Schatzker Type IV Medial Tibial Plateau Fractures: A Computed Tomography–based Morphological Subclassification

SHI-MIN CHANG, MD, PHD; YING-QI ZHANG, MD; MENG-WEI YAO, MD; SHOU-CHAO DU, MD; QING LI, MD; ZHEN GUO, MD

**abstract**

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Schatzker type IV medial tibial plateau fractures have an unfavorable prognosis, likely due to the mechanism of injury (fracture-dislocation/subluxation type) and possibly due to the involvement of the posterolateral plateau, which is different from previously thought. The aim of this study was to propose a new subclassification of Schatzker type IV fracture patterns based on 2-dimensional (2-D) computed tomography and three-dimensional (3-D) reconstruction. The authors defined Schatzker type IV medial tibial plateau fractures as AO/OTA 41 type B fractures (partial articular), with partial or total medial plateau involvement, leaving at least the anterolateral quadrant intact. The images of 42 fractures (42 patients) were evaluated. The fractures were further anatomically divided into 2 groups: Group 1 were classic medial unicondylar fractures and Group 2 were more complicated variants involving both condyles, characterized by medial condyle fractures with lateral plateau extension, usually with articular impaction of the centroposterior lateral plateau. Twelve (29%) cases involved only the medial condyle, and 30 (71%) involved both the medial and lateral condyles. Twenty-nine (69%) cases demonstrated posterior coronal fractures. The most common patterns were bicondylar posteromedial plateau fractures with posterolateral quadrant depression (bicondylar posterior fractures: 14 cases, 33%) and total/subtotal medial condyle fractures with posterolateral quadrant depression (13 cases, 31%). The isolated unicondylar posteromedial split fracture was uncommon (2 cases, 5%). Computed tomography–based reconstruction enhances the understanding of fracture anatomy and the relationships between fracture fragments. In Schatzker type IV medial tibial plateau fractures, the involvement of posterolateral quadrants is common.

The authors are from the Department of Orthopedic Surgery (S-MC, M-WY, S-CD, QL, ZG), Yangpu Hospital, Shanghai; and Tongji Hospital (Y-QZ), Tongji University School of Medicine, Shanghai, PR China.

Drs Chang and Zhang contributed equally to this work and should be considered as equal first authors.

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Correspondence should be addressed to: Shi-Min Chang, MD, PhD, Department of Orthopedic Surgery, Yangpu Hospital, 450 Tengyue Rd, Shanghai 200090, PR China (shiminchang11@aliyun.com).

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Tibial plateau fractures involve the articular surface (plateau) and adjacent metaphysis (condyle) of the proximal tibia. The most common systems for classifying tibial plateau fractures are the Schatzker classification and the AO/OTA classification.

The Schatzker classification, first described in 1979, is now popular throughout the world and divides fractures into unicondylar (types I-IV) and bicondylar (types V and VI) fractures. The fractures can also be divided into low-energy variants (types I-III) and high-energy variants (types IV-VI). In the Schatzker system, fracture types are classified in what was presumed to be an increasing order of severity. However, Schatzker later believed that the type IV fracture carried the worst prognosis, likely due to its high variability and combination of bony and soft tissue injuries.

Schatzker type IV fractures occur in the medial plateau. The fracture lines of a type IV fracture are usually described as lying in the sagittal plane, and medial buttress plating is widely recommended as a treatment. In 2007, Wahlquist et al further classified type IV fractures into 3 subtypes according to the sagittal fracture line location: either medial to (subtype A), within (subtype B), or lateral to (subtype C) the intercondylar spines. These fractures were also described by Moore in 1981 as fracture-dislocation/subluxation and classified as Moore types I and II.

Compared to plain radiographs, computed tomography (CT) scans can provide more detailed information about intra-articular fractures. Through the widespread use of CT, the authors have found that in some type IV cases—especially in posteromedial shearing fractures—the fracture line may appear in the coronal plane. In clinical practice, the coronal posteromedial fragment is difficult to stabilize through a standard medial approach with a medial buttress plate. In addition, these posteromedial fractures are often complicated by posterolateral tibial plateau impaction, which is difficult to reduce and fix.

