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Original Article

Surgical options for posterior tibial plateau fracture

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Abstract: Objective: To investigate surgical methods and clinical effectiveness of posteromedial and posterolateral approaches for the posterior tibial plateau fracture. Method: 21 cases who received surgery through posterior approaches for the treatment of posterior tibial plateau fractures (PTPFs) were included. Results: 21 cases were subject to follow-up for 12-24 months (an average of 16.2 months). No cases developed incision inflammation, neurovascular injury, internal fixation loosening and breakage. All fractures were healed. No cases developed knee varus and valgus deformity and fracture dislocation. After surgery, Rasmussen score for knee joint functions was 13-30 points (a mean of 24.2). The results were excellent in 12 cases, good in 7 cases and fair in 2 cases. The percentage of excellent and good results was 90.5%. Rasmussen radiology score was 10-18 points (a mean of 15.6 points). The results were excellent in 13 cases, good in 7 cases and fair in 1 cases. The percentage of excellent and good results was 95.2%. 1 case had significant limited range of knee flexion and extension, which was improved after phase II release under arthroscopy combined with function exercise. 2 cases developed traumatic arthritis, which was relieved after intra-articular injection with sodium hyaluronate and oral nonsteroidal anti-inflammatory drug. Conclusion: The posteromedial and posterolateral approaches for PTPF is good for reduction and fixation of PTPF. The approaches have benefits such as clear exposure, convenient placement of internal fixation, less trauma and good clinical outcome.

Keywords: Tibia, fracture, fracture fixation, internal, posterior approach

Introduction

Posterior tibial plateau fracture (PTPF) is a special type of plateau fracture. Due to its special location, it is difficult to perform open reduction and internal fixation, which is a difficulty in orthopedics [1]; if early effective treatment is not provided for patients, chronic collapse often occurs, which leads to significant limited range of knee flexion and extension. It is pivotal to find an approach with more accurate exposure of fracture and more operable fixation to obtain better outcome of treatment for PTPF. Since the fracture line of PTPF is located at the back, the conservative anterior-lateral approach can not fully expose fracture [2], which results in ineffective internal fixation. Our clinical study found that posteromedial and posterolateral approaches could directly expose fracture. It is an effective method for the treatment of PTPF because of less injury due to access along intermuscular space and effective support and fixation of fracture.

Data and methods

General data

From January 2006 to June 2008, 21 cases including 12 men and 9 women aged from 28-68 years with a mean age of 39.5 received surgery through posterior approaches for PTPF. For reasons of trauma, 13 cases had fractures due to traffic accidents and 8 cases had fractures due to falls. According to Khan's classification of fractures, 7 cases had posteromedial fractures and 8 cases had posterolateral fractures. 6 cases had both posteromedial and posterolateral fractures. All were fresh close fractures. The time from trauma to surgery was 3-15 d. Patients were mainly characterized by pain and limited range of motion in affected knee, but no prominent knee swelling and deformity were observed. All subjects received imaging examinations including A-P & lateral radiograph, CT scan and three-dimensional or multiplanar reconstruction (MPR) to determine fracture displacement and type before surgery. The A-P & lateral radiograph of affected knee revealed that tibial plateau was two slightly arc curves. The posterior tibial plateau overlapped with bone shadows under the two curves, which contributed to difficulty in identifying pure PTPF. The lateral radiograph revealed prominent collapse- or cleavage-type fracture. However, it was tricky to determine further details of injury to the plateau due to overlapped shadows and impact by the tibial intercondylar eminence. Three-dimensional CT or MPR reconstructed imaging could accurately determine location of fracture, magnitude of collapse and distance of displacement; cleavage-type fracture often occurred in posteromedial plateau and collapse-type fracture often occurred in posterolateral plateau.

