

## Original Research Article

# Prospective study of management of Schatzker's type V and VI tibial plateau fractures by different types of plate osteosynthesis

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## ABSTRACT

**Background:** Schatzker's type V and type VI fractures are bicondylar tibial plateau fractures which pose a challenge to the treating orthopaedician. Several studies have compared unilateral locked plate and double plating for their treatment and showed no statistically significant difference between these two fixation methods. So the quest for ideal implant for internal fixation (unilateral plating and dual plating) of these fractures continues. Hence we decided to do this study.

**Methods:** A prospective study of Surgical Management of thirty seven cases of Schatzker's type V and VI tibial plateau fractures by different types of plate osteosynthesis (single unilateral locking plate and dual incision locking buttress plate) was carried out. The functional outcomes were assessed by the hospital for special surgery knee score system.

**Results:** 18 patients were fixed with a unilateral locking plate, 19 patients were fixed with a dual incision bilateral locking plates. All patients had satisfactory articular surface reduction and axis of alignment on immediate postoperative radiographs. All cases achieved union by 4.8 months approximately. All patients had either excellent or good HSS score. Mean HSS score at recent follow-up was 86.10 in DP group and 83 in SP groups (t value 2.81, p values 0.008).

**Conclusions:** We conclude that single plating and dual plating fixation of complex proximal tibial plateau fracture Schatzker's type 5 and type 6 ensures stable fixation, immediate mobilization, satisfactory radiological outcome, very high union rates and excellent functional assessment outcome with a very low rate of complications.

**Keywords:** Proximal tibial plateau fracture, Schatzker's type V and type VI, Single & dual plate, Precontoured locking compression plate

## INTRODUCTION

The tibial plateau is one of the most critical load bearing areas in the human body. Fractures of the tibia plateau affect knee alignment, stability, and motion. Appropriate treatment of these fractures is critical for minimizing patient disability and reducing the risk of complications, particularly posttraumatic arthritis. Schatzker's type V and type VI fractures are bicondylar tibial plateau fractures caused by high velocity trauma. Manson Hole (1956) at the Chicago Orthopedic society

has rightly mentioned that - these fractures are tough, and pose a challenge to the treating orthopedist due to following reasons: 1. Subcutaneous location of the anteromedial surface of the tibia. 2. They are often associated with soft tissue injuries and high risk of wound complications.<sup>1</sup> 3. Requiring reconstruction of the articular congruity and restoration of the anatomic alignment, rigid fixation of the fragments for early joint motion and weight bearing. 4. Minimal soft-tissue invasion during surgery, providing a proper local environment for fracture healing.<sup>2-4</sup>

The ideal treatment of these fractures is controversial. Treatment options include percutaneous screws fixation, an external fixator, hybrid external fixation, limited internal fixation combined with a tensioned wire fixator, unilateral periarticular locking plate and dual incision buttress plates. The advent of locked plates and angle stable constructs specifically designed for the proximal tibia made it possible to achieve fixation of many displaced bicondylar injuries through unilateral plating only. However there may be change in alignment and articular reduction on long follow-up. Buttressing of both the medial and lateral sides with conventional double plating is good for managing bicondylar fractures because this may provide sufficiently rigid fixation to prevent medial collapse and subsequent varus deformity. However, this may require excessive dissection through injured soft tissue, leading to wound complications or compromised osteosynthesis and delayed fracture healing. Initially Dual plating (DP) through a single extensile incision has shown an incidence of deep wound infection of 23–88%.<sup>5</sup> But with the newer two incision DP technique, the incidence has dropped to 4.7–8.4%.<sup>1</sup> Dual plating utilizing locked plates through dual incision gives excellent to good functional outcome with minimal soft tissue complications. Several studies have compared the biomechanical strength of unilateral locked screw plate and double plating for the treatment of bicondylar tibial plateau fractures and showed no statistically significant difference between these two fixation methods.<sup>5-7</sup> So the quest for ideal implant for internal fixation (unilateral plating and dual plating) of these fractures continues. Hence it was decided to do this study with an objective of comparing single unilateral locking plate and dual incision bilateral locking buttress plate and their functional outcome.

