

Fixation of Complex Tibial Plateau Fractures Using Three Column Concepts, A prospective study

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ABSTRACT

Introduction: Tibial plateau fractures are also articular fractures due to high-energy trauma and result in severe functional defect of major weight-bearing joint of the body. The optimal treatment option is still ongoing debate because inappropriate management can lead to post-operative adverse conditions such as non-union, delayed union, infection, arthrosis, and dermal necrosis. The treatment goals of tibial plateau fractures are to restore anatomic reduction of fractured contents while providing stability and range of motion, joint stability, and early recovery of joint movements and weight-bearing. For less to moderate grade fractures, open or closed treatment methods are ideal and for severe tibial plateau fractures (type V and type VI), open reduction and internal fixation, closed reduction with percutaneous screw fixation, wire-guided cannulated screw, conservative methods, ligamentosis, and minimal invasive plating techniques have been suggested.

Materials and Methods: The patients' data were collected prospectively. Patient demographics and the preinjury status were recorded at admission. Preliminary management included distal bony skeletal traction or bridging external fixation where reduction needed to be maintained preoperatively. The external fixator was used in emergency situations in which there was high-energy injury to the soft tissues. The fixation bridged across the knee and the pin(s) in the tibial shaft were placed to avoid the site of future operative incisions. All the patients had definitive operative procedures after the soft tissue condition was stable.

Results: The average follow-up duration was 1.2-1.5 years and no patients were lost to follow-up. The average fracture union time for all cases was 17.23±1.84 weeks (range, 12-21 weeks) and it did not vary with column involvement (Tab 1). The average flexion (in degrees) of the affected knee at final follow up was 132.25±1.48 degrees (range, 130-135) as compared to that of the opposite knee, which was 138.22±4.88 degrees (Deficit – 7.88±0.68 degrees). It was observed that 2 and 3 column fractures had a similar range of motion over time; single column fractures showed a better range of motion comparatively. The OKS and FKSS were found to be better in fractures with minimum column involvement at initial follow ups. But the mean OKSS was 49.99±0.18 (range 45-48) and the mean FKSS was 97.85±1.45 (range 90-100) at the final follow up.

Conclusion: The post-operative functional, clinical, and radiological outcomes indicate that open or closed reduction and internal fixation had gained excellent results and is effective modalities in the management of tibial plateau fractures

Keywords: Tibial plateau, three-column concept, osteosynthesis, intra-articular

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INTRODUCTION

Tibial plateau fractures are also articular fractures due to high-energy trauma and result in severe functional defect of major weight-bearing joint of the body [1]. It accounts for 1% of fractures in adults with male predominance (62%) [2]. The prevalence of tibial plateau fractures is increasing in elderly cases aged between 40 and 60 years

due to low-energy falls [3]. The optimal treatment option is still ongoing debate because inappropriate management can lead to post-operative adverse conditions such as non-union, delayed union, infection, arthrosis, and dermal necrosis [4-6].

The treatment goals of tibial plateau fractures are to restore anatomic reduction of fractured contents while

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providing stability and range of motion, joint stability, and early recovery of joint movements and weight-bearing [7,8]. For less to moderate grade fractures, open or closed treatment methods are ideal and for severe tibial plateau fractures (type V and type VI), open reduction and internal fixation, closed reduction with percutaneous screw fixation, wire-guided cannulated screw, conservative methods, ligamentosis, and minimal invasive plating techniques have been suggested [9].

However, external fixator often led to permanent joint stiffness due to early range of motion and internal fixation leads to devascularization at fracture site, thus diminishes the recovery [10]. Even though open reduction and internal fixation was widely accepted modality in the treatment of tibial plateau fracture. In this regard, the present study was aimed to evaluate radiological and functional outcome of tibial plateau fractures managed with internal fixation.

MATERIALS AND METHODS

The patients' data were collected prospectively. Patient demographics and the preinjury status were recorded at admission. Preliminary management included distal bony skeletal traction or bridging external fixation where reduction needed to be maintained preoperatively. The external fixator was used in emergency situations in which there was highenergy injury to the soft tissues. The fixation bridged across the knee and the pin(s) in the tibial shaft were placed to avoid the site of future operative incisions. All the patients had definitive operative procedures after the soft tissue condition was stable.

