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Outcome of distal tibia fractures managed with locking compression plate using MIPPO technique

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Abstract
Introduction: Treatment of distal tibial fracture with or without intra-articular involvement is challenging, for reasons like poor healing due to precarious blood supply. Various modality of surgical treatment such as closed intramedullary nailing, Open Reduction and internal fixation with conventional plate osteosynthesis and external fixation has been tried so far. But none of them have good functional outcome but had high complication rate. The newer technique of distal tibia fractures fixation using MIPPO (minimally invasive percutaneous plate osteosynthesis), involves less soft tissue handling and minimal periosteal stripping resulting in low infection rate and faster healing.
Aim of the Study: To study the functional and radiological outcome of distal tibial fractures managed with MIPPO (minimally invasive percutaneous plate osteosynthesis), using locking plates and to look for complications in MIPPO.
Materials and Methods: In this study, 55 patients with distal third tibial extra articular Metaphyseo-diaphyseal fractures with or without associated fibula fractures were treated with MIPPO. The present prospective study was conducted in the department of Orthopaedics at a tertiary care hospital, between September 2014 to September 2018, followed up for a period of 1 year.
Results: All fractures had a good clinical and radiological union. The fractures were stabilized with MIPPO, at an average of 4.27 days post- trauma, with an average operative time of 76.5 minutes. Functional outcome evaluation was done using Olerud-Molander ankle score, at the end of 1 year. Average radiological union time of 19.6 weeks and there were one delayed union and one nonunion. None of the cases had implant failure or any significant deformity with good to excellent results in 88.5 % cases.
Conclusion: From this study, it is concluded that Minimally invasive percutaneous plate osteosynthesis technique (MIPPO), using locking plate is the most effective procedure for closed extra-atricular distal tibial Dia-metaphyseal fractures.

Keywords: Distal tibia, MIPPO, locking plates, biological fixation

1. Introduction
Treatment of distal tibial fracture with or without articular involvement is challenging because of its anatomical characteristics which are unique like, subcutaneous location with very ample blood supply and its close proximity to the ankle joint [1]. The goal of Orthopaedics Surgeons intervention is to restore the tibial anatomy, to fix the epi-metaphyseal block with the diaphysis and to avoid complications [2]. The type of fracture, associated soft tissue injury, the method of treatment and the quality of the reduction are the most important variables that affected the final clinical result [3].
Various modality of surgical treatment such as closed intramedullary nailing, Open Reduction and Internal Fixation with conventional plate osteosynthesis and external fixation has been tried so far. But none of them have good functional outcome but had high complication rate.
Conservative treatment by cast application lead to ankle and knee stiffness affecting quality of life of the patient [4]. Closed intramedullary interlocking nailing of distal tibia fracture can be a good option, but the hourglass shape of the distal tibia does not allow anatomical reduction resulting in rotational and angular malalignment. External fixation is indicated in severe soft tissue injury or as a temporary stabilizing device. Pin tract infection, malreduction and joint stiffness are the drawbacks of external fixation [1].

Though ORIF with conventional plating provides anatomical reduction and address the rotational, angular Malreduction, it is associated with extensive soft tissue injury due to dissection and periosteal stripping which devitalize the fracture fragment resulting in nonunion, infections and wound dehiscence.

The newer technique of distal tibia fractures fixation with MIPPO (minimally invasive percutaneous plate osteosynthesis), involves less soft tissue handling and minimal periosteal stripping resulting in low infection rate and faster healing. The Precontoured anatomical locking plate used on the medial aspect prevents the Varus collapse, implant failure and also secure the fracture reduction without further displacement. This present study describes the minimally invasive technique and its effectiveness in distal tibial fractures.

2. Materials and Methods

The present prospective study was conducted in the department of Orthopaedics at a tertiary care Hospital, between September 2014 and September 2018. 55 patients were studied for minimally invasive plating osteosynthesis using locking plates. Two patients died due to associated medical comorbidities, one patient was lost for follow up. Hence functional evaluation was done on 52 patients.

Closed Distal tibia Extra articular Metaphyseo-diaphyseal fractures with or without associated fibula fracture in the age group of 20 to 80 years were included in the study, whereas, Fractures with intra-articular extension, Compound fractures, fractures associated with vascular injuries, Pathological fractures were excluded from the study.

On admission all patients were evaluated clinically and radiologically and were stabilized hemodynamically. Radiographs of ankle with leg AP & Lateral were taken. Splinting of fractured limb was a preliminary measure. Routine laboratory surgical profile was done for all patients and were obtained fitness for anaesthesia and surgery. Patients were operated as early as possible using MIPPO (minimally invasive percutaneous plate osteosynthesis), using locking plates. Informed consent was taken from all patients before undergoing surgery.