## METHODS

A prospective observational and clinical study of surgical management of thirty seven cases of Schatzker's type V and VI tibial plateau fractures by different types of plate osteosynthesis (single unilateral locking plate and dual incision locking buttress plate) and its functional outcome, was carried out. The study was carried out over a period of 24 months from August 2012 to September 2014, at our hospital based on:

Inclusion criteria were patients with type V and VI tibial plateau fractures according to Schatzker's classification, age of patients >18 years and <55 years and patients having minimum follow-up of 6 months.

Exclusion criteria were patients with open tibial plateau fractures, Pathological fractures, vascular injuries and patients with head injury or abdominal and thoracic trauma requiring operative intervention.

The study was performed with the approval of our institution's ethical review board. Informed consent

was obtained from all patients. Patients who presented to the institution with injury/trauma to knee were evaluated in detail clinically. Detailed history of patient including age, sex, mode of trauma and any other associated injury like injury to other limbs, head injury, chest or abdominal trauma were noted. Radiographs of injured knee, anteroposterior and lateral views were done. Plain CT scan with 3D images reconstruction of knee was done in all the cases with Schatzker's type V or VI tibial fractures. The following parameters were studied for recognizing fragment features and Pre-operatively planning was done to do either unilateral or bilateral plating. 1. Extension of fracture line. 2. Anatomical location of fracture line. 3. Comminution of fracture. 4. Severity of articular depression and comminution.

Patients were given above knee slab and limb elevation. Skin condition of injured knee like swelling and blisters were noted at admission and necessary medications and measures were given till it subsided and skin appeared normal. Decision for doing unilateral plating or bilateral plating was taken by senior operating surgeon. If there was significant comminution on medial side and if collapse into varus was suspected despite lateral plating, then bilateral plating was done.

## *Operative technique and approaches for unicondylar plating*

Unicondylar plating was done through anterolateral incision along with additional lag screw from medial side if required. A sand bag was placed under the ipsilateral gluteal region for the anterolateral approach, with a knee flexion of 15°–30°.

## *Surgical exposure*

Anterolateral approach- a curvilinear longitudinal incision was made starting from the lateral femoral epicondyle and passing over the Gerdy's tubercle and running parallel to the shin and 1 cm lateral to it. The iliotibial band was elevated from the Gerdy's tubercle and the underlying capsule. The tibialis anterior was elevated subperiosteally to expose the lateral surface of the lateral tibial condyle and shaft.

## *Reduction manoeuvre*

Reduction of the lateral articular surface was directly assessed by elevating the lateral meniscus from the anterior horn. Depression of the joint surface was addressed by impacting subchondral bone through the fracture gap or the created bony window in proximal third shaft. Intraoperative fluoroscopy was used for assessment of the medial joint surface and alignment of the reduction throughout surgery. Temporary k-wire fixation was applied to maintain the joint surface, and this acted as a guide for plate placement. Bone defects

were filled with autogenous cancellous iliac bone graft if required.

### ***Implant used***

A Pre-contoured 4.5 mm proximal tibia locking plates of Indian manufacture (hockey locking plate or T or L buttress locking plate) was placed over the lateral aspect of the tibia for fixation. Adequate sizes of cancellous locking screws (6.5 mm or 5 mm) were used in proximal part of tibia and 4.5 mm locking cortical bolts were used to fix the plate with the shaft. Additional lag screws for fixation or buttressing at the medial condyle were placed for large medial fragments via small incisions if required.

### ***Operative technique and approaches for bicondylar plating***

Along with the anterolateral plating, posteromedial locking plating was done through posteromedial incision.

### ***Operative technique***

The sand bag was placed under the contralateral hip if a posteromedial approach was used. In some patients we also flexed and adducted the contralateral hip with the pelvis rotated towards the injured side.

### ***Surgical exposure***

The posteromedial exposure consisted of a skin incision approximately 1 cm posterior to the palpable posteromedial edge of the tibia with a proximal extension curving along the distal portion of the pes anserinus tendons. The deep fascia overlying the medial gastrocnemius muscle was incised dorsal to the pes anserinus tendons. The pes anserinus tendons were subsequently retracted anteriorly and the medial gastrocnemius and popliteus muscles were elevated and retracted posteriorly, revealing the posteromedial aspect of the proximal part of the tibia. Dissection over the anteromedial surface of the tibia was minimized, and subperiosteal dissection was limited to the fracture margins and the area of anticipated plate placement.

