Functional outcomes of patients with direct vs indirect fixation of tibial plateau fractures with posterior column involvement

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Abstract

Background

The study was undertaken to compare the effectiveness of direct fixation of the posterior column of the tibial plateau versus indirect fixation using medial or lateral approaches, using the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire as the primary outcome measure.

Methods

A retrospective comparative study was conducted, with a minimum follow-up of two years on surgically treated patients, comparing direct fixation of the posterior column of the tibial plateau versus indirect fixation of the posterior column via a medial or lateral approach of the tibial plateau. These procedures were performed from January 2018 to January 2023 at the Orthopedic Hospital of the Red Cross in Mérida, Yucatán, Mexico.

Results

A total of 59 patients were obtained, of which 28 patients underwent direct posterior column fixation and 31 were operated with indirect posterior column fixation from classic medial or lateral approaches. Patients treated with direct posterior fixation showed significantly higher scores on the KOOS questionnaire in the symptoms (76.57 vs 70.0, p = 0.03), pain (83.21 vs 77.94, p = 0.02), and activities of daily living (87.54 vs 82.74, p = 0.03) subscales, as well as in the total scale score (75.14 vs 70.13, p = 0.04). No significant differences were found in the sports and quality of life subscales.

Conclusion

It was determined that patients undergoing direct posterior fixation presented significantly higher scores on the KOOS questionnaire, particularly in the symptoms, pain, and activities of daily living subscales. This suggests better long-term functional outcomes in patients undergoing direct fixation via a posterior approach.

Level of evidence: 3

Keywords: posterior column of tibial plateau, tibial plateau, KOOS questionnaire, posterior approach to tibial plateau

Introduction

Fractures of the posterior column of the tibial plateau represent a significant challenge in the field of orthopaedic traumatology. Although they represent only a subset of tibial plateau injuries, they are disproportionately associated with residual sagittal malalignment, chronic pain and post-traumatic osteoarthritis when anatomic reduction is not achieved.[1] Early recognition on computed tomography (CT) and careful surgical planning are therefore fundamental to preserving long-term knee function.[2-4] Early recognition and accurate classification are important, as posterior column involvement, sagittal malalignment and postoperative complications have been suggested to be associated with worse functional outcomes. However, high-level clinical evidence on this topic remains limited.[2] A complementary classification system to guide decision making was used, namely the Luo three-column concept (CT-based), which divides the proximal tibia into lateral, medial and posterior columns, emphasising coronal and sagittal plane instability.[3-4] A schematic of the three-column concept is provided in *Figure 1* to illustrate how fracture location dictated our surgical strategy.

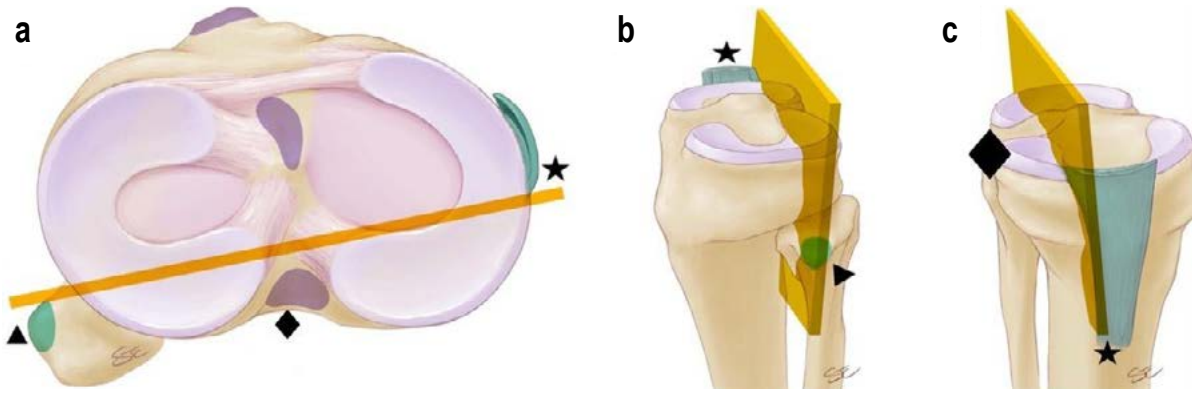

Figure 1. Schematic illustration of Luo's three-column concept:4 a) axial view of the proximal tibia showing division into medial (★), lateral (▲) and posterior (◆) columns by an oblique coronal plane (orange); b, c) coronal and sagittal reconstructions visualising the three-column corridor (gold wedge) that guides surgical planning.
This diagram was used to classify fractures and select surgical approaches and fixation strategies in the present study.

