

INSTRUCTIONAL LECTURE: TRAUMA

Posterolateral tibia plateau fractures: pros and cons of different surgical approaches

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- Posterolateral tibial plateau fractures are complex injuries requiring a thorough understanding of the anatomical structures involved, including the popliteus tendon, lateral collateral ligament and posterior horn of the lateral meniscus.
- Standard anterolateral or midline approaches provide limited access to the posterolateral corner, often necessitating specific surgical techniques to achieve optimal fracture reduction and joint stability.
- This review explores the main surgical approaches used for these fractures outlining their indications, advantages and limitations.
- Each section provides a step-by-step guide for an effective surgical technique, based on experience from a high-volume trauma center, to optimize exposure, reduction and fixation.
- Understanding the biomechanical and anatomical aspects of these fractures is crucial for selecting the most appropriate surgical strategy, minimizing complications and improving patient outcomes.

Keywords: posterolateral tibial plateau fractures; surgical approaches; trans fibular approach; Frosch approach; fracture fixation; knee biomechanics; joint stability; orthopedic trauma

Introduction

Posterolateral tibia plateau fractures represent a unique and challenging subset of tibial plateau injuries. These fractures typically involve the posterior aspect of the lateral tibial plateau, which is critical for knee joint stability and load distribution (1). The increasing incidence of high-energy trauma, particularly in younger populations involved in road traffic accidents or sports-related injuries, has highlighted the importance of understanding the complexity of these fractures and their management (2).

This article explores the surgical options available for treating posterolateral tibia plateau fractures, examining their advantages and disadvantages, while sharing a practical guide to managing these injuries based on the clinical experience of a high-volume trauma center.

The anatomy of the posterolateral tibial plateau is intricate and demands a detailed understanding to plan surgical

intervention effectively (3). It involves a combination of cortical and cancellous bone, articulates with the lateral femoral condyle and is closely associated with very important knee stabilizers such as the popliteus tendon (PT), the lateral collateral ligament (LCL) and the posterior horn of the lateral meniscus (4). Injury patterns may range from split fractures and depressed fragments to more complex multi-fragmentary configurations, often accompanied by ligamentous injuries (5). These patterns are usually identified through advanced imaging techniques, particularly computed tomography (CT) with three-dimensional reconstruction (6).

The choice of surgical approach for posterolateral tibia plateau fractures remains a debate among orthopedic surgeons. While the goal of any intervention is to restore joint congruence, stability and alignment, the

complexity of this region presents significant challenges (7). Historically, surgeons relied on indirect reduction techniques *via* anterolateral or midline approaches. However, these approaches have limited access to the posterolateral corner, which can lead to suboptimal outcomes, such as residual articular step-offs or instability (7, 8). Modern techniques, including extended anterolateral approach (9), the Frosch approach (10), modified Frosch approach (11), posterolateral transfibular approach (12) and the direct posterior approach (13), have expanded the armamentarium available to surgeons, each offering distinct advantages and limitations for the management of tibial plateau fractures involving the posterolateral column.

This article will review these approaches, highlighting their technical details, indications and potential pearls and pitfalls. The discussion will also focus on how patient factors, fracture characteristics and surgeon expertise influence decision-making. Finally, the authors described the preferred surgical technique for managing posterolateral tibia plateau fractures, emphasizing the critical steps and key considerations to optimize patient outcomes.

Surgical approaches for posterolateral tibial plateau fractures

Extended anterolateral approach

The anterolateral approach to the proximal tibia is commonly used to manage proximal tibial plateau fractures. However, this approach offers limited visualization of the posterolateral corner and reduction of posterolateral fractures is often achieved only with indirect techniques (14). Krause *et al.* (15, 16) illustrated that the anterolateral approach allows the exposure of only 36.6% of the articular surface, which can be increased to 65–80% when an osteotomy of the LCL insertion is performed.

Fractures involving the posterolateral and posterocentral segments (type 41-B3 and 41-C3 according to AO/OTA classification) are not properly visualized by the classic anterolateral approach and thereby, direct reduction of displaced posterior rim fractures is not possible.

