Original Article

Tibial plateau fractures osteosynthesis—a case series of 88 patients evaluating surgical approaches, results and complications

José Lito Mónico[1,2]^, Renato Andrade[3,4,5], Pedro Matos[1,6], Lisete Mónico[7], João Cura Mariano[1], João Espregueira-Mendes[3,4,8,9,10], Fernando Fonseca[1,6]

[1]Department of Orthopaedics Centro Hospitalar e Universitário de Coimbra, Coimbra, Portugal; [2]Centro de Saúde Militar de Coimbra, Portuguese Army, Coimbra, Portugal; [3]Clínica do Dragão, Espregueira-Mendes Sports Centre—FIFA Medical Centre of Excellence, Porto, Portugal; [4]Dom Henrique Research Centre, Porto, Portugal; [5]Faculty of Sports, University of Porto, Porto, Portugal; [6]Faculty of Medicine, University of Coimbra, Coimbra, Portugal; [7]Faculty of Psychology and Educational Sciences, University of Coimbra, Coimbra, Portugal; [8]ICVS/3B's—PT Government Associate Laboratory, Braga/Guimarães, Portugal; [9]3B's Research Group—Biomaterials, Biodegradables and Biomimetics, University of Minho, Headquarters of the European Institute of Excellence on Tissue Engineering and Regenerative Medicine, Barco, Guimarães, Portugal; [10]School of Medicine, University of Minho, Braga, Portugal

Contributions: (I) Conception and design: JL Mónico, J Cura Mariano, J Espregueira-Mendes, F Fonseca; (II) Administrative support: JL Mónico; (III) Provision of study materials or patients: JL Mónico, R Andrade, P Matos, J Cura Mariano, F Fonseca; (IV) Collection and assembly of data: JL Mónico, R Andrade, P Matos, L Mónico; (V) Data analysis and interpretation: JL Mónico, R Andrade, P Matos, L Mónico; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: José Lito Mónico. Department of Orthopaedics Centro Hospitalar e Universitário de Coimbra, Coimbra, Portugal; Doctor of Medicine, Centro de Saúde Militar de Coimbra, Portuguese Army, Rua Vandelli 2, 3030-405 Coimbra, Portugal. Email: jlmonico@gmail.com.

Background: Tibial plateau fractures can be treated using different surgical approaches and different fixation methods. With multiple surgical options available, optimal treatment is still controversial. With variable results, surgical osteosynthesis remains challenging, being the choice of appropriate fixation method fundamental for a favourable clinical outcome. Our goal is to analyse the surgical outcomes of patients with tibial plateau fractures submitted to osteosynthesis using different surgical approaches.

Methods: There were 88 tibial plateau osteosynthesis performed over a 5-year period. Among others, surgical approach, fixation methods and surgical outcomes were analysed.

Results: The overall complication rate was 11.4%, with deep infection being the most common. Single surgical approach had a lower complication rate (2.25%) than double approaches (33.3%). The type of plate used was not correlated with postoperative complications. Unsatisfactory surgical reductions were obtained in 15.9%. There was negative significant association between the baseline Schatzker classification and the reduction. The type of plate usage was not associated with unsatisfactory reductions, but locking compression plates (LCPs) were associated with more anatomical reductions comparing to compression plates. Bone graft was used in 51% of patients and there was no correlation with fracture reduction, fracture consolidation or postsurgical complications.

Conclusions: The severity of the tibial plateau fracture is associated with the surgical outcomes. If an acceptable reduction can be obtained, single surgical approach and single plate osteosynthesis is a safer option than double surgical approaches with double plating.

Keywords: Tibial plateau fractures; single and double surgical approaches; fracture plate fixation; fracture fixation outcomes

Received: 30 June 2020; Accepted: 21 December 2020; Published: 15 July 2021.
doi: 10.21037/aoj-20-95
View this article at: http://dx.doi.org/10.21037/aoj-20-95

^ ORCID: 0000-0003-4751-2559.

Introduction

Tibial plateau fractures involve the proximal articular surface of the tibia and have a bimodal incidence, with high-energy trauma in younger patients and low-energy falls in elderly osteoporotic patients. Surgical treatment aims to restore the mechanical alignment of the lower limb, anatomic reduction of the articular surface and stable fixation to allow for early range of motion (1). The short-term results of surgical fixation of tibial plateau fractures are usually good, but the long-term outcomes can be variable and are associated with a higher risk of end-stage arthritis and total knee arthroplasty (2).