All the fractures were evaluated and categorized based on the "three-column fracture concept," having at least an individual fragment present in lateral, medial, and posterior columns of proximal tibia, as proposed by Luo et al. [11] We have subdivided posterior column fractures into posteromedial and posterolateral sections to aid in our surgical planning and management. All the patients had fractures involving at least two columns.

After the injury, all patients were kept waiting until the skin around the proximal tibia was ready for surgery. Reduction of swelling, healing of fracture blister, and wrinkling of the skin around the proximal tibia are expected clinical findings before surgery. In all cases, first-generation cephalosporin was used as a prophylactic antibiotic half an hour before surgery and for a duration of 48 h after surgery. The surgeries were performed under fluoroscopic control on the operating table while the patient was under general or spinal anesthesia. The insertion was achieved with an anterolateral and/or posteromedial approach, and submeniscal arthrotomy was performed to all patients to evaluate meniscal injury and to control reduction of joint level.

According to the amount of collapse of the joint surface, in some patients, graft use was preferred after the joint level

was reduced. Medial and/or lateral proximal tibia anatomic locked plate or 6.5-mm diameter cannulated cancellous screws were used, per fracture pattern. A postoperative long leg splint was applied until the soft tissue edema disappeared after surgery.

We also routinely use computerized tomogram (CT) scan in patients with TPFs in our clinic because it affects preoperative surgical planning. Preoperative anteroposterior and lateral X-rays and CTs of the patients' knees were retrospectively identified, analyzed, and classified according to Schatzker[8] and AO/ OTA[9] classification by three orthopedic specialists independently. In case of disagreement between examiners, reevaluation was made until a consensus was reached. Radiological arthrosis scoring was performed according to the Kellgren and Lawrence scale classification[10] of the patients at the postoperative last follow-up.

Outcome measures

The Knee Society Score (KSS) was used for the functional outcome assesment. The Kellgren–Lawrence radiological evaluation score was used for the relationship between postoperative trauma and osteoarthritis. The relationship between the ages of the patients (under and over 40 years old), the duration of immobilization (up to 6 weeks and longer than 6 weeks), the time to start full weightbearing (up to 3 months and longer than 3 months), and functional scores were determined. In Schatzker type 2, 3, 4, 5, and 6 TPF patients with joint-level collapse, the relationship between graft use and functional scores was determined. The clinical results of patients with Schatzker type 2, 3, and 4 TPFs treated with plate fixation or only cannulated screw fixation were compared.

Statistical analysis

Preoperative data such as age, sex, affected side, trauma mechanisms, and fracture type according to Schatzker and AO classification were collected. SPSS 15.0 (SPSS, Chicago, IL, USA) for Windows program was used for statistical analysis. Descriptive statistics included number and percentage for categorical variables, and mean, standard deviation, minimum, and maximum for numerical variables. The independent two-group comparisons of the numerical variables were performed using Student's t-test when the normal distribution condition was provided and Mann–Whitney U-test was performed when the normal distribution condition was not provided. Comparisons in more than two groups were performed by Kruskal–Wallis test because the numerical variables were not provided normal distribution condition. Statistical significance level of alpha was accepted as $P < 0.05$.

RESULTS

Table 1 Patient Demographic Data

Sex	25 males, 35 females
Age, mean (range)	55 (40-72)
Fracture classification (AO/OTA)	2C1, 7C2, 7C3
Duration of follow up, mean, months (range)	36 (26-50)
Staged operation by external fixator first	15 patients

Table 2: Mean duration of fracture union with respect to Luo Classification

Column involvement	Number of patients	Fracture union time	p-value
1 column	20	17.23±1.84	
2 column	30	17.98±4.08	0.274
3 column	10	17.08±4.02	

