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Functional Outcome of Comminuted Meta-Diaphyseal Fractures of Proximal Tibia Treated by Stainless Steel Bridging Plate

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ABSTRACT

Proximal Tibial meta-diaphyseal fractures are challenging injuries because of subcutaneous anteromedial surface of bone and frequent soft tissue complications. Good management requires stable fixation with minimal soft tissue handling. Locking compression plate (LCP) applied as an external fixator fulfills these criteria and can be an important tool in the armamentarium of an orthopaedic surgeon. To study the clinical, functional and radiological outcome of comminuted fractures of metaphysis and diaphysis proximal tibia treated by stainless steel bridging plate in skeletally mature patients. This was a prospective study conducted in Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak-124001, Haryana (India) between July 2023-February 2024 in skeletally mature patients with posttraumatic comminuted fractures of metaphysis and diaphysis of proximal tibia fractures were included. Patient were evaluated retrospectively in terms of union, maintenance of reduction, complications and final outcome using KSS (Knee society scoring) for proximal fractures. Following all principles of fracture reduction, union was achieved in all patients with mean time to radiological union being 20 weeks. The mean Range of Motion (ROM) was 106 degrees with According to KSS results were excellent in 28 patients (41%), good in 26 (38%), fair in 15(21%) 6 patients developed complications in the form of infection during the course of our study, but were completely treated by the end of the study. We found this technique to be more biological, simple to do surgery, effective in maintaining reduction till union, more patient friendly in comparison to traditional large, bulky fixators and with minimal complications.

INTRODUCTION

Fractures around Knee joint are among the most difficult fractures to treat effectively. The status of the soft tissues, the degree of comminution sustained at the time of injury affect the long term clinical results. The goal of operative treatment is to obtain anatomic realignment of the joint surface while providing enough stability to allow early motion. This should be accomplished using techniques that minimize osseous and soft tissue devascularization in the hopes of reducing the complications resulting from treatment. Minimally invasive locking plate osteosynthesis (MILPO) is a burgeoning technique providing an alternative to intramedullary devices, external fixation and conventional plate osteosynthesis in complex proximal tibial fractures management^[1,2] The use of MILPO technique, which is rather flexible and allows reducing the surgical trauma. Still articular fractures seem to require precise and stable fixation^[3]. The biological complication results from extensive surgical stripping of bone blood supply in an attempt to achieve perfect reduction and absolute stability. Depending on more tolerant, forgiving technologies of internal fixation, single lateral locking plate using MIPO technique has been advocated as a means of decreasing the risk of skin damage, ligament damage, and surgical site infection^[4-6] In our institutions, we have been using a single lateral locking plate system characterized by percutaneous technology. This is a better understanding of fracture healing in respect to the balance between mechano-biological tradeoffs. The purpose of this study was to evaluate the perioperative results and functional outcome following operative treatment of complex proximal tibial fractures using the surgical strategy (a single lateral locking plate/MIPO technique).

MATERIALS AND METHODS

This study was done both Retrospectively and prospectively in Department of Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak-124001, Haryana (India) between July 2023-February 2024. The cases being selected were those who had comminuted fractures of meta-diaphyseal region of proximal tibia, were operated with stainless steel bridging plate. Minimum of 1/3rd to half of the plate holes are left empty to achieve the relative stability and minimum of 3 screws or 6 cortices are fixed in each fracture fragments.

Inclusion Criteria:

- Patients with complete clinical records.
- Patients with multifragmentary fracture of metaphysis and diaphysis of femur and tibia.
- Closed fractures or Compound fractures with Gustilo Anderson's Grade I or Grade II type.
- Age: >15yrs.

- Patients treated primarily with stainless steel bridge plating
- Patients followed up as outpatients for at least 24 weeks.
- Medically and surgically fit patients for surgery.

Exclusion Criteria:

- Compound fracture of Gustilo Anderson's Grade III type.
- Pathological fracture.
- Fracture treated with rigid fixation technique.
- Patient not willing for operation.

