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Dr. Naveen DS
Assistant Professor, Department of Orthopedics, J.J.M Medical College, Davanagere, Karnataka, India

Dr. Devaraj P
Junior Resident, Department of Orthopedics, J.J.M Medical College, Davanagere, Karnataka, India

Dr. Arjun V Patil
Junior Resident, Department of Orthopedics, J.J.M Medical College, Davanagere, Karnataka, India

Dr. Abhishek Yadav
Junior Resident, Department of Orthopedics, J.J.M Medical College, Davanagere, Karnataka, India

Corresponding Author:
Dr. Devaraj P
Junior Resident, Department of Orthopedics, J.J.M Medical College, Davanagere, Karnataka, India

A prospective study on surgical management of complex distal metaphyseal fracture of tibia with hybrid external fixation

Dr. Naveen DS, Dr. Devaraj P, Dr. Arjun V Patil and Dr. Abhishek Yadav

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Abstract

Background and Objectives: Fractures of distal tibia are among the most difficult fractures to treat. The short distal segment presents difficulty in choosing the appropriate fixation method. The greatest challenge lies in the relatively tight soft tissue around the ankle. The difficulty in treating the fracture of tibial metaphysis is exemplified by orthopedists, who in the first half of 20th century, believed the injuries were so severe and operative repair was fraught with so many complications that the fracture was deemed not amenable for surgical reconstruction. Since there was no definitive protocol for the treatment of such fractures, the Hybrid External Fixator seemed suitable for such fractures as they combine the advantages of monolateral and circular fixation, Tensioned wires provide improved fixation in the peri-articular fragments. It allows early weight bearing and movement of the knee and ankle at all times.

Methods: A Prospective study of 31 cases of surgically managed fractures of distal Tibia using Hybrid External fixation undertaken at Department of Orthopedics, J.J.M Medical College, Davanagere from 1st June 2018 to 30th November 2021 who follow Inclusion and Exclusion criteria and followed up for a period of 6-24 months.

Results: 6 patients were lost to follow up before removal of the fixator and were thus not included in the statistics. All the fractures consolidated at an average of 13 weeks and the fixators were removed. All the studied fractures resulted in good union. 2 of 4 compound fractures and 4 of the 10 simple fractures developed pin tract infections which were suppressed using antibiotics. 8 patients had stiffness of the ankle joint. This was probably due to the patient in compliance to the physiotherapy regimen. 2 cases had a malunion with an anterior angulation of 5 degrees but had a good ankle function. At 6 months, results were based on objective and subjective parameters by Ovadia and Beals. 9(36%) patients had excellent outcome, 12 (48%) had good, 3(12%) had fair and 1(4%) patient had a poor outcome.

Interpretation and Conclusion: Hybrid external fixator is simple, rapid and straightforward application, reduced surgical time, minimally invasive and adjustable. It has negligible complications and resulted in excellent results for this type of fractures.

Keywords: metaphyseal distal tibial fractures; hybrid external fixators

Introduction

Fractures of distal tibia are relatively uncommon injuries, representing only 1% of all the fractures of lower limb and 5-7% of those of tibia [1-3]. Fracture of the distal tibia are serious complex injuries sometimes very difficult to treat. The short distal segment represent difficulty in choosing the appropriate fixation method. Challenge also lies in the relatively tight soft tissue and gross swelling around the ankle associated with these fractures. The intraarticular group of these injuries-pilon fractures or plafond fractures need the articular reconstruction for maximal ankle knee function [1]. They are only 1-10% of all lower extremity fractures [4]. Intra articular and extra articular fractures of distal tibia present a wide spectrum of soft tissue and bony injury patterns that can produce permanent impairments. For patients treated operatively the residual disabilities are not only attributable to the severity of the injury, but also to the complications and side effects of the operative intervention [5, 6]. The distal tibia possesses inherent vulnerability to comminuted fractures due to the lack of muscular origin [7]. The low energy type of fracture often get dramatic results with open reduction and internal fixation, but high energy fractures documented too show a high amount of complications due to soft tissue coverage, skin necrosis, infections, and also the usual comminuted nature of the fractures. [8]

