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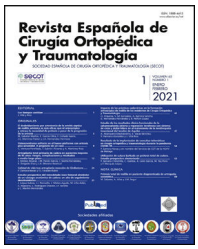

ORIGINAL ARTICLE

[Translated article] The use of arthroscopy does not increase the incidence of complications in the management of Schatzker IV–VI tibial plateau fractures

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Deep venous thrombosis

Abstract
Background and objective: The use of arthroscopy for tibial plateau fractures type I, II and III according to Schatzker classification has increased, yet its employment for tibial plateau fractures Schatzker IV, V and VI is controversial due to the potential risk of compartment syndrome, deep vein thrombosis and infection. We aimed to compare the rate of operative and postoperative complications among patients with these types of tibial plateau fractures treated with and without arthroscopy at the time of definitive reduction and osteosynthesis.
Methods: Retrospective cohort study. Patients with diagnosis of tibial plateau fracture Schatzker IV, V or VI who underwent reduction and definitive osteosynthesis with or without the use of arthroscopy were included. The development of compartment syndrome, deep vein thrombosis, and fracture-related infection was evaluated up to 12 months after the definitive surgery.
Results: Two hundred eighty-eight patients were included: 86 with arthroscopic assistance and 202 without it. The overall complication rate in the group with and without arthroscopic assistance was 18.60% and 26.73%, respectively ($p = .141$). No statistical association was found between the use of arthroscopic assistance and the development of the analysed complications.
Discussion and conclusion: The use of arthroscopy to support reduction or addressing concomitant intra-articular injuries did not increase the risk of complications in patients with high-energy tibial plateau fractures at 12 months of follow up.

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PALABRAS CLAVE
Fractura de mesetas tibiales;
Artroscopia de rodilla;
Reducción con asistencia artroscópica;
Síndrome compartimental;
Infección relacionada a fractura;
Trombosis venosa profunda

El uso de artroscopia no aumenta la incidencia de complicaciones en el manejo de fracturas de mesetas tibiales Schatzker IV-VI

Resumen
Antecedentes y objetivo: El uso de asistencia artroscópica en fracturas de mesetas tibiales tipos I-III según la clasificación de Schatzker se ha popularizado; sin embargo, aún existe controversia con respecto a su uso en fracturas Schatzker IV-VI, por el potencial riesgo de complicaciones. El objetivo de este trabajo es comparar la tasa de complicaciones intra o postoperatorias entre pacientes con fracturas de mesetas tibiales de este tipo tratados con y sin artroscopia al momento de la reducción y de la osteosíntesis definitiva.
Materiales y métodos: Estudio de cohortes retrospectivo. Se incluyeron pacientes con diagnóstico de fractura de mesetas tibiales Schatzker IV-VI sometidos a reducción y osteosíntesis definitiva, y al manejo de lesiones asociadas con o sin el uso de artroscopia evaluando la aparición de síndrome compartimental, trombosis venosa profunda e infección relacionada a fractura con seguimiento mínimo de 12 meses posterior a la cirugía definitiva.
Resultados: Se incluyeron 288 pacientes: 86 operados con asistencia artroscópica y 202 sin asistencia artroscópica. La tasa de complicaciones total en el grupo con y sin asistencia artroscópica fue del 18,60 y del 26,73%, respectivamente (p = 0,141). No hubo asociación estadísticamente significativa entre el uso de asistencia artroscópica y el desarrollo de las complicaciones analizadas.
Discusión y conclusiones: El uso de artroscopia de rodilla como apoyo de la reducción o como adyuvancia para el tratamiento simultáneo de lesiones intraarticulares concomitantes no aumentó el riesgo de complicaciones en el postoperatorio inmediato ni tras 12 meses de seguimiento.

Introduction

Tibial plateau fractures account for 1.3% of all fractures in adults and are often challenging to manage because they are difficult to resolve.[1] The aim of surgical treatment is to achieve anatomical joint reduction and stable fixation, ensuring care of the soft tissues.[2] Arthroscopy is a tool that allows direct visualisation and assistance in fracture reduction, while facilitating the detection and management of concomitant intra-articular injuries.[2–5]

While the use of arthroscopy in type I–III tibial plateau fractures according to the Schatzker classification has become popular,[6–12] there remains controversy around its use in high-energy tibial plateau fractures (Schatzker IV–VI) due to the alleged risk of compartment syndrome secondary to extravasation of lactated Ringer's solution or saline,[1,13–16] infection, and deep vein thrombosis (DVT).