The historical literature has accepted a step deformity up to 10 mm, but the articular malreductions superior to 2 mm are associated with inferior clinical outcomes (3). As the amount of articular displacement increases, the clinical outcome deteriorates (3). Tibial plateau fractures are also associated with soft tissue injuries and relatively common postoperative complications, such as infection and compartment syndrome (1). Aiming the optimal treatment, Schatzker proposed a classification centred on the pathoanatomy of tibial plateau fractures and suggested surgical osteosynthesis method (4). Osteosynthesis methods and techniques have evolved over the years, reducing surgical complications a further optimizing surgical treatment. Various surgical approaches are now commonly used to manage various types of tibial plateau fractures, such as standard anterior, anterolateral, and anteromedial (5). For posterolateral tibial plateau fractures, a posterior approach is recommended (1). With multiple surgical options available, osteosynthesis of tibial plateau fractures remains challenging and can present variable results, being the choice of appropriate fixation method fundamental for a favourable clinical outcome.

Our goal is to analyse the surgical outcomes of patients with tibial plateau fractures submitted to osteosynthesis using different surgical approaches. We hypothesize that patients submitted to double surgical approaches have higher rates of postoperative complications.

We present the following article in accordance with the STROBE reporting checklist (available at http://dx.doi.org/10.21037/aoj-20-95).

Methods

Patient selection

This is a case series of consecutive patients submitted to osteosynthesis due to tibial plateau fractures. We reviewed all patients with tibial plateau fractures submitted to osteosynthesis in one trauma centre between 1st January 2013 and 31st December 2017. Inclusion criteria also consisted of adult patients (18 years or older) with a minimum of 12 months follow-up.

Assessment and classification

Preoperative radiographs were reviewed and classified according to both Schatzker and Gustilo & Anderson classification systems (*Table 1*) (4,6).

Surgical technique

Osteosynthesis was performed through cannulated screws with a mini-invasive lateral incision approach. Unilateral locked plating or compression plating was achieved through a single antero-lateral incision. Posterior shearing tibial plateau fractures were fixed through a posterior approach while dual plating was employed through two separate posteromedial and lateral incisions. If patient was unfit for internal fixation, external fixation devices were applied percutaneously. Bone defects were filled with autograft or allograft, from centre's bone and tissue bank, depending on the surgeon's choice and allograft availability.

Postoperative surgical outcomes

Standard antero-posterior (AP) and sagittal radiographs of the proximal half of tibia were obtained postoperatively and at follow-up appointments to assess fracture reduction and consolidation. At 12 months follow up, a radiographic analysis was performed and fracture reductions were considered: anatomical, if proximal tibial line in the X-ray has less than 2 mm step-off; satisfactory, if the step-off is between 2 mm and 5 mm and unsatisfactory if step-off greater than 5 mm or varus/valgus malalignment greater than 5º. Nonunions were determined by incomplete healing on radiographs, at least 6 months postoperatively, plus pain in weight bearing. Deep infection was defined as an infection requiring operative debridement.

Statistical analysis

The statistical analysis was performed using the Statistical Package for Social Science version 24® (IBM SPSS). Considering a significance level of 0.05 for all statistic inference situations. Absolute (n) and relative (%)

Table 1 Schatzker and Gustilo classifications

Schatzker classification	Gustilo classification
Type I: lateral split fracture	Type I: wound ≤1 cm, minimal contamination or muscle damage
Type II: lateral split-depressed fracture	Type II: wound 1–10 cm, moderate soft tissue injury
Type III: lateral pure depression fracture	Type IIIA: wound >10 cm, extensive soft-tissue damage, adequate tissue for flap coverage
Type IV: medial plateau fracture	Type IIIB: extensive periosteal stripping, wound requires soft tissue coverage
Type V: bicondylar fracture	Type IIIC: vascular injury requiring vascular repair, regardless of degree of soft tissue injury
Type VI: metaphyseal-diaphyseal disassociation	

frequencies were computed for the categorical variables. Continuous variables were tested for outliers and normality (Kolmogorov-Smirnov test). These were described using mean and standard deviation (if normally distributed) or median and interquartile range otherwise. Results are reported with one decimal. Proportions were compared using the Chi-squared test. For further analyses, we excluded open fractures to reduce potential selection bias due to confounding and homogenize the comparisons. Fractures classified as Schatzker I, II and III were organized in group I; while Schatzker IV, V and VI were organized in group II. A binary logistic regression was performed to evaluate the influence of surgical approaches and Schatzker fractures groups (independent variables) on the postsurgical complications (dependent variable).

