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# INJURED MORPHOLOGY AND SELECT THE CORRESPONDING APPROACH OF POSTERIOR TIBIAL PLATEAU FRACTURES ON COMPUTED TOMOGRAPHY WITH THREE-DIMENSIONAL RECONSTRUCTION

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## ABSTRACT

***Background:*** *Posterior tibial plateau fractures occur when a fall causes the femoral condyle to impact the knee joint while it is in a bent position. This fracture type is not typical among accident cases and normally is relative to high-energy trauma. A computed tomography with a three-dimensional knee joint can accurately establish the knee joint performance to evaluate and diagnose articular surface, type of fractures and surgical planning.* ***Objectives:*** *To examine the morphology of posterior tibial plateau fractures using 3D CT scans. To select and determine the appropriate surgical approach for each type of fracture.* ***Materials and methods:*** *This study included 25 cases of posterior tibial plateau fractures, all of which were treated using three-dimensional CT scans at Can Tho University of Medicine and Pharmacy Hospital and Can Tho Central General Hospital from June 2022 to April 2024.* ***Results:*** *Samples in the study comprised 25 patients, out of whom male respondents were 40%, and female respondents were 60%. The average age was 39.84 ± 14.37 with the highest proportion being the age group 16-40 years old (48%). Isolated fractures of the posterolateral column accounted for 4%, isolated fractures of the posteromedial column for 8%, fractures involving the posteromedial and medial columns for 24%, and posterolateral and lateral column fractures for 16%. The most complex fractures, involving all three columns, accounted for the highest rate of 48%. Most patients underwent surgery in the supine position (92%) for the anterolateral, anteromedial, and posteromedial approach, with 2 patients in the prone position for the reverse L-shaped approach. Our choice of surgical approach is relatively consistent with international studies.* ***Conclusions:*** *The research provides many morphological tibial plateau fractures with 3D CT scans to support classifying the posterior tibial plateau fractures and assists the surgeon in selecting the most suitable surgical approach and optimizing bone fixation techniques tailored to each specific fracture type.*

***Keywords:*** *injured morphology, tibial plateau fractures, three-column, approach.*

## I. INTRODUCTION

The tibial plateau fracture is related to the joint surface of the upper end of the tibia articulating with the distal end of the femur, accounting for about 1% of all fractures. Among them, the posterior column fracture of the tibial plateau occurs when a fall mechanism impacts the femoral condyle on the knee joint in a flexed position [1], [2]. This fracture type is less common and is usually associated with high-energy trauma. Initial clinical imaging

is usually performed with a straight knee X-ray, which is commonly used to assess bone fracture morphology, surgical planning, and prognosis, following the Schatzker classification. However, in instances of intricate fractures with substantial joint damage, conducting CT scans of the knee joint with 3D reconstruction is often imperative to thoroughly assess the bone fracture morphology, determine optimal surgical approaches, minimize unnecessary dissections during surgery, and mitigate surgical complications [3], [4].

Currently, at Can Tho, there exists no systematically conducted research on evaluating the role and significance of 3D CT scans of the knee joint in patients with tibial plateau fractures involving the posterior column. Therefore, this study was initiated to better understand the different types of posterior tibial plateau fractures and the corresponding surgical approaches used for their treatment.

## II. MATERIALS AND METHODS

### 2.1. Materials

Patients were diagnosed with posterior tibial plateau fractures and treated with surgical fixation using plates and screws.

**- Inclusion criteria:** Patients aged 16 and above, diagnosed with closed posterior tibial plateau fractures confirmed by CT scans, who consented to participate in the study, and were scheduled for post-operative follow-up evaluations as per the hospital's protocol.

**- Exclusion criteria:** Pathological fractures; patients with accompanying cervical spine or lumbar spine injuries resulting in paralysis of both lower limbs; patients with pelvic fracture tibial plateau fractures in limbs with congenital deformities, previously treated or operated tibial plateau fractures.

