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Clinico-Radiological Outcome of Bicondylar Tibial Plateau Fracture Treated with Dual Incision and Dual Pre-contoured Locking Plate: A Prospective Study

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Abstract: ***High energy tibial plateau fractures remain a challenge to orthopaedic surgeons, with the Schatzker's type-V (bicondylar) and the Schatzker's type-VI fracture being the most difficult to treat. Bicondylar fracture account for 10 to 30% of all tibial plateau fracture with a significant number of perioperative complications.[3-6] There is a controversy regarding a number of issue pertaining to the management of this fracture, including classifications, surgical approach and method of fixation. Early management of these fracture are critical for minimizing patient disability and reducing the risk of complication. The purpose of this study is to compare the long term functional, clinical and radiological outcome of bicondylar tibial plateau fracture. Materials and Methods: A prospective study was carried out from September 2015 to October 2017. We studied 32 patient bicondylar tibial plateau fracture and each patient were treated with dual incision and dual pre-contoured locking plate. The patient was followed up for minimum of 18 months. The final outcome was assessed using modified Rasmussen's clinical and radiological criteria. Results: The modified Rasmussen's functional outcome at the final follow up (18 months) was excellent in 15 (46.9%) patient, good in 12 (37.5%) , fair in 4 (12.5%) and poor in 1 (3.1%) patient. The average Rasmussen's functional score was 26.7 (range, 19 – 30). Discussion & conclusion: Osteosynthesis in bicondylar tibial plateau fractures in adults is a challenge to every orthopaedic surgeon. Though there are number of implants and surgical techniques to address the problem, the surgical treatment of tibial plateau fracture remain controversial. We recommend to fix the bicondylar tibial plateau fracture with dual incision and dual pre-contoured locking plate as it provide good surgical exposure, minimal soft tissue complications rate, reasonable amount of stability, acceptable alignment of articular congruity, reasonable time to union and allow early range of motion of knee & early weight bearing with good functional***

Keywords: Bicondylar tibial plateau fracture, Schatzker classification, modified Rasmussen's criteria, dual incision technique with dual pre-contoured locking plate.

1. Introduction

High energy tibial plateau fractures remain a challenge to orthopaedic surgeons, with the Schatzker's type-V (bicondylar) and the Schatzker's type-VI fracture being the most difficult to treat[1]. Bicondylar fracture account for 10 to 30% of all tibial plateau fracture with a significant number of perioperative complications [2,3-6]. There is a controversy regarding a number of issue pertaining to the management of this fracture, including classifications, surgical approach and method of fixation.

Both the AO (Arbeitsgemeinschaft für Osteosynthesefragen) and Schatzker's classifications (Figure 9 & 10) are widely used, but shows suboptimal reliability as both classifications are based on X-ray imaging only. Various studies have shown that computer tomography (CT) and especially spiral CT (SCT) with 3-dimensional (3D) reconstruction substantially improved the reliability of both classifications and treatment planning in complex tibial plateau fracture [7-9].

Luo et al proposed a CT based classification of "three-column fixation" concept (by using a column-specific fixation technique) in treating complex tibial plateau fractures, which is especially useful for multi-planar fractures involving the posterior column. The combination of posterior and anterolateral approaches is a safe and effective way to have direct reduction and satisfactory fixation for such difficult tibial plateau fractures [10,11]. Chang et al classified the tibial articular plateau into four quadrant and fractures are classified as isolated or combination of quadrants [12,13].

The goal of treatment in bicondylar tibial plateau fracture is anatomical reduction of articular surface, restoration of axial alignment and early joint motion. Degree of soft tissue injury is an important factor in deciding the timing of surgery and approach [14]. Various treatment methods have been described by various authors, each with its own merits and demerits [15]. Among them, double buttress plating technique gains the greatest popularity because of its advantages in diminishing the risks of articular incongruence, malalignment of mechanical load axis, and posttraumatic degenerative joint disease [16].

However, the traditional technique of open reduction and dual plating through a single midline incision needs extensive soft tissue stripping and has high incidence of wound

complications [17,18]. Due to these, dual plating via two incision i:e posteromedial and anterolateral incision has received support from many authors because it allow direct visualisation of the articular reduction with less amount of soft tissue stripping and complications[19,20]. Although external fixation techniques have been shown to treat high-energy tibial plateau fractures with severe soft tissue injuries effectively [21,22]. It provides adequate stable fixation with advantage of minimal soft tissue compromise [23,24].

