Posterior Circumferential Support in Tibial Plateau Fractures

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ABSTRACT
Surgical techniques commonly used today for tibial plateau fractures do not properly contemplate multiplanar bone comminution nor the presence of posterior bone fragments. We have faced this problem when treating a patient with a Schatzker VI type fracture, in which the commonly used osteosynthesis was supplemented with a posterior horizontal circumferential plate. Bone consolidation and good results were achieved in the short term in the case we present. From the analysis of the cited literature, we concluded that several techniques for containing posterior tibial plateau bone comminution have been developed. Among them, circumferential osteosynthesis is a technique to take into account.
Key words: Tibial fractures; tibial plateau; internal fixation; posteromedial approach.
Level of Evidence: IV

Soporte circunferencial posterior en fracturas de platillo tibial

RESUMEN
Las técnicas quirúrgicas que más se utilizan en la actualidad para fracturas de platillo tibial no contemplan correctamente la conminución ósea multiplanar ni la presencia de fragmentos óseos posteriores. Nos hemos enfrentado con esta problemática al tratar a un paciente con fractura de platillo tibial tipo Schatzker VI, en la cual se suplementó la osteosíntesis habitualmente utilizada con una placa horizontal circunferencial posterior. Se logró la consolidación ósea y los resultados funcionales a corto plazo fueron buenos. Del análisis de la bibliografía citada, se concluye en que se han desarrollado varias técnicas de contención posterior de los platillos tibiales, y la osteosíntesis circunferencial es una técnica por considerar.
Palabras clave: Fracturas de tibia; meseta tibial; fijación interna; abordaje posteromedial.
Nivel de Evidencia: IV

INTRODUCTION

Complex fractures of both tibial plateaus (Schatzker V and VI / AO-OTA type C) can have different patterns. In these cases, surgical options range from external fixators to internal fixation with plates and screws. However, the most widely used techniques do not correctly consider multiplanar comminution or the presence of posterior fragments.[1]

We have faced this problem when treating a patient with a Schatzker VI fracture with posterior comminution, which we decided to fixate with an anterolateral proximal tibia locking plate and a T-plate associated with a posterior circumferential horizontal plate.

The objective of this report is to describe the treatment of a patient with a complex tibial plateau fracture with posterior comminution and to conduct a literature review. The published cases, the surgical techniques, the osteosynthesis used, as well as the proposed approaches and techniques have been evaluated.

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CLINICAL CASE

A 76-year-old woman, with no relevant medical history, who suffered a low-energy accident on a public space. Initially, she was treated at another healthcare center where she was diagnosed with a tibial plateau fracture in her right knee. Once stabilized, she was referred to our hospital with transcalcaneal skeletal traction. The patient presented swelling, joint effusion, and a medial hematoma on the right knee; no neurovascular alterations were observed.

The knee radiograph and computed tomography revealed a fracture of the tibial plateau classified as Schatzker VI (Figures 1 and 2). With a deferred knee MRI, an associated third-degree injury of the medial collateral ligament was diagnosed.

The patient underwent surgery four days after the accident due to her soft tissue condition.

Figure 1. Initial frontal (**A**) and lateral (**B**) radiograph of the knee.