### ***Reduction manoeuvre***

We typically fix the medial column first. If the medial condyle was severely comminuted, then we approached and fixed the lateral column first to maintain the length. Articular surface was reduced under direct visualization through the submeniscal arthrotomy, supplemented by the image intensifier if required. Kirschner wires were then used as joysticks to fine-tune the reduction of individual fragments or to correct the tilt of articular fragments. The reduced fragments were then provisionally fixed with Kirschner wires. The Kirschner wires were later replaced with inter-

fragmentary screws, either separately or through the plate. We elevated the depressed fragment through a separate cortical window on the medial tibial wall using a bone punch in cases of antero-medial fragment fracture. The depressed fragment was elevated with compacted cancellous bone beneath it and the resultant metaphyseal void was filled with autogenous cancellous iliac bone graft if required.

### ***Implant used***

After reducing the postero-medial fragment, a small 3.5 mm postero-medial proximal tibial locking plate was slid beneath the pes anserinus. Image intensifier was utilized to position the plate below the level of the joint line and the plate was then fixed to the bone with the 4mm cancellous locking screws in metaphyseal part and with 3.5 mm cortical locking screws in distal part. For anterolateral plating similar procedure was done as mentioned before.

Intraoperative findings are noted like type of anaesthesia, tourniquet time, duration of the surgery, no of c-arm shoots were noted and Intra operative articular reduction. Postoperatively Antibiotics were continued in the post-operative period I.V for 3 days and oral antibiotics till suture removal (14 days).

Postoperatively patients were put in a long knee brace for 2 weeks. Isometric quadriceps exercises and knee range of motion were encouraged from 3rd day. Patients were allowed non-weight crutch walking for at least 6-8 weeks; after that partial weight bearing was started. Full weight bearing was allowed only after radiological healing of the fracture. Follow-up visits were done at 6 weeks interval until fracture healing was seen and later every 3 months till 1 year and every 6 months until at least 2 years. At follow-up visits, they were evaluated clinically and radiologically for fracture healing and alignment. At each visit radiological assessment was done. X-ray of the involved knee with leg was done to assess: 1. signs of union 2. secondary loss of reduction 3. failure of fixation 4. failure of implant 5. reaction to metal. At each follow-up range of motion was assessed in operated limb.

### ***Radiographic assessment***

Articular reduction was scored as satisfactory if there was a  $\leq 2$  mm step or gap.<sup>1</sup> Coronal alignment was considered satisfactory if the medial proximal tibial angle was  $87^{\circ} \pm 5^{\circ}$ . Sagittal alignment was considered satisfactory if the posterior proximal tibial angle was  $9^{\circ} \pm 5^{\circ}$ . Bony union was defined radiographically when at least three cortices united. Nonunion was defined as no evidence of healing after 6 months. An increase of  $5^{\circ}$  malalignment or an articular depression of 2 mm compared with the first postoperative radiograph was defined as secondary loss of reduction. Complications during the follow-up period were recorded like: 1.

infection 2. stiffness ( $<90^\circ$  knee flexion). 3. posttraumatic arthritis 4. non-union. 5. hardware impingement 6. implant failure. The functional outcomes were assessed by the HSS knee score system (hospital for special surgery, HSS) and SMFA score (short musculoskeletal function assessment, SMFA) at the each follow-up.