In this study, the timing of surgery depended on the soft tissue conditions and surgery was delayed if the fractures had established severe swelling and skin blister. Patients who had open fractures underwent debridement and then MIPO after no signs of infection. Waiting for surgery, all patients were treated with trans-calcaneal traction or external fixator. The mean time elapsed from injury to definitive surgical treatment was 7 days (range 0-14 days). Patients who sustained multiple fractures, which included ipsilateral ankle fractures and patellar fractures. They were successfully managed by combining internal fixation techniques frequently employed for the treatment of each of these injuries. For surgery, patients were positioned supine on a radiolucent table. The ipsilateral iliac crest was prepared and draped for possible autogenous bone grafting. With this surgery strategy of a single lateral locked plating/MIPO is first turned type C fracture into type A fracture by reconstructing the articular fragments as a single articular block. Then the metadiaphyseal component is bridged with submuscular plating usually from the lateral side. The typical sequence of lateral locked plating can be outlined as follows:

- Articular fracture reduction and fixation.
- Indirect reduction of the reconstructed articular block to the diaphysis.
- Percutaneous locking plate insertion and fixation.

Articular displaced split fractures were reduced indirectly by a reduction forceps under image intensifier. For centrally depressed articular fragments (when reduction was not feasible by ligamentotaxis), a window through the cortical bone was made in the subchondral metaphyseal region. For bad results closed reduction may be conducted, the articular surface was visualized with a small arthrotomy. Once the elevation of the depressed articular fragments was done and the lateral split fragment is reduced to the medial condyle, subchondral screws were placed using 3.5 mm cortex screws. In some cases, screws were not placed in the proximal part of the lateral plate to avoid interfering with the reduction and bone grafting of the

depressed part of talar surface that was often performed via the anterolateral approach.

A lateral curved incision was made from the Gerdy tubercle extending distally for about 5.0 cm. The metaphyseal and diaphyseal component of the fracture was reduced using indirect reduction methods. The restoration of the length was the most crucial step. Otherwise, the metadiaphyseal component was reduced and aligned by manual longitudinal traction, pointed reduction forceps, collinear reduction clamp, *et al.* If necessary, we performed direct reduction through the open trauma wound with short extending incisions as needed for access. An acceptable alignment ($<5^\circ$ in sagittal and coronal plane, $<10^\circ$ in rotation) is achieved.

Then the locking plate was introduced submuscularly through an anterolateral approach. The position of the plate was verified with image intensifier images in both AP and lateral views along the axis of the tibia. Reconfirmation of fracture reduction was then performed with image intensifier before the plate was confirmed the plate is provisionally fixed to the bone using two 2.0 mm K-wires inserted proximally and distally. One bicortical locked screw was placed in the end hole of plate at site of insertion, and then a second screw was inserted at the opposite end of the plate through a stab incision. Check fluoroscopy images was repeated. Final fixation was achieved with locking screws at either end of the plate. A total of four or five 5.0 mm locking screws were placed to the proximal fragment and three or four screws were placed in the shaft fragment. This construct aimed for combining absolute stability by fixed angle stability and relative stability by bridging technology. After fixation, the stability of the knee joint should always be checked.



Fig 1(a): Holding fracture fragment by reduction forceps (b) plate selection (c,d) use of fluoroscopic guidance

To achieve early functional restoration of the limb, both passive and active joint motion of the knee joint must be started as soon as possible. The amount of weight bearing should be tailored according to the fracture fixation construct. Usually partial weight bearing could begin around 6 weeks postoperatively and progressively increased weight bearing depends on both clinical and x-ray findings.

RESULTS AND DISCUSSIONS

The present study consists of 69 cases of fracture of the proximal tibia. All the cases were fixed using stainless steel locking compression plate by Bridging plate method.

