International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2016; 2(4): 368-374

www.orthopaper.com
Received: 27-08-2016
Accepted: 28-09-2016

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A study of tibia plateau fractures treated with locking tibia plate: A study of 63 cases

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DOI: http://dx.doi.org/10.22271/ortho.2016.v2.i4f.57

Abstract
Objectives: To evaluate the results of locking plate system for tibia plateau fractures in Indian population with emphasis on functional outcome, soft tissue complications, rate of infection and time to union.
Introduction: Tibia plateau fractures are resulting from a combination of axial loading with varus or valgus stress. Inadequate and inappropriate treatment may result in significant functional loss. Tibia plateau fractures are difficult lesions to treat because of the involvement of the articular surface, the often occurring comminution, and the precarious condition of the soft tissues, especially following high-energy trauma.
Materials and Methods: A cohort of 63 tibia plateau fractures, surgically treated, from July 2013 to December 2015, was reviewed with a minimum 6 months up to maximum 2 years. Fractures were classified according the Schatzker classification. The assessment of the functional outcome was done with the use of the modified Rasmussen's clinical and radiological score.
Results: According to modified Rasmussen's scoring system, 40% patients had excellent results, 39% had good results, 11% had fair results and 10% had poor results. In our study of 63 patients, 38 were managed by MIPPO reduction, 25 were managed by ORIF. Median age of the patients was 37 years. The average time to union was 12.88 weeks. Infection was seen in 5 cases, Varus deformity in 2 cases, Knee joint stiffness in 3 cases and Implant Failure in 2 cases. Poor results were associated with high energy fractures and inadequate physiotherapy follow-up.
Conclusions: Locking plates especially by MIPPO technique gives excellent results in tibia plateau fractures with minimum complications. Achieving and maintaining anatomical reduction becomes easy with locking plates, which helps in early mobilization and hence obtaining good functional outcome and there is no substitute for early physiotherapy.

Keywords: Tibia plateau, locking plates, MIPPO, modified Rasmussen's score, Schatzker classification

Introduction
Low and high-energy tibial plateau fractures usually result from axial loading in combination with varus/valgus stress forces, present a variety of soft tissue and bony injuries that can produce permanent disabilities and their treatment is often challenged by severe fracture comminution, instability, displacement and extensive soft tissue injuries. These fractures constitute about 8% of all fractures in elderly and 1% overall. In young adults they are the result of high-energy trauma; most commonly road traffic accidents (RTAs) while in the elderly usually follow domestic falls. Potential complications vary with the degree of trauma energy and include open fractures requiring coverage procedures, compartment syndrome and neurovascular injury. Associated injuries include cruciate and collateral ligament injuries and meniscal tears. Complex fractures include significant articular comminution and depression, condylar displacement, metaphyseal fracture extension and open or closed soft tissue injuries. New implants and surgical techniques have provided new options for the treatment of tibial plateau fractures. These include techniques of limited incision reduction for joint surface restoration (MIPPO), low implant profile, improved design matching the periarticular bone surface, percutaneous plates (LISS) and fixed angled plate (that can theoretically resist varus collapse) and screw designs (LCP). Locking plate in bicondylar tibial fractures might be a stable enough fixation when medial condyle is not comminuted and there is no separate posteromedial fragment.

Dual plating is needed in bicondylar tibial plateau fractures with a separate posteromedial segment, complete separation of the entire medial plateau and medial articular comminution. The objectives of surgical management are precise reconstruction of the articular surfaces, stable fragment fixation, normal limb alignment, repair of all concomitant ligamentous and other soft tissue lesions and early mobilization with functional range of knee motion. Despite a plethora of articles, results of various methods of management remains controversial in this view, success of surgical management needs descriptive evaluation. The purpose of this study was to evaluate the outcome of lateral locking plates used in tibia plateau fractures in terms of union, complications and functional outcome of patients.

Aims and Objectives

This study was taken up with the following aims:

- To study the early (minimum 6 months follow-up) results of tibia plateau fractures fixed with locking tibia plate from lateral aspect
- To study the factors affecting the outcome of tibia plateau fractures
- To study fracture patterns and complication rates

Materials and Methods

This study was carried out at Tirtiary Care Hospital Hospital from July 2013 to December 2015, inclusive of both. During this period, 86 patients with proximal tibia fractures were identified of which 74 patients were enrolled in the study based on the inclusion and exclusion criteria. With 11 patients being lost to follow-up during the course of study before completing at least 6 months of follow-up, we had 63 patients remaining to study. Three fractures of type IV Schatzker were fixed with medial buttress and hence were not included in the final analysis.