The soft tissue covering the proximal tibia is thin and delicate, consisting only of skin and underlying fascia. Soft tissue complications are frequent and massive swelling and blistering can occur, particularly following high-energy trauma. Careful assessment of the soft tissues is critical before surgery and definitive treatment of complex fractures in this area are often delayed to allow swelling to subside and soft tissue recovery.

The patient is positioned supine; the knee is flexed approximately at 30–60° to ensure the patellar engagement on the femoral trochlea.

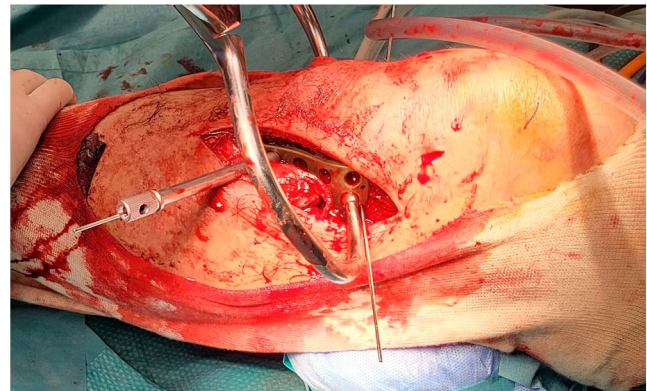


Figure 1

Intraoperative view of anterolateral approach used to perform lateral plating of a left tibial plateau fracture of 38-year-old male patients. Note the limited visualization of the posterolateral corner of the knee.

The skin incision starts approximately 3–5 cm proximally to the joint line just lateral to the border of the patellar tendon. The incision is curved and oriented to Gerdy's tubercle and extended distally to the tibial shaft 1 cm laterally to the anterior tibial crest (Fig. 1). The dissection is epiperiosteal and does not disturb the nerve supply to the extensor compartment. The knee joint capsule is incised longitudinally with gentle dissection of the lateral meniscus from synovium. The meniscotibial ligament is dissected, and varus stress is applied to allow direct visualization of the articular surface. The meniscus should be isolated and gently elevated with sutures (submeniscal arthrotomy) with careful preservation of the anterior and posterior attachments. The distal dissection is performed by incising the tibialis anterior fascia and detaching the proximal muscle fibers from the tibial shaft.

Posterolateral transfibular approach (Lobenhoffer approach)

To overcome the challenge of unsuccessful fracture reduction, Lobenhoffer *et al.* (12) described a posterolateral transfibular neck approach to the tibial plateau. This technique provides direct access to the posterolateral aspect of the tibial plateau, ensuring clear visualization of the fracture site. It facilitates the reduction of depressed and comminuted fractures in this region. In addition, this approach supports lateral buttressing of the lateral tibial plateau and can be effectively combined with simultaneous posteromedial and/or anteromedial approaches when necessary. Importantly, it preserves the proximal tibial soft tissue envelope and maintains its vascular supply, minimizing the risk of complications.

The patient is positioned supine with knee flexed at 60°. A 6 cm skin incision is made anterior to the biceps tendon aspect to the fibular head. The common peroneal nerve

(CPN) is identified above the biceps femoris and dissected down to the fibular head.

Above the fibular head, the branch of the CPN to the proximal tibiofibular joint is transected using sharp dissection. The intermuscular septa surrounding the peroneal muscles are exposed and divided. The peroneus longus muscle is detached to expose the nerve as it enters the lateral compartment. The posterior septum is then incised, releasing the nerve. Similarly, the anterior septum and the tibialis anterior and peroneus longus muscles are detached to expose and release the deep peroneal nerve. Next, the peroneus longus muscle insertion is detached from the proximal fibula to expose the fibular neck. A 3.2 mm drill is used just lateral to the biceps tendon insertion, followed by a 4.5- or 6.5-mm tap, depending on the fibula's medullary canal diameter. A curved osteotome, matching the width of the bone, is then used to osteotomize the fibular neck, 2 mm above the peroneal nerve.