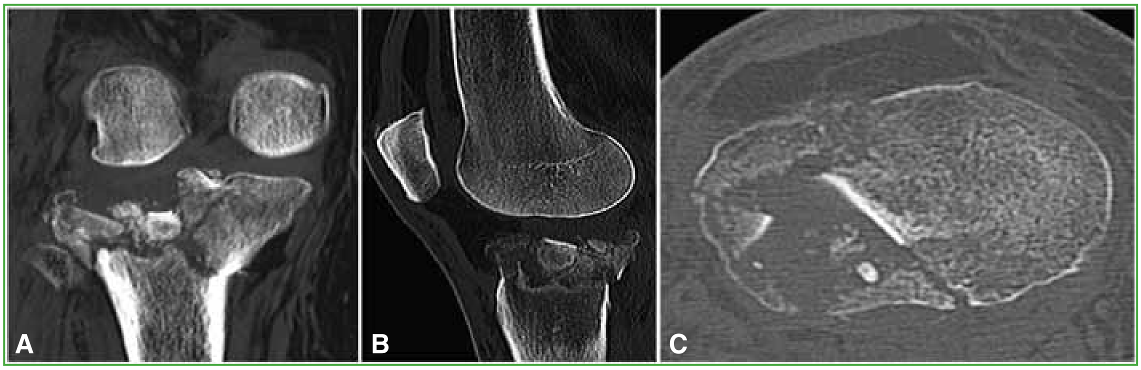

Figure 2. Initial computerized tomography of the knee. **A.** Posterior coronal plane. **B.** Sagittal plane. **C.** Axial plane.

Surgical technique

With the radiograph and tomography, preoperative planning was conducted. In this case, the patient was referred with transcalcaneal traction; therefore, it was not necessary to remove the external tutor. The patient was placed supine with enhancement of the left hemipelvis on a radiolucent table. Adequate asepsis and antisepsis of the right lower limb up to and including the ipsilateral iliac crest was performed in the surgical field and, before exsanguinating the limb, a hemostatic Esmarch bandage was placed on the thigh.

In the first stage, a posteromedial approach was performed. The limb was placed in abduction and external rotation with a slight knee flexion. The approach extended from the medial femoral epicondyle to the posterior border of the tibia at the level of the metaphyseal-diaphyseal junction. This incision should be straight or slightly curved; it can be prolonged both proximally and distally, if necessary. After traversing the subcutaneous tissue, the internal calf fascia and the pes anserinus tendons were identified. This site was incised in order to have a better posterior access. By means of a manual dissection, the muscular and bone planes were separated, thus avoiding the injury of noble structures with surgical instruments. The tendon of the semimembranosus muscle was then retracted proximally and medially; the medial calf muscle was retracted distally and laterally. If there is tension that prevents adequate visualization, we suggest partially disinserting the proximal and medial insertion of the soleus muscle. In this way, we obtain a wide visualization of the posteromedial column and an indirect access to the posterior portion of the lateral plateau.

Once the fracture had been identified, indirect reduction was performed by longitudinal traction of the limb and hyperextension of the knee, and then the main fragment was temporarily stabilized with pins. This is followed by direct reduction with the placement of a 3.5 mm posteromedial T-plate as a support.

Given the insufficiency of this configuration to contain all the fragments, it was then decided to contour a 3.5 mm, 8-hole LCP Reconstruction Plate after the articular rim of the tibial plateau to serve the function of a periarticular support. This need was resolved by means of a blunt dissection of the posterior lateral tibial ridge. The lateral half of the plate is contoured, emulating the lateral plateau. Once slid, with the help of two screwdrivers, the contouring of the medial half of the plate was completed, thus achieving circumferential coaptation and then fixated with locking screws.

Subsequently, the enhancement was removed and the patient was repositioned in strict dorsal decubitus position. A femoral distractor was placed as varus distraction of the external tibial plateau. Then, an anterolateral approach was performed, extending from the posterior aspect of the lateral condyle to a point located at a distance of two fingers lateral to the tibial crest; distal to the anterior tuberosity of the tibia. The incision should be centered between the head of the fibula and Gerdy's tubercle. The distal two-thirds of this incision are usually sufficient for the approach, although, if necessary, it can be extended proximally. If a minimally invasive technique is performed, the middle third of this incision is selected. After passing through the subcutaneous tissue, the iliotibial band was identified and incised following the orientation of its fibers. Below was the tibialis anterior muscle, which was disinserted in its proximal and anterior portion to give place to osteosynthesis. Finally, a transverse capsulotomy distal to the lateral meniscus was performed to visualize the acquired joint reduction. The fracture was reduced and supported by means of an autologous tricortical iliac crest bone graft. Direct reduction and stabilization were performed with a 3.5 mm 5-hole proximal tibial regional locking plate (Figure 3).

Finally, due to varus-valgus instability, the medial collateral ligament was reconstructed with a 4.5 mm anchor. Good clinical and radiological stability was confirmed. The wounds are thoroughly washed with physiological solution and closed by conventional planes with separate stitches. The postoperative tomography showed adequate reduction of the fracture.(Figure 4).

