RESEARCH ARTICLE

Clinical, Functional and Radiological Results of Bicondylar Tibial Plateau Fractures (AO41.C) Treated by Osteosynthesis with Plates and Screws

Iris E. Blasco-Smaranda, MD; Sarah Mills-Gañán, MD; María J. Minotta-Quebradas, MD; Patricia Crespo-Lastras, MD; Juan C. Rubio-Suárez, MD; E. Carlos Rodriguez-Merchan, MD, PhD

Research performed at Department of Orthopedic Surgery, La Paz University Hospital, Madrid, Spain

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Abstract

Objectives: Bicondylar tibial plateau fractures are technically demanding fractures that have a high rate of complications. The aim of this study was to analyse the outcomes of patients diagnosed with bicondylar tibial plateau fractures (AO41.C of the AO/ASIF classification) who were treated by osteosynthesis with plates and screws.

Methods: A retrospective observational study of 27 patients was conducted. The mean follow-up was 49.52 months. The minimum follow-up was 2 years. The mean age of the patients was 51.44 years. Fifty-two percent of the patients required external fixation due to poor soft tissue condition, with a mean time to definitive surgery of 9.42 days. The 27 patients were definitively treated by open reduction and internal fixation with plates and screws. In 21 patients, the osteosynthesis was carried out with two plates using a dual approach (anterolateral and posteromedial). In addition to the medial and lateral plate, in 2 patients, a posterior plate was used. In 4 patients, the chosen option was a synthesis with a single plate through the anterolateral approach.

Results: The average score on the KOOS (Knee Injury and Osteoarthritis Outcome Score) scale at the end of the follow-up was 53.26 points. The use of external fixation did not correlate with a worse clinical result at the end of the follow-up. According to the Kellgren-Lawrence scale, all patients presented different degrees of arthritic changes. The main complication was discomfort related to the hardware, and 15 patients (55,56%) underwent hardware removal. One of the patients also required a high tibial corrective osteotomy due to the malunion of the fracture in valgus.

Conclusion: Although a notable reduction and union of the fracture are achieved, bicondylar tibial plateau fractures result in a major loss of articular function and posttraumatic radiological changes.

Level of evidence: IV

Keywords: Bicondylar tibial plateau fractures, Complications, Plate and screw fixation, Results

Introduction

Bicondylar tibial plateau fractures represent 1-2% of all fractures, affecting both condyles in 15-36% of cases.[1-4] They are usually the result of a high-energy trauma, with associated damage in the soft tissues and a pattern of injury that depends on the magnitude of the force, bone quality and the age of the patient.[4,5] In older patients, poor bone quality can result in complex patterns associated to low-energy traumas, usually with less soft tissue damage.[6]

Fractures classified as type V and VI according to Schatzker's classification,[7] are intra-articular and involve both condyles. They are usually associated with major comminution, metaphyseal-diaphyseal disruption, severe soft tissue injuries and articular instability.[4,6]

The aim of surgical treatment is to restore the articular axis and achieve a stable and consistent joint, while

Corresponding Author: E. Carlos Rodriguez-Merchan, Department of Orthopedic Surgery, La Paz University Hospital, Madrid, Spain
Email: ecrmerchan@hotmail.com

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maintaining the integrity of the soft tissues.[8,9] Treatment can be performed through the use of external fixation or through open reduction and internal fixation (ORIF) using plates and screws.[4] The latter technique requires good understanding of the fracture, in addition to optimal handling of the soft tissues.

The classic classifications of bicondylar fractures were based on evaluating the image in 2 dimensions.[7,10] The widespread use of computed tomography (CT) has allowed better evaluation of fracture lines and has made it clear that impairment of the posterior column, above all the posteromedial fragment, is much more frequent than initially believed.[8,10-12]

To achieve good results, it is essential to fully understand the fracture lines in a three-dimensional view, in order to select the appropriate surgical approach and optimal plate positioning.[13,14] When properly applied, this treatment restores articular stability, the joint surface and the limb axis, thus allowing early mobilisation and rehabilitation of the limb.

However, this technique is not free of complications, such as surgical wound dehiscence, joint stiffness, infection, nonunion, or secondary osteoarthritis, all of which could negatively affect clinical outcomes.[15] There are few publications in the literature on the outcomes of surgical treatment for such fractures, despite their apparent association with persistent symptoms.[16-20]

The aim of this study is to analyse the radiological, clinical and functional outcomes of patients diagnosed with bicondylar tibial plateau fractures (AO 41.C) who were treated at our centre with plate and screw osteosynthesis.

