Original Article | Journal of Clinical Orthopaedics 2024 July-December; 9(2):88-94

Study of Functional Outcome of Intra-articular Proximal Third Tibia Fractures Treated with Locking Compression Plate

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Abstract

Background: The study aimed to provide an estimate of the functional outcome following the use of locking compression plate (LCP) in the management of intra-articular proximal third tibia fractures.

Materials and Methods: A prospective cohort study was carried out on 30 intra-articular proximal third tibia fractures which were operated with LCP fixation between August 2020 and July 2021. Primary outcome measurement was carried out using Rasmussen's functional knee grading criteria.

Results: Functional outcome assessed by Rasmussen's functional knee grading criteria showed Excellent results in 16/30 (53.33%) of patients, good result in 9/30 (30%) of patients (overall 83.33% acceptable results), and fair in 4/30 (13.33%) and poor result in 1/30 (3.33%) of patients. Post-operative complications occurred in eight out of 30 of our patients (26.67%). Open reduction and internal fixation was more commonly used (76.67%) as compared to minimally invasive percutaneous plate osteosynthesis (23.33%). We commonly applied a combined principle of fixation (bridging + compression) across 46.67% of our fracture fixations. Primary surgical approach used was almost equal across our study between medial/posteromedial (53.33%) and anterolateral (46.67%).

Conclusion: We conclude that the LCP system with its various type of fixation act as a good biological fixation including difficult fracture situations. However, this also involves the risk that may occur unless properly planned preoperatively and follow guided principles intraoperatively.

Keywords: Proximal tibia, locking compression plate, Rasmussen functional knee grading criteria.

Introduction

The knee joint is one of the three major weight bearing joints in the lower extremity. Proximal tibial fractures are one of the most common intra-articular fractures around the knee joint. In general, these injuries fall into two broad categories, high-energy fractures and low-energy fractures.

The majority of tibial plateau fractures are secondary to high speed velocity accidents and fall from height [1]. Here, the fractures results from direct axial compression which are usually with a valgus (more common) or varus moment and indirect shear forces [2].

The extra-articular fractures of the proximal tibia occure usually secondary to direct bending forces applied to the metadiaphyseal region of the upper leg. Older patients with osteogenic bone are more likely to sustain depression type fracture due to their subchondral bone being less likely to resist axial directed loads [3].

Complex fractures include significant articular comminution and depression, condylar displacement, metaphyseal fracture extension, and open or closed soft-tissue injuries [2]. Potential complications vary with degree of trauma energy and include soft-tissue injuries requiring coverage procedures, compartment syndrome, peroneal nerve injury, vascular injury, and associated ligaments and meniscal injuries.

There have been many classifications described for tibial

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Submitted Date: 13 Jul 2024, Review Date: 19 Aug 2024, Accepted Date: 16 Sep 2024 & Published Date: 10 Dec 2024

Journal of Clinical Orthopaedics | Available on www.jcorth.com | DOI: https://doi.org/10.13107/jcorth.2024.v09i02.678

plateau fractures. The classification by Hohl and Luck included non-displaced, local-depressed, split-depressed, and splitting fractures and later included comminuted fractures [4]. In 1981, Moore proposed a classification system for tibial condyle that took consideration of soft-tissue injury [5]. However, the most widely accepted classification is the one proposed by Schatzker et al. It is based on fracture pattern and fragment anatomy and includes six categories [6].

Historically, Cooper and Cooper first described the fractures of the proximal tibia in 1825 [7]. Since then various surgeons have adopted their own method of fracture fixation either by conservative measures like early knee traction mobilization for minimally displaced fractures and functional cast bracing, or surgically by open reduction and internal fixation (ORIF). For ORIF of tibial plateau fractures, several methods can be used like unilateral fixation with single plate, dual plating or bicolumnar plating, hybrid external fixator or a less invasive stabilization system (LISS). The literature has plenty of articles enumerating merits and demerits of each of these fixation techniques and as such there is no clear consensus as to which procedure yields the best results. Hence, the ideal fixation method for high energy tibial plateau fractures still remains controversial [8].

The aim of surgical treatment of the proximal tibia fracture is to restore congruent articular surfaces of the tibial condyles thus maintaining the mechanical axis and restoring the ligamentous stability. Eventually, it will achieve functional painless and also good range of motion in the knee joint.

There are various clinical studies which have established that bone beneath a rigid conventional plate becomes thin and atropic and are prone for secondary displacement due to insufficient buttressing and secondary fractures after removal of plate. Fracture site takes longer period to osteosynthesis due to interruption of vascular supply to bone due to soft tissue and periosteal stripping.