The early rehabilitation protocol included active isometric exercises and single-foot gait with the assistance of a four-point walker. Since she had undergone a ligament reconstruction, the patient was protected with a knee extension splint for 45 days. Then, she started with active and passive joint range of motion exercises and achieved a maximum extension of 20 ° and a flexion of 70 ° / 80 ° a week after removing the splint. The pain score was 7/10 on the visual analog scale. Two and a half months after surgery, with radiological evidence of bone consolidation, the patient began protected progressive partial weight-bearing. Follow-up controls at four and six months showed full extension and flexion of 130 ° / 135 °; a score of 2 on the visual analog scale for pain and a functional score of 60/90 on the Knee Society Score. She was granted medical discharge with annual control.

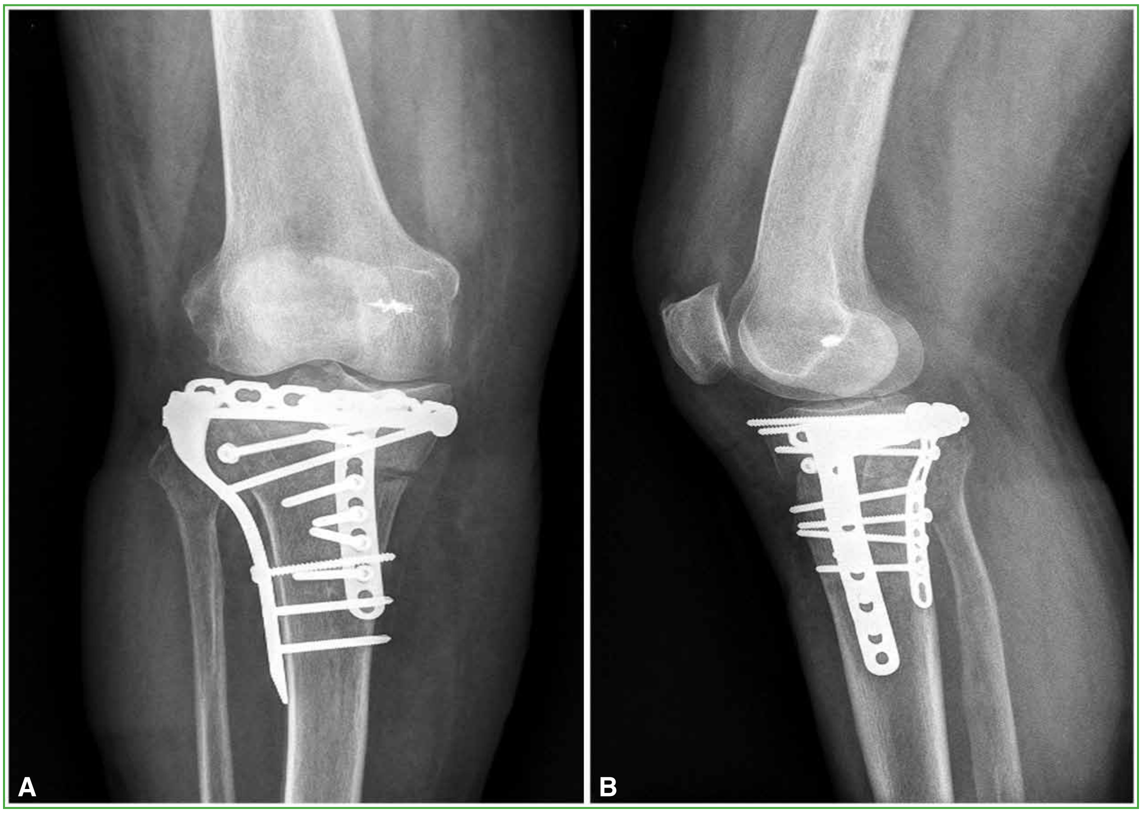

Figure 3. Postoperative frontal (**A**) and lateral (**B**) radiograph of the knee.

