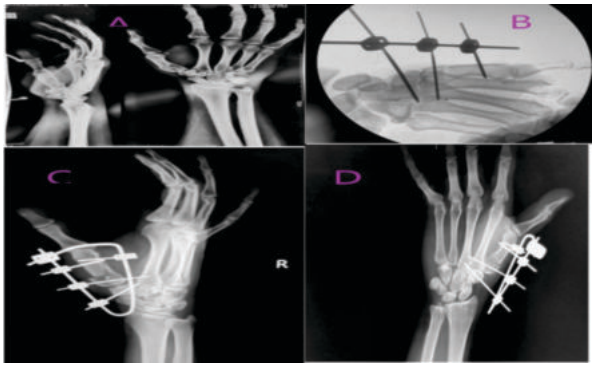

Fig 2- Radiographs

A- Pre operative radiograph

B- Intra-operative radiograph

C- Post operative radiograph with external frame in situ

D- Post operative radiograph with external frame in situ

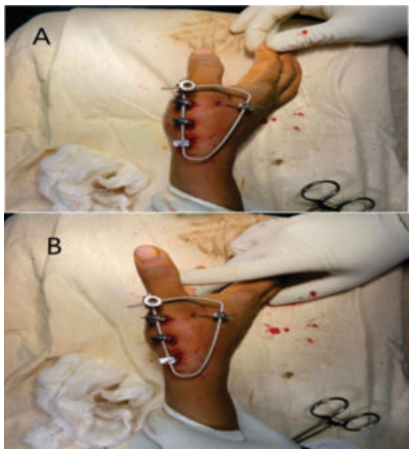

Fig 3-JESS frame created taking care not to damage superficial branch of radial nerve.

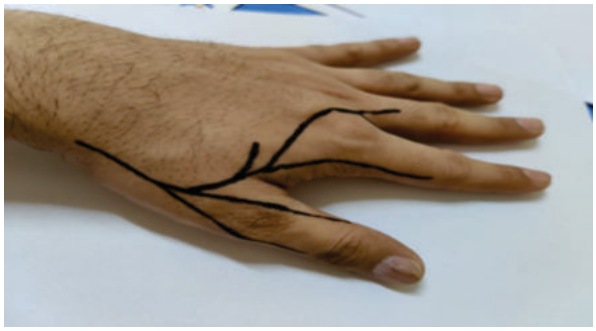

Fig 4- Surface marking of superficial branch of Radial nerve to prevent iatrogenic injury during pin insertion.

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