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Centro de Saúde Militar de Coimbra (Study #03/CSMC/2020) and individual consent for this retrospective analysis was waived.

Results

There were 94 patients identified and 6 of those were lost in the follow-up. The remaining 88 patients were included in this study. Average follow-up time of 26 months (minimum 14 months, maximum 6 years). Patient demographics, fracture classifications and mechanism of injury are presented in *Table 2*. Detailed information regarding surgical treatment, approaches and complications are presented in *Table 3*.

Two patients treated initially with external fixation were submitted to follow-up surgeries. One patient was submitted to osteosynthesis with cannulated screws. The other patient was submitted to surgical debridement, due to deep infection, and knee arthrodesis.

The overall complication rate was 11.4%. Postsurgical complications and surgical approaches are presented in *Table 4*. Analysing the postsurgical complications, we found that patients submitted to a single surgical approach had a lower complication rate (2.25%) as compared to double approaches (33.3%). There was statistical association between double approaches and the number postoperative complications (P=0.018). The use of double plate was also associated with the postoperative complications (P=0.09). There was no association between the type of plate used, the use of locking compression plates (LCPs) or compression plates (straight, L or T shaped), and the postoperative complications.

Fracture reduction according baseline Schatzker classification are presented in *Table 5*. There was negative significant association between the baseline Schatzker classification and the reduction (P=0.003), i.e., the higher the type of fracture, the most unsatisfactory results were obtained. However, it was still possible to achieve good results in more complex fractures (4.5% of anatomical reduction for both type V and IV). The type of plate usage was not associated with unsatisfactory reductions (P=0.715), but LCPs were associated with more anatomical reductions comparing to compression plates (P=0.043).

Bone graft was used in 51% of patients. Group I (Schatzker grades I, II and III) had a more frequent need of bone grafting (*Table 6*). There was no statistical significance between bone graft usage and fracture reduction (P=0.66), fracture consolidation (P=0.332) or postsurgical

Table 2 Patient demographics, fracture classifications and mechanism of injury

Collected data	N (%)
Gender	
Male	45 (51.1)
Female	43 (48.9)
Age	53±15
Schatzker	
I	14 (15.9)
II	27 (30.7)
III	6 (6.8)
IV	7 (8.0)
V	14 (15.9)
VI	20 (22.7)
Gustilo & Anderson	
Closed injury	82 (93.2)
I	3 (3.4)
II	1 (1.1)
IIIA	1 (1.1)
IIIB	0 (0.0)
IIIC	1 (1.1)
Mechanism of injury	
Fall	30 (34.1)
Fall from height	9 (10.2)
Vehicle crash	14 (15.9)
Motorcycle	11 (12.5)
Bike crash	2 (2.3)
Pedestrian vs. automobile	9 (10.2)
Crush	9 (10.2)
Assault	2 (2.3)
Sports related	2 (2.3)

Table 3 Surgical treatments, approaches and complications

Collected data	N (%)
Osteosynthesis	
Cannulated screws	7 (8.0)
Compression plates	27 (30.7)
Locking compression plate (LCP)	40 (45.5)
Double plating	12 (13.6)
External fixation	2 (2.3)
Surgical approaches	
Anterior	65 (73.9)
Posterior	4 (4.5)
Mini-invasive	10 (11.4)
Double	9 (10.2)
Reduction	
Anatomical	27 (30.7)
Satisfactory	47 (53.4)
Unsatisfactory	14 (15.9)
Complications	
None	78 (88.6)
Deep infection	6 (6.8)
Wound dehiscence	2 (2.3)
Intra-articular screw	2 (2.3)

complications (P=0.670). The group II (Schatzker grades IV, V and VI) had higher rate of complications (*Table 7*), regardless of using a single or double approach (*Table 8*). The binary logistic regression analysis showed that higher grade of Schatzker fractures (group II, Schatzker IV, V and VI) had a significantly higher odds of postsurgical complications (P=0.041, odds ratio 1.716). The surgical approaches did not display any significant statistical association with postsurgical complications (P=0.283, odds ratio 2.546).

