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Original Article

Recent progress in the diagnosis and treatment of posterior tibial plateau fractures

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Abstract: The posterior tibial plateau fracture is drawing increasing attention from orthopedists in recent years with the popularity of CT. However, due to the particular and severity of posterior tibial plateau fracture, there is still controversy in its classification and treatment. It is very difficult to achieve the ideal reduction and fixation by conventional techniques and approaches. The modified posterior approach is favorable for posterior tibial plateau fracture, but disadvantages remain. Recently, the lateral approach is applied by doctors. It is ideal for treatment of posterior tibial plateau fracture. Because of the complexity of local anatomical structure, the operative management of posterior tibial plateau fractures is a contentious issue as revealed in the recent surge of published literature addressing the surgical approach. This review mainly summaries the diagnosis, classification and surgery of the posterior tibial plateau fractures.

Keywords: Tibial plateau, fracture, diagnosis, operative approach

Introduction

Posterior tibial plateau fracture is relatively rare in tibial plateau fractures. Tibial plateau, the contact surface of a tibia with terminal femur, is an important loading structure of a knee. Therefore, once fracture occurred, medial and lateral parts of the plateau unevenly stood force, resulting in osteoarthritis and various pathological changes [1]. Tibial plateau fracture could be caused by indirect violence or direct violence. Some scholars thought that, in double condyle fractures of tibial plateau, incidence of posterior-medial block fracture was 59%. In the past, doctors and patients lacked of sufficient knowledge about posterior tibial plateau fracture due to various causes [2, 3]. In recent years, with rapid development of imaging technology, clinicians gradually improve diagnosis and treatment means of posterior tibial plateau fracture [4, 5].

Because direct violence or indirect violence-induced posterior tibial plateau fracture would result in serious consequences, early diagnosis and treatment is very important. The traditional surgical method for open reduction is difficult to operate as posterior tibial plateau has complex structure. In addition, open reduction and internal fixation for posterior tibial plateau fracture is adopted to restore the lower limb force line and maintain the joint stability, but there is controversy on the surgical approach and internal fixation way. In treatment of such fractures, different opinions exist currently. Therefore, this article reviewed status quo of diagnosis and treatment of posterior tibial plateau fracture.

Clinical diagnosis

To achieve an accurate diagnosis, (1) carefully asking the medical history to help doctors in time understand knee flexion or extension status, intensity and direction of violence at the time of injury, thus having a preliminary judgment for classification of fracture [6]. (2) Physical examination should be conducted to determine whether the fracture was open fracture or closed one, whether blood vessels, ligaments and nerves were injured and whether osteofascial compartment syndrome was accompanied [7]. (3) Besides medical history

and physical examination, imaging examination is crucial for diagnosis of posterior tibial plateau fracture. X-ray examination is the preferred imaging method to assess fracture. The fracture line is located at coronal plane of a knee joint in case of posterior tibial plateau fracture, especially posterior-lateral tibial plateau fracture [8]. For such fractures, since posterior-anterior and lateral X-ray film easily results in missed diagnosis, an additional oblique film and the X-ray films are needed as the control so as to further understand medial and lateral fracture morphologies [8]. Three-dimensional reconstruction of a spiral CT scanner, which could intuitively, three-dimensionally, multi-angularly shows location, severity and displacement of the fracture and is better than X-ray examination in detection rate and classification judgment of the fracture, has been widely used in diagnosis and treatment of bone and joint system [9, 10]. Therefore, spiral CT has an important clinical significance for diagnosis of posterior tibial plateau fracture. Besides, and MRI is also necessary because it helps to display extent of soft tissue damage at fracture site so that the doctors can more easily judge the necessity of immediate surgical repair [8]. In recent years, with rapid developments of spiral CT, MRI and other imaging techniques, we have in-deep understanding and knowledge about posterior tibial plateau fracture, and the doctors could make a early diagnosis of posterior tibial plateau fracture by using imaging manifestations [11, 12].

