Morphologic Study of Posterior Articular Depression in Schatzker IV Fractures

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abstract

The Schatzker classification of tibial plateau fractures is widely accepted. Type IV fractures are medial tibial plateau fractures that are either split off as a wedge fragment or depressed and comminuted. Posterior articular surface depression in Schatzker type IV tibial plateau fractures can be seen as a unique variant that increases the difficulty of reduction of the articular surface. Its morphologic characteristics have not been fully studied, and the incidence is sometimes underestimated. The goal of this study was to evaluate the morphologic characteristics of posterior articular depression in Schatzker type IV fractures based on computed tomography measurements. From January 2009 to December 2011, the medical records, including digital radiologic data, of all patients treated for tibial plateau fracture at the authors’ institution were retrospectively analyzed. Articular surface depression deeper than 5 mm was the criterion for study inclusion. The depression depth, precise location of the articular depression center, surface area percentage, and distance of the fracture gap to the depression center were calculated. One hundred fifteen cases of Schatzker type IV fracture were retrieved, and a total of 47.83% (55 of 115) cases had posterior articular surface depression. The average depth of the depressed articular surface was 12.41 mm, the surface area percentage was 20.15% of the entire tibial plateau, and the gap distance from the medial direction was 41.40 mm, 2.8 times longer than that from the posterior direction, which was 14.91 mm. Posterior articular surface depression occurs in nearly half of Schatzker type IV fractures, and the posterior approach provides more direct access to the depression than the medial approach.

Tibial plateau fractures are usually classified by the AO/Orthopaedic Trauma Association or the Schatzker classification system. The latter is easier to remember and to use when devising a treatment protocol, and so it is widely employed. Schatzker type IV fracture is a medial tibial plateau fracture with a split or depressed component that indicates a classic medial approach.1 For anatomic reasons, the articular surface depression in type IV fracture is rarely located strictly in the medial plateau; instead, it is often located in the posterior-central or posterior-lateral region, which is difficult to expose and reduce with a medial approach.2 To address the posterior articular depression, some authors still use a medial incision in the supine position3 and some recommend a posterior incision in the prone position.4,5 Regardless of whether a medial or posterior incision is used, the fracture gap is always an essential consideration in the surgical approach to the impacted surface.

To the authors’ knowledge, no study has analyzed the location of the articular depression or the precise distance of the key gap, which may help orthopedic surgeons to make an appropriate surgical plan. Based on the substantial database at the largest trauma center in eastern China, this study was conducted to research the incidence and morphologic features of posterior articular surface depression in Schatzker type IV tibial plateau fractures.

MATERIALS AND METHODS

After approval was obtained from the authors’ institution’s human subject review board, medical records, including digital radiologic data, for all patients treated for tibial plateau fractures from January 2009 to December 2011 were examined. Three observers, including 2 orthopedic trauma surgeons (Q.Z., C.H.) and 1 radiologist specializing in the musculoskeletal system (D.W.), reviewed the radiographic images and computed tomography (CT) scans on clinical picture archiving and communication system workstations. The fracture type was determined through consensus by the 3 observers. According to Schatzker et al,1 in type IV fracture, the medial plateau is either split off as a wedge fragment or is depressed and comminuted, and it may be combined with fractures of the tibial spine. The border between the medial plateau and the lateral plateau is the anatomic axis of the tibia on standard anterior-posterior radiographic images; on axial CT images, the posterior region is defined according to the 3-column conception.6

A total of 115 adult patients with Schatzker type IV fracture were identified in the database. Using the coronal CT reformation, depression depth was obtained by measuring the distance between the normal articular surface and the most depressed articular surface. Because articular depression of more than 5 mm indicates a surgical procedure,7,8 patients with no depression or a shallow depression were excluded. Four patients with articular depression and no involvement of the posterior plateau were also excluded. Finally, 55 patients met the inclusion criteria during the study period.

Of these 55 patients, 44 were men and 11 were women. Average age was 45.2 years (range, 25-70 years). The cause of injury included electric bicycle and motorbike accident in 35 cases, pedestrian-vehicle accident in 13 cases, automobile-automobile collision in 5 cases, and fall from a height in 2 cases. Eight cases had concomitant ipsilateral proximal fibular fractures.

