

Outcome evaluation of staged treatment for bicondylar tibial plateau fractures

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KEYWORDS

Tibial plateau fracture
Plate osteosynthesis
Damage control surgery
Treatment outcome

ABSTRACT

Background: The universal accepted strategy for treating high-energy tibial plateau fractures remains a topic of ongoing debate. The challenge for the practicing orthopaedic trauma surgeon is to provide anatomical articular fracture reduction, with successfully managing the complex soft-tissue injury that is commonly present at patient admission. The primary aim of the actual study was to evaluate the results of a staged protocol for the treatment of high-energy bicondylar tibial plateau fractures. The secondary aim was to describe the technique used for the definitive fixation of this complex fracture pattern.

Methods: Thirty patients with unstable high-energy closed bicondylar tibial plateau fractures (17 Schatzker V and 13 Schatzker VI) were managed. There were 24 men (80%) and six women (20%). All of them were skeletally mature with their age ranging from 19 to 67 years (mean of 33.1±3.4 years). Treatment involved a two-stage procedure with appropriate emergency care, preoperative planning, and definitive fixation. Initial treatment, named 'damage control on complex articular fracture elements', consisted on temporary bridging external fixation. Definitive treatment was delayed in a mean of 10 days (ranging from seven to 13 days) and was performed when the soft-tissue conditioning demonstrated either complete or almost complete remission of the inflammatory reaction due to the 'first hit'. Conventional implants were used in the 30 patients. All patients were evaluated clinically and radiographically.

Results: Twenty-six (86.7%) patients had a moderate level of activity, three (10%) patients had a very light level of activity, and one (3.3%) patient was unable to have any kind of work activity and is currently supported by the Brazilian Welfare. Using the visual analog scale mean pain score was 30 (ranging from 10 to 60); even the patient with the workers' compensation had no severe pain. All patients except three have no difficulty with stairs, giving way, locking, swelling, and squatting, but were unable to run. Three (10%) patients had problems with stairs and could not bend the operated knee more than 90°. One of them had a varus knee but no instability. Ninety percent of the patients were either very satisfied or somewhat satisfied with their outcome. The three dissatisfied patients suffered postoperative complications, most commonly wound infections. Four (13.4%) patients with former anatomical reduction had a residual articular step-off or diastasis of less than 3 mm after fracture healing. All patients had no or mild arthrosis at the time of the last outpatient consultation.

Conclusions: The two-staged procedure presented herein showed to be an effective strategy for managing bicondylar tibial plateau fractures. The protocol used for these complex traumatic injuries follows very well defined steps, which means acute stabilization with a linear bridging external fixation, adequate soft tissue handling, preoperative planning, and definitive surgical fixation after seven to 14 days. The model presents a more biological approach to optimizing functional outcome with an acceptable complication rate and minimal risk of loss of reduction in these high-energy tibial plateau fractures.

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Introduction

Bycondilar tibial plateau fracture is one of the most therapeutic challenging traumatic injuries of the appendicular skeleton [1]. Even the more experienced orthopaedic trauma surgeons find some

degree of difficulty, arising mainly due to multiplanar articular comminution, metaphyseal-diaphyseal dissociation, severe soft-tissue damage, and joint instability [1–3]. As a consequence, complications are expected in a great number of patients, with 50% being related to the soft tissues [4–6].

Current strategies have acutely focused both on the restoration of skeletal alignment and the management of soft-tissue envelope [1–3]. This should only be accomplished by temporary fracture fixation. However, due to the inherently local instability, neither

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removable knee immobilizers nor skeletal traction should be routinely used for high-energy tibial plateau fracture [2]. Several authors have proposed the use of a staged protocol for these lesions, with application of bridging external fixation [7–9]. Narayan et al. have suggested that the so-called ‘travelling external fixator’ allows for reduction of swelling, permits better and repeated soft-tissue inspection, helps bring the fracture into appropriate axial alignment, and facilitates imaging investigation [2]. Following this protocol, definitive surgical intervention is delayed until the diameter of the lower limb is reduced and the ‘wrinkle sign’ is observed [1–3,7–10].

