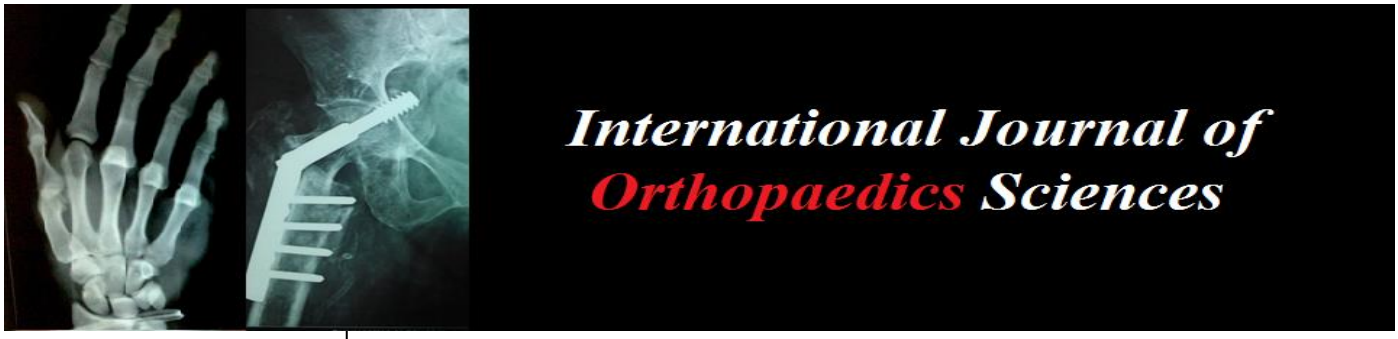

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Functional outcome of locking compression plate in the management of proximal tibia fracture

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Abstract
Background: The proximal tibia 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 where fractures result from direct axial compression, usually with a valgus (more common) or varus movement and indirect shear forces. Proximal tibial fractures present a spectrum of soft tissue and bony injuries that can produce permanent disabilities.
Objective: This study evaluates the effectiveness of LCP (locking compression plate) in the management of proximal tibia fractures based on clinio-radiological assessment.
Methods: It is a prospective observational study with sample size of 30 and all patients having intraarticular and or juxtaarticular fracture of proximal part of tibia, using AO classification system. Post operatively patients were followed up after 2 weeks, 6 weeks and at 3 month then monthly till union.
Results: Fair to good functional results were correlated with associated injury whereas excellent results were obtained with those who did not sustained other associated injury.
Conclusion: locking compression plate offers a good treatment option for intraarticular and juxtaarticular fractures of proximal part of tibia without the need for additional medial stabilization.
Level of evidence: prospective level III follow up study.

Keywords: Proximal tibia fracture, functional outcome, locking compression plate

1. Introduction
The proximal tibial fractures are one of the commonest intra-articular fractures in orthopaedic practice. These injuries are devided into two categories, high energy fractures and low energy fractures. Most of tibial plateau fractures are secondary to high velocity accidents and fall from height [1]. Such injuries usually resulted from a valgus or varus movement and indirect shear forces across the knee [2]. Degree of Soft tissue involvement, bone quality, patient's age, and post traumatic knee stiffness are important contributing factors which influence the functional outcome [3, 4]. While dealing with such fractures our goals of treatment are restoration of joint congruity, equal limb alignment, a stable knee, functional range of knee motion, and union of fracture site [5]. Many of complications like infection, delayed union, loss of reduction may be resulting due to different surgical techniques which impairs the normal blood supply to bone and soft tissue enevelope and thereby impair fracture healing and functional outcome. Role of Conservative management while dealing with these fractures are limited and they are often resulting in malunion, nonunion, rotational deformity, knee stiffness. So there has been great change towards it's treatment modality and hence operative management of these fractures come in a role. Operative modalities include intramedullary implants, simple external fixation, hybrid or thin-wire external fixation, plate fixation including locking compression plate or a combination of all techniques together [6].
Locked plating (LCP) has become popular in recent times and has clear biomechanical advantages when compared with conventional plating. The LCP system combines the principles of conventional plate osteosynthesis with those of internal fixator systems. It uses both of standard screws and locking head screws which achieve fixed angle stability [7]. LCP as an internal fixator is a construct in which the screws (pins/bolts) are locked in the plate

