**ORIGINAL RESEARCH**

# Extraarticular proximal tibia shaft fractures – A comparative study on fixation techniques and fuctional outcome between intramedullary nailing and plate osteosynthesis

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**ABSTRACT**

**Background**– Extraarticular Proximal tibia fractures of tibial shaft in adults impose high challenges in the management due to high energy soft tissue injury hence Surgical treatment requires special respect for the soft tissues while taking into account the specific biomechanical properties of the proximal tibia. **Objectives** - To assess and compare the outcome and the clinical factors associated with the outcome of intramedullary nailing and plating in the treatment of extra-articular proximal tibial fractures. **Method** - prospective randomized clinical study conducted in the department of Orthopedics, SDM College of Medical Sciences,sattur,Dharwad India, from July 2019 to August 2022 Patients meeting the inclusion criteria were divided in to two operative groups of intramedullary nailing and plating using a computer generated random number, Primary & Secondary outcomes evaluated. **Result** – Out of 36 patients included, 13 (44.8%) underwent closed intramedullary nailing &16 (55.2%) closed plate osteosynthesis union was achieved in 34 of 36 (94.4%) patients at final follow up. 14 patients (38.9%) had malreduction. There is no significant difference in the knee society score between the nailing group and the plating group, as assessed by the Mann Whitney U test (p value=0.079). **Conclusion** - There are no specific indications for both treatment modality ,Even though significantly high rates of malreduction occur in intramedullary nailing compared to plate osteosynthesis there is no significant difference in the functional outcome, Intramedullary nailing and plate osteosynthesis can be used with good functional outcome in the treatment of extra-articular proximal tibia fractures.

**Key words** – proximal tibia, fracture, osteosynthesis. malreduction, infection



## INTRODUCTION

Fractures of extra-articular proximal tibial shaft is relatively uncommon, accounting for 5% to 11% of tibial shaft fractures.(1)(2) Extra-articular proximal tibial shaft fractures are often the result of high energy transfer with bone fragmentation and extensive soft tissue damage.(3)

Treatment of extra-articular proximal tibia fractures remains problematic. Because the proximal fragment is short, closed reduction and immobilization affords minimal control and leads to high rate of varus malunion with closed treatment. Closed treatment is reserved for non displaced and minimally displaced fractures with little soft tissue injury.(4) Operative treatment is reserved for displaced fractures and fractures with severe soft tissue injuries. Surgical treatment requires special respect for the soft tissues while taking into account the specific biomechanical properties of the proximal tibia.(3)

The goals of surgical treatment include correction and maintenance of sagittal and coronal alignment, restoration of length and rotation and early functional knee and ankle range of motion. Treatment options include intramedullary nailing, plate osteosynthesis, half pin external fixation, hybrid or thin wire external fixation or combination techniques.(5)

Deforming forces created by the extensor mechanism around the knee together with significant

comminution made plate osteosynthesis as the preferred method of treatment.[6] However plating of the proximal tibia has been associated with infection, fixation failure and serious soft tissue complications that can follow extensive exposure. Intramedullary nailing has been used for stabilization of extra-articular proximal tibia fractures, however malunion rates have been reported. Pin track infections and malunion are frequent complications of external fixation. External fixation is indicated for fractures with short proximal fragments and in extensive soft-tissue injuries that would preclude the use of other surgical techniques.[4]

Recent design changes to intramedullary nails and adjunctive fixation techniques have increased the popularity of intramedullary nailing for the treatment of extra-articular proximal tibia fractures. Both intramedullary nailing and plating are now applied using indirect fracture reduction techniques that require minimal dissection.[6]

Though intra medullary nailing and plating have been routinely used in the treatment of extra-articular proximal tibial fractures and there are many studies showing the efficacy of intramedullary nailing and plating in the treatment of extra-articular proximal tibial fractures ,there is a paucity of literature comparing intramedullary nailing and plating in the treatment of extra-articular proximal tibial fractures and there are no prospective randomised controlled studies comparing these two treatment methods.

## OBJECTIVES

The purpose of this study is to compare these two treatment methods and assess the ability of each technique to obtain and maintain fracture reduction and determine rates of possible complications.

To assess and compare the outcome and the clinical factors associated with the outcome of intramedullary nailing and plating in the treatment of extra-articular proximal tibial fractures.

## STUDY SETTING

This is a prospective randomized clinical study conducted in the department of Orthopedics, SDM College of Medical Sciences,sattur,Dharwad India, from July 2019 to August 2022. All patients with extra-articular proximal tibia fractures, who met the inclusion criteria were operated either by intramedullary nailing or plate osteosynthesis following randomisation. They were followed up and outcome analysis was performed.

## PATIENTS

Patients with extra-articular proximal tibia fracture who presented to the department of Orthopedics, SDM College of Medical Sciences , sattur , Dharwad and met the inclusion criteria, were included in the study.