### 2.2. Methods

**- Study design:** A descriptive cross-sectional study.

**- Sampling method:** Convenience sampling method.

**- Location and study period:** Can Tho University of Medicine and Pharmacy Hospital and Can Tho Central General Hospital, June 2022 to April 2024.

**- Study contents:**

+ General characteristics: age, gender.

+ Tibial plateau fracture classification based on the three-column theory using CT scans.

+ Associated injuries: anterior cruciate ligament avulsion, posterior cruciate ligament avulsion, fibula fracture.

+ Surgical approach for posterior tibial plateau fractures: reverse L-shaped incision, anterolateral approach, anteromedial approach, posteromedial supine approach.

**- Statistical analysis:** The data were analyzed using SPSS 26.0 software.

## III. RESULTS

### 3.1. Patients' characteristics

Table 1. Age and gender distribution

| Age | Male (n = 10) | Female (n=15) | Total No. (n=25) | Percentage (%) |
|---|---|---|---|---|
| Median (years) | 38.50 ± 14.22 | 40.73 ± 14.90 | 39.84 ± 14.37 | |
| 16-40 years | 5 | 7 | 12 | 48 |
| 41-60 years | 4 | 6 | 10 | 40 |
| >60 years | 1 | 2 | 3 | 12 |

The average age in the study was 39.84 ± 14.37 years. The average age of males and females was respectively: 38.50 ± 14.22 and 40.73 ± 14.90. Ages 60 and below accounted for 88%, indicating that tibial plateau fractures commonly occur in younger or working-age individuals.

### 3.2. Injured morphology

Table 2. Posterior column fractures for each type of injury

| Fractured Column | Schatzker classification | Number of cases (n=25) | Percentage (%) |
|---|---|---|---|
| Posterolateral column | Schatzker I, II | 1 | 4 |
| Posteromedial column | Schatzker IV | 2 | 8 |
| Posteromedial + medial column | Schatzker IV | 6 | 24 |
| Posterolateral + lateral column | Schatzker I, II | 4 | 16 |
| All Three Columns | Schatzker V, VI | 12 | 48 |
| Total | | 25 | 100 |

There were 11 cases of left tibial plateau fractures and 14 cases of right tibial plateau fractures. The fracture types observed in our study are as follows: isolated fractures of the posterolateral column constituted 4%; isolated fractures of the posteromedial column comprised 8%; fractures involving both the posteromedial and medial columns made up 24%; fractures involving both the posterolateral and lateral columns constituted 16%; and fractures involving all three columns represented the highest proportion at 48%.

### 3.3. Associated injuries

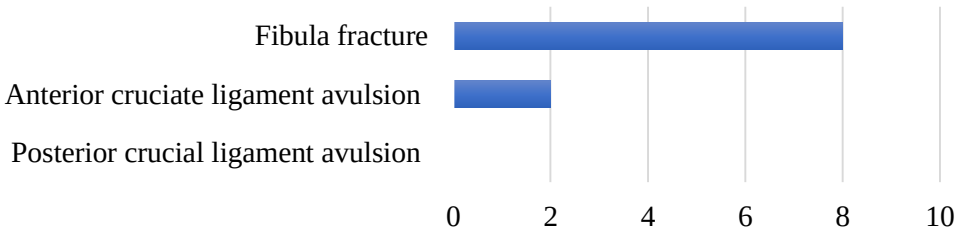


Chart 1. Ligament and fracture-associated injuries

Ligaments within the knee stabilization system were often affected when a tibial plateau fracture occurs. In our study, anterior cruciate ligament avulsion injuries were commonly associated with posterior tibial plateau fractures, accounting for 8% of cases, while there were no instances of posterior cruciate ligament avulsion injuries. Fibula fractures were also observed in 8 cases, accounting for 32% of cases.