LISS (Less Invasive Stabilisation System) allows insertion of plates through a smaller incision, minimising soft tissue damage and it also provides angular stability. LISS is used as single lateral plate to fix bicondylar tibial plateau fracture, thus avoiding medial soft tissue stripping [25,26]. But Gosling et al reported high incidence of mal-reduction and loss of reduction when LISS is used to fix bicondylar tibial plateau fracture [27].

Barei et al has demonstrated presence of posteromedial split fragment in 33% of bicondylar tibial plateau fracture. Posteromedial incision is probably the best approach for the fixation of this posteriomedial split fragmen[28]. Chang SM et al used posteromedial approach with an inverted 'L' shaped incision and anterolateral approach to fix four quadrant tibial plateau fracture. Posteromedial plate is usually an antiglide plate [13].

The effective management of subchondral voids following the successful elevation of depressed plateau fragments remains particularly challenging and controversial. Historically and probably still, the gold standard treatment is cancellous autograft harvest from iliac crest [29,30]. However, it is associated with major and minor complication of 9% and 21% respectively [31]. The cancellous autograft harvest has questionable cellular population, biological quality, and structural strength particularly in elderly, which has led to development of bone substitute as alternative option [32].

2. Materials and Methods

A prospective study was conducted in the department of Orthopaedics, regional Institute of Medical Sciences (RIMS), Imphal, Manipur, India from September 2015 to October 2017 after taking Ethical approval from RIMS- IEC before starting the study. The patients with bicondyalr tibial plateau fracture who attended Orthopaedics department and fulfilled the inclusion criteria where treated with dual incision and dual pre-contoured locking plate. Thirty two patients participated in the study. The final outcome was assessed using modified Rasmussen's criteria [33] and results were analyzed by SPSS IBM Inc.

Inclusion criteria

1) Closed bicondylar tibial plateau fracture, Schatzker's type V or OA/OTA type c.
2) All adult patients aged 18-65 years, irrespective of sex.
3) Age of the fracture should be within 12 days of injury at the time of operation.
4) Soft tissue injury of Tscherne grade 0, I or II.
5) Gustilo – Anderson type I and II open fracture.

Exclusion criteria

1) Patients under 18 years and above 65 years of age.
2) Pathological fractures.
3) Patients with severe head injury and distal neurovascular deficit.
4) Patients with delay surgery (>12 day).
5) Medically unfit patient
6) Loss for follow up.

Operative technique

The patients were operated under spinal or general anaesthesia. Patient were placed in the supine position and affected limb was prepared with 10% betadine solution & draped . A tourniquet was applied at the thigh and kept for a maximum of one and half hours. If the surgery took more than this, it was completed without tourniquet.

A straight posteromedial incision was given 1 cm posterior and parallel to the posteromedial edge of tibial metaphysis. Proximally it was extended upto popliteal crease, if the pattern of fracture has posterior fragment, incision was extended laterally along the popliteal crease to form an inverted 'L' shaped incision. Then the dissection is carried out in the interval between the medial head of gastrocnemius and pes-anserines anteriorly. The pes -tendons was mobilized anteriorly and proximally keeping their tendon intact. The medial head of gastrocnemius muscle was then elevated and retracted posteriorly and laterally, exposing the posterior proximal tibia. If the fracture had more posterior fragment, popliteus and flexor digitorum longus was elevated from the posterior surface of tibia and retracted along with soleus and neurovascular bundle. For the posteromedial split fracture, inferior 'V' shaped cortical spike was reduced anatomically under direct visualizations and fixed with preliminary k-wire. The fragment was then fixed with appropriate pre-contoured LCP in antiglide fashion, usually with four to six 3.5 mm cortical screw and position of screw was confirmed under IITV guidance. First screw was non-locking and distal to fracture.