## INCLUSION CRITERIA

- Skeletally mature adults (18 years and above)
- Major fracture line occurring in the region extending from > 4cm below the knee joint articular surface to a region distally 1.5 times the medial to lateral joint width of the proximal tibial articular surface
- Extra-articular proximal tibia fractures OTA classification(41A2,41A3)
- Closed fractures Tscherne grades 0,1,2 and open fractures Gustilo and Anderson type I and II.

## EXCLUSION CRITERIA

- Bone loss
- Deep wound infection
- Fracture of the proximal tibia with intra-articular extension requiring open reduction
- Known metabolic disease
- Pathological fractures
- Compartment syndrome of leg diagnosed preoperatively
- Retained hardware or existing deformity in the affected limb that would complicate intramedullary nailing and plating
- Symptomatic knee arthritis
- Surgical delay greater than 3 weeks for closed fractures and 24 hours for open fractures
- Ipsilateral femur fractures(floating knee)
- Patients unable to comply with postoperative rehabilitaton protocols or instructions (eg., head injured with low Glasgow coma score<7, or mentally impaired)

A total of 41 patients were included in the study during the period between July 2019 to august 2022. Two patients died before intervention due to necrotizing fasciitis and three patients had incomplete follow up and were excluded from the study, leaving 36 patients in the study.

## INFORMED CONSENT

Informed consent was obtained from all the patients after explaining them the study in their own language.

## RANDOMISATION

Those patients meeting the inclusion criteria and those who consented for participating in the study were included in the study. Patients were randomised into one of the two operative groups of intramedullary nailing and plating using a computer generated random number.

All the patients included in the study received preoperative treatment and evaluation according to the standard protocol observed in the hospital. Anteroposterior and lateral radiographs of the fracture site were taken for all patients. All closed fractures were immobilized in an above knee plaster prior to surgery. Six patients with Gustilo Anderson type I open fractures were initially treated with wound debridement, above knee plaster and intravenous

antibiotics. Two patients with Gustilo Anderson type II open fractures were treated with wound debridement, temporary external fixation and intravenous antibiotics. Definitive surgery (ie, intramedullary nailing or plating) was performed on all patients with open fractures, once wounds healed.
Post randomisation, patients were operatively managed by either fracture fixation with a reamed, interlocking intramedullary nail or open reduction and internal fixation with a lateral tibial head buttress plate.

**SURGICAL TECHNIQUE**
All surgeries were performed by experienced surgeons. Standard methods of intramedullary nailing and plating of fracture fixation were used. All surgeries were performed under regional anaesthesia and under tourniquet. Intramedullary nailing was done with a metaphyseal diaphyseal nail with a proximal Herzog curve (Zimmer company; product code 2253). Plating was performed using a 4.5mm lateral tibial head buttress plate.

**POST OPERATIVE MANAGEMENT**
All patients received 3 doses of perioperative antibiotics. All patients, treated by either intramedullary nailing or plating, were immobilized in an above knee plaster for 7-10 days for soft tissue healing. Knee and ankle range of motion exercises were started after the first wound inspection on postoperative day 3. All patients received postoperative care and analgesia according to the standard protocol followed in the hospital. Patients were followed up clinically at 3months and at 6months. All patients were assessed clinically by the author and biplanar radiographs were taken in the immediate postoperative period, at 3 months and 6 months. Weight bearing was started only if radiograph showed evidence of union. The patients were assessed for the following parameters.

**PARAMETERS STUDIED**
**Primary outcome:** knee society score
**Secondary outcome measures:**
1. Union: defined as cortical healing on at least 3 cortices in 2 follow up radiographs with no interval alignment or implant changes.[6]
2. Non union: defined as a failure of progressive radiographic healing over a 3month period at a minimum of 6 months from fracture treatment.[5]
3. Malreduction: more than 5 degrees angulation in coronal or sagittal plane and/or more than 1cm shortening.[5][6]
4. Infection: either superficial (wound infection only) or deep infection (at bone implant interface) which is detected with wound swab positive and/or clinically presence of foul smelling discharge from wound site.
5. Compartment syndrome
6. Implant failure: defined as loss of fixation of implant in bone.

Functional outcome of the patients was measured using the knee society score.[38] Knee society score, malalignment and union were measured at 3 months and at 6 months follow up. The other secondary outcome measures like infection, compartment syndrome and implant failure were assessed in the immediate post operative period, at 3 months and at 6 months. Anteroposterior and lateral radiographs were taken using the standard radiation exposure and tube distance for all the patients. Fracture alignment was determined on each of the radiographs by making goniometric measurements as described by Freedman and Johnson.[14] Normal frontal plane alignment was defined as 0degrees and normal posterior tilt (apex anterior angulation) of the articular surface relative to the shaft in the sagittal plane was defined as 8degrees.[6][33] Malalignment was defined as a deformity of >5degrees in any plane.[6][33]

**METHOD OF ANALYSIS**
Analysis was performed using Statistical Analysis software SPSS version 20 (year 2011). Subject baseline characteristics were summarized using frequency, percentage. All continuous variables which followed Gaussian distribution were represented as mean ± SD and those that followed non Gaussian distribution were represented as median and inter quartile range. Chi square test was used to compare the categorical data. After checking for normality of the distribution, appropriate tests were used for comparison of 2 groups - continuous data that followed Gaussian distribution were compared by using independent sample t test and data that followed non Gaussian distribution were compared using Mann Whitney U test. All statistical analysis was carried out at 5% level of significance and the p value of $<0.05$ was considered as significant.

