Original article

Prone and direct posterior approach for management of posterior column tibial plateau fractures

K.-C. Lin*, Y.-W. Tarn, G.-Y. Lin, S.-W. Yang, C.-J. Hsu, J.-H. Renn

Department of Orthopaedics, Kaohsiung Veterans General Hospital, 813 Kaohsiung, Taiwan, ROC

A R T I C L E   I N F O

Article history:
Received 20 August 2014
Accepted 7 December 2014

Keywords:
Tibial plateau fracture
Posterior column
Posterior approach
Prone position
Proximal tibial fracture

A B S T R A C T

Introduction: The three-column fixation concept is becoming popular in orthopedic practice. Posterior column fracture is an uncommon type of tibial plateau fracture. The supine position for the surgical approach is familiar to most surgeons; however, it is difficult to achieve good reduction and fixation in posterior column fracture.

Hypotheses: The prone position and direct posterior approach can achieve proper reduction and fixation for posterior column tibial plateau fracture, yielding good functional outcome.

Materials and methods: Between January 2010 and January 2012, 184 tibial plateau fractures were diagnosed and operated on in our institution. Sixteen posterior column tibial plateau fractures (10 male and 6 female patients, with a mean age of 41.5 ± 14.3 years) were diagnosed by preoperative plain films and CT scans. Ten patients presented with fracture-dislocation of the knee joint. A direct posterior approach in prone position was used to reduce the tibial condyle and fix it with an anti-glide buttress plate. Radiographic evaluation included reduction quality and bone union. Functional evaluation included Lysholm score and Tegner activity score.

Results: All fractures healed within 6 months, without secondary displacement. Ten knees had postoperative anatomic reduction (0 mm step-off) and 6 had acceptable reduction (<2 mm step-off). At 34.4 ± 9.6 months, median extension was 3 (5–10) and flexion 135 (100–145). The mean Lysholm score was 95 (75–100) and the mean Tegner activity score was 6 (5–8). All patients were satisfied with the operation. No cases of post-traumatic osteoarthritis of the knee occurred during follow-up.

Conclusions: The prone position and direct posterior approach has great advantages in terms of reduction and stable fixation, yielding good results.

Type of study: Retrospective, case series.

Level of evidence: ∗ Level IV.

© 2015 Elsevier Masson SAS. All rights reserved.

1. Introduction

Posterior column fragments are relatively uncommon in proximal tibial fracture. It is a specific fracture pattern that is not well described by the AO (41-B2.2/B3.2) or Schatzker (IV, V, VI) classification systems [1], because these classification systems do not differentiate cases in which the medial fragment is primarily posterior and sometimes associated with a dislocation or subluxation of the knee joint. Recently, posteromedial fracture was well defined in the revised Duparc classification [2], using important findings to classify Schatzker type IV fractures as spinocondylar (74%), unicodylar (19%), posteromedial (5%) or bicondylar (2%). Posteromedical fractures, either isolated or associated with another fracture, were a challenge for observers to classify, because they are not described in the Schatzker [1] or AO classifications. Several reports have illustrated the importance of coronal plane proximal tibial fracture (posteromedial or posterolateral fracture), which are only visible on lateral radiographs or computed tomography scans. If wrongly diagnosed, they may lead to the use of inappropriate fixation techniques that result in poor outcome [2].

Moore classified this type of fracture but did not describe management in depth [3]. On the Moore classification, type 1 fracture-dislocation corresponds to the modified Duparc category of posteromedial split fracture, and type 2 to medial spinocondylar and lateral spinocondylar fracture (Fig. 1A).

These fractures are mostly caused by high-energy trauma and are sometimes associated with significant ligament and soft tissue injuries. They may include anterior cruciate ligament (ACL) avulsion fracture, posterior cruciate ligament (PCL) avulsion fracture, and posterolateral corner (PLC) injuries. This fracture pattern,
However, is inherently unstable and difficult to adequately reduce and stabilize by conventional techniques and approaches [4–6].