Consensus has not yet been reached on the optimal fixation method when the posterior column is displaced. Traditional management uses indirect reduction through anterolateral or medial approaches; however, growing biomechanical and clinical evidence suggests that direct posterior buttress plating, performed in the prone position via a midline posterior 'L-inverted' approach, may provide superior fragment control. Studies conducted in China and Taiwan have also reported encouraging functional and bone healing outcomes with this approach, especially in posterolateral or posteromedial shear patterns.[5-8] Most supporting studies are retrospective case series with heterogeneous fracture mixes, and only a few directly compare posterior versus indirect fixation. High-level clinical data remain limited.[9-11]

To objectively evaluate the functional outcomes in patients undergoing surgery for posterior column fractures of the tibial plateau, the KOOS (Knee injury and Osteoarthritis Outcome Score) questionnaire is used. This tool assesses pain, joint mobility, and functional capacity of the knee, and has become a standard for measuring the impact of these fractures on patients' quality of life.[12-14] The present retrospective comparative study analyses patients treated at a single trauma centre before and after the staged adoption of the posterior approach. Our primary aim was to determine whether direct posterior fixation yields superior KOOS outcomes at a minimum two-year follow-up when compared with indirect medial or anterolateral fixation. Secondary objectives were to compare complication rates and to describe fracture patterns in our resource-limited setting.

Patients and methods

A retrospective comparative study of two case series was carried out at the Orthopedic Hospital of the Mexican Red Cross from January 2018 to January 2023; all enrolled patients had a minimum follow-up of two years.

This study was approved by the Institutional Review Board of the Orthopedic Hospital of the Mexican Red Cross and written informed consent was obtained from all participants. All patients with tibial plateau fractures involving the posterior column who sustained high-energy trauma, such as motor-vehicle collisions, falls from height or sports injuries, confirmed by CT, treated at the Orthopedic Hospital of the Mexican Red Cross between 2018 and 2022, and with complete records plus a minimum two-year follow-up were included. Patients operated between January 2018 and June 2020 with indirect fixation via a medial or anterolateral approach formed series A, whereas those treated from July 2020 onward with posterior approach with direct fixation constituted series B. Exclusion criteria were associated knee ligament injury, fragility fractures, initial treatment elsewhere or loss to follow-up (*Figure 2*).