This study was mainly an observational prospective study. However, data for some patients (n = 31) was collected retrospectively from available medical records. Such patients were followed up prospectively for a minimum of six months post-operative time.

Inclusion Criteria of our study were

- All the fractures of the tibia plateau with intra articular extension, with recent (<4 weeks) history of trauma.
- Closed fractures, open grade I and open grade II fractures were included.

Exclusion Criteria of our study were

- Pathological fractures
- Fractures in children (< 18 years)
- Old neglected fractures
- Pregnant females
- All open grade III fractures
- Crush injuries
- Previously operated Fractures
- Fractures with existing or impending compartment syndrome
- Neurological problems (local or general) which could affect the functional outcome assessment.

Primary & Pre-operative Management

Patients satisfying the selection criteria were identified after emergency management as per ATLS protocol in the casualty. History taking, general examination and local examination were conducted in the trauma care centre. Once stabilized, relevant X-rays were asked for. Fractures were classified according to Schatzker classification. When needed CT scan with or without 3D reconstruction was obtained.

Necessary investigations for surgical fitness were conducted. Closed fractures with edema were splinted and regular calf girth charting was done with oral proteolytic enzymes, intravenous antibiotics and limb elevation. Surgery was done after swelling subsided. The closed fractures were operated as soon as the fitness for anesthesia was obtained. Open fractures were dressed daily after primary thorough debridement. Once the wounds healed surgery was planned.

Surgery

All surgeries were done under image control on plain table for open reduction and on fracture table for MIPPO in supine position.

Decision between Open or MIPPO tibia plating:

The fracture patterns dictated the operative approach. Fractures of type I, II with <5mm of articular depression, V and VI were attempted to be reduced by ligamentotaxis and manipulation on traction table and proceeded with MIPPO if successful. However for articular step fractures irreducible by closed technique, intraoperative decision was taken to convert MIPPO to open reduction. Fractures of type II with >5mm of articular depression, type III and type IV were directly taken for open reduction. Preliminary reduction was done with traction and manipulation under image intensifier before starting the surgical procedure.

Postoperative regime: The patient was immobilized with an above knee posterior slab and care was taken to prevent dependent edema of limb. Intravenous antibiotics were given for first 3 days followed by oral antibiotics in closed fractures. However in open fractures intravenous antibiotics were given till trauma wound showed signs of healing. A post-operative X-ray was advised when the patient could be shifted comfortably, usually after 48 hours of surgery. Depending on the post-operative fracture stability and pain tolerance of the patient, quadriceps strengthening exercises, knee and ankle mobilization exercises and non-weight bearing-crutch walking were started. After suture removal between 10-15th day, the patient was discharged with either partial or non-weight bearing-crutch walking depending upon the stability of the fixation.

Data collection, Follow-up & Evaluation

Data related to demographics, mechanism of injury, details of trauma, hospitalization detail, operation description, post-operative rehabilitation, complications, clinical and functional outcome were collected during the period of hospital stay and follow up visits in the OPD clinic. Follow up was conducted regularly at the interval of 4 weeks. The patients were followed up in the outpatient department. At the time of follow up a thorough clinical evaluation was done for progress of union, healing of trauma wound and joint stiffness. Once the fracture had shown early signs of union, partial weight bearing was started on the injured limb. On follow up the patients were evaluated clinically and radiologically according to Modified Rasmussen's Score.

Statistical Analysis: Descriptive statistical methods and expression of results in terms of mean, chi-square test and others using Microsoft excel software with significant p value <0.05 were used for computation of data.

