Minimally invasive percutaneous plate osteosynthesis in treatment of diaphyseal tibial fractures without the use of image intensifier – a study of 30 cases

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Abstract

Objective: The aim of our study was to evaluate the results of diaphysealtibial fractures, treated with minimally invasive percutaneous plate osteosynthesis without use of the image intensifier, in the terms of rate of union of the fracture, range of motion and rate of complications.

Materials and Methods: 30 patients (25 males, 5 females) who were operated upon using the minimally invasive percutaneous plate osteosynthesis (MIPPO) principles without the use of image intensifier for tibial diaphyseal fractures. After indirect reduction, the plate was advanced through a sub muscular extraperiosteal tunnel without opening of the fracture site. The plate was fixed using screws through the incisions made at the proximal and distal ends. Clinical and radiological evaluations were made after surgery. Full weight bearing was allowed after an average of 21.66 weeks. Duration of union and complications were analyzed.

Results: The mean duration of union was 19.4 weeks. All cases showed union but malunion occurred in two cases.

Conclusion: MIPPO without the use of image intensifier is a very effective alternative treatment for tibial diaphyseal fractures showing high union rates, low complications and no risk of radiation exposure.

Keywords: Image intensifier, Biological plate, Fracture, Tibia, Diaphyseal, Malunion, Mesh terms; Tibial fractures, Fracture fixation, Non union, Plate fixation, MIPPO.

Introduction

Tibia is the most commonly fractured long bone of the body. Most controversies arise regarding treatment of the tibial fracture, due to their topography, frequency, mode of injury and sometimes the type of treatment which is opted. As a result of these factors these fractures have become a source of permanent or temporary disability and even today it is a big challenge for the attending surgeon to achieve union.[1] Now a days it is preferred to have a stable biological fixation over a rigid fixation. During the biological fixation the maximum importance is given to the soft tissues and the vascularity of the bone.[2]

The earliest attempt of biological plating was made about 25 years back by Boitzy and Weber, but it gained popularity in the 1980's. The development of various different techniques namely indirect reduction technique,[3] the development of wave plate[4] and the bridging plate[5] brought changes to the fracture treatment using plates and paved the way for the era of biological plating. The emphasis changed from being mainly concerned with the type of implant to protect the soft tissues by adopting less invasive fixation techniques.[6]

The principles of Biological fixation are:[7]

1. Manipulation at a distance from the fracture site leading to Repositioning and realignment; the soft tissues are preserved (Indirect reduction techniques).
2. Leaving the fragments of the comminuted fractures out of the mechanical construct, while preserving their blood supply.
3. Usage of biocompatible materials and low elastic modulus.
4. Limited operative exposure.

The MIPO technique was developed not only to improve the fracture healing rate,[8,9] but also to limit the soft tissue elevation at the fracture site.[10]

MIPO has technically evolved into minimally invasive percutaneous plate osteosynthesis (MIPPO). The operative procedure is thus simplified, the damage to the fragments minimized, and the fracture healing accelerated.[8]

Advantages of MIPPO are:[11]

1. Simpler technique which is easy to master, learning curve is shorter.
2. There is No need of further expensive instrumentation.
3. Better rates of union of fractures.
4. Decreased infection rate.
5. Decreased need of bone grafting.
6. It is the ideal technique for the patients with multiple injuries.
7. There is possibility of early mobilization of the involved.
8. Decreased incidence of re-fracture after plate removal.

Orthopaedic surgeries have become less invasive over the last decade, because of the development of minimal-invasive techniques and implants. Because of this, the use of intra-operative fluoroscopy is indispensable in orthopaedic procedures nowadays. This has caused many orthopaedicians to rely heavily on the use of ionizing radiation for such procedures. Surgeons and their staff may perform hundreds of similar procedures in a given year, making them vulnerable to the effects of long-term sub threshold exposure. As surgeons continue to study the purported clinical benefits of minimally invasive procedures, however, more often than less the surgeons are not well informed about the availability and use of the fluoroscopic units, which ends up in unnecessary exposure to radiation.[12] Recent study showed higher incidence of malignant diseases amongst the exposed persons in an orthopaedic hospital.[13]

Materials and Methods

The study was conducted on 30 cases of fracture involving the Tibia on whom the technique of minimally invasive percutaneous plate osteosynthesis (MIPPO) was used without image intensifier, admitted in Orthopedics Department, Government medical college and Rajindra Hospital, Patiala.