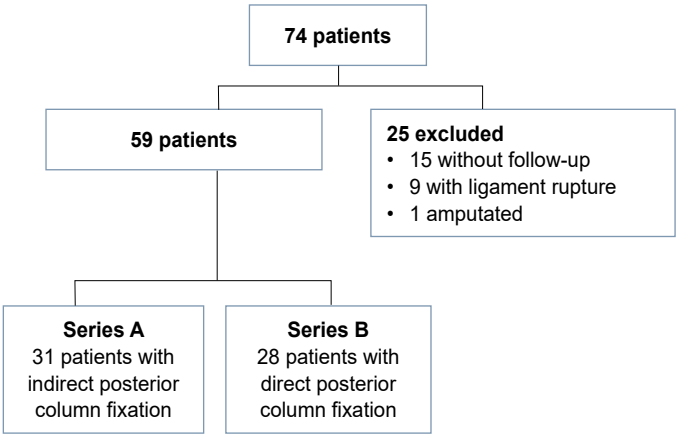

Figure 2. Flowchart of patient selection and allocation

Technique selection and surgical approach

All fractures were classified preoperatively with CT using the Luo three-column concept (lateral, medial, posterior). Up to mid-2020 our unit lacked posterior-column expertise, so patients with CT-confirmed posterior involvement were treated exclusively with indirect reduction and fixation in the supine position through standard anterolateral or, when indicated, medial approaches (series A). Following dedicated training completed by two senior orthopaedic trauma surgeons in mid-2020, the service introduced direct posterior fixation as the preferred method; from July 2020 onward, every eligible case was managed prone via a midline posterior approach, with fluoroscopic confirmation of reduction and stabilisation using a contoured T-shaped buttress plate and locking screws (series B) (*Figure 3*). All operations were performed by the same two senior surgeons, and this phased adoption inevitably creates a chronological bias that is acknowledged in the study limitations section.

Postoperative protocol

All patients received the same postoperative regimen: intravenous antibiotics for 24 hours, early passive range-of-motion exercises on day 1, partial weight-bearing at six weeks, and full weight-bearing when radiographic union was evident (*Figure 4*).