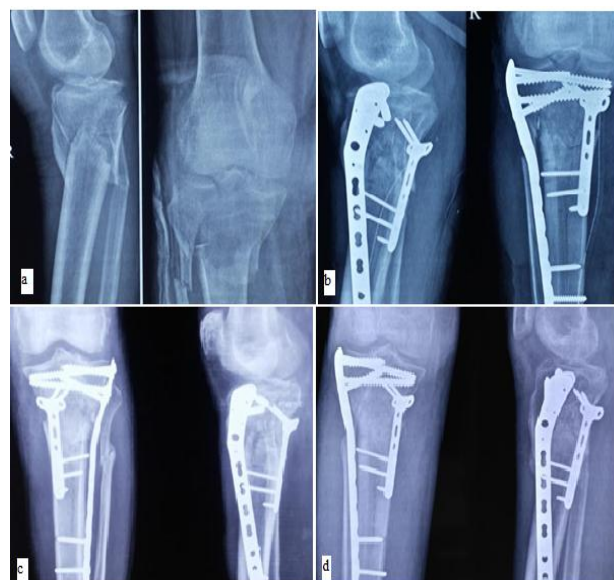
### Statistical analysis

Analyses were performed using IBM SPSS version 22 software (SPSS Inc, Chicago, IL). Coded data were entered into an excel sheet. Outcome measures were presented by mean, SD, proportions and confidence intervals. Comparison of quantitative measures was done by t test and difference in proportions by Chi-square test. P value  $\leq 0.05$  was considered as statistically significant.

## RESULTS

Forty four (44) patients were enrolled during this study, out of those we lost 7 patients during follow up who could not be traced. Of the 37 patients, 18 patients were fixed with a unilateral locking plate, 19 patients were fixed with a dual incision bilateral locking plates. No significant differences existed regarding gender ratio, mean age, side of injured limb, and mechanism of trauma between two groups. Swelling and blisters were treated conservatively by strict limb elevation, ice packs and magnesium sulphate dressing till it subsided and wrinkles on the skin developed. Mean duration between injury and surgery was 12 days (range 6- 20 days). All single plate (SP) fixations were done by using laterally applied locking plate while two cases were augmented with two cancellous screws for medial tibial condyle fixations. All dual plate fixations (DP) were done by using a lateral plate from anterolateral side and posteromedial plate from posteromedial incisions. According to type of fracture, total number of schatzker's type 5 fractures in SP fixation were 7 and in DP fixation were 6, similarly Schatzker's type 6 fractures in SP group were 11 and in DP group were 13. Waiting time for both type of Schatzker's was same and clinically insignificant. Though the study of incidence of posteromedial fragment in such type of bicondylar fractures was not a part of study but we had an opportunity to find out the incidence of such fragment in these fracture as in all the cases pre-operatively CT scan with 3D images reconstruction was done. We found posteromedial fragment in 16 patients (43%). Out of these 16 patients, 5 patients were fixed with single plating and remaining 11 patients were fixed with dual plating however all the patients with posteromedial fragments in both the group had good to excellent functional outcome. Bone grafting was done in 3 (16.66%) in single plating group and in 4 (21.05%) in the double plating group. In surgical details, there was a statistically significant increase in surgical time with the DP group 156 minutes (p value 0.04) as compared to SP group 134 minutes. There was statistically insignificant difference in blood loss (p value 0.5) between SP group

(200 ml) and DP group (213 ml), and no of c-arm shoots (p value 0.31) between both groups. Tourniquet time is significantly less in SP group (104 minutes) as compared to DP group (122 minutes) (p value 0.05). 17% and 21% patients received bone grafting in SP and DP group respectively. Postoperatively all patients in SP and DP group had satisfactory articular surface reduction and satisfactory axis of alignment. We found secondary loss in terms of axis of alignment in 2 patients in SP group (11.1%) and in 1 patient in DP group (5.6%) and all 3 cases were varus malaligned. Mean medial proximal tibial angle (MPTA) was 86 degrees in DP group and 83 degree in SP group. Similarly secondary loss in terms of articular surface reduction was present in SP group in 2 patients (11.1%) and in 1 patient in DP group. According to radiographs, all cases achieved union by 4.8 months approximately and we had no cases with non-union or implant failure.



**Figure 1: a) Pre-op X-ray showing bi-condylar schatzker type 6 fracture of patient A; b) Post op X-ray-dual plating; c) 3 months follow-up; d) 12 months follow up, shows union. HSS score was 86 at last follow-up.**



**Figure 2: a) Pre-op X-ray showing Schatzker type 6 fracture of patient B; b) Post-op X-ray-dual plating; c) 9 months follow-up shows union. HSS score at final follow-up was 92.**



There was one case with superficial infection in lateral wound of DP group. No organism was isolated on aerobic and anaerobic culture and healed subsequently, however prolonged oral antibiotic therapy of 2 weeks was given in this patient. There were no cases of deep infection or osteomyelitis. None of patients developed vascular injury, nerve injury or compartment syndrome. 4 patients developed extension lag in the range of 0-5 degree in SP group while 3 patients developed extension lag in DP group. Mean knee flexion was 121 degrees in DP group and 124 degrees in SP group. No patients had stiffness of joint ( $<90^{\circ}$ ). One patient in each group reported discomfort due to hardware impingement for which implant removal was done after bony union.