(frame). Forces are transferred from the bone to the fixator across the screwplate threaded connection. Locking the screw in the fixator increases its stability and thus it decreases the risk of reduction loss. Furthermore, the advantage of using LCP also does not jeopardize the blood supply to the bone as no contact between the fixator and the bone is needed. This new technology of internal fixators behaves in a similar way to the external fixator and aims to preserve biology rather than mechanics. When combined with minimally invasive techniques of surgery, it may cause relatively less iatrogenic tissue damage when compared with conventional plating system [8, 9, 10]. These qualities make locked plating system as a new option to surgeons for treating fractures of the proximal tibia.

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

2. Material and Methods

2.1 Source of data

The study was conducted in the Department of Orthopaedics, North DMC Medical College and Hindu Rao Hospital, Delhi between February 2017 to April 2018. Thirty patients with fractures of proximal part of tibia were included in the study.

2.2 Study design: Prospective Observational Study

2.3 Sample size

Thirty patients having intra-articular and or juxta-articular fractures of proximal part of tibia were included in the study using AO classification system.

2.4 Statistical methods applied

Previously researchers have performed studies on functional outcome of tibial plateau fractures fixation by plating. The functional outcome of good to excellent results in these articles ranges between 70 - 95%. Therefore, assuming (p)=80% as the functional outcome with 15% margin of error, the minimum required sample size at 5% level of significance is 27 patients.

Formula used:

$$n = \frac{Z^2_{\alpha/2}\, pq}{d^2}$$

=1.96*1.96*0.80*0.80
(0.15*0.15)
= 27

Where
p is the observed functional outcome
$q = 1 - p$
d is the margin of error
$Z_{\alpha/2}$ is the ordinate of standard normal distribution at α% level of significance

The observations and results obtained were subjected to standard statistical analysis. Descriptive statistics was analyzed with SPSS version 17.0 software. Continuous variables are presented as mean ± SD. Categorical variables are expressed as frequencies and percentages.

Inclusion criteria

1. Patients aged 18 years and above and of either sex
2. Patients with tibial plateau fracture type AO type A3, C1, C2, and C3.
3. Patients who were willing to give consent for the participation in the study
4. Fracture proximal tibia plateau

Exclusion criteria

1. Patients with pathological fractures
2. Patients with compartment syndrome
3. Patients with major medical illness
4. Patients with polytrauma fractures
5. Patients with proximal tibial fractures with neurovascular deficit
6. Patients medically unfit for surgery.

Anterolateral approach was commonly used for reduction and fixation of this fracture except in conditions where medial condyle was severely comminuted or when there was posteromedial plateau fracture, where anteromedial and posteromedial approaches were also used. MIPPO technique was utilized in 11 cases and open reduction and internal fixation in rest 19 cases.

Post operative rehabilitations

Physiotherapy was started from the 2nd postoperative day which consist of static and dynamic quadriceps excercises, knee and ankle mobilization exercises and non weight bearing walking with axillary crutch support once pain subsided and then progressive weight bearing walking depending upon consolidation of callus.

Follow-up visits

The patients were followed up after 2 weeks, 6 weeks, 3 months and then monthly until fracture union occurred (Image 3) In every follow up the patients were assessed clinically and radiologically for union, range of motion at knee, instability, any deformity or any other associated complications. Union was defined as presence of bridging callus across atleast one cortex of fracture site on each of the antero-posterior and lateral radiological views. Nonunion was defined as absence of progressive fracture healing for three consecutive months extending beyond 6 months from injury. 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.