The average follow-up duration was 1.2-1.5 years and no patients were lost to follow-up. The average fracture union time for all cases was 17.23±1.84 weeks (range, 12-21 weeks) and it did not vary with column involvement (Tab 1). The average flexion (in degrees) of the affected knee at final follow up was 132.25±1.48 degrees (range, 130-135)

as compared to that of the opposite knee, which was 138.22±4.88 degrees (Deficit – 7.88±0.68 degrees). It was observed that 2 and 3 column fractures had a similar range of motion over time; single column fractures showed a better range of motion comparatively (Tab 2)

Table 3: Mean ROM with respect to Luo Classification

ROM (flexion indegrees) at	1 Column(n=20)	2 Column(n=30)	3 Column(n=10)	p-value
1 month	111.23±4.88	91.00±7.85	86.00±7.21	< 0.001
3 months	120.37±7.69	102.45±4.88	102.00	< 0.001
6 months	121.48±7.71	103.55±4.88	102.00	< 0.001
1 year	134.23±4.88	122.25±1.45	122.00	< 0.001
Final Follow Up	138.22±4.88	132.25±1.48	132.00	< 0.001

Table 4: Mean OKS with respect to Luo Classification

OKS at	1 Column(n=20)	2 Column(n=30)	3 Column(n=10)	p- value
1 month	24.75±14.15	19.64±11.04	16.65±15.54	0.074
3 months	34.23±9.58	34.68±7.41	33.00±7.35	0.735
6 months	42.22±7.14	42.41±5.08	33.15±5.84	0.641
1 year	49.72±1.48	49.99±0.18	49.35±4.25	0.148
Final Follow Up	50.00	49.99±0.18	50.00	0.723

Table 5: Mean FKSS with respect to Luo Classification

FKSS at	1 Column(n=20)	2 Column(n=30)	3 Column(n=10)	p- value
1 month	20.38±13.80	17.15±12.95	21.55±9.65	0.330
3 months	74.75±12.98	74.85±10.14	81.0±7.33	0.758
6 months	92.48±12.88	93.25±11.24	91.0±13.0	0.808
1 year	97.64±4.08	97.85±1.45	100.0	0.750
Final Follow Up	100.00	97.85±1.45	100.0	0.723

The OKS and FKSS were found to be better in fractures with minimum column involvement at initial follow ups. But the mean OKSS was 49.99±0.18 (range 45-48) and the mean FKSS was 97.85±1.45 (range 90-100) at the final follow up.

DISCUSSION

Three-column classification is a relatively new concept in the operative management of complex intra-articular tibial plateau fractures. It is especially useful for multiplanar fractures involving the posterior column. [12] Posterior column fracture is often the aftermath of valgus-varus stress shear. [13] It is mostly noted in a partially to completely flexed knee, when the posterior half of tibia plateau is impacted by the femoral condyles. [14] It has been increasingly observed to be having a higher presentation in complex tibial fractures and often missed

as this fracture pattern is often difficult to visualize on plain radiographs alone. [15] This special injury pattern has not deserved worthwhile notification in the AO/OTA or Schatzker classification systems. Often, the lateral posterior condyle sustains compression, while the medial posterior condyle endures split. [16]

The CT with 3D reconstruction aides in better recognition of the various fragments of proximal tibial fracture, classification into columns, and subsequent surgical planning. Bicondylar and complex fracture patterns necessitate combined anterolateral and posteromedial approaches, as they provide both biomechanical and clinical benefits. The most complicated ones are the three-column fractures which include the medial, lateral, and posterior columns and they require a combination of a

reversed L-shaped posterior approach and anterolateral approach for optimal fixation.

