



Comparative study of Modified Enders nail versus plating in fractures in distal one third Tibia

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Abstract

Background and Aim:

The subcutaneous location of the tibia makes it prone to the direct trauma and high energy trauma in a road traffic accidents. On the basis of location, distal tibia fractures are second in incidence next to tibia diaphyseal fractures¹. The aim of our study was to compare functional and radiological outcome of modified Enders nail versus plating in distal one third tibia fractures in adults.

Materials and methods:

This is a study of 40 patients, among them 20 treated with modified Enders nail and 20 treated with plating. 34 patients had concomitant fibula fractures. 28 had sustained closed fractures and 12 patients had sustained open fractures.

Results

Average time for fracture union was 16.05 weeks in the cases of Modified Enders nailing and 15.5 weeks in the cases of plating in distal tibia fractures.

Out of 20 patients of enders nailing, 2 patients had fracture site tenderness, pain on full weight bearing and radiological union of only 2 cortices out of 4. One of the patients had delayed union which healed after 25 weeks and one had Non-union which was treated with plating and fibular bone grafting. One patient had Enders nail irritation proximally, and the nail was removed. One patient required an additional procedure of skin grafting.

Out of 20 patients of plating, 3 patients had infection in which removal of the plate was done at 20 and 24 weeks in two cases and antibiotics were initiated which eventually lead to a Good and Fair outcome a 1 year follow up. One patient of the total three patient infected went on ankylosis of ankle, with plate breakage and consistent pus discharge, patient had undergone removal of implant, but infection of the bone had initiated and eventually had a poor outcome.

Conclusion:

Based on our results, the effectiveness of minimally invasive plate osteosynthesis and Modified Ender nailing has given Excellent/Good and comparable functional outcome in most of our cases.

Modified Ender nailing is a better choice than MIPO when there is unhealthy local skin condition.

Keywords: Tibia, Fibula, Enders nail, osteosynthesis, plate, fracture, union, MIPPO

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Introduction

In India, an alarming number of 1,00,000 lives are lost due to road traffic accidents every year, which is nearly 1/3rd of its fatalities. The injury due to these accidents commonly involve the long bones especially tibia due to its subcutaneous location. On the basis of location, distal tibia fractures are second in incidence next to tibia diaphyseal fractures¹.

The aim of treating these fractures is to preserve normal mechanical axis, ensure joint stability and restore a near full range of motion. This is a difficult task to accomplish in each and every case as we face compromised soft tissue condition and variable bone quality². The distal tibia due to its subcutaneous location tenuous blood supply pose a challenge to treating surgeons in terms of choosing an appropriate implant to achieve adequate union in time and good functional outcome.

A variety of treatment options are available. But there is no consensus on the best treatment modality³. Surgical fixation is considered for most distal tibia fractures which require meticulous preoperative planning. Available options for stabilizing fractures are closed reduction and intramedullary nailing or open reduction and internal fixation (ORIF) with plating or closed reduction and percutaneous plating (MIPPO) or external fixators/Ilizarov external fixation. The factors determining the fixation methods are pattern of fracture, quality of bone and condition of soft tissues^{3,4, and 5}. Non-surgical treatment is possible for stable undisplaced closed fractures. But malunion, shortening of affected leg, limitation of range of movement, early arthritic changes and functional loss have been reported. External fixation can be useful in open fractures with soft tissue injury which preclude nail or plate fixation, but may result in inaccurate reduction, a relatively high rate of malunion, or non-union and pin tract infection and pin loosening⁶.

Comparable and similar primary union rates were noted after surgical treatment of distal tibia shaft fractures with both nonlocked plates and reamed intramedullary nails. Also the rates of infection, non-union, and secondary procedures

were similar. Also on comparing the two Intramedullary nailing was associated with more malalignment versus plating⁷. Concerns regarding difficulties with reduction/loss of reduction, inappropriate fixation in fractures with articular extension, anterior knee pain⁸ and hardware failure have slowed the acceptance of intramedullary nailing as a treatment of fractures of the distal tibia.

Percutaneous plating has more preference in terms of preserving the soft tissue envelope and the periosteum and vascularity^{9,10,11}. Minimally invasive percutaneous plate Osteosynthesis (MIPPO) technique can address several of the issues associated with intramedullary nailing, while amalgamating all biological benefits of closed reduction and fixation¹².

