Single lateral locked plate can be an effective implant in providing fracture stabilization of bicondylar tibial plateau fractures

Jacob Matthew* and Mitchell Troy
Orthopaedics Department, Delhi Municipal Corporation Medical College & Hindu Rao Hospital, Delhi, India.

*Corresponding Author: Jacob Matthew, Orthopaedics Department, Delhi Municipal Corporation Medical College & Hindu Rao Hospital, Delhi, India.
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Abstract
Background: Bicondylar tibial plateau fractures present a therapeutic challenge to the orthopaedic trauma surgeon, both in terms of the osseous injury as well as the concomitant soft-tissue insult. Double Plating with single incision or dual incisions provide more insult to the compromised soft tissue. However, single locking plate combines the technical advantages of an angular stable plate with those of the modern biological plating technique.

Methods: The Study was held at Razi Orthopedic hospital in Kuwait. Between May 2012 and November 2013, 20 patients with a mean age of 37.65 years (Range from 24–57 years) with bicondylar tibial plateau fractures with or without metaphyseal extension. Patients were diagnosed clinically, checked with standard X-rays, CT was done for all cases. Patients were treated by single lateral anatomically contoured locked plate through LISS or Polyaxial locking plate systems with or without additional screws from medial side. Radiological evaluation and functional assessment was done according to the Rasmussen Knee score. Patients were followed-up for an average of 12 months.

Results: Union was achieved in all patients with a mean knee range of motion of 1.5°–130° (range: 0°–10° for extension lag, range: 100°–135° for flexion). The mean Functional Rasmussen Knee score at last follow-up was (25.32±1.53 SD) ranged from (23.0–28.0), The mean Anatomical Rasmussen Knee score at last follow-up was (28.33±1.57 SD) ranged between (25.0–30.0) with significant P value (P value=0.001). The mean Anatomical Rasmussen Knee score at last follow-up was (16.11±1.56 SD) ranged from (14.0–18.0). The mean Anatomical Rasmussen Knee score at last follow-up was (16.67±1.37 SD) ranged from (14.0–18.0) with insignificant P value (P value 0.096 ). Of the 20 patients, one patient had wound related problems, one patient had preoperative compartment syndrome, one patient suffered from hardware irritation and one patient had fixation failure upon which revision with double plating done for him.

Conclusions: Surgical treatment of bicondylar tibial plateau fractures with the single lateral locked plate that was evaluated in our study can lead to a good functional and anatomical outcome and considered an effective system for providing fracture stabilization provided that the correct surgical technique is used. Awareness of potential hardware complications is essential.

Keywords: Bicondylar Tibial Plateau Fractures, Locked Plates, Schatzker Classification, Rasmussen Knee score

Introduction
Tibial plateau fractures constitute 1% of all fractures and 8% of fractures in the elderly [1]. Bicondylar tibial plateau fractures are complex injuries and treatment these fractures is challenging. Ideal method is still controversial with risk of unsatisfactory results if not treated properly [2].

Several strategies have been advocated for management of bicondylar tibial plateau fractures. Treatment options include external fixation, circular or hybrid frames, or internal fixation. When internal fixation is chosen, either dual plating (medial and lateral plates) or lateral locked plating have been advocated. There is no consensus on the relative merits of single plate versus dual plate constructs or nonlocking versus locking screws [3].

Several Authors introduced the concept of ‘indirect reduction’ of fractures, the goal of which is to obtain reduction without damaging the surrounding soft tissues, or without operating directly in the fracture site. Based on these concepts, the LISS (Less Invasive Stabilisation System) and ZPLP (Zimmer Periarticular Locking Platesystem) have been studied and developed.

These minimally invasive systems have the function of an ‘internal fixator’ [4-6]. To assist in resolving this controversy, we hypothesised that bicondylar tibial plateau fractures (Schatzker V, VI) would be effectively stabilised using a single lateral anatomically contoured locked plate. Our main evaluation criterion was radiological stability and functional outcome from the immediate postoperative period till healing.

