OPEN

Current concepts in tibial plateau fracture management: a Spanish Orthopaedic Trauma Association review

Francisco Chana-Rodríguez, MD, PhD, FIOTA[a,*], Jordi Teixidor-Serra, MD[b], Juan Boluda-Mengod, MD, FIOTA[c], Jesús Gómez-Vallejo, MD, PhD, FIOTA[d], Ion Carrera-Fernández, MD, PhD, FIOTA[e], Alberto Delgado Martínez, MD, PhD, FIOTA[f], Theodore Miclau III, MD, FIOTA[g]

Abstract This article summarizes a symposium on topics regarding the current management of tibial plateau fractures presented by the Spanish Orthopaedic Trauma Association as a guest nation society at the Orthopaedic Trauma Association Annual Meeting in October 2023 in Seattle, Washington. These topics include staged treatment strategies, surgical planning, fracture classification, and factors influencing weight bearing. A staged protocol for treating high-energy fractures of the proximal tibia using spanning external fixation with quadrangular configuration is a simple and reproducible way to apply the device and reduce and span these fractures. Multicolumnar fractures can behave differently based on their categorization using the main deformity direction concept, defined as a theoretical vector representing the global displacement or deformity of the columns in a specific direction, and this can help surgeons decide on the definitive treatment. With the classification of columnar involvement and their variants, surgeons can use computed tomography scans to formulate solutions to approach and fix individual fracture patterns. Finally, a finite element analysis may inform the surgeon's decision for immediate weight bearing of a split plateau fracture after fixation with locking screw plates or cannulated screws.

Keywords: fracture, tibia, plateau, main deformity direction, finite, approach, external, fixation, classification

1. Introduction

Tibial plateau fractures represent a challenge for patients and surgeons because of their complexity and potentially devastating sequelae.[1] High-energy tibial plateau fractures have a concomitant soft-tissue injury. Hence, a biologic approach with temporary spanning external fixation, mindful of the vascularity of soft tissue and bone, can prevent many adverse outcomes.[2] Restoring the mechanical axis and articular congruence is critical to achieving good clinical function.[3] Preoperative computed tomography (CT) studies can influence a surgeon's surgical plan by helping to identify the fragments, select an approach, formulate a reduction sequence, and facilitate the selection of an appropriate implant for a selected case.[4,5] Fracture morphology, involvement of different areas of the plateau, surgical skills and surgeon experience, available fixation options, patient positioning requirements, and condition of the soft tissues are all factors to consider when choosing a definitive approach.

In the past decade, many surgeons have developed numerous approaches and conducted anatomical research studies, case series reports, and clinical comparison studies. Unfortunately, there is a lack of consensus on treatment methods, classifications, temporal management, and definitive fixation to achieve optimal functional results.

This article summarizes a symposium presented by the Spanish Orthopaedic Trauma Association (SOTA) as the guest nation society at the 2023 Annual Meeting of the Orthopaedic Trauma Association in Seattle, Washington. This symposium addressed these and other topically related areas.

2. Initial Management of Proximal Articular Tibial Fractures: Span, Scan, and Other Surprises

As an articular fracture, treatment of tibial plateau fractures follows the classic principles: articular reduction, stable fixation, early total mobilization, and prevention of post-traumatic

The authors state that none have a conflict of interest related to the content discussed in this manuscript for the past 3 years.

[a] Department of Traumatology and Orthopaedic Surgery, Rashid Hospital, Dubai, United Arabic Emirates, [b] Department of Traumatology and Orthopaedic Surgery, General University Hospital Vall d Hebron, Barcelona, Spain, [c] Department of Traumatology and Orthopaedic Surgery, Canarian University Hospital, Tenerife, Spain, [d] Department of Traumatology and Orthopaedic Surgery, General University Hospital Lozano Blesa, Zaragoza, Spain, [e] Department of Traumatology and Orthopaedic Surgery, Hospital Santa Creu I Sant Pau, Barcelona, Spain, [f] Department of Traumatology and Orthopaedic Surgery, Hospital University Jaén, Jaén, Spain, [g] Department of Traumatology and Orthopaedic Surgery, San Francisco General Hospital, San Francisco, CA.

* Corresponding author. Address: Rashid Hospital, 315 Umm Hurair, Dubai, United Arabic Emirates. E-mail address: fchanarodriguez@dubaihealth.ae (F. Chana-Rodríguez).

No funding received for the work.