For anterolateral approach, a curvilinear longitudinal incision was given, starting from the lateral femoral epicondyle and passing over the gerdy's tubercle and running parallel to the shin and 2 cm lateral to it. Width of longitudinal strip of skin between this incision and previous incision was maintained preferably at least 7cm to prevent the detachment of this skin flap from the deeper tissue. Iliotibial band and tibialis anterior origin was elevated closed to bone to exposed anterolateral aspect of lateral condyle of tibia upto the fibular head. Submeniscal exposure of articular surface was done through a transverse incision. A stay sutures were passed through the meniscus. Broken lateral cortex was elevated to enhance the exposure, depressed fracture surface was elevated and fixed with k-wire. When the tibial cortex was intact, a hole was made using triple reamer of DHS and depression was elevated using curved bone impactor. If the patient had a posterolateral split and/or depression fracture, we tried indirect reduction and where necessary anterior wedge shaped osteotomy was performed and artificial sagittal cleavage was created leading to posterolateral fragment. In patient with sagittal fracture line affecting the anterolateral

plateau, the anterolateral fragment was hinged back on its soft tissue attachment and impacted posterolateral articular surface was approached. Iliac crest bone graft or bone graft substitute were used to maintain the reduction and correct the residual depression of the plateau. The anterolateral plateau was then reduced using pointed reduction clamp to re-establish the contour of the anterior cortex and congruity of the articular surface. Reduction of displaced fragment was maintained with temporary k-wire. The position of the k-wire and articular reduction was confirmed using the IITV guidance. Then pre-contoured anatomic anterolateral proximal tibial locking plate was applied First fixation was done with cancellous screw going close to subchondral bone and most posterior was placed first; otherwise, it could not be visualize on IITV. Reduction was checked with IITV, when needed. Wound was closed in layers with negative suction drain and posterior above knee slab was applied.

Figure 1: Posteromedial incision

Figure 2: Pre-contoured posteromedial tibial plate fixation

Figure 3: Anterolateral incision

Figure 4: Pre-contoured anatomic anterolateral tibial plate fixation

Figure 5: Wound closure with negative suction drain

3. Results

The patients were prospectively recruited over 24 months of study period. A total of 38 patients were met with inclusion criteria. Of these, 32 patients agreed to participate and underwent surgical treatment with dual plating through dual incision. The final outcome was assessed using modified Rasmussen's criteria [33]. There was no loss to follow–up. The data collected were analyzed using SPSS IBM INC.

The following results and observation were made at the end of study. Out of 32 patient, there were 24 male (75%) and 8 (25%) female in the present study. The average age of patients was 35.9 years (range, 18-60 years). RTA was the most common mode of injury accounting for 20 (63%) cases followed by fall from height in 10 (31%) cases and sports injury in 2 (6%) cases. Type-I open fracture was found in 5 (16%) cases and 2 (6%) cases were of type-II open fracture. 59% of patients had left sided affection whereas the remaining 41% of the patient had right sided fracture. The mean duration between the time of injutry to surgery was 6.03 days ranging from 2 – 12 days and the average duration of surgery was 121.8 minute (Range, 100 – 200 minutes). The mean duration of hospital stay was 16.1 days. We did MRI and CT scan with 3D reconstruction in every patient to check for associated injury. There was 2 (6.3%) case of MCL injury, 1 (3.1%) case of LCL injury, 1 (3.1%) case of partial ACL tear, 4 (12.5%) case of fibula fracture and 1(3.1%) case of vascular injury (popliteal artery). The mean duration of union was 16.9 weeks (range 10 – 28 weeks)**.** Of 32 patients, 20 (62.5 %) patient did not have pain, 11 (34.4%) patient had occasional pain and Only 1 (3.1%) patient had stabbing pain on prolonged squatting during the follow-up period. The average pain score was 5.56. The average range of motion at final follow up was 128.75° (Range 90 - 140°). At the final follow-up, the articular reduction was anatomic in 24 (75%) patient, 5 (15.6%) patient had articular depression of < 2 mm and another 3 (9.4%) patient had articular depression of 2 mm. The mean medial proximal tibial angle was 87.0° with standard deviation of ± 2.5° (range, 83.3° - 94°). The mean posterior proximal tibial angle was 8.2° with the standard deviation of ± 2.4° (range, 4.9° - 13.3°).

Of 32 patient, Rasmussen's functional outcome at the final follow up (18 months) was excellent in 15 (46.9%) patient, good in 12 (37.5%) , fair in 4 (12.5%) and poor in 1 (3.1%) patient. The average Rasmussen's functional score was 26.7 (range, 19 – 30). The Rasmussen's radiological outcome was excellent in 8 (25%) patient, good in 20 (62.5%), fair in 3

(9.4%) and poor in 1 (3.1%) case. The average Rasmussen's radiological score was 7.9 (range, 4 -10)

Of 32 patient, 1 (3.1%) had mild degree of valgus deformity, 1 (3.1%) patient developed osteoarthroses and 3 (9.4%) patient suffered from infection with wound breakdown.