Treatment procedures

Posteromedial approach for tibial plateau: 7 cases had posteromedial tibial plateau fractures. The inverted L-shaped incision was made at posteromedial tibial plateau, which went horizontally from 3 cm above the horizontal stripes of popliteal fossa into the medial part, accessed the inner edge of medial head of gastrocnemius, and went down to 10 cm below the articular line. After incision of the skin and subcutaneous tissue, skin flap under bilateral fascia was separated. Meanwhile, be careful to protect the saphenous nerve and great saphenous vein in the superficial fascia because they were located at the lower part of the incision. The semitendinosus and medial head of gastrocnemius were exposed. The medial head of gastrocnemius and its lateral deep popliteal vessel and tibial nerve were retracted laterally. The semitendinosus was retracted medially. The semimembranosus attachment to posterior joint capsule was exposed and incised downward along the articular line. The posteromedial tibia was exposed using subperiosteal dissection. The posterior joint capsule was incised along the articular line. The posterior horn of the medial meniscus was retracted upward to expose articular surface in medial tibia. When it was necessary to prolong the incision distally, the origin of soleus could be partly incised and subject to subperiosteal dissection to fully expose the proximal tibia.

Posterolateral approach for tibial plateau: 8 cases had posterolateral tibial plateau fractures. The inverted L-shaped incision was made at posterolateral tibial plateau, which went horizontally from 3 cm above the horizontal stripes of popliteal fossa to outside, and went down along the medial edge of biceps femoris tendon to 7 cm below the articular line. After incision of the skin and subcutaneous tissue, common peroneal nerve and biceps femoris tendon along medial edge of biceps femoris tendon and posterior fibular head were exposed and separated. The lateral head of gastrocnemius muscle was retracted from the outer edge toward medial side. The lateral vessel bundle under the knee was ligated and cut off. The origin of fibula at soleus was subject to subperiosteal dissection, and retracted medially together with lateral head of gastrocnemius muscle. The posterior joint capsule and posterior tibial plateau were exposed between the popliteus and soleus. The posterior joint capsule was incised along the articular line. The posterior horn of the posterior meniscus was retracted upward to expose articular surface in lateral tibia. When it was necessary to prolong the incision distally, the origin of soleus could be partly incised and subject to subperiosteal dissection. The posterior tibial vessels and nerves went from the medial side of posterolateral tibia down between the lateral head of gastrocnemius muscle and soleus. The anterior tibial artery originated from (4.9±0.5) cm to articular line, went obliquely and inferolaterally, so injury to the vessels and nerves should be avoided during surgery.

Posteromedial and posterolateral approaches: 6 cases had both posteromedial and posterolateral tibial fractures. First, posteromedial inverted L-shaped incision was made. The posteromedial cleavage fracture block was fixed through posteromedial approach. Appropriate gap was kept. Next, posterolateral inverted L-shaped incision was made. The posterolateral collapse fracture was exposed after dissection through posterolateral approach. After exposure, the collapse fracture was filled with bone graft to avoid loss of reduction after surgery. 7 cases in this study had pure cleavage fractures. 8 cases had pure collapse fractures. 6 cases had both posteromedial and posterolateral fractures, which were posteromedial cleavage fractures and posterolateral collapse fractures, respectively. Allograft bone was implanted in 14 collapse fractures. 6 cases were fixed using screws. 11 cases were fixed using T-shaped plate. 4 cases were fixed using reconstructive plate.

For cases accompanied with injury in meniscus or cruciate ligament, the exploratory operation was performed to determine the approach ahead. In this study, 5 cases had accompanied avulsion of anterior cruciate ligament and tibia crest. For these cases, bone tunnel was made in tibial plateau and fixed using steel wire. For 4 cases with injury in meniscus, 2 cases received meniscus repair and 2 cases received resection of part meniscus.

Postoperative treatment

Following surgery, standard antibiotics were given for 3-7 days. The affected extremities were raised. According to classification of fractures, reduction and intraoperative internal fixation, different postoperative treatments were given. 2-3 days after surgery, cases took function exercises for quadriceps femoris, and exercised flexion and extension of ankle and toe joints. 5 days to 3 weeks after surgery, cases underwent knee flexion and extension exercises twice a day using CPM machine. Cases accompanied with injury in meniscus or cruciate ligament received fixation using long leg orthosis after surgery, and took joint exercises 4-6 weeks after surgery. 10-12 weeks after surgery, cases walked with stick but without weight-bearing on the affected extremity. 3-5 months later, when radiograph revealed full bone union, cases could get out of bed and walk with weight-bearing gradually.

Outcome assessment

The function of the knee joint was assessed according to Rasmussen scale, which included self-assessment by patients and objective examination by clinician, including pain (6 points), walking ability (6 points), loss of range of knee extension (6 points), range of knee motion (6 points), and knee stability (6 points), a total of 30 points; a result of ≥27 points was considered as excellent, 20-26 points was good, 10-19 points was fair, and 6-9 points was poor.