There has been an argument concerning the ideal method of definitive fixation of unstable bicondylar tibial plateau fractures. Recommended treatment modalities vary from closed alignment and circular external fixation to open reduction and internal fixation (ORIF). In the nineties, Dendrinis et al., Gaudinez et al., and Stamer et al. have shown the application of thin wire external fixation, with good results and several advantages over the classical plating techniques [11–13]. At this time, there has been an unacceptable rate of complication associated to additional trauma caused by formal ORIF [5]. However, more recent literature has shown improvements in the implants and surgical techniques for the ORIF of these difficult fractures. Several series describe the efficacy of one or double plating of proximal tibial fractures using a minimally invasive percutaneous technique [14–18].

Given the fact that soft tissues are often still inflamed, even with an apparent integral envelope, we’ve been choosing for the use of low profile conventional implants in an attempt to reduce the secondary local trauma, which means minimal invasion and maximal fixation. The primary aim of the present study was to evaluate the results of a staged protocol for the treatment of high-energy bicondylar tibial plateau fractures. The secondary aim was to describe the technique used for the definitive fixation of this complex fracture pattern.

Methods

Study subjects and initial management

Between January 2005 and January 2009, open reduction and internal fixation was performed in 215 patients with plateau fractures at the Orthopaedic and Trauma Department of the author's institution. One of the authors consecutively managed 43 patients with unstable high-energy closed bicondylar tibial plateau fractures, although 30 were included as study subjects. Exclusion criteria were skeletally immature patients, polytraumatized patients, open fractures, and closed fractures presenting with a compartment syndrome at admission.

Of these 30 patients, there were 24 men (80%) and six women (20%). All of them were skeletally mature with their age ranging from 19 to 67 years (mean of 33.1 ± 3.4 years). According to the Schatzker classification, 17 (56.7%) patients sustained a Schatzker V and 13 (43.3%) a Schatzker VI. Most of the injuries were due to road traffic accident [19]. The patient characteristics are given in Table 1.

Table 1
Demographic data from the 30 patients

	Patients (n=30)
Age (years) [range]	33.1 [19–67]
Gender (male/female)	24/6
Schatzker classification	
Type V	17
Type VI	13
Cause of injury	
Pedestrian crash	11
Bicycle accident	1
Motorcycle accident	13
Car accident	5

Source: SOTPNM, 2011

At admission, special attention was paid to peripheral circulation and neurological status. Due to the high-energy mechanism related to the injury, no attempt of definitive fixation was done, but temporary bridging external fixation was performed on an urgent basis (less than 24 hours after hospital admission). Between the hospital admission and the definitive surgical procedure, knee radiographs (anteroposterior, lateral, and oblique views) and CT-scan were performed for all patients. Preoperative planning was routinely done. All patients were operated on within 14 days after trauma, based on the soft-tissue conditioning (regression of inflammation, peripheral edema, ecchymosis, and skin blistering plus ‘wrinkle sign’ observation).

Definitive operative procedure

The definitive procedure was performed on a radiolucent table, with the knee flexed at 30° and tourniquet ischemia. Fluoroscopy was used during the procedure as a rule. The mean time of surgery was 150 minutes (ranging from 118 to 179 minutes). Intraoperative radiographic exposure time was not evaluated. The external fixation device was cleaned, protected, and kept in place during the operation.

Operative procedure followed always the same steps. The medial component of the lesion was approached first either by a 3-cm medial or a posteromedial incision, depending on the location of the metaphyseal medial plateau vertex. The *pes anserinus* structures were protected and moved away for better exposure of the fracture site. Anatomical articular reduction was done indirectly, based on the metaphyseal edges reduction, and checked with fluoroscopy. Temporary Kirschner wire (K-wire) fixation was used to facilitate the location of the plate. The fracture was stabilized with a four-hole one-third tubular plate (Baumer®, Mogi Mirim, Brazil), with a buttressing function. No screws or small length screws were temporarily used in the epiphyseal area in order to not compromise the lateral plateau condyle reduction.

