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Use of arthroscopy in management of tibial plateau fractures

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ABSTRACT

Introduction

Tibial plateau fractures are periarticular injuries of the proximal tibia often associated with soft tissue injury. They account for 1-2% of all fractures. Their impact on the articular surfaces and the development of osteoarthritis make them an interesting research topic in the orthopaedic field. With the development of arthroscopic treatment methods, many are thinking of ways to incorporate less invasive methods in the reduction and fixation of these injuries.

Review methods

English-language scientific literature found in PubMed and Google Scholar was used for the review. Articles were searched based on keywords. Each article was analyzed for knowledge currency and relevance for use in the review.

Description of the State of Knowledge

After searching the articles, 35 articles were selected for final analysis. The collected data provided the latest information on treatment of tibial plateau fractures (TPF) using arthroscopic tools with studies diving deep into both the technique and longer-term results.

Summary

The use of arthroscopy in treatment of tibial plateau fractures grows year by year with more and more clinicians being interested in limiting the soft tissue damage and other adverse effects of ORIF.

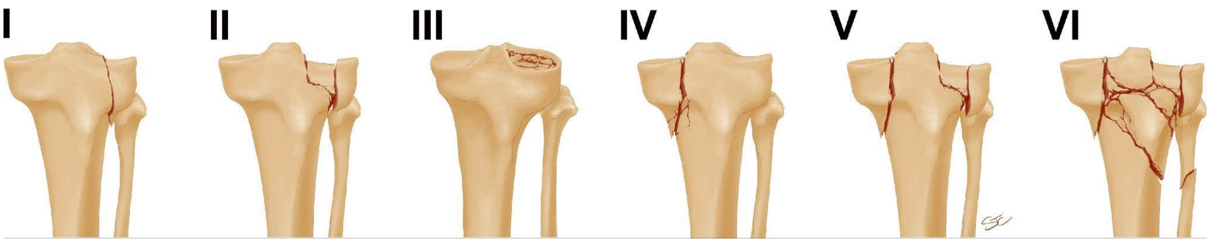
Keywords: Schatzker, arthroscopy, tibial plateau fracture

REVIEW

Schatzker classification of tibial plateau fractures

Tibial plateau fractures are joint injuries that present with a wide range of clinical symptoms and frequently result in long-term complications. In recent years, these complex fractures have attracted significant attention, not only in terms of their classification but also in relation to fixation techniques and anticipated outcomes. [1]

Schatzker posits that the indication for surgery was based on joint instability, rather than the degree of depression, which was a surgical criterion in other studies. In the event of any uncertainty regarding the stability of the joint, it was recommended that an examination under anaesthesia be performed. In 1979, Schatzker et al. [2] published their experience of managing 94 tibial plateau fractures. Since that time, the six basic types in Schatzker's classification have been validated and widely accepted as a practical and useful system for the classification of tibial plateau fractures. [3, 4]



The six principle tibial plateau fracture types as described by Schatzker:
Type I - split wedge of the lateral tibial plateau;
Type II - split wedge depression of the lateral tibial plateau;
Type III - pure depression of the lateral tibial plateau;
Type IV - split wedge of the medial tibial plateau;
Type V - bicondylar tibial plateau fracture, where there is continuity between the epiphysis and the diaphysis;
Type VI - bicondylar fracture with complete dissociation between the epiphysis and the diaphysis.

The Schatzker classification is based on a two-dimensional representation of the fracture. The classification of fractures is based on several factors, including the patient's age, bone quality, fracture morphology, and the energy of the traumatic event. The classification system encompasses types I to III, which pertain to fractures of the lateral tibial plateau.

Type I is a cleavage fracture of the lateral column, which is typically observed in younger patients with denser cancellous bone that resists impaction. This fracture typically occurs in the sagittal plane.

Type II is a split wedge fracture of the lateral column with depression, resulting from similar axial and valgus shearing and loading forces as Type I. However, it occurs in older patients with less dense metaphyseal bone, leading to impaction and depression of the articular surface.

Type III fractures are characterised by pure joint depression, with the metaphyseal cortex remaining intact. In the absence of impaction and depression of the plateau rim, the joint is typically stable. However, if this occurs, it can cause instability.

Types IV to VI are high-energy injuries associated with knee joint instability, ranging from subluxation to dislocation. A Type IV injury is defined as an isolated fracture of the medial column of the tibial plateau, caused by a varus shearing force. As the medial tibial plateau is denser, a higher force is required to fracture it, which makes Type IV a high-energy injury. It is often accompanied by a fracture-dislocation of the knee and potential neurovascular complications. [3, 4]

Bicondylar tibial plateau fractures, types V and VI, also result from high-energy trauma. Type V fractures preserve the continuity of the shaft with part of the overlying metaphysis and joint, usually the middle portion. This distinguishes type V from type VI fractures, where the continuity of the metaphysis is disrupted, and the articular surface loses contact with the diaphysis. It is often observed that types IV, V, and VI are accompanied by significant soft tissue damage, which is a consequence of the high energy required to cause these fractures.