OTAI (2025) e392

Received: 18 December 2024 / Received in final form: 29 January 2025 / Accepted: 7 February 2025
Published online 2 May 2025

http://dx.doi.org/10.1097/OI9.0000000000000392

osteoarthritis. Infection prevention is also added as a deleterious element of a good outcome. Elements such as articular stability, meniscal integrity, proper mechanical alignment in the coronal plane, and restoration of articular congruity are protective against the appearance of post-traumatic osteoarthritis.[3] In the 1980s and early 1990s, the emergence of fixation techniques for articular fractures encouraged early definitive reduction and internal fixation using a midline anterior approach. However, local complications such as surgical site infection, soft-tissue breakdown, malunion, nonunion, and joint stiffness were reported in up to 88% of patients.[6–8]

Consistent with the standards developed for distal tibia fractures, a staged strategy has been proposed to treat high-energy proximal tibia fractures.[2] Such treatment protocols follow the currently popularized span-scan-plan principles. In high-energy fractures, such as those classified as Schatzker VI, forceful mechanisms, open injuries with contamination, significant displacement and comminution, and soft-tissue damage (eg, blisters, burns, and abrasions), a staged strategy has demonstrated improved outcomes, particularly in infection rates (5%–11%), relative to similar fractures treated with immediate dual-incision approaches.[2] By contrast, some studies have appeared in the literature advocating early definitive fixation in some instances with comparable complication rates (7%–17%). However, the subjective assessment of the soft tissues, cohort heterogeneity, and individual centers' level of treatment expertise make global application difficult.[9]

Spanning external fixation follows principles that include the maintenance of bone length, axial alignment, and integrity of tissues for future surgical approaches, which differ from those used for definitive external fixation. The quadrangular configuration for temporary spanning external fixation has been proposed as an easy and reproducible assembly to reduce and span acute fractures, whether applied by orthopaedic trauma surgeons or general orthopaedists. When nonspecialists perform this configuration, it not only improves the initial reduction obtained but also facilitates and improves the definitive fracture reduction and reduces surgical time.[2]

Computed tomography scanning under osteotaxis, as with tibial pilon fractures, allows correction of fracture line definition. A 360-degree view allows identification of the fragments and comminution of the fracture. Thanks to this technique, new classifications have been created. Elements such as the column concept[5] and main deformity direction (MDD)[10] assist in decision making regarding approaches and the types of implants to use. Unfortunately, many of the surprises during treatment are not from the bone injuries. Instead, they result from missed and underestimated soft-tissue injuries, particularly the lateral meniscus and posterolateral complex.

Meniscal injuries can appear in 70%–80% of cases. High suspicion arises with fragment depression greater than 6 mm and separation more than 5 mm.[11] Previous magnetic resonance imaging (MRI) assessment and surgical approaches, particularly the submeniscal approach, are requisites for proper diagnosis and repair.

The presence of anteromedial fragments is suggestive of a posterolateral corner injury, which was diagnosed through an MRI study.[12] Varus and hyperextension deformity can create an anteromedial tibial plateau fracture and disrupt the fibular collateral ligament, popliteus tendon, and articular capsule (Fig. 1). Diagnosis and acute treatment with direct structure repair and techniques such as LaPrade augmentation improve the opportunity for better outcomes than can be seen with chronic injury management.

In conclusion, a staged strategy is indicated in high-energy tibial plateau fracture treatment. A quadrangular external fixator configuration can maintain proximal tibial axial alignment and length in nonemergent situations, avoid compromise of future approaches, improve the initial reduction and quality of definitive reduction, and reduce overall surgical time.

Scanning under osteotaxis has enabled the development of novel ways of evaluating fractures, including the column concept and MDD, which can improve the surgical approach and implant selection. The misdiagnosis of the lateral meniscus and posterolateral corner injuries can decrease definitive outcomes in tibial plateau fracture treatment. Suspicion of the presence of these conditions with specific injuries, including suspected posterolateral corner injuries, followed by MRI evaluation is essential for proper diagnosis and assessment. Acute treatment that includes anatomical fracture reconstruction improves the functional outcomes of these patients.