Patients were treated by using the MIPPO method. The joint line of the knee and the ankle were defined and marked on the skin. Manual traction and closed reduction was used to align the main fracture fragments. In all the fractures the anteromedial aspect was used to apply the plate. A 3–4-cm incision was given without disturbing the soft tissue envelope of the fractured fragments, at one end of the fractured area. All subcutaneous tissue and muscle were dissected deep to the bone without stripping the periosteum. The plate was applied along the surface of an extra-periosteal tract/tunnel and then extended across the fracture to the other side. A small size bone lever with flattened end available in different lengths or a periosteal elevator was used to make the tract. Sometimes the plate itself is used to make the tract. The tip of the tunneler used to make the tunnel should touch the bone and then be lifted up slightly during advancement of the tunneler to avoid stripping the periosteum. A pre-contoured plate, Dynamic Compression Plate or Locking Compression Plate, was applied according to the preoperative radiographic assessment, the location of the fracture and its anatomy. Appropriate length of the plate was selected once the tract was made. Along the previously created tract a contoured plate was made to slide. With the plate in situ traction was given manually and reduction was achieved by pointed reduction forceps and hook. The plate was secured by passing 3-mm Kirschner wires through the most proximal and distal holes, once satisfactory plate positioning was achieved. The same holes as that of Kirschner wires were used to place the second plate of similar size and length. This acted as an external guide to localize the screw holes and skin incisions without the requirement of fluoroscopy. Percutaneously introduced screws were used to fix the plate. The number and position of the screws inserted depended on the individual fracture pattern and bone quality. The goal was “balanced fixation”. The x-ray imaging at the end of the operation confirmed the anatomical restoration of length, alignment and rotation. Thus the use of fluoroscopy was restricted avoiding the harmful effects of radiation to the surgeon, staff and the patient.

The AO classification for tibial diaphyseal fractures was used to categorize and explain the outcome. The classification is as follows

42. Diaphyseal Tibial Fractures
42. A) Simple fracture
42. A1) Spiral
42. A2) Oblique
42. A3) Transverse
42. B) Wedge fracture
42. B1) Spiral Wedge
42. B2) Bending Wedge
42. B3) Fragmented Wedge
42. C) Complex fracture
42. C1) Spiral
42. C2) Segmented
42. C3) Irregular

The outcome was assessed using Savoie et al[14] criteria proximal diaphyseal fractures, Teeny and Wiss[15] clinical assessment criteria for fractures of distal diaphysis and Anderson et al criteria for the middle 1/3rd diaphyseal fractures of the tibia.[16]

6 Month follow up follow

Pre-Operative AP and lateral x-ray

6 Month follow up AP and lateral x-ray

Result

Maximum no. of patients i.e. total 15 out of 30 (50%) were between the age of 20 and 39 years while 13 patients (43.33%) belonged to the age group of 40 to 59 years & 2 patients (6.67%) were above 60 years of age. Mean age of the patients was 41.2 years. 25 patients (83.33%) were male out of 30 patients, while female were 5 in number (16.67%). Male to female ratio was 5:1.

The most common mode of trauma in the study was road traffic accidents. 27 cases out of the 30 (90%) road traffic accident was the cause of the injury, while in remaining 2 cases (6.67%) was due to fall from height and in 1 case (3.33%) from direct blow to the tibia. Right side was more commonly involved then the left. Out of 30 patients 18 patients (60%) had fracture of the right tibia while only 12 patients (40%) had fracture tibia left.

Majority of the patients 17 out of 30 (56.67%) had fracture in the middle 1/3rd of the tibia diaphysis while 5 out of 30 (16.66%) had in proximal 1/3rd and 8 out of 30 (26.67%) in distal 1/3rd respectively.

Table 1: Location of fracture in tibia diaphysis

Location of Fracture in Tibia Diaphysis	**No. of Cases**	**% age**
Proximal $1/3^{rd}$	5	16.66%
Middle $1/3^{rd}$	17	56.67%
Distal $1/3^{rd}$	8	26.67%

As per the AO classification 16 out of 30 (53.33%) patients had tibia diaphyseal fracture of type A, 9 cases (30%) of type B and 5 cases (16.67%) type C.

21 out of 30 patients (70%) did not have any associated medical condition while 9 had medical condition associated in the form of diabetes mellitus in 2 patients, hypertension in 3 patients and combined in 3 patients respectively, while one patient was Hepatitis B positive. 22 out of 30 patients (73.33%) were operated with in first 3 days of injury, while 7 out of 30 patients (23.34%) were operated with in 4 to 7 days and only one was operated after 1 week.

6 patients out of 30 (20%) had superficial infection of the wound as an early complications in 4 patients (13.33%) and in 2 patients (6.67%) there was failure to achieve reduction at the fracture site respectively. 2 patients (6.66%) had delayed union while 2 patients (6.66%) had malunion and none of the patients had nonunion. 6 out of 30 patients (20%) complained of palpable hardware while 4 patients (13.33%) had persistent pain even after the union at the fracture site.