Results

- A sample size of 63 (51 male, 12 female) patients was selected to evaluate fractures of Tibial plateau treated by locking plate from lateral side using either open reduction (25) or MIPPO (38).
- Majority (47) of the patients were in the age group 31-40 years (Range 18-60 years).
- The predominant cause of trauma was a road traffic accident (76%).
- We had seven cases of open fractures (OG I & II).
- Schatzker classification of fractures showed 7 of type I, 28 of type II, 2 of type III, 3 of type IV and 26 of combined type V & VI.
- 15 patients had associated injuries sustained during trauma which could have directly or indirectly influenced the functional outcome of the patients.
- Preference to MIPPPO was given in deciding the surgical method of fixation which was proved by statistical test. 38 patients underwent MIPPO and 25 underwent open reduction for fracture fixation.
- Most (51) patients were operated within first week of trauma. Average time period from injury to surgery was 4.0 days. The duration of hospital stay was not affected by type of surgical method used.
- 50 fractures united between 16-24 weeks. Average time of union was 12.88 weeks. Open fractures did not obviously show any abnormal delay in union time. Union time appeared independent of the type of surgical procedure.
- We had achieved <5 mm articular step-off in all except one patient, who had reasonably good result at 6 months follow-up. However, 5 patients developed articular depression of >5 mm during follow-up. Articular depression was not significant enough in any patient so as to affect knee range of motion.
- The mean loss of extension was 7.2° and mean flexion was 112.8°. 73% (n=47) had full range of movement at knee joint. 3 patients developed knee stiffness.
- Almost 40% of patients showed progression to Grade I Osteo-arthritis at 6 months of follow-up.
- 45 patients started weight bearing at 8 months of follow-up and 12 patients at 12 weeks. 6 patients required prolonged immobilization.
- Complications were seen in 13 patients. Three patients had joint stiffness but were able to ambulate independently. Implant removal was done in 3 cases. Two patients encountered implant failure due to progressive varus deformity. Infection was not a significant burden in the weightage of complications.
- Rasmussen's criteria showed 25 excellent and 24 Good and 7 fair functional scores. Only 6 patients scored poor on functional outcome. Average functional score was 25.76 and average radiological score was 8.24.
- Excellent results were more commonly seen in closed fractures, type II Schatzker's and fractures treated by MIPPO. By statistical analysis we also concluded that clinical and radiological results may vary in patients treated for tibia plateau fractures.

Table 1

Complication	Patients	Percentage (%)
Infection (Superficial)	2	3.17
Infection (deep)	3	4.76
Knee joint stiffness	3	4.76
Implant Failure	2	3.17
Varus deformity	2	3.17
Limping(due to shortening of limb)	1	1.58
None	50	79.36
Total	63	100

Complication

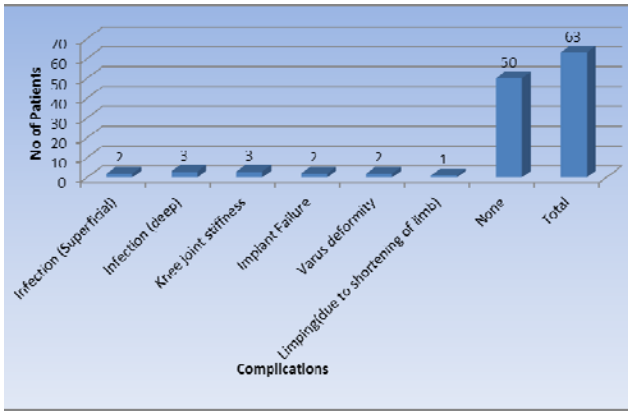
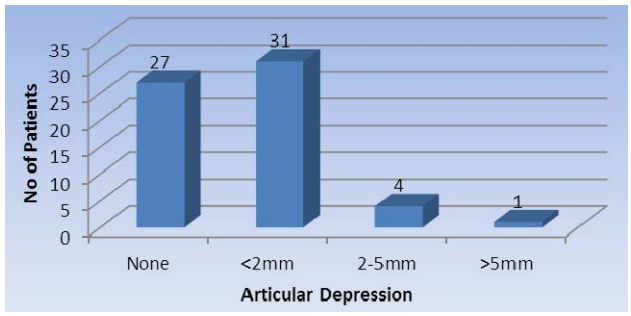


Table 2

Articular Depression	Patients	Percentage (%)
None	27	42.85
<2mm	31	49.21
2-5mm	4	6.35
>5mm	1	1.59
Total	63	100

Articular Depression



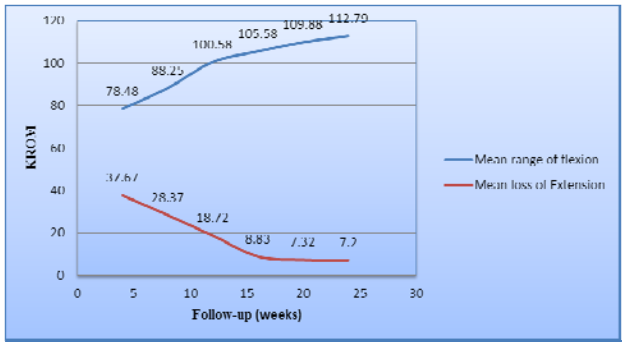
Knee range of Motion

- Mean loss of extension: 7.20° (Range 5-20°).
- Mean knee flexion: 112.79 (Range 10-160°).

