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ORIGINAL STUDY

# Treatment of posterolateral tibial plateau fractures through fibular osteotomy approach

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**The best approach for treating posterolateral tibial plateau fractures remains controversial. The aim of the present study was to evaluate the outcomes of patients with posterolateral tibial plateau fractures after open reduction and internal fixation with the fibular osteotomy approach.**

**Between January 2009 and July 2012, twelve patients with posterolateral tibial plateau fracture were treated using the fibular osteotomy approach with a proximal tibia locking compression plate. The epidemiological data, operation details, and clinical outcomes over 25.6 ± 2.1 months (range, 22-38 months) of follow-up were prospectively collected and analyzed.**

**The average surgical duration was 92.5 ± 14.5 min (range, 83–107 min). An anatomical reduction rate of 91.7% (11/12) was observed, although one patient with a lateral comminuted fracture and dislocation had a 2-mm joint surface depression postoperatively. The average fracture healing time was 11.6 ± 3.1 weeks (range, 8-15 weeks), with an average hospital for special surgery knee score of 94.1 ± 3.2 points (range, 80-100 points), an average knee flexion of 118.6° ± 18.1° (range, 96°-138°) and an average knee extension of 1.9° ± 2.2° (range, 0°-6.3°). No complications were found.**

**The fibular osteotomy approach with a proximal tibial compression plate can produce a satisfactory clinical outcome for patients with posterolateral tibial plateau fractures.**

**Keywords** : Posterolateral tibial plateau fracture ; fibular osteotomy approach ; internal fixation.

**Abbreviations**

ORIF: Open reduction and internal fixation
CT: Computed tomography
HSS: hospital for special surgery

## INTRODUCTION

Tibial plateau fractures are commonly encountered in clinical practice, and posterolateral tibial plateau fractures account for approximately 7% of all plateau fractures *(1)*. The injury results from the tibial articular surface being stressed by the valgus and by axial force when the knee joint is in a flexed or semi-flexed position *(2)*. This type of tibial plateau fracture is more problematic and disabling and can cause significant chronic

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posttraumatic instability of the knee *(3)*. Unstable flexion usually occurs unless residual impaction of the posterolateral tibial plateau is reduced *(4)*. Open reduction and internal fixation (ORIF) are essential to decrease posttraumatic complications in these patients. Although a great deal of experimental studies and clinical efforts have been made to develop surgical approaches to manage posterolateral tibial plateau fractures in the past few decades, controversy still exists as to the best surgical approach *(5,17)*.

Currently, the anterolateral and posterolateral approaches are recommended for this fracture *(6)*. Although the posterolateral approach results in direct reduction and fixation of the posterolateral tibial plateau fracture, it still has several limitations. First, the operative field is limited, and the complex local structure increases the iatrogenic injury risk *(7,8)*. Second, the medial part of the fibular head interferes with operative manipulation, and postoperative scars and anatomic changes result in easy damage to the vessels and nerves upon removal of the fixation *(9,14)*.

In this study, the fibular osteotomy approach was used for posterolateral tibial plateau fracture. This approach protects soft tissue and ligamentous structures and can preserve the soft tissue around the posterolateral fragments. The aim of our study was to evaluate the clinical outcomes of our patients with a posterolateral tibial plateau fracture managed with ORIF through a fibular osteotomy approach.

## METHODS

The study protocol, including the access to and the use of the medical records of the study subjects, was reviewed and approved by the Institutional Ethics Committee of Xi'an Hong Hui Hospital (permit number: 2016021).

Clinical records including preoperative radiographs (Fig. 1a) and computed tomography (CT) scans (Fig. 1b,c,d) and operative notes of patients with tibial plateau fractures managed and followed at Xi'an Hong Hui Hospital, between January 2009 and July 2012, were accessed through the Records Department of the hospital. The inclusion criteria were as follows: (1) posterolateral tibial plateau fracture, as revealed by CT scan; (2) treatment with ORIF through the fibular osteotomy approach; and (3) patients who received follow-up postoperatively.

Twelve patients with posterolateral tibial plateau fractures were treated with an LCP (Proximal Tibial Plate, DaBo, LCP-3.5, China) through a fibular osteotomy approach in our department (Table 1). The patients consisted of seven males and five females with a mean age of 30.5 ± 10.9 years (range, 21-39 years). All operations were performed by the same experienced surgeons, and data were collected prospectively. All patients presented with fresh fractures, and the preoperative waiting time was 6.5 ± 3.8 days (range, 4-14 days). The causes of the injury were traffic accidents for eight patients and falling from a height for four patients. One patient also had anterior cruciate ligament injuries. Four patients had posterolateral fractures alone, and seven had both posterolateral fractures and anterolateral fractures. One patient had a combined ankle fracture.