## RESULTS
### PATIENT AND DEMOGRAPHIC CHARACTERISTICS
**Table 1: Patient and demographic characteristics**

| Characteristics | Value |
|---|---|
| Total number of patients | 36 |
| Age range | 20-75 years |
| Mean age | 42.55 years |
| Gender distribution (n=36) | 27male / 9 female (3 : 1) |

**Table 2: Age wise distribution of patients**

| Age group | No. of patients(percentage) |
|---|---|
| 20-29 years | 7 (19.4%) |
| 30-39 years | 9 (25%) |
| 40-49 years | 10 (27.8%) |
| 50 years and above | 10 (27.8%) |
| Total | 36 (100%) |

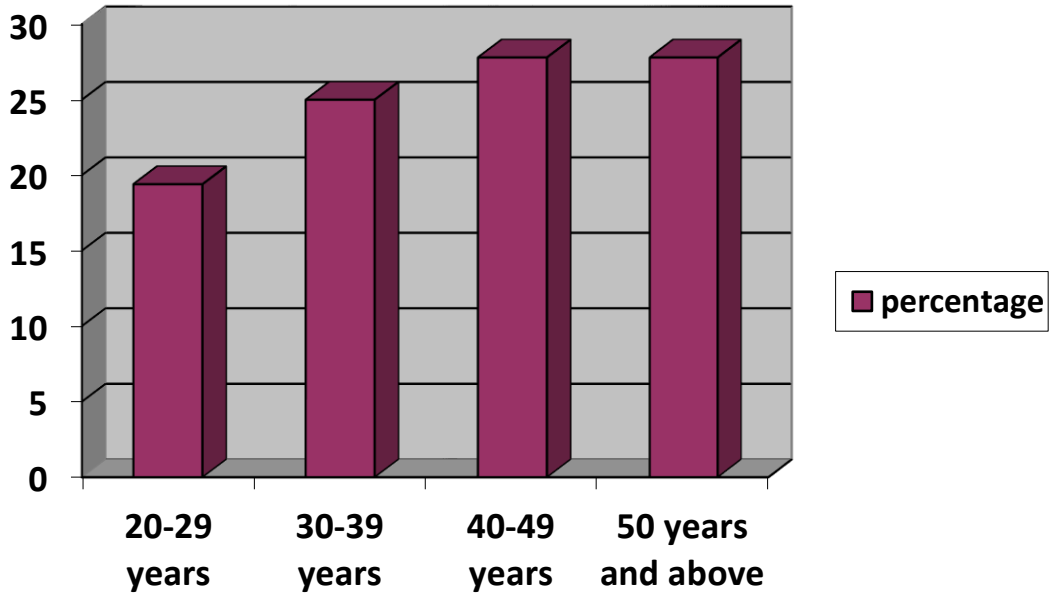


**Figure 1: Bar diagram showing percentage of patients in different age groups.**

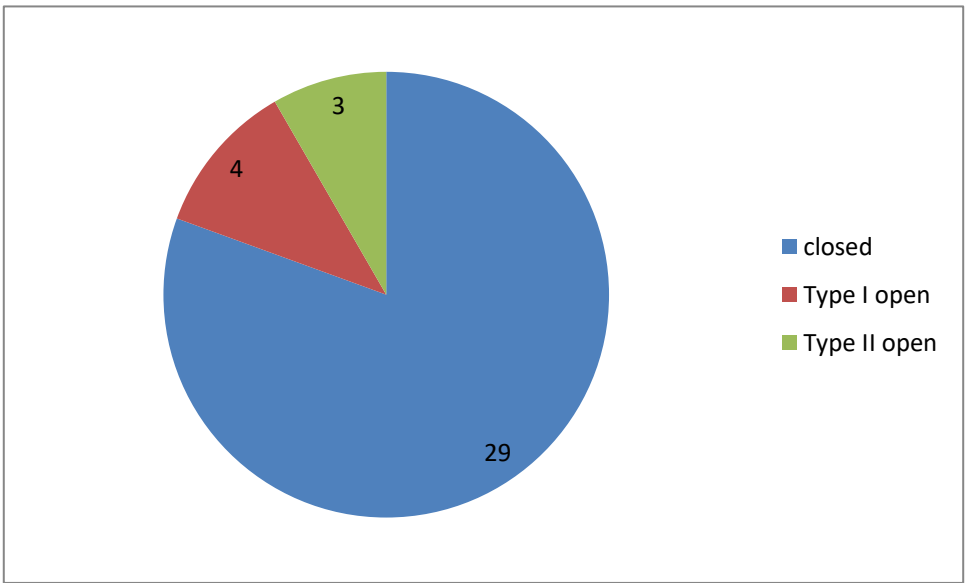


**Figure 2: Pie diagram showing distribution closed and open fractures in the study.**

**PATIENT DISTRIBUTION IN THE TREATMENT GROUPS**

**Table 3: Age wise distribution of patients versus treatment options**

| Age group distribution of patients | Treatment option | Treatment option | Total No. (%) |
|---|---|---|---|
| | Nailing No. (%) | Plating No. (%) | |
| 20-29 years | 3 (42.9%) | 4 (57.1) | 7 (100%) |
| 30-39 years | 6 (66.7%) | 3 (33.3%) | 9 (100%) |

