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Should locking compression plate be an implant of choice to fix the fractures of proximal tibia?: A prospective case study

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Abstract
We prospectively studied a case series of 30 patients with Proximal tibia fracture after surgically fixing the fracture using Locking Compression plate either by as less invasive stabilization system (MIPPO) or by open plating(ORIF). The functional outcome in terms of time to clinical and radiological union, range of movements and complications were studied. Young males were more prone owing to high energy road traffic accidents, the most common cause. The mean time to union was 19.6 weeks (4.6 months). The overall knee range of motion averaged 134 deg. (range 30-150 deg.) at the latest follow up. Deep infection occurred in 3 cases (all with ORIF technique); stiffness and restriction of movements < 90 deg. was seen in 2 and screw breakdown occurred in 1 case. Minor complications like extensor lag and superior tibiofibular subluxation in 1 case each. Majority of the complications occurred in A.O. types B3 and C3 fractures reflecting the severe nature of these types of injuries. Based on Rasmussen's functional criteria, excellent results were seen in 14 cases (46.66%), good in 15 cases (50%), fair in 1 case (3.33%) with no poor result.

Keywords: Locking compression plate, MIPPO, plate osteosynthesis, proximal tibia fractures

Introduction
Proximal tibia fractures present a spectrum of soft tissue and bony injuries that can produce permanent disabilities. Their treatment is challenged by fracture comminution, instability, displacement, extensive soft tissue injuries, compartment syndrome, peroneal nerve injury and vascular injury**.** The proximal tibial fractures are one of the commonest intra-articular fractures. These injuries fall into two broad categories, high energy fractures and low energy fractures. The majority of tibial plateau fractures are secondary to high velocity accidents and fall from height [1] where fractures result from direct axial compression, usually with a valgus (more common) or varus moment and indirect shear forces [2]. Older patients with osteopenic bone are more likely to sustain a depression type of fracture because their subchondral bone is less likely to resist axially directed loads [3].
The care of tibial fractures is addressed once life threatening injuries have been stabilized. The goals of treatment are restoration of joint congruity, normal limb alignment, knee stability, and a functional range of knee motion and union of fracture [4]. The orthopaedic surgeon determines the type and extent of the tibial fracture and decides on the type of treatment, which may include cast or functional cast bracing, open reduction and internal fixation with plates and screws, intramedullary nails, or external fixation devices [5].
New implants and surgical techniques have provided new options for the management of these fractures. The LCP system is a new type of extra medullary implant system which combines the facilities of conventional plate osteosynthesis with those of internal fixator systems. It administers the use of a combiplate permitting the use both of standard screws and locking head screws which achieve fixed angle stability. These characteristics may make locked plating an attractive option for treating fractures of the proximal tibia[6]. Whether this soft tissue preserving technique will improve the clinical outcome of patients is yet to be determined.

The purpose of this study was to determine whether fixation by locking compression plate is an effective method in the management of intra-articular and juxta-articular fractures of the proximal part of tibia**.**

Materials and Methods

Type of Study: *In vivo* Prospective observational study
Location of Study: The Central Institute of Orthopaedics, Vardhman Mahavir Medical College and Safdarjang Hospital, New Delhi
Study Location: October 2010 to March 2012.
Sample Size: Thirty patients
Inclusion Criterion: Intra-articular and juxta-articular fractures of proximal tibia.

Exclusion Criterion

- Children (<16 years)
- Open types II and III proximal tibia fractures
- Pathological fractures
- Previous osteotomy & compromised vascularity

Informed consent was taken from all the patients before including them in the study. A thorough history regarding mode and mechanism of injury and clinical examinations was undertaken.

Surgical Techniques

Patient positioning: Patient was placed on a simple operating table which was compatible with C arm image intensifier. The affected limb was painted and draped and was placed in 30^0 of flexion at the knee to relax the collateral ligamentous structures.

Incision: Anterolateral approach was commonly used. In cases where medial condyle was severely comminuted or when there was posteromedial plateau fracture, anteriomedial or posteromedial approaches were also used. MIPPO technique was utilized in 11 cases and Open Reduction and internal fixation in rest 19 cases.

Reduction of fracture: In case of MIPPO technique closed reduction of fracture was achieved with help of traction or simple towel support under the fragment or with the help of K wires and pointed reduction forceps in split fractures.
In case of depressed fractures, a bony window was created in the metaphysical area of ipsilateral side and the depressed fragment was elevated with the help of a bone punch or periosteal elevator or similar instrument with careful and gentle upward pressure till the articular fragment was elevated and reduced. The reduction was confirmed with the help of an image intensifier. The cavity thus created behind was filled with bone graft or bone substitute.