2.1 MIPPO Technique

Minimally invasive percutaneous plate osteosynthesis (MIPPO) is a modern concept of fracture fixation. The main aim of Minimally invasive percutaneous plate osteosynthesis is to preserve the biology at the fracture site, to maximize the healing potential of the injured bone, soft tissue, to facilitate pain free fracture site for patient and early recovery. This is achieved by carrying out the procedure without exposure of the fracture and by introducing the plate in a submuscular, epi-periosteal position with minimal disturbance of the fracture environment and vascularity of the bony fragments.

2.2 Principles of MIPPO Technique

There was decrease in devitalization of bone and damage to the soft tissue, delayed union, and nonunion. Surgery with Minimally invasive approach helps to reduce the iatrogenic trauma to the fracture ends and fracture fragments. Theoretically, the soft-tissue envelope preservation around the fracture zone has biological advantages. MIPPO for diametaphyseal fractures may involve direct percutaneous or indirect closed reduction and soft-tissue windows away from the fracture site. The main reduction method used in MIPO is indirect reduction.

2.3 Surgical Procedure

MIPPO is undertaken after initial resuscitation and resolution of significant soft-tissue edema, that would prevent wound closure. Subsidence of edema is noticed by looking at the wrinkles on skin. Under regional Anaesthesia and after applying tourniquet, patient was positioned supine on a radiolucent table, parts scrubbed, painted, draped. A locking compression plate was kept on the antero-medial surface of the leg and Visualised under C-arm, to choose the adequate length of plate. The fracture was reduced by indirect means without opening the fractured area. With traction counter-traction and Manipulatioin, Angulation, length of tibia and fibula, rotation, integrity of the ankle mortise were corrected. If the associated fracture fibula required fixation, fibula has to be fixed with plate/rush nail, prior to the fixation of tibia. After provisional reduction a 2-4 cm vertical incision was given at the Centre of the medial malleolus and a subcutaneous tunnel was opened with help of a tunnelling device.

The shin of tibia, was used as landmark to guide the proximal part of the plate onto the antero-medial surface of the titbia. The plate was kept on centre of bone in lateral view on the proximal fracture fragment with the help of a locking sleeve inserted into the most proximal hole. Following confirmation of fracture reduction and correct placement of plate on tibia, a drill bit or K-wire was used to fix the plate onto the tibia. Non locking cortical screws were inserted first in either the proximal or distal fragment as required to aid in the reduction of the fracture so as to pull the bone to the plate.

The locking screws were inserted only if the fracture reduction was satisfactory. The proximal holes can be located in thin patient by palpation through the skin or a similar sized plate was placed over the skin to localize the hole in the inserted plate (Mirror plate technique). The wounds were irrigated copiously and closed in layers, and limb was splinted with back slab. (Figure 1, pictures shows the procedure)

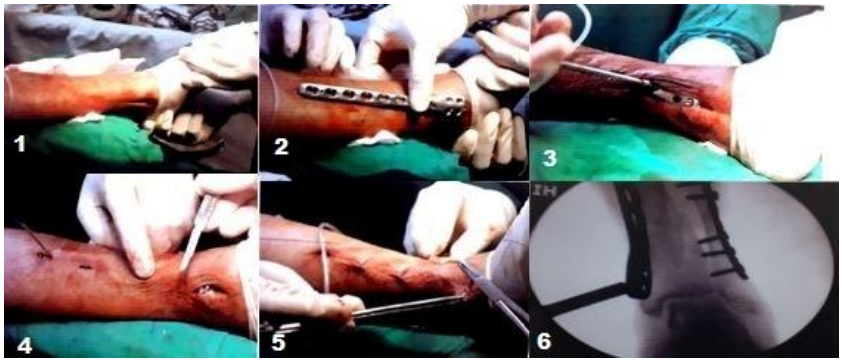

Fig 1: Steps in MIPPO

2.4 Post-Operative Protocol

2.4.1 Immediate

Limb elevation. Check X-Ray of the operated leg including ankle in both antero-posterior and lateral views. Intravenous antibiotics for three days postoperatively. Wound inspection on 2 or 3 rd day. To switch over to oral antibiotics by 3 rd post-operative day. Sutures removed on 10 post-operative day. Slab was continued

2.4.2 Follow up

The patients were followed up at 6 weeks 3 months 6 months and 1 year to assess the radiological union by taking check X-rays. The fracture union, was assessed at every follow up by observing the periosteal bridging callus at the fracture site at least in three cortices in the anteroposterior and lateral view x-rays. The results were evaluated using Olerud-Molander Ankle Score. After the 1st follow up after 4 weeks patient is allowed to mobilize the ankle and advised non weight bearing. Partial and full weight bearing were allowed based on the radiological union and consolidation of the fractures. During follow up patients were assessed for any complications like, Wound infection, Osteomyelitis, Nonunion, Delayed union, Malunion, Post traumatic arthritis, Skin irritation.