| | | | |
|---|---|---|---|
| 40-49 years | 6 (60%) | 4 (40%) | 10 (100%) |
| >or= 50 years | 3 (30%) | 7 (70%) | 10 (100%) |
| Total | 18 | 18 | 36 |

**Table 4: Treatment options**

| Closed vs open fractures No. (%) | Nailing No. (%) | Plating No. (%) |
|---|---|---|
| Closed (29) | 13 (44.8%) | 16 (55.2%) |
| Open (7) | 5 (71.4%) | 2 (28.6%) |

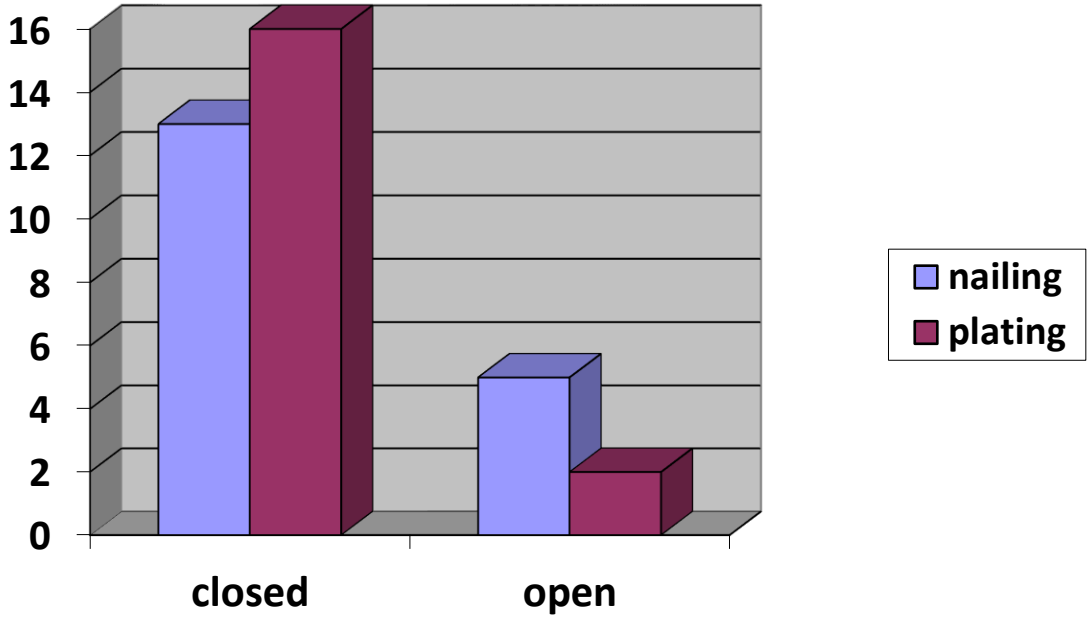


**Figure 3: Bar diagram showing distribution of closed and open fractures in the two treatment groups.**

**OUTCOME MEASURE ANALYSIS**

**KNEE SOCIETY SCORE AT 3 MONTHS**

**Table 5: Knee society score at 3months**

| Treatment group | Median (inter quartile range) | p value |
|---|---|---|
| Nailing | 133.5 (126.75-144.75) | |
| Plating | 139 (128.25-162.75) | 0.389 |

**KNEE**

**Table 6: Knee society score at 6 months**

| Treatment group | Median (inter quartile range) | p value |
|---|---|---|
| Nailing | 183 (177-189) | |
| Plating | 179 (160-180) | 0.079 |

**UNION**

**Table 7: Union and nonunion in the two treatment groups**

| | Nailing No. (%) | Plating No. (%) | Total No. (%) | $X^2$ | p value |
|---|---|---|---|---|---|
| Union | 18 of 18 (100%) | 16 of 18 (88.9%) | 34 of 36 (94.4%) | | |
| Non union | 0 | 2 of 18 (11.1%) | 2 of 36 (5.6%) | 2.118 | 0.146 |

