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Evaluation of results of minimally invasive plating Osteosynthesis (MIPO) technique in the treatment of fractures of distal tibia

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Abstract
Background: Fractures are the commonest injury among the victims of non-fatal road traffic accidents, and it commonly involves the bones of the lower extremity. This can be due to the interplay of gravitational force and velocity of the vehicle at the time of accidents. Tibial fractures are the most common type of long bone fractures and are the most common open fractures. Based on the fracture location in the bone, distal tibia fractures have the second highest incidence of all tibia fractures. The relatively tenuous blood supply, subcutaneous location of the tibia, mechanism of injury, and use of certain treatment methods contribute to a relatively high incidence of post traumatic complications following tibia fractures. These complex open fractures which are produced by high energy forces, threaten to pose a challenge to orthopaedic surgeons. Considerable advances in the methods and concepts of internal fixation along with newer innovations in implants help to meet such challenging tasks.
Aim: To evaluate the efficacy, functional and radiological outcome of distal third tibia fractures managed by minimally invasive plate osteosynthesis.
Methods: This is a prospective study, period from December 2019 to May 2021, and a minimum of 30 cases with fractures of distal tibia were attended in the casualty and OPD and were admitted in this hospital and were evaluated clinically and radio graphically.
Results: All fractures healed without the need of any secondary procedures. There was no noticeable mal- alignment or non-union. Functional outcome was good to excellent in all patients. Average time to bony union was 24 weeks.
Conclusions: From our study it is further proved that the effectiveness of minimally invasive plate osteosynthesis is a good and safe technique for treatment of distal tibial fractures without intra- articular comminution providing fracture healing, rapid functional recovery, along with avoidance of major complications.

Keywords: Distal Tibial fracture, locking compression plate, minimally invasive plate Osteosynthesis, Olerud-molander ankle score

Introduction
The process of rapid and unplanned urbanization has resulted in an unprecedented revolution in the growth of motor vehicles worldwide. The alarming increase in morbidity and mortality owing to road traffic accidents over the past few decades is a matter of great concern globally. Currently motor vehicle accidents ranks ninth in order of disease burden and are projected to be ranked third in the year 2020. Worldwide, every year almost 1.2 million people killed in road traffic, while the number of people that are injured could be as high as 50 million [1].
In India, over 80,000 persons die in the traffic crashes annually, over 1.2 million are injured seriously and about 300000 disabled permanently. For individuals more than 4 years of age, more life years are lost due to traffic crashes than due to cardiovascular diseases or neoplasms. The highest number of deaths due to road accidents during the years were reported in Tamil Nadu (11.6 %) followed by Uttar Pradesh (10.9 %), Andhra Pradesh (10.8 %) and Maharashtra (10.0 %). The wage-earning age group comprised of more than half of the road traffic casualties [2].

Fractures are the commonest injury among the victims of non-fatal road traffic accidents and it commonly involves the bones of the lower extremity. This can be due to the interplay of gravitational force and velocity of the vehicle at the time of accidents. Tibial fractures are the most common type of long bone fractures and are the most common open ones too. On the basis of the fracture location in the bone, distal tibia fractures have the second highest incidence of all tibia fractures [3]. The relatively tenuous blood supply, subcutaneous location of the tibia, mechanism of injury, and use of certain treatment methods contribute to a relatively high incidence of post traumatic complications following tibia fractures [4]. These complex open fractures which are produced by high energy forces, threaten to pose a challenge to orthopaedic surgeons. Considerable advances in the methods and concepts of internal fixation along with newer innovations in implants help to meet such challenging tasks.

The landmark paper by Ruedi and Allgower (1969) [5] which showed 74 % of their patients pain free and with good functional outcome at four years follow-up, revolutionized the management of distal tibia fractures. Thereafter, the 1970's and 1980's witnessed widespread application of the principles of ORIF in the management of distal tibia fractures. However, this was accompanied by a shockingly high rate of major complications including non-union up to 18 %, superficial infections up to 20%, osteomyelitis up to 17 %, arthrodesis rates of 27 %, below knee amputation rates of 6 %, post-traumatic osteoarthritis rates of 54% and mansions in 42% of patients [6, 7]. These high rates of complications made surgeons to realise the importance of soft tissue management in distal tibia fractures. Further analysis of Ruedi and Allgower's series at 9 years follow up still showed good results, [8] but most of the patients in his series had low-energy injuries. They presented another series [9] in 1979 which consisted of high-energy injuries and found that the overall results were not as good as those in patients with lower-energy injuries. This led many authors to conclude that incorporation of both fixation of fracture along with the avoidance of soft tissue complications yielded better results [10, 11]. Therefore the ideal method of treatment is one that would achieve a good reduction and stability while minimizing soft tissue compromise and devascularisation of the fracture fragments. Consequently, new tactics were utilized for the management of distal tibia fractures namely: delayed ORIF, limited ORIF, hybrid fixators and biological osteosynthesis [minimally invasive plate osteosynthesis – MIPO].