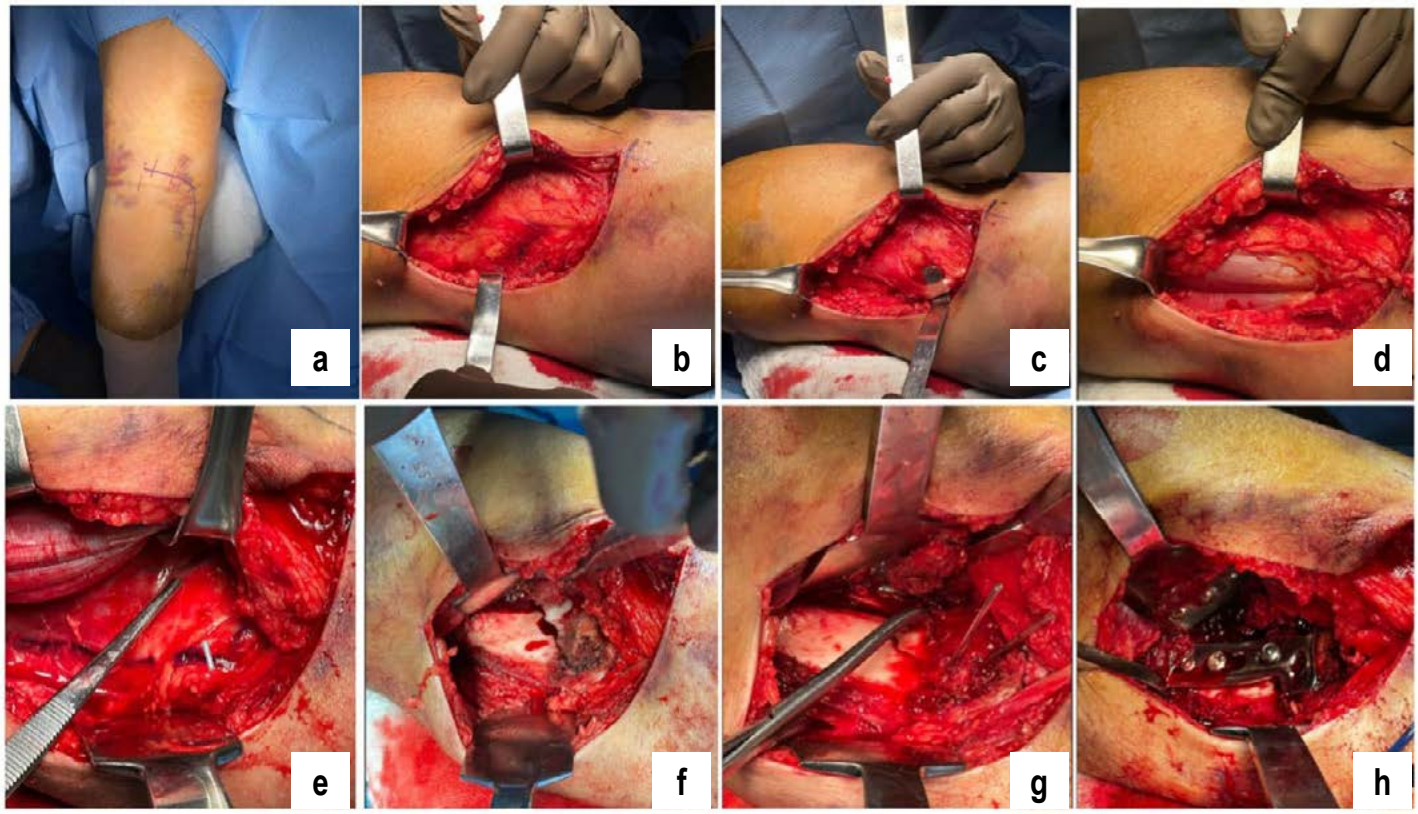

Figure 3. Posterior buttress plate approach for displaced posterior column fractures:

a) prone positioning and inverted 'L' skin incision in the posterior flexion crease; b) fasciocutaneous flap elevation with protection of the sural nerve and short saphenous vein; c) identification of hamstring insertions; medial retraction of the gastrocnemius; d) exposure of the popliteal neurovascular bundle; e) subperiosteal dissection of the popliteus, protecting capsular structures; f) posterolateral retractor placement for full visualisation of the posterior tibial plateau; g) provisional reduction with valgus extension manoeuvre and Kirschner wires; h) definitive buttress fixation with a contoured T-plate and locking screws. (All photographs from a single representative case; patient identifiers removed.)

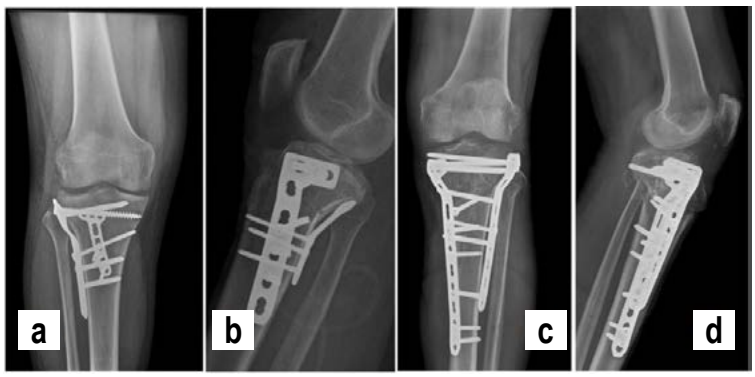

Figure 4. a) anteroposterior radiograph showing the result of direct posterior column fixation performed through a posterior approach to the tibial plateau; b) lateral view of the same patient at two-year follow-up; c) anteroposterior radiograph of a patient treated with indirect posterior column fixation through medial and lateral approaches; d) lateral view showing that no posterior buttress plate was used

Outcome assessment

Functional outcome was evaluated using the KOOS scoring system, which comprises five subscales (symptoms, pain, activities of daily living [ADL], sports/recreation, quality of life). Each subscale is transformed to a 0–100 scale; the total KOOS is the mean of the five subscales, with higher scores indicating better function.[15]

Statistical analysis

Continuous variables are reported as mean ± standard deviation (SD). Group comparisons of KOOS scores were performed with independent t-tests. A p-value < 0.05 was considered statistically significant. Analyses were conducted with SPSS v25[16] (IBM Corp, Armonk, NY, USA). Owing to the retrospective design of the study, no a priori power calculation was performed.

Results

Demographic and injury characteristics

All 59 fractures resulted from high-energy trauma; fragility or osteoporotic fractures were explicitly excluded, ensuring homogeneity of bone quality across groups. Every operation was performed by the two same senior orthopaedic trauma surgeons, eliminating variability due to surgeon experience. The two case series were similar with respect to demographic and injury-severity variables (*Table I*). Mean age did not differ significantly (49 ± 13 y in the direct fixation group vs 47 ± 14 y in the indirect fixation group; p = 0.56), and the male predominance was comparable (75% vs 74%; p = 0.91). Side distribution (left 61% vs 58%; p = 0.81) and injury mechanism (motor vehicle collision 68% vs 65%; p = 0.77) were likewise balanced. Fracture complexity, assessed by the CT-based Luo three-column concept, showed no statistical difference. Posterolateral shear was the dominant configuration in both groups (57% direct vs 58% indirect). Thus, age, sex distribution and fracture severity metrics were well matched, minimising baseline bias between the study arms.