Outcome measures

The clinical assessment and functional evaluation was done based on rating scale given by Rasmussen. This criteria is based on subjective complaints. (Pain and walking capacity) and clinical signs (Extension, total range of knee motion). The radiological assessment was also done. The effectiveness of Locked compression plate in the treatment of proximal tibial fractures was calculated as per Rasmussen score.

3. Results

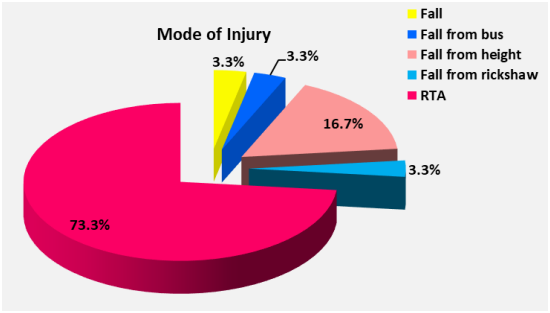

Fig 1: Mode of injury

Table 1: Type of fracture

TOF	Frequency	%
A3	6	20.0%
C1	2	6.7%
C2	10	33.3%
C3	12	40.0%
Total	30	100%

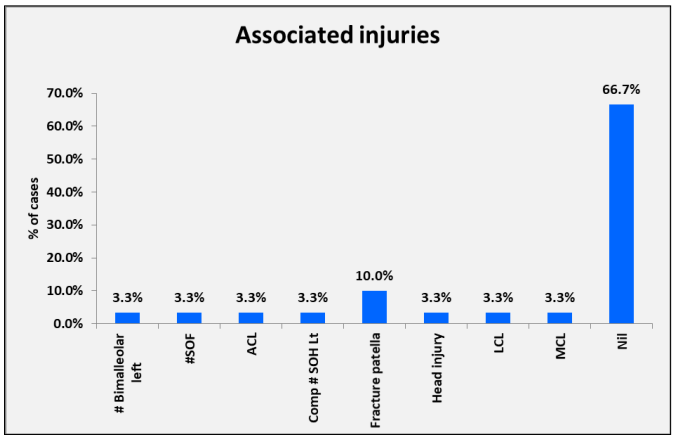

Fig 2: Associated injuries

Table 2: ORIF and MIPPO.

Technique	Frequency	%
MIPPO	10	33.3%
ORIF	20	66.7%
Total	30	100%

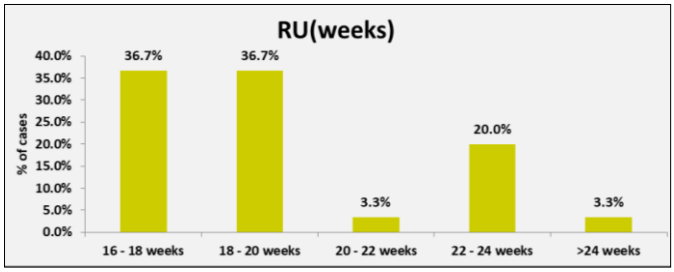

Fig 3: Radiological union (weeks)

Table 3: Radiological union (weeks)

RU (weeks)	Frequency	%
16 - 18 weeks	11	36.7%
18 - 20 weeks	11	36.7%
20 - 22 weeks	1	3.3%
22 - 24 weeks	6	20.0%
>24 weeks	1	3.3%
Total	30	100%
Mean ± SD	19.87 ± 3.24	
Median	20 weeks	
Min - Max	16- 28 weeks	

Table 4: Rasmussen score

Rasmussen score	Frequency	%
10 - 19	4	13.3%
20 - 26	9	30.0%
≥27	17	56.7%
Total	30	100%
Mean ± SD	24.67 ± 4.22	
Median	27	