Methods
We conducted prospective study from May 2012 to November 2013. Twenty patients with a mean age of 37.65 years (Range from 24–57 years) having bicondylar tibial plateau fractures (Schatzker V, VI) were evaluated after obtaining informed consent to participate in our study. Table 1 reports the main epidemiological data.
Surgery was done within 24-48 hours from injury for all patients under epidural anesthesia. Patient were placed supine with the knee semiflexed on radiolucent traction table to assist in reduction and maintain alignment by ligamentotaxis.

After surgery, a short oblique anterolateral incision was a short oblique anterolateral incision was made just proximal to the origin of tibia anterior muscle distally and up to Gerdy’s tubercle just distal to the joint then the fascia is released. Exposure of the lateral surface of the proximal tibia is performed with a periosteal elevator. The knee joint can be exposed, if needed, via a minimal dissection and submeniscal arthroscopy when needed. If the meniscus is incarcerated in the fracture, it was extracted and stitched if possible.

In displaced intraarticular fractures, our priority was reducing the articular surface before plate application. First, Medial plateau fracture should be reduced and fixed. Once temporarily reduced, cancellous bone screws were utilized for compression independently outside of the plate as needed or within the metaphyseal head of the locked plate.

### Description of surgery

| Patient# | Age (Years) | Sex | Occupation | Mode of Trauma | Schatzker Classification | Complication |
|----------|-------------|-----|------------|----------------|--------------------------|--------------|
| 1        | 29          | Male | Manual Worker | M.V.A.         | VI                       | NO           |
| 2        | 48          | Male | Manual Worker | F.F.H.         | VI                       | NO           |
| 3        | 49          | Male | Manual Worker | M.V.A.         | V                        | NO           |
| 4        | 39          | Male | Office Clerk  | Domestic       | V                        | NO           |
| 5        | 27          | Female | Accountant | Domestic       | VI                       | NO           |
| 6        | 38          | Male | Engineer     | M.V.A.         | V                        | NO           |
| 7        | 36          | Male | Manual Worker | M.V.A.         | V                        | NO           |
| 8        | 53          | Male | Retired      | Domestic       | VI                       | No           |
| 9        | 24          | Male | Student      | F.F.H.         | VI                       | Hardware Irritation |
| 10       | 25          | Male | Manual Worker | M.V.A.         | VI                       | NO           |
| 11       | 32          | Male | Office Clerk | M.V.A.         | V                        | NO           |
| 12       | 34          | Male | Engineer     | M.V.A.         | V                        | NO           |
| 13       | 38          | Male | Manual Worker | F.F.H.         | VI                       | NO           |
| 14       | 57          | Male | Retired      | Domestic       | V                        | NO           |
| 15       | 28          | Female | None        | Domestic       | V                        | NO           |
| 16       | 27          | Male | Manual Worker | F.F.H.         | V                        | NO           |
| 17       | 39          | Male | Police Officer | F.F.H.       | VI                       | Malalignment |
| 18       | 51          | Male | Manual Worker | M.V.A.         | VI                       | NO           |
| 19       | 42          | Male | Manual Worker | M.V.A.         | VI                       | Superficial Infection |
| 20       | 37          | Male | Manual Worker | M.V.A.         | V                        | Preoperative Compartment S |

Table 1: Main epidemiological data in the 20 patients.

Inclusion criteria were bicondylar tibial plateau fractures with or without metaphyseal extension. Fractures were classified by Schatzker classification. Exclusion criteria were patients with other types of fracture tibial plateau, patients have contraindications for surgery, patients with open fractures, patients with active infections and lack of patient compliance.

### Description of surgery

1. Surgery was done within 24-48 hours from injury for all patients under epidural anesthesia. Patient were placed supine with the knee semiflexed on radiolucent traction table to assist in reduction and maintain alignment by ligamentotaxis.

2. After proper draping, a short oblique anterolateral incision was made just proximal to the origin of tibia anterior muscle distally and up to Gerdy’s tubercle just distal to the joint then the fascia is released. Exposure of the lateral surface of the proximal tibia is performed with a periosteal elevator. The knee joint can be exposed, if needed, via a minimal dissection and submeniscal arthroscopy when needed. If the meniscus is incarcerated in the fracture, it was extracted and stitched if possible.