The lateral component of the fracture was then approached using a 10-cm linear incision centered on the tubercle of Gerdy. A submuscular plane of the lateral side was developed under the anterior compartment muscles. In some cases (11 of 30, 36.7%) a posterolateral dissection was required through a proximal fibula osteotomy [20]. When it was done, the common peroneal nerve was identified and protected before the bone cut. For better exposure of the fracture site, the meniscotibial ligament was incised and the lateral meniscus was detached. Direct articular reduction was done, temporarily fixed with K-wires and checked with fluoroscopy. No bone graft was used to fill the metaphyseal defect formed after subchondral fragment elevation. Instead, it was used a subchondral screw raft, with small fragment long cortical screws through a horizontally placed one-third tubular plate (as a ‘big’ washer) (Figure 1). Finally, either a conventional small fragment dynamic compression plate (DCP; Baumer®, Mogi Mirim, Brazil) (n=20, 66.7%) or a conventional narrow large fragment DCP (Baumer®, Mogi Mirim, Brazil) (n=10, 33.3%) was slid under the tibialis anterior muscle and fixed.

Before closure of the wounds, long epiphyseal screws were inserted through the medial plate. We tried always to position the plates in a 90-degree direction in order to facilitate the indentation of the medial and lateral screws (Figure 2). The lateral meniscus was checked for any rupture, fixed when it was present, and then reattached to the lateral tibia. Final reduction was checked with plain radiographs. The operated knee was protected with a bulky Jones dressing.

Post-operative protocol and follow-up evaluation

Intravenous antibiotics were administered for 24 hours. No pharmacological deep venous thrombosis (DVT) prophylaxis was

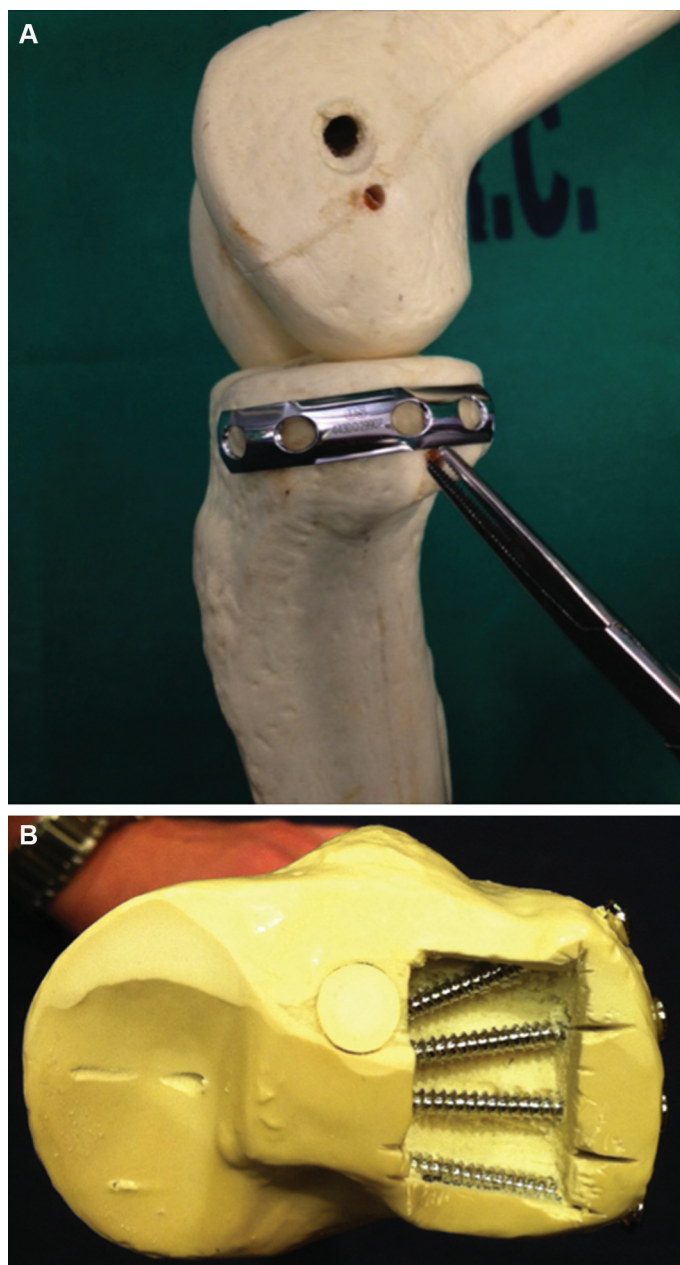


Fig. 1. A) Tibial model showing the adequate position of the horizontal plate on the lateral plateau. We prefer to use the one-third tubular plate, although other small fragment implants may be used. B) The same model viewed from above showing the disposition of the screws forming a subchondral rafting. Note that there is a tendency for screws to converge due to modeling of the implant.