3. Results and Analysis

In this study 52 cases of distal tibia meta-diaphyseal fractures were treated with MIPPO. The mean age of the patients ranged from 23-70 years and an average age of 45 years. The youngest being 23years and the eldest being 70years. Most of the patients are found to be between the age group of 31 to 40 years (Table 1). Among 52 cases total number of male cases were 36 (69.2%) and total number of female cases were 16 (30.8%) (Table 2). The preponderance of distal tibia fracture was high in males. In this series, road traffic accidents or automobile accidents are the major cause for injury leading to tibia fracture, up to the extent of 80.8 % (Table 3). Among all the fractures, majority were found to be of AO type 43A-1 about 32 patients (62%). There are 6 (11%) patients with AO type 43 A-2 and 14 cases (27%) with AO type 43 A-3 (Table 4).

Out of 52 patients, 32 (61.5%) patients were with Left distal tibia fractures and 20 (38.5%) patients with Right distal tibia fractures (Table 5). 44 patients (84.6%) had concurrent fibula fracture and 8 cases not associated with fibula fracture (Table 6). Among 44 fractured fibula, 36 fractures were fixed with internal fixator (plate/rush nail) and 8 cases (18.2%) did not underwent any surgery for fibula (Table 7).

In this study 40 cases (76.9%) were operated within a period of 1 to 7 days and 12 cases (23.1%) were operated around 8 to 14 days after getting fitness and after treating their primary morbid conditions (Table 8).The operative time for 6 cases (11.5%) took 45 to 60 minutes**,** 16 cases (30.8%) took 60 to75 minutes, 22 cases (42.3%) took 75 to 90 minutes**,** 6 cases(11.5%) took 90 to 105 minutes, 2 cases (3.9%) took 105 to 120 minutes**.** Average operating time in our series was 76.5 minutes (Table 9). Time taken for fracture to unite for 6 cases (11.5%) it took 12 to 16 WKS, 30 cases (57.7%) took 16 to 20 WKS, 14 cases (26.9%) took 20 to 24 weeks, with mean time for radiological union of fracture was 19.6 weeks (Table 10).

Among 52 cases complications are seen in 4 cases (7.7%) who had superficial infection, 4 cases had ankle stiffness (7.7%), 4 cases had Varus angulation (7.7%) less than 5 degrees. 1 case had (1.92%) delayed union and 1 case(1.92%) had nonunion (Table 11). Functional evaluation was done using Olerud-Molander-Ankle Score. At the end of 1 year, 28 cases (53.8%) had excellent results and good results were observed in 18 cases (34.7 %) in total there are 88.5 % patients with good to excellent results and 6 cases (11.5%) had fair results and no patient had poor results (Table 12).

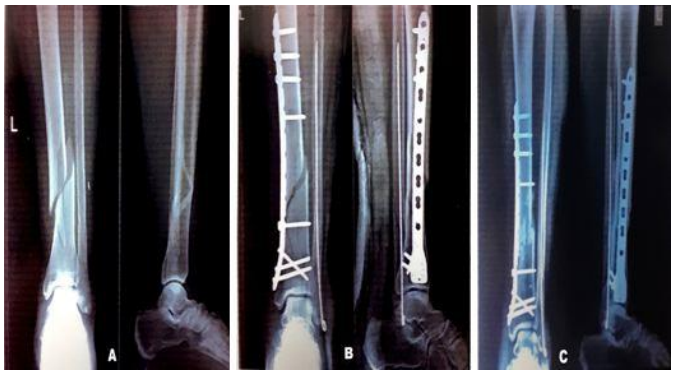

Fig 2: Normally Healed Tibia Fracture

A) At The Time of Fracture, B) Postoperative Image C) At 1 Year Follow Up With Normally Healed Fracture Site.