Out of 30 cases 5 had a fracture in the proximal part of the diaphysis of tibia near the knee joint, out of them 3 cases (60%) had achieved 0^{o} (extension gap) to $\geq 110^{o}$ (flexion) at the knee joint while 1 patient (20%) had $0\text{-}5^{o}$ (extension gap) to $90\text{-}110^{o}$ (flexion) range of movement and 1 patient (20%) had $>5^{o}$ (extension gap) to $< 90^{o}$ (flexion) range. Out of 30 cases 8 had a fracturein the distal part of the diaphysis of tibia near the ankle joint, the range of motion at ankle on average was 15.9 degrees of dorsiflexion (range 10-20 degrees) and planter flexion averaged 26.4 degrees (range 10-35 degrees). Out of 30 cases 17 had a fracture in the middle part of the diaphysis of tibia, the range of motion at ankle on average was 15.6 degrees of dorsiflexion (range 10-20 degrees) and planter flexion averaged 25.35 degrees (range 10-35 degrees) while 12 cases had achieved 0o(extension gap) to $\geq 110^{o}$ (flexion) at the knee joint while 4 patient had $0\text{-}5^{o}$(extension gap) to $90\text{-}110^{o}$ (flexion) range of movement and 1 had $>5^{o}$ (extension gap) to $< 90^{o}$(flexion) range respectively at knee.

The average time of Partial weight bearing was 9.13 weeks. The average time of full weight bearing was 21.66 weeks and 22 patients out of 30 had full weight bearing before 24 weeks while 8 took $\geq$ 24 weeks for full weight bearing. The time taken for complete radiological union ranged from 14–32 weeks with mean of 19.4 weeks, majority of the patient 13 cases (43.33%) had union among 16 to 19 weeks.

Table 2: Time interval of full weight bearing

Time Interval in Weeks	No. of Cases	%age
14-18 weeks	9	30%
19-23 weeks	13	43.33%
>24 weeks	8	26.67%

14 out of 17 patients (82.35%) of middle third diaphyseal fracture had excellent to good results as per modified Anderson et al[16] (1978) criteria. 4 out of 5 patients (80%) of proximal third diaphyseal fractures had excellent to good results as per Savoie et al[14] (1987) criteria. 5 out of 8 patients (62.5%) of the distal third diaphyseal fractures had excellent to good results as per Teeny and Wiss criteria[15] (1993).

Table 3

Results as per modified anderson criteria: Middle third fractures				
	Excellent	**Good**	**Fair**	**Poor**
Number of cases	7	7	0	3
% age	41.17	41.17	0	17.66%
Results as per savoie et al (1987): Proximal third fractures				
Number of cases	3	1	0	1
% age	60	20	0	20
Results as per teeny and wiss clinical assessment: Distal third fractures				
Number of cases	1	4	2	1
% age	12.5	50	25	12.5

Discussion

When the strain is kept <2% the primary healing takes place, and when the strain is kept between 2 and 10% which comprises a relative stability, the secondary healing takes place which is characterized by callus formation. Bone cannot be formed if the strain is >10%.[17]

The tibial diaphysial fracture have complex management, poor results were seen in the patients who were treated using the conservative methods such as cast or traction have poor results. Lots of complications were seen in the traditional open reduction and internal fixation because of the poor soft tissue coverage and extensive periosteal stripping during operation leading to high chances of infections and non-union.[18] Special instruments are required for the treatment of diaphysis fracture even though the Interlocking nailing is a well-established method. Many complications such as fat embolism syndrome, pain in anterior knee, angular malalignment and malunion have been seen with this method, and then it is a very costly technique alongside the requirement of a constant technical expertise in the metaphysical diaphysial junction area nailing,[19] thus MIPPO is the next logical step in the surgical treatment of fractures as it does indirect fracture reduction and preserving fracture biology and blood supply.

Mean age of the patients in our study was 41.2 years. Similar observations were made by Stinik et al[20] in which average age was 43 years and Maru et al[21] in which average age was 42 years.

In our study Males were more affected then females with male to female ratio 5:1 with 83.33% male and 16.67% females. Similar results were found in study of a conducted by Sunkad et al[22] with male 84% and Guven et al[23] in which males were 74% and females were 26%. Predominant male involvement is probably due to more outdoor activities by the males as compared to females and thus more prone to accidents/traumatic/sports injuries.

In the present study majority of the patients had fracture tibia in the middle of the diaphysis, 17 out of 30 (56.67%) while 5 out of 30 (16.67%) had in proximal 1/3rd and 8(26.67%) in distal 1/3rd. The observations are similar to the study by Tantray et al[16] in which 16% of the fractures (8 cases) involved the proximal third; 24% (12 cases) in the distal third and 60% (30 cases) in middle third of tibia.