Two mechanisms are found to be cause for the distal metaphyseal tibial fractures-low stress trauma secondary to rotational forces and high stress trauma which produces axial transmission of load with the talus pushed on to the distal tibia resulting in multifragmentary implosion of bones and cartilaginous structures [9, 10]. The most widely used classification of the distal metaphyseal fractures are divided into three groups-type A, extraarticular-type B ,partially intraarticular and type c ,completely intraarticular^[11] In fractures with severe soft tissue damage and metaphyseal comminution the introduction of plates and screws through an extensive exposure is associated with high rate of failure and severe complications such as surgical wound infections, osteomyelitis and nonunion [12-21]. Conservative treatment by cast application leads to prolonged immobilization ,leading to joint stiffness affecting the quality of life of the patient.^[22]Nailing also has its limitations of providing stability to small distal fragment [23, 24]. Introduction of the external fixator was a revolution in the evolution of management of these fractures. It has undergone a sea of change, simple to more complex frame and various pin arrangements. Hybrid external fixator combines the advantages of the monolateral pin fixators and the circular ilizarov wire fixators, the tensioned wires provide improved fixation in the small cancellous fragment , whereas the pin fixators give adequate stability to the diaphyseal fragment along with rigid fixation , it allows immediate mobilization of the joints and early weight bearing [25]. Hybrid external fixation represents a possible alternative method to provide a stable fixation and reduce complications [26]. Early motion has been touted as the functional savior of major intraarticular injuries [27].

Material and Methods

A Prospective study of 31 cases of surgically managed fracture of distal tibial metaphyseal using Hybrid ex-fix undertaken at Department of Orthopedics, J.J.M. Medical College, Davangere from June 2018 to November 2021.

Inclusion criteria

1. age >18 years of age
2. simple metaphyseal fractures of the distal tibia unsuitable for interlocking nailing and Complex metaphyseal fractures of the proximal tibia.

Exclusion criteria

1. age below 18 years.
2. Patients unwilling to undergo surgery.
3. Patients medically unfit for surgery.

Surgical Technique

Instruments and Implants

Ilizarov half rings, 5/8 rings, Bayonet edged Ilizarov wires-plain/olive, Slotted/cannulated wire connecting bolts, twisted connecting plates, 4.5mm Schanz pins, Pin clamps, Connecting rods, Nuts and Bolts, 3.5 mm drill bits, T-handle, 10/11 wrenches, 3.5mm drill sleeves, Wire bender/cutter, General instruments.

Operative Procedure

Type of Anesthesia- Lumbar Sub Arachnoid Block.
Position-supine with affected leg elevated with a pillow under the distal thigh for proximal end fractures.

Securing the distal fragment

- After reduction of the distal fragment, it was secured

using three Ilizarov wires.

- The wires were pushed manually till it hit the cortex, then drilled across both the cortices and hammered out through the opposite soft tissue.
- Nerves and vessels were avoided by the awareness of the anatomy, based on the safe corridor for pin insertion in the lower leg by Fred Behrens and Kate Searls.
- Two olive wires were placed at 40-70° to each other, one from posterolateral to anteromedial and posteromedial to anterolateral under fluoroscopic control.
- Minimal incisions were used to accommodate the beads in the olive wires.
- A third plain Ilizarov wire was placed in between the earlier two wires, parallel to the operating table.
- Appropriate size Ilizarov half ring was selected, so as to leave a gap of 2cms between the leg and the ring on all sides.
- The wires were fixed to the rings using cannulated/slotted wire connecting bolts and tensioned using Russian free hand technique with two 10/11 wrenches.
- Skin traction by the wires, if any were released using minimal incisions on the side of the skin stretching.

Securing the proximal fragment

- The regular tibial external pin fixator was used for the proximal fracture fragment Three 4.5mm Schanz pins were placed 3-4cms apart on the antero-medial surface of tibia perpendicular to the operating table.
- Generous (1.0-1.5cms) incisions were put and skin and fascia was cut.
- Drill holes were made using 3.2/3.5mm drill bit in the same sagittal plane.
- The Schanz pins were driven into the drill hole using a T-Handle to the extent that the proximal end of the threads of the pin were well buried in the proximal cortex.
- All the pins were placed in the same sagittal plane.
- The pins were connected to the connecting rods with the pin clamps.