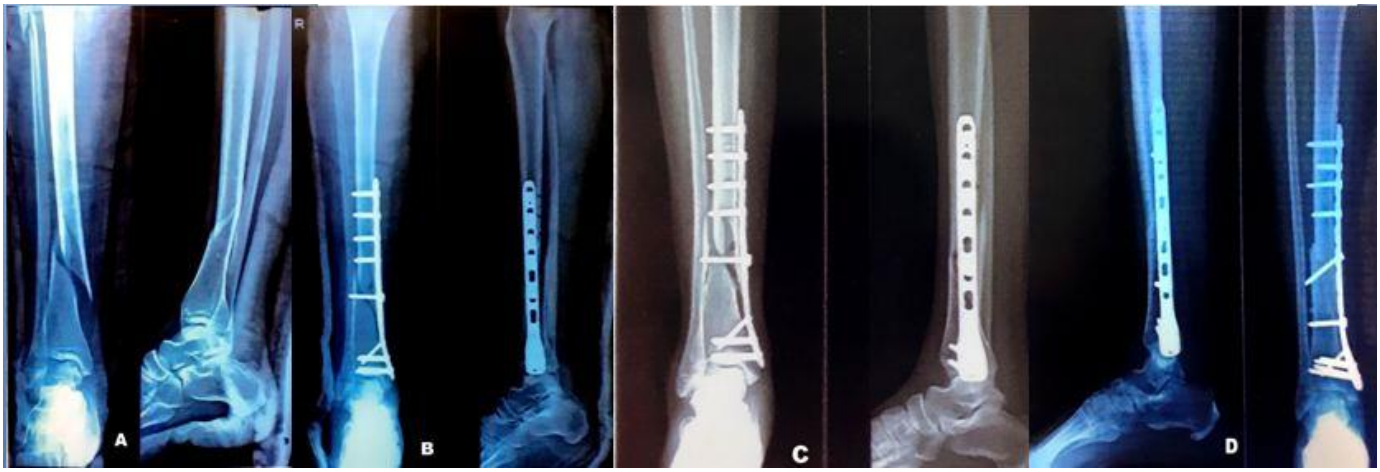

Fig 3: Nonunion Tibia

A) At the Time of Trauma B) Postoperative C) At 9 Months Follow up with Nonunion D) After Bone Grafting and Reallignment of Screws

4. Discussion

Distal tibia fracture with or without intra articular involvement is one of the difficult fractures to manage. None

of the treatment options available these days, pefectly fulfill requirements of fracture characteristics of distal diametaphyseal tibia. The goals in the management of treatment of distal tibial fractures are anatomical reduction, maintenance of joint stability, restoration of axial alignment, achievement of fracture union, pain free weight bearing and motion, without any wound complications.

Distal tibial fracture plan of management depends on fracture pattern, patient co-morbidity, soft tissue injury, fixation resources, and surgical experience. Open reduction and internal fixation with conventional plate requires extensive striping of periosteum is not an ideal treatment option because tibia being a subcutaneous bone and periosteum is important part which provides 2/3 rd of blood supply to tibia. Non union, delayed union and infection are reported with the range of 8.3-35% and 8.3-25% respectively with ORIF with plating, [1, 5] Similarly choosing external fixators as a definitive mode of treatment for distal tibia fractures were reported to be associated with higher rate of infection, implant failure and malunion or non union.

With the development of technique of MIPPO with LCP for fixation of distal tibia fractures with indirect reduction method, sub-cutaneous tunneling of the plate and application of locking screws with small skin incisions, prevents iatrogenic injury to vascular supply of the bone [6], which preserve extraosseous blood supply, respect osteogenic fracture haematoma, biologically friendly and stable fixation. MIPPO with LCP for distal diametaphyseal tbia fracture hes been found to be an effective treatment option [7-10]

Present study revealed the average age of patients with distal diametaphyseal fractures of tibia to be 45 years (range from 23 to 70 years). The fracture is more common in the age group of 31 to 40 years. It is comparable with a study on similar fractures conducted by Cory collinge *et al*. [10] in 2010, whose mean age was 43 years (range from 17 to 62), Shrestha D *et al*. [1] in 2011 their study patients mean age was 34 years (range from 17 to 65 yrs), Abdulla S *et al*. [11] in 2013 whose mean age was 32 years.

In our study the male preponderance for distal third tibial fractures was high, 69.2% (36 male and 16 female). However the study by Andrew Grose *et al*. [12] (2007) were comparable in the fact that they had 67% male patients. Shrestha D *et al*. [1] (2011) study shown no significant much diference in sex incidence (57% males and 43% females). Ch. Banikanta Sharma *et al*. [13] (2015) reported that the incidence of these fractures was significantly high in males, which was 85.7% compare to present study.

Most of the distal tibial fractures were result of high energy trauma includes road traffic accidents, fall from height, industrial injuries etc, 80.8% (42 cases) of total injuries in present study were due to RTA. Cory collinge *et al*. [10] in 2010 observed 100% high energy fractures in their study. Shrestha D *et al* [1] (2011) reported that half of the patients (50%) in their study was injured due to RTA, and 40% were due to fall. A study on similar fractures conducted by Ch. Banikanta Sharma *et al*. [13] in 2015 reported 81% of injuries were due to RTA.

In our study of 52 patients, according to AO classification 32 (62%) of the fractures were 43.A-1, 6 (11.0%) were 43.A-2, 14(27%) were 43.A-3. The present study could not be compared with the other studies because our primary aim was to study the distal metaphyseal fractures without intra-articular extension.

