Introduction

Tibial plateau fractures are quite rare, representing about 1,2 % of all fractures, (1) but can evolve in severe joint function's limitations if not correctly treated. The Schatzker classification is the most used and tibial plateau fractures are divided into six categories considering the involved compartment and articular depression. (2,3)
Tibial plateau fractures affect typically two specific groups: younger people as a consequence of a high-energy trauma or elderly patients in low-energy fractures secondary to osteoporosis or metabolic diseases. Commonly, pure splitting fractures (type I, IV, V, VI) occur in the first group, instead fractures with articular depression and comminution (type II-III) are more frequent in the second group, due to the worst quality of tibial cancellous bone (4).
Tibial plateau fractures are articular fractures so the goal in treatment is absolute stability, restoring articular surface, preserving local blood supply, and soft tissues as much as possible. Historically surgical treatments include external fixation, open reduction and internal fixation (ORIF) with plate and screws and percutaneous osteosynthesis with cannulated screws (reference); recently arthroscopic-assisted reduction and internal fixation (ARIF) has gained a prominent place especially in type II-III fractures (6).
This technique has many potential advantages, considering that proximal tibia fractures are associated with soft tissue injury in 71% of the cases, menisci in 57%, anterior cruciate ligament (ACL) in 25%, posterior cruciate ligament in 5% and collateral ligaments in 3% (7). Many different ARIF techniques have been proposed in recent years, requiring in some cases specific instrumentation or complex surgical strategies.
This study aims to describe the authors' ARIF technique in the treatment of type I-III tibial plateau fractures, with the use of instruments commonly used in anterior cruciate ligament reconstruction, evaluating clinical and radiological outcomes on xxx patients at short-term follow-up.

Surgical technique

Accurate pre-operative planning is performed to evaluate the fracture pattern and the best choice of treatment. In authors' practice, anteroposterior and lateral radiographs of the knee are usually completed by a computed tomography scan.
The patients' positioning is similar to the one used by authors for ACL reconstruction: patient supine, tourniquet at tight, and the possibility to fix the knee on the bed at 90 degrees of flexion, free of reaching a complete range of motion. The contralateral leg is positioned about 10 cm lower than the affected one to facilitate lateral x-ray projections with the c-arm. Standard portals (superomedial, anteromedial, and anterolateral) are used, the pressure pump should not be set higher than 50 mm Hg to avoid fluid effusion and the risk of compartment syndrome.
First of all fracture hematoma is evacuated and a full diagnostic inspection of all compartments is performed to evaluate associated lesions and to confirm the fracture pattern, avoiding to stress the knee in valgus with the risk of fracture compression. Then the fracture is reduced using the probe and a k-wire (2 mm) is inserted starting from anteromedial surface of the proximal tibia to the middle of the largest displaced fragment using an ACL tibial guide (Acufex Protract, Mansfield, MA) with the knee flexed of about 50°. A medial tibial corticotomy is performed with the 10 mm atraumatic cannulated reamer, commonly used in ACL reconstruction, using the k-wire as a guide. The cannulated reamer is introduced to reach about 2 mm below the subchondral bone, and the correct positioning is confirmed by fluoroscopic control. The reamer is left in place and used for elevating the fragment, using a small hummer, until the restoration of the joint surface, with the arthroscopy camera checking the restoration of the correct articular surface. In authorsâ€™ experience normally no graft or cement are needed to fill the depression. Final control of fragment reduction is

performed using fluoroscopy and two k-wires are placed from the lateral side parallel to the joint surface. The fracture is finally stabilized with two cannulated cancellous screws (7.3mm) with a washer. Placement and progression of screws are controlled under fluoroscopy.
A knee brace locked at 20 degrees is maintained for 2 weeks, then the brace is unlocked permitting full extension and flexion improved of 15 degrees every week.
Thromboembolic prophylaxis is usually started from the first access in the emergency room as an internal hospital protocol and continued till the recovery of partial weight-bearing.
During the not-weight-bearing period patients follow an isometric reinforcement program for quadriceps muscle and hamstrings stretching.
Full weight-bearing is allowed after clinical and radiological healing, usually not before 10-12 weeks after surgery.

Material and Methods

A case series of XXXX patients submitted to arthroscopic-assisted reduction and internal fixation of Schatzker type I-III was carried out in the authors' institution from XXXX to XXXX. The study was performed following the criteria of the Declaration of Helsinki and all patients gave their informed consent to their participation in the study.