The fractures were classified according to the Schatzker classification system based on preoperative computed tomography (CT) scan results. There was one patient with a Schatzker II fracture (posterolateral condyle split fracture), two with Schatzker III fractures (posterolateral condyle depression), five with Schatzker IV fractures (posterolateral condyle split and depression), and four with Schatzker V fractures (posteromedial condyle split and posterolateral condyle depression). According to the Orthopaedic Trauma Association (OTA) classification, there was one patient with a type 41-B1 fracture, four with type 41-B2 fractures, and seven with type 41-B3 fractures.

After the induction of general anesthesia or combined spinal-epidural anesthesia, the patients were placed in a supine position while lower limb blood flow was blocked by a pneumatic tourniquet. In this research, seven patients were operated on using lateral incision of the knee, and five were operated on using lateral and posteromedial incision of the knee.

Pure posterolateral fractures of the tibial plateau were Schatzker type II and III fractures. The designed surgical approach uses an approximately


*Fig. 1* — The patient was a 43-year-old male with a posterolateral splitting collapsed fracture of the tibial plateau. a) X-ray; b,c) 3D CT reconstruction showing posterolateral splitting collapse fracture of the tibial plateau; d) CT reconstruction showing posterolateral splitting collapse fracture of the tibial plateau; e) X-ray after the operation; f,g) X-ray two years after the operation.

Table I. — Demographic and operative details of patient

| Patient Number | Age (years) | Sex | Fracture Type (Schatzker classification) | Fracture Type (OTA classification) | Mechanism of injury | Preoperative waiting time (Days) |
|---|---|---|---|---|---|---|
| 1 | 30 | F | IV | 41-B3 | Falling from height | 6 |
| 2 | 46 | M | V | 41-B3 | Traffic accident | 8 |
| 3 | 43 | M | VI | 41-B3 | Traffic accident | 13 |
| 4 | 41 | F | III | 41-B2 | Traffic accident | 5 |
| 5 | 28 | M | III | 41-B2 | Traffic accident | 6 |
| 6 | 62 | F | IV | 41-B3 | Falling from height | 8 |
| 7 | 57 | M | V | 41-B3 | Traffic accident | 7 |
| 8 | 44 | M | IV | 41-B3 | Traffic accident | 8 |
| 9 | 65 | M | II | 41-B2 | Falling down | 3 |
| 10 | 31 | F | VI | 41-B3 | Traffic accident | 14 |
| 11 | 72 | M | II | 41-B2 | Falling down | 3 |
| 12 | 23 | F | V | 41-B3 | Traffic accident | 12 |

15-cm-long “S”-shaped incision starting from the fibular head flat above 5cm and extending down distally to 10cm. The common peroneal nerve is seen on the trailing edge of the biceps femoris, which was bluntly dissected freely along the medial anterior fibula. A rubber strip retractor was used as protection. The tibialis anterior muscle membrane was cut along the outer edge of the tibia and then stripped subperiosteally to expose the outer surface of the tibialis anterior. To retain the iliotibial band and keep the lateral collateral ligament at the fibula head, the fibula was truncated obliquely below the fibular head at approximately 2cm. The fibula was turned over at the proximal tibia, the joint capsule and coronary ligament were cut, the lateral meniscus was pulled to the proximal retractor, and the lateral and posterolateral tibial plateau were fully revealed . The posterolateral tibial plateau fracture was reset under direct vision. For the collapsed fracture fragments, the reduction was poked to reset it through the fracture gap or a small bone window hole was used to restore the smooth articular surface. The posterolateral split fracture could be temporarily fixed using Kirschner wire under the outside of the cartilage. Positive and lateral fluoroscopy was used with a “C” type arm X-ray machine to determine the satisfaction with the reset.

Bone defects caused by the collapse of bone were filled with artificial or autologous bone graft to restore the flatness of the articular surface. The “L” shaped steel plate was placed on the outside of the tibial plateau. Cartilage discharge nail technology could support the collapsed fracture. For posterolateral bone splitting, one screw at the rear side plate was used to fix it. The fibular osteotomy was fixed by tension band while paying attention to the position of the Kirschner wire to avoid peroneal nerve irritation.

Schatzker V tibial plateau fractures first involved performing a routine back-inside incision. After the reset of the medial condyle fracture or back medial condyle, three shaped or “T” shaped steel plates were used for fixation. A satisfactory fixation was confirmed using “C” type arm fluoroscopy. Then, a lateral incision was performed and reset with fibular osteotomy, and the lateral fracture was fixed. The surgery should avoid damage to the normal attachment fibular collateral ligament and biceps tendon. If there was a medial collateral ligament injury, then the first period repair was performed. If there was a broken meniscus, the broken area was stitched. Lateral torn meniscus was completely repaired during surgery if a longitudical meniscus tears occurs. In the event of more severe meniscal tears such as a bucket handle tear, arthroscopic surgical procedures may be necessary to repair the lesion. The lateral meniscus repair was done in nine patients. The drainage tube was placed inside the joint with a pressure dressing. There was one case of cruciate ligament rupture, and the patient refused surgery. By postoperative follow-up, the knee drawer test was negative.