### 3.4. Surgical approach selection

Table 3. Surgical approach choices

| Type of fractured column | Reverse L-shaped approach | Posteromedial supine approach | Anteromedial approach | Anterolateral approach | Total Surgical Approaches |
|---|---|---|---|---|---|
| Posteromedial column | 2 | 0 | 0 | 0 | 2 |
| Posterolateral column | 0 | 0 | 0 | 1 | 1 |

| Type of fractured column | Reverse L-shaped approach | Posteromedial supine approach | Anteromedial approach | Anterolateral approach | Total Surgical Approaches |
|---|---|---|---|---|---|
| Posterolateral + lateral column | 0 | 0 | 0 | 4 | 4 |
| Posteromedial + medial column | 0 | 0 | 6 | 0 | 6 |
| All Three Columns | 0 | 8 | 4 | 12 | 24 |
| Overall | 2 | 8 | 10 | 17 | 37 |

In our study, we employed four types of surgical approaches. The anterolateral approaches were predominantly utilized, comprising 45.9% of cases. The L-shaped posterior approach was used in at least 5.41% of cases.

## IV. DISCUSSION

### 4.1. General characteristics

Posterior tibial plateau fractures can occur following high-energy knee trauma, commonly seen in flexion after motor vehicle accidents, and daily activity mishaps, and can affect individuals of all ages, exhibiting a variety of fracture patterns and displacements. In our study group, we had an average age of 39.84 ± 14.37 years, had males comprising 40% and females 60% of cases. The most common age group was 16-40 years, accounting for 48% of cases. We observed no significant gender differences. Due to the relatively small sample size, the evaluation results are not conclusive in establishing the relationship between age and fracture type.

We classified posterior tibial plateau fractures according to two methods: Schatzker classification and Luo's three-column theory. This methodology not only provided valuable insights into the pathophysiology of tibial plateau fractures but also facilitated more precise treatment planning and management strategies tailored to the specific characteristics of each fracture pattern [5], [6].

Applying CT scans to aid in diagnosing complex bone fractures, especially in joint regions such as tibial plateau fractures, the incidence of fractures involving the posterior column had significantly increased, particularly in high-energy traumas. In some studies, tibial plateau fractures account for approximately 40-50% of all tibial fractures [7].

W. Mani *et al.* (2024) studied 243 patients included in the study, 147 were male (60.5%) and 96 were female (39.5%), indicating a slight male predominance. Fractures were observed in 226 patients (93%), as detected by CT scans. A total of 319 fractures across different anatomical regions were identified through CT scans. Comparisons between computed tomography scans and the combined methods showed no discernible differences in results. Overall, the utilization of both CT and X-ray together significantly improved diagnostic effectiveness compared to using X-ray alone [8]. Most subsequent authors also agree that CT scans provide additional valuable information for treating posterior tibial plateau fractures [5], [9].

### 4.2. Injured morphology

In our investigation comprising 25 cases, every patient underwent CT scans as a component of the study, revealing posterior column fractures of the tibial plateau in all instances. The fracture types observed in our study are as follows: Isolated fractures of the

posterolateral column were constituent of 4%, isolated fractures of the posteromedial column were constituent of 8%, fractures of the posteromedial and medial column were constituent of 24%, posterolateral and lateral column fractures were constituent of 16% and fractures of all 3 columns, this type of fracture is complex and accounts for the highest rate of 48%.

When employing the Schatzker classification, we merely assess whether the tibial plateau is fractured on the medial or lateral side without specifying the specific injury to the plateau. However, with the three-column classification, we can distinctly identify the specific plateau injury, the affected column's location and quantity, as well as the fracture fragment's central position. Consequently, solely relying on the Schatzker classification for surgical planning might confine us to accessing the tibial plateau from either the medial or lateral side, posing challenges in accurately realigning and securing the bone.

**4.3. Associated injuries**

The ligaments and meniscus are part of the knee stability system, often sustaining injuries when tibial plateau fractures occur. Treating tibial plateau fractures necessitates identifying and addressing these injuries during surgery, such as releasing trapped meniscus, suturing torn meniscus, reattaching ligament avulsions, documenting ligament injuries, and assessing joint integrity for further treatment planning, all aimed at preventing long-term instability, early joint degeneration, and impairment of knee function.