Hence, this gave birth to a new concept of biological fixation using the plates, also called as minimally invasive percutaneous plate osteosynthesis (MIPPO). However, this was difficult as conventional plates needed to be accurately contoured to achieve good fixation, and osteoporosis also posed the same problem of poor fixation with conventional plates [4].

This leads to the development of the internal fixators, PC-fix I and later PC-fix II. As more and more concepts about biological fixation become clearer the innovation of plates progressed leading to the development of LISS.

Thus research to combine these two methods has led to the development of the AO locking compression plate (LCP) [5]. This new system has been regarded to be technically mature. It offers numerous fixation possibilities and has also proven to be worth in complex fracture situations and in osteoporosis.

Materials and Methods

The aim of the study was to provide an estimate of the functional outcome following the use of LCP in the management of intra-articular proximal third tibia fractures.

A prospective analytical cohort study was carried out in the Department of Orthopaedics at a Government public hospital in Mumbai from August 2020 to July 2021.

Inclusion criteria

- Adult (18 years and above)
- Closed fracture or Grade I compound fracture
- Patients with recent history of trauma (<3 weeks)
- Patients who are medically fit for surgery
- Patients willing to participate in the study and available for follow-up.

Exclusion criteria

- Grade II and III compound fracture
- Patients with comorbidities
- Patients with age <18 years
- Patients with pathological fractures
- Patients admitted for re-operation
- Patients with existing neurological deficits
- Ongoing chemotherapy or radiotherapy for malignancy
- Patients who are unfit or not given written consent for surgery
- Patients with late presentation (>3 weeks).

Data were collected from patients fulfilling the inclusion and exclusion criteria, coming to our hospital casualty and outpatient department with proximal third tibia fractures, diagnosed on plain X-rays and further confirmed on computed tomography (CT) scans. All patients in the study, presenting with an intra-articular proximal third tibia fracture underwent ORIF with LCP.

Based on the outpatient and casualty registrations in the last 1 year before study initiation, the prevalence of adult patients with proximal tibia fracture was found to be 7% (i.e., 0.07).

Sample size (n) = [(Z2 p*(1-p)]/d2

Confidence level: 95% and Power of study: 80%

P = expected proportion (0.07)

D = marginal error rate (0.1)

Based on this, the sample size was calculated to be: 25

Considering a 20% leeway, a total of 30 patients were enrolled in the study.

All patients reported to the hospital with a history of trauma, swelling in and around the knee and severe pain, and inability to move the knee joint. Primary and secondary surveys were done with recording of the vitals and limb assessed for neurovascular compromise. After the necessary interventions, such as fluids and analgesics, standard anteroposterior, and lateral radiographs were ordered. Most patients underwent a CT scan for better delineation of the fracture lines and to assist in surgical

Figure 1: Anterolateral approach.

Figure 2: Medial/posteromedial approach.

planning. Appropriate splints were given; the patient admitted, and advised limb elevation and ice fomentation in the ward. Selected patients who satisfied all inclusion criteria were then registered, and all history and clinical details were recorded in the history sheet as per the study pro forma.

Surgical procedure

- All patients received intravenous broad-spectrum antibiotic before the operation and for 3–5 days after the surgery followed by oral antibiotics twice daily till suture removal
- Patients were placed in the supine position on radiolucent table with a sandbag under the ipsilateral gluteal region for the anterolateral approach. The sand bag was positioned under the contralateral hip while medial/posteromedial approach was used. Tourniquet was used for all the surgeries
- Anterolateral approach – For this approach, a curvilinear longitudinal incision was made starting from the lateral femoral epicondyle and passing over the Gerdy's tubercle and running parallel to the shin one cm lateral to it. The iliotibial band was elevated from Gerdy's tubercle and the underlying capsule. The knee capsule is incised and submeniscal arthrotomy is done to visualize articular surface. The tibialis anterior was elevated subperiosteally to expose the lateral surface of the lateral tibial condyle and shaft (Fig. 1).
- Medial/posteromedial approach – In this approach, the skin was incised one cm posterior to posteromedial border of proximal tibia curving proximally along the line of pes anserinus tendon. The saphenous vein and nerve were identified and retracted anteriorly. The deep fascia is incised to expose the pes anserinus tendon and medial head of gastrocnemius. The pes anserinus tendon was retracted anteriorly and the medial head of gastrocnemius was retracted laterally to expose posteromedial aspect of proximal tibia (Fig. 2).

Figure 3: Case 1 pre-operative X-rays.