Dati da raccogliere

- x-ray and CT scan
- mean age, mean FU, type of fracture, associated lesions, male vs female
- complications

Data collection
Rasmussen clinical and radiological scores
Time of fracture consolidation
VAS scale
Crosby-Insall satisfaction (?)
Statistical analysis (?) vedrei quando abbiamo i dati cosa possiamo ricavarne ma non penso sia possibile avere statistiche visto il numero di casi

Results

Discussion

The most important finding of this study was the reproducibility and safety of the ARIF of lateral tibial plateau using common instrumentation used in ACL reconstruction. The intra-operative arthroscopic evaluation of fracture reduction evidenced a good alignment of bone fragment, with the restoration of the articular surface. Clinical and objective scores at the final follow-up were good (poi inseriremo in base ai risultati).
Arthroscopy permits accurate evaluation of the fracture allowing an anatomical reduction using instruments with a tissue-sparing technique. A significant advantage of this technique is the possibility of performing a profuse lavage of the joint and it allows to evaluation and repair of any associated lesion (cartilage or menisci). Furthermore, arthroscopy is correlated to a faster hospitalization and rehabilitation protocol (6): in our experience...

In Literature there are several comparisons between arthroscopic-assisted reduction and open reduction technique and no study has shown a real superiority of a technique (6). Verona et al. (21) evaluated 40 patients divided into two groups (ARIF vs ORIF) for a mean follow-up of 44,4 months and they found no statistically significant differences in complications, radiological outcomes, or development of osteoarthritis even if ARIF- group showed better clinical results. Recently some authors (22) showed both techniques as reliable and comparable in terms of radiological results, satisfaction, and stable fixation; clinically were found no significant differences about IKDC and Lysholm except for HSS on a total of 317 patients evaluated for an average follow-up of 38 months.
Different techniques have been described to elevate the decalage. Rossi and colleagues (15) developed custom-made instrumentation with 4 basic elements: 2 cutting guides, a hollow trephine cutter with a saw-toothed tip, and a bone plunger; using this device they obtain a good restore of the articular surface without the need of bone grafts. The advantage of the technique proposed in this article is the potential implementation of this technique without special instruments, using standard ACL set-up.
Burdin (11), instead, inserted one or two K-wires into the fractured plateau using them as a joystick to elevate the fragment and to correct rotations in Schatzkers type I-II; in Schatzkers type III with isolated depression, he used a spatula or a cannulated curved osteotome after creating an anterior cortical window with a reamer.
According to Hartigan and colleagues (14), the best choice to elevate the fracture fragment was to use a bone tamp. In the proposed technique it was used the cannulated reamer itself to push-up (hammering on the cutter handle) the depressed area with double - arthroscopic and radiological - check; it seems easier and cheaper because there is no need of specific devices.
Many authors prefer to fill the depression with autograft, allograft, or bone graft substitutes and several studies have addressed this topic (16,17). Some authors (12) use a 1- to 2-cm-long bone graft harvested from iliac bone and they gently drive through the tunnel with a dilatator. Berkes and colleagues (18) used a structural allograft, reporting subsidence < 2mm at a minimum 6-month radiographic follow-up. Iundusi et al. (19) developed an injectable biphasic hydroxyapatite and calcium sulfate ceramic material with radiological and clinical satisfactory outcomes at an average 44 months follow-up. Some other surgeons, instead, prefer not filling the defect and they take autograft from the tibial metaphysis opposite the fracture and compacting the cancellous bone with a special device (15). The SOFCOT symposium held in 1999 found no significant difference between using or not bone graft (8). For many authors is better to fill the depression especially if it is greater than 6 mm or in patients over 55 years due to poor quality of cancellous bone (9,10,11). In our case series, there was no need for bone graft because the cancellous bone was compacted advancing the cannulated reamer. This was possible thanks to the little subsidence of reported fractures.
The learning curve of the arthroscopic technique is not too long and depends especially on the surgeonâ€™s experience and pattern fracture. In our case series, all procedures were carried out by the same fully trained surgeon, accustomed to performing shoulder and knee arthroscopies.
ARIF technique is not adapted to all types of fractures. Schatzker IV-VI types are patterns more complex and often reduction cannot be achieved by arthroscopy due to multifragmentary fracture and high risk of the compartmental syndrome. In this case, preferable an open reduction and plating becauseâ€¦(reference)
The follow-up of our study is too short to evaluate the development rate of osteoarthritis after this procedure. However in Literature..
In a very recent study (13) clinical and radiological outcomes were evaluated on 25 patients treated with ARIF with an average follow-up time of 14 months: the mean clinical Rasmussen score resulted in 26 (range, 24-30) and the average time for bone consolidation in Schatzker type I was 9.1 weeks, in type II was 10.2 weeks, and in type III it was 9.4.Ã‚Â
Chan et al (20) evaluated 54 patients treated with ARIF: 96% of patients reported good or excellent clinical and radiological outcomes with a mean follow-up of 6 years with full consolidation and without any complication.

According to our data, the results were similar to the high satisfaction of patients although the number of patients is much lower.