In our study, anterior cruciate ligament avulsions were in 2 cases (8%). We employed a surgical approach to repair the avulsed ligament attachment sites using 4.0mm screws and applied a zimmer knee immobilizer for the initial 4 weeks postoperatively, allowing only muscle-strengthening exercises and restricting knee flexion. Cases that have associated fibular fractures (32%) did not have surgical indications.

**4.4. Surgical approach selection**

Since the introduction of plating for tibial plateau fractures, classic surgical approaches, namely the medial and lateral approaches, have been widely utilized for fracture access by many authors worldwide. These approaches are based on the Schatzker classification for selection; however, since the Schatzker classification only addresses fractures of the medial and lateral plateaus, opting for these incisions for realignment and internal fixation is entirely reasonable. In cases where the plateau has fracture fragments extending posteriorly or involves the posterior column according to the three-column classification, using these incisions necessitates extensive soft tissue dissection from anterior to posterior, posing a risk of skin edge necrosis and making it challenging to directly access the fracture site, resulting in suboptimal reduction of the displacements. Insufficiently stabilized fractures may lead to secondary displacement, delaying early mobilization for patients and affecting the treatment outcome and knee joint function in the long run.

Luo *et al.* (2010) described the reverse L-shaped surgical approach in 29 patients who had complex tibial plateau fractures. When there was a lateral column fracture, patients could be placed in the prone position with the buttocks raised and knees flexed to facilitate fixation of the lateral tibial plateau [10].

Yoram A. Weil *et al.* (2008) studied 27 patients who had tibial plateau fractures, of whom 10 patients had fractures only in the medial tibial plateau and 17 patients had fractures in both the medial and lateral tibial plateau. The study showed that in patients who had

injuries to both tibial plateaus, the supine position could still be chosen for surgery, using the posterior approach to access and fixate the medial tibial plateau first, followed by using the lateral approach to address the lateral tibial plateau. Results showed that the posterior approach in supine patients was highly effective in reduction, and strong fixation, and provided convenience when combining the fixation of both medial and lateral tibial plateaus without changing the patient's position [11].

In our study, most patients underwent surgery in the supine position (92%), we had 2 patients in the prone position for the reverse L-shaped approach. When lateral and medial tibial plateaus were injured, corresponding to Schatzker V and VI fractures, we used a combination of the anterolateral and anteromedial approaches or the anterolateral and posteromedial supine approaches. The reverse L-shaped approach was only used for isolated fractures of the posterior tibial plateau. Our choice of surgical approach is relatively consistent with international studies [12].

Each type of injury corresponds to its surgical approach. In this study, we utilized 4 surgical approaches: the reverse L-shaped posterior approach, the posteromedial supine approach, the anteromedial approach, and the anterolateral approach. The reverse L-shaped posterior approach was used for isolated fractures of the posterior tibial plateau, accounting for 5.41% of cases. The anterolateral approach was commonly used in many cases, such as isolated posterolateral column fractures, posterior and anterior lateral column fractures, or three-column fractures (45.9%). The anteromedial approach was used in many cases, such as posterior and anterior medial column fractures, or three-column fractures (27%). Cases involving simultaneous fractures of the anterior and posterior columns on the same side were treated have a single surgical approach. A posteromedial supine approach (21.6%) in bicondylar fractures is considered advantageous for minimizing surgical soft-tissue injury, particularly when considering a separate anterolateral approach.

Indeed, a combined approach, whether it involves anterolateral and posteromedial or anteromedial and medial approach, represents an optimal strategy for achieving favorable functional outcomes in tibial plateau fracture fixation while minimizing complications.

## V. CONCLUSION

The prevalence of posterior tibial plateau fractures is on the rise in tandem with the increase in traffic accidents. Surgery remains the optimal treatment modality for facilitating the patient’s return to normal activities. However, it presents challenges for surgeons, particularly in cases of joint fractures where X-ray imaging may inadequately evaluate fracture patterns and displacements. The utilization of 3D reconstructed CT scans has greatly facilitated preoperative planning, assisting surgeons in selecting the most suitable surgical approach and optimizing bone fixation techniques tailored to each specific fracture type.

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