The use of arthroscopy as therapeutic support for fracture reduction and management of associated injuries has increased in the last decade,[13] and therefore it is important to define whether patients with high-energy tibial plateau fractures will be exposed to an increased risk of complications from using this technique.

The aim of this study is to compare the presence of early postoperative complications in patients with Schatzker IV–VI tibial plateau fractures treated with and without arthroscopic assistance at the time of reduction and definitive osteosynthesis.

Materials and methods

Study design

We conducted a retrospective cohort study, including patients with Schatzker IV–VI tibial plateau fractures undergoing surgery at a trauma centre between 2012 and 2020. The project was approved by the ethics committee prior to the start of the study.

A retrospective review of clinical records included patients over 18 years of age with a diagnosis of a Schatzker[17] IV–VI tibial plateau fracture undergoing reduction and definitive osteosynthesis between 2012 and 2020 at our centre. The patients included were divided into 2 groups according to the presence or absence of arthroscopic assistance at the time of definitive surgery. The latter was used as a diagnostic method in patients with no preoperative MRI study of intra-articular lesions, to assist joint reduction, or to perform intra-articular procedures such as meniscectomy, meniscus repair, or anterior tibial spine reinsertion.

The minimum postoperative follow-up was one year, ensuring systematic monthly check-ups, with no loss of follow-up because the patients were covered under work-related insurance.

Surgical technique in patients undergoing reduction and open osteosynthesis

The procedure is performed in the supine position in cases where a posterior approach and osteosynthesis is not required.

Starting with a medial approach is usually preferred because in the vast majority of cases the medial tibial plateau fracture feature has less comminution and this gives a good landmark for reduction. Using the medial to proximal epicondyle and the posteromedial border of the tibia as the main landmarks, a longitudinal incision of about 6–10 cm is made. The crural fascia should then be incised longitudinally and the gracilis and semitendinosus tendons identified. Care should be taken not to injure the saphenous neurovascular bundle. The superficial medial collateral ligament and the fracture feature are then identified. Reduction manoeuvres are performed, usually valgus and extension as required, using Weber forceps to reduce the plate to the diaphysis and mediolateral or posteromedial to anterolateral K-wires to maintain reduction. The anteromedial plate is used for fixation.

The anterolateral approach is then performed in an italic *S*-shape, using the lateral to proximal epicondyle, the head of the fibula to lateral, and the anterior tuberosity of the tibia medially as landmarks. After superficial dissection, the iliotibial band (ITB) is identified and elevated longitudinally from Gerdy's tubercle, extending the flap proximally longitudinally to the fibres of the ITB and distally elevating the tibialis anterior muscle from the anterolateral surface of the tibia. By direct vision and palpation with a spatula, the lateral interline is identified and a longitudinal submeniscal arthrotomy is performed, taking care not to injure the meniscus. Then 2 or 3 traction sutures are passed to the meniscus and/or joint capsule. By pulling these sutures proximally and applying a varus force, adequate exposure of the articular feature is achieved and the integrity of the body and anterior horn of the lateral meniscus can be assessed. The necessary manoeuvres for joint reduction are performed, usually by elevating the articular depression and applying varus to achieve reduction of the metaphysis. The joint mass is then compressed with Weber forceps to eliminate any residual widening of the plateau and fixed transiently with K-wires. Optionally, the defect of the depression can be filled with bone graft (autologous or heterologous). Finally, fixation is performed with the anterolateral proximal tibial plate.

Surgical technique in patients undergoing arthroscopy

All the patients underwent surgery in the supine position and with an ischaemia cuff on the thigh ipsilateral to their injury. A traditional arthroscopic technique including anterolateral and anteromedial portals was used in the patients treated with arthroscopy. No dry arthroscopy or fracturoscopy principles were used.[2] Two saline bags at free fall were used for inflow, without using an arthroscopic pressure pump. After evacuation of the haemarthrosis, a systematic and rapid diagnostic arthroscopy was carried out, inspecting the patellofemoral compartment, leaks, intercondylar groove, and medial and lateral tibiofemoral compartments. The presence of meniscal and chondral lesions, the presence of free bodies and the condition of the cruciate ligaments were assessed. In general, arthroscopy allows adequate visualisation of the fracture, and is more or less complex depending on joint displacement and comminution. Arthroscopy and associated injury management was performed before or after fracture reduction and fixation depending on the reason for its use. For example, in some cases it was used at the time of fracture reduction, in other cases it was used as diagnostic arthroscopy to detect concomitant intra-articular injuries at the start of surgery, and in other patients it was used after fracture reduction and fixation to manage meniscal injuries, or for anterior tibial spine reinsertion.