Indications for surgical intervention in tibial plateau fractures

The indications for surgical management of tibial plateau fractures have varied, with acceptable limits of articular displacement ranging from 2 to 10 mm. It has been demonstrated that residual tilt of the tibial plateau and varus or valgus malalignment are associated with an increased risk of arthrosis. Biomechanical studies have demonstrated that a 6-mm step-off of the lateral plateau results in a 7.6-degree increase in valgus and a 208% rise in contact pressure. In his evaluation of 131 tibial plateau fractures, Honkonen [5] recommended surgical intervention for more than 5 degrees of valgus malalignment, an articular step-off exceeding 3 mm, and condylar widening exceeding 5 mm. A number of factors may influence the long-term outcome, and surgeons should consider the fracture type, the presence of laxity, the location of articular displacement (central vs. submeniscal), associated soft tissue injuries, and patient characteristics such as age, activity level, and comorbidities. [6]

Use of arthroscopy in reduction of tibial plateau fractures; operational technique

In the 1980s, Caspari and Jennings [7] were the first to describe the percutaneous surgical approach for the treatment of tibial plateau fractures using arthroscopy, particularly for Schatzker I, II, and III fractures. They proposed that the combination of arthroscopy with percutaneous fixation could result in a reduction in both intraoperative and postoperative morbidity compared to open reduction techniques.

For good visualisation of the fracture and in order to address specific cases of depression, it is recommended that a preoperative CT scan be utilised, in conjunction with intraoperative fluoroscopy and arthroscopy. [8]

The primary objective of treatment is to realign the lower limb and subsequently reduce the articular surface if the depression exceeds 2 mm. In younger patients with depressions exceeding 6 mm or metaphyseal separations greater than 5 mm, it is probable that concomitant damage to the meniscus and ligaments will be identified. In such cases, surgical intervention is planned to include arthroscopy. . A variety of stabilization techniques are available, including the use of polymethylmethacrylate cement; either autologous or heterologous bone grafts; [9, 10]; the application of cannulated screws and the performance of MIPPO (Minimal Invasive Percutaneous Plate Osteosynthesis) with anatomical plates and adjustable locking screws positioned beneath the depression in complex fractures. In percutaneous surgery, the focus is not on the size of the incision, but rather on the preservation of the metaphysis and its vascularisation in order to ensure durable stability. This approach has been demonstrated to yield superior functional outcomes compared to open reduction and internal fixation, not only for Schatzker type I, II, and III fractures but also for complex fractures where open fixation may cause more harm and complications.

The process of fracture reduction and internal fixation is initiated when the area of maximum depression on the tibial plateau is identified, and a 2 mm K-wire is inserted from the metaphyseal region to the articular surface using the ACL ligamentoplasty tibial guide at a sixty-degree angle. The K-wire serves as a guide for a medial corticotomy of the tibia, which is performed with an 8–10 mm cannulated drill. Subsequently, a cylindrical beater is employed to facilitate the gentle elevation of the depressed fragments, in conjunction with the underlying cancellous bone, while maintaining vigilance over the restoration of the articular surface. The inferior facet of the meniscus serves as a reference for the height of the articular surface, which must be verified with the C-arm. The procedure for achieving fixation is as follows: two 6.5 mm cannulated cancellous screws are placed near the subchondral bone, with the intention of supporting the articular surface and preventing secondary displacement. The placement and advancement of these screws are monitored using an image intensifier. In the event that a substantial residual bone defect is present in the metaphyseal region, it is recommended that a volume of 10–20 cc of cancellous bone or bone graft substitutes be introduced into the defect. Concurrently, any associated meniscal lesions should be treated with either suturing or partial meniscectomy, and chondral lesions should be addressed with debridement or microfractures. [11]

To verify the reduction, a C-arm fluoroscopy system is typically employed, positioned in opposition to the affected leg. Furthermore, joint inspection via arthroscopy is a viable option. The surgical techniques employed are analogous to those employed in standard knee arthroscopy. An arthroscopy pump is employed to facilitate the removal of intra-articular blood clots and to assist in the assessment of tissue damage. Another approach is the use of a shaver with aspiration capability, which is employed to eliminate these clots. [12]