A reduction problem is often faced during posteromedial or posterolateral displacement of the tibial fragment under knee flexion. The supine position with a posteromedial or posterolateral approach requires extensive dissection for reduction purposes. Furthermore, the biomechanical principles of management of these fractures require placement of a posterior anti-glide buttress plate. Therefore, the posteromedial fragment sometimes cannot be optimally treated by conventional anterior, medial, or posteromedial approaches in the supine position [7].

A conventional vertical incision of the posteromedial collateral ligament and detachment of the medial capsule and medial head of gastrocnemius from the medial femoral condyle are required for full exposure of the posteromedial facet. Posterior approaches, such as described by Trickey in the 1960s, are more demanding and involve dissection of the neurovascular bundle [8,9]. To overcome these problems, Galla and Lobenhoffer described a direct posteromedial approach for managing Moore type I tibial head fracture-dislocations [10].

The main goal of the present study was to report a reverse L-shaped incision that allows more space for reduction and easier placement of implants. This approach does not involve dissection of the neurovascular bundle and allows excellent fracture visualization and appropriate placement of hardware, while minimizing soft tissue dissection. Furthermore, the prone position enables easy reduction by axial traction and hyperextension of the knee. Our hypothesis was that the prone position and direct posterior approach can achieve proper reduction and fixation for posterior column fracture, yielding good functional outcome.

### 2. Materials and methods

This is a retrospective study. Between January 2010 and January 2012, 184 patients with tibial plateau fracture were operated on in our institution. All patients had CT scan examination as well as plain radiographs for classification (Fig. 2B). Following Luo et al. [11], all fractures were classified using the “three-column” concept. Using the axial CT view, the tibial plateau was divided into three areas: lateral compartment, medial compartment and posterior column. These three columns are separated by three connecting lines: CA, CL and CM. Point C is the center of the tibia (midpoint of two tibial spines); point A represents the anterior tibial tuberosity; point M is the posteromedial ridge of the proximal tibia; and point L is the most anterior point of the fibular head. Point P is the posterior sulcus of the tibial plateau, which bisects the posterior column into posteromedial (PM) and posterolateral (PL) fragments (Fig. 3). Besides the axial view, accurate classification was usually ensured with the assistance of three-dimensional (3D) reconstruction. Patients with posterior column fracture were enrolled in the study. Sixteen knees were diagnosed as pure posterior column tibial plateau fractures (10 male and 6 female patients, with a mean age of 41.5 ± 14.3 years). There were 8 isolated PM fractures, 4 isolated PL fractures and 4 PM and PL fractures. Patients were followed up for at least 24 months (34.4 ± 9.6 months).

#### 2.1. Operative procedure

The patient was placed prone on a well-padded radiolucent table, and the injured leg was slightly elevated, with flexion of the knee joint. A tourniquet was used in all cases. Intraoperative fluoroscopic imaging was used to ensure proper reduction of the fracture and accurate location of the implants.
2.2. Fracture fragment-specific posterior approach

In case of isolated PM fragment (8 cases), a reverse L-shape medial incision (Lobenhoffer incision) was used. In both PM and PL split fragments (4 cases), a longer medial posterior reverse L-shaped incision approach was used (Fig. 4A). The superficial fascia was incised in the same direction, followed by dissection of the soft tissue flap. The popliteal neurovascular bundle was retracted and protected. The medial gastrocnemius muscle was retracted while performing the posteromedial approach. In case of isolated PL fragment (4 cases), a reverse L-shaped lateral approach was chosen (Fig. 4B). The interval between the common peroneal nerve and the lateral gastrocnemius was used, and the lateral gastrocnemius was retracted after deep dissection. It is crucial to identify the common peroneal nerve and protect it with a loop. Then, subperiosteal elevation of the soleus was used to obtain full exposure of the posterolateral fragment. With PL fragments, articular depression was usually associated. The depressed cartilage was directly addressed and elevated. An image intensifier was used to assist reduction. The subchondral defect was then filled with an artificial osteoconductive bone graft (7 cases).