3. Decision-Making Approaches in Multicolumnar Tibial Plateau Fractures Based on the Main Deformity Direction Concept

A big step forward in the understanding of tibial plateau fractures was the description of proximal tibial columns[5,13] and segments,[14] which emphasized the importance of the posterior columns (posteromedial and posterolateral). Multicolumnar fractures involving 3 or 4 columns represent complex injuries for which a universal surgical strategy may not be optimal for all cases.[10] These complex fractures can behave differently, as outlined by the MDD concept, which describes subtypes that might benefit from different surgical strategies. The MDD concept, proposed related classification, and decision-making algorithm published in 2021 are described further.[10]

The MDD is defined as a theoretical vector representing the global displacement or deformity of the columns in a specific direction. The "deformity" is produced by the most significant impact zone and direction of the femoral condyles on the tibial plateau. This deformity may manifest as angular, translational, and compressive displacement. The "direction" refers to the resultant of the deformity direction in sagittal plus coronal planes, or essentially, the direction in the axial plane. There are, therefore, 4 main types of MDD, posterolateral (PL), posteromedial (PM), anterolateral (AL), and anteromedial (AM), or the precise determination of the MDD in the axial plane according to a 360-degree evaluation (Fig. 2A). Various parameters for determining the MDD have been defined.

The proposed classification is based on 3 main factors: the number of affected columns (1C, 2C, 3C, 4C), which columns are involved (L+/−M +/−PM +/−PL), and the MDD (PM-MDD, PL-MDD, AM-MDD, AL-MDD). For supplementary information, the option to include the exact MDD (360-degree evaluation) allows for determining the precise location to counteract the deformity. In addition, consideration of the 8 articular segments helps name the exact location of joint fragments with depression or extrusion that require specific articular reduction (Fig. 2B).

Based on this classification, the proposed surgical strategy includes 2 main objectives, which form the basis of the algorithm. The first objective is to achieve direct control of the MDD. The

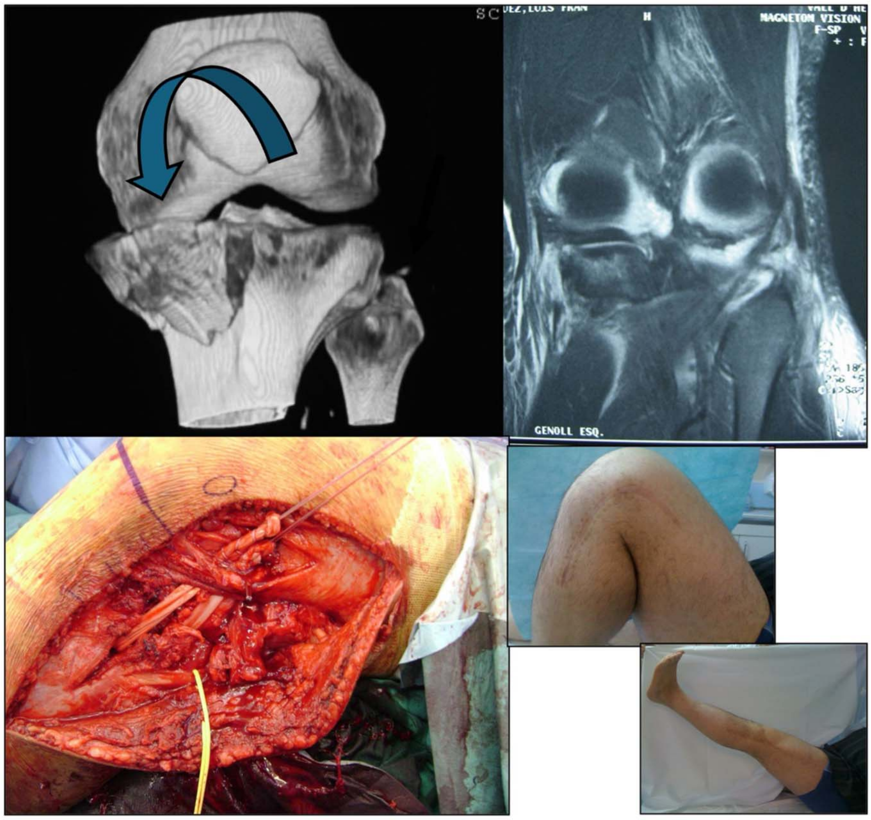

Figure 1. Clinical case with disruption of the fibular collateral ligament, popliteus tendon, and articular capsule.