Table 3

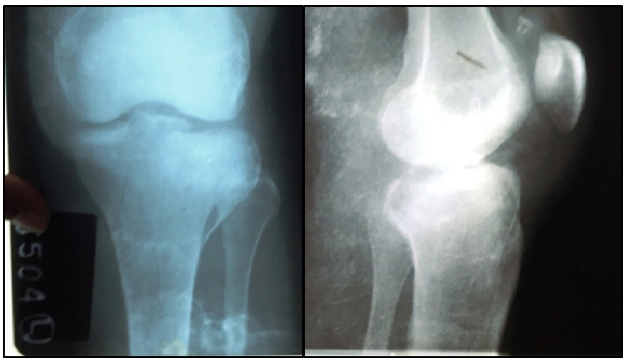
Follow-up (weeks)	Mean loss of Extension	Mean range of flexion
4	37.67	78.48
8	28.37	88.25
12	18.72	100.58
16	8.83	105.58
20	7.32	109.88
24	7.20	112.79

Progression of range of motion following surgery

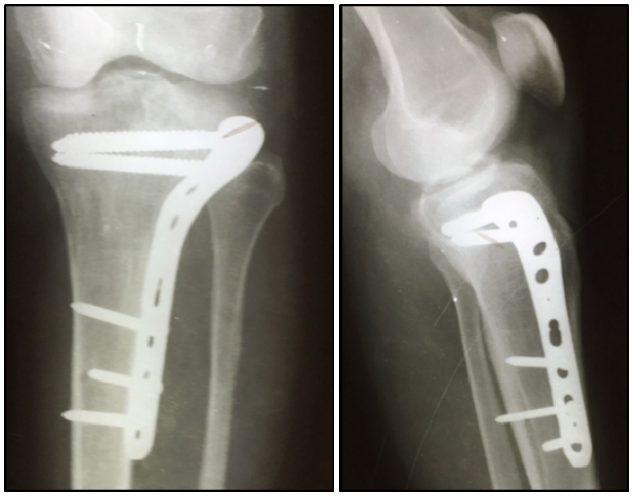


Clinical Photographs

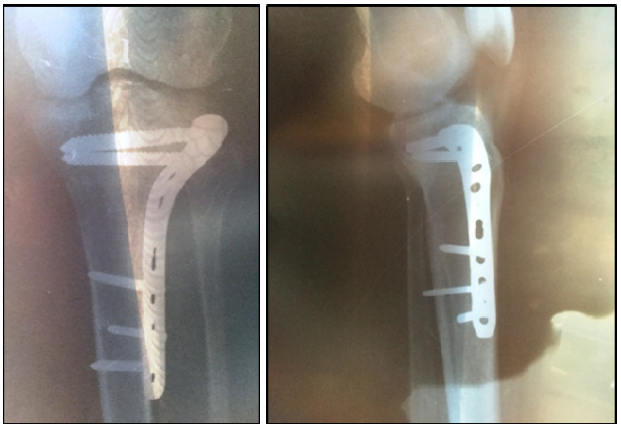
Radiology of the same Patient



Pre-operative AP x-ray Pre-operative Lateral x-ra



Immediate Post-operative AP x-ray Immediate Post-operative Lateral x-ray



6 months follow-up AP x-ray 6 months follow-up Lateral x-ray

Discussion

In this era, high velocity trauma and industrial accidents lead to increased number of tibia plateau fractures. Fractures of the tibia plateau are a cause of ongoing management problems and debate, and remains challenging for orthopaedic surgeons [2]. Fractures of the tibial plateau make up 1% of all the fractures. Published studies have shown that majority of the injuries affect the lateral tibial plateau (55-70%). Isolated medial plateau fractures occur in 10-23% of the cases, while bicondylar lesion is found in 10-30% of reported cases [3]. Our series also showed a similar pattern of fracture distribution.