Table 1: Patient demographic and fracture details

Details	*Number (%)*
Age (years)	35.9 (range, 18-60)
Gender	Male 24 (75%), Female 8 (25%)
Side	Left 59%, Right 41%
Nature of fracture	Closed Fracture 25, type-I open 5, Type-II open 2

Table 2: Surgical details of cases

Details	*Number (%)*
Average time to surgery	6.03 days (range, 2-12 days
Mean operating time (minute)	121.8 (100-200)
Mean duration of hospital stay (days)	16.1

Table 3: Follow-up clinical details of cases

Details	*Number (%)*
Mean ROM	128.75° (range, 90°-140°)
Mean time of union (weeks)	16.9 (range, 10-28)
Mean MPTA	87.0°±2.5°
Mean PPTA	8.2°±2.4

Table 4: Modified Rasmussen's Functional score [33]

Grade	*Number*	*%*
Excellent	15	46.9
Good	12	37.5
Fair	4	12.5
Poor	1	3.1

Figure 6: Pre-operative plain X-ray

Figure 7: Pre-operative 3D-CT scan

Figure 8: Post-operative plain X-ray

Figure 9: Follow-up assessment of knee showing extesion

Figure 10: Follow-up assessment of knee showing flexion

4. Discussions

The tibial plateau fractures are increasing day by day due to ever increasing road traffic accident. At the same time surgical treatment options are being modified continuously. Any fracture around the knee joint is of paramount importance as it would result in significant morbidity in the quality of life. Hence the treatment of such type of fracture has become a challenge for the orthopaedic surgeons

In our present study, the majority of the patients were males (75%) and most of them were in the age group of 25 – 45 years (62%) with the mean age of 35.9 years. This can be attributed to more incidence of RTA due to high level of activity, movement, and travel in the male patient. In our study, 19 (59%) patient had fracture on left side and 13 (41%) patients had right sided affection.

The Road traffic accident (motor vehicle accident and pedestrian struck by motor vehicle) is the most common mode of injury in tibial plateau fracture. In our present study, RTA account 63% of cases, followed by fall from height in 31 % and 6% in sports injury. Zala K et al [43] studied 24 patients, of which 75% injuries were due to road traffic accident. Lee et al [38] in their study of 45 cases found that 38 (84%) patient had bicondylar tibial plateau fracture due to

road traffic accident and 7 (16%) case due to fall. Nabil A et al [33] noted the mode of injury were RTA in 66 (56%) cases, 41 (35%) fall from height and 10 (9%) were due to sports related injury.

The tibial plateau fracture is a high velocity trauma and usually associated with significant soft tissue injury which demands the surgeon to delay surgery to have a well planned and precise preoperative surgical strategy to restore the joint with minimal additional soft tissue injury. The mean interval between injury and operation in our present study was 6.03 days ranging from 2 – 12 days. In our study, 11 cases were operated within 4 days, 17 cases between 5 - 8 days after soft tissue swelling & blisters were resolved and 4 cases with open fracture (Gustilo & Anderson type I in 2 and Type II in 2 case) who underwent primary debridement with wound closure at the time of injury were operated with secondary definitive treatment between 9 - 12 days after infections was controlled and wound healed. Ozkaya U et al [42] reported the mean interval between injury and operation was 4.2 days (range 0 – 10 days). Lee TC et al [45] operated 15 patient between 0 – 16 days with an average predefined surgery stay was 5.3 days.

In our study, the average duration of surgery was 149.9 min (ranged 100 – 200 min). Zhai Q et al [41] reported the range of operating time between 120–210 minute with mean operating time of 149.2 minute. In Z Yu et al [36], the duration of surgery was between 100 – 270 with mean operating time of 158.4 minute.

In our study, the mean durations of hospital stay was 16.1 days ranging from 12 – 28 day. Only one patient with deep soft tissue infection and wound break down was observed and managed till postoperative day 28 with re-debridement, dressing and intravenous antibiotic, infection was controlled & wound healed. In the study of Lee TC et al [45], the average hospital stay was 14 days with range of 7– 30 days. In the study of Chang SM [40], the mean duration of hospital stay was 29±8.6 days with a range of 20 – 41 days.