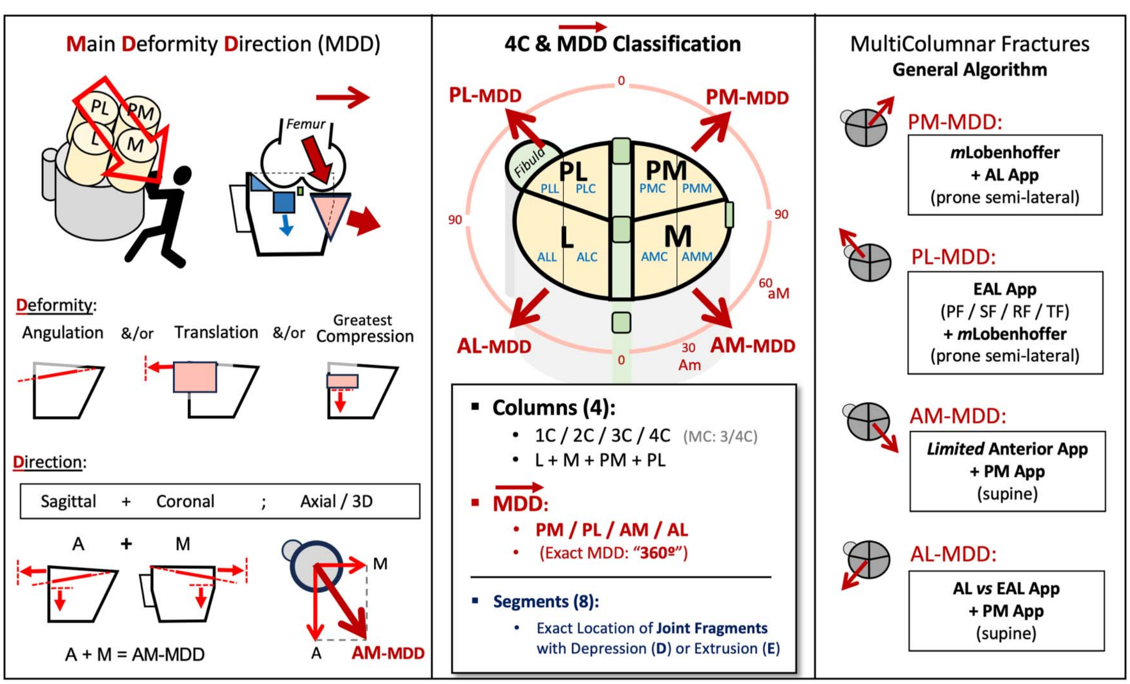

Figure 2. A, The MDD concept. Diagrams representing an anteromedial MDD. B, Four-column and MDD classification. The exact MDD can be expressed as degrees from 0 to 90 degrees in each quadrant (360 degrees concept). For example, in AM-MDD, 30 degrees (or Am) means more anterior than medial deformity direction. C, General algorithm for decision-making approaches in multicolumnar fractures according to the 4 main types of MDD.

second objective is to obtain simultaneous global fracture control, with the surgeon performing all necessary approaches with the patient in a fixed position.

The first approach is the primary method for establishing the MDD through a proposed general algorithm for decision-making approaches in multicolumnar fractures. By contrast, the second approach is a complementary strategy for managing other columns that require direct reduction or fixation. The chosen patient positioning seeks to optimize the control of the MDD and allows simultaneous access to the approaches (Fig. 2C):

- PM-MDD: A modified oblique Lobenhoffer approach addresses PM, PL, and medial columns. The deformities in the segments of the PL column caused by the PM-MDD (more significant depression in the posterolateral central segment) facilitate a more straightforward reduction through this approach. Simultaneously, an anterolateral approach, used to address the lateral column, can be performed with the patient in a fixed prone semilateral position.
- PL-MDD: A modified, extended anterolateral approach (EAL), with 4 deep progressive windows (prefibular [EAL-PF], suprafibular [EAL-SF], retrofibular [EAL-RF], or trans-fibular [EAL-TF]), can be used to address the lateral and PL columns. One of these progressive options manages the PL column deformities in these cases. Simultaneously, a modified Lobenhoffer approach to address PM and medial columns can be performed in a prone semilateral position.
- AM-MDD: A limited anterior approach can be helpful in these cases to manage the medial and lateral columns, particularly for articular depressions in the anteromedial central, anteromedial medial, and anterolateral central segments. A complementary posteromedial approach can be performed in a supine position.
- AL-MDD: An anterolateral or an EAL approach is used to control the lateral and the PL columns if required. In addition, a posteromedial approach can be performed in the supine position.