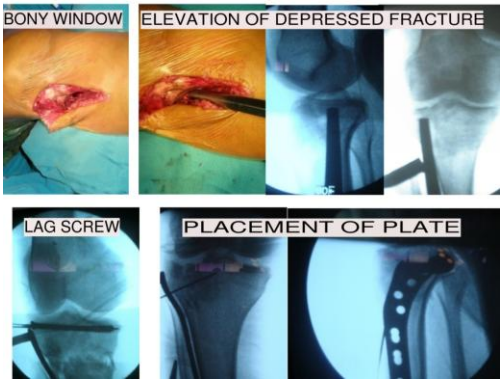
Determine the plate position: Using anatomic landmarks and fluoroscopy, the plate was mounted on intact or reconstructed plateau and temporarily fixed to bone with the help of 2 mm kirschner wires. Desired compression of articular fragments was achieved with the help of traditional lag screw prior to applying locking compression plate with locking screw.
Clinical examination and fluoroscopy were used to confirm that (a) screw projections in the proximal locking holes were parallel to the joint in the transverse plane and plate was oriented properly on the plateau. (b) Screw and plate placement were consistent with the preoperative plan (c) Alignment of the plate to the shaft of the tibia was correct in both anteroposterior and lateral views.

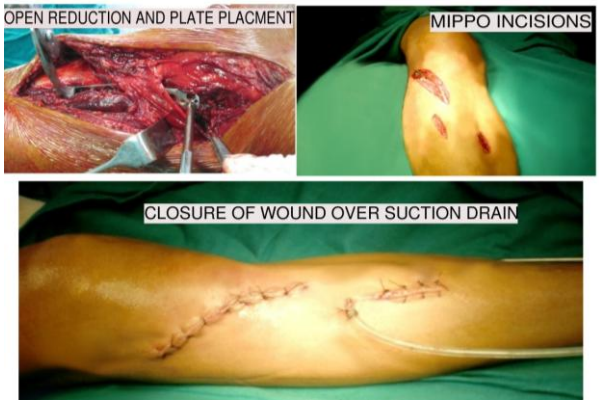
Placement of proximal screw: While the plate was placed against the bone, at least 3 proximal locking screws with bicortical purchase were placed after proper drilling and Measurement under C-arm guidance.

Placement of distal screw: In case of MIPPO technique, stab incision was given over skin over the distal screw site and deep tissue was retracted using artery forceps. Then screws of appropriate length were inserted after proper drilling and measurement.
The wound was closed in layers to cover the bone and plate over a negative suction drain using 2-0 vicryl for subcutaneous layer and 2-0 nylon or silk for skin.

Recovery and Rehabilitation

The drain was removed on the second postoperative day and the drain tip sent for culture and sensitivity analysis. IV antibiotics were continued for 3 days. If the cultures were positive for bacterial growth, antibiotics were continued accordingly till the cultures were negative.
Physiotherapy was instituted from the second postoperative day in the form of quadriceps drill, knee and ankle mobilization exercises depending on the type of fracture and the presence of other injuries. Mobilization was started as soon as the pain permitted; first with non weight bearing crutch support walking, followed by toe touch crutch support walking and then progressive weight bearing depending upon callus formation. The patients were followed up after 2 weeks, 6 weeks, 3 months and then monthly until fracture union occurred. In every follow up the patients were assessed both clinically and radio logically for union, range of motion at knee, instability, any deformity or any other associated complications.
Union was defined as pain-free full weight bearing in the absence of tenderness or mobility at the fracture site with the presence of bridging callus across atleast one cortex of fracture site on each of the anteroposterior and lateral radiological views [12]. Nonunion was defined as absence of progressive fracture healing for three consecutive months extending beyond 6 months from injury [12]. Malunion was defined as step off of the articular surface of 2mm or more on anteroposterior and lateral knee radiographs or malalignment of greater than 5^0 in any plane on full length tibia. A significant loss of knee range of motion was defined as flexion <90deg [22].
The functional evaluation was done based on rating scale given by Rasmussen [23]. The observations and results obtained were subjected to standard statistical analysis using S.P.S.S. software.





Observations and Results

Thirty patients with 30 tibial plateau fractures were included in this prospective study and following observations were made.

A) Age

The patients' average age was 37.48 years ranging from 18 to 68 years. 76% of the cases were in between 21-50 years of age.