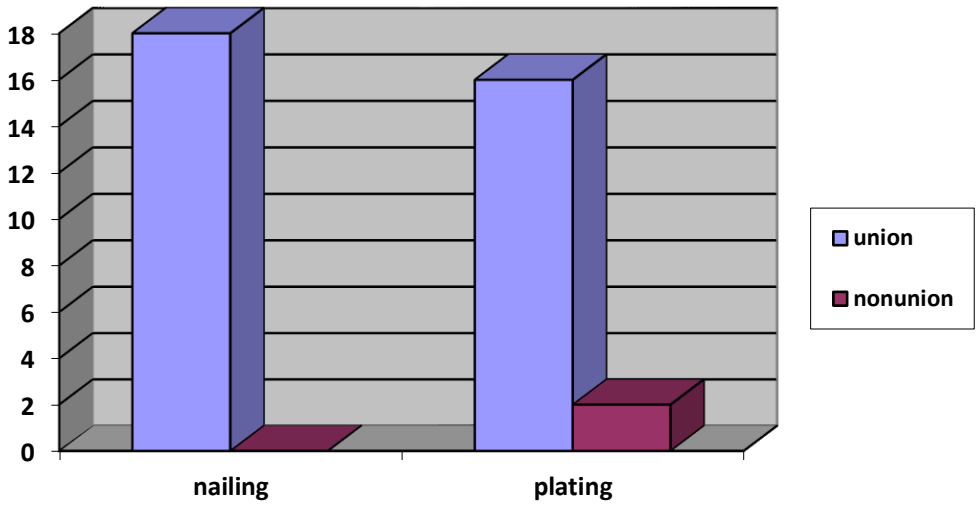


**Figure 4: Bar diagram showing union rates in the two treatment groups**

**INFECTION**

**Table 8: Infection in the immediate postoperative period and at 3 months**

| Treatment group | Closed/open | Infection absent No. (%) | Infection present No. (%) |
|---|---|---|---|
| Nailing | Closed fracture | 13 (100%) | 0 |
| | Open fracture | 4 (80%) | 1 (20%) |
| Plating | Closed fracture | 15(93.8%) | 1 (6.2%) |
| | Open fracture | 2 (100%) | 0 |

**Table 9: Infection at 6 months**

| Treatment group | Closed/open | Infection absent No. (%) | Infection present No. (%) |
|---|---|---|---|
| Nailing | Closed fracture | 13 (100%) | 0 |
| | Open fracture | 4 (80%) | 1 (20%) |
| Plating | Closed fracture | 16(100%) | 0 |
| | Open fracture | 1 (50%) | 1 (50%) |

**COMPARTMENT SYNDROME**

None of the patients in the two treatment groups developed compartment syndrome in the immediate postoperative period or at follow up.

**IMPLANT FAILURE**

**Table 10: Implant failure at 3months follow up**

| Treatment group | Implant failure No. (%) | $X^2$ value | p value |
|---|---|---|---|
| Nailing (N=18) | 3 (16.7%) | 3.273 | 0.070 |
| Plating (N=18) | 0 | | |

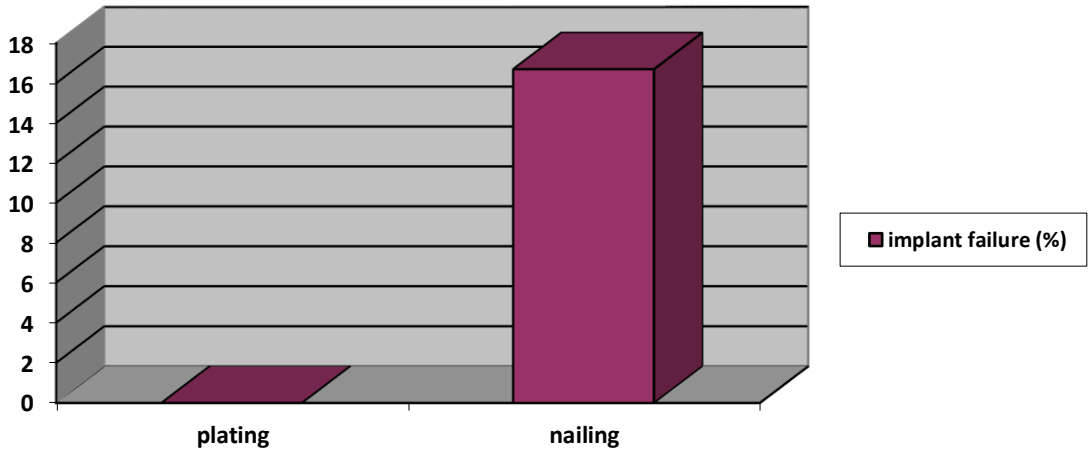


**Figure 5: Bar diagram showing comparison of implant failure percentage in the two treatment groups**

**MALREDUCTION**

**Table 11: Malreduction in the two treatment groups at 3months and at 6months**

| Malreduction | Nailing No. (%) | Plating No. (%) | $X^2$ value | p value |
|---|---|---|---|---|
| Absent | 8 (44.4%) | 14 (77.8%) | 4.208 | 0.040* |
| Present | 10 (55.56%) | 4 (22.2%) | | |