Fractures of tibia plateau are quite challenging to manage & notoriously difficult to reduce, align and stabilize and are prone to develop wound complications and infections. The spectrum of injuries to the tibia plateau is so variable that no single method has proven uniformly successful. High energy, complex bicondylar tibia plateau fractures, typically present with an associated severe soft-tissue injury. Extensive dissection through this tenuous soft-tissue envelope to achieve reduction and apply of conventional stabilizing implants, particularly through a midline incision, may significantly increase postoperative infection rates and implant failure leading to loss of fracture reduction hindering long-term successful outcome. Prompt diagnosis, thorough pre-operative assessment of the bony and soft tissue trauma [4, 5], adequate soft tissue monitoring and resuscitation, anatomic reduction and sound fixation allowing early joint movement and intensive rehabilitation [6-8] are mandatory for good clinical results [9, 10]. The usefulness of a staged approach and delayed fixation until local conditions are optimized has been documented by authors [11, 12]. Although spanning external fixator was less often used in our series, we could statistically prove that delay in surgery does not affect final outcome.

The implementation of contemporary reduction techniques and novel implants allow the surgeon to attain stable fixation without compromising the surrounding soft tissues. In our study group as well as in other similar studies [13-15] minimally invasive techniques with application of locking plating systems offered the ideal combinations in terms of bone fixation and soft tissue sparing. The advantage of MIPPO plating include biological fixation without extensive soft tissue stripping, earlier mobilization and shorter duration of hospital stay. However, in our series we did not find any statistically significant difference in hospital stay between open reduction and MIPPO. This could partially be attributed to the associated injuries that these patients had and also to the reluctance of the patients to go home without suture removal to avoid transport expenses.

We had no case of non-union in our series. Non-union is rare after low energy fracture, owing to the predominance of cancellous bone and its rich blood supply [16]. It is mostly seen in Schatzker VI at metaphyseal-diaphyseal junction [17]. In our study, analysis showed that time to union was independent of surgical method used. Literature is deficient in examining the union time in relation to the surgical method used. However the average time to union (12.88 weeks) in our study corresponds to published studies in the Indian scenario [18]. Incidence of infection/ wound dehiscence/malunion/early arthritis up to 20-50° esp. in high energy cases [19-27] have been reported. In this series the accumulative rate of local and systemic post-operative complications was 23% (15/63 cases). Infection was observed in 8% cases (n=5). The low incidence of infection in our study can be attributed to the fact that due care was taken to delay surgery in excessive soft tissue swelling, judicious use of MIPPO and avoiding medial incisions.

In 1971, Lucht and Pilgaand [28] stated that good outcome occurred in 78% of their patients even if articular depression was up to 10 mm. Waddell *et al*. [1] found that plateau depression or a widening of less than 10 mm was usually well tolerated. These reports indicated that favorable outcomes are possible for many tibial plateau fractures despite articular incongruities and displacements. Around 10% of our cases had more than 2 mm of depression. Despite this fact functional outcomes were not affected. Using the ANOVA test we could prove beyond doubt that articular depression did not affect the final knee range of motion. A rigid fixation and early physiotherapy reduces post traumatic Osteo-Arthritis. Early ROM physiotherapy shows good results in the form of functional arc of motion.

Numbers of authors [12, 19, 10, 6, 29-31] have reported radiological evidence of Osteo-arthritis in 20-37% 3-7 years post-surgery. In older patients Su *et al*. reported similar degenerative changes in 60% of patients of whom some underwent joint replacement. Our study was confined to a very short term of follow-up but y*et al*most 40% showed progression to Grade I osteoarthritis at six months after surgery.

Rasmussen scoring system as applied to our study showed good to excellent results in around 79% (49) of the patients. 11% (7) had fair and 10% (6) had poor results; whereas Rasmussen's radiological scores did not match the functional scores. Chi-square test for 4*4 table distribution of functional and radiological outcomes did not show any correlation between the two. Duwelins and Connolly [32] reported good results after non-operative or limited surgical approaches and noted that excellent clinical outcomes did not correlate well with the radiographic appearance of the knee. Some bias or error in judgment of radiographs is inherent in these types of studies. Martin *et al* [33] found that when observers make measurements independently of each other their measurements are different from each other by at least 12 mm 10% of the times. We cannot readily rule out objective bias in our radiological assessment. The better functional results in our study may be because of medium energy trauma, early appropriate treatment, young patients in the sample size (average age 37 years), exclusion of OG III fractures and fractures with developed or impending compartment syndrome.

A similar study by Mathur *et al* [34] involving 27 closed tibia plateau fractures treated with conventional plates showed excellent Rasmussen score in 37% and good in 52% of cases. These results are almost similar to that seen in our study. However their patient cohort had mainly low energy fractures with Schatzker type V & VI fractures accounting for 18 % of injuries as compared to 40 % in our group.