Figure 4: Case 1 post-operative X-rays.

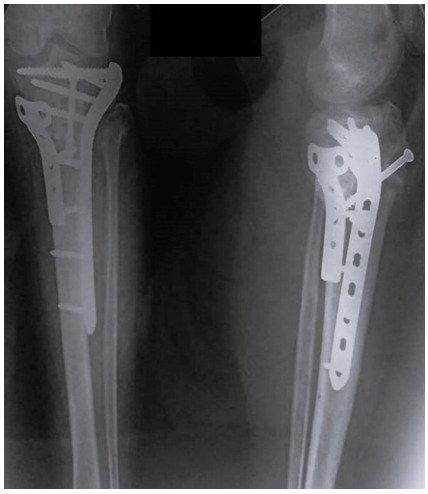

Figure 5: Case 1 post-operative 16 weeks.

Figure 6: Functional outcome at 16 weeks.

Subjective	Points
A. Subjective complaints	
a. Pain	
No pain	6
Occasional pain	5
Constant pain after activity	4
Significant rest pain	0
b. Walking capacity	
Normal walking capacity (in relation to age)	6
Walking outdoors for at least 1 h	4
Short walks outdoors for >15 min	2
Walking indoors only	1
Wheel-chair/bedridden	0
B. Clinical signs	
a. Extension	
Normal	6
Lack of extension (0–10°)	4
Lack of extension > 10°	2
b. Total range of motion	
≥140°	6
≥120°	5
≥90°	4
≥60°	2
≥30°	0
c. Stability	
Normal stability in extension and 20° of flexion	6
Abnormal instability 20° of flexion	5
Instability in extension < 10°	4
Instability in extension > 10°	2
Maximum	30
Excellent	27–30
Good	20–26
Fair	10–19
Poor	<10

Figure 7: Rasmussen's functional knee score.

Postoperatively, care was given to general condition, fluid balance, IV antibiotic and analgesics as per the protocol. This helped us to mobilize patient faster. Whenever stable internal fixation was achieved, the patient was mobilized after 48 h, after removal of drains. For 2–3 days range of motion allowed was 0–20° and from 5th day range of motion was gradually allowed to be increased to 90°. After suture removal, full range of movement was allowed. Whenever, there was doubt about stable fixation. External splinting in the form of plaster of Paris slab was given for support and advised to do static quadriceps exercises. Continue passive motion exercise was done daily with temporarily removal of slab under carefully supervision and splint reapplied. Partial weight bearing delayed until 6 weeks and full weight bearing allowed after 12–16 weeks (Figs. 3-6).

The first follow-up was usually between 6 and 8 weeks and later on patients followed up at regular interval of 6–8 weeks till complete fracture union.

During follow-up

- Clinical and radiological evaluation was carried out
- The course of fracture healing documented radiologically with a minimum 6 weeks interval. The moment of complete healing defined as radiologically complete bone regeneration at the fracture site
- Evaluation of any possible loss of reduction
- Assessment and analysis of any complication
- Grading of our results and functional scoring of the outcome was carried out by Rasmussen's functional knee grading criteria (Fig. 7).

Follow-up of our patients ranged from 16 weeks to 64 weeks.

Results

Baseline measures showed that most of our patients were in the age groups 31–40 (26.67%) and 41–50 (23.33%), with 76.67% of them being males. The patients belonged to a varied occupational background. Laterality of fracture was almost similar across both sides (56.67% and 43.33%). Schatzker Type VI was the most common fracture type encountered in our study (30%) (Table 1).

Operative parameters showed that ORIF was more commonly used in 23/30 (76.67%) of our patients as compared to MIPPO in 7/30 (23.33%) of the patients. We commonly applied a combined principle of fixation (bridging + compression) across 46.67% of our fracture fixations where articular reconstruction was essential and needed protection from collapsing. Compression was used in 6/30 (20%) of our patients where both rigid fixation and buttress effect were needed and bridging principle was used in 10/30 (33.33%) of our patients where the

Table 1: Baseline parameters

1. Age distribution

Age group (year)	Number of patients	Percentage
18–20	4	13.33
21–30	4	13.33
31–40	8	26.67
41–50	7	23.33
51–60	4	13.33
>60	3	10
Total	30	100

2. Sex distribution

Sex	Number of patients	Percentage
Male	23	76.67
Female	7	23.33
Total	30	100

3. The relationship of fracture to different occupations

Occupation	Number of patients	Percentage
Agriculturist	8	26.67
Business	6	20
Housewife	5	16.67
Laborer	7	23.33
Student	4	13.33
Total	30	100