The capsule of the proximal tibiofibular joint is released, and the fibular head is reflected proximally. The thin synovial membrane of the posterolateral corner of the knee is incised, and the joint is cleared of hematoma.

The lateral meniscotibial ligament is detached just posteriorly to the posterior cruciate ligament (PCL), exposing the tibial plateau. A meniscal suture is placed to elevate the lateral meniscus, providing clear access to the posterolateral tibia.

With this technique, the posterolateral tibial surface can be managed and fixed with plate, screws or bone grafting if required (17).

After the fixation of the posterolateral aspect of the tibial plateau, the fibular head is finally fixed with a 4.5 mm cortical screw or a 6.5 mm partially threaded cancellous screw (18).

Posterolateral approach without fibula osteotomy (Frosch approach)

The Frosch approach gained popularity due to its direct access to the posterolateral corner of the tibial plateau (10).

The patient is positioned laterally, supported by a pillow to induce varus stress from the weight of the leg, facilitating lateral opening of the joint gap. A 15 cm skin incision is made, starting 3 cm distal to the joint line and extending proximally, centered on the fibular head as an anatomical landmark.

The first surgical window is created through a standard anterolateral arthrotomy, involving a longitudinal incision of the iliotibial band, with gentle detachment of its anterior fibers from Gerdy's tubercle. This is followed by a submeniscal arthrotomy, as previously described. The second window is created posterior to the fibular head. The CPN is carefully dissected and exposed from the

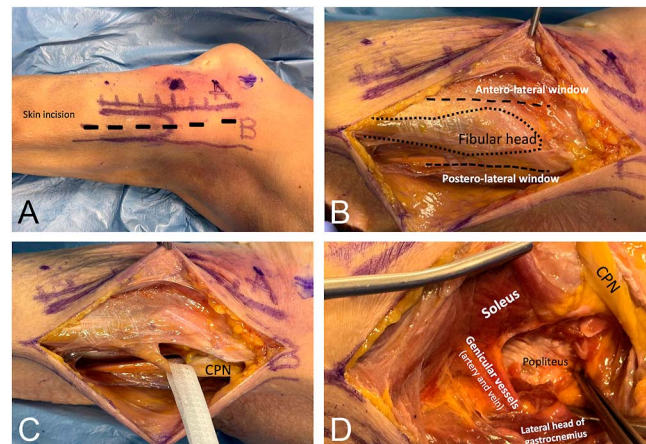


Figure 2

Lateral aspect of a cadaveric left knee demonstrating the anatomic skin landmarks to perform the posterolateral Frosch approach (A) superficial dissection to identify the peroneal head and the plane of anterior and posterior windows (interrupted line) (B) identification of deep peroneal nerve (CPN) that is isolated and reflected anteriorly (C) the posterior window performed through the soleus muscle and the lateral gastrocnemius allows the isolation of the posterolateral genicular vessels and the popliteus muscles that should be gently detached from the posterior tibial surface to expose the bone surface (D).

posterior aspect of the biceps femoris, ensuring its protection throughout the procedure.

Blunt dissection of the popliteal fossa is initially performed between the lateral head of the gastrocnemius and the soleus, allowing inspection of the soleus muscle belly. The popliteus muscle is then identified and retracted medially and cranially. The soleus muscle is gently detached 4–5 cm from its fibular insertion up to the peroneal neck, where the CPN enters the muscle belly.

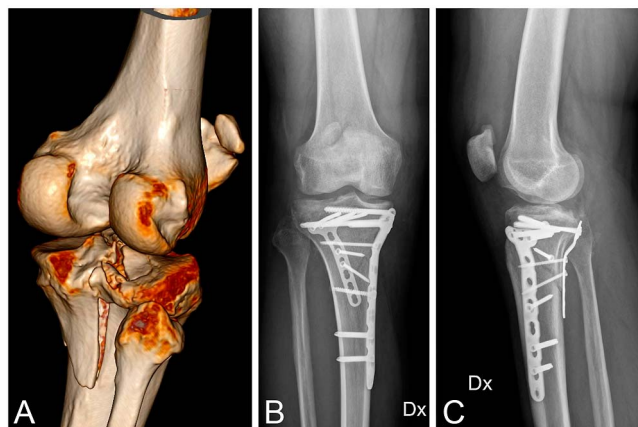
Figure 2 shows the details of the posterolateral approach (Frosch).