*p value significant

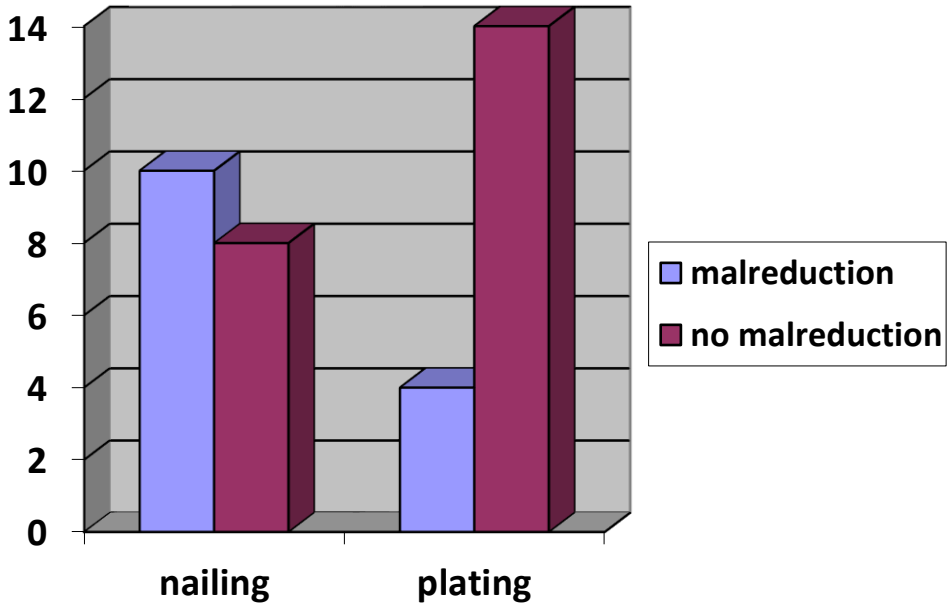


**Figure 6: Bar diagram comparing rates of malreduction in the two treatment groups.**

**LENGTH OF THE PROXIMAL FRAGMENT**

**Table 12: Length of proximal fracture fragment versus Malreduction**

| | Length of proximal fracture fragment (cm) | t value | p value |
|---|---|---|---|
| Malreduction present(n=14) | 6.43 | 0.946 | 0.351 |
| Malreduction absent (n=22) | 6.7 | | |

**COMPARISON OF KNEE SOCIETY SCORE WITH MALREDUCTION AT 6 MONTHS**

**Table 13: Comparison of knee society score with malreduction at 6months**

| Malreduction | Knee society score Median (inter quartile range) | p value |
|---|---|---|
| Present (n= 14) | 181.5 (138.75 - 187.25) | 0.987 |
| Absent (n=22) | 179.5 (177.5 – 182.25) | |

**A**

**B**

**C**

**Figure 7: A).Preoperative Anteroposterior and Lateral radiograph of a 42 year old male patient. B).Immediate post operative radiographs of the same patient treated with intramedullary nailing. C). Post operative radiographs at 6 months showing fracture union**