Distribution of cases with respect to age

Age group (years)	Number of cases	Percentage (%)
18 – 20	1	3
21 – 30	8	27
31 – 40	8	27
41 – 50	6	20
51 – 60	5	17
61- 70	2	6
Total cases	30	100

B) Sex

There were 23 males and 7 females

C) Laterality of Fracture

There were 15 cases with right sided injury and 15 cases with left sided injury. The ratio of right: left involvement was 1:1

D) Mode of Injury

Mode of injury was road traffic accidents in 22 cases and falls in the rest 8 cases.

F) Injury Surgery Interval

The average interval between injury and surgery was 6.5 days ranging from 1 to 17 days. 66.66% of the cases were operated within first 7 days of injury

G) Associated Injuries

8 cases (26.66%) were associated with multiple injuries. All these patients were successfully resuscitated and operated as soon as their general condition stabilized.

H) Time to Union

The mean time to union was 19.6 weeks (4.6 months) ranging from 16 to 28 weeks? 40% of cases united between 15-19 weeks. Maximum 57% of cases had union in between 20-24 weeks.

Distribution of cases according to time of union

Radiological Union (weeks)	Number of cases	Percentage (%)
15-19	12	40
20-24	17	57
25-29	1	3
Total	25	100

I) Range Of Motion

The overall knee range of motion averaged 134 deg. (range 30-150 deg.) at the last follow up. 93.33% cases had ROM > 90 degree. Only 8% (2 cases) had ROM < 90 degree. One of these cases had associated open fracture of ipsilateral femur which got infected resulting in stiffness at knee and another again had infected implant which required implant removal and external fixator application.

J) Complications

Out of the total 30 cases in the study, deep infection occurred in 3 (10%) cases (all with ORIF technique).

Stiffness and restriction of movements < 90 degree was seen in 2 cases. Screw breakage occured in 1 case.

Minor complications like extensor lag occurred in 1 case (associated with patella fracture) and superior tibiofibular subluxation in 1 case.

Of the total 10 complications, maximum occurred with type B3 fracture (40%) followed by C3 (30%)

K) Functional Grading Score

The results obtained were analyzed as excellent, good, fair and poor according to Rasmussen's criteria.

Based on Rasmussen's functional criteria were recorded [23]:-

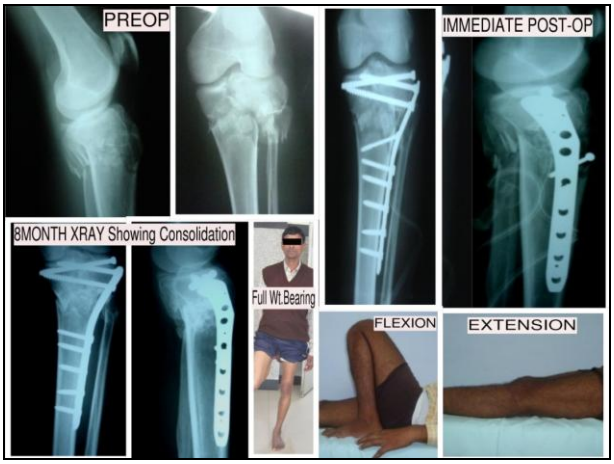
Excellent results in 14 cases (46.66%), Good in 15 cases (50%), fair in 1 case (3.33%)

No poor result.

Results according to functional grade and A.O. classification

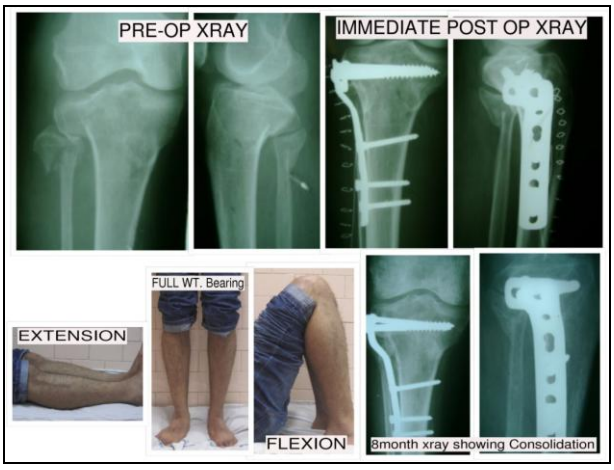
Functional grade	A.O. Type									Number of cases	Percentage (%)
	A1	A2	A3	B1	B2	B3	C1	C2	C3		
Excellent	-	-	3	1	-	3	-	3	4	14	46.66
Good	-	-	-	-	1	4	-	2	8	15	50
Fair	-	-	-	-	-	-	-	1	-	1	3.33
Poor	-	-	-	-	-	-	-	-	-	0	0
Total	-	-	3	1	1	7	-	6	12	30	100

Case 1



Case 2

Case 3



Complications

Discussion

In the present prospective study, 30 cases with 30 tibial plateau fractures were evaluated for the results with locking compression plate using MIPPO and ORIF technique.