Superficial infection was found in 4 patients (13.33%) similar observations were made by Williams and Schenk[24] in which it was 10% while in Sitnik and Beletsky[20] study superficial infection was 9%.

In our study the rate of Malunion was 6.66% (2 out of 30 cases) and similar observations were made by Tantray et al[16] and Sitnik and Beletsky,[20] in both the studies malunion was 6%.

Delayed union in our study was seen in 6.66% (2 out of 30 cases). Tantray et al[16] made similar observations, in which it was 8% while in Yang et al[25] delayed union was 8.33%.

Partial weight bearing in our study was achieved by average time of 9.13 weeks similar observations were made in Tantray et al[16] in which the time taken for partial weight bearing ranged from 6- 14 weeks (mean 9.625 weeks). The average time for partial weight bearing for proximal third diaphyseal fractures was 9.2 weeks. The average time for partial weight bearing for middle third diaphyseal fractures was 8.9 weeks.

In our study average time of full weight bearing was 21.66 weeks and 22 patients out of 30 had full weight bearing before 24 weeks while 8 took ≥ 24 weeks for full weight bearing similar observations were made by Tantray et al[16] in which the time taken for full weight bearing ranged from 12-32 weeks and the mean interval for full weight bearing was 22.25 weeks and Walia et al[26] in which mean time for full weight bearing was 23.27 weeks. The average time for full weight bearing of proximal third diaphyseal fractures was 20.4 weeks.

4 patients had delayed partial and full weight bearing. 2 of these patients had fractures of the middle third of the diaphysis with a fracture pattern of AO type 42B.3 (fragmented wedge fracture) and one of these 2 patients was HbsAg positive and developed superficial infection leading to delayed union and hence delayed weight bearing, while the other patient was diabetic and complained to persistent pain leading to delayed weight bearing. 2 other patients who had delayed weight bearing were the one who developed malunion as a result of failure to achieve reduction and one of these 2 patients had fracture in the middle third of diaphysis of AO type 42C.2, while the other patient had fracture in the distal third of diaphysis of AO type 42C.3.

In our study the time taken for complete radiological union ranged from 14 – 32 weeks with mean of 19.4 weeks similar observations were made by Aksekili et al[27] in which mean radiological union time was 17.96 weeks, Kim et al[28] had radiological union in 19.4weeks, Uppin et al[29] had radiological union in 19.5 weeks while Tantray et al[16] in which it was 22.25 weeks. The time taken for complete radiological union of proximal third diaphyseal fractures was 17.2 weeks. The time taken for complete radiological union of distal third diaphyseal fractures was 20.875 weeks. The time taken for complete radiological union of middle third diaphyseal fractures was 19.29 weeks. The average time of radiological union for proximal third diaphyseal fractures was found to be the least (17.2 weeks), probably due to the cortico-cancellous region of the bone and increased muscle cover at the fracture site. The average time of radiological union for distal third diaphyseal fracture was found to be the maximum (20.875 weeks), probably because it is the subcutaneous area of the bone and very less muscle cover.

As per the modified Anderson et al[16] (1978) criteria, in our study 14 out of 17 patients (82.35%) of middle third diaphyseal fracture had good to excellent results while 3 patients (17.66%) had poor results. 4 out of 5 patients (80%) of proximal third diaphyseal fractures had excellent to good results while single patient (20%) had a poor result as per Savoie et al[14] (1987) criteria. 5 out of 8 patients (62.5%) of the distal third diaphyseal fractures had excellent to good results while 2 out of 8 patients (25%) had fair result and 1 patient (12.5%) had a poor result as per Teeny and Wiss[15] (1993) criteria. Similar findings were observed in Raiturker et al[11] in which 93.75% had excellent to good results and in Pai et al[30] in which 86.9% had excellent to good result.

Conclusion

MIPPO technique provides a biological repair by preserving most of the osseous vascularity and fracture hematoma. The fractures wherein the locked nailing cannot be done like in vertical slit and markedly comminuted fractures, this technique can be used.

Due to preserved vascularity there is rapid fracture consolidation. Very fewer incidences of delayed union and non union are seen. There is decreased need for bone grafting and a decreased incidence of infection due to limited exposure.

By carefully inserting the plate sub-cutaneously through limited incisions there is lesser chance of vascular compromise. The method is less time consuming and cost effective. There is no need of any specialized instrumentation. The use of image intensifier can be restricted with careful pre operative planning and choosing the patient cautiously and hence the adverse effects of radiations can be minimized.

Informed consent was taken from all the patients.

Conflict of Interest: None.

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