Clinical classification

For classification of posterior tibial plateau, Schatzkerr classification [13] and AO classification [14] are the most commonly used methods currently. However, the former is not very suitable for classification of posterior tibial plateau fracture because it mainly describes sagittal plane fracture of medial and lateral tibial plateau and could not summarize coronal plane fracture of posterior condyle of tibial plateau although it comprehensively considers morphological features, pathophysiologic factors and treatment ways and is easy to remember. The latter (AO/OTA classification system [15]) describing the fracture morphology in detail classified posterior-lateral tibial plateau fracture into four types (i.e., posterior split of coronal plane of lateral tibial plateau, posterior depression of lateral tibial plateau, posterior-lateral split and depression of lateral tibial plateau, posterior-medial split and depression of lateral tibial plateau) [16], but it is difficult to remember.

All the current classification methods of tibial plateau fracture are gradually established based on X-ray films of knee joint, but there is no accurate and specific description of posterior tibial plateau fracture on coronal plane. Later, some scholars [17] proposed a new classification method after integrating previous classification methods, that is, the posterior tibial plateau fracture was classified as a separate type according to morphological distribution, i.e., P-type posterior plateau fracture, which was further divided into two subtypes (P1 posterior-medial split and P2 posterior-lateral split). Nevertheless, the method was too simple and could not accurately describe specific nature of the fracture [18].

Since existing classification systems could not describe posterior tibial plateau fracture well, some people proposed three-column classification of tibial plateau fracture on basis of CT with application of spiral CT [19], dividing tibial plateau fracture into medial posterior column, lateral column and posterior column. This method, helping orthopedists understand fracture classification well, is a valuable classification method of tibial plateau fracture and can help to guide choices of surgical approach and internal fixation methods, thus significantly improving diagnosis and treatment effect of posterior tibial plateau fracture [19-21].

However, this method only classified posterior tibial plateau fracture as posterior column fracture without specific and detailed classification of posterior column fracture and specific clinical guidance [20]. On the basis of three-dimensional CT reconstruction images with Schatzker classification, Chen HW proposed a more detailed classification of posterior tibial plateau fracture [22] and divided it into split fracture of posterior-medial condyle (I), split fracture of posterior-lateral condyle (II), depression fracture of posterior-lateral condyle (III), split and depression fracture of posterior-lateral condyle (IV), posterior-medial condyle split fracture and posterior-lateral condyle depression fracture (V), thereby further helping clinicians purposefully select an appropriate diagnosis and treatment plan so as to finally determine