routinely done. The patients were encouraged to perform active movement of their operated knee. Partial weight bearing with two crutches was started as soon as the patient could support postoperative discomfort. Immediate (<48 hours) post-operative CT scan evaluation was routinely done since July 2007 in all patients. Thus, 11 (36.7%) patients had this sort of imaging evaluation post-operatively.

Discharge occurred between the second and the third day after the definitive surgery. Follow-up routine anteroposterior, lateral, and oblique radiographs were obtained at two, six, and 12 weeks, and at six and 12 months. After one year the radiographs were done yearly. Full weight bearing was not permitted until fracture healing, which occurred normally at 12 weeks.

At each visit, patients completed the modified Lysholm rating system questionnaire, which is based on level of activity, pain,



Fig. 2. Detail of a post-operative anteroposterior radiograph of a Schatzker V tibial plateau fracture. Observe the indentation of the screws, as mentioned by Eggli et al. The aim is to increase the resistance to screwing pulling out.

function and knee stability, surgical history, complications, and satisfaction with the procedure [21]. In addition, at the last follow-up consultation, pain was specifically measured from the patient's perspective using the VAS score and radiographs were analyzed for loss of reduction, alignment after healing, and evidence of posttraumatic arthritis (scored by the Kellgren and Lawrence classification) [22].

The mean follow-up time was 48 months (ranging from 30 to 71 months). No patient was lost to follow-up. As a routine we collect at least three different phone numbers and two addresses from all patients (and their relatives) operated on in our Department. Since we have adopted this measure our ability to regularly follow the patients has dramatically improved.

Statistical analysis

Statistical analysis was carried out using paired sample t-tests for comparing some parameters from the Lysholm rating system questionnaire (pain, function and knee stability, and complications) at different time points. Statistical significance was taken at the 5% level.

Results

Initial management

Neurovascular assessment of the lower limb was carried out on patients in the Emergency Department once the primary survey was completed. No neurological deficit or vascular damage was found.

Clinical evaluation

- The modified Lysholm rating system questionnaire [21] and the VAS pain score [22].

Level of activity

Level of activity recovered fast and gradually between consecutive consultations in almost all patients ($p=0.004$). As mentioned before, patients were allowed and encouraged to either perform active movement of their operated knee and partial weight bearing with two crutches. Twenty-six (86.7%) patients experienced improvements in function relating to activities of daily living. At the last follow-up consultation they had a moderate level of activity, being able to comfortably walk on uneven surfaces and undertake

light and moderately heavy labor (level 4 at the modified Lysholm rating system questionnaire) [21]. Three (10%) patients had a very light level of activity, keeping a sitting position during working hours. One (3.3%) patient was unable to have any kind of work activity and is currently supported by the Brazilian Welfare. Except for this patient the other 29 (96.7%) had returned to work at two years, although three (10%) required to change their pre-injury occupation.

At two years, all patients except three (10%) have no difficulty with stairs, giving way, locking, swelling, and squatting, but were unable to run. Three (10%) patients had problems with stairs.

Pain

As proposed by Eranki et al., severe pain was defined as greater than 7 and low/acceptable pain level lower than 3 [21]. Pain reduced from a mean of 8.1 at two weeks to 3.2 at two years ($p < 0.001$).

At the last follow-up consultation, using the visual analog scale mean pain score was 30 (ranging from 10 to 60); even the patient with the workers' compensation had no severe pain.