In present study 44 (84.6%) among 52 patients had ipsilateral concurrent fibula fracture at different levels, of which 36 (81.8%) fractured at the level of tibial fracture, were fixed with ORIF with semitubular plate 26 (72.2%) or CRIF with rush nail 10 (27.8%). Fibula fracture associated with distal tibia fractures aid in reduction of tibia fracture, especially when fracture is at same level of tibia [14]. Some authors recommend to fix the fibula before tibia fixation to achieve better tibial alignment and to prevent valgus malalignment but clear consensus for fibula fixation is still lacking and remained controversial. Effects of an intact fibula associated with a tibial fracture was studied by Teitz *et al*. [6], They found that distal tibial fractures in patients aged 20 years or older with an intact fibula are associated with complications at the rate of 61%, which includes, 4% nonunion, 22% delayed union, and 26% varus malunion.

In present series, average duration of delay in surgery, after injury was 4.27 days. It is comparable with study on distal tibia fractures conducted by Shrestha D *et al*. [1] (2011) reported average injury-surgery interval was 4.45 days. They also noticed that union time of fracture site was not affected whether patients were operated before or after three days of injury. Due to sub-cutaneous location of distal diametaphyseal tibia, these fractures are prone to have gross swelling, skin injury and fracture blisters if leg is left un-splinted for long time.

Average operative time in present study was 76.5 minutes (range from 50 to 110 min). It is significantly less average duration comparatively 97.9 min reported by Guo *et al*. [15] (2010). VK Kumar *et al*. [16] reported average operative time in their study was 60 minutes. Radiological union and full weight bearing was achieved in majority of cases (30 case, 57.7%) in 16 to 20 weeks. The average time for radiological union of diametaphyseal fractures of distal tibia in present study was 19.6 weeks, showing similarity with other studies Lau TW *et al*. [17] (2008) reported 18.7 weeks, Ronga M *et al*. [7] (2010) reported average radiological union of 22.3 weeks, Shrestha D *et al*. [1] (2011) reported 18.5 weeks, Abdulla S *et al*. [11] (2013) reported average radiological union time of 17.5 weeks, VK Kumar *et al*. [16] in 2014 reported average radiological union time in their study on similar fractures was 16.1 weeks (range from 13-22 weeks).

In the present series there were 4 (7.7%) cases of superficial infection in the immediate post operative period, which were improved with antibiotics and daily dressings. 4 patients (7.7%) had ankle stiffness, required extensive physiotherapy ROM ankle mobilising exercises to regain adequate range of movement. Shrestha D *et al*. [1] (2011) reported superficial infection in 4 (10%) cases, ankle stiffness in 2 case (5%) among twenty patients. Abdulla S *et al*. [11] (2013) reports 10 % of cases in their study developed ankle stiffness. Shikhar D Singh *et al*. [18] (2015) reported rate of superficial wound infection was 10%. As MIPO technique was minimally invasive and used anatomically contoured distal tibial locking plates, no case of wound dehiscence were reported in our series.

Varus or valgus angulation of greater than 5 degrees and anteroposterior angulation of 10 degrees and shortening of 15mm or more are considered to be malunited [1]. In our series there was no valgus or varus malunion and 4 (7.7%) cases with Varus angulation of less than 5 degrees were reported. 1 case (1.92%) with delayed union was reported, Patient was on partial weight bearing and the most probable cause likely due to critical blood supply to the fractured fragments. Bone marrow aspirate from iliac crest was injected at fracture site under C-Arm guidance at 6 months follow up, which showed fracture site healing later. One case had nonunion (1.92%), most likely due to insertion of screw at fracture site, for which

bone grafting and realignment of plate was done by exchanging screws followed by which fracture site healed (Figure 3). Shikhar D Singh *et al*. [18] (2015) reported 3 cases (10%) of malunion, one (3.3%) case of delayed union among 30 patients in their study. Abdulla S *et al*. [11] (2013) reported one (5%) case of delayed union among 20 patients.

In the present study, the average Olerud- Molander ankle score was 82.7 at the end of six months, which had significantly improved compared to score 51.5 at 12 weeks. We achieved 18 (34.7 % cases good, 28 (53.8%) cases excellent and 6 (11.5%) cases fair results among 52 patients at the end of 1 year. Abdulla S *et al*. [11] (2013) reported 80% excellent results with this operative method. Shikhar D Singh *et al*. [18] in 2015 reported 46% excellent, 30% good, 13.3% fair and 10% poor results (Olerud- Molander Ankle Score). Atin Kumar Kundu *et al*. [14] in 2015 reported 75% excellent, 10%good, 10% fair and 5% poor results in their study on 17 patients (Teeny and Wiss criteria).

Thus, On the basis of the finding of this present study it is found that MIPPO technique is a biological repair that preserves most of the osseous vascularity and fracture hematoma, reduces surgical time, tourniquet time, along with smaller incisions. There are fewer incidences of superficial infection, ankle stifness, varus angulation of less than 5 degrees and delayed union, Thus providing for a better outcome in terms of radiological union and clinical improvement with speedy recovery and good functional outcome in majority of patients (88.5%). The technique of MIPPO is safer and efficacious modality of the treatment for distal tibial fractures.

