Section: Orthopedic

Review Article

REVIEW ON MANAGING TIBIAL PLATEAU FRACTURES

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ABSTRACT

Tibial plateau fractures are multifaceted injuries that can lead to significant disability if not treated properly. Management is better in the era of advances in three-dimensional imaging, fixation devices, and minimally invasive techniques. The primary goal of treatment is to optimize articular reduction, stable fixation, and alignment of the lower limb while maintaining soft tissue integrity to allow for early rehabilitation. Numerous surgical techniques have shown good outcomes depending on the fracture types and the condition of the overlying soft tissues, including dual plating, ARIF, external fixation, tibioplasty, and jail screw technique. New innovations in patient specific CT-based classification systems, 3D printing technologies, and patient- optimized surgical tools (POST) have improved surgical planning and surgical accuracy. There is no one gold standard method. Overall, the best outcomes will derive from individualized treatment plans that respect soft tissue integrity, adhere to the principles of proper fixation, and endorse early mobilization postoperatively.

Keywords: Tibial plateau, ARIF, Tibioplasty, plating.

INTRODUCTION

One of the complex fracture injuries which can lead to the loss of function in individuals is tibial plateau fracture. It is one such fracture that can cause significant morbidity.[1] These fractures are produced by low or high-energy trauma. Mostly, the “third age” population and younger adults are affected by these fractures.[2] The position of the knee at the time of injury, the shape of the tibial plateau, and a high-energy impact force (from both coronal and axial directions), all of these create multiple force vectors together. These forces result in complex fractures with malalignment of the limb, irregular shapes, and fragmentation of the bone.[3] This fracture can also damage the surrounding soft tissue. It often extends through both the metaphysis and epiphysis. The complex the fracture will be, the more it will make the treatment difficult which will also affect the outcomes. Even for experienced surgeons, managing these fractures is challenging. Often different opinions surround the management of these fractures. The main goals are to achieve a stable fixation of the joint surface along with a good reduction, and restore proper alignment of the limb. However, the condition of the soft tissue cover is the most important factor which will influence how and when surgery can be done.

Nowadays, several modern treatment methods have emerged to fix these injuries using a biological approach. The biological approach means that the surgeons try to fix the bone in a way that the soft tissue envelope gets the least possible damage and the blood supply (vascularity) is preserved to the bone fragments.[4] This reduces complications, improves healing, and gives overall better outcomes. However, even with careful surgical techniques, recovery can include several complications and recovery can be slow. The complications include malalignment of the limb, limited joint movement, second osteoarthritis, and an unstable knee. In some situations, patients may require additional surgeries, which increases risk and adds to the economic burden. There is no proper agreement currently related to the best way of managing these complex injuries. The medical literature includes many different treatment plans and different techniques.[5,6] The purpose of this review is to provide a clear summary of the latest advanced techniques in orthopaedic management of this injury pattern based on current evidence.

The most important thing is to understand the exact pattern and shape of tibial plateau fractures. This helps doctors in choosing the best treatment. According to Millar et al., there are at least 38 different classification systems used in only to describe tibial plateau fractures.[7] Therefore, it is not possible to cover all of them in a single article due to its large number of classification systems.

Schatzker classification is one of the most well-known systems which was introduced in 1974.[8] 6 main types of proximal tibial fractures are described in this and it has been widely used for many years. This system also helps in linking the type of fracture with how the injury happened and recommends the treatment. [Figure 1] shows the classification that divides proximal tibial fractures into 6 groups. However, there are certain limitations of the Schatzker system. One is that it is based only on antero-posterior X-rays (front-to-back). This means that the full picture of the shape geometry the fracture is not shown in this. Often certain fracture patterns are missed, especially shearing injuries at the back of the tibia. Therefore, the results may lead to less effective treatment and incorrect classification. Moreover, about 10% of the tibial plateau fractures do not fit into the Schatzker classification which include fractures that cause knee instability or fracture-dislocation.[9] Hohl and Moore classification is more suitable for such cases [Figure 2]. Another classification, AO classification, is mainly based on antero-posterior (AP) X-rays. This is similar to the Schatzker classification which is why both have similar limitations. CT scans are used to assess tibial plateau fractures. With the increased use of CT scans, the importance of fixing the posterior part of the tibia (especially the postero-medial fragment) increased within surgeons.