Although there is general agreement on the overall surgical technique, several aspects remain the subject of debate. The utilisation of arthroscopy in complex proximal tibial fractures (Schatzker types V and VI) has been proposed as a means of enhancing the quality of the reduction and avoiding the necessity for an extensive arthrotomy. In such instances, arthroscopy should be combined with rigid fixation, which may be achieved through the use of a plate or external device. [13]

Contraindications for arthroscopy in tibial plateau fractures

Herbort et al. [14] observed that not all tibial plateau fractures are suitable for arthroscopic-assisted osteosynthesis. High-energy fractures, such as those classified as Schatzker IV-VI, are associated with a potential risk of fluid extravasation and compartment syndrome, although such cases are rarely reported in the literature. Tornetta et al. [15] proposed that the use of arthroscopic-assisted osteosynthesis should be limited to Schatzker types I, II, and III. [16, 17]

In the case of older patients, the use of arthroscopy may result in an extended procedure, and thus it is not a routine practice. [12]

Use of arthroscopy in tibial plateau fractures regarding soft tissue damage

In younger patients with depression exceeding 6 mm and separation surpassing 5 mm, arthroscopy is indicated to address concomitant meniscal and ligament injuries.

Arthroscopy offers a comprehensive view of intra-articular lesions, which are detected in a significant percentage of cases (ranging from 22% to 56%) [18, 19]. This technique allows for the treatment of various issues, including meniscus, ligament, or cartilage damage in a single procedure, which cannot be assessed through fluoroscopy alone. [20]

Among the intra-articular lesions, meniscus injuries are the most prevalent, occurring in 10% to 50% of cases. The lateral meniscus is more frequently affected than the medial one. In the case of peripheral meniscal lesions, the preferred treatment is repair, with minimal resection being considered only when repair is not feasible. Furthermore, any meniscus entrapped within the fracture can be readily released.

Anterior cruciate ligament (ACL) injuries are also common, comprising 33% partial tears and 13% full tears [9, 21, 22]. There is a certain degree of controversy surrounding the necessity of ACL tear repairs, given that they necessitate prolonged joint lavage, which increases the risk of compartment syndrome. Furthermore, the traction achieved through ligamentotaxis on a fracture table significantly complicates arthroscopic procedures. Nevertheless, there is a consensus that immediate reinsertion of any bony avulsion of the ACL's tibial insertion is necessary, while posterior cruciate ligament (PCL) reconstruction, if required, can be delayed. [12]

The series demonstrated statistically significant differences in the morphology of meniscal tears associated with various Schatzker classifications. The most prevalent type of meniscal tear observed in the study was the longitudinal tear. Furthermore, our findings indicated a significantly higher prevalence of complex tears, which were most frequently observed in bilateral meniscus lesions and were more commonly identified in Schatzker VI and Schatzker V fractures compared to other Schatzker classifications.

It is notable that meniscal tears are particularly common on the same side as the fracture. This may explain the higher frequency of lateral meniscal tears observed in this series, given the predominance of lateral tibial plateau fractures. Furthermore, our findings indicate that the most prevalent meniscal injuries associated with TPFs occur in the lateral meniscus, followed by the bilateral menisci, and then the medial meniscus. [1, 23]

Adverse outcomes and risks associated with an arthroscopic procedure

As with any technique, this procedure is not without certain disadvantages. Fluoroscopy is required to create a tunnel beneath the articular surface and to place the BioComposite interference screw, which exposes both the patient and operating staff to radiation. Furthermore, the drilling of a guidewire through the articular surface carries the risk of iatrogenic cartilage damage on the femoral side or the displacement of the fracture fragment into the joint. Additionally, the procedure necessitates the drilling of a tunnel in the proximal tibia, which requires the use of an ACL aiming guide. This guide itself carries a risk of cartilage injury and the development of osteoarthritis, which is less extensive than that observed in open surgery [24]. Furthermore, the creation of an additional tunnel in the proximal tibia may result in tunnel convergence if future ligamentous reconstructions are required. [20]

It is of the utmost importance to maintain intra-articular pressure below 50 mmHg in order to prevent the risk of compartment syndrome [12] which, while a feared complication, is extremely rare. Only one documented case has been reported, by Belanger and Fadale in 1997 [25]. Furthermore, instances of thromboembolism and infection are also exceedingly rare [13].

The use of arthroscopy for tibial plateau fractures type I, II and III according to Schatzker classification has increased, yet its employment for tibial plateau fractures Schatzker IV, V and VI is controversial due to the potential risk of compartment syndrome, deep vein thrombosis and infection, yet Franulic et al. [26] reported no instances of compartment syndrome in ARIF of Schatzker IV, V, VI fractures.