Study variables

The primary outcome of this study was the total complication rate up to 1 year of follow-up, which included the presence of intra- or postoperative compartment syndrome (post-CS), DVT, and fracture-related infection (FRI). All these variables were managed dichotomously (present or absent). Post-CS cases were considered positive whenever clinical diagnosis or compartment pressure measurement using a device designed for that purpose (Intracompartmental Pressure Monitor, Stryker®, Kalamazoo) determined the need for fasciotomy. Only DVTs confirmed by lower extremity Doppler ultrasound performed by a specialist radiologist were considered positive. Diagnosis of FRI was based on the confirmatory criteria established in the 2018 International Expert Consensus by the group of Metsemakers et al.,[18] including the presence of fistula, operative wound dehiscence, two or more positive cultures for the same agent, or confirmation by histological study.

The reasons for the use of arthroscopic assistance in these patients were studied and demographic data such as age (years), sex (male or female), and smoking (present or absent) were extracted; mechanism of injury (%), laterality (right or left), Schatzker IV–VI classification (%), preoperative compartment syndrome (%), bone exposure (%), and use of external fixator (%) prior to definitive fixation, and the timing of the procedure with respect to the date of the accident (days) for both groups. These variables were used to establish other associations with the primary outcomes, even if these were not explained by the use of arthroscopic assistance.

Statistical analysis

Descriptive statistics were performed for the statistical analysis as appropriate for each case: continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as proportions and/or percentages. Contingency tables and Pearson's χ^2 test were used to assess the association between the use of arthroscopic assistance and the presence of post-CS, DVT, and/or FRI. However, considering that some preoperative factors could condition the mentioned outcomes, logistic regression models were constructed for each of the primary outcomes, with a stepwise selection method, including age,

Table 1 Patient demographics and descriptive characteristics of the initial injury prior to definitive surgery.

Arthroscopic assistance	(+)	(−)	*p*-Value
Age (years)	42.51 ± 1.36	47.19 ± .83	.003
Sex (M:F)	3:1	7:2	.762
Smoking (%)	18.60%	23.76%	.335
Laterality (R:L)	1:1	1:1	.650
Schatzker classification (%)			
IV	60.47%	39.53%	.001
V	43.24%	56.76%	.023
VI	16.67%	83.33%	.001
Preoperative complications (%)			
Bone exposure	1.16%	9.90%	.009
Compartment syndrome	0%	12.87%	.001
Preoperative external fixator (%)	37.21%	69.31%	.001
Osteosynthesis timing (days)	7	8	.077
Total		288 patients	

(−): without arthroscopic assistance; (+): with arthroscopic assistance.

sex, smoking, Schatzker classification, bone exposure, preoperative compartment syndrome, external fixator, timing of the procedure, and the use of arthroscopic assistance. These models were used to establish associations with the use of arthroscopic assistance and other variables, if any. Finally, a post hoc power analysis was performed using G*power 3.1 software, establishing an effect size (small-moderate), significance level $\alpha = .05$ and sample size of 288 patients, yielding a power of .92. Stata BE v17.0 was used for all other calculations.

Results

Patient characterisation

A total of 288 patients were included for analysis: 86 operated with arthroscopic assistance and 202 without arthroscopic assistance. All patients were followed for at least one year after reduction and definitive osteosynthesis. Patient demographics and descriptive characteristics of the injury are shown in Tables 1 and 2.

Arthroscopic assistance and postoperative complications

Of the 86 patients in whom arthroscopic assistance was used, 30.23% had a Schatzker IV tibial plateau fracture, 37.20% Schatzker V, and 30.23% Schatzker VI. Table 3 details the reasons why arthroscopic assistance was used. The overall complication rate in the arthroscopically assisted group was 18.60%, with no statistically significant difference when compared to the non-arthroscopically assisted group of patients ($p = .141$); it was even higher in the non-arthroscopically assisted group (26.73 vs. 18.60%). There was also no statistically significant association between the use of arthroscopic assistance and any of the complications assessed; these are summarised in Table 4. It should be noted that no patient operated with arthroscopic assistance had intraoperative or postoperative compartment syndrome.