Of the 59 patients included, 31 were managed with direct posterior fixation. Among these, 19 had posterolateral column fractures treated with a 4.5 mm locked anatomical lateral plate

Table I: Patient demographics and fracture patterns

Variable	Total (n = 59)
Age (years), mean SD	48 (13.75)
Male sex	44 (75%)
Female sex	15(25%)
Left side, n (%)	35 (59%)
Right side, n (%)	24 (41%)
Posterolateral pattern, n (%)	34 (57%)
Posteromedial pattern, n (%)	9 (15%)
Three-column pattern, n (%)	13 (22%)
Posterior column pattern, n (%)	3 (4%)

Table II: KOOS scores by fixation method

KOOS subscale	Direct (mean ± SD)	Indirect (mean ± SD)	p-value
Symptoms	76.57	70	0.03*
Pain	83.21	77.94	0.02*
Activities of daily living (ADL)	87.54	82.74	0.03*
Sports and recreation	63.29	58.52	0.14
Quality of life	67.11	61.42	0.06
Total KOOS	75.14	70.13	0.04*

Higher values indicate better function (0 = extreme problems; 100 = no problems).
* Statistically significant, < 0.05

plus a posterior T-buttress plate; one posteromedial case received a posterior buttress plate combined with a conventional 4.5 mm locked medial plate; six three-column fractures were stabilised with a locked medial plate, a 4.5 mm locked lateral plate and a 3.5 mm posterior T plate; and three isolated posterior column fractures were treated with a standalone 3.5 mm posterior T-buttress plate.

The remaining 28 patients underwent indirect fixation. Fifteen posterolateral fractures were managed through an anterolateral approach with a single locked lateral plate, relying on indirect reduction of the posterior fragment. Eight posteromedial fractures received a locked medial plate with indirect posterior fixation via the same medial approach. Finally, seven three-column injuries were addressed with medial and lateral locked plates, indirectly stabilising the posterior column through combined medial and lateral exposures.

Surgical complications

Early post-traumatic osteoarthritis was the most frequent adverse event overall, occurring in six of 28 patients (21%) in the direct fixation group and ten of 31 patients (32%) in the indirect fixation group (p = 0.31). Superficial wound complications were uncommon: none were recorded after posterior fixation, whereas two cases (7%) of superficial infection were documented after indirect fixation; both resolved with oral antibiotics and local care. No cases of deep infection, sepsis, implant failure or re-operation were observed in either cohort. Importantly, no vascular or neurological injuries were encountered despite routine mobilisation of the neurovascular bundle during the posterior approach. Mean operative time did not differ significantly between techniques (direct fixation = 124 ± 25 min vs indirect fixation = 118 ± 20 min; p = 0.22), suggesting that the introduction of the posterior approach did not prolong surgery once the learning curve had been overcome.

Mean KOOS scores at ≥ 24 months are presented in *Table II*. Direct posterior fixation resulted in significantly higher scores for symptoms, pain, ADL, and total KOOS. Differences in sports and quality of life subscales did not reach statistical significance.

Direct posterior fixation resulted in higher KOOS scores for symptoms, pain, ADL and overall function, while also demonstrating lower complication rates, particularly with respect to early arthritis and wound problems, than indirect fixation. Notably, no re-operations, implant failures or neurovascular injuries occurred in either group.

If we compare the score differences, we can observe that in the subcategories of symptoms, pain and daily activities, there is a statistically significant difference regarding the scores obtained, but not in the subcategory of recreational activity and quality of life, despite obtaining better scores in the groups where direct posterior fixation was performed. Similarly, it was also found that the difference in the total scores of the KOOS scale is statistically significant, giving a better score to patients who underwent posterior fixation.