The average age in the present study was 37.48 years (ranging from 18 to 68 years). Horesh *et al.* in their study found the average age to be 40.6 years (range from 30 to 70 years) [15]. Lee *et al.* in a similar study found the average age to be 42 years ranging from 18 to 82 years [20]. This reflects that the tibial plateau fracture is common in young adult age group who are involved in outdoor activities.

In our series 23 cases were males and 7 cases were females. The male to female ratio was 3.3:1. Blokker *et al.* in their study on 64 patients had 34 males and 30 females with male to female ratio of 1.13:122. The higher male to female ratio in our study is probably because males are more involved in outdoor activities especially in our Indian scenario: In the present study there was an equal incidence of right and left sided injury. The ratio of right to left leg involvement was 1:1. However study of Ryan *et al.* noted right predominance with right to left leg ratio of 1.4:1 [22].

Occupationally proximal tibia fractures were seen in people with high level of activity, movement and travel. It is most commonly seen with people who travel more like businessmen and agriculturists. In our series majority were businessmen 10 (33.33%) followed by housewives 6 (20%), students 5 (16.66%), agriculturists 4 (13.33%) and labourers 4 (13.33%) respectively. We had maximum number of cases due to road traffic accidents (RTA) (22 cases, 73.33%) followed by falls (8 cases, 26.66%). Lee *et al.* in a similar study reported an incidence rate of 80% due to RTA, 11.4% due to fall from height, 5.8% due to blow, 2.8% due to gunshot injury [20].

In our study out of 30 cases, 12 cases were Type C3 (40%), 7 were Type B3 (23.33%), 6 were Type C2 (20%), 3 were Type A3 (10%), 1 was type B1 (0.33%) and 1 was Type B2 (0.33%) as per A.O. classification. A.O. Types C2, C3 & B3 fractures alone accounted for about 83.33 % of all proximal tibia fractures. Weigel and Marsh [16] in their study on 23 proximal tibia fractures found that A.O. types C2, C3 and B3 accounted for 95.6 % of cases.

In our series 8 cases (26.66%) had associated multiple injuries. Ryan JK *et al.* reported that of 58 tibia plateau fracture patients, thirty nine (67%) suffered from multiple injuries [22]. Blokker *et al.* in their study of 64 patients of tibia plateau fractures found that 26 (40.6%) cases had associated multiple injuries [9].

The above mentioned findings suggest that tibia plateau fractures are often caused by high velocity trauma which is associated with higher incidence of A.O. types C2, C3 and B3 fractures and may or may not be associated with multiple injuries.

In our study the average time interval between injury and surgery was 6.5 days (ranging from 1 to 17 days). 66.66% of cases (20 cases) were operated within first 7 days of injury. Gosling *et al.* in their similar study found average time to surgery was 7.5 days (range 0 to 28 days) [19]. Lee *et al.* found that all patients underwent operation within a mean time of 12 days (range 1 to 30 days) [20]. While Mikulak *et al*, Blokker *et al.* and Stannard *et al.* reported mean delay in surgery of less than 5 days [9, 13]. The delays in surgery in our study have been due to following reasons. A few patients were referred late to our hospital after getting primary treatment outside. Some patients had swelling and abrasions around the knee at the time of presentation; hence surgery was delayed till swelling

subsided and skin condition improved. Early fixation was not possible in polytrauma patients who were unfit for early definitive surgery.

In our study the average time to union was 19.6 weeks (4.6 months) ranging from 16 to 28 weeks. Lee *et al.* in their similar study found average time to healing of the 25 fractures was 4.2 months (range 3 to 7 months) [20]. Ryan *et al.* in their comparative study found that average time to union with locking plate was 6 months (range 3 to 14 months) [22]. Stannard *et al.* in their study found that average time to union was 15.6 weeks [13]. Egol *et al.* in their similar study observed average time to union of 4 months [18]. In other studies where these type of fractures were managed by other methods like external fixation or external fixation with limited internal fixation, the time to union was between 5.76 to 7 months.