In biological osteosynthesis, the fracture hematoma and soft tissue attachment of the comminuted fragments are not disturbed, thereby preserving the oestrogenic capacity and vascularity of the fragments. The fracture site is stabilized by fixing the plate to the proximal and distal major fragments by minimal soft tissue dissection. Rotational and angular alignment and limb length are restored by indirect reduction, thereby improving the functional outcome. In biological internal fixation recognition of the optimum requirements for bone healing now takes precedence, with mechanical stabilisation being less rigid while still allowing painless function and reliable healing.

Methodology

This study was carried out in Narayan Medical College and Hospital, Jamuhar. This is a prospective study, period from December 2019 to May 2021, and a minimum of 30 cases with fractures of distal tibia were attended in the casualty and OPD and were admitted in this hospital and were evaluated clinically and radio graphically.

Inclusion criteria

1. Age group: >18 years.
2. Gender: Male and female patients.
3. All patients with closed / open distal tibial fractures with or without articular.

Involvement ranging from AO/OTA Type-A 1 to C 1, presented within seven days from the date of injury.

Exclusion criteria

1. Children and adolescent patients < 18 yrs.
2. Patients with proximal two –third tibial fractures.
3. Patients with severely comminuted articular fractures (AO/OTA type-C2, C3).
4. Patients with severely crushed soft - tissues.
5. Patients with head injuries.

Fractures were classified according to the AO/OTA classification and patients were shifted to the ward after initial temporary immobilization with below knee POP slab. All the routine investigations were done on all the patients pre-operatively with complete medical and anaesthetic fitness of patient for surgery.

Method of Treatment

With proper anesthesia choice all patients will be operated by senior surgeons Using Minimally Invasive Plating Osteosynthesis [MIPO] With Locking compression plate (LCP) and Dynamic compression plate (DCP) under C-arm.

Surgical Exposure

Fibula: Fibular reduction and fixation was performed with limb in slight internal rotation using the lateral approach to the fibula, with 1 / 3 rd. tubular plate and 3.5 mm cortical screws.2 cases fixed with Recon plate with 3.5 cortical screws.

Tibia

In our study we used the technique of MIPO. The patient was positioned in supine on the 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 a small counter incision made proximally to optimally align the plate on tibia and fixed with percutaneously placed screws by stab incisions under image intensifier guidance. Distal segment screws inserted with same incision.

Post-operative protocol

- Wound inspection done on 2nd day.
- Ankle and knee mobilisation started on 2nd day.
- Suture removal on 12th post-operative day.
- Patient advised non weight bearing until radiological evidence of union.

Patients were followed from 6 weeks to 6 months on OPD basis at intervals of 6 weeks, 12 weeks and 6 months. During this period in each visit clinical evaluation of wound healing, pain, ankle function and range of movements were assessed and recorded. Clinically fracture was considered united when there was no tenderness at the fracture site and full ankle function is present. Radio graphically fracture was regarded as united when there is no visible fracture line. Results were

evaluated by the use of OMAS score based on pain, function, range of motion and anatomy for each case assessed and recorded.

Results

This study included total 30 surgical cases of patients with distal tibia fracture, most of the patients were brought to the causality or admitted through outpatient department basis, clinical history were elicited. Careful clinical examination of skeletal system and soft tissue injuries were recorded. Radiographs were taken. Leg was immobilized in below knee POP slab. Once patient's general condition stabilized and planned for operative fixation.

30 cases were done with MIPO plating technique. Fixation rigidity was checked on table, post-operative check radiographs taken. Patients were mobilized with walker non weight bearing; all patients were encouraged Knee ROM from day 1. Sutures were removed on the 12th post-operative day. All patients were followed up at 6th week, 12th week and 6th month.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 21, IBM Inc. Descriptive data was reported for each variable. Descriptive statistics such as mean and standard deviation for continuous variables was calculated.

Summarized data was presented using Tables and Graphs. Shapiro Wilk test was used to check the normality of the data. As the data was found to be normally distributed bivariate analyses was performed Paired T-test Level of statistical significance was set at *p*-value less than 0.05 and was denoted as *.