Limitation of study: Less sample and follow up period is suboptimal.

Table 1: Age Distribution

Age group	Number of patients	percentage
21 - 30	8	15.4%
31 – 40	16	30.8%
41 – 50	6	11.5%
51 - 60	14	26.9%
>61	8	15.4%
Total	52	100.0%
Mean Age	45 years	

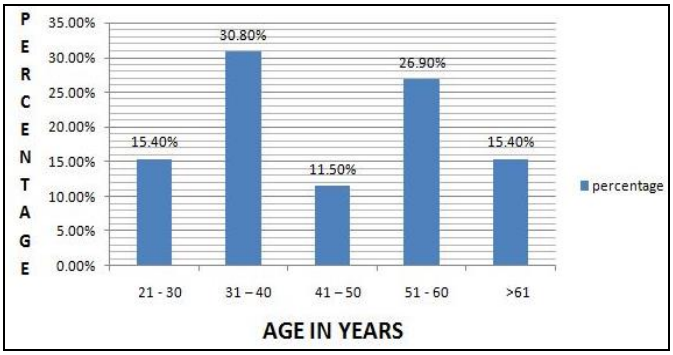

Fig 4: Percentage of age group

Table 2: Sex Distribution

Sex distribution	Number of cases	percentage
Male	36	69.2%
Female	16	30.8%
Total	52	100.0%

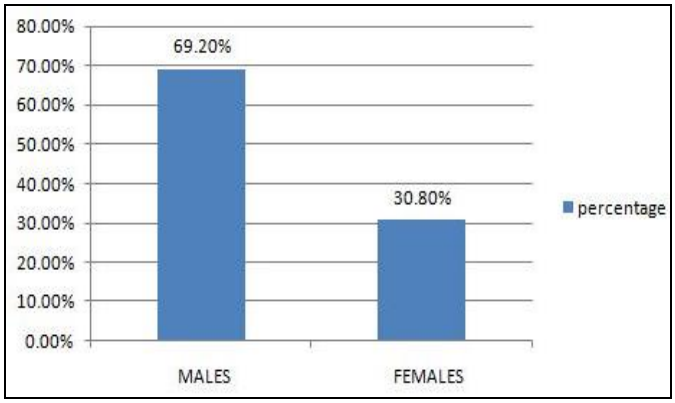

Fig 5: Sex percentage

Table 3: Mode of Injury

Mode of Injury	No of Cases	Percentage
Rta	42	80.8%
Accidental Fall	10	19.2%

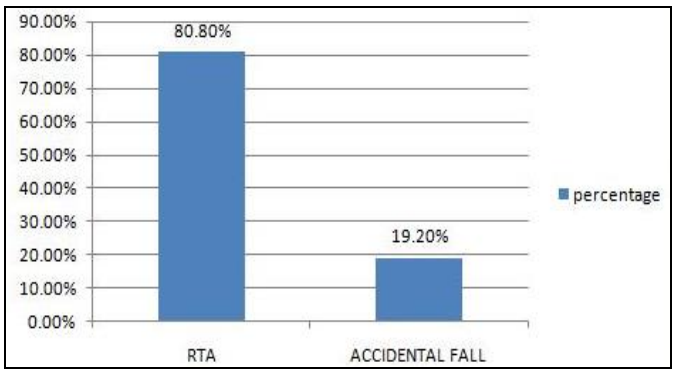

Fig 6: Mode of injury

Table 4: AO/OTA Classification

AO/OTA Classification	Number of cases	Percentage
43 A1	32	62.0%
43 A2	6	11.0%
43 A3	14	27.0%

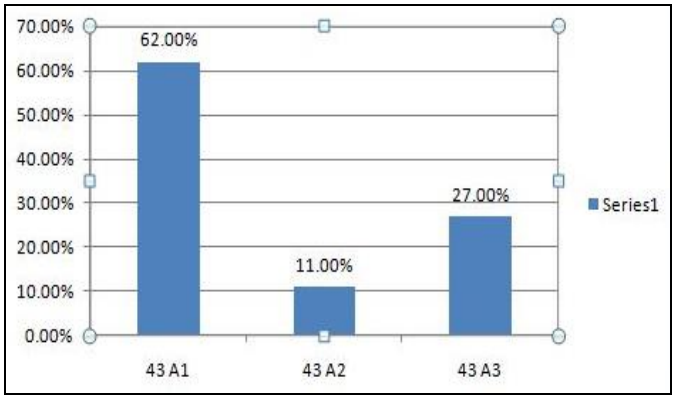

Fig 7: Ao classification

Table 5: Side Affected

Side Distribution	Males	Females	Total Cases	Percentage
Right	12	8	20	38.5%
Left	24	8	32	61.5%