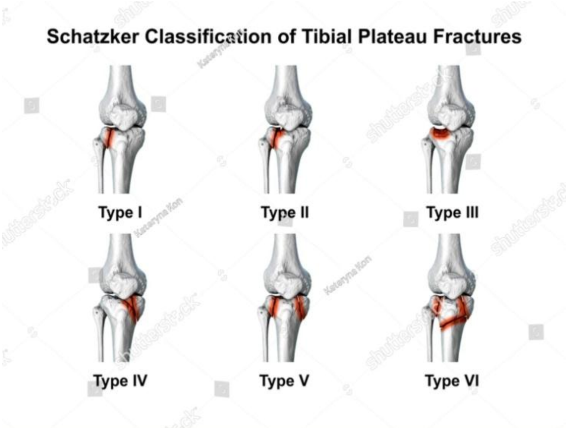

Figure 1: Schatzker Classification

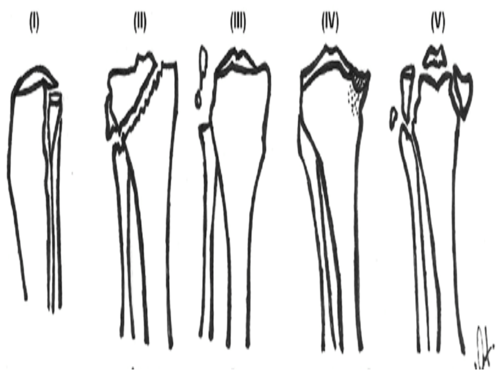

Figure 2: Hohl and Moore Classification

The "three-column concept" was introduced by Luo et al. to understand the proximal tibial fractures.[10] This is based on cross sectional CT images of the tibial plateau. According to this model, the proximal tibia (top part of the tibia) is divided into 3 columns; medial, lateral, and posterior. In [Figure 3], these 3 columns are divided by 3 lines; OA, OB, and OC. All of these lines start from a central point (O) which is located at the midpoint of the tibial spines. The line OA goes to the tibial tuberosity. The line OB goes to the postero-media ridge. The line OC goes to the front of the fibular head.