Discussion

The most important finding of the current study was that treatment of tibial plateau fractures was associated with an overall 84.1% of satisfactory or anatomic reduction. Although tibial plateau fractures can be treated non-surgically (7), surgical treatment provides stability, proper alignment, congruent articular surfaces, early range of motion and faster recovery (1). However, surgical osteosynthesis for tibial plateau fractures can lead to many complications, such as: wound dehiscence, deep infection, deep venous thrombosis, compartment syndrome, pseudarthrosis, peroneal nerve injury, fixation hardware failure and arthrofibrosis (1,8). Aiming to decrease the

Table 4 Postsurgical complications and surgical approaches

Surgical approaches	None	Deep infection	Wound dehiscence	Intra-articular screw
Single (%)	64 (72.7)	2 (2.3)	1 (1.1)	2 (2.3)
Double (%)	6 (6.8)	2 (2.3)	1 (1.1)	0 (0.0)
Percutaneous (%)	7 (8.0)	1 (1.1)	0 (0.0)	0 (0.0)
External fixation (%)	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)

Table 5 Fracture reduction according to baseline Schatzker classification

Schatzker	Anatomical	Satisfactory	Unsatisfactory
I	9	4	1
II	7	18	2
III	1	5	0
IV	2	5	0
V	4	7	3
VI	4	8	8
All (%)	27 (30.7)	47 (53.4)	14 (15.9)

Table 6 Bone graft usage according to Schatzker groups

Schatzker	Bone graft	
	No	Yes
Group I (%)	15 (31.9)	32 (68.1)
Group II (%)	27 (69.2)	12 (30.8)

Table 7 Post-surgical complications according to Schatzker groups

Schatzker	Complications	
	No	Yes
Group I (%)	46 (97.9)	1 (2.1)
Group II (%)	31 (79.5)	8 (20.5)

Table 8 Post-surgical complications according to Schatzker groups and surgical approaches

Schatzker	Surgical approach	Complications	
		No	Yes
Group I (%)	Single	46 (97.9)	1 (2.1)
	Double	0 (0.0)	0 (0.0)
Group II (%)	Single	25 (83.3)	5 (16.7)
	Double	6 (66.7)	3 (33.3)

risk of these complications, percutaneous surgeries and new fixation devices have been developed (1,8), such as external fixation, percutaneous screw fixation, less-invasive stabilization systems, and staged external and internal fixation. Still, there is no consensus regarding which method of fixation is the most appropriate (9).

The use of laterally applied fixed-angle devices has greatly reduced the need for supplemental medial fixation to neutralize the metaphyseal-diaphyseal injury component. However, these implants have not eliminated the need for the second posteromedial approach in order to reduce and stabilize displaced medial plateau fractures (10). Surgical treatment implies additional soft tissue injury, which decreases blood supply and increases the risk of surgical complications previously described. Analysing the surgical approaches and plates used in our cohort studied, we found that patients submitted to a single surgical approach or single plate osteosynthesis had fewer complications comparing to patients submitted to double approaches or double plating. However, if we perform a binary logistic regression analysis in order to reduce potential bias and upgrade the quality of the comparison, higher Schatzker classification is the only factor statistically associated with postoperative complications. Higher Schatzker classification usually implies a higher mechanism of trauma, causing additional soft tissue injury and makes patients more prone to additional surgical complications. As such, double surgical approach or double plating may have confounded the postsurgical complications outcomes. As few patients were submitted to double surgical approach or double plating, the interpretations that we can infer from these approaches are limited.

In our experience, LCP have better rates of anatomical reductions and the same rates of unsatisfactory reductions or

postsurgical complications comparing to compression plates. Plates with 4.5 and 3.5 mm may have similar biomechanical proprieties (11) but they have different clinical results (12). While 4.5 mm plates are associated to higher risk of fracture devitalization, due to extensive stripping of muscle from bone, peroneal nerve injury and soft tissue impingement, the 3.5 mm plates reduce the risk of these complications and are easier to apply (12). In cancellous bone, the 3.5, 4.5 and 6.5 mm screws have all equivalent pull-out strength (11,13). The 3.5 mm screws can be placed closer to the articular surface and in increased number, possibly providing better mechanical support to the reduced articular fragments. Pre-contoured anatomic plates show several advantages, such as decreased intraoperative time and minimally invasive surgical techniques, however some plates might not match completely to the bone shape of the proximal tibia, which can compromise fracture reduction or stable fixation and even cause soft tissue impingement (14). Conversely, the 3.5 mm plates can be shaped and easily applied on the bone during the surgery. Non-locking screws can also achieve good compression between fracture fragments, stabilizing the fracture (14); although extremely highly comminute fractures, fragments' compression might not be good for articular surface reconstruction or fracture stabilization. Even in Schatzker's type V and VI fractures, two 3.5 mm plates can be successfully used with double surgical approaches, anterolateral and posteromedial. In these cases, the lateral plate is used as a buttress device and the medial plate as an anti-glide device, single lateral plating cannot provide sufficient stability or mechanical support (15).