4. Laterality of fracture

Laterality of fracture	Number of patients	Percentage
Right	17	56.67
Left	13	43.33
Total	30	100

5. Type of fracture (Schatzker classification)

Type of fracture	Number of patients	Percentage
I. Pure split	6	20
II. Split with depression	0	-
III. Central depression	0	-
IV. Medial condyle fracture	8	26.67
V. Bicondylar fracture	7	23.33
VI. Metaphysio-diaphyseal dissociation	9	30
Total	30	100

Table 2: Operative parameters

1. Method of reduction and fixation

Method of reduction	Number of patients	Percentage
ORIF	23	76.67
MIPPO	7	23.33
Total	30	100

2. Principle of fixation

Principle	Number of patients	Percentage
Compression	6	20
Bridging	10	33.33
Combined	14	46.67
Total	30	100

3. Surgical approach

Side	Number of patients	Percentage
Medial/Posteromedial	16	53.33
Anterolateral	14	46.67
Total	30	100

ORIF: Open reduction and internal fixation, MIPPO: Minimally invasive plate osteosynthesis

Table 3: Complications

Complications	Number of patients
Knee joint stiffness	3
Post-operative loss of reduction	1
Infection	1
Varus deformity	1
Knee instability	2
Total	8

Table 4: Functional results

Clinical result	No. of cases	Percentage
Excellent	16	53.33
Good	9	30
Fair	4	13.33
Poor	1	3.33
Total	30	100

fracture was extending into the metaphyseal region and due to lack of purchase in the metaphyseal region. Primary surgical approach used was almost equal across our study between medial/posteromedial (53.33%) and anterolateral (46.67%) (Table 2).

Post-operative complications occurred in eight out of 30 of our patients (26.67%), which included knee stiffness in three patients, post-operative loss of fixation in one patient, infection in one patient, varus deformity in one patient, and knee instability in two patients (Table 3).

We had no cases of any purely implant-related complications such as screw loosening, screw breakage, or implant failure. One patient with knee joint stiffness had an associated ipsilateral

inter-condylar fracture of the femur and the other two patients developed knee joint stiffness due to a lack of post-operative mobilization. Two patients had knee instability due to an associated anterior cruciate ligament injury. One patient developed a varus deformity due to post-operative collapse of the medial condyle. In one patient, medial condyle collapse occurred in post-operative period due to toggling of cancellous screw applied to condyle.

One patient developed a deep infection of the operative site. The plate was removed and treated with antibiotic and above knee POP cast applied and the fracture united at 24 weeks.

Average time for union of fracture ranged from around 16 to 24 weeks.

Functional outcome assessed by Rasmussen's functional knee grading criteria showed Excellent results in 16 (53.33%) patients, good result in 9 (30%) patients and fair in 4 (13.33%), and poor result in 1 (3.33%) patients (Table 4).

Discussion

Proximal third tibial fractures are one of the most common intra-articular fractures. The incidence of this fracture is increasing regularly due to road traffic accident (RTA). At the same time, the surgical treatment options for the same are also being modified continuously. Any fracture around the weight bearing joint like knee joint is of paramount importance as it would result in significant morbidity and quality of life.

Hence, it has become a challenge for the orthopedic surgeons to treat the proximal tibial fractures. The innovators thus developed new technologies called MIPPO and LCP system to overcome these difficulties and for early restoration of the strength of bone and function of the knee joint with minimal injury to soft tissue.

Keeping our aims of the study at high, we presented the clinical study of surgical treatment of 30 intra-articular proximal third tibial fractures. We analyzed the results in terms of age of patients and sex distribution. Furthermore, the occupation of the patient, laterality of fracture, mode of violence, analysis of the types, method of reduction and fixation, principle of LCP fixation, surgical approach, and complications were analyzed.

The majority of fracture occur between the age of 18 and 67 years with maximum incidence being involving the productive age group 31–50 years (50%). In our series, majority of the patients were males, around 80%, and this can be attributed to our Indian setup, whereas the female population largely work indoor and does not travel much. Proximal tibial fractures were seen in people with high level of activity, movement and frequent travel, as they are more prone to RTAs such as businessmen and agriculturist. In our series, majority were agriculturists 26.67% followed by laborer 23.33%, businessman 20.00%, housewife 16.67%, and students 13.33%, respectively.

In our study, the most common mode of injury was the RTA, other being fall from height. The right tibia was affected in 57% and the left tibia was affected in 43% of cases. Thus, there was not much difference in the laterality of the fracture.

