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Functional outcome of 59 patients of bicondylar tibial plateau fractures treated with internal vs external fixation: Selection criteria

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Abstract
Background: The purpose of this prospective study was to evaluate the Functional results of Internal versus External fixation of bicondylar tibial plateau fractures decided on specific selection criteria.
Materials and Methods: Fifty nine patients with tibial condyle fractures (Schatzker type V and VI) were recruited in the study between Nov 2013 and Dec 2015 at our tertiary care hospital in Bengaluru, India. Open reduction and internal fixation with Dual Buttress plates, Buttress plate and CC screws was done in 38 patients (closed, Type I & II open with good skin conditions). Hybrid External fixation was done in 21 patients (closed, Type I & II open with bad skin conditions, Impending compartment syndrome). They were followed up at six weeks, six months and twelve months and was evaluated for the functional outcomes by Hospital for special surgery knee scoring system (HSS).
Result: 86% of our patients had good to Excellent results according to HSS score. The outcomes between both modes of fixation were not significantly different at 1 year follow up. There was no difference in total arc of knee motion. Mean range of knee flexion in internal fixation was 115.79 $\pm$ 21.29^0, External fixation was 115.24 $\pm$ 13.37^0. Average HSS Score at final follow up for internal fixation was 78.87 $\pm$ 10.94 and external fixation was 78.71 $\pm$ 9.05. 2 patients needed flap surgery due to wound complications, 3 patients experienced infection following internal fixation compared to external fixator. 1 patient experienced non union following external fixation.
Conclusion: Both methods of fixation in Bicondylar tibial plateau fractures gives a favourable functional outcome provided selection criteria is followed strictly.
Level of Evidence: Level 3.

Keywords: bicondylar tibial plateau fractures, internal fixation, dual buttress plate, hybrid external

1. Introduction
Tibial plateau fractures makes it as a topic of considerable interest due to its involvement of a major weight bearing joint leading to significant functional impairment and complications [1]. These are one of the most common intra-articular fractures showing 1.2% of all fractures [2]. High- energy counterpart including bicondylar type (Schatzker type V) and the comminuted type (Schatzker type VI) poses a big challenge to orthopaedic surgeons around the world to treat [3].
Patients age, quality of bone and the amount of force over the proximal tibia decides the pattern and type of injury [4]. Bicondylar fractures are frequently associated with articular depression, multiple displaced condylar fracture lines, metadiaphyseal fracture extension and comminution, meniscal detachment, acl injury, soft tissue complications include open wounds or extensive closed injuries [5-8]. Schatzker VI are frequently associated with compartment syndrome in about 30% [9] or may present as open fractures [10], infection in about 8.4%- 18% [9], wound breakdown, joint stiffness, joint instability, malunion, nonunion and post traumatic arthrosis.
The impact energy of the injury will be absorbed by the very thin soft tissue layer overlying the subcutaneous proximal tibia. Which results in extensive dissection of soft tissue leading to careful surgical management of the underlying bony injury preventing complications [11, 12]. Due to both high energy fracture communition and the soft-tissue involvement of these

fractures leads to the high rate of unacceptable outcomes with both non- surgical and surgical management [13].

Treating these high energy tibial plateau fractures aims at maintaining joint stability, articular surface congruity and extra articular alignment without much soft tissue dissection and early mobilization of knee joint [14] along with reducing known complications.

Treatment choices include cc screws, dual buttress plates, fixed angled locking compression plate, hybrid dual plates (combination of locking plate and buttress plate) [15], tubular external fixator, hybrid external fixation [3], Limited internal fixation combined with a tensioned wire [16]. Different surgical approaches in open reduction and fixation were used including anterior midline incision [17], medial and lateral incision, posterior approaches. "Early motion has been touted as the functional savior of major intra articular injuries" [18].

Functional outcome and complications of Schatzker V and VI tibial plateau fractures has been evaluated and compared in the current study treated with internal fixation using Dual plates through Anterior midline incision and external fixation using Hybrid external fixation.