Ender's nailing is considered as an excellent semiconservative treatment for tibial shaft fractures, maintaining adequate elasticity at the fracture sites where much callus is formed, leading to a good union¹³. Not much literature is available regarding its use in distal tibial fractures, however its use in diaphyseal tibial fractures have been studied by many.

The successful management of these injuries, demands a thorough knowledge of fracture pattern and technical aspects of fracture fixation; and a tailored postoperative management.

The purpose of this study

1. To set the indications for both modalities of fixation.
2. To compare the clinical and radiologic outcomes of patients treated by both methods.

Materials and Methods:

This is a study of 40 patients, among them 20 treated with modified Enders nail and 20 treated with plating. 34 patients had concomitant fibula fractures. 28 had sustained closed fractures and 12 patients had sustained open fractures. Age was ranging from 18 to 65 years. Average age was 40.72 years. 34 males and 6 females were there.

INCLUSION CRITERIA:



Patients who sustained lower one third of the tibia fracture which were treated by nailing/plating were included in the study. Both open and closed fractures were included.

EXCLUSION CRITERIA:

Patients with pathological fractures, stress fractures, paediatric patients (<14 years of age), metabolic bone diseases, distal tibia fractures with intra articular involvement were all excluded. Patients with history of refracture were also excluded.

These 40 patients had a minimum of 1 year follow-up and were included in our study. At follow up, the clinical examination was done by two examiners

independently followed by functional and radiological scoring with Ankle and Hind foot Score (AOFAS score) and RUST (Radiographic union Score for Tibia) scoring RUST score and functional scores and measurement of radiographic parameters¹⁴.

RADIOGRAPHIC OUTCOME:

RUST (Radiographic union Score for Tibia)

The RUST score is a novel fracture assessment tool that was developed to help standardise the radiographic assessment of tibial fractures¹⁶. This score assesses cortical bridging, which has been shown to correlate with the biomechanical strength of the fracture site in in-vivo models.

A score is given to each cortex - anterior, posterior, medial and lateral and the RUST score is the sum of all cortex scores. A cortex with a visible fracture line and no callus was given a score of 1, a cortex where callus and a visible fracture line was present was scored as 2, and a cortex with bridging callus and no fracture line within the callus bridge was scored as 3 (Table 1). The scores of all cortices were then combined to give a minimum score of 4 (definitely not healed) and a maximum of 12 (completely healed). Radiographic cortical bridging by callus and the lack of a fracture line offer the most reliable signs of bone healing between observers¹⁷. We performed the RUST scoring for both the subsets at 3 months and 6 months follow up

Radiographic Criteria		
Score per cortex	Callus	Fracture line
1	Absent	Visible
2	Present	Visible
3	Bridging	Visible

Table: 1 RUST (Radiographic union Score for Tibia)¹⁵

CLINICAL OUTCOME:

Ankle and Hind foot Score (AOFAS score):

The American orthopaedic Foot and Ankle Society Score (AOFAS) introduced

Kitaoka et al¹⁸ was performed at 1 year follow up for all our patients. We included the Ankle and Hind foot score of it. It has nine questions divided into three components.

1. Pain
2. Function
3. Alignment

Total score possible for a patient was 100 points. Alignment of the foot and range of motion of the ankle (measured by orthopaedic goniometer) was completed by the examiner on clinical assessment and assessing the radiographs. The other questions were completed

by the patients. The individual scores were then added together to obtain an overall functional score, which was then expressed as a percentage of the normal (100 points)

THE CRITERIA FOR ACCEPTABLE FRACTURE REDUCTION INCLUDED -

- i. <7 degree malalignment in frontal plane
- ii. <10 degree malalignment in sagittal plane
- iii. Limb shortening <1.5 cm.

THE GOALS OF OPERATIVE TREATMENT OF DISTAL TIBIA FRACTURES:

- i. Anatomical Alignment
- ii. Stable fixation
- iii. Early Mobilization
- iv. Early functional rehabilitation of the ankle.



PRE OPERATIVE EVALUATION

All patients were examined. Local examination of affected limb was done to rule out compartment syndrome and neurovascular status, surrounding soft tissue status and other skeletal injuries and systemic examination was also done. Patients with Open injury were given thorough wash and wound debridement under local anaesthesia was done in the Emergency ward. Antibiotic coverage was given. Patients were applied above knee slab and admitted in the ward, routine investigations were done for all patients. Routine X Ray Ankle AP, Lateral views were taken and CT ankle was done to check for involvement of any associated fractures. Assessment of fracture pattern and degree of comminution was done and documented.