References

1. Cole P, Levy B, Schatzker J, Watson JT (2009) Tibial plateau fractures. In: Browner B, Levine A, Jupiter J, Trafton P, Krettek C (eds) Skeletal trauma: basic science management and reconstruction. WB Saunders Co., Philadelphia, PA, pp 2201–2287
2. Schatzker J, McBroom R, Bruce D (1979) The tibial plateau fracture: the Toronto experience: 1968–1975. Clin Orthop Relat Res 138:94–104
3. Müller ME, Nazarian S, Koch P, Schatzker J, Heim U. *The Comprehensive Classification of Fractures of Long Bones*. Berlin: Springer,1990.
4. Siegler J, Galissier B, Marcheix PS, Charissoux JL, Mabit C, Arnaud JP. Percutaneous fixation of tibial plateau fractures under arthroscopy: a medium term perspective. Orthop Traumatol Surg Res. 2011;97(1):44-50.
5. ----
6. Chase R, Usmani K, Shahi A, Graf K, Mashru R. Arthroscopic-Assisted Reduction of Tibial Plateau Fractures. Orthop Clin North Am. 2019 Jul;50(3):305-314. Review.
7. Lubowitz JH, Elson WS, Guttmann D, et al. Part I arthroscopic management of tibial plateau fractures. Arthroscopy 2004;20:1063–70.
8. Chauvaux D, Le Huec JC. Arthroscopie et fracture du plateau tibial : faut-il combler ou non ? In: Annalesde la Société franc¸aised'arthroscopie. Montpellier: Sauramps médical; 1999, p. 143—5 [In French].
9. Chauvaux D, Le Huec JC, Roger D, Le Rebeller A. Traitement chirurgical sous contrôle arthroscopique des fractures des plateaux tibiaux. Rev Chir Orthop 1991;77(1):288 [In French].
10. Roerdink WH, Oskan J, Vierhout PA. Arthroscopically assisted osteosynthesis of tibial plateau fractures in patients older than
55 years. Arthroscopy 2001;17:826—31.
11. Burdin G. Arthroscopic management of tibial plateau fractures: Surgical technique. Orthop Traumatol Surg Res 2013;99S:S208–18.
12. Afsar T. Ozkut et al. Arthroscopic Technique for Treatment of Schatzker Type III Tibia Plateau Fractures Without Fluoroscopy. Arthrosc Tech. 2017 Feb; 6(1): e195–e199.
13. Zawam S.H.M., Gad A.M. Arthroscopic Assisted Reduction and Internal Fixation of Tibial Plateau Fractures. Open Access Maced J Med Sci. 2019 Apr 15; 7(7): 1133–1137.
14. David E. Hartigan, Mark A. McCarthy, Aaron J. Krych, Bruce A. Levy Arthroscopic-Assisted Reduction and Percutaneous Fixation of Tibial Plateau Fractures. Arthrosc Tech. 2015 Feb; 4(1): e51–e55
15. Rossi R, Castoldi F, Blonna D, Marmotti A, Assom M. Arthroscopic treatment of lateral tibial plateau fractures: a simple technique. Arthroscopy. 2006;22:678.e1–6.

16. Chen HW, Liu GD, Wu LJ. Clinical and Radiological Outcomes Following Arthroscopic-Assisted Management of Tibial Plateau Fractures: A Systematic Review. Knee Surg Sports Traumatol Arthrosc 2015 Dec;23(12):3464-72.

17. Hofmann A, Gorbulev S, Guehring T, Schulz AP, Schupfner R, Raschke M, Huber-Wagner S, Rommens PM; CERTiFy Study Group. Autologous Iliac Bone Graft Compared With Biphasic Hydroxyapatite and Calcium Sulfate Cement for the Treatment of Bone Defects in Tibial Plateau Fractures: A Prospective, Randomized, Open-Label, Multicenter Study. J Bone Joint Surg Am 2020 Feb 5;102(3):179-193

18. Berkes MB, Little MT, Schottel PC, Pardee NC, Zuiderbaan A, Lazaro LE, Helfet DL, Lorich DG. Outcomes of Schatzker II Tibial Plateau Fracture Open Reduction Internal Fixation Using Structural Bone Allograft. J Orthop Trauma. 2014 Feb;28(2):97-102

19. Iundusi R, Gasbarra E, D'Arienzo M, Piccioli A, Tarantino U. Augmentation of tibial plateau fractures with an injectable bone substitute: CERAMENT™. Three year follow-up from a prospective study. BMC Musculoskelet Disord. 2015; 16: 115.

20. Chan Y-S, Chiu CH, Lo YP, et al. Arthroscopyassisted surgery for tibial plateau fractures: 2- to 10-year follow-up results. Arthroscopy 2008;24:760–8.

21. Verona M, Marongiu G, Cardoni G, Piras N, Frigau L, Capone A Arthroscopically assisted reduction and internal fixation (ARIF) versus open reduction and internal fixation (ORIF) for lateral tibial plateau fracture: a comparative retrospective study. J Orthop Surg Res 2019 May 24; 14 (1):155

22. Le Baron M, Cermolacce M, Flecher X et al. Tibial plateau fracture management: ARIF versus ORIF – clinical and radiological comparison. Orthop Traumatol Surg Res. 2019 Feb;105(1):101-106