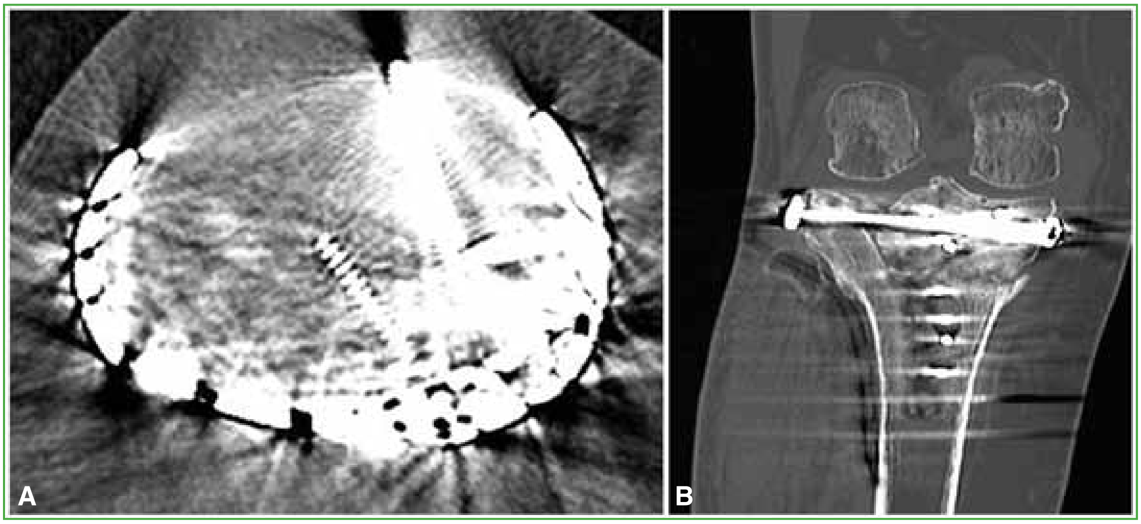

Figure 4. Postoperative computerized tomography of the knee. **A.** Axial plane. **B.** Posterior coronal plane.

DISCUSSION

The problem that occurs in cases of tibial plateau fractures begins with the understanding of the fracture and with the decision of the type of osteosynthesis to use. The most commonly used classifications of tibial plateau fractures are based only on frontal radiographic projections, as are the AO / OTA and Schatzker classifications.[2-5] This inclines the surgeon to give more importance to the medial and lateral fixation, neglecting the posterior involvement.[6] Added to this, comminution makes the interpretation of the fracture pattern even more difficult, turning these posterior fractures into injuries that often go unnoticed and underestimated in surgical planning.

It was shown that the surgical plan was modified in 59% of the cases when tomographic images were used.[7] In this way, some authors have proposed that posteromedial fragments are much more frequent than what is published.[8] This prompted authors such as Kahn et al.[9] to create a tomographic classification of tibial plateaus that includes the posterior fragments. Subsequently, Luo et al.[6] created the "3-column concept" and Chang et al.[10] divided the tibial plateaus into "quadrants" using axial tomographic planes. Finally, Chen et al.[5] created a new classification of posterior tibial plateau fractures, called "posterior split"[11] or "posterior wedge".[12]

The morphology of the posteromedial and posterolateral fragments has been analyzed, justifying the differences of the fragments in the asymmetry of the femoral condyles.[5] It has been suggested that these fractures follow a common pattern, a medial plateau fracture, which is concave, usually producing two long fragments (posteromedial and anteromedial) without subsidence.[13] The posteromedial fragment usually has a V-shaped cortical line. On the other hand, the convex outer plateau fractures and depresses with a variable degree of comminution.

The literature on the subject includes several attempts to develop posterior support techniques for tibial plateaus in recent years. The importance of this lies in the primary function of the medial column in the mechanical axis of the limb. At present, the treatment of choice for bicondylar tibial plateau fractures is the double approach and fixation with plates (medial and lateral) as support.[10,14,15] However, this technique is insufficient for fractures with multiplanar joint comminution, especially when there is a posterior fragment or a coronal fracture line close to the posterior cortex.[1,3,8,16] The use of modern locking plates does not achieve the necessary support for these posterior fragments.[1,3] If they are placed on the anterior side, their pre-molded contour would not allow the use of locking screws to secure those posterior fragments.[17] As explained by De Boeck et al.,[11] by using only an anterior approach, screws could be placed in an anteroposterior direction, but it is difficult to achieve a correct reduction in this way.