TIMING OF SURGERY

All the study patients were taken up for the surgical procedure between the 2nd and 12th day after the trauma. The duration of surgery was minimum 60 min and maximum 120 minutes. The average duration of surgery was 90 min. Those patients to whom fibula fixation was done took more surgical duration.

SURGICAL TECHNIQUE FOR MODIFIED ENDERS NAILING

Total 40 patients were included, and the cases were randomised, 20 patients were operated with Modified Ender nailing and 20 patients were

treated with distal tibia plating. Cases were divided into subset of Ender nailing and distal tibia plating alternatively.

Surgical procedures were performed by either a consultant, or a post graduate registrar under supervision with all aseptic precautions, proper draping, and long thin support under leg for to check cross table lateral view and with tourniquet applied for emergency use. (Figure 1)

Fracture was reduced using traction and manipulation at the ankle, two or three Enders nails were used, according to the diameter of the bone. The entry point is proximal to the fracture site i.e. proximal end of the tibia which helps us in preserving the biology of the fracture (Figure 1 & 2). Nails were buried into the distal dense bone stock which provides axial and rotational stability.

Acute bends at the distal end of the nail were given for the 'hook' effect, while pre bending of the nail was done. Nails are given a bend either C shaped or E/S shaped according to the reduction of the fracture planned. Two/Three pre bent C shaped nails are advanced from both the sides of proximal tibia which prevent varus and valgus malunion while the S shaped is passed just medial and anterior to the proximal tibia bone which eliminates the risk of procurvatum and recurvatum. (Figure 3)



Figure 1 : Anatomical Landmarks for the entry point

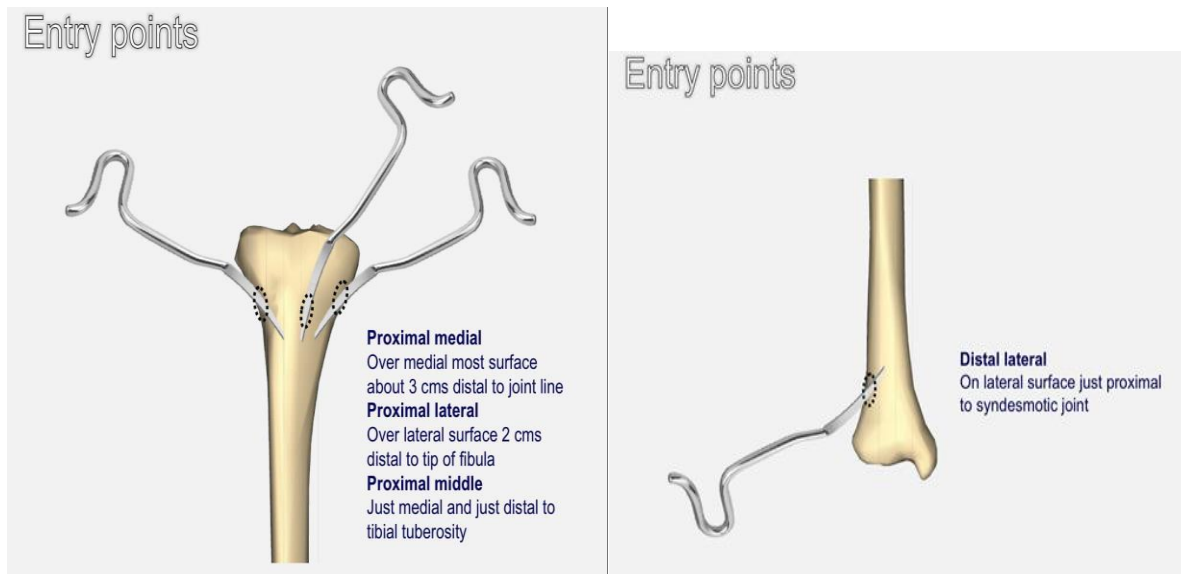


Figure 2 : Entry points on proximal and distal tibia

Entry into the bone is taken using an awl and with the help of the rotator the nail is controlled and passed through the fracture site, this manoeuvre also aids in reduction of the fracture without much manipulation at the local site. 3.0, 3.5 and 4.0 mm of ender nail are used depending on the diameter of the bony canal. Extractor helps us in removing the nail if it misses the canal or causes the loss of the reduction, under C-arm control. Reduction has to be confirmed under C-arm control.