The tibial plateau fracture is always associated with significant ligamentous and soft tissue injury which require serious attention from the surgeon. We did MRI and CT scan with 3D reconstruction in every patient to check for associated injury. In our present study, partial tear of MCL were seen in 2 cases and 1 case of LCL injury which were repaired intra-operatively. There was 1 case of partial ACL tear and 4 cases of proximal fibula fracture which were managed conservatively and 1 case of popliteal artery injury which was managed along with vascular surgeon. Khatri K et al [46] found associated ipsilateral knee ligament and meniscal injury in 8 (12.3%) patient (3 medial collateral injury, 1 lateral meniscus injury with medial collateral injury, 2 ACL injury & 1 PCL injury). The injury was managed conservatively. In the study of Prasad et al [15], 2 patients had popliteal artery injury, common peroneal nerve injury was in 1 case, 10 case of collateral ligament strain, 2 case of tibial tuberosity avulsion, 1 case of impending compartment syndrome, 3 case of other bone fracture.

We achieved 100% union between 10 - 28 weeks with the average time of union was 16.9 weeks. This is comparable with the other standard studies. Yu Z et al [36] achieved 100 % union rate with mean time of union was 15.4 weeks (range, 12 – 30 weeks). In the study of Ebrahim GH et al [34], the average time to union was 15 weeks (range, 12 – 23 weeks). Prasad et al [15] achieved union in all the cases between 8 – 22 weeks with the average time of union was 14 weeks.

In our study, the average range of motion was 128.75° (range, 90° - 140°) which is comparable with other standard studies. In the study of Prasad et al [15], the mean range of motion was 128.5° (range, 120° - 135°). Zhai Q et al [41] also reported range of motion between 105° - 140° with a mean of 123.3°. Z Yu et al [36] noted range of motion between 85° - 130° with the average ROM of knee was 107.6°.

In the present study, we achieved anatomic reduction of articular surface in 24 (75%) patient whereas in 8 (25%) patient there was slight loss of articular reduction of < 5 mm during the course of follow up period (5 patient had step off of < 2mm and 3 patient had step off of 2mm). Of these, 5 patients with articular step off of < 2mm showed good functional result and 3 patients with step off of 2mm showed fair functional result at the final follow up. We achieved anatomic condylar width in all the patients. Khatri K et al [46] reported loss of reduction of > 4 mm in 5 patients. Among them, 4 had good functional result and 1 had fair outcome. None of their patient had tibial plateau widening of > 5 mm. Eggli S et al [35] achieved anatomic reduction with articular step off of < 2 mm and 2 patients had step off between 2 mm and 5 mm. They achieved anatomic condylar width in all 14 patients.

At the final follow up of our study, the mean medial proximal tibial angle in coronal plane was 87°±2.5°, ranged from 83.3° - 94°. Only one patient with MPTA of 94° had valgus mal-alignment. The mean posterior proximal tibial angle measured in sagittal plane was 8.2°±2.4° with range of 4.9°-13.3°. Yu Z et al [36] reported medial proximal tibial angle of 85.3°±4.0° and posterior proximal tibial angle was 9.3°±3.8°. Eggli S et al [35] demonstrated medial proximal tibial angle of 87±5 degree in 12 patients. One patient with non-anatomic coronal alignment had varus MPTA of 81° and one in valgus with 93° of MPTA. The posterior proximal tibial angle was measured as anatomic in 13 cases with PPTA of 9±4 degree. Prasad et al [15], at the final measurement of tibial angle found mean medial proximal tibial angle was 84.05° (range, 83° - 93°) and mean posterior proximal tibial angle of 8.25° (range, 3° - 14°)