In conclusion, the algorithm presented can represent a general guide for making decisions on the surgical management of these complex fractures. However, it is crucial to emphasize the importance of individualizing each case based on evaluating the columnar involvement, MDD, and fracture segments. The MDD concept can be helpful and relevant for planning the surgical strategy, including decisions regarding patient positioning, approaches, reduction, and fixation. Direct control of the MDD and simultaneous global fracture control can assist with selecting an optimized strategy in multicolumnar fractures.[10]

4. Surgical Approaches for Tibial Plateau Fractures

A decade-and-a-half ago, anteroposterior and lateral X-ray images of the tibial plateau were largely relied on to classify fractures and determine possible approaches,[15,16] with lateral and medial approaches managed in a supine position and posterior approaches in a prone position. Following the establishment of a CT-based columnar classification system, columnar-based approaches became popular, with the medial, lateral, and posterior columns divided into 2 areas—posteromedial and posterolateral.[5] This change in how fractures were evaluated led to several surgical approaches and their variants to address individual fracture patterns. Generally, tibial plateau fixation should begin with the posterior columns (if involved) and then with the anterior columns through the anterior approaches.

4.1. Approaches in the Supine Position for Anterior Column Fractures

Anterolateral and anteromedial approaches are intuitive. Although they allow for excellent intra-articular visualization through the submeniscal window, combined osteosynthesis of the posterior columns cannot be performed through these approaches. Primary fixation of these fractures can be a valuable complement to the reduction of the anterior columns once posterior osteosynthesis has been accomplished through prone approaches.

4.2. Approaches in the Prone Position for Posterior Column Fractures

Trickey described his classical approach in 1968[17]; it was beneficial but more demanding than anterior approaches because it involves the dissection of the neurovascular bundle. To overcome these problems, the direct posteromedial approach[18] has been described with an extension for posterolateral fractures.[19] Subsequently, more direct posterolateral approaches were designed to reach the posterolateral fragments through intermuscular planes in the shape of an inverted L. Still, they have the problem of distal extension, which is made impossible by the exit of the anterior tibial artery.[20]

4.3. Approaches in the Supine Position for Posterior Column Fractures

Anterior approaches to reach posterior columns theoretically save surgical time and potential injury to the posterior soft-tissue structures. For this reason, supine approaches for the posteromedial and posterolateral columns have become popular. For the posteromedial approach, no important anatomical structures obscure reaching the posterior plateau. However, with the supine posterolateral approach, there can be difficulties with the lateral ligament, head of the fibula, peroneal nerve, and, at the bottom of the approach, the distal complex of the popliteal vessels.

More complex approaches have been developed to avoid this, such as the transfibular approach with proximal abatement of the lateral ligamentous complex with osteotomy of the fibula neck.[18] During the osteotomy we should avoid injury to the lateral capsule, the external meniscus, and the peroneal nerve itself. To mitigate this issue, a supine posterolateral approach without fibula osteotomy was recommended, which was an intuitive but complex approach.[21] This approach uses a minimal space to reduce fracture, including an inverted triangle delimited by the peroneal nerve and the posterior vessels, with the proximal base being the articular line. Moreover, the roof of this structure is formed by the lateral gastrocnemius, which can make the placement of plates with screws challenging (Fig. 3). To address this limitation, proximal structures (ie, the lateral femoral epicondyle osteotomy, including the popliteus tendon) can be detached, increasing lateral articular visualization without risk to neurovascular or posterolateral soft-tissue structures.[22]

In conclusion, surgeons must know at least 1 approach for each column, knowing that the posterolateral approach in prone might provide little bone exposure.

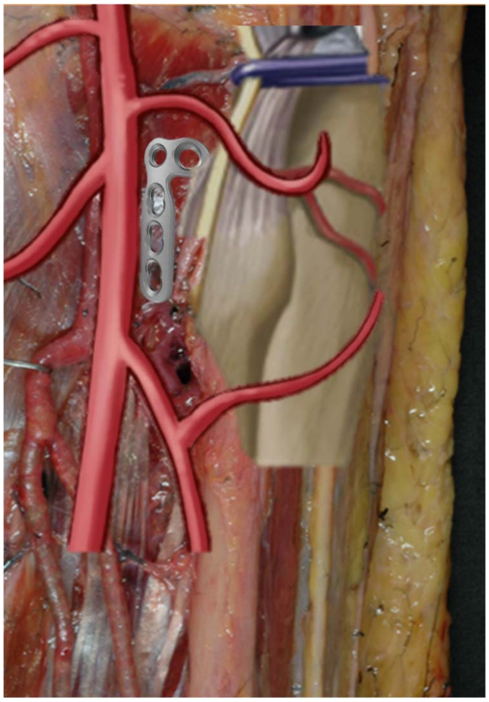

Figure 3. Inverted triangle delimited by the peroneal nerve and posterior vessels, with the proximal base being the articular surface.