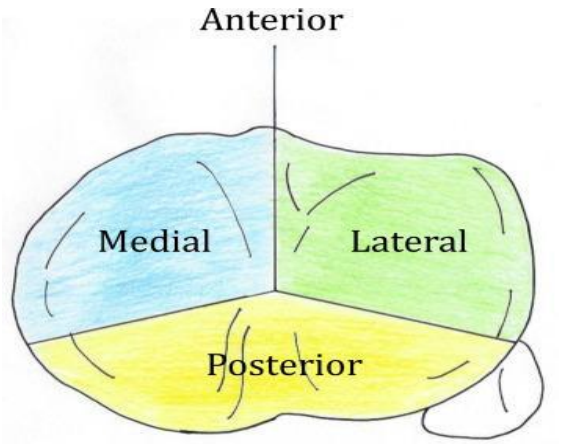

Figure 3: Three Column Classification

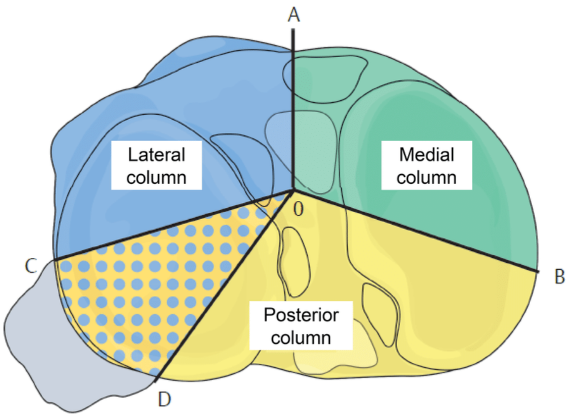

Figure 4: Revised Three Column Classification

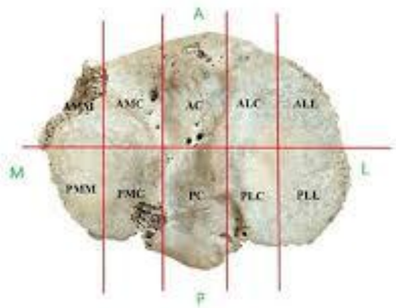

Figure 5: Segmental Classification

Proximal tibial fractures can be treated in several ways, depending on the type and severity of the injury. Treatment options include conservative methods for select cases, temporary external fixators followed by fixation with locked plates, fine wire devices, arthroscopically assisted procedures, and intramedullary nailing in some situations. A good recovery mainly depends on how well the joint surface is restored, how stable the fixation is, and how soon the patient can start moving the knee. It's also important to restore the normal length and alignment of the tibia to ensure a successful outcome after surgery. However, the condition of the nearby soft tissues and the patient's other health issues are very important when deciding the right time for surgery. In severe cases, splints, casts, and traction can be part of the initial treatment to control damage. Still, the most commonly preferred method in these cases is a knee-spanning external fixator. These external fixators help align the broken bone fragments through a process called ligamentotaxis, where the surrounding soft tissues help pull the bones into place.[14] They also keep the fracture stable, reduce pain, and allow soft tissue healing by avoiding further injury. One possible downside of these fixators is residual knee stiffness after treatment. For placing pins in the femur, an anterolateral position is preferred over the lateral position. Although the anterolateral setup is slightly less stable from a mechanical viewpoint, it is more comfortable for the patient when lying in bed. The placement of the tibial pins depends on where the surgeon plans to make incisions during the next stage of treatment to avoid interfering with those areas.[15]

Since Schatzker first recommended it in 1979, the standard treatment for bicondylar tibial fractures has been dual plating of both the medial and lateral parts of the bone using conventional plates through a single midline incision.[16] This approach was widely used for many years. However, over time, doctors noticed a high number of soft tissue complications, including wound dehiscence (wound reopening) and deep infections. These issues raised concerns and sparked a debate about using a more biological approach to osteosynthesis, meaning techniques that better protect the soft tissues and promote natural healing. In the following years, many surgeons began to support a double incision approach. This method uses two separate incisions, postero-medial and anterolateral, to apply dual plates. Several studies reported that this technique resulted in fewer wound problems and fewer complications overall.[17,18] More recently, however, some researchers have begun to re-evaluate the single midline incision approach. They emphasize that it provides better visibility of the fracture sites and makes it easier to perform a salvage arthroplasty (joint replacement) later, if needed.

In a 2004 study, Barei and associates used dual plating through two different incisions to treat 83 patients with complex bicondylar tibial plateau fractures.[19] They discovered an 8.4% deep infection rate. Jiang et al. treated 84 similar cases later in 2008 and reported a lower infection rate of 4.7%.[20] An even lower rate of 3.8% was reported by Zhang et al. in 2012 after studying 79 patients with tibial plateau fractures.[21] These results demonstrate that, in comparison to earlier single incision techniques, the use of two incision techniques results in fewer deep infections. The creation of better and more biologic implants, in addition to a greater understanding of surgical techniques, has significantly improved treatment, particularly for severely comminuted (shattered) or osteoporotic (weakened bone) fractures. Less Invasive Stabilisation System (LISS), a new implants system, and locking compression plates (LCP) along with Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) as a procedure, give the doctors the possibility to make a soft tissue-friendly stable fixation. New designs of orthopedic implants have a lower height, meaning they are less dominating and more neutral from a biological perspective. Besides being implemented alone, they can also be combined with conventional implants for superior outcomes.