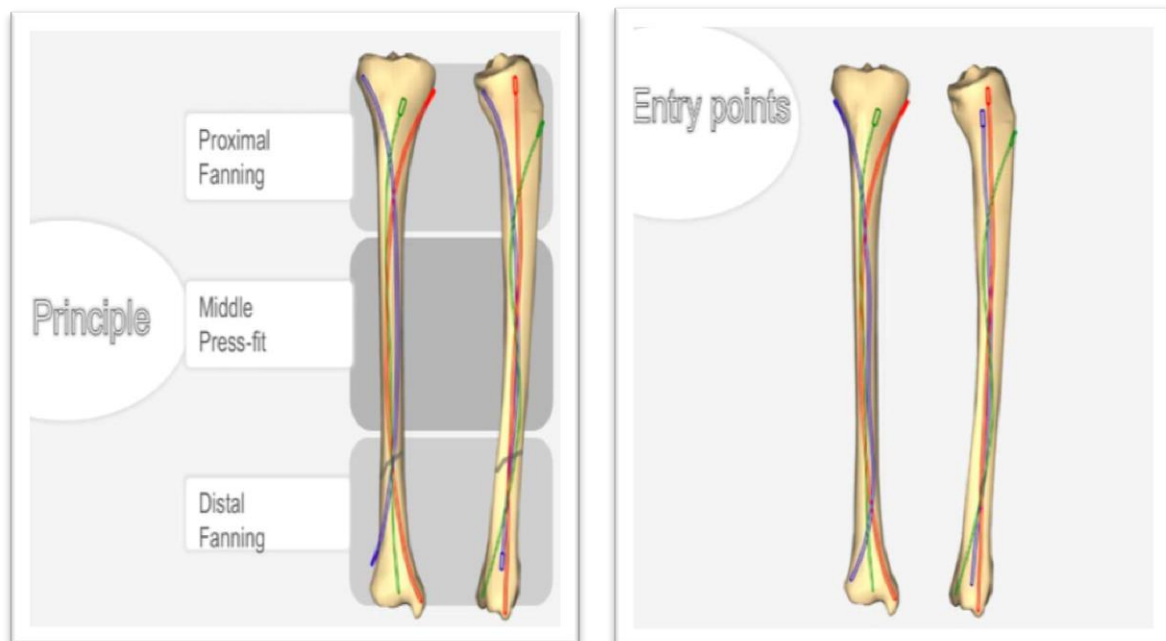




Figure 3 : Pre contouring and nail configuration

Fanning is aimed at both the distal and the proximal ends which provides better rotational and angular stability, at the fracture. Every fracture is approached differently in terms of how many nail, which nail from which side and the reduction and its maintenance. This aids in treating more patterns of the fracture with logical steps.

We had a total 20 cases, Out of which 16 cases had fibula fracture, fibula was fixed in 12 cases among them TEN nail was performed in 7 cases, K wire was used in 1 case and in 4 cases Fibular plating was done.

One case had associated posterior malleolus injury and was treated with plating and one case had associated medial malleolus fracture, in which Cancellous screw was used.

SURGICAL EXPOSURE FOR PLATING:

Surgical incisions and approaches to reduce and fix fractures of distal third tibia have been modified to decrease the incidence of wound complications and better soft tissue handling. (Figure 4) Extensile incisions are avoided to lessen the risk of wound dehiscence and adequate closure.