Table 1: Mean age of the study population

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	30	25	65	43.27	11.188

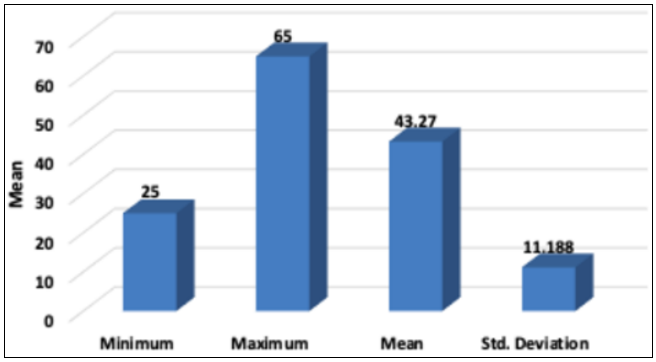

Fig 1: Age

A total of 30 subjects were recruited in the present study. Mean age was found to be 43.27 ± 11.78 years.

Table 2: Gender wise distribution of the study population

	Frequency	Percent
Male	17	56.7
Female	13	43.3
Total	30	100.0

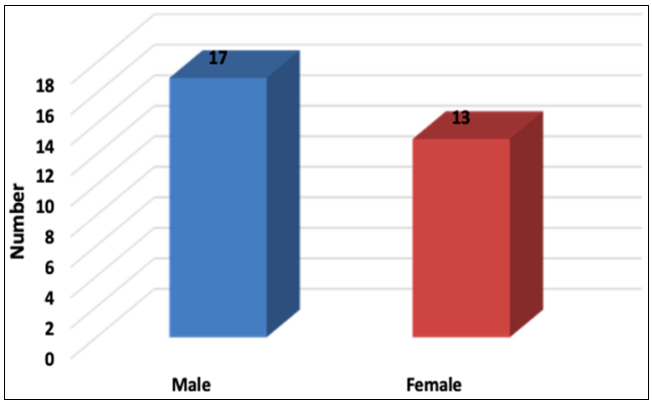

Fig 2: Gender wise distribution

Out of total 30 study participants, 17 were males and 13 were females

Table 3: Fracture distribution according to AO-OTA alphanumeric classification system

	Frequency	Percent
43 Al	17	56.7
43 A2	8	26.7
43 A3	5	16.7
Total	30	100.0

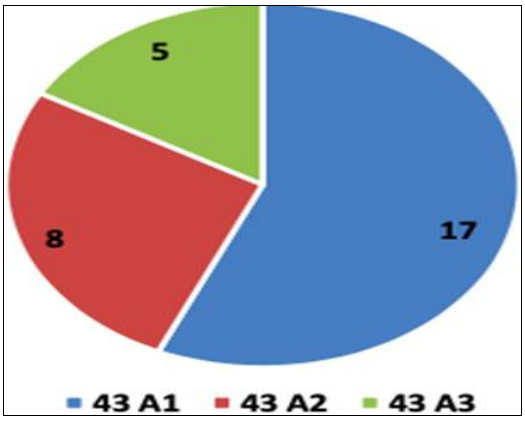

Fig 3: Fracture classification based on AO system

Out of 30 subjects, 17 were having 43 A1 fracture, 8 subjects were having 43A2 fracture and only 5 subjects were having 43 A3 fractures.

Table 4: Mean TRU score

	N	Minimum	Maxim urn	Mean	Std. Deviation
TRU in	30	10	14	11.27	1.617
Weeks					

Mean TRU score was found to be 11.27 ± 1.61

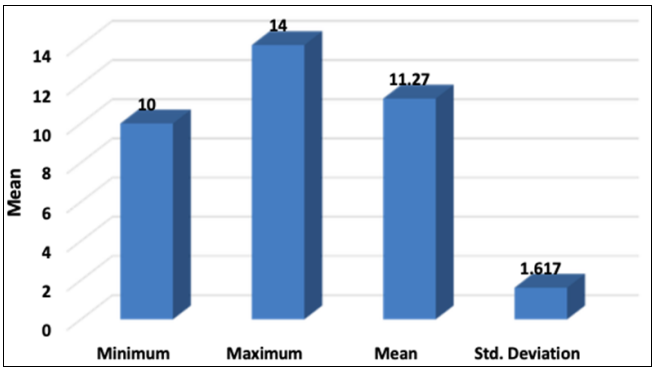

Fig 4: TRU in weeks

Table 5: OMAS score

	N	Minimum	Maxim urn	Mean	Std. Deviation
6th week	30	34	60	47.47	6.745
12th week	30	64	88	76.80	5.816
6 month	30	91	98	94.30	2.507