Looking for a solution to this problem, several authors have innovated and described new techniques for the support of fractures with posterior compromise. However, most of them describe techniques used in cases with patterns without comminution and with simple posteromedial or posterolateral fragments.

In 1994, Georgiadis et al.[18] published the use of anti-slip posterior plates for the containment of posterior fragments. Since then, the vertical posterior plate was the common osteosynthesis for these patterns and there are numerous case series reported. (Table). In general, these configurations seek to support the posterior fragments with the posterior plate and at the same time use, if necessary, lateral plates so that their screws hold both tibial plateaus together.

Zeng et al.[19] conducted a biomechanical study of four methods of fixation of posteromedial fragments of the tibial plateau: 6.5 mm anteroposterior interfragmentary screws, 4.5 mm 6-hole anteromedial LC-DCP plate, lateral locking plate of 5 proximal tibia holes and 3.5 mm posterior T-plate. They simulated 28 tibial plateau fractures in synthetic bone and exposed these configurations to an axial load, measuring the force required for failure in each type of construction. This study demonstrated that a supportive posterior T-plate is, from a biomechanical point of view, the most stable configuration in vitro for posteromedial fragments.

In 2008, Bermúdez et al.[17] described the placement of a horizontal plate to stabilize posterior fragments of each tibial plateau. The horizontal position of the plate allows the placement of screws in an anteroposterior direction that pass through the bone fragments to be fixed. The molding of the plate adds a greater supportive effect without the need to put screws in the back of the plate, only in its ends, to fixate it. These authors suggest using a 3.5 mm reconstruction plate, due to its malleability for casting. If it is necessary to remove the implant, the extraction can be performed by standard approaches, without posterior approaches, thus avoiding injury to posterior neurovascular elements. As a disadvantage, this construction is insufficient for posterior metaphyseal instability.

Table. Literature review.

Year	Author	Study	Approach	Position	Type of osteosynthesis
1994	Georgiadis et al. [18]	Case series (4 patients)	Anterolateral and posteromedial	Supine decubitus.	Contoured one-third tubular plate or T-shaped support plate.
1995	De Boeck et al. [11]	Retrospective (7 patients)	S-shaped posteromedial	Prone decubitus.	1 T-shaped support plate
1997	Lobenhoffer et al. [21]	Retrospective (168 cases)	Posteromedial and transfibular (plus fibula osteotomy)	Prone decubitus.	Interfragmentary compression screws + support plate
2005	Bhattacharyya et al. [16]	Retrospective case series (13 patients)	S-shaped posterior	Prone decubitus.	1 3.5 mm cloverleaf plate
2005	Carlson et al.[12]	Case series (5 cases)	Posteromedial and posterolateral	Prone decubitus.	2 parallel support plates
2008	Weil et al. [3]	Surgical technique	Posteromedial and lateral	Supine decubitus.	1 posterior antiglide plate
2008	Bermúdez et al.[17]	Case report (2 cases)	Extended anterolateral and posteromedial	Prone decubitus.	1 or 2 horizontal support plates
2009	Brunner et al. [22]	Case series (5 cases)	S-shaped direct posterior	Prone decubitus.	3.5 mm antiglide support plate
2010	Yu et al.[23]	Prospective surgical technique. (82 patients).	Anterolateral plus fibula osteotomy	Supine decubitus.	L-shaped support plate
2010	Frosch et al.[24]	Surgical technique	Modified posterolateral.	Lateral decubitus.	1 3.5 mm L-shaped plate
2010	Lugones et al. [25]	Surgical technique (15 patients)	Posteromedial and lateral	Prone decubitus.	1 4.5 mm T-shaped plate
2010	Luo et al.[6]	Prospective cohort (29 cases)	Inverted L-shaped posterior (for medial or posterior spine fracture) and anterolateral	Floating supine decubitus	1 support plate
2012	Chang et al.[10]	Prospective (12 patients)	Posteromedial and anterolateral	Floating supine decubitus	Triple plating (1 lateral plate + 1 medial plate + 1 antiglide posterior coronal plate)
2013	He et al.[4]	Case series (8 patients)	Inverted L-shaped posterior	Prone decubitus.	1 3.5 mm LC-DCP support plate or 3.5 mm T-shaped plate.
2014	Aly et al.[20]	Prospective surgical technique. (29 patients).	Posteromedial and lateral	Supine decubitus.	Plate plus cerclage Tension band
2014	Chang et al.[13]	Prospective surgical technique (16 patients)	Posteromedial and anterolateral	Floating supine decubitus	Support plates
2015	Chen et al.[5]	Prospective (39 patients)	L-shaped posterolateral or posteromedial	Prone decubitus.	T-shaped support plates
2015	Robledo-Herrera et al.[2]	Observational (7 patients)	Posteromedial	Supine decubitus.	3.5mm and 4.5mm T-plates / Reconstruction Plates / Hockey Stick Plate
2016	Garner et al.[26]	Descriptive surgical technique	Comparative description of 5 approaches to posterolateral fractures.	According to the approach	-
2016	Hake et al.[27]	Descriptive surgical technique	Lobenhoffer posteromedial	Prone decubitus.	Antislip plate
2016	Giordano et al.[1]	Case report	Lateral plus posteromedial	Supine decubitus.	Horizontal support plate