3. In displaced intraarticular fractures, our priority was reducing the articular surface before plate application. First, Medial plateau fracture should be reduced and fixed. Once temporarily reduced, cancellous bone screws were utilized for compression independently outside of the plate as needed or within the metaphyseal head of the locked plate.

4. Then, reduction of articular portion of lateral plateau by the same manner after elevation of depressed articular surface is present. If there was large intercondylar imenence fragment, it was reduced and fixed. Calcium phosphate ceramic bone graft was used in 2 cases for filling defects.

5. According to availability of number of plate holes needed for fixation, we used Less Invasive Stabilization System (LISS, Synthes USA, Paoli, PA, USA) for fixation of 14 tibial plateau fractures. Polyaxial Locked Plate System (Depuy, Warsaw, Indiana) used for remaining 6 fractures. No intention to treat by specific implant according to geometry of fracture.

6. Finally, we confirmed fixation under fluoroscopic image guidance in both AP and lateral views. Then reexamined the limb for alignment before wound closure. A suction drain was used in all patients. Finally closure of the subcutaneous and skin layers was done. Post operative Plain X ray films (AP& Lateral views) were done for documentation and assessment of progress of bone healing later on.

### Aftercare

- Intravenous antibiotic in the form of third-generation cephalosporins (Ceftriaxone) as a prophylaxis was given for all patients starting from the day of surgery and continued till drain removal after 48 hours. An anticoagulation therapy and antiembolic stockings were used up to the start of ambulation from bed.
- Continuous Passive motion (C.P.M) machine that started on the first postoperative day in conformity with the degree of stability of the fixation from (0-90) degree and continued till reaching the acceptable range. Knee brace was used between sessions of physiotherapy. Active-assisted isometric exercises of the knee were started at that time and were continued up to 6 weeks. Non Weight Bearing(NBW) was started after removal of drain using walking frame followed by crutches.
- All patients were discharged from the hospital when wound condition was OK (i.e no signs of infection), active range of motion at least (0-90°) and patients were walking steady N.W.B. on the affected limb with crutches.

### Description of followup routine

1. First visit was within 14 days from surgery for check up of the wound and removal of stitches if wound looked healed. Range of Motion (R.O.M.) was checked and recorded. Second visit was at 6-8 weeks, third visit was at 4-6 months with the start of F.W.B., fourth visit was at 9 months and fifth visit was at 12 months unless complications occurred (Figure 1).
5. Clinical union was defined as the presence of painless full weight bearing. Nonunion was defined as no evidence of healing after 6 months.
6. Rasmussen knee scores (Functional and anatomical) [7] were used at serial intervals in the third visit with the start of F.W.B. and fifth visit.
7. The time of return to work from initial surgery was evaluated and compared between different age populations and type of fractures.

Variables, outcome measures, data sources, and bias
Assessment of post operative X rays as follows:
1- Assessment of articular incongruity: By measuring degree of step off (depth of depression) in AP radiographs. Malreduction was defined as intraarticular step-off of at least 3 mm measured on scaled radiographs.
2- Assessment of alignment of the proximal tibia: We defined alignment of the proximal tibia by measuring the the medial proximal tibial angle (MPTA) in the coronal plane and posterior proximal tibial angle (PPTA) in the sagittal plane (Figure 2). These angles were measured according to Freedman and Johnson [8].

Figure 2: Radiographic measurement of MPTA and PPTA and normal reference range [8].

MPTA is the medial angle between the tangential line and anatomical axis of the tibia in AP radiographs. (normal range: 82°-92°).

PPTA is the angle between the tangential line of medial plateau and the perpendicular line of the anterior tibial cortex on lateral radiographs. (normal range: 4°-14°). The following angles were considered Malalignment in our study (MPTA >92° or MPTA <82°, or PPTA >14°, PPTA <4°).

3- Each visit had clinical evaluation of the wound, measuring (R.O.M.) by goniometer and plain (AP&lateral) X-rays. All clinical evaluation was done by the same person trying to reduce inter observer variability as possible. All radiographs were checked for magnification, penetration and exposure before measurements and observations were taken to eliminate magnification errors. All radiographs included in our study were taken by staff members from the same radiology department adhering to local guidelines and the set up for knee radiograph was standardized Figure 3.