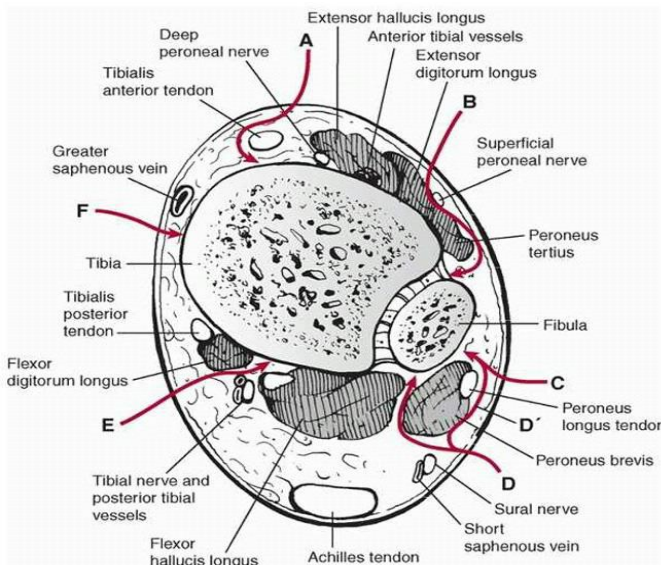


Figure 4: Neurovascular plane for plating

In our study we used the technique of MIPPO. With MIPPO plate constructs it is preferable to choose as long an implant as possible for the widest distribution of load at the fracture site. A variety of pre-contoured distal tibia plates are available. If such an implant is not available, it is important to contour the plate prior to insertion or occasionally 4.5 mm standard or locking plate (LCDCP or LCP) can often be used, but distal purchase may be compromised without a specially designed plate. For distal fractures and osteoporosis, locking head screws (LHS) may be more stable distally.

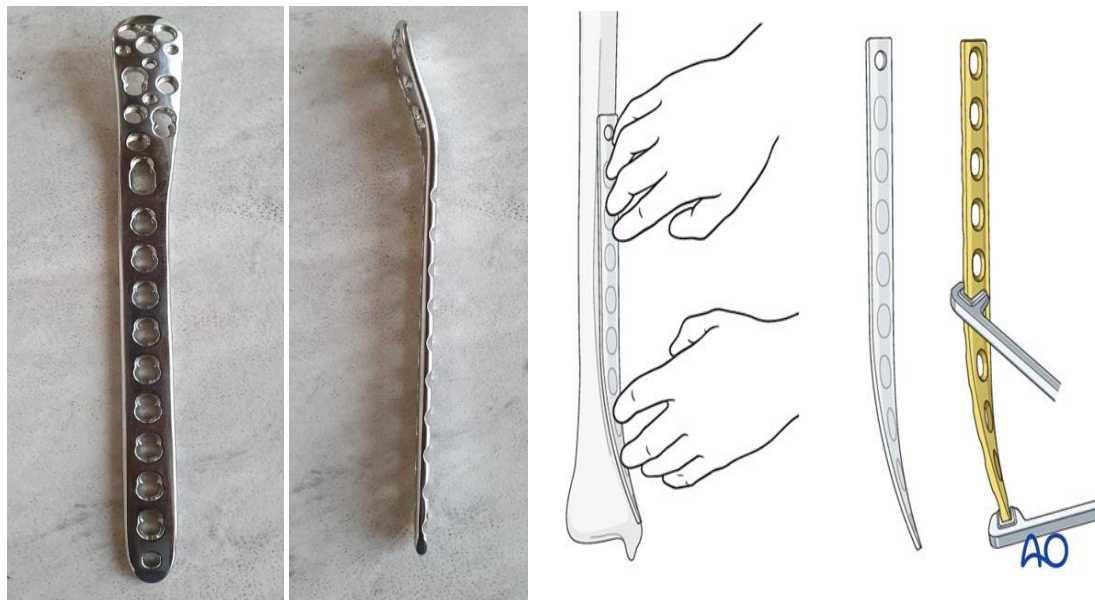


Figure 5: Distal Tibial plate and contouring

The patient was positioned in supine on operating table, after closed percutaneous reduction of distal tibia, 2 cm vertical incision was made over the medial malleolus. Plate was inserted after creating a tunnel in a retrograde manner and temporary fixation can be performed with K-wires through the screw holes to approximate final plate position before insertion of screws.

A small counter incision made proximally to optimally align the plate on tibia and fixed with percutaneous placed screws by stab incisions under image in guidance. Distal segment screws inserted with same incision.

It is crucial that the plate is positioned very close to the bone, especially at the supra-malleolar level, to prevent soft-tissue irritation by the plate.

We had 20 cases of distal tibia fracture in which plating was done.

- Cases with only tibia plating – 6
- Cases with both tibia and fibula plating – 7
- Cases with tibia plate and fibula intramedullary device – 4
- Cases in which fibula was not fixed – 5
- Case with no fibula fracture- 3

POST-OPERATIVE PROTOCOL

- Immediate post-operative X-rays were done for documentation purpose
- Wound inspection done on 2nd day Post operatively
- Ankle and knee mobilisation started on 2nd/3rd day
- Suture removal on 15th post-operative day.
- Patient advised non weight bearing until radiological evidence of union
- Follow up every month with radiographs

- Radiological examination once in every 4 weeks and RUST scoring was documented at 3 months and 6 months.
- Once radiological union visible started partial to full weight bearing was allowed.
- All cases were assessed using the AOFAS ankle and hindfoot score at 1 year follow up.