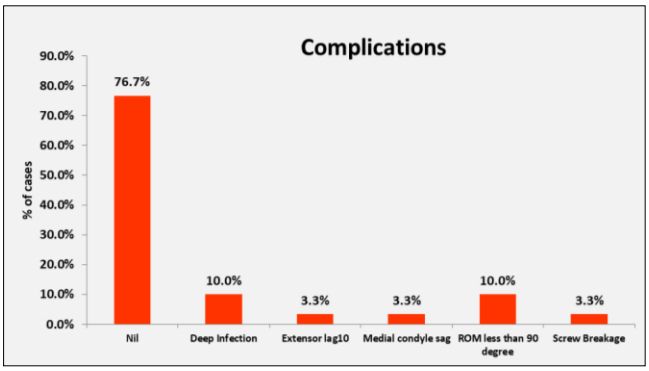

Fig 4: Complications

Table 5: Functional results

Functional Results	Frequency	%
Excellent	16	53.3%
Good	11	36.7%
Fair	3	10.0%
Total	30	100%

Table 6: Correlation of functional results with type of fracture

TOF	Functional Results			p value
	Excellent	Good	Fair	
	n (%)	n (%)	n (%)	
A3	5 (83.3%)	1 (16.7%)	0 (0%)	0.031
C1	2 (16.7%)	0 (0%)	0 (0%)	
C2	5 (50.0%)	1 (20.0%)	3 (30.0%)	
C3	4 (33.3%)	8 (66.7%)	0 (0%)	
Total	16 (53.3%)	11 (36.7%)	3 (10.0%)	

Table 7: Correlation between associated injuries and functional results

Associated Injury	Functional Results			p value
	Excellent	Good	Fair	
	n (%)	n (%)	n (%)	
No	13 (81.3%)	0 (0%)	7 (63.6%)	0.023
Yes	3 (18.8%)	3 (100%)	4 (36.4%)	
Total	16 (100%)	3 (100%)	11 (100%)	

Table 8: Comparison of mean Rasmussen score with associated injuries

Associated Injury	n	Mean Rasmussen score ± SD	Median	Min - Max	p value
No	20	26.05 ± 2.86	27.50	20 - 29	0.038
Yes	10	21.90 ± 5.24	25.50	11 - 27	

4. Discussion

In this study, 30 cases of proximal tibia fractures were evaluated for the results with locking compression plate using MIPPO and ORIF technique. The average mean age in the present study was 40.40 years (ranging from 23 to 68 years). Horesh *et al.* in their study found the average age to be 40.6 years (range from 30 to 70 years). [11] It means proximal tibia fracture is common in young age group. In our study the main mode of injury of the proximal tibial fracture patients is RTA in 73.3% and fall from the height in16.7% of the cases (Fig.1). The study of Kutbe *et al.*, states that the majority of