After dissection, the posterolateral fragment is visualized and debrided of soft tissue within the L-shaped area of the tibial plateau. Figure 3 shows the clinical case of medial and posterior plating performed through the medial approach and posterolateral (Frosch) approach.

Modified Frosch approach

Through a deeper understanding of the posterolateral approach and a high-volume case series of complex tibial plateau fractures, the modified Frosch approach was subsequently developed (11).

This technique combines the benefits of both the posterolateral and anterolateral approaches, offering enhanced surgical view, improved fracture reduction and excellent overall clinical outcomes.

**Figure 3**

Preoperative CT scan (A) of a 42-year-old male patient affected by posterolateral right tibial plateau fracture. The 6-month anteroposterior (B) and lateral (C) radiographs show posterior synthetic bone grafting and buttress plating plus medial plating performed through the Frosch approach and a medial approach with excellent radiographic results.

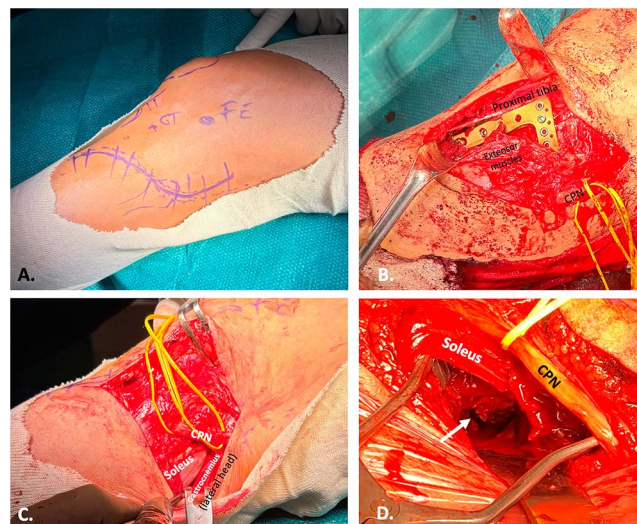
The patient positioning remains the same as in the standard Frosch approach. The skin incision (approximately 12 cm in length) follows an S-shaped trajectory, centered over the fibular head. It begins 2 cm lateral to the tibial crest, about 6 cm distal to the tibial tuberosity, extending proximally. As it reaches the fibular head, it curves posteriorly before straightening again. Proximally, the incision terminates approximately 4 cm posterior to the lateral femoral condyle.

The first crucial step is the identification and careful dissection of the CPN to ensure its protection throughout the procedure. The surgical window lies between the biceps femoris tendon anteriorly and the lateral head of the gastrocnemius posteriorly in the proximal region, while in the distal region, it is bordered posteriorly by the peroneus longus muscle. The proximal and posterior aspect of the lateral gastrocnemius protects the popliteal vessels.

Figure 4 shows the view of surgical windows of the modified Frosch approach and Fig. 5 demonstrates the reliability of double plating with the same incision in posterolateral tibial plateau fracture.

At this stage, optimal visualization and control of the fractured fragments are achieved. In cases of tibial plateau depression, this approach allows the elevation and grafting of the depressed articular surface.

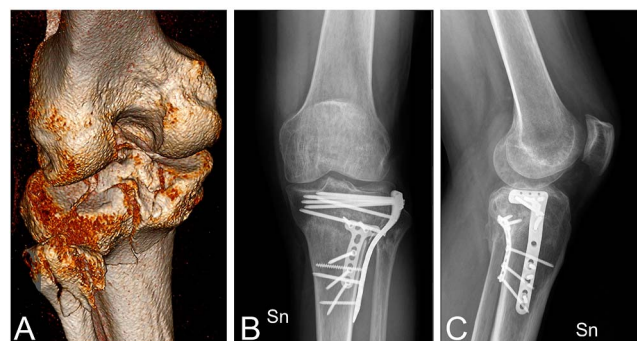
Fixation of the posterior tibial plateau is usually performed using a 3.5 mm T-shaped plate. Once the posterior segment is fixed, the same approach enables the surgeon to proceed with lateral fixation. The CPN is carefully retracted posteriorly, and a standard lateral approach is performed as previously described.