Area of Articular Surface Depression

Axial CT images from proximal to distal were reviewed, and the image in which the fibular tip first appeared was selected and analyzed. The area of surface depression and the entire tibial plateau were measured on this image with the picture archiving and communication system. The surface area percentage was the percentage of the affected region in the entire plateau.

Location of the Center of Articular Depression

In the same image, the center of the region of articular surface depression, which was an irregular closed polygon, was calculated by a computer program developed by the authors based on calculus. The program automatically located the center of the depression on the image and charted the outline of the region of depression.

Distance of the Fracture Gap

This type of fracture has at least 2 gaps from the tibial cortex to the center of the depression on axial CT image: 1 starting in the medial or anterior direction and the other starting in the posterior direc-
tion. The distance of the fracture gap was measured from the midpoint of the displaced cortex to the center of the articular depression. Using the 3-column concept, the shortest distance in the medial column and that in the posterior column were measured (Figure 1).

Statistical Analysis
Statistical analyses were performed with SPSS version 17.0 software (SPSS Inc, Chicago, Illinois). Descriptive statistics and scatter plots were used for morphologic results. Values between groups were compared with the independent samples t test. Differences were considered significant at \( P<.05 \).

RESULTS
Among 115 cases of Schatzker type IV tibial plateau fractures, 55 cases had posterior articular surface depression; the incidence was 47.83%. Of these 55 cases, the average depth of the affected surface was 12.41±0.42 mm (range, 6.4-19.3 mm), the surface area percentage was 20.15%±0.71% (range, 12.0%-41.5%) of the entire tibial plateau, and the distance of the fracture gap in the medial column was 41.40±0.77 mm (range, 32.1-55.7 mm), 2.8 times longer than that in posterior column, which was 14.91±0.45 mm (range, 8.9-24.2 mm). The location of the center of articular depression was shown in the scatter plot (Figure 2).

According to the description of a posteromedial fragment and an entire plateau fragment in Schatzker type IV fractures, these 55 cases could be further divided into 3 groups based on the morphologic features of the medial fragments: (1) a total medial plateau fragment group (29 cases); (2) a posteromedial fragment group (15 cases); and (3) a comminuted medial fragment group (11 cases) (Figure 3). Depression depth, surface area percentage, and fracture gap distance in the medial column and the posterior column are shown in the Table. In each of the 3 groups, the distance of the fracture gap in the medial column was significantly longer than that in the posterior column, 2.5, 3.6, and 2.6 times, respectively. No significant difference was seen in depression depth or surface area percentage between any 2 groups (\( P>.05 \)). Compared with the other 2 groups, patients with a posteromedial fragment had a longer fracture gap distance in the medial column and a shorter distance in the posterior column. The differences were statistically significant.

Discussion
The Schatzker et al classification, based on the idea that “certain pathoanatomic and etiological factors as well as therapeutic features demand certain injury types be grouped together,” is 1 of the most widely accepted classifications of tibial plateau fractures. Schatzker type IV fracture is a medial tibial plateau fracture with a split or depressed component, and its differentiation from type V fracture is the intact lateral cortex. Because the medial tibial plateau is concave on the tibial side and the lateral tibial plateau is convex on the femoral side, the articular depression caused by axial load transmission is usually in the lateral plateau instead of the medial plateau. Therefore, the articular depression in type IV fracture, which is considered a medial plateau fracture by many surgeons, was underestimated. However, in this study, the authors found that its incidence was not as low, affecting nearly half of fractures. Because type IV fractures are illustrated without articular depression in almost all schematic diagrams in textbooks, surgeons must consider this possibility and determine the morphologic features of the fracture before surgery.

Unlike lateral plateau split-depression fractures (Schatzker type II) in the anterior-lateral region, most articular depressions in type IV fractures were found in the posterior-central or posterior-lateral region instead of the anterior-medial region. This finding may have an anatomic cause or may be related to the mechanism of injury. First, the medial plateau is harder than its counterpart. When bearing the force of trauma, it could be split before being impacted. Second, in the current study, many patients were riding a bicycle or motorcycle at the time of injury, and therefore the knee joint would have been in flexion at the time of injury. When the flexion angle is increasing, the lateral femoral condyle moves toward the posterior position. Therefore, the depression should occur in the posterior-central or posterior-lateral region, and when the axial force is combined with the varus force and medial dislocation, the depression may occur in the posterior-central region (Figure 4).