After waking from anesthesia, most patients were encouraged to begin lower limb muscle exercises, which included functional exercises of the quadriceps, flexion and extension exercises of the ankle joint and flexion and extension exercises of the knee joint using a continuous passive motion machine twice a day. Partial weight bearing was allowed 8 weeks after the operation. Full weight bearing exercises were started 12-16 weeks after surgery. Every patient received antibiotics from the day of surgery until 48 hours after the surgery. A pain pump was used to control local pain. Each patient received X-rays (Fig.2e) and CT examinations, and the fracture reduction and fixation conditions were observed.

The modified hospital for special surgery (HSS) knee scoring system was used to evaluate postoperative knee function (Fig.2h). Hospital radiographs and charts were reviewed by two orthopedists. Age, gender, duration of surgery, cause of injury, and bone healing time were recorded. Morbidity, mortality, complications, and radiographic changes 2 years after surgery were also recorded (Fig.2f,g). Fracture healing was indicated by the presence of continuous bony callus at the fracture site without clinical symptoms, and the fracture healing time was defined as the time from the surgery to the day that fracture healing was confirmed.

The follow-up visits occurred l, 3, 6, 12 months later and then once every 6 months. Patients were asked about the improvement in symptoms and had physical examinations conducted and X-ray films collected to assess fracture healing during follow-up. Complications that occurred during follow-up were recorded. At the last follow-up, the modified hospital for special surgery (HSS) knee scoring system was used to assess the knee function.

The analyses and calculations were performed using SPSS 15.0 software. Data were expressed as the mean ± SD. Paired samples were processed with t-tests. P values < 0.05 were considered statistically significant.

## RESULTS

Follow-up was completed for twelve fractures in twelve patients with an average follow-up time of 25.6 ± 2.1 months (range, 22-38 months). Eleven patients achieved anatomic reduction. Among the twelve patients, one patient with a lateral comminuted fracture and dislocation still had a 2-mm joint surface depression postoperatively. The average HSS score was 94.1 ± 3.2 points (range, 80–100 points). There was an average knee flexion of 118.6° ± 18.1° (range, 96–138°) and an average knee extension of 1.9° ± 2.2° (range, 0–6.3°). Radiographs obtained at the final follow-up showed that fixation was stable in all patients, with no fracture displacement or plate rupture observed.

The average operation duration and bleeding volume during operation were 92.5 ± 14.5min and 105± 20.6ml, respectively. There were no occurrences of wound infection, plate loosening or breakage, nonunion, valgus knee deformity, or fracture re-displacement in any of the patients. All patients were followed with anteroposterior and lateral X-ray and CT, which showed anatomic reduction or near-anatomic reduction.

## DISCUSSION

Lateral tibial plateau fracture is a fracture involving the latter part of the lateral condyle of the tibia with symptoms of splitting and collapse. It can be a fracture of only the lateral condyle of the tibia or combined with tibial condyle or metaphyseal fractures. The mechanism of the injury of the lateral tibial plateau fracture is that the knee joint is pressed by the valgus and axial stress when the knee is in flexion *(10)*. Therefore, the injury surface was more likely to be on the coronal plane fracture line, which is a rare injury *(11)*. Such fractures occur on the positive and lateral area of the knee joint and appear negative on X-ray films, especially for simple compression fractures that sometimes show only a partial increase in the density of the outer platform on X-ray films *(12,16)*. Because fracture type is prone to misdiagnosis, preoperative CT scan with two-dimensional plus three-dimensional reconstruction is required to define the type of fracture *(13)*. Lateral tibial plateau fractures has not been given much attention in clinical practice. The commonly used Schatzker classification system and AO classification systemdo not adequatelydescribe it. According to CT-based three-column types by Zhang W et al. *(17)*, posterolateral fractures are mostly posterior column fractures. Brown et al. *(4)* showed that the local stress level increased 75% while the articular surface was 3mm, and the greater the articular surface, the more the local stress increased. Therefore, if the collapse was >3mm, the CT scan showed the fracture block located at the posterolateral tibial plateau near the head of the fibula, and the fracture should be treated with surgery. The posterolateral bone should be treated with anatomical reduction and rigid internal fixation to restore the integrity of the articular surface and reduce the incidence of postoperative loss of reduction.