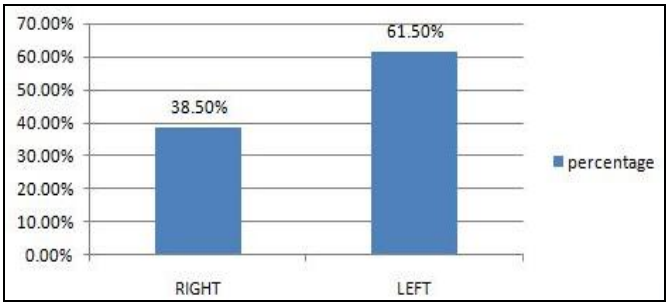

Fig 8: Side affected percentage

Table 6: Concurrent Fibula Fracture

Fibula Fracture	No of Cases	Percentage
With fracture	44	84.6%
Without fracture	8	15.4%
Total	52	100%

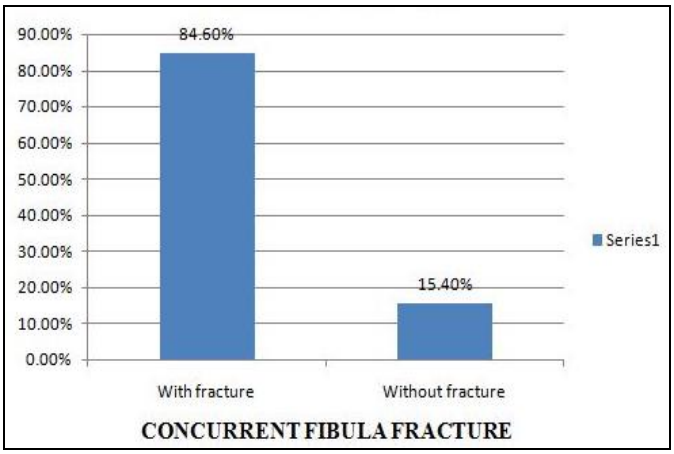

Fig 9: Fibula fracture

Table 7: Fixation of Fibula

Fixation of Fibula	No of cases	Percentage
Done	36	81.8%
Not Done	8	18.2%
Total	44	100%

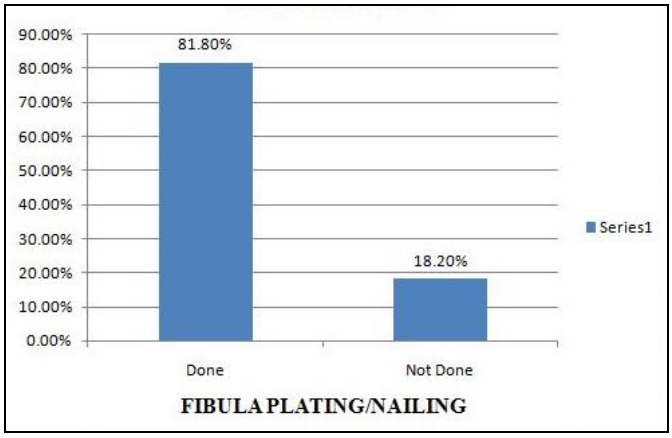

Fig 10: Fixation of fibula

Table 8: Time interval between injury and surgery

Time interval in days	Number of cases	Percentage
1 – 7 days	40	76.9%
8 – 14 days	12	23.1%
Mean interval	4.27 days	

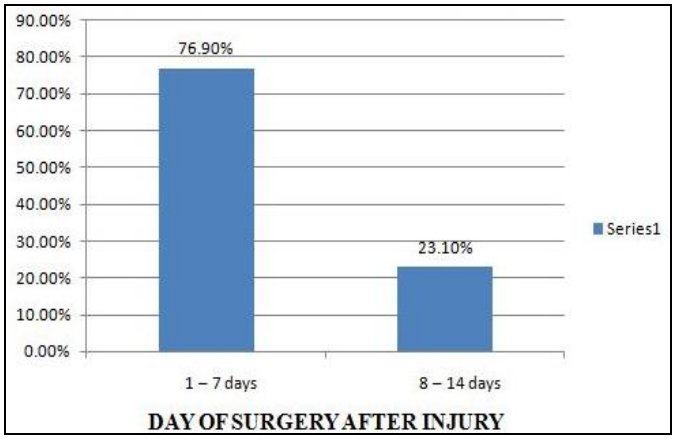

Fig 11: Tine interval between injury and surgery

Table 9: Operative Time

Operative time in minutes	No of cases	percentage
45-60	6	11.5%
60-75	16	30.8%
75-90	22	42.3%
90-105	6	11.5%
105-120	2	3.9%
120-135	0	0
MEAN:76.5		