Fracture reduction and frame assembly

- Fracture reduction was obtained using longitudinal traction (Ligamentotaxis), confirmed using the image intensifier. The pin fixator assembly was connected to the ring assembly using a twisted connecting plate.
- All the nuts and bolts were tightened.
- A diagonal strut was connected from the proximal Schanz pin or the connecting rod to the lateral most hole of the half ring for extra stability.
- The compound fractures were treated with primary or secondary flap reconstructions or split thickness skin grafting as deemed suitable by the plastic surgeon.

Post-operative regimen

Active mobilization of the ankle, knee and non-weight bearing of the patient using standard walking frame was done from the first post-operative day under the supervision of a physiotherapist. Intravenous antibiotic regimen was continued for 5-7days (12-14 days in compound fractures) after the surgery. Another 5 days of oral antibiotics were advised. Regular cleansing of the pin exit points was done. Compound fractures were dressed as per instructions from the plastic surgeon.

Follow up

The patients were followed up at intervals of three weeks for

up to 6-10 months to assess the radiological union and to check the stability of the construct.

The fracture was designated as united, when there was periosteal bridging callus at the fracture site at least in three cortices in the antero-posterior and lateral views. Trabeculations extending across the fracture site was also taken into consideration. Partial and full weight bearing were allowed based on the radiological union and consolidation of the fractures. Uncomplicated fixators were removed after complete fracture union. Fixators with pin tract infections were removed earlier and a patellar tendon bearing cast was applied which were removed after radiological union of the fracture. Ovadia and Beals based results on objective and subjective evaluation. This scoring system was used in this study to assess the results.

Results

The present study consists of 31 cases of metaphyseal fractures of the distal tibia. 6 patients were lost to follow up before removal of the fixator and were thus not included in the statistics. The age of the patients ranged from 22-62 years with the fracture being most common in the 4th decade and an average age of 41.6 years. Out of 25 patients, 15 (60%) patients were males and 10 (40%) patients were females showing male preponderance. In our study, 20 (80%) of patients sustained injury following road traffic accident and 5 (20%) patients sustained injury following fall. Out of the 25 cases, 16 (64%) cases were closed fractures and 9 (36%) cases were open fractures. Open fractures: Classification of the 9 cases of open fractures based on Gustillo Anderson classification of open fractures, 3 (33%) were type I compound 2 (22%) were of type II compound, 2 (22%) were type IIIA and 2 (22%) were type IIIB. All patients with closed had some form of soft tissue injury 5 (31%) patients had c1 injury, 9 (56%) had c2 injury and 2 (13%) had c3 injury according to Tscherny classification. The fracture pattern was classified based on AO/OTA classification for fractures of distal tibia of the 25 cases studied, 5 (20%) cases were A1, 5 (20%) were A2, 12 (48%) were A3 and 3 (12%) cases were C1 type of fracture. The duration of surgery ranged from 40 to 70 minutes for the distal tibia averaging 52 minutes. The fractures of the distal tibia united with an average of 13.42 weeks (13-22 weeks). All the fractures consolidated at an average of 13 weeks and the fixators were removed. Two cases showed malunion with anterior angulation of 5 degrees but had a good ankle function. The results were based on the objective and subjective parameters as described by Ovadia DN and Beals RK. At the end of 6 months of 25 patients treated showed 9 (36%) patients had excellent outcome 12 (48%) had good, 3 (12%) had fair and 1 (4%) patient had a poor outcome.

Associated Injuries

All except 2 of 25 cases studied had an associated fracture of the lower third of fibula. The two cases with intact fibula had to be osteotomized to give adequate compression at the tibial fracture site.

Statistics of Surgery

All the 25 cases were operated under Spinal anaesthesia. All the cases studied underwent closed reduction under fluoroscopic control. Follow up ranged from 6 months to 10 months.

Complications

Intra-operative complications: There were no cases of

intraoperative complications.

Post-operative complications

1. Pin tract infections

6 of the patients developed superficial pin tract infections, which were treated with daily dressings and appropriate antibiotics after pus culture and sensitivity. All these infections subsided on the above said treatment. However, as a precautionary measure, the fixators were removed earlier (8-10) weeks and a patellar tendon bearing cast was applied in these patients, which were removed after radiological union of the fracture.