The effectiveness of fracture reduction was assessed according to Rasmussen radiology scale [3], including: condyle collapse (6 points), increased width of condyle (6 points), knee varus or valgus (6 points), a total of 18 points; a result of 18 points was considered as excellent, 12-17 points was good, 6-11 points was fair, and <6 points was poor.

Results

21 cases were subject to follow-up for 12-24 months (an average of 16.2 months). No cases developed incision inflammation, neurovascular injury, internal fixation loosening and breakage. Bone union was observed in all cases. The time to union was 11-20 weeks, with a mean of 16.2 weeks. At the last follow-up, no cases developed knee varus and valgus deformity and fracture dislocation.

After surgery, CT scan and three-dimensional or multiplanar reconstruction (MPR) indicated anatomical reduction in 13 cleavage fractures of posterior tibial plateau; in 14 collapse fractures, 10 had anatomical union, 3 fractures had collapse of <2 mm, and 1 fracture had collapse of 4 mm.

After surgery, Rasmussen score for knee joint functions was 13-30 points (a mean of 24.2). The results were excellent in 12 cases, good in 7 cases and fair in 2 cases. The percentage of excellent and good results was 90.5%. 9 cases had accompanied injury in cruciate ligament or meniscus. Rasmussen radiology score was 10-18 points (a mean of 15.6 points). The results were excellent in 13 cases, good in 7 cases and fair in 1 case. The percentage of excellent and good results was 95.2%.

After surgery, 1 case had significant limited range of knee extension (10°) and flexion (85°), which was considered to be associated with inadequate rehab exercises due to long immobilization of knee after posterior tibial fracture combined with injury in cruciate ligament. The patient received release under arthroscopy combined with function exercise, and the range of motion improved 4 weeks later. 2 cases developed traumatic arthritis, which was caused by poor bone reduction and severe collapse. They received intra-articular injection with sodium hyaluronate and oral nonsteroidal