Discussion

In this retrospective series of 59 tibial plateau fractures with posterior column involvement, direct posterior buttress plating produced clinically meaningful gains in KOOS subscores for pain, symptoms and ADL, and reduced early post-traumatic osteoarthritis by 11 percentage points (21% vs 32%) compared with indirect fixation. These findings reinforce the biomechanical premise that a buttress plate placed on the posterior cortex converts shear into compression and prevents secondary collapse, as demonstrated in studies by Söylemez and Andonov.[17,18] Clinically, various approaches, such as the medial incision for the application of the posteromedial plate, have shown favourable clinical results, with high rates of anatomical reduction, low incidence of complications, and high knee scores on various scales.[18,19]

The KOOS scale has proven to be a valuable tool for evaluating functional outcomes in patients with tibial plateau fractures, including those affecting the posterior column. Consistent with previous studies,[20] the findings of this study reveal that these patients have significantly lower KOOS scores compared to the general population, especially in the pain and symptoms subscales, which underscores the impact of these fractures on quality of life and knee function. Although no statistically significant differences were found in the sports and recreation and quality of life subscales, the direct posterior fixation group showed numerically higher scores in both measurements, suggesting a possible trend towards better outcomes in these areas, although studies with larger samples would be required to confirm this. The findings of this study are consistent with studies such as those by Van den Berg and Kołodziejczyk,[7,21,22] which reaffirm the utility of the KOOS scale for evaluating patients with tibial plateau fractures; factors such as varus trauma mechanism and delayed surgery can negatively influence the results. The difference in KOOS scores compared to other studies such as that by Kołodziejczyk et al. reported an average KOOS score of 82% in surgically treated patients,[20,22] while this study found an average of 75%. This difference could be attributed to the learning curve at our centre of approximately three years, suggesting encouraging results in the future, and highlighting the improvement in the posterior fixation group, possibly due to greater joint stability and anatomical restoration.

Regarding long-term recovery, the significant improvement in KOOS scores at three years with posterior column fixation coincides with other studies, as does the sports subscale with incomplete recovery, indicating a possible long-term impact on sports function.[22]

Posterolateral extension was the most common pattern in our cohort (59%), consistent with the 61.9% incidence reported in van den Berg's 218-fracture series.[21] In that study, adherence to the updated three-column concept yielded higher KOOS scores overall, even though a stand-alone benefit of posterior fixation could not be proven. We cited van den Berg et al. to illustrate that failure to recognise posterior involvement, whether fractures were managed operatively or nonoperatively, was associated with worse KOOS outcomes; our intent was not to equate our surgically treated cohorts with their nonoperative subset. In our material, early arthrosis was likewise the leading complication but occurred less often after direct posterior fixation, and the proportion of complication-free patients was greater (57% vs 39%). Taken together, these parallels highlight the importance of recognising posterior involvement and restoring sagittal alignment through CT-based three-column analysis and, when indicated, buttress plating. Up to mid-2020, all posterior-column fractures, including posterolateral patterns, were treated indirectly through an anterolateral window, because our team had not yet adopted the posterior approach. After two senior surgeons completed dedicated training, every CT-confirmed posterior fragment, regardless of column pattern, was buttressed directly. Among the 34 (59%) posterolateral fractures, 19 were stabilised with a posterior buttress plate once the technique was available, whereas 15 were managed indirectly via anterior or anterolateral fixation during the earlier period. This stratification was driven by the timing of surgical training and by fragment displacement rather than location alone, thereby explaining the mixed treatment allocation and contextualising the functional outcomes reported.

Collectively, our findings add to the growing body of evidence suggesting that careful three-column assessment and, when appropriate, posterior fixation, may help reduce complications and improve medium-term functional results. In line with previous reports, studies using the prone posterior approach have described better knee flexion and favourable longer-term outcomes after direct buttress plating of posterior fragments.[23]

The functional advantage we observed likely derives from buttressing the displaced posterior fragment rather than from the skin incision per se; small, minimally displaced fragments treated indirectly did not show a similar KOOS improvement, irrespective of anteromedial or anterolateral approach.