The fracture pattern dictates the treatment plan, the risk for complications, and, to some extent, the patient outcome. Because different fracture patterns require different patient positioning, surgical approaches, and treatment strategies, it is important to distinguish significantly different injuries from each other. In this way, treatment can be matched to the fracture pattern, which can optimize outcomes and improve communication between physicians.

A thorough understanding of fracture morphology can help surgeons better understand the mechanism of injury and Figure 1: Schematic drawing showing the 4 articular plateau quadrants of the tibial plateau: anterolateral (AL), posterolateral (PL), anteromedial (AM), and posteromedial (PM).

Figure 2: Total medial condyle fracture with partial lateral plateau split en bloc. The fracture line runs in the sagittal direction through the lateral plateau; the medial plateau articular surface is intact. Schematic drawing showing the characteristics of the fracture pattern (A). Anteroposterior (B) and lateral (C) radiographs of a total medial condyle fracture with partial lateral plateau split fracture in sagittal orientation. The fracture spike is located in the medial aspect. Coronal computed tomography image showing that the split fracture line passes through the lateral tibial plateau (D). The articular medial plateau is intact.
allow them to plan and select the appropriate surgical procedures. However, currently, no consensus has been made regarding the classification of medial tibial plateau fracture patterns. The aim of this article is to present the authors’ attempts to further clarify the Schatzker type IV fractures and to introduce a new morphological subclassification based on CT 2-dimensional (2-D) and 3-dimensional (3-D) reconstruction.

MATERIALS AND METHODS

This retrospective image study (radiographs, CT, and 3-D reconstruction), which received institutional review board approval, was conducted at a Level 1 trauma center. A total of 45 cases with Schatzker type IV tibial plateau fractures were retrieved from January 2007 to June 2013. After exclusion of patients younger than 18 years and those with inadequate imaging documentation (incomplete radiograph or CT images), 42 cases remained for the study. They included 27 men and 15 women, with an average age of 46 years (range, 21-65 years). The mechanism of injury was a traffic accident in 26 cases, a fall from a height in 11 cases, and simply a fall in 5 cases.

The authors defined Schatzker type IV tibial plateau fractures as AO/OTA 41 type B fractures (partial articular) with partial or total medial plateau involvement, leaving at least the anterolateral quadrant intact. This means that the anterolateral metaphyseal cortex is spared, and a small portion of the intact articular surface remains attached to the intact...
On the basis of the 3-column classification of Luo et al. and Zhu et al., the tibial plateau was further divided into 2 condyles and 4 articular plateau quadrants—the medial and lateral condyles and the anteromedial, anterolateral, posteromedial, and posterolateral quadrants (Figure 1).

The images were viewed on clinical picture archiving and communication system (PACS) workstations by 2 orthopedic trauma resident surgeons (Y.-Q.Z, Q.L.), who first evaluated the images separately and then worked together to achieve a consensus. The fracture morphology was described on the basis of tibial plateau quadrant involvement, major fragment location, fracture type (split and/or depression), and fracture line orientation.

**RESULTS**

In this new subclassification system, Schatzker type IV fractures are further divided into 2 groups according to the fracture line orientation and area involvement. Group 1 are the classic medial unicondylar fractures, composed of...
5 subgroups: (1) anteromedial quadrant plateau fracture (oblique-coronal fracture line); (2) posteromedial quadrant plateau fracture (oblique-coronal fracture line); (3) partial sagittal medial plateau fracture (sagittal fracture line located medial to the intercondylar spines); (4) total medial plateau fracture (sagittal fracture line located within the intercondylar spines); and (5) comminuted medial plateau fracture (complex fracture line). Group 2 are the more complicated bicondylar variants, characterized by medial plateau fractures with lateral plateau extension and are divided into 3 subgroups, including (6) total medial condyle fracture (Wahlquist-C) (Figure 2), (7) total/subtotal medial condyle fracture with posterolateral quadrant depression (Wahlquist type B) (Figure 3), and (8) posteromedial plateau fracture with posterolateral plateau depression (Figure 4).