In recent years, most scholars have advocated the use of the posterior approach or posterolateral approach, and posterior support steel plate treatment has achieved good results in this type of fracture. However, this approach has the risk of damaging blood vessels, and nerve impact around the tibial artery bifurcation makes the incision extend distally. As the patient takes a prone position while his knee is bent slightly, the posterior joint space is narrow, which creates a limited exposure range of the fracture for as mall and deep incision. The posterior muscles of the knee are rich with tough ligaments and tendons. Therefore, it is difficult to strip. However, the posterior capsule is plump, and the posterior cruciate ligament ends there. All these factors make it more difficult to expose and look directly at the articular surface. It is difficult to accurately determine restoration during surgery. There is no obvious reference anatomical structure during reset reduction. Meanwhile, the bevel at the back of the tibial plateau can impact the lateral bone reset. This issue can easily lead to an undesirable reset. Chang et al. *(5)* reported that 4 of 8 patients with posterolateral lateral tibial plateau fractures treated with a posterolateral approach developed 10° to 20° flexion contracture. This contracture could have some impact on patient knee shape and gait.

Yu et al. *(15)* reported that the method to treat tibial plateau fractures through the fibular head could help in lateral tibial plateau fracture reduction and fixation. After fibula head osteotomy, the syndesmosis should be stitched in accordance with the anatomical level. We believe that the proximal tibiofibular joint is amphiarthrotic, and the joint capsule is tight. Thus, it is very difficult to suture according to anatomical level. Meanwhile, after part of the fibula head is resected, the proximal tibiofibular joint capsule will heal with the outside bone of the fibula head, which will form scar tissue due to the difficulty of the ligament and bone healing together. This healing will influence the action of the proximal tibiofibular joint.

We chose to treat lateral tibial plateau fractures with fibular osteotomy, which has certain advantages over traditional incision. The incision extends far and wide from the fibular head and fibula and can fully meet the demand of exposure, reduction and fixation. For V and VI tibial plateau fractures, the patient's position is not required to change during the surgery, which is also one advantage of the approach. There are no major blood vessels or nerve tissues on the front and rear side of the incision. The soft tissue outside of the knee joint is thin and easy to reveal. The surgery should carefully avoid the peroneal nerve below the fibula head. The proximal tibiofibular joint capsule should be cut off during the surgery by an oblique osteotomy below the fibular head to increase the contact area to enhance the healing of the osteotomy of the fibula. Meanwhile, proximal traction can fully reveal the outer part of the posterolateral knee. The articular surface can achieve anatomical reduction, and this reduction can reduce the stress concentration and prevent joint degeneration. The steel plateau in the proximal tibiofibular joint capsule can cause tibiofibular joint separation, but it has no significant effect on the tibiofibular joint or its movement. The movement of the tibiofibular joint includes upper and lower movement and rotation. For the safety of the fibular head resection, domestic and foreign scholars took the tibiofibular joint as a transplant donor, and the follow-up showed no functional disability. None of the patients developed ankle pain after surgery.

Currently, there is no unique design for the fixing of anatomical plates for posterior-lateral tibial plateau fracture. Some scholars have suggested that reconstruction plates can be used as a support plate to fix the posterior and lateral fracture block. We chose an “L” shaped steel plate whose proximal transverse hole can fully contain the posterolateral parts of the tibial plateau. Meanwhile, nail technology can be used to support the articular surface. Bone grafts can be used when necessary. This part of the fibular osteotomy was fixed using tension straps. The outside structure, especially the composite structure of the fibula head, should be kept intact as much as possible while performing fibular osteotomy. If these structures are cut, the doctor should suture the joint capsule and ligaments according to anatomical level to strengthen the stability of the lateral treatment. Be aware of common peroneal nerve injury. For preoperative patients with fibular head fracture, doctors should turn up the fibula head in a proximal direction to reveal the posterior-lateral part of the tibial plateau as a prerequisite of reserving the iliotibial ligament and lateral collateral ligament ending point. The fibular head should be fixed by tension straps after completing the reduction and fixation of the posterolateral tibial plateau.

## CONCLUSION

Fibular osteotomy can fully expose the lateral tibial plateau fracture and can achieve satisfactory reduction and fixation, but there is no obvious advantage in surgery time or bleeding because of the relatively complex surgical process, which requires the peroneal nerve anatomy and fibula to be truncated and fixed. We do not suggest the removal of the internal fixation. To date, there are no reported results from removing the internal fixation for complications. The steel plateau located between the tibiofibular joint and its influence on joint movement requires further observation. There are few cases in this research, and the follow-up time was relatively short. The incidence of traumatic arthritis still requires long-term follow-up observation. The superiority of this approach requires a longer time and a larger sample to be confirmed. in 95,5 % of the operated levels after 6 months.

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