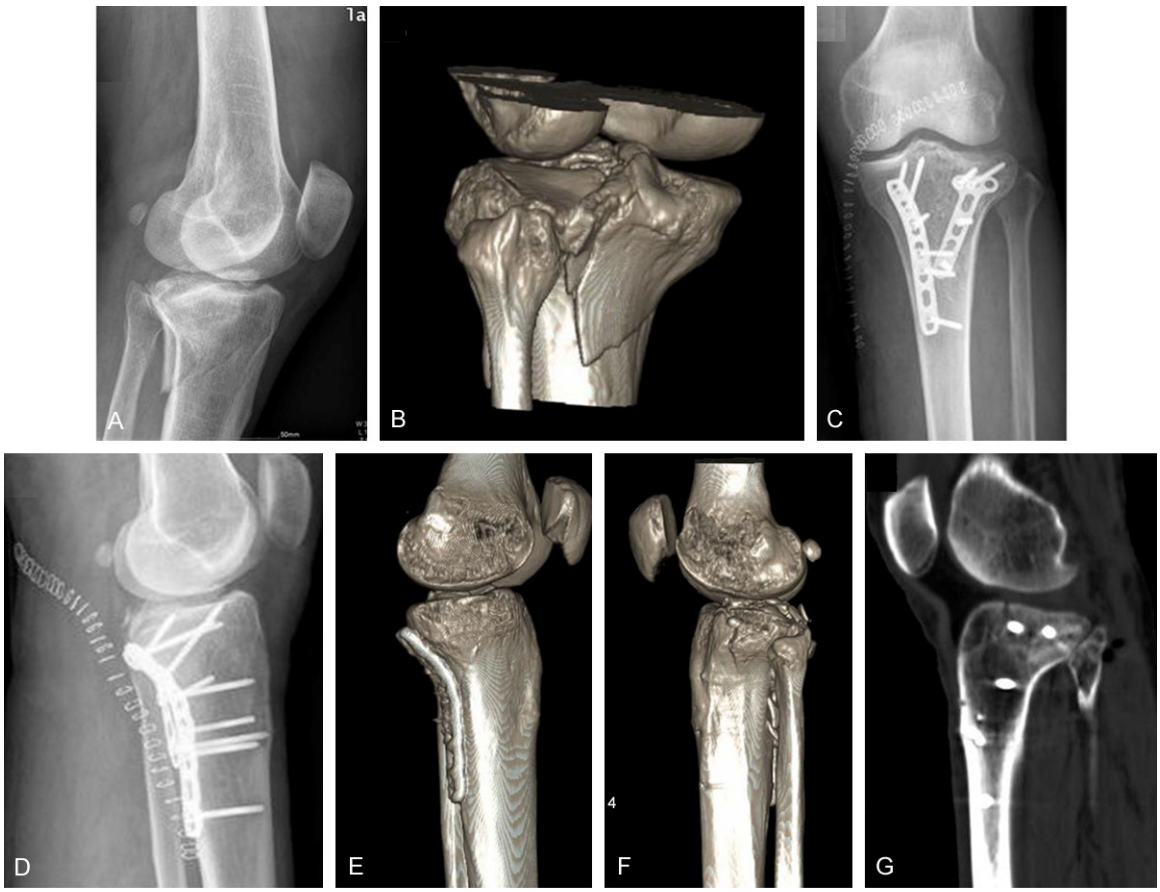

Figure 1. Posterior-medial approach in treating posterior tibial plateau fractures. A. Lateral X-ray film before the surgery showed the posterior tibial plateau fracture. B. CT image before the surgery showed posterior-medial split and posterior-lateral depression of tibial plateau. C, D. Anteroposterior and lateral X-ray films after the surgery showed satisfactory reduction. E-G. CT reconstruction images after the surgery showed satisfactory reduction.

the surgical approach and surgical method, and improve postoperative rehabilitation of patients. However, the classification method, isolating posterior tibial plateau fracture again, has very large limitation. How to integrate posterior tibial plateau fracture into the existing fracture classification system is a problem urgently to be solved at present.

In clinical practice, differences exist often between classification results from X-ray film and CT scan because spiral CT scan could be more helpful for clinicians to comprehensively understand fracture, and the classification based on CT findings has better guidance for selection of surgical approach and internal fixation to develop a preoperative plan. This is the most ideal classification method so far. Therefore, we should effectively made use of imaging technology, which not only could accurately reflect severity of fracture type, but also aid in diagnosis and guide treatment and predict outcome. It is a pity that no a specific ideal classification system is available in clinic, so clinicians are required to further improve the existing classification by analyzing bulk of cases.

Surgical treatment

Ordinary tibial fracture could be treated by standard reduction and fixation techniques, but for fractures involving posterior tibial plateau, especially combining with other soft tissue contusion as well as injuries of nerve, muscle and blood vessel, there is a certain difficulty in the treatment, and clear and timely diagnosis is crucial to timely treatment. Several surgical methods for treating posterior tibial plateau fracture are described one by one below.

Anterior approach of knee joint

Nusselt T used anterior-lateral incision and anterior-medial fenestration and poking with