Using multiple logistic regression models, adjusting for age, sex, smoking, Schatzker classification, bone exposure, preoperative compartment syndrome, external fixator, and/or timing, we found that the association of the

Table 2 Most frequent mechanisms of injury, in decreasing order.

Motorbike accident	108 (37.50%)
Road traffic accident	48 (16.67%)
Fall from a height	33 (11.49%)
Torsion at ground level	29 (10.07%)
Direct blow	26 (9.03%)
High-energy torsion	14 (4.86%)
Motor collision	13 (4.51%)
Crushing	9 (3.12%)
Assault by third party	3 (1.04%)
Cycling collision	3 (1.04%)
Scooter accident	1 (.35%)
Other[a]	1 (.35%)

[a] Patient losing consciousness at the time of the accident, and does not remember the mechanism of injury.

Table 3 Most frequent causes for the use of arthroscopic support.

Assistance in joint reduction	30 (34.80%)
Medial meniscus repair	12 (13.90%)
Partial medial meniscectomy	11 (12.70%)
Reinsertion of the anterior tibial spine	11 (12.70%)
Partial lateral meniscectomy	7 (8.13%)
Diagnostic arthroscopy	7 (8.13%)
Lateral meniscus repair	4 (4.65%)
Chondral injury repair	4 (4.65%)
Total	86 (100%)

Table 4 Association between the use of arthroscopic assistance and postoperative complications.

Arthroscopic assistance	Post-CS	DVT	FRI	Total (*n*)
(−)	2 (.99%)	25 (12.38%)	33 (16.34%)	202
(+)	0 (.00%)	8 (9.30%)	8 (9.30%)	86
p-Value	$p = 0.354$	$p = 0.454$	$p = 0.126$	288

DVT: deep vein thrombosis; FRI: fracture-related infection; post-CS: post-operative compartment syndrome; (−): without arthroscopic assistance; (+): with arthroscopic assistance.

use of arthroscopic assistance remained statistically non-significant for any of the 3 main outcomes.

Regarding the timing of definitive osteosynthesis, on average patients underwent surgery at 7.56 ± 6.13 days. The patients who had developed DVT at follow-up were operated earlier than the other the patients, showing a statistically significant difference between both groups (5.52 vs 7.82 days $\Delta 2.3$; $p = .046$). This difference remained significant even when adjusted for the use of arthroscopic assistance ($p = .030$). However, the presence of FRI was statistically significantly associated with the presence of bone exposure ($p = .020$) and preoperative compartment syndrome ($p = .007$, regardless of arthroscopic assistance, while the presence of post-CS was the only complication that was not associated with any of the variables in this study.

Discussion

The main finding of the present investigation is that the use of arthroscopy at the time of definitive Schatzker IV–VI tibial plateau fracture osteosynthesis was not associated with a statistically significant increase in compartment syndrome, fracture-related infection, and/or DVT. These complications were even less frequent in patients undergoing surgery with arthroscopic assistance compared to those operated without, although this difference was not statistically significant.

Arthroscopically assisted tibial plateau fracture fixation was described by the groups of Jennings[19] and Caspari et al.[20] in 1985, and has since been popularised by other authors.[7,12,21,22] Since then, the benefits of arthroscopic assistance in tibial plateau fracture management have been supported by several studies, which report that arthroscopy improves the quality of joint reduction, and also allows diagnosis and management of associated intra-articular injuries in the same surgical act.[13,19,22] Jiang et al.[23] in their recent systematic review and meta-analysis describe an increase in the diagnostic rate of intra-articular injuries (37.7 vs. 65.6%), shorter hospital stays and a lower complication rate (5.6 vs. 9.1%) in patients undergoing reduction and osteosynthesis using arthroscopic assistance. In this study, we observed the use of arthroscopy as a diagnostic tool, an aid during joint reduction, and as a tool to perform complementary intra-articular procedures such as meniscus repair, partial meniscectomy, anterior tibial spine reinsertions, and chondral injury repair.