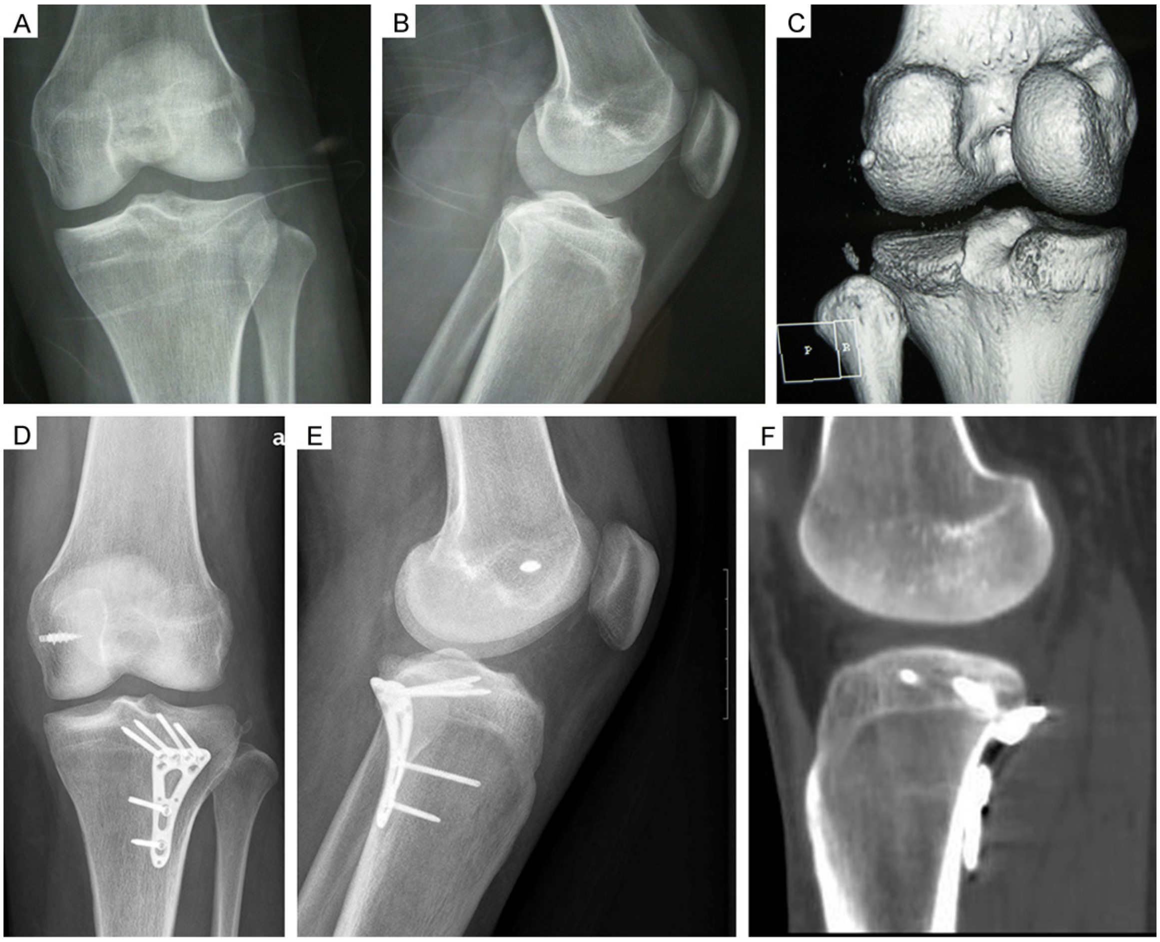

Figure 1. Female patient, 24 years, had left posterolateral TPF due to fall, and underwent internal fixation with steel plate through posterolateral approach. A, B: A-P & lateral radiograph before surgery; C: Three-dimensional CT reconstruction before surgery indicated left posterolateral collapse TPF; D, E: A-P & lateral radiograph after surgery indicated good reduction of fracture; F: CT reconstruction at sagittal position after surgery indicated good reduction of collapse fracture.

anti-inflammatory drug, and the pain relieved 6 weeks later (**Figure 1**).

Discussion

Classification of PTPFs

The posterior tibial fracture is caused by hit from femoral condyle during suffering vertical or varus or valgus stress when knee is at half flexion or flexed position. Currently, there are many classifications for tibial plateau fractures, among which, Schatzker classification [4] and AO classification [5] were most widely used. The former one takes morphologic features, pathological and physical factors, and treatment options into consideration, which is easy to remember. The later one provides more details about the morphology of fractures, but it is difficult to remember. The current classifications of tibial plateau fractures are based on knee radiograph. Less is known about the PTPFs in coronal plane. Khan et al [6] proposed a new classification which classified PTPFs as an independent type including posteromedial cleavage and posterolateral collapse; however, the nature of fractures was not accurately described, which was too simple. As the advance in imaging technology such as CT, more is known about the PTPFs. Yang et al [7] suggested three-column classification of TPFs based on CT, which included medial column, lateral column and posterior column. It was a useful classification of TPFs and helped surgeons better understand the types of fractures, and provided guide for surgical approaches and internal fixation, although the classification of posterior fractures involving posterior column was not described. In this study, we noted CT classification [8] for PTPFs to guide surgical approaches and internal fixation methods.

Section of surgical approach

Posteromedial TPF: The conservative anterior-medial approach can expose the posteromedial tibial plateau and fracture site laterally, but it is easy to injure medial collateral ligament during dissection involving large area. The skin edge may be necrotic. Also, the exposure area is limited, which makes it more difficult to perform reduction and fixation. The posteromedial approach is now widely used for medial fractures in clinical practice [9]. Good exposure was obtained by making incision to expose posteromedial TPF. During exposure by this approach, there were fewer anatomical structures; important vessels and nerves were protected in medial head of gastrocnemius muscle, which reduced probability of injury and increased safety. During procedure, the incision was made through the gap between the semitendinosus and medial head of gastrocnemius muscle. Due to high mobility, the posterior tibia could be adequately exposed, which reduced the surgical injury. During the surgery, the injury of saphenous nerve located in superficial fascia at the proximal incision should be avoided. Moreover, to maintain normal anatomy of muscles, the medial head of gastrocnemius muscle was not cut off, and excess retraction of medial head of gastrocnemius muscle was avoided during the surgery, which helped to avoid loss of knee and ankle flexion caused by fibrillation of muscles or neuratrophy.