Post-operative slab was given to the patients for 2-3 days and afterwards ankle mobilisation was initiated as soon as possible. Weight bearing was only advised after visible signs of union on X-rays. Regular dressing was done and post-operative calcium supplements were given, if required.

RESULTS

Out of the 40 patients there were 34 males and 6 female patients. The mean age of the patients at the time of injury is 40.72 years (range of 18 to 65 years). The minimum follow up period was 6 months and a maximum of up to 18 months.

Out of 40 patients, 28 (70%) had sustained closed fractures and 12 (30%) patients have sustained open fractures. Open fractures were further classified by Gustilo and Anderson's Method (Table 2)

Fracture Characteristics				
Type	Closed	Open Fracture (Gustilo Anderson)		
		I	II	III
No.	28	6	2	4
Percentage	70%	12 (30%)		

Table 2: Fracture characteristics the study group

Out of total 12 cases of open injury, Modified Ender nailing was done in 9 cases, while plating was done in 3 of the total 12 cases of compound injury.

The average time taken to do surgery was 4 days (range of 1 day to 12 days). Concurrent fibula fracture was present in 34 out of 40 cases and concurrent fibula fixation was done in 24 cases.

Knee range of movements was assessed in all the 40 cases, in the cases of plating all cases had almost near knee movements, while in Modified ender nailing- 1 case had painful range of movements at the knee due to the hardware irritation. Range of movements were normal after the removal of the nail.

Average time of union was 16.05 weeks in the cases of Modified Enders nailing and 15.5 weeks in the cases of plating in distal tibia fractures. The average time taken to partial weight bearing was 8.45 weeks in cases of ender nailing and 7.2 weeks in the plating group. The average time taken to full weight bear walking was 15.2 weeks in cases of Modified Enders nailing and 15.5 weeks in cases of plating. The average time taken to return to work was 19 weeks for Modified Enders nailing and 17 weeks in Plating.

Surgery	No.	RUST score		AOFAS score				AOFAS (average)
		3 months	6 months	Excellent	Good	Fair	Poor	
Enders	20	7.1	11.6	9	10	0	1	89.5
Plating	20	8.3	11.4	9	9	1	1	89.4

Table 3: Radiological outcome RUST score between the two groups

In 20 cases of Modified Enders nailing, we observed 7.1 and 11.6 RUST Score at 3 months and 6 months respectively, while average AOFAS score was 89.5, (minimum was 40 and maximum was 96). One patient had poor functional outcome due to non-union.



In 20 cases of plating, we observed 8.3 and 11.4 RUST score at 3 months and 6 months respectively, and the average AOFAS score was 89.4 (minimum was 40 and maximum was 96)

Initial RUST score was more in cases of plating but eventually at 6 months the score were almost similar to cases of Modified Ender nailing. The mean RUST (at 6 months) score was 11.6 in Modified Enders nailing and 11.4 in plating. Functional AOFAS score was similar in both groups. Out of total 40 patients, 14 patients in the study had excellent results while only 2 patients had poor outcomes.

Complications

Out of 20 patients of ender nailing, 2 patients had fracture site tenderness, pain on full weight bearing and radiological union of only two cortices out of 4. One of the patients had delayed union which healed after 25 weeks and one had Non-union which was treated with plating and fibular bone grafting. One patient had Enders Nail irritation proximally, and the nail was removed. One patient required an additional procedure of skin grafting.

Out of 20 patients of tibia plating, three patients had an infection in which removal of the plate was done at 20 and 24 weeks in two cases and antibiotics were initiated which eventually led to a Good and Fair outcome at 1 year follow up. One patient of the total three patient infected went to ankylosis of the ankle, with plate breakage and consistent pus discharge, patient had undergone removal of the implant, but infection of the bone had initiated and eventually had a poor outcome.