2. Materials and Methods

The prospective study was conducted between Nov 2013 to Dec 2015 at our 350 bedded, tertiary care hospital. Patients who presented with tibial condyle fractures falling in category of Type V and Type VI of Schatzker classification [19] and above 18 years of age were included in the study.

Patients below 18 years of age, Type I, Type II, Type III and Type IV of Schatzker classification, Pathological fractures, fractures associated with active infection, vascular injuries and impending compartment syndrome were excluded from the study. Patients who refused to participate in study or were lost to follow-up were also excluded from study.

Fifty nine patients were included in the study including 38 patients treated with internal fixation and 21 patients treated with external fixation and followed for minimum of 12 months. Selected patients were postoperatively assessed for functional and radiological outcome at each follow up. Informed consent was obtained from all individual participants included in the study. Institutional Ethical committee approval was taken. Selection criterias were decided for both the methods of fixation.

2.1 Selection criterias for internal fixation

Closed Fractures with good skin conditions, Type 1 open fractures with good skin conditions, Type 2 open fractures with good skin conditions, without impending compartment syndrome

2.2 Selection criterias for external fixation

Closed fractures with blisters and bad skin conditions, Type 1 & 2 open fractures with blisters and bad skin conditions, Type 3 open fractures, Fracture with Impending compartment syndrome needing fasciotomy primarily.

Same Surgical team and one orthopaedic observer was appointed to collect the data in each follow up. All the patients with preoperative AP and Lateral x-ray views of knees (Figure 1) and computed tomography(CT) scan with 3D reconstruction pictures were reviewed to note the type of the fracture, the location and extent of articular depression and fracture extension into the diaphysis was also done. Fractures were classified according to schatzker's classification [19]. Soft tissue injuries were classified by the Gustilo–Anderson classification of open fractures [20, 21]. The neurovascular status, compartment syndrome, and the presence of any fracture blisters were noted. Preoperative planning done according to type of fracture.

Fig 1: Pre-op AP & lateral X-ray of Type VI fracture treated with internal fixation

Antibiotics Prophylaxis (Inj. Cefotaxime 1gm) Intravenous was administered before tourniquet inflation in closed fractures. In open fractures Inj. Cefotaxime 1gm, Inj. Amikacin 500mg, Inj. Metronidazole 100 mg intravenous were administered in emergency room.

3. Operative procedure

Patients were operated under regional anaesthesia in supine position on a radiolucent OT table with a sand bag under ipsilateral gluteal region, bone grafting site (Illiac crest) draped separately. Tourniquet was used for all the surgeries. Patella, patellar tendon, tibial tuberosity, medial and lateral joint lines were marked.

3.1 Internal fixation

Anterior midline longitudinal Incision given just lateral to shin of the tibia starting proximally from lower pole of patella till distally according to the fracture extension. Full thickness flaps were raised on both medial and lateral side, consisting of subcutaneous fat to the deep fascia. The aponeurosis over the tibialis anterior muscle is incised longitudinally. Tibialis anterior muscle was elevated subperiosteally to expose the lateral surface of the lateral tibial condyle and shaft. All of the fractures were reduced with Indirect and direct reduction. Depressed fractures are visualized with C-arm guidance are elevated by making a window in Antero medial cortex with a bone tamp. Percutaneously drilled K wires were then used as joysticks to fine-tune the reduction of individual fragments or to correct the tilt of articular fragments. Once elevated, provisional stabilization of the articular fragments to the medial or lateral condyle using K wires were done. At this point resultant metaphyseal void was filled with autogenous cancellous bone graft harvested from ipsilateral iliac crest if necessary.

Final fixation was done with interfragmentary screws (two or three 6.5 mm cannulated cancellous lag screws) either separately or through the plate parallel to the joint under c-arm guidance followed by metaphyseal buttress plating with 4.5mm "T" plate on the medial condyle below the insertion of Semimembranosus tendon and 4.5mm "L" buttress plate for lateral condyle over the lateral surface. Finally incision was irrigated and closed over a suction drain with subcutaneous vicryl and skin staples. Patient was given above knee slab postoperatively. Postoperative radiographs were reviewed to assess the adequacy of articular reduction, metaphyseo-

diaphyseal reduction and alignment.