Medial incision is classic for type IV fractures and is suitable for addressing fragments in the medial plateau. However, exposing the impacted surface during surgery can be challenging. To address this key articular surface, Potocnik et al used the classic medial incision, widened the fracture gap with a bone spreader, and reduced the impacted surface under direct fluoroscopic control. Sciadini and Sims recommended the intra-articular osteotomy technique in a second anterior-lateral...
Table

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Depression Depth (Range), mm</th>
<th>Surface Area (Range), %</th>
<th>Distance in Medial Column (Range), mm</th>
<th>Distance in Posterior Column (Range), mm</th>
<th>Distance in Medial Column/ Posterior Column, times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fragment</td>
<td>29</td>
<td>12.0±4.6 (6.4-19.3)</td>
<td>20.2±6.1 (13.2-41.5)</td>
<td>12.5±3.1 (11.5-24.2)</td>
<td>13.2±4.2 (10.7-24.2)</td>
<td>1.2±0.2 (10.7-24.2)</td>
</tr>
<tr>
<td>Posteromedial fragment</td>
<td>15</td>
<td>12.2±4.6 (6.4-17.7)</td>
<td>20.3±6.1 (13.2-44.1)</td>
<td>12.5±3.1 (11.5-24.2)</td>
<td>13.2±4.2 (10.7-24.2)</td>
<td>1.2±0.2 (10.7-24.2)</td>
</tr>
<tr>
<td>Comminuted fracture</td>
<td>11</td>
<td>13.5±4.6 (8.6-16.7)</td>
<td>20.4±6.1 (13.2-44.1)</td>
<td>12.5±3.1 (11.5-24.2)</td>
<td>13.2±4.2 (10.7-24.2)</td>
<td>1.2±0.2 (10.7-24.2)</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>12.4±4.6 (6.4-19.3)</td>
<td>20.3±6.1 (13.2-44.1)</td>
<td>12.5±3.1 (11.5-24.2)</td>
<td>13.2±4.2 (10.7-24.2)</td>
<td>1.2±0.2 (10.7-24.2)</td>
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approach, converting the fracture pattern to a Schatzker type V fracture and creating a new fracture gap on the lateral side. With this technique, the distance along the lateral gap to the key surface was shorter than that from the medial incision, but iatrogenic trauma increased. A posterior incision and the prone position were also recommended by many authors, from posteromedial or posterolateral, especially in the posteromedial fragment group.

The distance of the fracture gap to the key surface was shorter with the posterior approach than with the medial approach; however, there was no precise number. In this study, the authors found that the mean distance from the posterior direction was 14.91 mm, and from the medial direction it was 41.40 mm. Therefore, the posterior approach might be direct and instrumental. However, the posterior approach and the prone position also have limitations. First, this technique could not address the meniscus injury, which is common when the lateral surface depression is deeper than 10 mm. The injured lateral meniscus might incarcerate in the region of depression and hinder reduction of the surface. Second, some large depressions or those located mainly in the posterior-central region were beyond the posterior approach. In this case, the supine position and an anterior dual incision might be more reasonable; the second anterior-lateral incision could address the meniscus injury and create a fracture gap that shortens the distance to the center of the depression.

Limitations
The current study had 2 potential limitations. The first is its retrospective nature. Second, the incidence of posterior depression in type IV fractures might be unnecessarily high because many patients with complex fractures were transferred to the authors’ trauma center, whereas those with simpler type IV fractures were not transferred from nearby low-level hospitals.

Figure 4: Illustration of the mechanism of injury showing axial force and varus force (dotted arrows) and the main force and direction of trauma (solid arrows) (A). Original radiograph and computed tomography scan and illustration showing posterior movement of the lateral femoral condyle when the flexion angle is increased from 60° to 120° (B).
**Conclusion**

Posterior articular surface depression occurs in 47.83% of Schatzker type IV tibial plateau fractures. A posterior approach provides a more direct approach to the region of depression than a medial approach.

**References**