2. Ankle stiffness

We had 8 patients with ankle stiffness. This was probably due to the in compliance of the patient to the advised physiotherapy regimen, as there was no means to monitor the physiotherapy of the ankle joint after discharge of the patient. Ankle stiffness ranged from restriction of ankle movement from 20%-90%. The patient who had 90% restriction had an equinus deformity.

3. Anterior angulations

2 patients developed an anterior angulation of 5 degrees. This however did not grossly hinder with the mobility of the joints or daily activities of the patients.

Discussion

Fractures of distal tibia are among the most difficult fractures to treat effectively. The status of the soft tissues, the degree of comminution and articular damage sustained at the time of injury affect the longterm clinical results. The goal of operative treatment is to obtain anatomic realignment of the joint surface while providing enough stability to allow early motion. This should be accomplished using techniques that minimize osseous and soft tissue devascularization in the hopes of decreasing the complications resulting from treatment. The present study was undertaken to determine the efficacy of the Hybrid External Fixator in treatment of the fractures of the distal tibial metaphysis. We evaluated our results and compared them with those obtained by various other studies.

Our study revealed the average age of patients with such injuries to be 41 years (22-62). It is comparable with a study on similar fractures conducted by RF Gaudinez, Arati R. Mallik and Monroe Szporn^[28], whose average age was 35, and also study by R. Barbieri, Richard Schenk, Kenneth Koval *et al.*^[29] where average age was 39 years.

In our study, the male preponderance for such kind of injuries were 60% compared to the study by Barbieri *et al.*^[29] which was 59% possibly due to the fact of male dominance over the female in traveling, occupational injuries etc., in India. However, the study by Ovadia and Beals^[30] were comparable in the fact that they had 67% male patients.

Gaudinez *et al.*^[28] observed 93% high energy fractures in his study. Ovadia and Beals^[30] could attribute only 46% of such injuries to be of high energy. However, our present study correlates with the study conducted by Barbieri *et al.*^[29] similar fractures in which they noted 75% high energy trauma. Our study showed 80% high energy trauma.

Our study had 36% open injuries. This was comparable to studies conducted by Barbieri *et al* had 30% and Gaudinez *et al.*^[28] has 21% of open injuries. The average surgical time was 52 minutes (40-80 minutes). It is comparable with the average of 62 minutes taken by Gaudinez *et al.*^[28] In their

study, the average time for fracture union in various studies conducted using various methods was 13-16 weeks. Our study had an average fracture union of 13 weeks which were comparable with studies conducted by Barbieri *et al* where average fracture union of 14 weeks and Gaudinez *et al.* [28] had an average of 13 weeks.

There were 9 excellent, 12 good and 3 fair results. There were 6 cases of pin tract infection (24%), 8 cases of knee stiffness (32%), 2 cases had a malunion with an anterior angulation of 5 degrees but had a good ankle function. Pin tract infection resolved in all patients with regular dressings.



Preop Xrays



Immediate Postop

14 Months Followup



Full Weight Bearing

Ankle Dorsiflexion

Ankle Plantar Flexion

Conclusion

According to the study, 25 patients with fractures of the distal tibial metaphysis had undergone closed reduction and application of the hybrid external fixator. This technique has resulted in the effective stabilization of these fractures. It does provide adequate stability and allows early motion. The

closed reduction not only helps in achieving reduction in difficult situations, but also in rapid union, because it facilitates preservation of blood supply to the fragment. This method limits further damage to the already compromised soft tissue. Its greatest advantage is in open fractures where wounds can be left open. It is also effective in extraarticular

fractures occurring within 5cm of the joint because, intramedullary nails often do not provide enough stability and plates would require extensive soft tissue dissection. It is a simple, has a rapid and straight forward application and has a reduced surgical time. Tensioned wires provided unproved fixation in small and osteoporotic fragments. When encountered with the unreconstructable tibial metaphyseal fracture, those with comminution or poor bone stock, closed reduction and Hybrid External Fixator satisfies the goals of fracture and soft tissue healing, without obviating any other means of further treatment. Although, a larger sample of patients and longer follow up are required to fully evaluate this method of treatment, we strongly encourage its consideration in the treatment of such complex fractures.

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