Knee was immobilized with above knee slab for 3-4 weeks following which patient was encouraged to start knee movements to prevent stiffness. Non weight-bearing mobilization with axillary crutches or a walking frame and quadriceps exercises were started on the 1 POD. Partial weight bearing Gait was started after 12 weeks with full bearing gait after 16-20 weeks. Patients treated with internal fixation were called and Final follow up x rays were collected (Figure 2) and Final knee flexion and extension (Figure 3) results were noted.

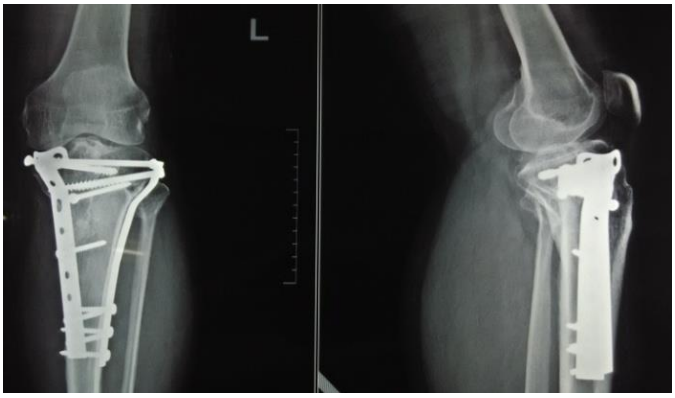

Fig 2: AP & Lateral X ray of Internal Fixation at Final follow up (12 months)

Fig 3: Knee flexion & extension at Final follow up (12 months) treated with internal fixation

3.2 External fixation

For depressed fracture fragment in the articular surface (Figure 4) a window is made and elevated with a bone tamp. Manual longitudinal traction and Valgus force is applied to reduce the fracture fragments and when reduction is achieved, a reduction clamp is used to hold the reduction prior to fixation and K wire is inserted across the fracture fragment.

Fig 4: Pre op AP & Lateral X ray of Closed Type VI fracture with impending Compartment syndrome treated with External fixation

The articular fragments is then stabilized with the insertion of large fragment cannulated screws (6.5 mm) parallel to the joint in the subchondral bone across the main fracture lines in a lag fashion. After the articular surface is reduced, Hybrid external fixator frame is applied next to secure the metaphysis to the diaphysis of the tibia. The circular frame is assembled with the use of two rings or one ring depending upon the extension of the fracture fragments. Rings are sized to the limb to provide 3-4 cms of clearance circumferentially. The leg tends to "sag" posteriorly against the frame and therefore sterile towels or sponges are used to maintain this clearance posteriorly throughout the procedure. Fine wires are then placed across the proximal part of the tibia parallel to the joint surface in the safe zone. The proximal wires are kept 1 cm from the joint line to avoid Intra-articular penetration. First wire is passed horizontally from lateral to medial, anterior and proximal to the centre of the tip of fibular head. The second wire from posteromedial to anterolateral and sometimes third wire from the center of the fibular head from the posterolateral to anteromedial cortex under fluoroscopic control keeping an angle of 30 to 60 degrees between the wires.

The ring is then assembled with the wires and wires were tensioned. All Bolts are tightened. Both the rings are assembled with each other. The fixation is made stronger by using schanz pins in the rings for more stability. The rings assembly is then assembled with the uniplaner construct using 4.5 schanz pins placed 3-4 cms apart on the anteromedial surface of tibia. The pins were connected to the connecting rods with the pin clamps. In the case of impending compartment syndrome, fasciotomy was done with 2 incisions one on posteromedial side and on anterolateral side of leg, wound left open with moist sterile dressing. Split skin graft was done 2 days later. Post op Radiographs were taken (Figure 5a &5b).