Fracture characteristics	
Variable	No.
Male/female	59/10
Age	41 years (range, 25-63 years)
Right/left	47/22
Mechanism of injury	
Motor vehicle crash	58 (84%)
Fall	11 (16%)
Isolated fracture	47 (68%)
Multiple fractures	14 (20%)
Polytrauma	8 (12%)
Distal fracture extension	
The proximal third of the tibial shaft	49 (71%)
The middle of the tibial shaft	20 (29%)
Closed	22 (32%)

Table 1: Showing Proximal tibia fracture pattern

Fracture Pattern	No. of Patients
A1	6
A2	2
A3	1
B1	18
B2	11
B3	14
C1	04
C2	04
C3	09
Total	69

Of the 69 cases treated with Stainless steel locking compression plates 54 (78%) took 50-70 minutes and 15 (22%) took 71-90 minutes. The average time duration was 69 minutes. All the surgeries were done under tourniquet application and no surgery took more than 90 mins of tourniquet time. No. of holes plate used: Of the 69 cases treated with Stainless steel locking compression plates 37 (54%) were of 6-8 holes, 24 (35%) were of 9-11 holes and 8 (11%) were of 12-14 holes. The average plate holes used was 9 holes. Of the 68 cases treated with Stainless steel locking compression plates 37 (54%) were of 6-8 holes, 24 (35%) were of 9-11 holes and 8 (11%) were of 12-14 holes. The average plate holes used was 9 holes.

Table 2: Showing No. of holes plates Used

No. of Holes plates Used	No. of Patients	Percentage
6-8	37	54
9-11	24	35
12-14	08	11

No. of plate holes left empty

All the fractures united with an average of 20 weeks ranging from 16-28 weeks.

Table 3: Showing duration of fracture union

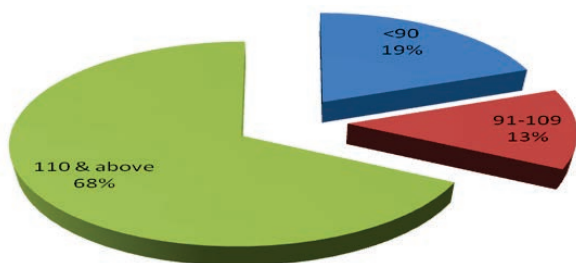
Duration (Weeks)	Number of patients	Percentage (%)
16-18	15	22
>18-20	16	23
>21-22	14	20
>23-24	17	25
>25-26	03	4
>27-28	04	6
Total	69	100

Table 4: Movements of Knee (Flexion In Degrees)

Range Of Knee Flexion (In Degrees)	No. Of Patients	Percentage
<90	12	17
90-109	36	52
110 and More	21	31

Normal knee flexion is 140 degree. Laubeth^[7] has demonstrated that average motion required for: Normal sitting 93 degree Stair climbing 100 degree Squatting 117 degree Thus, acceptable knee flexion compatible with daily activity would be 100-110 degree. The average knee flexion at the final follow-up was 106 degrees. 68% of patients (47-69) had a flexion of ≥ 110 degrees. The average knee flexion in Type C fractures was compared to Type A fractures, which shows that intra-articular fractures lead to intra-articular stiffness and decreased range of motion. Four of our patients, who had Type- C fractures had extension lag which persisted even after physiotherapy.

Knee society score in open fracture was 75.6 and closed fracture was 80.3. Knee society score average was 78.42 with minimum of 65 and maximum of 91 in proximal tibia fractures. According to KSS results were excellent in 28 patients (41%), good in 26 (38%), fair in 15(21%)



Graph 1: Movements of Knee (Flexion in Degrees)

Table 5: Showing Complications

Complication	Number of Patient	Percentage (%)
Superficial Skin Infection	6	9
Joint Stiffness	4	6
Varus Angulation knee(10)	1	2
Deep Infection	1	2
Screw loosening	1	2



Fig 2: 42-year-old man with a proximal tibial fracture with diaphyseal involvement closed AO type 42 C3 Fracture (a) preop AP view



(B) Preoperative lateral view



(C) Post op AP view



(D): Post op lateral view



(E): Ap view at 24 week follow up



(F): Lateral view at 24 week follow up



(G): Clinical photograph at 24 week follow up knee flexion



(H): Knee extension



(I): Squatting



(J): Single leg standing

Age/Sex: In our study of 69 patients with proximal tibia Proximal meta-diaphyseal fractures the mean age of the patients was 41 years and there were 47 males (68%) and 22 females (32%). This is a reflection of the mechanism of injury which was high energy trauma in 70% of our patients of which most of whom were younger. The reason being that, in male patients there was more outdoor activities, so they were more prone to vehicular accident and majority females being house wives were less exposed to road traffic accidents. P.A Cole^[8] in 2004 also found the majority of patients in productive age and average of 45 years, Correlated well with the study of Ricci^[9] and Stannard^[10] with average of 53 years and 38 years respectively.