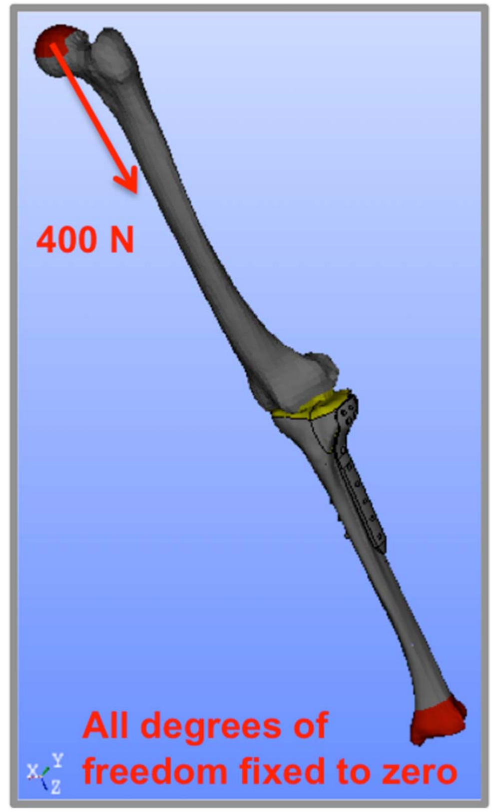

Figure 4. Models of load force applied to the femur against the tibial plateau and demonstration of the measured interfragmentary motion (IFM).

5. Split Fracture of the Lateral Tibial Plateau With Locking Screw Plate Versus Cannulated Screw Fixation: A Finite Element Study

Lateral tibial plateau fractures represent approximately 60% of tibial plateau fractures because of specific geometry of the knee and tibiofemoral joint forces. Most of these fractures are low-energy split fractures, and some are associated with depression of the articular surface.[23] Frequently, surgical treatment consists of arthroscopic-assisted reduction and *ad minimum* fixation with percutaneous cannulated screws.[11] Arthroscopic visualization of the reduction allows for improved anatomical reduction and diagnosis and treatment of meniscus- or ligament-associated injuries. Although arthroscopic-assisted percutaneous screw fixation is a less-invasive surgical technique, some authors prefer locking plate fixation.

Both treatments require a 6–8 week period of non–weight bearing postoperatively, even in those cases with simple fractures or anatomical reductions.[24] This non–weight-bearing period likely delays the final functional outcome, increases health care costs, and causes the absence of mechanical forces applied to the knee to harm cartilage preservation.[25] In this study, a split fracture of the lateral tibial plateau (LTP) was recreated in a finite element (FE) model of a human tibia to study the ability to limit weight bearing immediately after surgery. A locking screw plate and a cannulated system were modeled to reduce the fracture virtually, and 80-kg static body weight was simulated.

400 N load force was applied to the femoral model, which pressed against the tibial plateau, corresponding to weight bearing in an 80-kg patient (Fig. 4). Interfragmentary distance (ID) was calculated anteriorly through multiple pairs of nodes distributed in the fracture plane. ID and bone tension values were calculated according to the total weight percentage applied.

The results of this study demonstrated that the medial and lateral reaction forces on the tibial plateau were 325 N and 75 N with the Polyax device (DePuy, Leeds, United Kingdom) and 367 N and 33 N with the cannulated screws, respectively. The reaction forces between the fragment and the tibia were 1 order of magnitude higher with the cannulated screws than with the Polyax device. In addition, while the lateral fragment was slightly compressed with the Polyax plating system, there was a tendency to separate from the tibia with cannulated screws. Accordingly, the maximum interfragmentary motion (IFM) calculated with the cannulated screws was more than twice that calculated with the Polyax. However, the values did not exceed 0.03 millimeters (Fig. 5).