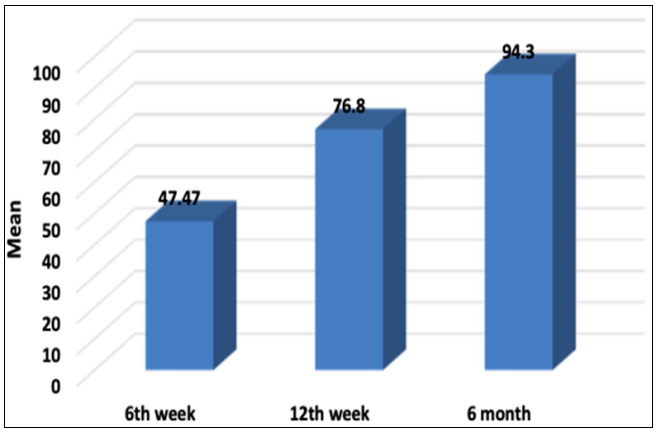

Fig 5: OMAS score

OMAS score on 6th week was found to be 47.47 ± 6.74, at 12 week it was found to be 76.80 ± 5.81 and at 6 month it was found to be 94.30 ±2.50.

Table 6: Comparison of mean OMAS from 6th week to 12th week to 6 month

OMAS	Mean	N	Std. Deviation	Std. Error Mean	P Value
6th week	47.47	30	6.745	1.232	0.0001*
12th week	76.80	30	5.816	1.062	
6 th week	47.47	30	6.745	1.232	0.0001*
6th month	94.30	30	2.507	.458	

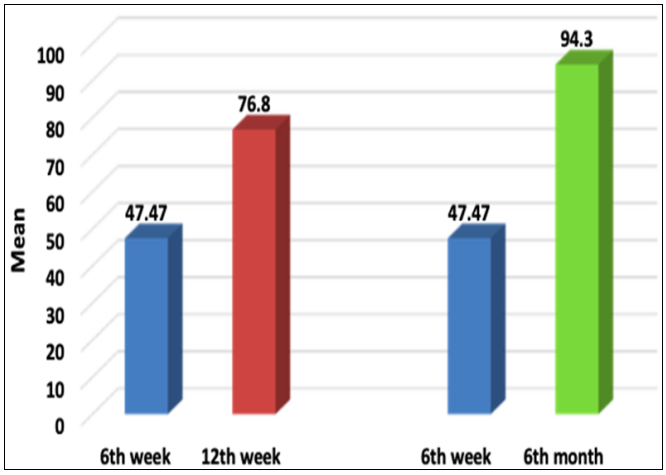

Fig 6: Comparison of OMAS score

Significant increase was seen in mean OMAS score from 6th week to 12th week and from 6th week to 6th month when compared using Paired t test as $p < 0.05$.

Discussion

Minimally invasive plate osteosynthesis (MIPO) is the logical next step in the surgical treatment of fractures. It relies primarily on the indirect reduction of the fracture using various techniques, excellently described in the classic works of Mast and Ganz [12]. In this way, the fracture environment is better preserved, as well as the blood supply to the bony fragments [13, 14]. Theoretical advantages include less infection and wound problems and better fracture healing [15].

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, thus 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 [16-18].

In our study we used a single-stage fixation of all distal tibial fractures. We used medial distal tibial locking compression plate for all cases. This plate is a low profile plate of 3.5 mm system. The Medial distal tibial 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.

In our study 21 patients had associated fibula fracture out of which 15 patients the level of fibula fracture was within 7 cm from the tip of lateral malleolus. In this 10 cases fibula fixation was done.

Mast *et al.* [17] recommended primary definitive internal fixation if the patient was presented early within 8 to 12 hours following injury. They advocated a delay in the definitive procedure for about 7 to 10 days for soft tissue to heal, if the patient presented late. In our study the average duration of delay in the definitive treatment was about 3 to 12 days.