Mode of Injury: In our study most of the injuries were caused by road traffic accidents affecting mostly males. We had 58 (84%) RTA injuries, 11 (16%) Falls.

Fracture Pattern: In our study of 69 proximal tibia fractures, most of the fractures fall into type 41, A1, B1,B2,B3, C3 and type-42 of AO classification of proximal tibial fractures. Different authors used different criteria for the surgical management of these fractures. P. A. Cole^[8] treated 44 proximal tibial fractures with locking compression plate and enrolled patient with type-41 A2, A3, C1, C2, C3 and proximal type-42 of AO classification.

Time of Union: The average time to union was 20 weeks in our study. Radiological union of the fracture i.e. characterized by cortex to cortex healing and bridging callus of the fracture in both AP and lateral views of follow up x-rays, was considered as satisfactory union. These results are comparable with other documented standard series of Ricci^[9], Cole^[8], Stannard^[10] and Egol^[11], wherein high union rates, good knee joint range of motion, good alignment and fewer complications were noted. In Egol^[11] study time to union was 17 weeks. Time to union increased with increase in age of the patient. Time to union in Type C fractures generally was found to be longer compared to Type A fractures.

Range of Motion: An average of 110° knee joint range of motion was achieved. Soft tissue damage, intraarticular fracture, severity of fracture, treatment option and physiotherapy determined knee range of motion. Both Cole^[8] and Egol^[11] reported similar range of movement results when using locked plate for proximal tibia fractures (range 0-122° and 0-109° respectively).

Infection: We had superficial infection in 6 cases out of 69 patients who completed the study. The patient had superficial infection for 6-8 weeks which delayed bone union and full weight bearing. The infection subsided after debridement, dressing and course of IV

antibiotics. But in one case with deep infection we removed the plate after fracture is united. The infection rate in our series was 9%.

These findings are comparable with the studies conducted by Egol^[11] who reported no infection, Stannard^[10] reported 5.9% rate of infection and Cole^[8] with 4% rate of infection. All the infections were superficial and well controlled by debridement and IV antibiotics. Most of them occurred in open injuries.

The Knee Society Score And Results: Evaluation according to the Knee Society Score showed a mean Knee society score of 78.42 with a range of 65-94. Results were excellent in 6 patients (23%), good in 18 (69%), fair in 2(8%) and poor in 2(8%). Excellent and Good results accounted for 92% of cases and remaining 8% as Fair results. Younger patients had better results than older age. The time to union increased with increase with age.

CONCLUSION

At the end of the present study, the following conclusion could be drawn from the Bridge plating of the comminuted fractures of meta-diaphyseal region of proximal tibia using stainless steel locking compression plate. There is an increase in the complexity of proximal meta-diaphyseal fractures of tibia with increasing road traffic accident. While bridging a fracture, care must be taken to select a strong plate of adequate length of at least 2-3 times of the fracture length and leave at least one third to half of the plate holes without filling screws. Even though stainless steel has a high modulus of elasticity and ductility than the titanium, it can be safely used to achieve relative stability and rapid callus formation. Although, a larger sample of patients and longer follow up are required to fully evaluate this method of treatment and long term complications, we conclude that the stainless steel locking compression plate system acts as a good biological fixation. Stainless steel plate has enough flexibility to be used as bridge plate to achieve callus formation and fracture union with a few complication which can be prevented by properly following the principles of bridge plating intra operatively and post operatively. Thus we strongly encourage consideration of this cost effective way of treating such complex fractures by Stainless steel Locking compression plates.

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