A total of 42 patients were included in the study (Table). Twelve (29%) cases involved only the medial condyle, and 30 (71%) involved both the medial and lateral condyles. Twenty-nine (69%) cases demonstrated posterior coronal fractures. The most common pattern in this case series was the bicondylar posteromedial plateau fracture with posterolateral plateau quadrant depression (bicondylar posterior fractures: 14 cases, 33%). The second most common pattern was total/subtotal medial plateau fracture with posterolateral plateau depression (13 cases, 31%). Interestingly, the authors found the isolated unicondylar posteromedial quadrant plateau fracture to be uncommon (2 cases, 5%).

The morphological characteristics of the fracture patterns are summarized in the Table.

### Discussion

Historically, Schatzker type IV fractures referred to medial condyle fractures, which accounted for approximately 10% of all tibial plateau fractures. These were frequently attributed to a high-energy trauma and described as either split-wedge types or depressed and comminuted types. The fracture involvement area and fracture line orientation could be highly variable, and the medial articular surface may or may not have been violated. The fracture line could pass within the medial articular surface (Wahlquist type A) but typically passed more laterally through the intercondylar eminence (Wahlquist type B) or through the lateral tibial plateau (Wahlquist type C), separating the medial condyle from the remainder of the tibia.

With large medial condyle fractures, the medial collateral ligament and cruciate ligaments were typically torn, allowing the medial condyle to dislocate laterally. In cases of isolated unicondylar fractures, the authors observed that the isolated fragments were often displaced laterally, leading to a posteromedial split or posteromedial split-depression, also called posterior bicondylar fractures.