In our experience, anatomical or acceptable fracture reduction was achieved in most of the patients (84.1%). We found that unacceptable reductions or fracture alignment was correlated to fracture severe comminution rather than to the type of plate. The knee's articular incongruity can be quite tolerable if other factors are present. Factors such as joint stability, healthy meniscus retention and good coronal alignment appear to be more relevant to the clinical outcome than anatomic articular reduction (16). Still, articular congruency is very important but plain radiography cannot accurately estimate the surgical reduction. Standard radiological control is a fast, practical and economical assessment of fracture reduction in our current practice, that can even be available during surgical osteosynthesis. However, comparing to CT scan or direct visualization, fracture articular reduction with standard radiological control can be limited due to heterogeneous physician-based observation, poor sensitivity and specificity (17). Direct visualization, with submeniscal arthrotomy or arthroscopic assessment allows for more anatomic articular reconstruction, but an arthrotomy with extensive soft tissue dissection might increase the risk of devascularizing fracture fragments and provoke arthrofibrosis or knee stiffness (17).

Repairing bone defects with bone graft augmentation has been considered the gold standard method for dead space filling, stable fixation, structural support and uneventful bony union (18). In metaphyseal areas of load bearing bones, such as the tibial plateau, the autologous bone graft has been intensively used and it is considered as the gold standard grafting material due to its osteoinductivity, osteogenicity and osteoconductivity proprieties. Autologous bone graft has some limitations because it needs to be harvested, causing donor site morbidity, and there are also concerns regarding the bone's cellular population, biological quality and structural strength, especially in the elderly osteoporotic patients. Avoiding some of these problems, allografts can be very expensive but they have short incorporation time, no graft specific complications or donor site morbidity, sufficiently compression tolerance, high union rate and provide adequate structural support (19). With high availability, due to our centre bone and tissue bank, we extensively use bone allografts when there is need for bone graft augmentation. The bone graft was used in 51% of patients of our study, mostly on Schatzker type II, III, V and VI fractures. Almost all of the fractures [87] healed without any complications related to the type or size of the plate. Only one malunion due to deep infection was recorded. The use of bone graft does not appear to be a determinant factor in fracture healing, postoperative reduction or postoperative complication rate.

Limitations

Some limitations must be noted. This is a retrospective study and the research data is therefore conditioned by record accuracy. The amount of bone graft used is not specified and it might influence the surgical outcome. Sample size of patients submitted to double plate osteosynthesis or double surgical approach is small, which may have influenced the statistical analysis. Schatzker classification indicates the fracture pattern, still this classification does not accurately report fracture deviation, which can influence surgical treatment and outcome. This classification is observer dependent and it is based on AP radiographs, missing major fracture lines in the coronal plane. Lastly, the surgical procedures were performed by

a set of different surgeons, which may have influenced surgical technique reproducibility and the surgical outcome.

Conclusions

The severity of the tibial plateau fracture is associated with worse surgical outcomes and higher postsurgical complications rates. However, it is possible to achieve good reductions in more complex fractures. Double surgical approaches or double plate osteosynthesis may be just confounding factors, still if an acceptable reduction can be obtained, single surgical approach and single plate osteosynthesis is a safer option.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at http://dx.doi.org/10.21037/aoj-20-95

Data Sharing Statement: Available at http://dx.doi.org/10.21037/aoj-20-95

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/aoj-20-95). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Centro de Saúde Militar de Coimbra (Study #03/CSMC/2020) and individual consent for this retrospective analysis was waived.

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doi: 10.21037/aoj-20-95
Cite this article as: Mónico JL, Andrade R, Matos P, Mónico L, Cura Mariano J, Espregueira-Mendes J, Fonseca F. Tibial plateau fractures osteosynthesis—a case series of 88 patients evaluating surgical approaches, results and complications. Ann Joint 2021;6:26.