In 2014, Aly et al.[20] evaluated the treatment of displaced fractures of both tibial plateaus with plateau cerclage wiring combined with a plate with screws. The technique consists of a posteromedial approach and then the placement of an anterolateral plate and a loop of wire around the proximal part of the tibia. To facilitate the placement of the wire, they suggest the use of a specific guide used in plastic surgery of the anterior cruciate ligament. This configuration allows a certain centripetal compression of the fragments thanks to the twisting of the wire.

In 2016, Giordano et al.[1] described a case in which a pre-molded one-third tubular plate placed horizontally was used to contain the posterior edge of the tibial plateaus, calling this technique a “hoop plate”. They performed a lateral approach with osteotomy of the fibular head to achieve reduction of the anterolateral and posterolateral fragments under direct vision. The plate was placed from the lateral to the medial side. To facilitate placement, they suggested using a Cobb elevator to release the path of the plate prior to placement. The authors advise performing this maneuver on a flexed knee to avoid injuring the neurovascular bundle. Once the plate was placed, it was tightened with a clamp, compressing through the holes at the ends of the plate, thus achieving interfragmentary compression.

Giordano et al. suggest this technique for tibial plateau joint fractures with impaction of the posterior border and the cortical wall. The use of a low profile, moldable one-third tubular plate allows combination with other plates, if necessary.

As an advantage, the horizontal plates grant circumferential containment and keep both plateaus together. Also, thanks to the use of screws, interfragmentary compression can be performed. If fragments are so small that they cannot tolerate screw penetration, interfragmentary compression can be achieved by pretensioning the plate.

As disadvantages, the removal of posterior horizontal plates is more difficult compared to that of lateral plates. They are also insufficient for the stabilization of the facet joint with the metaphysis, requiring a second plate to achieve this.

Routine techniques for treating complex tibial plateau fractures do not account for minute fragments on the posterior ridge. As suggested by Giordano et al., the containment of the posterior articular and cortical fragments requires a type of osteosynthesis that has a centripetal support function, stabilizing the fracture in the axial plane, either with wire loops or with horizontal molded plates.

FINAL CONSIDERATIONS

Posterior comminution fractures are complex patterns to approach surgically. The use of a molded plate, placed horizontally from a posteromedial approach, allows adequate containment and support of the posterior fragments. The normal anatomy of the plateau is mimicked with greater integrity. It contributes to the fixation of the posteromedial component, which is mainly responsible for contributing and preserving an adequate mechanical axis to the knee. It is an applicable technique that could provide functional postoperative outcomes similar to those of traditional settings.

Conflict of interests: The authors declare they do not have any conflict of interests.

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