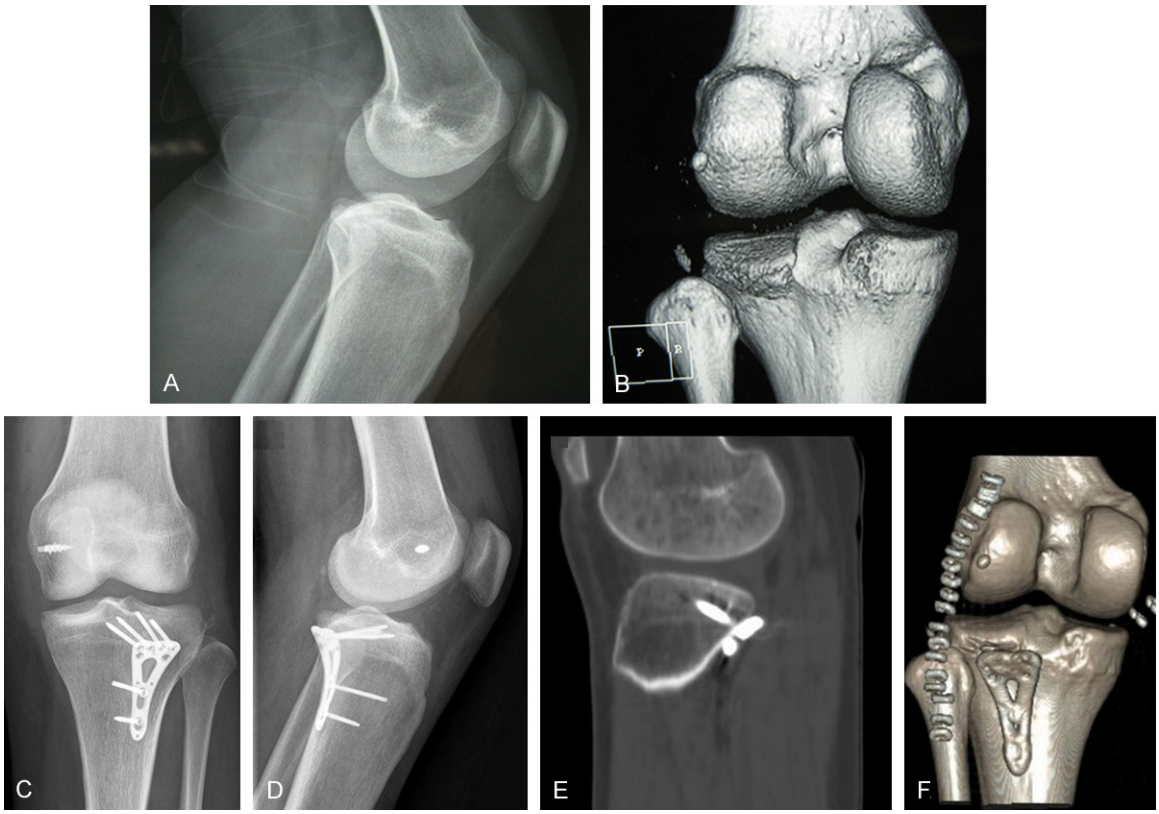

Figure 2. Posterior-lateral approach in treating posterior-lateral tibial plateau fractures. A. Lateral X-ray film before the surgery showed the posterior tibial plateau fracture. B. CT image before the surgery showed posterior-lateral depression of tibial plateau. C, D. Anteroposterior and lateral X-ray films after the surgery showed satisfactory reduction. E, F. CT reconstruction images after the surgery showed satisfactory reduction.

lateral support plate fixation to treat posterior-lateral tibial plateau fracture, and the results showed small damage, but exposure of the fracture site was not very clear due to blocking of femoral condyle and meniscus so as to affect subsequent clinical judgment and surgical treatment effect [23]. In the study by Vasanad GH et al., the anterior-lateral incision with anterior-lateral fenestration and poking was used to treat posterior-lateral depression fracture and C-arm X-ray examination was conducted to judge reduction of the depression articular surface [24]. Yu Baoqing et al. used anterior-lateral approach with whole or partial resection of the fibular head and considered that the method was conducive to reduction and fixation of posterior-lateral condyle fracture of tibial plateau [25].