In our present series of 32 patients we evaluate each patient with modified Rasmussen's criteria. Irrespective of associated ligament injuries, complications and radiological outcome, we were able to achieve excellent result in 15 (46.9%) patient, good result in 12 (37.5%), fair in 4 (12.5%) and 1 (3.1%) case with poor result. The average modified Rasmussen's functional score was 26.7 points (range, 19 – 30). The over-all satisfactory result, in our series was 84.4%. These results are comparable with other documented standard studies. Zhai Q et al [41] operated 26 patient and

the final Rasmussen's score was excellent in 17 cases and good in 9 cases with the average Rasmussen's score of 27.2 (range, 21- 30). Zala K et al [43] studied 24 patients, of which 19 patients achieved excellent knee score, 4 achieved good and 1 patient achieved fair result. Eggli S et al [35] studied 14 patients and Lysholm knee score was very good in 11 cases and good in 3 cases. The mean Lysholm knee score was 83.5 points (range, 64.5 – 92). Khatri K et al [46] assessed patient using Oxford knee score and noted excellent result in 54 (83%) cases, good in 7 (10.7%), fair in 3 (4.6%) cases and poor in 1 (1.5%) case with average score of 43.96. Rohra N et al [44] assessed 34 cases using knee society score and found excellent result in 24 (70.59%) cases, good in 8 (23.53%), fair in 1 (2.94%) and poor in 1 (2.94%) case.

Rohra N et al [44] reported excellent Rasmussen's radiological outcome in 11 (32.35%) cases, 21 (61.76%) patient had good result and 2 (5.88%) cases had fair radiological outcome. Zhai Q et al [41] reported excellent radiological result in all cases with average score of 16.4 (range, 14 – 18). In our present study, the Rasmussen's radiological outcome was excellent in 8 (25%), good in 20 (62.5%), fair in 3 (9.4%) and poor in 1 (3.1%) of case with average score of 7.9 (range, 4 – 10). In our study, it was noted that the functional result had no significant association with the follow up radiographs (p value > 0.05)

Different studies have been done by Yu et al [36], Prasad et al [15], Zhang et al [37], Barie et al [28].., and concluded that double plate fixation technique in high energy tibial plateau fracture via two incision technique is a feasible treatment option for boicondylar and complex tibial plateau fracture and their results are comparable with our present study.

The open double plate fixation has been reported to be associated with the significant amount of peri-operative complications. In our present study, the infection and wound breakdown was seen in 3 cases in the immediate postoperative day. Of the 3 cases, 2 cases had superficial wound infection and 1 case had deep infection. The superficial infection were controlled with antibiotic and dressing and the deep infection case was managed with debridement, irrigation, dressing, intravenous antibiotic and implant was retained till bony union. We noted 1 case of valgus angulation with non-anatomic coronal alignment but the patient had good functional result. We found 2 cases of extension lag of < 10° in 2 cases, 1case of posttraumatic arthritis. Most of the patient in our study had excellent pain score (62.5%), 11 (34.5%) cases had occasional pain and only 1 (3.1%) case had stabbing pain in certain position. In our study, we achieved 100% union. Ozkaya U et al [42] studied 108 patient in which 3 cases developed superficial infection which improve after oral antibiotic and 1 case developed deep infection which healed after re-debridement, plate removal and cast brace. Yu Z et al [36] reported 9 cases of stiff knee, 3 cases of varus deformity, 2 cases of incisional wound infection, 10 cases of traumatic arthritis of knee joint, and 1 case of delayed union. Khatri K et al [46] reported, superficial wound infection in 6 patients, 3 cases of deep wound infection, 2 cases of delayed union and 1 case of non-union. Lee et al [39] reported deep infection in 3 cases, superficial infection in 5 cases, stiffness in 7 cases, arthritis in 7 cases, angulation in 1 case, non-union in 7 cases. But Eggli S et al [35] in their series of 14 patient found no infection after ORIF with dual approach and considered it as safe approach with good surgical exposure.

5. Conclusion

Osteosynthesis in bicondylar tibial plateau fractures in adults is a challenge to every orthopaedic surgeon. Though there are number of implants and surgical techniques to address the problem, the surgical treatment of tibial plateau fracture remain controversial.

Based on our research and our result being encouraging in comparison to the literature, we recommend to fix the bicondylar tibial plateau fracture with dual incision and dual pre-contoured locking plate as it provide good surgical exposure, minimal soft tissue complications rate, reasonable amount of stability, acceptable alignment of articular congruity, reasonable time to union and allow early range of motion of knee & early weight bearing with good functional results.

However, a larger group and a longer follow-up are required to ascertain the outcome of bicondylar tibial plateau fracture fixed with dual incision and dual pre-contoured locking plate as well as to determine the ideal method of fixation techniques.