Barei *et al.* [18] demonstrated that distal tibia fractures with intact fibula, on the whole was considered as less severe injury than those with fractured fibula. An intact fibula was identified as less severely injured than C type fractures. The first principle of management by Ruedi and Allgower [5] was restoration of fibular length which remains vital to obtaining good results. The goal of fibula fixation was restoration of limb length, to prevent varus tilt and rotation and gross mechanical alignment. In our study out of 25 cases, 21 cases had fibula fracture. Out of which 15 cases the level of fibula fracture was within 7 cm from tip of lateral malleolus. Fibula fracture fixation was done in 10 cases which showed restoration of limb length without malalignment. Out of 10 cases in 8 cases we used 1/3 tubular plate for fibula fixation whereas in other 2 cases we used 3.5 mm recon plate. In fibula fixation cases 1 case was developed superficial infection in immediate postoperative period which settled with appropriate antibiotics and daily dressing, whereas 1 case went on to a deep infection with wound gaping for which implant removal followed by hybrid external fixator application was done. This case was developed delayed union and hence subsequently bone grafting was done. Later fracture united well without complication. In remaining 11 cases fibula fracture was either an UN displaced fracture or was at a different level thus not affecting stability.

Helfet *et al.* [16] in their study had a superficial infection rate of 3 % and deep infection of 6% in their series of 32 fractures treated with locking compression plate.

Bahari *et al.* [18] observed one case of hardware failure and two of superficial infection. There was one case of deep infection. Three patients had metalwork removal due to plate impingement. In our study we had 64 % of excellent functional outcome, 32 % had good results and 4 % had fair result in average follow up of 9.9 months. We observed 1 case superficial infection (4 %), 1 case deep infection (4 %) which was acceptable when compared to the above studies.

Mario Ronga MD [19] *et al.* and Nicola Maffulli MD *et al.* [20] in their study of minimally invasive locked plating of distal

tibial fractures, they had the following outcomes – of the 21 cases they achieved union in 20 cases and one case went in for non-union. They had 3 cases of angular deformities all less than 7 and no patient had a leg-length discrepancy. Compared to their study, in our study all cases went in for union in mean duration of 18.28 weeks. Two cases had delayed union and two cases had varus angulation deformity-one had acceptable varus angulation of 5 degree and another had 10 degree varus angulation was unacceptable. Even though there was varus angulation this patient had excellent functional outcome. In case of unacceptable varus angulation retrospective analysis we observed that this could have been prevented by fixing fibula fracture.

Conclusion

From our study it is further proved that the effectiveness of minimally invasive plate osteosynthesis is a good and safe technique for treatment of distal tibial fractures without intra-articular comminution providing fracture healing, rapid functional recovery, along with avoidance of major complications.

- Radiological score showed anatomical reduction if minimally invasive plate osteosynthesis was done along with fibula plating.
- Hence it can be taken as treatment of choice especially in case with displaced intra articular distal tibial fractures.
- There is decrease in the rate of deep infection in patients treated with MIPPO technique because of minimal exposure and decreased soft tissue damage. As a result a good radiological union is achieved.
- Rigid fixation by LCP using MIPPO technique helps in early mobilization of ankle movements and reducing ankle stiffness thus improving clinical and functional outcome.
- Thus we conclude that when extra- articular closed tibial fractures are treated with LCP using MIPPO technique gives good radiological and functional results.

Case illustrations

Armamentarium

Fig 7: PSRE-operative radiograph

Fig 8: Intraoperative

Fig 9: Post-operative

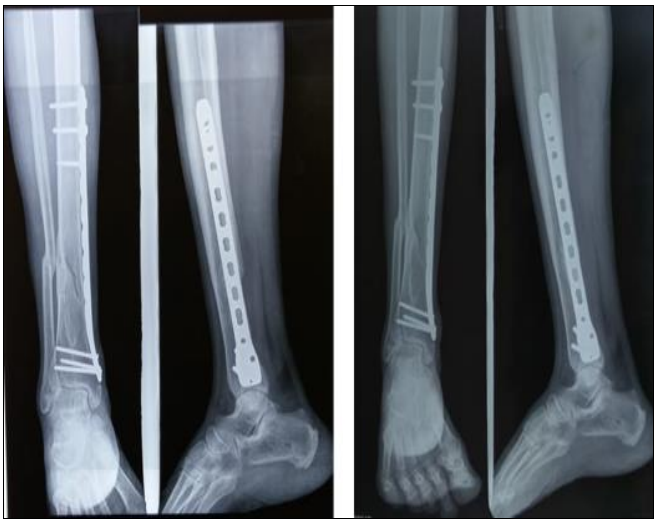

Fig 10 (a): Radiograph - 6th week

Fig 10 (b): Radiograph - 6th month

Functional outcome

Fig 11: Dorsiflexion

Fig 12: Plantar flexion

Conflict of Interest
Not available

Financial Support
Not available

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