Because the fibular head, attached by the lateral collateral ligament, biceps femoris tendon and arcuate ligament, plays a role in supporting the fibula, removal of the fibular head necessarily results in damage of the normal anatomy near the tibia. For exposure and fixation of fracture, the approach to damage adjacent structure is not the optimal treatment mean. Although anterior approach had achieved some clinical efficacy, it could not completely expose posterior tibial plateau due to blocking of femoral condyle and meniscus. Moreover, as articular surface of the tibial plateau is irregular and it is difficult to accurately judge flatness of articular surface depending on X-ray examination, this approach to expose posterior tibial plateau fracture clinically is subjected to certain restrictions and is not conducive to anatomical reduction of fracture. Anterior approach for treatment of posterior tibial plateau fracture has been applied rarely in clinic, but could be used for complex tibial plateau fracture by combining with posterior incision [26, 27]. Therefore, it is very important to look for other surgical methods for treatment of posterior tibial plateau fracture.

Posterior approach of knee joint

Compared with above anterior approach of knee joint, posterior approach used for enter-

ing posterior space of the joint could obtain sufficient surgical field to effectively avoid damage of adjacent nerves and ligaments. More importantly, this method requires smaller surgical scope of stripping so as to reduce bleeding and incidence of blood circulation obstacle in the flap. Posterior approach could be divided into posterior-median approach, posterior-medial approach (**Figure 1**) and posterior-lateral approach (**Figure 2**). De Boeck and Opdecam [28] used posterior S-shaped approach of knee joint to treat 7 cases of posterior split fracture of tibial plateau, and all patients achieved satisfactory clinical outcomes without surgery-related complications. Bhattacharyya et al. [29] also adopted posterior S-shaped approach of knee joint for treatment of 13 patients with posterior split fracture of tibial plateau, and the results showed incision dehiscence in one case, knee flexion contracture in one case, healing of all fractures, no neurovascular injury, no loss of reduction, and satisfaction of 88.9%. However, in the procedures by the above authors, the medial head of gastrocnemius muscle was cut, which was not conducive to early function exercise of the knee joint. Some people used posterior S-shaped approach of knee joint without cutting the medial head of gastrocnemius muscle to treat 5 patients and also achieved satisfactory clinical outcomes [30]. Alpert et al. [31] thought that posterior S-shaped approach of knee joint for treatment of posterior split fracture of tibial plateau was not commonly used by orthopedists as familiarity with deep anatomical knowledge is necessary. Moreover, S-shaped incision would cause large trauma and is required to turn up large skin flap, which is not conducive to healing of skin. Furthermore, during the operation, blood vessels and nerves need to be exposed, possibly injuring blood vessels and nerves. Li YC et al. [32] found that excellent, good, satisfactory and poor outcome were displayed in 16, 13, 7and 3 limbs of posterior approach group with small incision, and in 19, 11, 8 and 4 limbs of posterior approach group with tiny incision after adopting posterior approach with small incision and tiny incision for 81 limbs of 79 patients with complex tibial plateau fracture accompanied by condyle fracture, and Rasmussen functional knee score and radiological score method [33] to assess efficacy after operation. Hence, it was considered that there was no significant difference in knee function rehabilitation between using posterior small incision and using posterior tiny incision. Compared with posterior small incision, posterior approach with tiny incision had less skin necrosis and incision infection rate. Frosch [34] et al. introduced a new lateral-position posterior-lateral approach without severing fibular neck for treatment of six patients with tibial plateau fracture, and the results showed no complications or reduction loss. The modified posterior approach for surgical treatment of posterior tibial plateau fracture, which was operated through intermuscular space, had the advantages of small damage to normal bone tissue and soft tissue, convenience in reduction and fixation of posterior condyle fracture of plateau, clear exposure, and convenient placement for internal fixation, small trauma and good clinical efficacy. In summary, it was the ideal surgical approach for treatment of posterior tibial plateau fracture.

Posterior approach, which is the same as our posterior-lateral approach in deep space and featured by simultaneous treatment of the accompanying anterior-lateral tibial plateau fracture, could be regarded as an ideal surgical approach to treat posterior-lateral tibial plateau fracture with anterior-lateral tibial plateau fracture. Consequently, it can be a complement to the modified posterior approach for posterior tibial plateau fracture. However, because this approach requires lateral position, the position needs to be changed in case that posterior-medial tibial plateau fracture is accompanied, resulting in inconvenience to the surgical operation. The above-mentioned combination of anterior and posterior approach can fully expose various blocks of tibial plateau fracture so that fracture site can achieve anatomic reduction easily and the support plate is stable and reliable for fixation. Therefore, this method could obtain very good clinical efficacy if we can timely and accurately master surgical indications.