References

[1] Ali AM, Yang L, Hashmi M, Saleh M. Bicondylar tibial plateau fractures managed with the Sheffield hybrid fixators. Biomechanical study and operative technique. Injury 2001;32(4):SD86-91.
[2] Sivananthan S, Sherry E, Warnke P, Miller MD. Mercer's textbook of orthopedics and trauma. In: Rajasekaran S, Kamath V, Dheenadhayalan J, editors. Tibial plateau fractures. 10th ed. Hodder Arnold, Hachette, UK; 2012. P. 372-76
[3] Mallik AR, Covall DJ, Whitelaw GP. Internal versus external fixation of bicondylar tibial plateau fractures. Orthop Rev 1992;21:1433–36.
[4] Young MJ, Barrack RL. Complications of internal fixation of tibial plateau fractures. Orthop Rev 1994;23:149–54.
[5] 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(5):710–17.
[6] Watson JT. High-energy fractures of the tibial plateau. Orthop Clin North Am 1994;25(4):723–52.
[7] Wicky S, Blaser PF, Blanc CH, Leyvraz PF, Schnyder P, Meuli RA. Comparison between standard radiology and spiral CT with 3D-reconstruction in the evaluation, classification and management of tibial plateau fractures. Eur Radiol 2000;10(8):1227-32.
[8] Walton NP, Harish S, Roberts C, Blundell C. AO or Schatzker ? How reliable is classification of tibial

plateau fractures? Arch Orthop Trauma Surg 2003; 123(8):396-98.
[9] Hu YL, Ye FG, Ji AI, Qiao GX, Liu HF. Three-dimensional computer tomography imaging increases the reliability of classification systems for tibial plateau fractures. Injury 2009;40(12):1282-85.
[10] Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma 2010;24(11):683–92.
[11] 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 and its reproducibility. J Trauma Acute Care Surg 2012;73(3):731–37.
[12] 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(7):955–62.
[13] Chang SM, Wang X, Zhou JQ, Huang YG, Zhu XZ. Posterior coronal plating of bicondylar tibial plateau fractures through posteromedial and anterolateral approaches in a healthy floating supine position. Orthopedics 2012;35(7): 583–88.
[14] Kumar G, Peterson N, Narayan B. Bicondylar tibial fractures: Internal or external fixation. Indian J Orthop 2011;45(2):116-24.
[15] Prasad GT, Kumar TS, Kumar RK, Murthy GK, Sundaram N. Functional outcome of Schatzker type V and type VI tibial plateau fractures treated with dual plates. Indian J Orthop 2013;47(2):188-94.
[16] Chin TY, Bardana D, Bailey M, Williamson OD, Miller R, Edwards ER, et al. Functional outcome of tibial plateau fractures treated with the fine-wire fixators. Injury 2005;36(12):1467-75.
[17] Fernandez DL. Anterior approach to the knee with osteotomy of the tibial tubercle for bicondylar tibial fractures. J Bone Joint Surg Am 1988;70(2): 208–19.
[18] Stevens DG, Beharry R, McKee MD, Waddell JP, Schemitsch EH. The long-term functional outcome of operatively treated tibial plateau fractures. J Orthop Trauma 2001;15(5):312–20.
[19] Watson JT. Tibia: proximal. In: Rüedi TP, Murphy WM, editors. AO principles of fracture management. Stuttgart, Germany: Thieme; 2000.p.499-517.
[20] Jiang R, Luo CF, Wang MC, Yang TY, Zeng BF. 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(2):139-43.
[21] Piper KJ, Won HY, Ellis AM. Hybrid external fixation in complex tibial plateau and plafond fractures: An Australian audit of outcomes. Injury 2005; 36(1):178-84.
[22] Catagni MA, Ottaviani G, Maggioni M. Treatment strategies for complex fractures of the tibial plateau with external circular fixation and limited internal fixation. J Trauma 2007;63(5):1043-53.
[23] Kumar A, Whittle AP. Treatment of complex (Schatzker Type VI) fractures of the tibial plateau with circular wire external fixation: Retrospective case review. J Orthop Trauma 2000;14(5):339-44.
[24] Mikulak SA, Gold SM, Zinar DM. Small wire external fixation of high energy tibial plateau fractures. Clin Orthop Relat Res 1998;365:230-8.
[25] William MR, Jonas RR and Joseph B. Treatment of complex proximal tibia fractures with the less invasive skeletal stabilization system. J Orthop Trauma 2004;18(8):521–7.
[26] Egol KA, Su E, Tejwani NC, Sims SH, Kummer FJ, Koval KJ. Treatment of complex tibial plateau fractures using the less invasive stabilization system plate: Clinical experience and a laboratory comparison with double plating. J Trauma- Inj Infection & Critical Care 2004;57(2):340–6.
[27] 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.
[28] Barei DP, Nork SE, Mills WJ, Coles CP, Henley MB, Benirschke SK, et al . Functional outcome of severe bicondylar tibial plateau fractures treated with dual incision and medial and lateral plates. J Bone Joint Surg Am 2006 Aug; 88(8):1713-21.
[29] Larsson S, Hannink G. Injectable bone-graft substitutes: current products, their characteristics and indications, and new developments. Injury 2011;42(2):S30-4.
[30] Veitch SW, Stroud RM, Toms AD. Compaction bone grafting in tibial plateau fracture fixation. J Trauma 2010;68(4):980-3.
[31] Finkemeier CG. Bone-grafting and bone-graft substitutes. J Bone Joint Surg Am 2002;84-A:45A-64.
[32] Moore WR, Graves SE, Bain GI. Synthetic bone graft substitutes. ANZ J Surg 2001;71:354-61.
[33] Rasmussen PS. Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment. J Bone Joint Surg Am 1973;55(7):1331-50.
[34] Ebraheim NA, Sabry FF, Haman SP. Open reduction and internal fixation of 117 tibial plateau fractures. Orthopaedic 2004;27(12):1281-87.
[35] Eggli S, Hartel MJ, Kohl S, Haupt U, Exadaktylos AK, Roder C. Unstable bicondylar tibial plateau fractures: A clinical investigation. J Orthop Trauma 2008 Dec;22(10):673-79.
[36] Yu Z, Zheng L, Li J, Ma B. Functional and radiological evaluations of high-energy tibial plateau fractures treated with double buttress plate fixation. Eur J Med Res 2009 May 14;14(5):200-05.
[37] Zhang Y, Fan DG, Ma BA, Sun SG. Treatment of complicated tibial plateau fractures with dual plating via a 2 – incision technique. Orthopaedics March 2012;35(3):359-64.
[38] Hassankhani EG, Kashani FO, Hassankhani GG. Treatment of complex proximal tibial fractures (Types V & VI of Schatzker classification) by double plate fixation with single anterior incision. Open J Orthopaedics 2013;3(4): 208-12
[39] Lee MH, Hsu CJ, Lin KC, Renn JH. Comparison of outcome of unilateral locking plate and dual plating in the treatment of bicondylar tibial plateau fracture. J Orthopaedic Surg Res 2014;9:62.
[40] Chang SM, Hu SJ, Zhang YQ, Yao MW, Ma z, Wang X, et al. A surgical protocol for bicondylar four-quadrant