This prospective study with some data collected retrospectively has inherent limitations related to its design, the absence of randomisation between different treatment strategies, and the short period of follow-up, as well as in terms of the accuracy and reproducibility of the radiographic measurements. Still there are results in our study which show trends that approach the accepted level of significance. Vast majority of cases were fixed using stable angle plating via MIPPO techniques and others by open reduction. Both techniques provided reasonable method of fracture reduction and stabilization using the lateral locking plate. Closed reduction results in fewer and less serious complications, marginally faster union time and superior clinical outcome.

With the introduction of locking plates, many limitations of conventional plating have been overcome. The angle stable locking screws allow screw fixation of the opposite condyle with a single plate thus avoiding extensive soft tissue dissection [35]. The use of locked plate technology allows the orthopaedic surgeons to manage fractures with indirect reduction techniques while providing stable fracture fixation [36, 37]. Main problem for the treatment split depression fractures where the reason is usually a minor trauma is not infection but secondary loss of reduction due to missing stability of conventional implants, especially in osteoporotic bones [38-44]. Unilateral plate fixation for treatment of bicondylar fractures as well as split depression fracture seems

to offer advantages in particular concerning infection rate and implant failure.

Our own collective consisted of 26 patients with a bicondylar Schatzker type – V & VI tibia plateau fracture. Of these 13 required only a lateral locking plate and 7 others an additional medial supporting screw. All these cases would have required a bilateral conventional double, plate osteosynthesis, if treated without locking plate & screws. No loss of reduction, especially of the contralateral tibia plateau, occurred.

However, Obtaining proper alignment is technically demanding with the Locking plate system. To obtain optimal alignment when using the Locking plate system, it is important to understand that the unique properties of this fixed-angle plate and screw construct affects fracture alignment differently than traditional plating systems. Traditional constructs reduce bone to plate with the tightening of screws where the alignment of the fracture reduction is largely determined by the plate contour. If necessary, traditional plates can be bent to provide satisfactory reduction once bone is reduced to plate. Insertion of fixed-angle screws does not reduce bone to plate with screw tightening. Therefore, because all screws in the Locking plate system are locking screws, satisfactory alignment must be obtained independent of the relative contour of the bone and plate. If the bone is properly aligned without being completely in contact with the plate, then the fixed angle screws should be inserted to maintain this alignment because reducing the bone to the plate with clamps or other instruments will only introduce malalignment. Critical evaluation of the one fracture with implant failure in this series illustrates an important concern when using the Locking plate system.

There are few conditions which require selection of traditional implants. If patient is having a severely comminuted intra-articular fracture component, many authors found that the Locking plate system was not ideal for supporting such comminuted or depressed lateral articular fractures. The system provides two proximal screws that each angle slightly away from the articular surface. This configuration supports the medial side from collapsing into varus, but it is difficult to get these screws proximal enough to support the lateral subchondral bone. In cases that require implants to support the subchondral bone, other implants should be considered.

The indications and uses for locking plate technology continue to be defined. One important problem to avoid is the creation of an over stiff construct by placing locked screws when not needed (more than what is needed). The resultant relative lack of motion at the fracture site can, in some situations, be too stiff to allow fracture healing. This has led some to refer to locking plates as “nonunion generators.” Thus, the indications and correct utilization of locking plates is important to understand so they are not used inappropriately and compromise fracture healing. In addition, newer techniques such as “hybrid” plating (use of both locking and non-locking screws in a single construct) and far cortical locking (obtaining purchase in far cortex while bypassing proximal cortex) have evolved to combat these problems sometimes seen with locking plate.

The outcome of tibia plateau fractures is governed by multiple factors. Based on our study and with support of literature we recommend a staged approach, minimally invasive techniques, use of fixed angle construct that allows early range of motion and restoration of articular congruity for improving the outcome of this fracture. A study with better design, large number of subjects and better level of evidence will further clarify the role of locking plates in tibia plateau fractures.

Conclusion

We conclude that closed reduction and internal fixation with MIPPO technique gives excellent results for displaced fractures belonging to Schatzker Type I. In Type II, Type III, and Type IV. ORIF can be done, but MIPPO technique shows good results. Type V and Type VI can be managed by either MIPPO technique or open reduction and internal fixation with Locking plate with or without bone grafting especially in young individuals who require perfect anatomical reconstruction of the articular surface, stable fixation, early ROM physiotherapy, and rehabilitation which help patient to achieve knee arc of motion in the functional degrees earlier. However aseptic operation technique, surgeons experience in handling soft tissues and patient related factors are important determinants for success of your surgery and post-operative complications. Moreover a large number of subjects and multicentric study is needed to show the strict association.