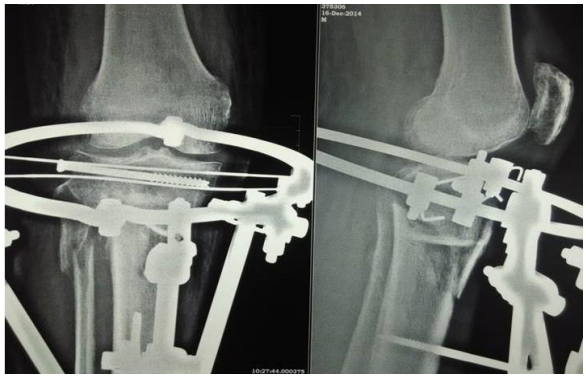

Fig 5a: Post op X-ray of fracture treated with hybrid external fixation

Fig 5b: Post fixation showing Hybrid external fixator

Non weight-bearing mobilization with walking frame and quadriceps exercises and knee rom were started on the 1 POD. Partial weight bearing Gait was started after 12 weeks with full bearing gait after 16-20 weeks, Removal of exfix and cast application after 10- 12 weeks.

Post operative antibiotic coverage was given for a period of 5-7 days. Active digital movements and limb elevation were encouraged to prevent swelling of the toes. First wound inspection done after 24 hours. On 2-3rd post op day patient was discharged. Suture Removal was done at 3 weeks Patients were called for review at 2 weeks, 6 weeks, 12 weeks and at monthly intervals thereafter till bony union (Figure 6) and maximal functional recovery to assess the fracture healing and knee joint movements (Figure 7).

Fig 6: AP & Lateral X ray of external fixation at final follow up (12 months)

Fig 7: Knee flexion & extension at final follow up (12 months) treated with external fixation

All the patients who satisfied the selection criteria were called for follow up at 6 weeks, 6 months, 12 months and were questioned and examined regarding functional recovery according to the scoring proforma and their responses noted. The results were analyzed according to the Hospital for special surgery knee scoring system (HSS) and statistically compared with each follow ups. The patients were questioned regarding the degree of pain in knee, requirement of support to walk and examined for varus or valgus stability, degree of motion measured by Goniometer, quadriceps strength, extension lag and quantity of varus or valgus deformity with Goniometer if present. The scores were graded as poor (<60), fair (69-60), good (84-70), and excellent (100-85).

Statistical analysis in our study was done using Mann-Whitney u test and Wilcoxon matched pairs test to see statistical significance between clinical scoring at each postoperative follow up. The data collected was entered in Microsoft Excel and Statistical analyses were performed using the SPSS software using p value (< 0.05).

4. Results

Sixty nine patients with tibial plateau fractures of Schatzker type V and VI had been treated in our institution between Nov 2013 to Dec 2015. Ten patients had been lost to follow up. The remaining 59 patients with Schatzker type V (n=20) and VI (n=39) fractures were included in this prospective study (Table 1). Forty nine patients were men and ten patients were women. Fifty five were a result of vehicular accidents and four were a result of fall from height. The age of the patients varied from 19 to 65 years (mean 40.70 years). Hospital stay varied from 4 to 8 days. The duration of follow up was 12 months. Seven patients had an open fracture. No patients had preoperative nerve palsy.

Table 1: Fracture distribution according to type

Schatzker type	Closed fractures	Open fractures (Gustilo-Anderson)	Total
V	18	2 (II)	20
VI	34	5 (I, II, IIIB)	39
Total	52	7	59

All patients underwent surgery at a mean interval of 24 h (range 6-78 h) depending upon severity of the injury and fitness for surgery. Emergency surgeries were done in six patients of whom two had an open fracture.

Tourniquet was applied in all the patients. Primary Bone grafting was done in 2 patient of type V and 5 patients of type VI. Pre-op Impending compartment syndrome was present in 9 patients, Hybrid External fixation was done with primary Fasciotomy.