Function and knee stability

Knee flexion improved from a mean of 50° at two weeks to 115° at two years ($p < 0.001$). Knee extension improved from a mean of 5° at two weeks to full extension at two years ($p = 0.001$). There was no difference in flexion and extension recovering during the consecutive outpatient consultations.

At the last follow-up visit, three (10%) patients could not bend the operated knee more than 90°. One (3.3%) of them had a varus knee but no instability. At this time no patient presented more than 10° of valgus or varus opening of the injured knee tested in maximum extension compared to the contralateral side ($p > 0.05$).

Surgical history and complications are described later in the text.

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Satisfaction with treatment

At the last follow-up consultation, 90% (27 of 30) of the patients were either very satisfied or somewhat satisfied with their outcome. The three (10%) dissatisfied patients suffered postoperative complications, most commonly wound infections.

Pain, function and knee stability, and complications are presented in Table 2.

Radiographic analysis

On the follow-up radiographs, 29 of 30 (96.7%) patients had a normal valgus alignment of the operated knee and one (3.3%) has a varus deviation of 15°. Four (13.4%) patients with former anatomical reduction had a residual articular step-off or diastasis of less than 3mm after fracture healing. All patients had no or mild arthritis (Kellgren and Lawrence Grade 1) at the time of the last outpatient consultation (Figure 3).



Fig. 3. A 36-year-old man status post motorcycle accident with a bycondylar tibial plateau fracture. A) Pre-operative radiographs and CT scan show the posterior component of the fracture, including the avulsion of the LCP tibial origin (arrow). B) Post-operative radiographs taken 30 months after the injury show complete restoration of the articular component and adequate alignment of the knee axis. Note the complete posterior horizontal plating acting as a buttressing.

Table 2

Pain, function and knee stability, and complications at different time points

	2 weeks	12 weeks	12 months	Last follow-up
Pain (mean, 95% CI)	8.1 (6.7–9.2)	5.9 (4.0–7.3)	4.1 (3.1–6.5)	3.0 (1.1–5.9)
Function and stability (mean, 95% CI)				
Flexion	50° (20–80°)	80° (20–95°)	105° (25–125°)	115° (25–135°)
Extension	5° (0–25°)	3.5° (0–15°)	0° (0–8°)	0° (0–5°)
Complications (%)				
Superficial wound drainage	6.7%	–	–	6.7%
Late infection	–	3.3%	–	3.3%
Loss of knee axis	–	–	3.3%	3.3%
P-t syndrome	–	–	6.7%	6.7%

Source: SOTPNM, 2011

Surgical history and complications

Two (6.7%) patients had early problems with the surgical incisions and superficial draining, requiring other hospital admission, debridement of the wounds, and antibiotics. Both had satisfactory wound healing without further complications. One (3.3%) patient developed a late infection with loss of fixation and varus deviation of the knee axis. He had plating removal, bridging external fixation, sequential debridement, and venous antibiotics for prolonged time. Although the infection had been solved, he evaluated with a varus painless almost stiff left knee (ROM 5° to 25°). The overall re-operation rate was 10%.

Other two (6.7%) patients had persistent swelling on the operated leg, later diagnosed as post-thrombotic syndrome. They were managed with soft compressive sockets and medication under the supervision of a Vascular Surgeon.

Discussion

Rationale for the proposed protocol

Tibial plateau fractures continue to attract great interest for both the clinicians and scientists [23–32].

Several authors have been showing the difficulty to manage bycondilar tibial plateau fractures [1–20]. This is also our impression. Many factors have been pointed out to confirm this observation, as the presence of articular comminution, metaphyseal-diaphyseal dissociation, severe soft-tissue damage, and joint instability [1–3]. Until recently, due to the high complication rates, standard fixation included the use of an external fixator with or without limited articular internal fixation [2,3,11–13,33]. Some authors have proposed the use of circular external fixation because it allows postoperative adjustments in alignment and contact between fragments with minimal disruption of the precarious biology remaining in this area. Although definite circular external fixation seems to be a logical solution, there are some problems and obstacles related to their use for a prolonged time [2,5]. In addition, it is necessary to have some expertise to apply it.