References

1. Schutz M, Kaab MJ, Haas N. Stabilization of proximal tibial fractures with the LIS-System: early clinical experience in Berlin. Injury. 2003; 34(suppl 1):A30-A35.
2. Raikin S, From son-MI. Combined limited internal fixation with circular frame external fixation of intraarticular tibial fractures; Orthopedics. 1999; 22(11):1019.
3. Hohl M. Part I: Fracture of proximal Tibia and Fibula. Rockwood and Green and Bucholz. Fractures in adults, 3rd Ed, Philadelphia, and JB Lippincott. 1991.
4. Dirschl DR, Dawson PA. Injury severity assessment in tibial plateau fractures. Clin Orthop Relat Res 2004; 423:85-92.
5. Hu YL, Ye FG, Ji AY *et al*. Three-dimensional computed tomography imaging increases the reliability of classification systems for tibial plateau fractures. Injury. 2009; 40:1282-5.
6. Dirschl DR, Del Gaizo D. Staged management of tibial plateau fractures. Am J Orthop (Belle Mead NJ). 2007; 36:12-7.
7. Gaston P, Will EM, Keating JF. Recovery of knee function following fracture of the tibial plateau. J Bone Joint Surg Br. 2005; 87:1233-6.
8. Honkonen SE, Kannus P, Natri A *et al*. Isokinetic performance of the thigh muscles after tibial plateau fractures. Int Orthop. 1997; 21:323-6.
9. Schwartsman R, Brinker MR, Beaver R, Cox DD. Patient self-assessment of tibial plateau fractures in 40 older adults. Am J Orthop (Belle Mead NJ). 1998; 27:512-9.
10. Lachiewicz PF, Funcik T. Factors influencing the results of open reduction and internal fixation of tibial plateau fractures. Clin Orthop Relat Res. 1990, 210-5.
11. Tscherne H, Lobenhoffer P. Tibial plateau fractures. Management and expected results. Clin Orthop Relat Res 1993; 292:87-100.
12. Egol KA, Tejwani NC, Capla EL *et al*. Staged management of high-energy proximal tibia fractures (OTA types 41): the results of a prospective, standardized protocol. J Orthop Trauma. 2005; 19:448-55. Discussion 56.
13. Gosling T, Schandelmaier P, Marti A *et al*. Less invasive stabilization of complex tibial plateau fractures: a biomechanical evaluation of a unilateral locked screw plate and double plating. J Orthop Trauma. 2004; 18:546-51.
14. Krettek C, Gerich T, Miclau T. A minimally invasive