tibial plateau fractures. Int Orthop 2014; 38(12):2559-64.
[41] Zhai Q, Hu C, Luo C. Multi-plate reconstruction for severe bicondylar tibial plateau fractures of young adult. Int Orthop 2014; 38(5):1031-35.
[42] Ozkaya U, Parmaksizoglu AS. Dual locked plating of unstable bicondylar tibial plateau fracture. Injury 2015;46(2):9–13.
[43] Zala KL, Ashar SM, Tank P. Study of outcomes of dual plate osteosynthesis in Schatzker type 5 and 6 fractures of proximal tibia. J Res Med Den Sci 2015; 3(2):131-35.
[44] Rohra N, Suri HS, Gangrade K. Functional and radiological outcome of schatzker type V and VI tibial plateau fracture treatment with dual plates with minimum 3 years follow-up: A prospective study. J Clin Diagn Res 2016 May;10(5):RC05-10
[45] Lee TC, Huang HT, Lin YC, Chen CH, Cheng YM, Chen JC. Bicondylar tibial plateau fracture treated by open reduction and fixation with unilateral locked plating. Kaohsiung J Med Sci 2013;14(10):568-77.
[46] Khatri K, Lakhotia D, Sharma V, Kiran Kumar GN, Sharma G, Farooque K. Functional evaluation in high energy (Shatzker type V and type VI) tibial plateau fractures treated by open reduction and internal fixation. Int Scholarly Res Notices 2014:589538;8.

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