Furthermore, autologous bone grafting, despite being considered the standard procedure, can result in donor site pain, making heterologous bone grafts or bone cements more favourable alternatives, particularly in younger patients. [9]

Postoperative care

Drainage is not necessary. Patients typically remain in the hospital for 4 to 7 days [13]. Following surgery, it is recommended by Benea et al. [11] that the knee be immobilized in a fixed brace for a period of 2–4 weeks, with periods of active mobilization (0–90°) protected by a mobile brace, in conjunction with muscle strengthening exercises, without weight-bearing. Gradual partial weight-bearing is typically permitted around 8–12 weeks, with full weight-bearing only permitted after clinical and radiological confirmation of fracture healing. Furthermore, postoperative care encompasses pain management and the prevention of deep venous thrombosis. It is recommended that patients undergo clinical and radiological evaluations at 4, 8, and 12 weeks post-surgery, as well as at 6 months and 1 year.

Hermanowicz et al. [20], however, recommends that a continuous passive motion machine can be initiated on the first day following surgery and used for 30 minutes, six times a day, for a period of nine weeks. The flexion angle should be gradually increased to 90° by the sixth week. It is recommended that patients walk with crutches for the full nine-week period, with progressive weight-bearing commencing from the fourth week. Manual therapy should commence on the third postoperative day.

Results

The described arthroscopy-assisted technique offers excellent visualisation during surgery, thereby avoiding the specific disadvantages of open procedures such as soft-tissue trauma and the potential need for lateral femoral condyle or fibular head osteotomy [10]. This approach facilitates a more rapid recovery, reduces the risk of infection, and allows for early rehabilitation, which is crucial for preventing knee stiffness. Furthermore, it helps to avoid other complications that are commonly associated with open surgery, such as proximal tibiofibular joint instability, common peroneal nerve injury, and anterior tibial artery injury. Arthroscopic procedure also results in a reduction in morbidity rates [12]. This technique obviates the necessity for a second surgical procedure to remove implants and eliminates the risk of skin irritation caused by the implants. [20]

Study conducted by Deng et al. [27] has shown that the group of patients treated by arthroscopic procedure had less intraoperative blood loss, shorter hospital stay and better knee joint range of motion compared to the ORIF group ($p<0.05$). In addition, it resulted in better radiological outcomes based on Rasmussen radiological score ($p<0.05$) [28]. ARIF can achieve comparable clinical outcomes and superior radiological results for the treatment of lateral TPFs compared to conventional ORIF.

There is a consensus that arthroscopy ensures the highest quality joint reduction. Fowble et al. [29] reported a 100% satisfactory reduction rate with ARIF, in comparison to a 55% satisfactory reduction rate with ORIF. Kiefer et al. [30] achieved an 80% success rate in achieving good-quality reductions using arthroscopy. In a study by Van Glabbeek et al. [31], only one reduction failure was observed out of 20 separation/subsidence fractures that were managed arthroscopically. In addition, Ohdera et al. [32] observed an 85% satisfactory reduction rate with arthroscopy, in comparison to a 55% satisfactory reduction rate with open surgery. [17]

Research conducted by Siegler et al. [24] demonstrated that minimally invasive techniques resulted in a reduction in arthritic changes when compared to open reduction and internal fixation (ORIF). Furthermore, Ohdera et al. [32] demonstrated that the duration of surgery for arthroscopic reduction with internal fixation (ARIF) and open reduction and internal fixation (ORIF) was comparable. [12]

In the majority of studies, the short- and medium-term outcomes were favourable. Nevertheless, there is a paucity of studies with follow-ups extending beyond three years. Cassard et al. [33] reported knee and function scores exceeding 90%, while Scheerlinck et al. [34] found excellent HSS knee scores in 79% of patients after more than five years of follow-up. and also observed that 63% of patients returned to their previous level of sports activity, in comparison to 87% in a study by Holzach et al. [35]. It is important to note that significant joint space narrowing was observed in 10% to 30% of patients with follow-ups longer than three years. [13]

CONCLUSION

Arthroscopic methods of treating tibial plateau fractures produce good results and have the potential to cause fewer adverse effects in patients. Arthroscopic skills need to be developed in orthopaedic surgeons to offer injured patients the best possible treatment. In addition, methods to reduce compartment syndrome should be worked on to do so as safely as possible.

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Writing - rough preparation: Dawid Łoś, Aleksandra Nowak, Dawid Dziedziński, Anita Janus, Agata Kaptur

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Supervision: Dawid Łoś, Aleksandra Nowak, Dawid Dziedziński, Anita Janus, Agata Kaptur

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