**Figure 4**

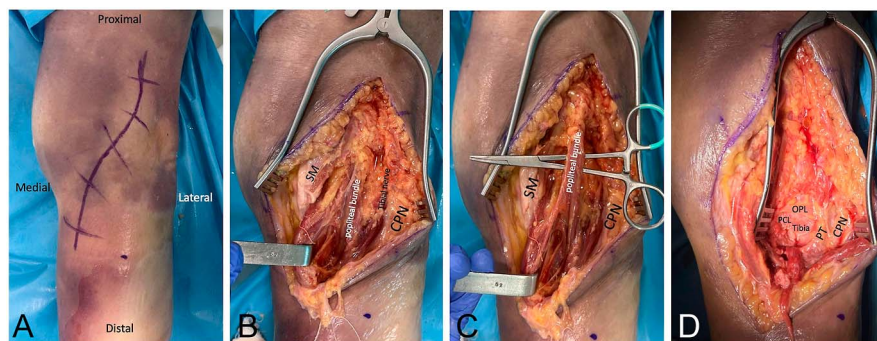
Left knee of 42-year-old male patient affected by posterolateral tibial fracture, with anatomic skin landmarks to perform a modified Frosch approach, specifically Gerdy's tubercle (GT), femoral epicondyle (FE) and tibial tuberosity (TT) are marked on the left knee (A). The intraoperative view of the anterior surgical window (anterolateral approach), left knee, to perform anterolateral tibia plating after dissection of CPN (B). The intra-operative view of posterior window through the intermuscular plane between the soleus and lateral head of gastrocnemius muscle after dissection and protection of CPN (C). Intraoperative view of posterolateral tibial fracture (white arrow) of a left knee after the dissection of CPN and completion of the posterolateral window of modified Frosch approach (D).

Direct posterior approach

The direct posterior approach is primarily neurovascular and is rarely utilized in orthopedic trauma surgery (19). The medial and lateral approaches generally provide excellent access to the respective columns. However, in selected cases where the posterocentral region

**Figure 5**

Preoperative CT scan (A) of a 28-year-old male patient affected by posterolateral left tibial plateau fracture. The 1-year anteroposterior (B) and lateral (C) radiographs show double plating (posterolateral and anterolateral) and posterior bone grafting performed through the same modified Frosch approach with excellent radiographic results.

**Figure 6**

Posterior aspect of a cadaveric right knee demonstrating the anatomic skin landmarks to perform the direct posterior approach (A) superficial dissection to identify the semimembranosus muscle, the popliteal vascular bundle, the tibial nerve and CPN (B) identification and isolation of the popliteal vascular bundle (C) that is reflected medially to expose the posterior tibial surface with the tibial origin of the PCL, the PT and the CPN (D).

(both medial and lateral) cannot be adequately addressed using other approaches, this technique may be necessary, for instance, in cases of PCL bony avulsion (20).

The patient is positioned in the prone position, with the two heads of the gastrocnemius muscle, along with the semimembranosus and semitendinosus muscles, serving as key anatomical landmarks.

A gently curved incision is made, beginning laterally over the biceps femoris muscle and extending distally to the medial head of the gastrocnemius muscle, bringing the incision obliquely across the popliteal fossa.

After the skin incision and division of the subcutaneous fat tissue, the crural fascia is opened along the midline while preserving the small saphenous vein and the sural nerve, which, if necessary, can be looped with a silicone sling and retracted laterally. Next, the heads of the gastrocnemius muscle are separated along the midline under slight flexion using scissors or a blunt raspator. Since the tourniquet is not inflated, the popliteal artery can now be palpated digitally. The neurovascular bundle can then be identified between the muscle bellies, encircled with a clamp, and looped. The neurovascular bundle, along with the lateral head of the gastrocnemius muscle, the plantaris muscle and the sural nerve, is retracted laterally using a Langenbeck retractor. The medial head of the gastrocnemius muscle is also held medially with a Langenbeck retractor. This allows exposure of the posterior knee joint capsule. Figure 6 identifies the main surgical steps for the direct posterior approach.