Lateral approach

Posterior-lateral approach is not applicable to complex tibial plateau fracture due to complex local anatomical structure, limited scope of exposure and risk for damage of significant anatomical structure [35]. In some posterior-lateral fracture patients, blocking of medial protrusion of the fibular head would affect opera-

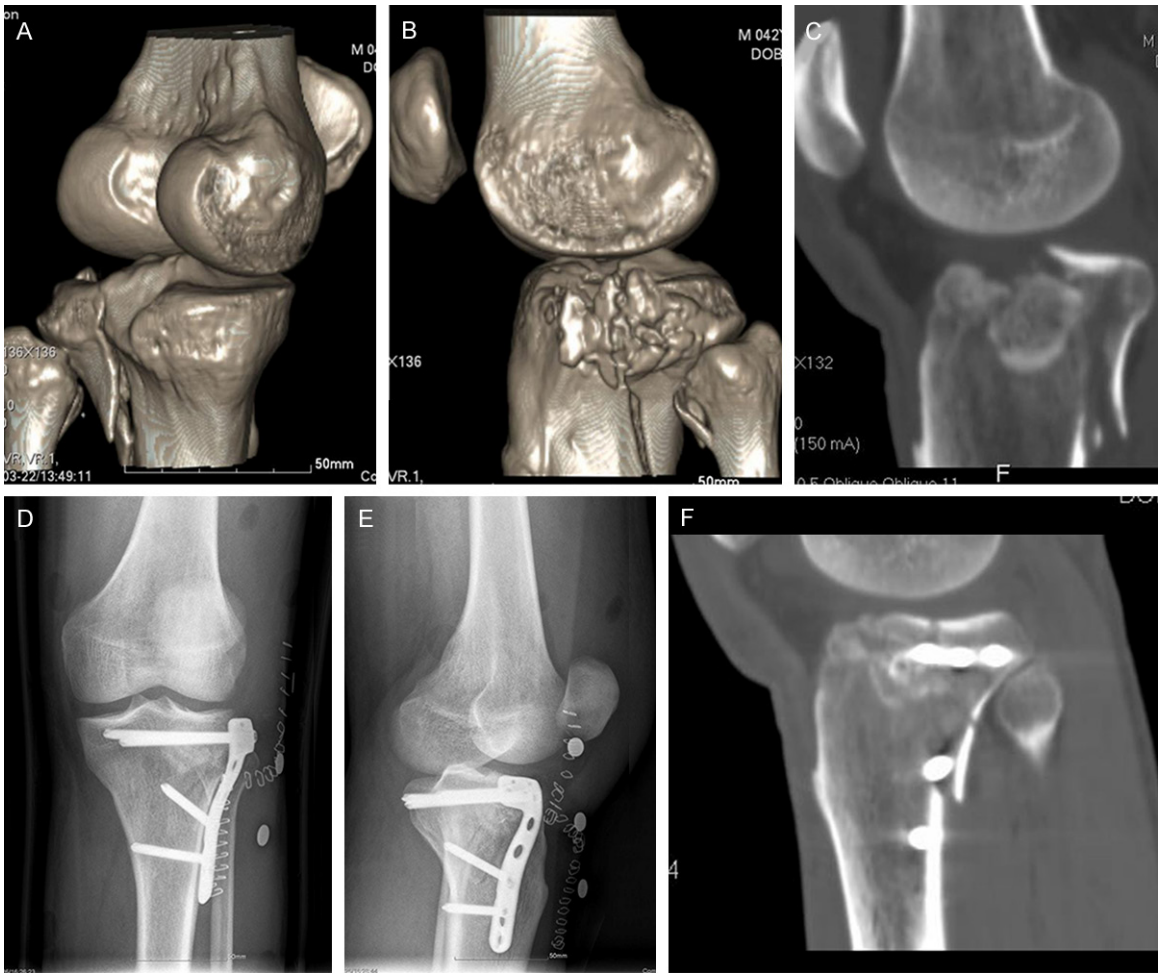

Figure 3. Expanded anterior-lateral approach in treating posterior-lateral tibial plateau fractures. A-C. CT images before the surgery showed posterior-lateral split of tibial plateau. D, E. Anteroposterior and lateral X-ray films after the surgery showed satisfactory reduction. E, F. CT reconstruction images after the surgery showed satisfactory reduction.