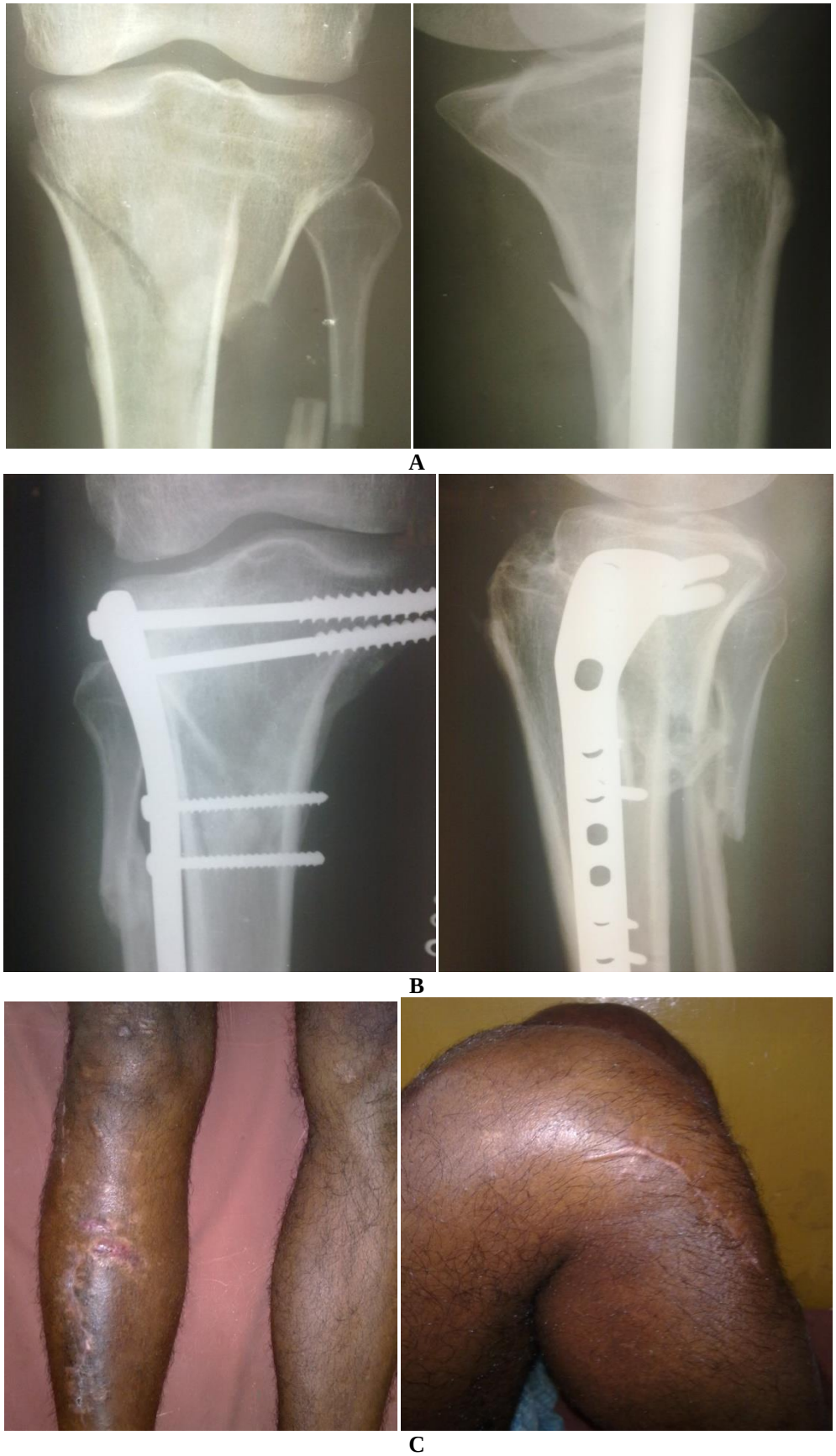

**Figure 8: A). Preoperative anteroposterior and lateral radiograph of 37 year old male patient. B). post operative radiographs at 6 months showing fracture union. C).Clinical photographs of the same patient at 6 months showing full knee flexion on the operated limb treated with plating**

## DISCUSSION

Extra-articular proximal tibia fractures are often the result of high energy injuries with comminution, displacement and extensive soft tissue damage.[4][39] They account for 5% to 11% of all tibial fractures.[1][2] Tytherleigh et al in an epidemiological analysis of 523 tibial fractures reported that 6.3% fractures were located in the extra-articular proximal tibial segment.[2] There are no epidemiological data from India on the prevalence of extra-articular proximal tibial fractures among tibial shaft fractures. In our study, during the study period from July 2011 to August 2013, there was 8% incidence of extra-articular proximal tibia fractures. Of the 511 patients with tibia fractures who presented to our emergency department, 41 patients had extra-articular proximal tibia fractures.

There are various treatment options for the treatment of extra-articular proximal tibia fractures. These include closed treatment with casting and functional bracing, intramedullary nailing, plating and external fixation.[4]

In the present study, we compare the outcome of patients with extra-articular proximal tibia fractures treated with either intramedullary nailing or plate osteosynthesis. There is a paucity of literature comparing outcome of intramedullary nailing and plate osteosynthesis in the treatment of extra-articular proximal tibia fractures and there are no prospective randomised clinical trials comparing intramedullary nailing and plate osteosynthesis in the treatment of extra-articular proximal tibia fractures. Currently, there is an ongoing multicentre randomised trial in Boston comparing intramedullary nailing and plating in the treatment of proximal tibial fractures.

Several studies have been reported in literature using various techniques to achieve and maintain reduction in intramedullary nailing of extra-articular proximal tibia fractures.

**Table 14: Comparison of various studies of extra-articular proximal tibia fractures treated with intramedullary nailing:**

| Parameters | Lang et al[1] | Cole et al[42] | Tornetta et al[23] | Buehler et al[11] | Ricci et al[20] | Nork et al[5] | Vidyadhara et al[29] | Wysocki et al[43] | This study |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1995 | 1995 | 1996 | 1997 | 2001 | 2006 | 2006 | 2009 | 2011-2013 |
| No. of fractures | 32 | 13 | 25 | 14 | 12 | 37 | 45 | 15 | 18 |
| Management | Conventional intramedullary nailing | Blocking screws | Semiextended knee position | Universal distractor | Blocking screws | Temporary plating, universal distractor | Semiextended position, blocking screws | Temorary external fixator | Use of newer implant design |
| Malreductions | 27 (84%) | 1 (7.7%) | 0 | 1 (7.1%) | 1 (8.3%) | 3 (8.1%) | 7 (15.6%) | 1 (6.7%) | 10 (55.56%) |
| Union | 30 (93.7%) | 13 (100%) | Not mentioned | 13 (92.9%) | 10 of 11 (90.9%) | 31 of 33(93.9%) | 45 (100%) | Not mentioned | 18 (100%) |
| Nonunion | 2 (6.3%) | 0 | Not mentioned | 1 (7.1%) | 1 of 11 (9.1%) | 2 of 33 (6.1%) | 0 | Not mentioned | 0 |
| Infection | 1 (3.1%) | Not mentioned | Not mentioned | Not mentioned | 1 of 11 (9.1%) | 2 of 33 (6.1%) | Not mentioned | Not mentioned | 1 (5.6%) |