Likewise, the series by He, Yang and Yin et al. indicate that both standard and modified posterior approaches provide reliable exposure, accurate reduction and stable fixation.[10,20] Although our exposure is an L-inverted posterior incision rather than the classic posteromedial Lobenhoffer window, both techniques share the key element of direct buttress plating of the posterior fragment; thus, we cite Schwartz data as mechanistically comparable.[24]

While our results are consistent with these data, the retrospective design and limited sample size prevent us from drawing firm conclusions about superiority; larger, prospective studies are needed before universal recommendations can be made, particularly in lower-volume centres such as ours.

The absence of neurovascular injury or implant failure aligns with the < 2% complication rates reported for posterior approach and related techniques.[23-25] Moreover, the lower incidence of early osteoarthritis after posterior plating supports Hoekstra's concept that restoring posterior slope protects articular cartilage.[26] Even so, our mean follow-up of 32 months is insufficient to assess late degeneration; series with > 5 years of follow-up cite arthroplasty conversion rates exceeding 10%.

Several factors temper the strength of our conclusions, such as the retrospective design, limited sample size, absence of severity matching and an intermediate (≈ 32-month) follow-up. These constraints mandate cautious interpretation. Definitive evidence will require prospectively powered, multicentre trials that stratify fractures by displacement and mechanism, quantify restoration of tibial slope, and randomise posterior, inverted-L and posterolateral approaches. Only then can we establish clear indication thresholds for posterior buttress plating and its long-term impact on function and osteoarthritis.

Clinical implications

Routine CT-based three-column analysis (*Figure 1*) proved invaluable for tailoring the surgical plan. Although posterolateral involvement predominated in our cohort (59%), this distribution reflects the high-energy case mix of our trauma centre and should not be generalised. In resource-constrained settings, a single low-profile posterior plate can eliminate the need for dual anteromedial–anterolateral constructs, potentially lowering implant cost and soft-tissue morbidity, but it requires specific training and meticulous fluoroscopic control.

While our data suggest that direct posterior fixation may improve functional recovery and reduce complications, extrapolation to other institutions – particularly those with different injury patterns or surgical resources – should be cautious. Nevertheless, the technique proved feasible and reproducible even in a lower-volume centre serving a predominantly Maya population in southern Mexico, supporting its applicability in diverse, resource-limited environments. Larger, multicentre prospective studies are needed to confirm the role of posterior fixation across fracture patterns; extended follow-up will clarify its effect on late osteoarthritis and arthroplasty conversion. Comparative trials of alternative posterior approaches and implant constructs should further refine the optimal strategy for managing tibial-plateau fractures with posterior-column involvement.

Conclusions

Direct posterior fixation provided more reliable anatomic reduction and was associated with higher KOOS scores – particularly in the pain, symptoms and ADL sub-scales – than indirect anterolateral/medial fixation in this series of posterior-column tibial-plateau fractures. These findings highlight the usefulness of CT-based three-column assessment for surgical planning and confirm the KOOS questionnaire as a sensitive measure of functional outcome.

In our single-centre case series, the posterior approach appeared to lower the incidence of early arthrosis and other complications. However, reproducibility across different institutions or case volumes cannot be assumed from a retrospective study of this size; broader applicability will require prospective, multicentre investigations that stratify fractures by displacement and mechanism. Until such data are available, the decision to employ posterior buttress plating should be individualised, weighing fragment morphology, surgeon experience and resource constraints.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study ethics approval was obtained from the Orthopedic Hospital of the Mexican Red Cross Ethical Review Board (Ref: 20 CI 31 050 016). All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed written consent was obtained from all patients for being included in the study.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

NR: study conceptualisation, data capture, manuscript preparation, assisted in the surgical procedure
RE: study design, data analysis
CV: manuscript revision, assisted in the surgical procedure
GB: manuscript revision, performed the surgical procedure
FM: manuscript revision, performed the surgical procedure
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