Healing time in SP group was 18.16 weeks and in DP group was 17.1 weeks which was statistically insignificant.

**Table 1: Healing time (union) in weeks.**

Healing time (in weeks)	Single plating	Dual plating
14-15	3	7
16-17	4	3
18-19	5	4
20-21	4	3
22-23	1	2
24-25	1	0
Total	18	19

**Table 2: HSS score.**

HSS score	Single plating	Dual plating	Statistical value
Hss score 6 months	72.44	74.47	T value 1.35; p value 0.138
Hss score 9 months	77.11	80.57	T value 2.14; p value 0.03
Hss score last follow-up	83	86.10	T value 2.81; p value 0.008

**Table 3: HSS score grading at last follow-up.**

HSS score	Single plating	Dual plating
Excellent	7	12
Good (70-74)	11	7
Fair (60-69)	0	0
Poor ( $<60$ )	0	0
Total	18	19

Mean HSS score at recent follow-up was 86.10 in DP group and 83 in SP groups which is statistically significant (t value 2.81, p values 0.008). All patients in our series had either excellent or good HSS score. None of the patient had fair or poor results. Mean SMFA score

was 27.68 in DP group and 30.38 in SP group which is statistically insignificant (t value -1.95, p value 0.06).

**Table 4: SMFA score.**

SMFA score	Single plating	Dual plating	Statistical value
SMFA score 6 months	43.05	41.47	t value-0.59, p value 0.56
SMFA score 9 months	35.16	33.15	t value-1.03, p value 0.31
SMFA score last follow-up	30.38	27.68	t value-1.95, p value 0.06



**Figure 3: a) Pre-op X-ray showing Schatzker type 5 fracture of patient C; b) Post-op X-ray-good alignment-single plating; c) 7 months follow-up X-ray showing varus malalignment having medial proximal tibial angle  $<82$  degrees.**



**Figure 4: a) Pre-op x-ray showing schatzker type 5 bicondylar fracture of patient D; b) Post-op X-ray showing satisfactory articular surface reduction-dual plating; c) 6 months follow-up X-ray showing loss of articular surface reduction of lateral condyle having step-up of  $>2$  mm as compared to post-operative X-ray.**

## DISCUSSION

In our study, we included a series of 37 bicondylar tibial plateau fractures (TPFs) Schatzker type V or VI, which were all followed up for at least 6 months. We

found high incidence of Schatzker's type 6 in our series which corresponds to many series as described below.

**Table 5: Incidence of type of fracture in various studies.**

Authors	Schatzker's type 5	Schatzker's type 6
Lee et al <sup>8</sup> (SP)	8 (53.3%)	7 (46.7%)
Lee et al <sup>9</sup> (DP)	17 (56%)	13 (44%)
Zheng et al <sup>10</sup> (DP)	23 (42.6%)	31 (57.4%)
<b>Our study</b>	13 (35.1%)	24 (64.9%)

The average time to radiological union of fracture was 17 weeks in the present series, which was comparable to most other series. All fractures in SP group healed by 18.16 weeks (range 14-24 weeks) and in 17.1 (range 14-22 weeks) weeks in DP group which is statistically insignificant. All patients united by 24 weeks in our series.

**Table 6: Time for radiological union.**

Authors	Time for radiological union	
	Single plating	Dual plating
Biggi et al <sup>11</sup>	18 weeks	-
Neogi et al <sup>12</sup>	14 weeks	15.2 weeks
Tien ching lee et al <sup>8</sup>	18 weeks	-
Zheng et al <sup>10</sup>	-	15.4 weeks
<b>Our study</b>	18.6 weeks	17.1 weeks

#### **Hardware impingement**

2 cases of hardware impingement, one in each group was found in which patient was complaining of discomfort over the lateral aspect of injured knee especially while walking too far or climbing stairs and they requested us to remove it after bony union of the tibial plateau fracture. In other studies, increased cases of hardware impingement were noted.