**Table 15: Comparison of various studies of extra-articular proximal tibia fractures treated with plate osteosynthesis:**

| Parameter | Bolhofner[30] | Gerber,Ganz[13] | Boldin et al[33] | Naik[32] | This study |
|---|---|---|---|---|---|
| Year | 1995 | 1998 | 2006 | 2013 | 2011-2013 |
| No. of fractures | 41 | 18 | 26 | 49 | 18 |
| No. of patients | 35 | 18 | 25 | 47 | |
| Management | Lateral plate and medial external fixator | Lateral plate and medial external fixator | LISS* | PCP** | Lateral tibial buttress plate |
| Malunion | 1 (2.4%) | 1 (5.5%) | 0 | 10(20%) | 4 (22.2%) |
| Union | 41 (100%) | 18 (100%) | 100 (%) | 46 (94%) | 16 (88.9%) |
| Nonunion | 0 | 0 | 0 | 3 (6%) | 2 (11.1%) |
| Infection | 2 (5%) | 1 (5.5%) | 0 | 4 (8.5%) | 2 (11.1%) |
| Knee society score | Not determined | Not determined | 184(median) | | 179 (median) |
| Lower extremity functional score | Not determined | Not determined | Not determined | 59(mean) | |

*less invasive stabilization system plate
**Percutaneous locked plating

**Table 16: Comparative studies comparing intramedullary nailing and plate osteosynthesis:**

| Parameters | Bhandari et al(36) | Lindvall et al(6) | This study |
|---|---|---|---|
| Year | 2003 | 2009 | 2011-2013 |
| Study type | Meta analysis | Retrospective | Prospective randomized |
| No. patients | 273<br>Nailing -199<br>Plating -74 | 56<br>Nailing – 22<br>Plating - 34 | 36<br>Nailing -18<br>Plating – 18 |
| Malreduction/malunion No. (%) | Nailing- 40 (20.1%)<br>Plating- 7 (9.4%) | Nailing- 9 (41%)<br>Plating- 5 (15%) | Nailing- 10 (55.6%)<br>Plating- 4 (22%) |
| Non union No. (%) | Nailing- 7 (3.5%)<br>Plating- 1 (1.3%) | Nailing- 5 (22.7%)<br>Plating- 2 (5.8%) | Nailing- 0<br>Plating- 2 (11.1%) |
| Infection No. (%) | Nailing- 5 (2.5%)<br>Plating- 10 (13.5%) | Nailing- 5 (22.7%)<br>Plating- 8 (23.5%) | Nailing- 1 (5.5%)<br>Plating- 2 (11.1%) |
| Compartment syndrome No. (%) | Nailing- 11 (5.5%)<br>Plating- 1(1.3%) | Nailing- 0<br>Plating- 0 | Nailing- 0<br>Plating- 0 |
| Implant failure No. (%) | Nailing- 15 (7.5%)<br>Plating- 0 | Not determined | Nailing- 3 (16.7%)<br>Plating- 0 |

The patients were distributed uniformly in different age groups. There was uniform distribution of closed and open fractures in the two treatment groups (p value=0.206). There was no significant difference in the functional outcome in patients treated with intramedullary nailing and plate osteosynthesis, as determined by the knee society score at 3months (p value=0.389) and at 6months (p value=0.79).

There were no significant differences in the other parameters like union (p value=0.146), infection (p value at 3months=1.00, at 6months=0.310), implant failure (p value=0.070). There was significant difference in malreduction between intramedullary nailing (55%) and plating (22%) at 3 months and at 6 months (p value=0.04).

The high rates of malreduction following intramedullary nailing of extra-articular proximal tibia fractures might be due to the deforming forces acting around the fracture by the soft tissue attachments around the tibia and also due to surgeons experience in applying the adjunctive surgical techniques in intramedullary nailing of extra-articular proximal tibia fractures. Though the rates of malreduction was high following intramedullary nailing of extra-articular proximal tibia fractures, there was no significant difference in the final clinical outcome of patients treated with either intramedullary nailing or plate osteosynthesis.

Both intramedullary nailing and plate osteosynthesis can be used in the treatment of extra-articular proximal tibia fractures with good clinical outcome.

## CONCLUSION

Extra-articular proximal tibia fractures are the result of high energy injuries and account for 5% to 11% of all tibia fractures. Various treatment options are available for the treatment of extra-articular proximal tibia fractures. The indications for conservative treatment and external fixation are well defined. Conservative treatment is reserved for non displaced

and minimally displaced fractures with little soft-tissue injury. External fixation is reserved for extra-articular proximal tibial fractures with severe soft tissue injuries. There are no specific indications for intramedullary nailing and plate osteosynthesis in the treatment of extra-articular proximal tibia fractures.

Even though significantly high rates of malreduction occur in intramedullary nailing compared to plate osteosynthesis in the treatment of extra-articular proximal tibia fractures, there is no significant difference in the functional outcome of patients treated with either intramedullary nailing or plate osteosynthesis in extra-articular proximal tibia fractures as inferred from the results of this study. Intramedullary nailing and plate osteosynthesis can be used with good functional outcome in the treatment of extra-articular proximal tibia fractures.

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