tion of the reduction and placement of the support plate. Because of scar formation and anatomical structural variation, blood vessels and nerves are easily damaged when internal fixation is removed [36, 37]. Therefore, in recent years, some scholars used lateral approach to treat posterior-lateral tibial plateau fracture. After adopting the expanded anterior-lateral approach for treatment of 10 patients with posterior-lateral tibial plateau fracture, Chen HW et al. thought that this approach combined with 3.5 system locking plate fixation not only could directly expose the fracture site, but also provide an effective treatment for posterior tibial plateau fracture [38] (**Figure 3**). Through describing posterior-lateral approach for posterior-lateral tibial plateau fracture via the fibular neck, Solomon et al. [39] thought that this approach allowed direct observation of posterior-lateral compression and comminuted fractures, was conducive to reduction, was safe and allowed a plate to be placed deep to posterior site compared with traditional anterior-lateral approach.

The advantages of the above approach include exposure of the entire lateral tibial plateau using lateral incision of joint capsule and meniscotibial ligament, less soft tissue interference, unnecessarily severing fibular head, feasibility of anatomical reduction under direct vision and sufficient space for operation without involvement of important blood vessels and nerves during the operation and additional trauma. Moreover, it is simple to remove phase II plate, and the risk for damage to blood vessels and nerves is small.

Arthroscopic approach

With development of arthroscopic technique, some scholars [40-43] use an arthroscope to treat posterior tibial plateau fracture currently. Abdel-Hamid MZ et al. thought that all the posterior tibial plateau fractures were accompanied by injuries of adjacent soft tissue, among them, meniscuses and anterior cruciate ligament were most vulnerable to injury, and posterior tibial plateau fracture accompanied by soft tissue injury was a good indication for diagnosis and treatment with arthroscope [40]. Cassard X thought that arthroscopic approach for treatment of posterior tibial plateau fracture had advantages of fast recovery, short hospital stay and low complication rate, and the postoperative long-term effect was very good especially in patients with type III and IV fractures. Meanwhile, percutaneous bone suture could only be carried out under arthroscopic control, with the advantage of unchanged anatomical structure [41].

Just because of particularity of posterior tibial plateau fracture, there is no consensus on surgical approach in clinical practice. Through analyzing the literatures, we find that there is a greater controversy about surgical approach of posterior tibial plateau fracture in clinical practice at present. Although arthroscopic approach would cause small damage, indirect reduction under an arthroscope was very difficult, and reduction under direct vision was necessary for posterior tibial plateau fracture with posterior cortex injury. A good approach can not only fully expose fracture site, but also maximize protection of adjacent soft tissue, blood vessels, nerves and ligaments and should be conducive to internal fixation. Posterior approach could meet above requirements and has the following advantages: unnecessary exposure of important blood vessels and nerves, satisfactory exposure of fracture ends and available fracture reduction and fixation under direct vision; besides, using this approach, fracture block could be directly fixed via posterior part to anterior part so as to prevent fracture shift to posterior part. Posterior approach was undoubtedly the optimal surgical approach to in treatment of posterior tibial plateau fracture at present, but surgeons were required to be familiar with the anatomical structure of posterior-lateral knee joint.

Conclusion

In summary, the goal for treatment of posterior tibial plateau fracture is to recover the articular surface flatness and the lower limb force line by surgery. Nevertheless, the surgery still needs to be improved by the systemic anatomic and biomechanic studies as well as the clinical summaries of multi-center studies in large-scale patients due to some difficulties in the surgical operation clinically and various degrees of defects in approaches and fixation methods.

Disclosure of conflict of interest

None.

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