Complications	Modified Enders Nailing (n=20)	Plating (n=20)
Delayed Union	1	0
Non Union	1	0
Infection	0	3
Percentage	10	15

Table 4: Complications between two groups

Re surgery	Modified Enders Nailing (n=20)	Plating (n=20)
Skin grafting	1	0
Removal of implant	1	3
Debridement	0	1
Percentage (%)	10	20

Table 5: Re-surgeries between two groups

The overall results of our study in both the groups were comparable. Apart from the delay in radiological signs of union there were no other significant differences noted between both the subset. Time to surgery was also less in cases treated with Modified ender nailing as local swelling and skin condition were not hindrance unlike in the cases of the distal tibia plating. The Enders nail is much less invasive as compared to the MIPPO and both the groups had similar time for union.

Discussion

Minimally invasive plate percutaneous osteosynthesis (MIPPO) and Enders Nailing rely primarily on the indirect reduction of the fracture using various techniques, MIPPO has been excellently described in the classic works of Mast and Ganz¹⁹, while conventional Enders has been described well in the literature. In this way, the fracture environment is better preserved, as well as the blood supply to the bony fragments^{20,21}. Theoretical advantages include less infection and less wound problems and better fracture healing²³.



The region of the distal tibia and ankle joint, the soft tissues injuries are frequently involved and play a central role in the choice of the surgical fracture treatment. Very often, it is the initial condition of the surrounding soft tissues that limits the possibilities for osteosynthesis and directly relates to the outcome of distal tibia fractures²²⁻²⁴.

When fixing comminuted metaphyseal fragment to the distal diaphysis in an attempt to restore proper axial alignment, often considerable hardware and wide surgical dissection is required. Percutaneous plating of the distal tibia offers a similar stability as classic ORIF, however without the need for extensive dissection. Therefore fewer soft tissue complications can be expected, allowing the use of this technique even in the presence of moderate to severe soft tissue contusion or grade I or II open fractures. As such, it promises to be a valid alternative to external (hybrid) fixation, although two-stage procedures may be performed^{25,26}. On the other hand, Ender nail helps in the reduction due to the Modified curves of the nails and the property of elastic recoiling. Axially stable reduction is considered ideal while treated with the modified Ender nailing. If severe comminution is present and the fracture line is extending distally, it's ideal to go for plating rather than nailing. Though if distal fibula is fixed it helps in providing the axial stability.

Theoretically, Stress risers can arise in the plate which does not happen in Modified Ender nailing, as it holds throughout the length of the bone. We used medial distal tibia anatomical locking compression plate. This plate is a low profile plate. The Medial distal tibia plate is a pre-contoured plate to that of the distal tibia and thus allows placement of the plate without disruption of fractures fragments. The thread holes in the plate locks to that of the screw head and minimize plate-bone interface and maintain the vascularity at the fracture site.

Modified Ender nailing is good alternative especially in cases where there is soft tissue insult and poor skin condition, as the approach is minimal and stability is adequate, we have used two or three ender nail according to the diameter

of the bone. The entry is proximal to the fracture site i.e. proximal end of the tibia which helps us in preserving the biology of the fracture. Medial Nails are buried into the distal bone cortex stock of the medial malleolus which provides axial and rotational stability. Nails are given bend of C shaped or E/S shaped according to the reduction of the fracture planned. Two C shaped nails are passed from the both the sides of proximal tibia which prevent varus and valgus malunion while the S shaped is passed just medial and anterior to the proximal tibia bone which eliminates the risk of procurvatum and recurvatum.

Removal of the implant can be difficult in cases of plating, especially in the long standing cases while it's easier in Ender nailing as the eye helps in easy removal by hook extractor. Wrong placement of the screw, improper plate positioning, inadequate reduction of the fracture (any visible gap and lack of collapse), more radiological exposure and local soft tissue irritation and cost ineffective are some disadvantages of the plating, while improper technique and not correct bends can lead to difficulty in reduction in cases of Ender nailing. Malunion occurs mostly due to two reasons accepted mal-reduction and loss of reduction in post-operative period.

Patients' acceptance was better observed in cases of Modified Ender nailing in comparison to cases of plating.

Conclusion

From our study it is concluded that the effectiveness of minimally invasive plate osteosynthesis and Modified Ender nailing has given Excellent/Good and comparable functional outcome in most of our cases.

Modified contouring, precise entry points and fanned out placements of Ender nails, induce better rotationally stable fixation & good reduction in all axes than the conventional techniques of the Ender nail. This modification also prevents migration of nail that was limitation of old conventional method.

Modified Ender nailing is a better choice than MIPPO when there is unhealthy



local skin condition.

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