### Table

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Fracture Line Location</th>
<th>Fracture Line Orientation</th>
<th>Fracture Type</th>
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<tbody>
<tr>
<td>Group I: classic medial plateau fractures</td>
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<tr>
<td>1. Anteromedial quadrant plateau fracture</td>
<td>Through medial plateau</td>
<td>Oblique-coronal: from anterolateral to posteromedial</td>
<td>Split or split-depression</td>
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<tr>
<td>2. Posteromedial quadrant plateau fracture</td>
<td>Through medial plateau</td>
<td>Oblique-coronal: from postero-medial to posterolateral</td>
<td>Split</td>
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<tr>
<td>3. Partial medial plateau sagittal fracture (Wahlquist-A)</td>
<td>Through medial plateau</td>
<td>Sagittal: from anterior to posterior</td>
<td>Marginal split or split-depression</td>
</tr>
<tr>
<td>4. Total medial condyle fracture (Wahlquist-B)</td>
<td>Through intercondylar spine, no articular violation</td>
<td>Sagittal: from anterior to posterior</td>
<td>Split</td>
</tr>
<tr>
<td>5. Medial plateau comminuted fracture</td>
<td>Complex</td>
<td>Anteromedial and postero-medial fragments</td>
<td>Split or split-depression</td>
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<tr>
<td>Group II: medial plateau fractures with lateral plateau extension</td>
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<tr>
<td>6. Total medial condyle fracture with partial lateral plateau split (Wahlquist-C)</td>
<td>Through lateral tibial plateau, medial plateau articular intact</td>
<td>Sagittal: from anterior to posterior</td>
<td>Split</td>
</tr>
<tr>
<td>7. Total/subtotal medial condyle fracture with posterolateral quadrant depression</td>
<td>Through intercondylar spine and lateral plateau, medial plateau articular intact</td>
<td>Oblique: from anteromedial to posterolateral</td>
<td>Lateral plateau central depression or centroposterior split-depression</td>
</tr>
<tr>
<td>8. Posteromedial plateau fracture with posterolateral quadrant depression</td>
<td>Through medial and lateral plateau</td>
<td>Coronal: from posteromedial to posterolateral</td>
<td>Postero-medial split, postero-laternal split-depression, also called posterior bicondylar fractures</td>
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ligaments may stay attached (or partially attached) to the medial condyle, whereas the remaining lateral plateau and shaft are displaced laterally, away from the femur and medial plateau fragment, leading to a fracture-dislocation/subluxation pattern (Moore types I-II). These severe injuries include a risk of associated injuries, such as meniscus tears, ligament injuries, compartment syndromes, peroneal nerve injuries, and popliteal vascular injuries. Wahlquist et al found that the more the fracture line moved laterally, the greater the risk for these associated complications, especially compartment syndromes. Chan et al found a high incidence of associated anterior cruciate ligament injuries with posteromedial fracture patterns. Computed tomography scanning and 3-D reconstruction lead to an accurate understanding of the fracture anatomy and the pathological relationship of fracture fragments. In Schatzker type IV fractures, the fracture line may be a pure sagittal split but, more commonly, it is oblique to the frontal plane, resulting in an isolated coronal split with the apex of the fracture occurring posteromedially (posteromedial fragment) or in the more common split-depression fracture pattern (total/subtotal medial or posteromedial split with posterolateral depression). In the authors’ series, 27 (64%) cases had lateral plateau depression in the centroposterior area, and for the 16 posteromedial quadrant-shearing fractures, 14 (87.5%) were combined with posterolateral plateau quadrant depression. In a literature review, the authors found that the most commonly reported unicondylar posteromedial split fractures (or fracture-dislocations) were truly bicondylar posteromedial split with posterolateral depression fracture patterns (posterior bicondylar fractures: Group 2, subgroups 7 and 8). For example, in a recent morphological study of 75 cases of Schatzker type IV tibial plateau fractures, Yang et al found that 27 (84%) of 32 posteromedial fractures were characterized by a posteromedial plateau split with posterolateral plateau depression. Carlson described posterioromedial split with posterolateral depression fracture patterns as posterior bicondylar tibial plateau fractures. Weil et al and Doornberg et al classified these bicondylar fracture patterns as Schatzker type
V or VI. Potocnik et al.\(^{19}\) described this uniform injury pattern as posteromedial fracture-dislocation and noted 3 characteristics: (1) posteromedial tibial plateau split fracture, (2) posteroentral lateral tibial plateau depression fracture, and (3) avulsion fracture of the anterior cruciate ligament attachment from intercondylar eminence. This combination may be called a fracture triad of posterior bicondylar tibial plateau fractures.

In a clinical setting, it is critically important to recognize the extended complex variants of the classic unicondylar Schatzker type IV fractures, as they each require different approaches and treatment strategies. For fracture patterns in Group 1, surgical exposure is straightforward based on the fragment location, and plate fixation in buttress mode is the preferred treatment. For fracture patterns in Group 2 with a lateral plateau sagittal split (subgroup 6), a medial approach with a heavy buttress plate over the fragment spike is usually sufficient. For fracture patterns combined with centroposterior lateral plateau coronal depression (Group 2, subgroups 7 and 8), the operative strategies vary widely. They include a posterior midline incision,\(^{20}\) separate posteromedial and posterolateral incisions,\(^{21}\) an extensive anterior midline incision,\(^{22}\) a large medial incision,\(^{19}\) or combined posteromedial and anterolateral dual incisions with intra-articular osteotomy,\(^{23,24}\) and the use of arthroscopy assistance.\(^{25}\) The authors prefer to use a single inverted L-shaped posteromedial incision in the prone position.\(^{9,26,27,28}\) By retracting the medial gastrocnemius-soleus muscle laterally and elevating the popliteus muscle, both the medial and lateral posterior condyles are sufficiently exposed, facilitating direct fixation with a buttress plate (Figure 5).

**Conclusion**

Based on 2-D and 3-D CT images, Schatzker type IV tibial plateau fractures are further classified into 2 groups: the classic medial plateau fractures (unicondylar) and the extended variants of medial condyle fractures associated with centroposterior impaction of the lateral plateau (bicondylar). This subclassification system may improve the understanding of fracture anatomy, preoperative treatment planning, the reduction and fixation strategy, and patient functional outcome.

**References**

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