tibial plateau fractures are caused due to high speed motor vehicle accidents, violent trauma & fall from height [12]. We took cases of proximal tibia fractures according to AO classification. A3 cases being 20%, C1 6.7%, C2 33.3% and C3 40% (Table 1) which is similar to the study of Dankai Wu *et al.* [14] who also took similar cases in the study. Ricci *et al.* [15] also used AO classification In his study A3 Cases were 47%, C2 31.1% and C3 were 21.1%.In our study it was observed that 66.7% of the patients had nil associated injuries while 10% had Fracture Patella and 3.3% of the patients each had fracture bimalleolar of the left side, fracture Shaft of femur, anterior cruciate ligament injury, fracture shaft of humerus Left side, head Injury, LCL and MCL injuries (Fig.2). Ryan JK *et al.* reported that of 58 tibial plateau fracture patients, thirty nine (67%) suffered from multiple injuries [16]. Blokker *et al.* in their study of 64 patients of tibial plateau fractures found that 26 (40.6%) cases had associated multiple injuries. [17] In our study, it was observed that 66.7% had ORIF technique and 33.3% had MIPPO technique (Table 2). In the study of Kutbe S and Mahesh U, MIPPO was used in 24% of cases and ORIF IN 76% of the cases. [12] Further, it was observed that mean RU was 19.87 ± 3.24 weeks and median was 20 weeks (Fig.3, Table 3). 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). [13] In other studies 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. [16, 18, 19] 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 [18], Ryan *et al.* [16], Stamer *et al.* [20] and Sangwan *et al.* [19] who found the knee range of motions to be 103, 103.8, 107 and 107.8 deg respectively. Even in comparison with open reduction and internal fixation using conventional plate as done by Lachiewicz *et al.* [21] and conservative treatment done by Decoster *et al.* [22] who found the values to be 110 and 107 deg. respectively, our results were better. It was observed that 56.7% of the patients had Rasmussen score of ≥27 while 30% had score of 20-26 and 13.3% had score of 10-19. Further, it was observed that mean Rasmussen score was 24.67 ± 4.22 and median score was 27 (Table 4). This suggests that most of our patients had good or excellent results. This is similar to the study by Ramnath DS *et al.* [23] which showed that 90% of the patients had good and excellent results. The mean Score in the study by Arumagam *et al.* [24] was observed to be 22.89. In our study 76.7% of the patients had nil complications, 10% of patients each had deep infection (Fig.4). Egol *et al.* [25] reported no infection after locking plate fixation, the 10% prevalence of infection in our study is supported in studies by Stannard *et. al* [26] with a 5.9% rate of infection, although the deep infection rate is 8-87% after double plating [27,28] With external fixator, deep infection and osteomyelitis remain a significant problem with rate of 7-13% [20, 2]. In our study a single locking screw breakage was noted in 1 case but the fracture united. Majority of the complications occurred in A.O. types C3 fractures reflecting the severe nature of these types of injuries. 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. [13, 16, 26] In our study it was observed that 53.3% of the patients had excellent functional results, 36.7% of patients had good results and 10% had fair results (Table 5). A study by Ramnath DS *et al.* [23] also states that 60% of patients had excellent results, 30% had good results and 10% had fair results. The study by Arumagam *et al.* [24] also showed that 50% had excellent results, 22.22% had good results, 16.67% had fair result and 11.11% had poor result. It was observed in our study that there was a significant difference in distribution of patients for functional results among the various categories of types of fractures (p value of 0.031) (Table 6). The patients with good and fair results were mostly C2 and C3 types or those having associated injuries. Uchida H *et al.* it [29] was observed observed a significant relationship between the type of fracture and the functional results. In our study we also observed that the mean Rasmussen score for associated injuries was 21.90 ± 5.24 (Table 8) and for no associated Injury the mean score was 26.05 ± 2.86. There was significant difference in mean Rasmussen score with associated injuries (p value of 0.038). It was also observed that there was a significant association in distribution of patients for functional results and associated injuries (p value of 0.023) (Table 7). Fair to good functional result was correlated with associated injury and excellent result was correlated with no associated injury. The study by Swaroop *et al.* [30] also states a significant association between multiple associated injuries and the functional outcome. 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 make it an implant of choice to surgeons that can be used with tibial plateau fractures without supplemental medial fixation and without loss of alignment during fracture healing. A minimally invasive approach and lack of periosteal and soft tissue stripping play an important role in the successful use of this implant here. The locking plate functioned well in our series of patients, yielding good range of motions, high union rate with relatively low complications rates.

5. Conclusion

At the end of our study, conclusions could be drawn from the treatment of proximal tibia fractures with locking compression plate as Proximal tibia fractures are increasing with the increase in outdoor avtivities like road traffic injuries. These fractures requires good clinical and radiological assessment and treatment planning. Preoperative soft tissue status and their repair at the right time significantly affects the result outcome. Locking compression plate offers a good treatment option for intra-articular and or juxta-articular fractures of proximal part of tibia without the need for additional medial stabilization as it provides-

1. better healing rates, 2. Restoration of the articular congruity, 3.Better biomechanical stability, 3. Good range of motion, 4 Early rehabilitation, 5.Decreased rate of complications.

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