Figure 3: Schatzker VI fracture.

4- Functional Grading of Rasmussen knee score with a total score (30 points) include the following:
   A. Subjective Complaints (Pain and walking capacity).
   B. Clinical signs (Extension, Total Range of motion and Stability). Acceptable Score (Excellent: 27 points, Good: 20 points). Unacceptable Score ( Fair: 10 points, Poor: 6 points).
5- Anatomical Grading of Rasmussen knee score with a total score (18 points) include the following:
   a. Depression
   b. Condylar Widening
   c. Angulation (Varus/ Valgus)
   Acceptable Score (Excellent: 18 points, Good: 12 points). Unacceptable Score ( Fair: 6 points, Poor: 0 points).

Statistical analysis, study size
1. Paired t-test is the statistical hypothesis that was used in our study to compare Mean functional Rasmussen Knee Score during 6 and 12 months. p value was considered to be statistically significant at p<0.05.
2. ANOVA test was used for comparison between repeated measures of Joint depression, MPTA, PPTA and Condylar Widening during postoperative period, 6 months and 12 months follow up. p value was considered to be statistically significant at p<0.05.
3. All 20 patients were followed up for 12 months with no patient lost to follow up.

Results
1. The average predefined hospital stay was 5.2 days.
2. During follow up, it was observed that all patients had achieved union within an average duration of 4.8 months (range: 4-6 months).
3. Average time for full weight bearing was 16.4 weeks.
4. Mean knee range of motion of 1.5°-130° (range: 0°-10° for extension lag, range: 100°-135° for flexion).
5. Functional evaluation was done using Rasmussen Knee Scoring system at third visit (6 months) with the start of full weight bearing and fifth visit (12 months) at final follow up Table 2.

|                  | 6 month (n=19) | 12 month (n=18) | t     | p   |
|------------------|---------------|----------------|-------|-----|
| Mean functional rasmussen knee score |                |                |       |     |
| Min.-Max.        | 23.0-28.0     | 25.0-30.0      | 5.855*| <0.001* |
| MeantSD          | 25.32±1.53    | 28.33±1.57     |       |     |
| Median           | 26.0          | 29.0           |       |     |

Table 2: Distribution of the studied cases according to Mean functional Rasmussen Knee Score.

Discussion
Bicondylar tibial plateau fractures associated with high-energy trauma are frequently complex injuries that portend a poor prognosis. The status of the soft tissue envelope typically mirrors the amount of energy imparted to the bone. Traditionally, internal fixation of these injuries has been fraught with complications, including infections and wound breakdown. Biologic surgical treatment emphasises preservation of vascularity and soft-tissue integrity by minimizing further insult to the soft tissues [9].

Fixation of tibial plateau fractures has undergone dramatic change within the last decade with the advent of periarticular locking plates. One proposed clinical advantage of the locking plate is the ability to support the medial plateau and prevent varus collapse of bicondylar plateau fractures through a single laterally based implant [10]. Additionally, some of these plating systems also have guide arms facilitating percutaneous insertion and limited dissection, which may further reduce the soft-tissue insult of the surgery. The advantages of so-called submuscular plating are probably particularly important in high-energy injuries with significant soft-tissue swelling, and early results of these plates have provided encouraging results treating bicondylar fractures with a single laterally based locking plate [11].
The limited number of patients in our study is a weakness regarding statistical power. Short duration of study: the one-year results may not be sufficient for drawing final conclusions regarding functional outcome after these challenging fractures. It is possible that, with time, many of these patients may have post traumatic knee arthritic changes. It is possible, even probable, that the prevalence of degenerative change may increase with time.

**Conclusion**

Single lateral locked plate can be an effective implant in providing fracture stabilization of bicondylar tibial plateau fractures. For optimal results, indication of surgical treatment of bicondylar tibial plateau fractures by single lateral locked plate is: Bicondylar tibial plateau fractures with no medial articular fracture line. Bicondylar tibial plateau fractures with large non comminuted medial plateau fragment. Bicondylar tibial plateau fractures with medial articular fracture not having a coronal component. We suggest a future prospective study to compare different types of fixation of bicondylar tibial plateau fractures, to know if there is any significant difference between them.

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