Regarding the stresses transmitted to the trabecular bone, the maximum shear stresses were 0.17 megapascals (MPa) and 0.66 MPa with the Polyax and cannulated screws, respectively (Fig. 6). Maximum principal stresses were always 1 order of magnitude higher with the cannulated screws than with the Polyax, and the most significant computed values were 0.24 MPa and 0.13 MPa in traction and compression, respectively. Trabecular bone stresses tended to concentrate around the screws near the fracture plane with the Polyax. At the same time, they showed a tendency to concentrate around the start of the screw threads with the cannulated screws. Maximum von Mises stresses within the simulated implants were generated by the contact with the cortical shell, with values of nearly 20 MPa for the Polyax and 32 MPa for the cannulated screws. The simulated body weight led to clinically acceptable IFM, and possible traumatic bone shear stresses were predicted near the cannulated screws.

In conclusion, split fractures of the LTP fixed with either a locking screw plate or cannulated screws showed no clinically relevant IFM in a FE model. The locking screw plate showed higher mechanical stability than cannulated screw fixation. The

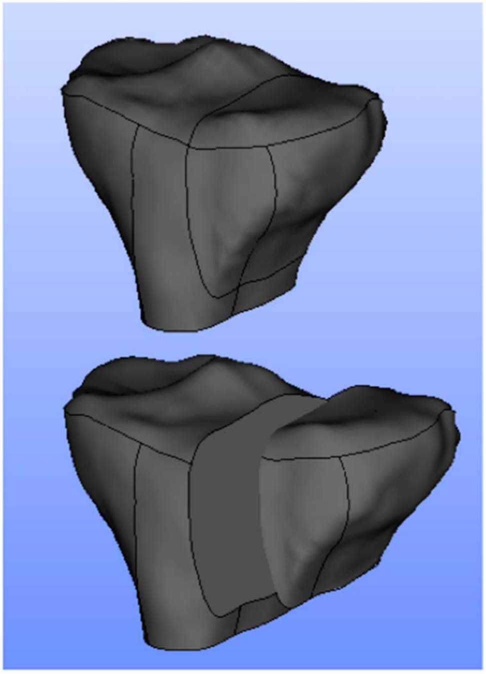

Figure 5. Fragment displacement under tension.

locking screw plate might also allow full or at least partial weight bearing under static posture at time 0.[26]

6. Conclusions

The treatment of tibial plateau fractures continues to evolve. The span-scan-plan principle in high-energy proximal tibia fractures can reduce complications through spanning external fixation in a quadrangular configuration, as it is an easy and reproducible assembly to reduce and span these fractures. The MDD concept, defined as a theoretical vector representing the global displacement or deformity of the columns in a specific direction, could aid in the definitive treatment decision making for tibial plateau fractures. Surgeons should be familiar with at least 1 approach for each affected tibial plateau column, understanding that the posterolateral approach in a prone position may limit access to posterolateral fragments. A finite element study of split fractures of the lateral tibia plateau showed higher mechanical stability of a screw plate construct compared with cannulated screw fixation, allowing for at least partial weight bearing.

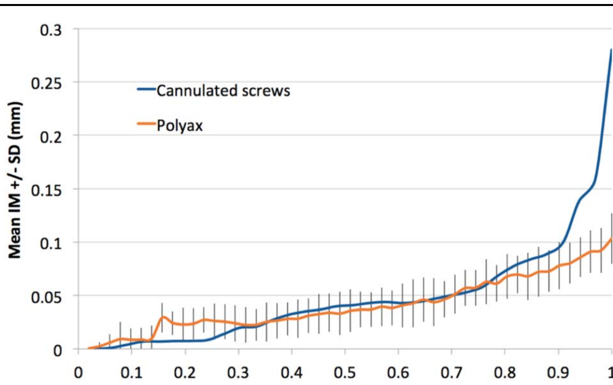

Figure 6. Interfragmentary movements associated with load with the Polyax and the cannulated screws.