Research indicates that LCP/buttress plates and double buttress plate fixation methods have similar stability. In dual plating, the majority of studies testify to good results, while a few have reported that loss of reduction occurred in about 4.5% to 10% of cases.[22] On the contrary, there are other studies which express doubts about dual plating due to the higher complication rates that it brings, such as deep infection, non-union and wound healing problems. Some doctors prefer to do a single LCP or LISS plate placed on the side to fix the lateral condyle and catch the medial fragment. On the other hand, it can be difficult to get a perfect reduction done and there is always the chance of loss of reduction even after the surgery. Some studies, like those performed by Egol et al. and Ikuta et al., indicate good outcomes, whereas others, including those by Barei et al. and Weaver et al., have divulged a higher incidence of malreduction or loss of reduction with single plate fixation.[19,23-25] In summation, the published material is not uniform and the conclusions are still conflicting. The advent of CT-based classification systems, for instance, the one developed by Luo et al., has been a great aid in comprehending fracture patterns as well as in the selection of the most appropriate methods and implants for treatment. Luo et al. also brought in the “three-column fixation” idea, by using a posterior method with an upside down L-shaped incision together with an anterolateral approach to secure all three columns.[10] Since that time, several authors have gone along this way and made slight modifications to this technique while still adhering to the same principle.

In the case of complex tibial plateau fractures, the ARIF technique, which is minimally invasive, provides surgeons with direct access to the joint space. Thus, joint surface reduction is done with the best control and precision and also the identification and treatment of intra-articular injuries are made possible at the same time. ARIF is a method that is commonly regarded as safe and effective for the treatment of fractures of the Schatzker type I to IV.

Nevertheless, its application in type V and VI fractures remains contentious. A systematic review led by Chen et al. that covered 19 studies and 609 patients showed that the majority of the fracture types treated with ARIF were Schatzker types II and III.[26] The clinical Rasmussen scoring system indicated that 90.5% of patients had good or excellent results, while 90.9% expressed satisfaction with their treatment. In total, only six cases of severe complications were noted, one of which was compartment syndrome.

Iatrogenic compartment syndrome that may be caused by fluid leakage during surgery is one of the major risks in such difficult cases as tibial plateau fractures. Granted, the occurrence of this complication is very rare but patients are still supposed to be under close watch after the operation. Some research results point to a lower infection risk with ARIF than with ORIF, yet the evidence is scanty so that the conclusion may be drawn only tentatively.[27] Dry arthroscopy—also called “fracturoscopy”—using a standard 4.0 mm, 30-degree angled scope has recently been endorsed for checking fracture reduction during surgery. This technique has proven to be superior to fluoroscopy in the evaluation of reduction regarding the posterior-lateral corner or the posterior-lateral central fragment types of fractures. Consequently, a lot of surgeons are now into the use of arthroscopy-assisted methods. In a recent cadaveric study, Behrendt et al. compared the latero-central segments of the tibial plateau fractures by means of three methods: fluoroscopy, “fracturoscopy” with a 4.0 mm, 30-degree scope, and “nanoscopy” with a 1.9 mm straight scope.[28] Their results revealed that “nanoscopy” allowed for the entire lateral condyle to be seen better than with both fluoroscopy and “fracturoscopy.”

Along with the earlier specified procedures, there exist a few more methods that are adopted in orthopaedics to deal with the issue of tibial plateau fractures. External fixators of different configurations could be utilized not just as a temporary means of stabilization but also as a definitive garnering treatment. Circular or hybrid frame fixators using fine wires for both reduction and fixation have become especially indispensable where there is a critical soft tissue injury, and open surgery through the injured tissue is strongly discouraged. One of the major benefits of these fixators is that they permit patients to early mobilization and weight bearing, thus speeding up the whole rehabilitation process. Circular fixators such as Ilizarov frames and Taylor Spatial frames are quite often used for the final management of these fractures. However, there are some concerns regarding correct reduction and the risk of pin tract infections, which have been reported in approximately 10-20% of the cases. Although having external fixators for long duration is usually uncomfortable for patients leading to dissatisfaction and poor compliance, still, these devices are considered the best choice in difficult tibial plateau fractures associated with substantial soft tissue damage. Many surgeons, as cited by Subasi et al. in 2007, now mix external fixators with minimally invasive techniques such as limited open reduction, internal fixation with cannulated cancellous screws, frame extensions, or incision-based bone grafting to fill metaphyseal gaps or treat severe comminution, in order to get rid of problems like malreduction or inadequate fixation.[29]