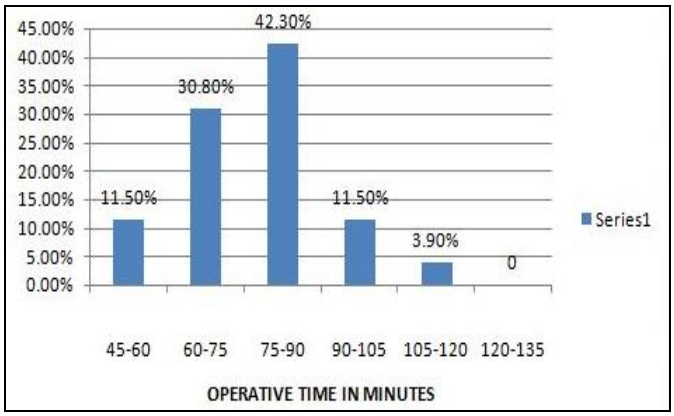

Fig 12: Time taken for surgery

Table 10: Time for Fracture Union

Time(weeks)	No of cases	percentage
12-16	6	11.5%
16-20	30	57.7%
20-24	14	26.9%
MEAN	19.6 weeks	

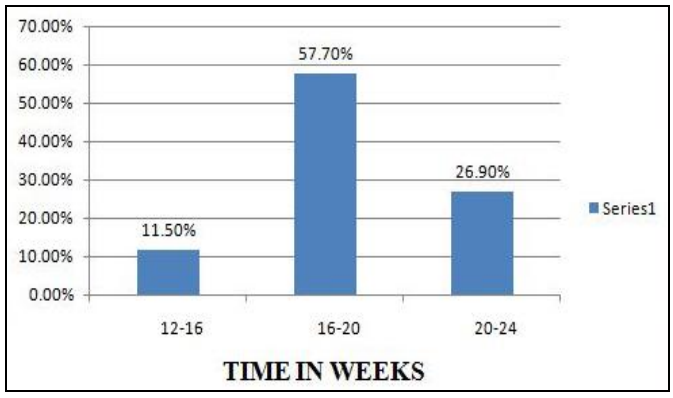

Fig 13: Time taken for fracture union

Table 11: Complications

Complications	No of Cases	Percentage
Superficial infection	4	7.7%
Ankle stiffness	4	7.7%
Varus angulation less than 5 degrees	4	7.7%
Delayed union	1	1.92%
Nonunion	1	1.92%
Cases without any complications	38	73%

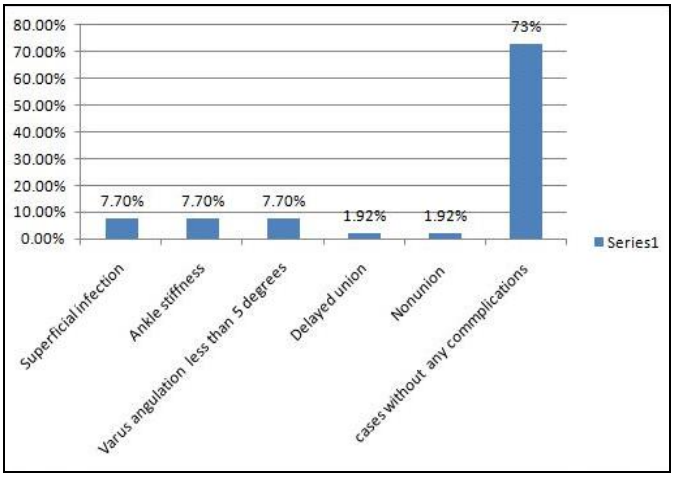

Fig 14: The show of percentage series

Table 12: Clinical Results

Clinical Results	No of Cases	Percentage
Good To Excellent	46	88.5%
Fair	6	11.5%
Poor	0	0

Olerud-Molander- Ankle Score >27: good/excellent and < 27: fair/poor

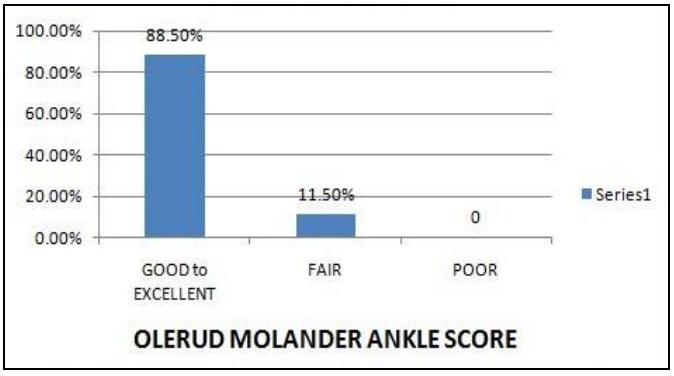

Fig 15: Clinical results

5. Conclusion

From this study, it is concluded that Minimally invasive percutaneous plate osteosynthesis technique (MIPPO), using locking plate is the most effective procedure for closed extra-atricular distal tibial diametaphyseal fractures with excellent results and fewer complications.

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