In many cases, the bony avulsion of the PCL can already be identified at this stage. If the avulsion fracture cannot be identified, the posterior capsule is carefully opened vertically with a scalpel. Care must be taken to avoid injuring the PCL. The fracture and the PCL are directly visualized beneath the capsule. The avulsion fracture is debrided from soft tissue, and the fracture surfaces are cleaned of blood clots using a small curette, if necessary. The fragment is then repositioned using a raspator or ball spike and, if needed, temporarily fixed with a Kirschner wire. For the implantation of a dorsal plate on the tibial plateau, the skin incision should be extended distally. After exposing the dorsal capsule, the fracture can already be identified. In the distal access area, the soleus and

popliteus muscles, and the medial inferior genicular artery running transversely along the upper border of the popliteus muscle, are visualized and looped using a clamp.

The soleus and popliteus muscles are incised at their medial origin and bluntly detached from the dorsal tibial surface using a raspator. Together with the flexor digitorum longus and tibialis posterior muscles, they are then retracted laterally using Hohmann retractors. A Hohmann retractor is also placed medially.

Table 1 summarizes the surgical technique with advantages and disadvantages of each surgical approach.

Discussion

The management of posterolateral tibial plateau fractures underscores the importance of tailored care (21). Each surgical approach offers unique advantages and limitations, making it essential to tailor the choice of technique to the specific fracture pattern and patient features. Tibial plateau fractures are complex injuries that require careful management to restore joint congruency, maintain stability and prevent long-term complications such as post-traumatic osteoarthritis (22). Posterolateral tibial plateau fractures present a challenge due to their unique anatomical and biomechanical considerations (23). This region of the tibial plateau is difficult to access surgically, and failure to achieve anatomical reduction can lead to poor functional outcomes.

The posterolateral tibial plateau is characterized by a concave surface that articulates with the lateral femoral condyle. This area is reinforced by several critical structures, including the lateral meniscus, the PT and the LCL (4). These anatomical aspects contribute to the intrinsic instability of fractures in this region, making precise reduction and stable fixation paramount to successful treatment. Moreover, the biomechanical forces exerted on the posterolateral tibial plateau during weight-bearing activities further complicate management, necessitating strong and stable fixation constructs (23).

Table 1 Brief summary of different surgical approaches for posterolateral tibial plateau fractures, with pros and cons of each surgical choice.

Approach	Description	Advantages	Disadvantages
Extended anterolateral approach	Incision laterally to the patellar tendon, providing access to the proximal tibia	• Widely used for proximal tibial plateau fractures • Good for managing lateral and anterior fractures	• Limited access to the posterolateral corner • Requires osteotomy of the LCL insertion to increase exposure
Posterolateral transfibular approach (Lobenhoffer approach)	Provides a direct access to the posterolateral tibial plateau by osteotomizing the fibula	• Direct access to the posterolateral tibial plateau • Allows direct reduction of depressed and comminuted fractures • Preserves anterior soft tissue envelope	• Requires fibular osteotomy • Involves more complex dissection, including nerve exposure and protection
Posterolateral approach without fibula osteotomy (Frosch approach)	Direct access to the posterolateral corner without fibula osteotomy	• Avoids fibula osteotomy • Direct exposure of the posterolateral corner • Suitable for fractures with less complex displacements	• Limited access to anterolateral tibial plateau • Limited visualization in some fracture types • Complex soft tissue dissection
Modified Frosch approach	Combination of posterolateral and anterolateral approaches with enhanced surgical view	• Improved visualization and fracture reduction • Possibility of double plating and bone grafting • Flexible for complex fractures	• Requires longer incision • Complex dissection and nerve exposure • Increased operative time
Direct posterior approach	Midline or posteromedial incision with mobilization of the gastrocnemius muscle for direct access to the posterior tibia	• Excellent visualization of posterior central tibial plateau • Ideal for posterior displacement and posterior cruciate bony avulsion • Allows placement of posterior buttress plates or screw	• Requires meticulous soft tissue handling • Risk of bleeding and neurovascular damage • Risk of wound dehiscence or infection • Limited lateral exposure

LCL, lateral collateral ligament.