Anterior midline incision was given in all the patients. Knee arthrotomy was not performed and Articular congruity and reduction was visualized with flouroscopy. The mean duration of the surgery was 1 h 13 min. Radiographs in the AP and lateral planes were performed in the immediate postoperative period to verify articular reduction and meta-diaphyseal alignment restoration in all the cases.

All patients were followed up at 6 weeks, 6 months, 12 months and the functional outcome of our patients was graded by the Hospital for Special Surgery Knee Scoring criteria. Fourteen patients had scores between 85 and 100, Thirty seven patients had scores between 70 and 84, Six patients between 60 and 69 and Two patients in less than 60 at final follow up with division of both the groups as shown in Table 2. 86% of our cases got Excellent to Good results. We found a statistically significant difference in HSS score with $p = 0.00$ between 6^{th} week and 6^{th} month, 6^{th} month and 12^{th} month follow up in both the methods of fixation but no statistically significant difference at 6^{th} week, 6^{th} month and 12^{th} month with $p > 0.05$ between both the methods of fixation and also between schatzker V and schatzker VI type of fractures. Patients showed a mean of 115.79 ± 21.29 degrees of knee flexion in Internal fixation which is comparable to 115.24 ± 13.37 degrees in External Fixation.

Table 2: HSS Score in Both the methods of Fixation at final follow up

Hss Score	Internal Fixation		External Fixation	
	NO.	Mean Score	NO.	Mean Score
Poor (<60)	2	51 ± 11.31	0	0
Fair (60-69)	3	65 ± 3	3	64.33 ± 3.22
Good (70-84)	24	77.88 ± 4.42	13	77.31 ± 3.95
Excellent (85-100)	9	92.33 ± 2.5	5	91 ± 2.74
Total	38	78.87 ± 10.94	21	78.71 ± 9.05

Thirteen patients had extension lag. Three patients had deep infection with two having skin necrosis, Two patient had valgus malalignment, One patient had varus malalignment. All patients had bony union, Five patients had one or two screw back out and had undergone further surgery to remove the same after bony union. One patient developed increased compartment pressure after skin closure that required fasciotomy and later underwent secondary suturing. Two patients developed common peroneal nerve palsy postoperatively but recovered 6 weeks following surgery with no residual numbness at final follow up in Internal Fixation group as compared to External Fixation shown in Table 3.

Table 3: Complications in both the Methods of Fixation

Complications	Internal Fixation	External Fixation
Deep Infection	3	1
Skin Necrosis	2	0
Valgus Collapse	2	2
Varus Collapse	1	1
Screw Back Out	5	0
Common peroneal Nerve palsy	2	0
Non union	0	1

Internal Fixation had subsequent additional procedures required in eight patients. Wound debridement and coverage with gastrocnemius flap and split skin grafting were done in two patient who had skin necrosis with wound dehiscence and deep infection with persistent purulent discharge at the site of anterior midline skin incision due to tight primary skin closure one of which was type 3b open fracture. One of these patients required removal of the implant and fixation with external fixation together with flap coverage. These patients were kept on injectable antibiotics for 2 weeks according to the culture and sensitivity reports which showed kleibsiella organism. The flap went on to heal uneventfully. But the Functional outcome of these patients were poor at the final follow up.

5. Discussion

The goal of treatment for any intraarticular fracture is to achieve a stable, aligned, congruous joint with painless restoration of motion & function. Fractures of tibial plateau have the potential to be devastating injuries especially when they have significant bony & soft tissue involvement & are displaced with knee instability & incongruity. Till now no particular technique is successful consistently due to the variability of tibial plateau injuries [22].

Hohl M *et al* reported that operating within 14 days of injury, better on the day of injury or just after the swelling reduces is technically easier with open reduction and internal fixation depending upon soft tissue envelope recovery, operating surgeons experience, and the co-morbid conditions of the patients. Soft tissue recovery is indicated by decrease in blisters and edema with return of skin wrinkle. [23] During the follow-up period of one year it was found that the clinical functional score (HSS score) and Knee Flexion compares well with other reported series of studies as in Table 4. In both the methods of Fixation.