medial approach for proximal tibial fractures. Injury. 2001; 32(Suppl. 1):SA4-13.
15. Musahl V, Tarkin I, Kobbe P *et al*. New trends and techniques in open reduction and internal fixation of fractures of the tibial plateau. J Bone Joint Surg Br. 2009; 91:426-33.
16. Shrestha BK, Bijukachhe B, Rajbhandary T *et al*., Tibial plateau fractures: four years review at B&B Hospital, Kathmandu University Medical Journal. 2004; 2, 4 (8):315-323.
17. Buckle R, Blake R, WAtson JT *et al.* Treatment of Complex Tibial plateau fractures with Ilizarov external fixator. J orthop Trauma. 1993; (7)167.
18. Burri C, Bartzke G, Coldewey J *et al*. Fractures of the tibial plateau. Clin Orthop. 1979; 138:84-93.
19. Canadian Orthopaedic Trauma Society. Open reduction and internal fixation compared with circular fixator application for bicondylar tibial plateau fractures.
20. Ebraheim NA, Sabry FF, Haman SP. Open reduction and internal fixation of 117 tibial plateau fractures. Orthopedics. 2004; 27:1281-7.
21. Gosling T, Schandelmaier P, Muller M *et al*. Single lateral locked screw plating of bicondylar tibial plateau fractures. Clin Orthop Relat Res. 2005; 439:207-14.
22. Hsu CJ, Chang WN, Wong CY. Surgical treatment of tibial plateau fracture in elderly patients. Arch Orthop Trauma Surg. 2001; 121:67-70.
23. Jiang R, Luo CF, Wang MC *et al*. A comparative study of Less Invasive Stabilization System (LISS) fixation and two-incision double plating for the treatment of bicondylar tibial plateau fractures. Knee. 2008; 15:139-43.
24. Mahadeva D, Costa ML, Gaffey A. Open reduction and internal fixation versus hybrid fixation for bicondylar/severe tibial plateau fractures: a systematic review of the literature. Arch Orthop Trauma Surg. 2008; 128:1169-75.
25. Partenheimer A, Gosling T, Muller M *et al*. Management of bicondylar fractures of the tibial plateau with unilateral fixed-angle plate fixation. Unfallchirurg. 2007; 110:675-83.
26. Rademakers MV, Kerkhoffs GM, Sierevelt IN *et al*. Operative treatment of 109 tibial plateau fractures: five- to 27-year follow-up results. J Orthop Trauma. 2007; 21:5-10.
27. Sirkin MS, Bono CM, Reilly MC, Behrens FF. Percutaneous methods of tibial plateau fixation. Clin Orthop Relat Res. 2000; 375:60-8.
28. Lucht U, Pilgaard S. Fractures of the tibial condyles. Acta Orthop Scand. 1971; 42:366-76.
29. Marti RK, Kerkhoffs GM, Rademakers MV. Correction of lateral tibial plateau depression and valgus malunion of the proximal tibia. Oper Orthop Traumatol. 2007; 19:101-13.
30. Rasmussen PS. Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment. J Bone Joint Surg Am. 1973; 55:1331-50.
31. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture. The Toronto experience 1968-1975. Clin Orthop Relat Res. 1979, 94-104.
32. Duwelius PJ, Connolly JF. Closed reduction of tibial plateau fractures. A comparison of functional and roentgenographic end results. Clin Orthop Relat Res. 1988, 116-126.
33. Marsh JL, Weigel DP, Dirschl DR. Tibial plafond fractures. How do these ankles function over time. J Bone Joint Surg Am. 2003; 85A:287-295.
34. Mathur H, Acharya S, Nijhawan VK, Mandal SP. Operative results of closed tibial plateau fractures. Indian J Orthop. 2005; 39(2):108-112.
35. Gosling T, Schandelmaier P, Muller M, Hankemeier S, Wagner M, Krettek C. Single lateral locked screw plating of bicondylar tibial plateau fractures. Clin Orthop Relat Res. 2005; 439:207-14.
36. Moore TM, Patzakis MJ, Harvey JP. Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. J Orthop Trauma. 1987; 1:97-119.
37. Apley AG. Fractures of the lateral tibial condyle treated by skeletal traction and early mobilisation; a review of sixty cases with special reference to the long-term results. J Bone Joint Surg Br. 1956; 38-B:699-708.
38. Blokker CP, Rorabeck CH, Bourne RB. Tibial plateau fractures. An analysis of the results of treatment in 60 patients. Clin Orthop Relat Res. 1984, 193-9.
39. Watson JT. High-energy fractures of the tibial plateau. Orthop Clin North Am. 1994; 25:723-52.
40. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture. The Toronto experience 1968–1975. Clin Orthop Relat Res. 1979; 138:94-104.
41. Jensen DB, Rude C, Duus B, Bjerg-Nielsen A. Tibial plateau fractures. Comparison of conservative and surgical treatment. J Bone Joint Surg Br. 1990; 72:49-52.
42. Lachiewicz PF, Funcik T. Factors influencing the results of open reduction and internal fixation of tibial plateau fractures. Clin Orthop Relat Res. 1990; 259:210-5.
43. Bendayan J, Noblin JD, Freeland AE. Posteromedial second incision to reduce and stabilize a displaced posterior fragment that can occur in Schatzker Type V bicondylar tibial plateau fractures. Orthopedics. 1996; 19:903-4.
44. Dendrinos GK, Kontos S, Katsenis D, Dalas A. Treatment of high-energy tibial plateau fractures by the Ilizarov circular fixator. J Bone Joint Surg Br. 1996; 78:710-7.

Bibliography

1. Rockwood and Green's Fractures in Adults
2. Campbell's Operative Orthopaedics
3. Textbook of Orthopedics and Trauma - GS Kulkarni
4. Apley's System of Orthopaedics and Fractures
5. Turek's Orthopaedics: Principles and Their Application
6. Essential Orthopaedics - J. Maheshwari
7. Chapman's Orthopaedic Surgery - Michael W. Chapman
8. SURGICAL EXPOSURES IN Orthopaedics - The Anatomic Approach
9. BD Chaurasia's Human Anatomy
10. Atlas of Human Anatomy - Frank H. Netter, MD
11. Mercer's Textbook of Orthopaedics And Trauma