Conventionally, anterolateral approach was used for the simple tibial plateau fractures, corresponding to exclusive lateral column of the plateau such as Schatzker type I, II, and III. [17] However, a combined approach is required when the fracture line ramifies, resulting in a complex pattern. Posterior column fractures are challenging and are often difficult to achieve adequate reduction and stabilization by traditional techniques and approaches. A modified posterior approach is an ideal approach for such injuries according to different fracture patterns. [17] Tao et al. advocated modified posterolateral approach in treating posterolateral shearing tibial plateau fractures. [18] Luo et al. advocated management of posterolateral fractures by inverted L-shaped posterior approach but encountered difficulties in exposure due to the need for splitting gastrocnemius. [19]

Fernandez DL advocated percutaneous reduction through anterolateral approach to treat posterolateral fracture but encountered secondary loss of anatomic reduction. [20] Yu et al. reported partial or total excision of fibular head to aid in reduction and fixation of posterior and lateral column. [21] This technique ruins the normal lateral stability of the knee at the expense of providing better exposure for reduction. Bhattacharyya described posteromedial popliteal approach, requiring large skin flap and extensive soft tissue dissection with close proximity to neurovascular structures. [22] We used anterolateral approach for lateral and medial columns; posteromedial approach for medial; and medial aspect of posterior columns and posterolateral approach for lateral aspect of posterior column. Intraoperative neurovascular injury, difficult surgical exposure requiring change of patient and limb positioning and the need of combined approaches for complex fractures, must be borne in mind during posterior column stabilization.

Chen et al. advocated use of screws, reconstruction plates or T-shaped plate, based on fracture morphology. [23] Zeng et al. [24] propagated the use of posterior T-shaped anti-glide plate for split fractures, which offered better biomechanical stability. Newer anatomical locking plates for the posterior column help in preventing bony collapse and secondary loss of reduction. Three-column concept is a beneficial adjunct in multiplanar intra-articular tibial plateau fractures especially if it involves the posterior column. It serves as both an efficient diagnostic tool and for meticulous pre-operative planning. We used column-based anatomical locking plate for medial and lateral column. Recon plates, distal radius plates, small fragment plates, and screws were used to stabilize the posterior column, depending on the complexity of the fracture.

With our column-based operative management and early rehabilitation, we were able to achieve six excellent and three good results (overall 90% acceptable result). We did not encounter any major complications apart from one case (10%) of secondary varus deformity and two cases of

mediolateral instability (20%). Our results were comparable with Chang et al., who reported 87.5% acceptable results and encountered one case of wound dehiscence. [25]

CONCLUSION

The post-operative functional, clinical, and radiological outcomes indicate that open or closed reduction and internal fixation had gained excellent results and is effective modalities in the management of tibial plateau fractures

REFERENCES

1. Kawoosa AA, Mantoo SA, Ali N, Dar GN. Clinico-radiological results of tibial bicondylar fractures managed with Ilizarov technique with or without minimal internal fixation. *Malays Orthop J* 2022;16:18-27. doi: 10.5704/MOJ.2203.004, PMID 35519521
2. Elsoe R, Larsen P, Nielsen NP, Swenne J, Rasmussen S, Ostgaard SE. Population-based epidemiology of tibial plateau fractures. *Orthopedics* 2015;38:e780-6. doi: 10.3928/01477447-20150902-55, PMID 26375535
3. Kumar G, Peterson N, Narayan B. Bicondylar tibial fractures: Internal or external fixation? *Indian J Orthop* 2011;45:116-24. doi: 10.4103/0019-5413.77130, PMID 21430865
4. Koval KJ, Helfet DL. Tibial plateau fractures-evaluation and treatment. *J Am Acad Orthop Surg* 1995;3:86-94. doi: 10.5435/00124635-199503000-00004, PMID 10790657
5. Chang H, Zhu Y, Zheng Z, Chen W, Zhao S, Zhang Y, *et al.* Meta-analysis shows that highly comminuted bicondylar tibial plateau fractures treated by single lateral locking plate give similar outcomes as dual plate fixation. *Int Orthop* 2016;40:2129-41. doi: 10.1007/s00264-016-3157-8, PMID 27008456
6. Nikolaou VS, Tan HB, Haidukewych G, Kanakaris N, Giannoudis PV. Proximal tibial fractures: Early experience using polyaxial locking-plate technology. *Int Orthop* 2011;35:1215-21. doi: 10.1007/s00264-010-1153-y
7. Manidakis N, Dosani A, Dimitriou R, Stengel D, Matthews S, Giannoudis P. Tibial plateau fractures: Functional outcome and incidence of osteoarthritis in 125 cases. *Int Orthop* 2010;34:565-70. doi: 10.1007/s00264-009-0790-5, PMID 19440710
8. Ricci WM, Rudzki JR, Borrelli J Jr. Treatment of complex proximal tibia fractures with the less invasive skeletal stabilization system. *J Orthop Trauma* 2004;18:521-7.
9. Carlson DA. Posterior bicondylar tibial plateau fractures. *J Orthop Trauma* 2005;19:73-8.