Table 4: Comparison of functional outcome with the literature

Study	HSS Score		Knee Rom	
	IF	EX	IF	EX
COTS [16]	67	72	109	120
Yu Z [14]	77.3		107.6	
Yao Y [24]	80.35		115	
Weiner LS [25]		90		
Babis GC [26]				115
Ariffin HM [2]				120
Present study	78.87	78.71	115.79	115.24

It was also found in present study that HSS functional score at 6 months of follow up showed a similar functional outcome at 12 months which showed that Improvement in the functional score after 6 months greatly depends on the physiotherapy and less depends upon the surgical technique. Poor to fair results found in patients who developed severe deep infection and had undergone multiple additional surgeries thereafter. It will be difficult in external fixation to achieve stable fixation without sparing knee joint [27]. Dual incisions are better than single incision [12] Anterior Midline Incision for the Internal Fixation which gives us access to both the condyles with single Incision was used in present study. To prevent skin flap necrosis dissection should be done subperiosteally. Reduction was done using K wires as the joystick with indirect methods to prevent excessive periosteum stripping. To fix the comminuted fractures with Dual Buttress plate i.e 2 plates each on both the condyles in the case of proximal fibula fractures. Post fixation closure of the skin should not have any tension.

Proximal tibia fracture complexity and susceptible thin soft tissue coverage has led to increased rate of severe complications despite of successful restoring of anatomical axis and joint congruity with open reduction and internal fixation [16] Barei *et al* showed a high rate of deep infection despite using "modern" techniques including delayed definitive surgery (mean nine days after the injury), double small and widely spaced incisions with minimal soft-tissue dissection and the use of low-profile implants in high energy tibial plateau fractures [12]. Due to these known and devastating complications of internal fixation many alternative procedures have been introduced for management of these fractures, including percutaneous reduction techniques and stabilization with circular fixator frames [16]. One Internal Fixation was done with plate in current study in patient with Type 3B open fracture after primary wound debridement against the decision criteria and got grave results due to severe infection needing plate removal and exfix application. Thus giving a clue not to use Internal Fixation in Type 3 open fractures.

Current study confirmed the significant rate of complications seen following open reduction and internal fixation despite

the use of better soft-tissue handling techniques. The rate of deep infection in Internal fixation group in the present study was 7.89% which is lesser as compared to 8.4% reported by Barei *et al*. [12]. Internal fixation showed higher rates of infection rates than the external fixation requiring implant removal and multiple secondary procedures. External fixation has shown lower rates of deep infection and provides flexibility to achieve soft tissue coverage, plastic surgery procedures like flaps and SSG and is better for soft tissue handling.

Successfully overall limb alignment was restored in all except six patients at the time of the final follow-up in both groups. Preoperatively bone grafting was planned but not done intraop lead to delayed valgus collapse. Bone grafting should be done whenever necessary in the case of depressed fragments to maintain articular congruity and prevent late collapse. All Fractures united in all patients although one patient had Non Union in external fixation group. Reoperations in the open reduction and internal fixation group tended to be of greater severity and included numerous soft-tissue procedures for bone. Early restoration of joint congruity, normal anatomical axis restoration, joint stability and early movement of the joint remains the principal factors in preventing early arthritis after intraarticular fractures [28].

6. Conclusion

Internal fixation with Dual buttress plates for high-energy tibial plateau fractures gives excellent to good functional outcome but is associated with soft tissue complications due to deep infection. Dual plates does anatomic reduction and rigid fixation of articular surface thus allows early mobilization of the joint requiring aggressive physiotherapy preventing the knee stiffness and providing favourable functional outcome. External Fixation with Hybrid external fixation is good option and reserved for patients with bad skin condition, impending compartment syndrome and Type 3 open fractures providing good stability without handling of soft tissues thus causing less complications and allows easy secondary soft tissues procedures handling. Both methods of fixation in Bicondylar tibial plateau fractures gives a favourable outcome provided selection criteria is followed strictly.

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