Nowadays, we prefer to use the external fixation as a temporary device for acute stabilization of the fracture. This involves a two-stage procedure with appropriate emergency care and a temporary spanning external fixator applied across the knee to provide bony stability [7–9,14]. This approach mimics the concept of the damage control, where the second-hit phenomenon must be diminished as an attempt to add few or very little trauma to an already traumatized region. Egol et al. and Tejwani and Achan contend that high-energy tibial plateau fractures are not amenable to knee immobilizers or skeletal traction due to the necessity of closed monitoring of the compromised soft tissue [8,9].

The time of definitive fixation should be defined by the healing of the skin, which means re-epithelization of blisters, absence of pitting edema, and the 'wrinkle sign' [10]. Many authors have shown good results with this protocol [8,9,14–18]. However, every attempt must be done to avoid aggressive handling of the soft tissues during the new procedure. Although it was not the aim of the current research, we feel that extensive incisions, gross dissection, prolonged surgeries, and bulky implants are factors that determine a poor outcome in high-energy tibial plateau fractures. This may be partly explained by the fact that the soft tissues are unable to tolerate additional trauma. A new inflammatory reaction caused by one of these factors probably enhances the rate of complications related to the formal open reduction and internal fixation largely used few years ago.

A reasonable operative strategy includes the use of a two-incision technique starting with the reduction of the posteromedial component. Egli et al. have shown good results and minimal

complication rate with the application of a stepwise reconstruction strategy of the tibial plateau starting with the reposition and fixation of the posteromedial fragment, followed by reposition and fixation of the lateral tibial condylar component [14]. These authors proposed the routine use of low profile implants (small fragment plates) with 90-degree between the fixation devices. Using a similar approach, Oh et al. observed that double conventional plating using minimally invasive percutaneous technique could provide favorable results in the treatment of proximal tibial fractures [16]. More recently, several authors have been publishing good results with isolated lateral locked plates [15,17,18]. Ricci et al. highlighted the easiness of its application due to the anatomical contoured design, minimal bone contact, and locking screws, which is critical in very small articular fragments and insufficient bone stock [18]. However, its usage in some countries has been strongly limited by the high cost as has been mentioned by some authors [16].

Despite the new developed locked plates, the use of conventional implants seems to give adequate stability but it is necessary to obtain good purchase of the screws in the epiphyseal fragment. As proposed by Egli et al., we think the use of bilateral plating in a 90-degree direction can facilitate this due to the indentation of the medial and lateral screws [14]. In our study, using the same protocol we had satisfactory clinical and radiographic outcomes in approximately 90% percent of the patients. Loss of reduction with or without fixation failure occurred in 13.4% of the patients.

Finally, we did not use bone graft in the metaphyseal area to support the subchondral articular fragment. Welch et al. have demonstrated that either cancellous autograft did not maintain an anatomical reduction in a goat model of standardized cylindrical subchondral defects created bilaterally beneath the subchondral bone of the articular cartilage in the lateral tibial plateau fractures [34]. As a matter of fact, in the same model these authors have shown that augmentation with calcium phosphate cement prevented subsidence of the fracture fragment and maintained articular congruency as the fracture healed [34]. Once again, it is necessary to emphasize that the use of bone graft substitutes in developing countries has been strongly limited by the high cost. In contrast, we prefer to use subchondral raft screws in order to prevent articular collapse. Karunakar et al. have tested four different constructions for split depression fractures of the lateral tibial plateau in a cadaveric model [35]. They observed no significant difference in the overall stiffness between the four fixation constructs, supporting the use of subchondral raft screws when a central depression is a significant component of the overall fracture pattern.

We routinely prefer the use of longer cortical small fragment screws because this allows a great number of metallic implants in the subchondral area of the tibial plateau when compared with the traditional 6.5-mm cancellous screw. Instead of an isolated screw and washer construction, we use a horizontal rafting plate, as proposed by Bermúdez et al., mainly when we had to stabilize the posterior or the posterolateral fracture fragment [36,37]. This seems to be a very elegant way to a buttress plate and a subchondral raft with the same implant. We prefer in the majority of the patients a one-third tubular plate, although in few cases we have either used a small fragment DCP, a reconstruction plate, or a distal radius T-plate.