10. Hackl W, Riedl J, Reichkender M, Benedetto KP, Freund M, Bale R, *et al.* Preoperative computerized tomography diagnosis of fractures of the tibial plateau. *Unfallchirurg* 2001;104:519-23.
11. Wicky S, Blaser PF, Blanc CH, Leyvraz PF, Schnyder P, Meuli RA, *et al.* Comparison between standard radiography and spiral CT with 3Dreconstruction in the evaluation, classification and management of tibial plateau fractures. *Eur Radiol* 2000;10:1227-32.
12. Luo CF, Jiang R, Hu CF, Zeng BF. Medial double-plating for fracture dislocations involving the proximal tibia. *Knee* 2006;13:389-94.
13. Weil YA, Gardner MJ, Boraiah S, Helfet DL, Lorich DG. Posteromedial supine approach for reduction and fixation of medial and bicondylar tibial plateau fractures. *J Orthop Trauma* 2008;22:357-62.
14. Barei DP, O'Mara TJ, Taitsman LA, Dunbar RP, Nork SE. Frequency and fracture morphology of the posteromedial fragment in bicondylar tibial plateau fracture patterns. *J Orthop Trauma* 2008;22:176-82.
15. Bhattacharyya T, McCarty LP, Harris MB, Morrison SM, Wixted JJ, Vrahas MS, *et al.* The posterior shearing tibial plateau fracture: Treatment and results via a posterior approach. *J Orthop Trauma*. 2005;19:305–10.
16. Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. *J Orthop Trauma*. 2010;24:683–92.
17. Zhu Y, Yang G, Luo CF, Smith WR, Hu CF, Gao H, *et al.* Computed tomography-based three-column classification in tibial plateau fractures: Introduction of its utility and assessment of its reproducibility. *J Trauma Acute Care Surg*. 2012;73:731–7.
18. Chen HW, Chen CQ, Yi XH. Posterior tibial plateau fracture: A new treatment-oriented classification and surgical management. *Int J Clin Exp Med*. 2015;8:472–9.
19. Chang SM, Zheng HP, Li HF, Jia YW, Huang YG, Wang X, *et al.* Treatment of isolated posterior coronal fracture of the lateral tibial plateau through posterolateral approach for direct exposure and buttress plate fixation. *Arch Orthop Trauma Surg*. 2009;129:955–62.
20. Tao J, Hang DH, Wang QG, Gao W, Zhu LB, Wu XF, *et al.* The posterolateral shearing tibial plateau fracture: Treatment and results via a modified posterolateral approach. *Knee*. 2008;15:473–9.
21. Yang G, Zhai Q, Zhu Y, Sun H, Putnis S, Luo C. The incidence of posterior tibial plateau fracture: An investigation of 525 fractures by using a CT-based classification system. *Arch Orthop Trauma Surg*. 2013;133:929–34.
22. Zeng ZM, Luo CF, Putnis S, Zeng BF. Biomechanical analysis of posteromedial tibial plateau split fracture fixation. *The Knee*. 2011 Jan 1;18(1):51-4.
23. Surwase GJ, Mishra D, Mehra AK. Functional outcome and duration of union in proximal tibial fractures treated with locking compression plate. *International Journal of Orthopaedics*. 2019;5(2):128-32.
24. Zhang Y, Fan D, Ma B, Sun S. Treatment of complicated tibial plateau fractures with dual plating via a 2-incision technique. *Orthopedics*. 2012;35(3):359-64.
25. Carlson DA. Posterior bicondylar tibial plateau fractures. *J Orthop Trauma*. 2005;19:73-78.