2.3. Fracture fixation

After reduction of the articular surface, further reduction of the broken posterior cortex was accomplished through the placement of a 3.5 mm small fragment anti-glide buttress T-plate (Synthes, Paoli, PA, USA) (Fig. 5). Reduction was achieved by direct compression by the buttress plate. Inserting the screw just below the fracture site first optimized reduction, followed by tight screwing of the other holes one by one. It was important to visualize the distal bone spike as well as the previously exposed proximal fracture line at the metaphyseal and articular (submeniscal) level to assess anatomical reduction. After intraoperative checking of the fracture and joint stability, the various layers were closed over one or two suction drains.

2.4. Postoperative care

All patients were immobilized in a knee brace in full extension for 2 weeks, then a gradual range of motion (ROM) of 0–90 degrees was achieved over the next 4 weeks. Full ROM could be achieved after 3 months. Toe-touching or partial weight bearing (about 5–10 pounds) was allowed during the first 6 weeks postoperatively. Subsequently, full weight bearing was allowed and the patient was referred for physiotherapy.

2.5. Postoperative evaluation

Patients were seen for clinical and radiological assessment at 6 weeks and 3, 6, 12 and 24 months.

Two independent surgeons evaluated the postoperative films. Reduction quality of the articular surface was evaluated from lateral plain film and was categorized as anatomic (0 mm step-off), acceptable (&lt;2 mm step-off) or poor (2–4 mm step-off). Union was defined as no fracture site pain reported by the patient and no fracture gap on last radiographic evaluation. Functional outcome was assessed using Lysholm score (0–100) and Tegner score (0–10). Post-traumatic osteoarthritis was graded on the Kellgren-Lawrence system.

No statistical analysis was performed.

3. Results

3.1. Radiological results

Ten patients showed anatomic postoperative reduction (0 mm step-off) of the articular surface and 6 patients showed acceptable reduction (&lt;2 mm step-off).

All fractures healed within 6 months without secondary displacement.

3.2. Clinical results

Patients achieved a median extension of 3° (5–10°) and flexion of 135° (100–145°).

The median Lysholm score was 95 (75–100) and the mean Tegner activity score was 6 (5–8). All patients were satisfied.

Nine patients had grade 1 post-traumatic osteoarthritis; 7 patients were grade 0. No cases of advanced post-traumatic arthritis were observed at last follow-up (Table 1).

3.3. Complications

No cases of deep infection were observed. One case had an acute superficial surgical site infection, treated by oral antibiotics. One patient had a superficial dehiscence postoperatively that healed without further treatment. One patient had wound-edge skin necrosis, successfully treated by surgical debridement.

4. Discussion

Moore’s classification [3] takes account of higher-energy injuries and resultant knee instability. Posteromedial fractures were first described by Postel et al. in 1974 and later included in the Duparc classification (Fig. 1B), these fractures lead to specific problems in terms of approach and fixation [2].

Numerous case series have advocated the use of supine approaches for the treatment of complex tibial plateau fractures involving bilateral tibial condyles [12–16]. For comminuted three-column tibial plateau fractures, several approaches have been described for exposure of posteromedial or posterolateral split fractures. These standard techniques have in common the problem of an extensive approach with incision of the posteromedial ligament, detachment of the medial capsule and the medial gastrocnemius muscle from the femoral condyle, and the potential requirement for
Fig. 4. Reverse L-shaped skin incisions. A. Posteromedial approach. B. Posterolateral approach.

Fig. 5. A. A case of a posterolateral fragment with depressed cartilage: posterior fixation and anatomic reduction. B. A case of a posteromedial fragment. C. A case of a posterior column fracture with posteromedial and posterolateral fragments: fixation using two posterior plates.
Table 1 Patient data.