It is often challenging to reduce the depressed fragments of the tibial plateau, especially in patients with osteoporotic bones. Often the depressed fragments are lifted with a metal tamp, and bone grafts may be considered to fill the space. In weak or osteoporotic bone, this sometimes damages the joint surface, causes malalignment, or even fractures the bone. In response to some of these issues, a new method called tibioplasty has been developed. Tibioplasty is a technique based on the successful kyphoplasty procedures of the vertebra. In this method, a small hole is made in the medial metaphysis, and an osteointroducer with a trocar tip advanced beneath the depressed fragment (figure 6). Then a balloon is slowly inflated with contrast material. To check the spread of the contrast and make sure of correct positioning, fluoroscopy is used.

Figure 6: Tibioplasty technique

Jail Screw Technique

During the tibioplasty, the device is inflated to approximately 200 psi and the reduction is visually monitored in real-time using fluoroscopic guidance to confirm alignment in both AP and lateral views. The balloon is subsequently deflated and subsequently removed. The cavity created by the balloon for the fracture is inserted and filled with calcium phosphate cement which can provide direct mechanical support to the fracture. The balloon technique is minimally invasive and creates a consistent space for stable subchondral support. Other fixation techniques like the jail screw technique have slightly better biomechanical performance advantages compared to the traditional two-screw method which had a modestly improved stiffness and less potential for screw cut-out albeit not statistically significant. Advances like 3D printing and patient-optimised surgical tools (POST) have also provided visualization of fracture geometry, advanced pre-operative planning to allow surgeons to appreciate details on fracture geometry and use of life-size models to simulate fixation. Huang et al. showed the utility of these models improved surgical accuracy, reduction/fixation and reduced complications.[30]

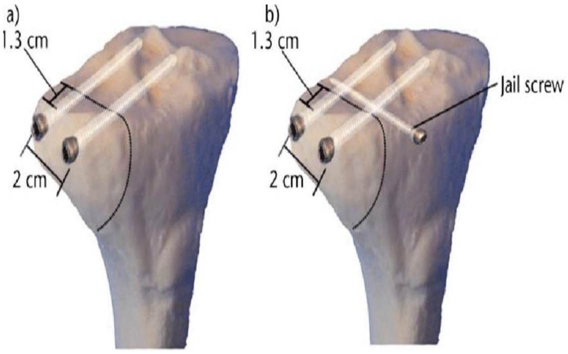

Figure 7: Jail Screw Technique

CONCLUSION

There have been considerable advancements in the management of tibial plateau fractures, because of the use of three-dimensional imaging, better fixation devices, and a greater understanding of fracture complexity. Most surgeons agree that the overall goal is to achieve an anatomic articular reduction, stable fixation, and proper mechanical alignment of the lower limb to facilitate early rehabilitation. Additionally, because tibial plateau fractures typically involve significant soft tissue injury, it is important to limit additional surgical trauma. There is no one best treatment, as the management plan will depend upon fracture type, soft tissue condition, co-morbidities, surgeon experience, and available implants. The best results are often achieved from an individualized plan of management that includes soft tissue care, staged procedures if indicated, and the general principles of anatomic reduction, stable fixation and early mobilization.

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Conflict in the interest

The authors had no conflict related to the interest in the execution of this study.

Permission

Prior to initiating the study, approval from the ethical committee was obtained to ensure adherence to ethical standards and guidelines.

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