Traditional surgical approaches to tibial plateau fractures, such as anterolateral or standard lateral approaches, often fail to provide adequate visualization of the posterolateral tibial aspect (15, 16). Consequently, alternative strategies have been developed to address the fracture involving the posterolateral tibia. Among the described approaches, the authors’ preferred technique is the modified Frosch (11), which combines the advantage of the anterolateral approach to perform standard lateral plating to the direct visualization of the posterolateral column, with a posterior window allowing a posterior buttress plating to manage the posterolateral fragment. Furthermore, this approach does not require fibula osteotomy minimizing-related complications. However, it has a steep learning curve and requires careful handling of neurovascular structures, particularly the CPN, which is essential to avoid iatrogenic complications.

Fixation strategies for posterolateral tibial plateau fractures have evolved significantly over time (1, 24). Conventional plate fixation techniques often struggle to

achieve stable fixation in this region due to the concave geometry of the posterolateral fragment and the presence of dense cortical bone (23). As a result, novel fixation constructs have been developed, including raft plating techniques, which utilize buttress plates positioned along the posterolateral cortex to resist shear forces. In addition, the use of small-fragment fixation, including screw-only constructs, has gained popularity in select cases, particularly for minimally displaced fractures or in situations where soft tissue concerns preclude extensive hardware placement (24).

Biomechanical studies have provided valuable insights into the optimal fixation strategies for posterolateral tibial plateau fractures. Research comparing various fixation constructs has demonstrated that posterior plating techniques generally offer superior resistance to displacement compared to traditional lateral plating alone (25, 26). In particular, dual-plating constructs, incorporating both anterolateral and posterolateral plates, have shown enhanced stability, especially in

complex bicondylar fractures (25, 27). Finite element analysis and cadaveric studies have further reinforced the importance of achieving subchondral support through perpendicularly placed screws to prevent secondary collapse (25, 26, 28).

Despite advancements in surgical techniques and fixation strategies, complications remain a concern in the management of posterolateral tibial plateau fractures. Nonunion, malunion and hardware-related issues are among the most commonly encountered problems (1, 24, 29). Inadequate reduction or suboptimal fixation can lead to persistent joint incongruity, increasing the risk of post-traumatic osteoarthritis (22). Moreover, the relatively limited soft tissue coverage in the posterolateral region raises concerns regarding wound healing complications and infection (24). Surgeons must carefully balance the need for stable fixation with the potential risks associated with extensive soft tissue dissection.

Rehabilitation following surgical treatment of posterolateral tibial plateau fractures plays a crucial role in optimizing functional outcomes (1). Early range-of-motion exercises are encouraged to prevent joint stiffness. However, weight-bearing protocols must be tailored to the stability of the fixation construct, with delayed weight-bearing often necessary in cases with extensive comminution.

Conclusion

The surgical management of posterolateral tibial plateau fractures is a complex and evolving field. Advances in surgical techniques and instrumentation have expanded the options available to orthopedic surgeons, enabling more precise and effective treatment of these challenging injuries. While each approach has its strengths and weaknesses, the ultimate goal remains the same: to restore joint congruity, stability and function while minimizing complications.

Based on clinical experience, preoperative planning, meticulous surgical strategy and individualized postoperative care are critical to optimizing outcomes. By combining evidence-based principles with practical expertise, we can continue to improve the management of posterolateral tibial plateau fractures and enhance the quality of care for our patients.

ICMJE Statement of Interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the work reported.

Funding Statement

This work did not receive any specific grant from any funding agency in the public, commercial or not-for-profit sector.

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