In our study the overall knee range of motion averaged 134 deg. (range 30-150 deg) which is comparable to those of Stannard *et al.* (127 deg.) [13] and Cole *et al.* (122 deg.) [17] and was better than that of Lee *et al.* (105 deg.) [20] and Ryan *et al.* (109 deg.) [22]; all of these used LCP as the method of fixation. When we compared range of motions in our study with those of other methods of fixation like external fixation, still our results were significantly better; as determined from the studies by Kumar & Whittle [24], Ryan *et al.* [22], Stamer *et al.* [14]. Who found the knee range of motions to be 103, 103.8, and 107 deg respectively. Even in comparison with open reduction and internal fixation using conventional plate as done by Lachiewicz *et al* [11]. and conservative treatment done by Decoster *et al.* [10]. who found the values to be 110 and 107 deg. respectively, our results were better. We feel that using locked plating for stabilisation gives better results in terms of range of motions.

In our series deep infection occurred in 3 cases (10%) (All with ORIF technique). All of them were treated with debridement followed by antibiotic therapy and infection was resolved in two cases. However one required implant removal and application of external fixator. Although Egol *et al.* reported no infection after locking plate fixation, the 10% prevalence of infection in our study is supported in studies by Stannard *et al.* with a 5.9% rate of infection, Ryan *et al.* with an infection rate of 7% in locking group and Lee *et al.* with deep infection of 8 % [18, 13, 22, 20]. However the deep infection rate is 8-87% after double plating. With external fixator, deep infection and osteomyelitis remain a significant problem with rate of 7-13%. Kumar and Whittle reported only a 7% incidence of deep infection yet had amputation in three of those four patients [24].

In view of the above mentioned infection in 3 cases, knee stiffness resulted in two of them; both related to the prolonged duration of treatment and none because of the tibial procedure.

The less incidence of infection in locking plate using minimum invasive technique is due to aseptic technique, minimum soft tissue handling, small incision and minimal duration of surgery. This gives the method an edge over the open methods where extensive exposure is made and a lot of hardware is used especially in bicondylar fractures.

In our study no case of non-union was found. Although Ryan *et al.* reported 10% of nonunion in locked plating group and Cole *et al.* also reported 2.5% of nonunion but our study is supported by Stannard *et al.* and Lee *et al.* who found no case of nonunion in their study [22, 17, 13, 20].

In our study a single locking screw breakage was noted in 1 case but the fracture united well. The screw breakage may be due to the fact that patient started early weight bearing. Superior tibio-fibular subluxation was observed in one patient without affecting functional outcome of patients. Majority of the complications occurred in A.O. types B3 and C3 fractures reflecting the severe nature of these types of injuries.

Based on functional criteria we recorded excellent results in 14 cases (46.66%), good in 15 cases (50%) and fair result in 1 case (3.33%) with no poor result. Although the series is small but the results are satisfactory and encouraging in 96.66% of patients (excellent in 46.66 % and good in 50 %). The unacceptable result (fair in 3.33%) is seen in A.O. type C2 injury. This patient had associated open fracture of ipsilateral femur which got infected affecting patients mobility and resulting in knee stiffness.

We believed that locking compression plate when used with MIPPO technique combines the beneficial aspect of minimally invasive osteosynthesis with benefits of a fixed angle construct secondary to the locking screw and plate design. The combination of these factors creates an implant that can be used with high energy tibial plateau fractures without supplemental medial fixation and without loss of alignment during fracture healing. Additionally, this technique appears to minimize the risk of infection.

The limitation of the study is the short follow-up period and the limited number of patients.

The combination of a minimally invasive approach and lack of periosteal and soft tissue stripping all are likely to play a role in the successful use of this implant in proximal tibial fractures. The locking plate functioned well in our series of patients, yielding a high union rate, good range of motions, with relatively low complications rates in difficult high energy fractures. Excellent and good functional outcome was noted in most of the patients. Long term follow-up and prospective randomized studies are required to establish the role of LCP in the management of proximal tibial fractures. However based on these result, the LCP by MIPPO or ORIF technique could be implant of choice for the management of these difficult fractures.

Conclusion

Proximal tibia fractures are increasing with the increase in road traffic accidents. Preoperative soft tissue status and their repair at the right time significantly change the outcome. As this injury commonly involves young productive males of the society, it becomes imperative to treat them in a way that they are rehabilitated at the earliest so that they can resume their daily routine in pain free and active way. The principles of locking compression plate facilitates early union and early mobilization of the injured extremity thereby decreasing the morbidity to a large extent. It offers a good choice as an implant for intra-articular and juxta-articular fractures of proximal part of tibia without the need for additional medial stabilization as it provides improved healing rates, restoration of the articular surface, better biomechanical stability, good range of motion, decreased rate of complications (infections, non-union, and stiffness), decreased incidence of reoperation and early rehabilitation.

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