<table>
<thead>
<tr>
<th>Patients number</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Three-column classification</th>
<th>Associated injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>58</td>
<td>PM</td>
<td>ACL avulsion fracture, spleen rupture</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>52</td>
<td>PM + PL</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>21</td>
<td>PM + PL</td>
<td>Nil</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>36</td>
<td>PM</td>
<td>Spleen rupture</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>40</td>
<td>PM</td>
<td>ACL avulsion fracture</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>50</td>
<td>PM + PL</td>
<td>PLC injuries, peroneal nerve palsy, ACL avulsion fracture</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>55</td>
<td>PL</td>
<td>Nil</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>60</td>
<td>PL</td>
<td>Nil</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>51</td>
<td>PM + PL</td>
<td>Spine fracture</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>42</td>
<td>PM</td>
<td>Nil</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>41</td>
<td>PM</td>
<td>Nil</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>26</td>
<td>PL</td>
<td>Nil</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>36</td>
<td>PM</td>
<td>ACL avulsion fracture</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>21</td>
<td>PL</td>
<td>Nil</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>58</td>
<td>PM</td>
<td>Femoral Frx, pelvic Frx</td>
</tr>
<tr>
<td>16</td>
<td>M</td>
<td>17</td>
<td>PM</td>
<td>PCL avulsion fracture</td>
</tr>
</tbody>
</table>

Mean ± SD 41.5 ± 14.3

Fracture-dislocation Follow-up (months) Postoperative reduction Kellgren and Lawrence grade Lysholm scores Tegner scores Final ROM

Yes 36 Anatomic 1 95 7 5–135
Yes 30 Acceptable 1 92 6 10–120
Yes 48 Anatomic 0 95 7 10–140
No 48 Acceptable 0 90 6 10–125
Yes 40 Anatomic 1 90 6 5–135
Yes 24 Acceptable 1 80 5 15–100
No 48 Anatomic 0 95 6 5–140
No 34 Anatomic 1 90 5 5–140
Yes 24 Anatomic 0 98 6 5–145
Yes 35 Acceptable 1 93 6 10–135
No 36 Acceptable 1 93 6 15–130
No 48 Acceptable 0 98 8 5–140
Yes 28 Anatomic 1 75 6 10–130
No 24 Anatomic 0 98 6 5–140
Yes 24 Anatomic 1 95 6 5–130

| Frx: fracture; ACL: anterior cruciate ligament; PCL: posterior cruciate ligament; M: male; F: female; PM: posteromedial fracture; PL: posterolateral fracture; ROM: range of motion; anatomic reduction: 0 mm step-off; acceptable: 0–2 mm step-off. |

detachment of the hamstrings to achieve adequate exposure and reduction of the fracture [3,6,12]. Supine approaches for posterolateral fracture are described by Solomon et al. [17] with a transfibular approach. This approach requires detaching the peroneus longus tendon from the fibular head, and osteotomy is needed. Complications entailed by this approach are iatrogenic common peroneal palsy and non-union of the fibular head. Frosh et al. [18] reported a new posterolateral approach without fibular osteotomy. With this approach, the lateral collateral ligament can be usually preserved. This approach laterally dissects the capsule and the meniscotibial ligament to expose the entire lateral tibia plateau. Damage to soft tissue is less, but exposure of the peroneal nerve is similar to the isolated posterior approach described by Trickey in 1968.

Numerous authors advocated using a posterior approach in dealing with posterior column fractures. Bhattacharyya et al. [9] presented the results of 13 patients with tibial plateau fracture-dislocations with large posteromedial fragments (Moore type I), treated via a variant of the posterior approach initially described by De Boeck and Opdecam [19]. This approach entails great risk of neurovascular damage, as extensive dissection is required. [10]. Lobenhoffer described a posterior approach in 1997 [6] and modified it in 2003 with Gall. This approach is used by many surgeons, allowing less dissection and direct access to posteromedial fractures.

Luo et al. [11] first introduced a computed tomography-based “three-column fixation” concept and evaluated clinical outcomes (using a column-specific fixation technique) for complex tibial plateau fractures. They reported a “floating position”, based on lateral decubitus with the lower leg rotated into a prone position when the posterior approach to the tibial plateau is performed. We extended the concept of fixing the posterior column by the posterior approach using a “direct prone position”. This direct posterior approach can optimize the reduction and fixation of posterior column fractures with both PM and PL fragments.

The advantages and disadvantages of two approaches are summarized in Tables 2 and 3.