In this series, we studied 30 cases and of out of them most of the patients fall into Type IV, Type V, and Type VI Schatzker classification. Different criteria are being used by different authors for the surgical management of these fractures. Honkonen [9] conducted 130 tibial plateau fractures taking into consideration of (a) condylar widening of >5 mm; (b) lateral condyle step off >3 mm; and (c) all medial condylar fractures. Burri et al. [10] in 1979 indicated 1 mm of articular depression as their indicative criteria for surgery. Bowes and Hohl [11] and Segal et al. [12] stipulated 5 mm of articular depression as their criteria and Honkonen [9] indicated 3 mm depression as a criterion for surgery. In our series, the indications for surgery were same as the standard indications for tibial plateau fractures – 3 mm depression was considered as an indication for surgery in our series.

We used the MIPPO technique for reduction and fixation in 7 patients (23.33%), wherein both duration of procedure and soft-tissue injuries were less compared to ORIF technique. Wound healing was also better and faster compared to ORIF technique, but it demands more surgical techniques. In our series, we used the combined principle of fixation in 14 patients (46.67%) and achieved good articular reconstruction and protection from collapse during post-operative period. We used bridging type of principle of fixation in 10 patients (33.33%) in metaphyseal comminution fractures and osteoporotic patients. We did not use bone graft in these patient as LCP implant system provide good fixation and prevent collapse of fracture during post-operative period. We used the compression type principle of fixation in 6 patients (20.00%) were both rigid fixation and buttress effect were needed, but postoperatively due to toggling of condylar screws (non-locking screws) there was a collapse of condyle in two patients.

In our series, we approached with medial/posteromedial incision in 16 patients and this approach needed less soft-tissue stripping from bone, can contour plate to bone appropriately, and easy to perform MIPPO technique and we preferred anterolateral approach in 14 patients with lateral condylar displacement fracture and only soft-tissue injury on the medial side of proximal tibia.

We had no cases of any purely implant related complications and average time for union of fracture was around 16–24 weeks.

Three patients developed knee stiffness. One developed due to an associated ipsilateral fracture of the femoral condyle and the other two developed knee joint stiffness due to lack of post-operative mobilization. They were treated with physiotherapy and thus regained a considerable range of motion. One patient developed deep infection by 7th post-operative day secondary to uncontrolled diabetes and skin infection in the thigh region.

He was then treated with IV antibiotics (ceftriaxone and amikacin), implant removal, and above knee pop cast application. Subsequently, infection was controlled and fracture union occurred at end of 24 weeks postoperatively. One patient developed loss of reduction with collapse of medial condyle at end of 8 weeks of post-operative period. It was treated with above knee pop cast for 12 weeks and subsequently fracture united with minimal depression of medial condyle. Another patient developed varus deformity due to collapse of the medial condyle at 9 weeks of post-operative period due to early weight bearing. He was treated with the application of above knee pop cast for 2 weeks and was advised to wear a knee brace while walking. Two patients had associated anterior cruciate ligament injury. They were treated with above knee pop cast till fracture unite and to wear knee support while walking and to undergo ACL repair in subsequent days.

The period of immobilization was again individualized depending on the security of stable fixation. The benefits of early knee motion include reduction of knee stiffness and improved cartilage healing (regeneration) with promotion of good callus formation and remodeling.

In spite of all these complications, we were able to achieve 53.33% excellent results and 30% good results (overall 83.33%, acceptable results) with our standard surgical care. In addition, we have 13.33% fair and 3.33% poor results in term of functional outcome. These results are comparable and on par with other documented standard studies.

Conclusion

At the end of the study, we infer that with the increase in RTAs, the intra-articular proximal third tibial fractures are increasing and these fractures need optimum treatment as most of them involved the productive men. Pre-operative soft-tissue status and their repair should be done at the right time as they significantly change the outcome.

Hence, we conclude that the LCP system with its various types of fixation act as a good biological fixation including difficult fracture situations. However, this also involves the risk that may occur unless properly planned preoperatively and follow guided principles intraoperatively.

Further study on the subject needs to be conducted with a larger sample size and along with a comparison to other standard methods for treatment for a more detailed understanding of the treatment protocol of such injuries.

Clinical relevance

To assess the functional outcome of intra-articular proximal third tibia fractures treated with LCPs using Rasmussen's functional knee grading criteria.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Asif A, Yadav SH, Kumar PG, Bhajandas PBK, Jain A, Panchal LC. Study of Functional Outcome of Intra-articular Proximal Third Tibia Fractures Treated with Locking Compression Plate. Journal of Clinical Orthopaedics July-December 2024;9(2):88-94.