**Table 7: Complications.**

Complications	Neogi et al <sup>12</sup> (61)	Hsuan lee et al <sup>9</sup> (45)	Zheng et al <sup>10</sup> (54)	Ehlinger et al <sup>13</sup> (20)	Our study (37)
<b>Infection</b>	7	3	2	1	1
<b>Cellulitis</b>	-	5	-	-	-
<b>Hardware impingement</b>	9	7	-	9	2
<b>Implant failure</b>	-	1	-	-	-
<b>Stiffness</b>	-	7	9	1	-
<b>Non union</b>	-	7	1	-	-
<b>Post traumatic arthritis</b>	-	7	10	-	0

**Table 8: Showing incidence of loss of alignment in different studies.**

Study	Loss of alignment (%)
<b>Single plating (SP)</b>	
Gosling et al <sup>6</sup>	14
Neogi et al <sup>12</sup>	17.24
Our study	11
<b>Double plating (DP)</b>	
Lee et al <sup>9</sup>	0
David barei <sup>14</sup>	6.2
David barei <sup>14</sup>	6.2

#### **Infection**

Although the open reduction method may involve a larger incision wound, more intraoperative dissection, and greater blood loss, we recorded only one patient with superficial wound infection in lateral wound of DP group. No organism was isolated on aerobic and anaerobic culture and healed subsequently, however prolonged oral antibiotic therapy of 2 weeks was given in this patient.

Rest all incisions healed primarily. There were no cases of deep infection or osteomyelitis. Other studies showed high incidence of infection but we noted very low incidence in our series.

#### **Assessment of articular surface reduction and alignment postoperatively**

Neogi et al had noticed postoperative malalignment and malreduction in their series and he found the incidence of malalignment postoperatively in 3 cases (10.9%) in SP group and in 2 cases (6.2%) in DP group.<sup>12</sup> However such incidence of malalignment and malreduction in immediate post-op X-rays in our series was absent, which is notable.

#### **Secondary loss of reduction and alignment**

##### **Malalignment on follow-up**

Malalignment was common with delayed loss occurring in 11.1% and 5.26% in SP and DP group respectively in our study. Varus collapse was the only pattern for

change of alignment. In spite of this varus collapse, functional assessment outcome was excellent in these cases. Malalignment has also been reported at a significant rate in other series. The criteria used for malalignment have varied. Quality of radiographs and the reliability of the measurement techniques make it hard to compare the different series.

#### Malreduction on follow-up

In our study 2 cases in SP group and 1 case in DP group had malreduction at last follow-up showing step or gap of >2mm. Results of our studies are comparable to other studies.

**Table 9: Showing mal-reduction in different studies.**

Study	Total cases	Malreduction
<b>Single plating (SP)</b>		
Ehlinger et al	20	5 (25%)
Biggi et al <sup>11</sup>	58	5 (8.6%)
Neogi et al <sup>12</sup>	29	2 (7%)
Our study	18	2 (11%)
<b>Dual plating (DP)</b>		
Prasad et al <sup>15</sup>	40	4 (10%)
Neogi et al <sup>12</sup>	32	1 (3.12%)
Zheng et al <sup>10</sup>	54	5 (9.2%)
Our study	19	1 (5.26%)

#### Functional outcome

##### HSS score

Mean score in our series is comparable to other studies.

**Table 10: Mean HSS score in different series.**

Authors	Mean HSS score at last follow-up	
	SP group	DP group
Neogi et al <sup>12</sup>	79	80
Zheng et al <sup>10</sup>	-	77.3
Lee et al <sup>8</sup>	89.6	-
Our study	83	86.1

##### SMFA score

Mean SMFA score was 27.68 in DP group and 30.38 in SP group which is statistically insignificant (t value - 1.95, P value 0.06). Barai et al evaluated the bicondylar fixation of these fracture via two incisions and used this SMFA score.<sup>14</sup> He found a mean SMFA score of 26.05 which is comparable to our series.

#### CONCLUSION

We conclude that single plating and dual plating fixation of complex proximal tibial plateau fracture Schatzker's type 5 and type 6 ensures stable fixation, immediate

mobilization, satisfactory radiological outcome, very high union rates and excellent functional assessment outcome with a very low rate of complications.

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