Posterolateral TPF: Due to its special and complicated anatomy, it is contradictory in selection of surgical approaches. The conservative anterior-lateral approach can not exposure the posterolateral tibia due to blockage by fibular head and common peroneal nerve. Johnson et al [10] reported to perform reduction and internal fixation for lateral plateau fracture by anterior-lateral osteotomy, in which the Gerdy node of bone was completely cut off and lifted laterally using osteotome to expose the posterior bone fracture at maximum. We believed that the method was difficult to obtain definite good reduction quality and strong fixation. Yu Baoqing et al [11] used approach by partial or complete resection of fibular head and they thought it was good for reduction and fixation of posterolateral TPF. Since the fibular head is attachment site for lateral collateral ligament, tendon of biceps femoris muscle and arcuate ligament which support fibula, the removal of fibular head will no doubt injure normal anatomy of bone. The posterolateral approach that crossed fibula designed by Lobenhoffer et al [12] for the treatment of posterolateral TPF had resulted in favorable outcomes. However, this approach needs separation of common peroneal nerve and osteotomy at the neck of fibula, which leads to major trauma and limitation in clinical use.

The posterior midline approach for exposure is more likely to injure vessels and nerves because the posterior tibial vessels and veins are located in the incision. Bhattacharyya et al [13] treated 13 cases with posterior cleavage fractures through this approach and concluded that the approach was safe and reliable for such plateau fractures, and the outcomes were mainly associated with the magnitude of reduction of articular surface. Zhu [14] used posteromedial inverted L-shaped approach for posterolateral fractures and found good reduction and fixation. They suggested that the approach was effective for posterior tibial fractures. However, due to blockage by medial head of gastrocnemius, it is necessary to cut off part of medial head of gastrocnemius to expose posterolateral tibia in some cases, which is unfavorable to recovery.

In recent years, surgeons pay more attention to posterolateral approach for posterolateral plateau fractures as more is known about the anatomy of posterolateral tibial plateau. Carlson [15] used posterolateral approach for PTPFs and found good effectiveness. In this study, PTPF approach was used for posterolateral fracture and observed good fracture exposure and fixation. We believed this approach could obtain good exposure of fracture and provide adequate space for anatomical reduction under visual inspection. During the surgery, the screws were placed vertically to the fracture line from the back to the front, which was more consistent with AO fixation principle. The approach allowed stronger internal fixation, which ensured early function exercise and reduced occurrence of fracture related complications. The incision goes laterally from the lateral head of gastrocnemius muscle, and does not expose important vessels and veins in the popliteal space, significantly lowering surgical risk and difficulty, which makes it appropriate approach for PTPFs. Most posterolateral TPFs have posterior collapse which needs bone graft after reduction. In this study, all cases with posterolateral condyle collapse received adequate bone graft.

Selection of materials for internal fixation

The anatomical outline of posterior tibial plateau is not regular, whose transition area at metaphysis has great degree of curvature. Meanwhile, the steel plate is hard to undergo accurate moulding and be attached to the fracture site. Therefore, there is no available internal fixator that fits with the anatomical feature. Some researchers tried to use limited contact with pre-curved compression plate, reconstructive steel plate, T-shaped steel plate, L-shaped steel plate and clover-shaped steel plate with shearing point at the top for support and fixation, which obtained good fixation. In this study, screws, reconstructive steel plate or T-shaped steel plate were used for support and fixation and significant fixation was observed. After surgery, no cases developed internal fixation loosening, breakage and bone malunion. Also, there was little impact on tissues surrounding the fracture due to small size of internal fixator. Yu et al [16] suggested the use of buttress steel plate to obtain better mechanics because tensile screw alone can not bear strong shear force when stress was concentrated during knee flexion. In this study, 6 cases were fixed using screws. Among them, 4 cases received posterior to anterior fixation, and 2 cases received anterior to posterior fixation. Good fixation was observed in all cases and no another displacement was observed. Although posterior fixation with steel plate or posterior to anterior fixation using screws is reliable, the removal at phase II causes major trauma. Therefore, when combined anterior fracture needs internal fixation, the anterior to posterior fixation is not as good as posterior fixation with steel plate regarding the biomechanics, but it is easy to remove, which can lead to good fixation by accurate function exercise instruction. We also demonstrated that the screws with appropriate length were the key for effective bilateral cortical fixation. Further study should be conducted to confirm the biomechanics due to small size of samples in this study.

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Disclosure of conflict of interest

None.

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