References

1. Honkonen SE. Degenerative arthritis after tibial plateau fractures. *J Orthop Trauma*. 1995;9:273–277.
2. Oleo-Taltavull R, Corro S, Tomas-Hernandez J, et al. Staged treatment of bicondylar tibial plateau fractures: influence of frame configuration and quality of reduction on outcomes. *Eur J Trauma Emerg Surg*. 2024;50:1033–1041.
3. Giannoudis PV, Tzioupis C, Papathanassopoulos A, et al. Articular step-off and risk of post-traumatic osteoarthritis. Evidence today. *Injury*. 2010;41:986–995.
4. Ren D, Liu Y, Lu J, et al. A novel design of a plate for posterolateral tibial plateau fractures through traditional anterolateral approach. *Sci Rep*. 2018;8:16418.
5. Luo CF, Sun H, Zhang B, et al. Three-column fixation for complex tibial plateau fractures. *J Orthop Trauma*. 2010;24:683–692.
6. Moore TM, Patzakis MJ, Harvey JP. Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. *J Orthop Trauma*. 1987;1:97–119.
7. Mallik AR, Covall DJ, Whitelaw GP. Internal versus external fixation of bicondylar tibial plateau fractures. *Orthop Rev*. 1992;21:1433–1436.
8. Young MJ, Barrack RL. Complications of internal fixation of tibial plateau fractures. *Orthop Rev*. 1994;23:149–154.
9. Virkus WW, Caballero J, Kempton LB, et al. Costs and complications of single-stage fixation versus 2-stage treatment of select bicondylar tibial plateau fractures. *J Orthop Trauma*. 2018;32:327–332.
10. Boluda-Mengod J, Guimera-Garcia V, Olias-Lopez B, et al. A proposal of a new algorithm for decision-making approaches in open reduction and internal fixation of complex tibial plateau fractures—SOTA algorithm (Spanish Orthopaedic Trauma Association). *Injury*. 2021;52(suppl 4):S87–S98.
11. Burdin G. Arthroscopic management of tibial plateau fractures: surgical technique. *Orthop Traumatol Surg Res*. 2013;99:S208–S218.
12. Pierrie SN, Harmer LS, Karunakar MA, et al. Limited added value of the posterolateral approach. *J Knee Surg*. 2016;29:21–27.
13. Kfuri M, Schatzker J. Revisiting the Schatzker classification of tibial plateau fractures. *Injury*. 2018;49:2252–2263.
14. Krause M, Preiss A, Muller G, et al. Intra-articular tibial plateau fracture characteristics according to the “Ten segment classification”. *Injury*. 2016;47:2551–2557.
15. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture. The Toronto experience 1968–1975. *Clin Orthop Relat Res*. 1979;138:94–104.
16. Meinberg EG, Agel J, Roberts CS, et al. Fracture and dislocation classification compendium-2018. *J Orthop Trauma*. 2018;32(suppl 1):S1–S170.
17. Trickey EL. Rupture of the posterior cruciate ligament of the knee. *J Bone Joint Surg Br*. 1968;50:334–341.
18. Galla M, Riemer C, Lobenhoffer P. Direct posterior approach for the treatment of posteromedial tibial head fractures. *Oper Orthop Traumatol*. 2009;21:51–64.
19. Lobenhoffer P, Gerich T, Bertram T, et al. Treatment of posterior tibial plateau fractures via posteromedial and posterolateral exposures. *Der Unfallchirurg*. 1997;100:957–967.
20. Tao J, Hang DH, Wang QG, et al. The posterolateral shearing tibial plateau fracture: treatment and results via a modified posterolateral approach. *Knee*. 2008;15:473–479.
21. Frosch KH, Balcarek P, Walde T, et al. A new posterolateral approach without fibula osteotomy for the treatment of tibial plateau fractures. *J Orthop Trauma*. 2010;24:515–520.
22. Krause M, Frings J, Isik H, et al. Comparison of extended lateral approaches to the tibial plateau: the articular exposure of lateral epicondyle osteotomy with and without popliteus tendon vs. fibula osteotomy. *Injury*. 2020;51:1874–1878.
23. McGonagle L, Cordier T, Link BC, et al. Tibia plateau fracture mapping and its influence on fracture fixation. *J Orthop Traumatol*. 2019;20:12.
24. Jian Z, Ao R, Zhou J, et al. A new anatomic locking plate for the treatment of posterolateral tibial plateau fractures. *BMC Musculoskelet Disord*. 2018;19:319.
25. Sun H, He QF, Zhang BB, et al. A biomechanical evaluation of different fixation strategies for posterolateral fragments in tibial plateau fractures and introduction of the ’magic screw’. *Knee*. 2018;25:417–426.
26. Carrera I, Gelber PE, Chary G, et al. Fixation of a split fracture of the lateral tibial plateau with a locking screw plate instead of cannulated screws would allow early weight bearing: a computational exploration. *Int Orthop*. 2016;40:2163–2169.