Outcome variables for the proposed protocol

The findings of the current study demonstrated both that the level of activity and the function of the knee improved over the time in almost all patients. This was illustrated for the 90% of patients that referred to be either very satisfied or somewhat satisfied with their final outcome. Using a very similar protocol, other authors have also shown convincing and enthusiastic results, characterized

by excellent to good clinical and radiographic outcomes [4,6,9,14,16]. More aggressive protocols, based on immediate definitive fixation, forceful manipulation of the fragments, and the use of bulky implants are directly associated to biological failures. One should keep in mind that approximately 50% of the complications observed on these high-energy fractures are related to the soft-tissue envelope in the proximal tibia [5].

Our study also showed that pain reduced from a mean of 8.1 at two weeks to 3.2 at two years. Even the patient with the workers' compensation had no severe pain at the last follow-up consultation. Based on this data and previous investigations, we feel that knee stability is a very important protective finding in these patients [3,38–40]. At the time of the last outpatient visit, no patient presented more than 10° of valgus or varus opening of the injured knee tested in maximum extension compared to the contralateral side. Weigel and Marsh reported favorable results despite injury to the articular surface, imperfect reductions, and associated meniscal and ligament injuries [3]. They stated that although each of these lesions may have the potential to produce post-traumatic arthritis and decreased patient function, 19 of their 22 patients had good or excellent final outcome.

Post-traumatic arthritis is another interesting aspect to be discussed. Contrary to the expectations, even in patients with clear signs of post-traumatic degenerative changes we rarely perform a joint arthroplasty. Once again, other authors seem to have the same impression [3,38–40]. As mentioned by Weigel and Marsh, the articular surface of the knee appears to be relatively resilient and resistant to progressive post-traumatic loss despite severe acute injury [3]. In our series, all patients had no or mild arthritis (Kellgren and Lawrence Grade 1) at the time of the last outpatient consultation. We had no patient with severe osteoarthritis, although four with former anatomical reduction had a residual articular step-off or diastasis of less than 3 mm after fracture healing and one had a varus knee deviation after deep infection and loss of fixation. Honkonen previously showed that the development of arthritis did not correlate with articular step-off [41].

Strengths and weaknesses of the current study

We believe the strengths of this study are mainly related to its well-detailed design and objectives, as demonstrated by the clear description of the proposed protocol, incorporation of subjective and objectives measurement tools, and a medium to long follow-up evaluation. Compared to other similar studies dealing with the same high-energy injury, either using external, internal, or combined fixation methods, we could observe quite a convincing and enthusiastic outcome. Barei et al. have stated that the use of two incisions, temporary spanning external fixation, and proper soft-tissue handling may contribute to a lower wound complication rate than was reported in the past [4].

There are some weaknesses on the actual study. Due to the cost limitation we didn't use the modern locked pre-contoured implants developed for the knee region. Many authors have demonstrated that it is possible to manage even these difficult high-energy injuries using just a single incision with these implants [15,17,18]. In this context, one can argue that this is a real factor that might be related to fewer complications. However, our findings did not present more complications due to the double incision technique. Many authors have shown that using a minimally invasive percutaneous technique with adequate soft-tissue handling can provide favorable results in the treatment of proximal tibial fractures [4,8,9,16]. A further weakness of this study is the absence of a control paired group. However, the use of statistical tests comparing both lower limbs differences seem to at least prove a significant improvement in all measures taken during the consecutive outpatient evaluations.

Conclusion

The two-staged procedure presented herein showed to be an effective strategy for managing bicondylar tibial plateau fractures. The protocol used for these complex traumatic injuries follows very well defined steps, which means acute stabilization with a linear bridging external fixation, adequate soft tissue handling, preoperative planning, and definitive surgical fixation after seven to 14 days.

Conventional low profile implants can be used with bilateral plating in a 90-degree direction. Routine application of autogenous bone graft may not be necessary once subchondral raft screws are used.

The model presents a more biological approach to optimizing functional outcome with an acceptable complication rate and minimal risk of loss of reduction in these high-energy tibial plateau fractures. It provides good fracture stability and good union rate.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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