The strong points of the prone posterior approach are as follows. First, identification of tibial subluxation in tibial condylar fractures is critical. Second, adequate reduction of tibial posteromedial condylar fractures can reduce postoperative tibial subluxation. The posteromedial fragment of the fracture can be easily reduced with hyperextension of the knee in the prone position. Third, after reduction of the posteromedial fragment, an anti-glide plate is applied for adequate and rigid fixation in tibial fracture subluxation or dislocation. Prone positioning of the patient facilitates both fracture reduction and placement of an anti-glide buttress plate [20]. After reduction, the posteroanterior direction screws more easily achieve a buttress effect. The main disadvantage of this approach is that patients with head, chest or abdomen injuries cannot easily be monitored in the prone position and may not tolerate it well.

The pitfalls and possible complications are as follows. The supine approach can deal with joint depression better than the prone approach in most situations. Sometimes it is not as easy to reduce depressed cartilage in the prone position. Possible minor complications include superficial wound necrosis with dissection of the posterior wound, fat detachment and flexion contracture. Major complications include brachial plexus palsy and blindness; possible C-spine injuries have been reported [21,22].
Table 2
Advantages and disadvantages of two approaches for the posterior column TPF.

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prone approach</td>
<td>Achieves direct reduction</td>
<td>Risk in polytrauma patients: e.g., chest trauma, C-spine injury</td>
</tr>
<tr>
<td></td>
<td>Easy to apply anti-glide buttress plate</td>
<td>Requires more time for setup</td>
</tr>
<tr>
<td></td>
<td>Easy to insert screws directly posteriorly to anteriorly</td>
<td>May injure the peroneal nerve in the posterolateral approach</td>
</tr>
<tr>
<td>Supine approach</td>
<td>Easy to treat lateral plate fractures</td>
<td>Not easy to insert screws directly posteriorly to anteriorly</td>
</tr>
<tr>
<td></td>
<td>Suitable in most tibial plateau fractures</td>
<td>May incur problems in reduction of the posterolateral fragment</td>
</tr>
<tr>
<td></td>
<td>Suitable in metadiaphyseal fractures for restoration of alignment</td>
<td>May incur problems in reduction of the posteromedial comminuted fragment</td>
</tr>
</tbody>
</table>

TPF: tibial plateau fracture.

Table 3
Comparisons of the two approaches for managing posterior column TPF.

<table>
<thead>
<tr>
<th></th>
<th>Prone approach</th>
<th>Supine approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Safety</td>
<td>More risk in polytrauma patients</td>
<td>Safer in polytrauma patients especially C-spine injury</td>
</tr>
<tr>
<td>2. Preparation</td>
<td>More time needed</td>
<td>Less time needed</td>
</tr>
<tr>
<td>3. Dissection</td>
<td>Less injury to Pes anserinus</td>
<td>Extend lateral dissection trauma</td>
</tr>
<tr>
<td>4. Exposure</td>
<td>Can expose both PM and PL fragments</td>
<td>Needs transfibular dissection to expose PL fragment</td>
</tr>
<tr>
<td>5. Articular reduction</td>
<td>Not much difficulty</td>
<td>Much difficulty in PM and PL</td>
</tr>
<tr>
<td>6. Fixation</td>
<td>Easy to apply anti-glide buttress plate</td>
<td>Great difficulty in applying plate and maintaining its position</td>
</tr>
<tr>
<td>7. Screwing</td>
<td>Easy to insert screws directly posteriorly to anteriorly</td>
<td>May injure the peroneal nerve in PL approach</td>
</tr>
<tr>
<td>8. Perioperative fluoroscopy</td>
<td>Similar</td>
<td>Similar</td>
</tr>
</tbody>
</table>

PM: posteromedial; PL: posterolateral.

The limitations of the present study include the fact that this was a small, single-center series. Some cases did not have postoperative CT scanning to accurately quantify articular reduction and fixation. There was no control group in our series. No statistical analysis comparing supine versus prone approaches was possible.

In conclusion, using the prone posterior approach with a reverse L-shaped incision to manage fragments of the posterior column in tibial condylar fractures can achieve anatomic reduction and rigid fixation, resulting in a good functional outcome.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgments

The authors thank Ms Ching Hui-Huang for preparation of the diagrams. Without her help, the article would not have been completed.

References