However, while there is evidence to show the advantages of arthroscopy, there are still no large series demonstrating its safety in high-energy fracture patterns. Of the 6 studies reviewed in the review by Jiang et al.,[23] only 2 included patients with Schatzker IV fractures, and only one study included Schatzker V or VI fractures.[8] Wang et al.,[24] in a study of Schatzker I–IV tibial plateau fractures, concluded that arthroscopically supported reduction and osteosynthesis achieves better radiological results, without increasing the risk of compartment syndrome, operative wound infection, and/or DVT. This study did not include patients with Schatzker V and VI high-energy fractures. However, in the study by Dall'oca et al.[8] only one out of 50 patients had a DVT complication after arthroscopy. The latter study included only 13 patients with Schatzker IV–VI tibial plateau fractures treated with adjunctive arthroscopy.

Some authors have advised against the use of arthroscopy in high-energy tibial plateau fractures because of the potential associated complications. Tornetta et al. state that Schatzker V and VI injuries contraindicate arthroscopic support, whereas this procedure could be used safely in isolated lateral column injuries.[14] Similarly, the group of Herbort et al.[25] state that complex high-energy fracture patterns contraindicate knee arthroscopy given the occasional case report of iatrogenic compartment syndrome caused by saline extravasation into the proximal third of the leg.[15,16] These papers base their recommendations on two case reports.[15,16] In our review, we found no series reporting an increased rate of post-arthroscopic compartment syndrome, which is consistent with our series in which there were no cases of postoperative compartment syndrome after arthroscopic assistance for the management of high-energy tibial plateau fractures. Chan et al.[6] also discuss this in patients with Schatzker V and VI fractures. In their series of 18 patients, they report no cases of infection, thromboembolic event, or postoperative compartment syndrome. This is similar to our results, but they include significantly fewer patients.

This tool should be used with caution, limiting its use time to avoid the described theoretical soft tissue compromise. As a group, we did not perform arthroscopy in the initial damage control surgery of high-energy fractures. For Schatzker V or VI fractures with significant initial damage to the surrounding soft tissue, we believe that arthroscopy should be used with care and limited, or even avoided, until the soft tissue is in good condition. In these cases we use a two-stage approach: first damage control with an external fixator and then definitive management with arthroscopic assistance if necessary.

Regarding the other complications analysed, our results show a higher rate of infection and DVT in the group of patients without arthroscopy. This coincides with that previously published by Dall'oca et al.[8] who reported a lower incidence of infection in bicondylar injuries using arthroscopy compared to traditional open reduction in a series of 100 tibial plateau fractures. Elabjer et al.[26]examined 78 patients with lateral tibial plateau

fractures (Schatzker I–III) and found no difference in postoperative infection rates. However, there have been no studies suggesting that adjunctive arthroscopy increase infection rates.

Similarly, when analysing the association between the use of arthroscopic assistance and the development of DVT, no increase in the incidence of this complication following arthroscopy has been demonstrated.[6,7,26] However, the results of the secondary analysis with regression models used in this study, indicate that there are other factors that would explain the presence of these complications: the presence of DVT was inversely related to the timing of definitive surgery, while the development of FRI was associated with the presence of bone exposure and preoperative compartment syndrome, regardless of arthroscopic assistance. Notably, the development of post-CS was not related to any of the variables assessed in this study; however, it is difficult to draw conclusions regarding this complication because of its low incidence in our series.

Limitations

Certain clinical and radiographic factors of fractures such as degree of displacement or joint comminution were not analysed. Additional surgical variables such as surgery time, surgical approach, quality of reduction, or associated intra-articular injuries and their specific treatment were not evaluated, which could be relevant to the presence or absence of complications. Nevertheless, according to our literature search, our series is the largest series of patients with Schatzker IV–VI tibial plateau fractures analysing complications after adjunctive arthroscopy.

Conclusion

Knee arthroscopy to support reduction or as adjunct for the simultaneous treatment of concomitant intra-articular injuries did not increase the risk of compartment syndrome, infection or DVT in patients with Schatzker IV–VI tibial plateau fractures in the immediate postoperative period or after 12 months of follow-up. However, its use should be rational, carefully selecting those patients who are likely to be managed concomitantly with this tool.

Level of evidence

Level of evidence III.

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Conflict of interests

The authors have no conflict of interests to declare.

Right to privacy and informed consent

The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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