Materials and Methods

A retrospective observational study was conducted, including patients diagnosed with bicondylar tibial plateau fractures (AO41.C) according to the AO ("Arbeitsgemeinschaft für Osteosynthesefragen")/ASIF (Association for the Study of Internal Fixation) classification system,[10] between June 2014 and June 2019, with a minimum follow-up period of two years.[21] For each selected patient, demographic data such as age, gender, and the presence of comorbidities were collected. Fracture type was classified by the principal investigator based on the AO/ASIF classification,[10] additionally documenting the fracture according to Shatzker[7] classification and Luo's classification[12] and the fracture morphology according to the Spanish Orthopaedic Trauma Association (SOTA) algorithm.[22]

Upon admission, all patients were stabilized and immobilized using an inguinopedic splint. They were kept under observation for at least the first 24 hours post-injury to monitor for the development of compartment syndrome and to allow for periodic re-evaluation of soft tissue status. External fixation was employed within the first 24 hours in patients presenting with high-energy trauma or soft tissue complications.

Of the medial proximal tibial angle (MPTA), the posterior proximal tibial angle (PPTA), the presence of articular step-off, and condylar widening. Following the method described by Assink et al,[23] articular step-off was evaluated in axial, sagittal, and coronal planes, with measurements greater than 3 being recorded. An articular step-off greater than 2 mm was considered pathological.

Definitive surgery was postponed until clinical stabilization was achieved in patients with associated injuries, and until soft tissue conditions were appropriate for surgical intervention—characterized by re-epithelialization of blisters, the presence of shiny and wrinkled skin, and positive skin fold signs. Both the time to definitive surgery and the need for external fixation were recorded.

Condylar widening was measured according to the method described by Johannsen et al, with a widening of less than 2 mm considered normal. Similarly, a medial proximal tibial angle (MPTA) of 87° ± 5° and a posterior proximal tibial angle (PPTA) of 9° ± 5° were considered within normal limits.[24-26]

Regarding definitive surgery and postoperative protocol, all patients underwent definitive surgery performed by a specialized lower limb fracture unit consisting of seven surgeons. Treatment involved ORIF with plates and screws. The surgical approach, as well as the number and configuration of plates, was individualized based on the characteristics of each fracture. Postoperatively, quadriceps strengthening exercises and free active knee range of movement were started on the first day after surgery, with weight-bearing on the operated limb restricted. Partial weight-bearing with crutches was allowed after 6-8 weeks, progressing to full weight-bearing after 3-4 months. During follow-up, the occurrence of complications and the need for hardware removal were recorded.

The clinical outcomes were assessed at the end of follow-up using the KOOS (Knee Injury and Osteoarthritis Outcome Score),[27-29] and the SF-36 (36-Item Short Form Health Survey) questionnaire.[30] Articular range of motion and joint stability were also evaluated. Radiological outcomes were assessed on weight-bearing X-rays and at the final follow-up using the Modified Rasmussen Score.[31] The presence of osteoarthritis was evaluated using the Kellgren-Lawrence scale.[32] Radiological images were evaluated independently by two different researchers.

Articular step-off was defined as a depression of the articular surface greater than 2 mm, while loss of alignment was defined as a secondary displacement of more than 5 mm in the frontal or sagittal plane compared to previous postoperative imaging.[16]

Patients were excluded if definitive surgery was performed at another institution, if follow-up was less than two years, or if critical data - especially final clinical scale scores - were missing [Table 1]. Statistical analysis was performed using JASP software, version 0.17.2.1. Categorical data were compared using the Fisher exact test or chi-square test, and quantitative variables were analyzed using the Student's t-test. A p-value of <0.05 was considered statistically significant.

Results

A total of 27 patients were included, with a mean age of 51.44 ± 11.86 years. Sixteen patients (59.26%) were women and eleven (40.74%) were men. Eleven patients (40.74%) had comorbidities [Table 2]. Based on ASA (American Society of Anesthesiology) classification,[32] thirteen patients (48.15%) were ASA I, nine (33.33%) ASA II, and five (18.52%) ASA III. The most frequent fracture mechanism was accidental falls (12 patients, 44.44%), followed by traffic accidents (10 patients, 37.04%). Other mechanisms included crush injuries (4 patients, 14.81%) and falls from height (1 patient, 3.7%). One patient had an open type II bicondylar tibial plateau fracture, classified according to the Gustilo system.[33]

Table 1. Inclusion and exclusion criteria used in this study.

Inclusion criteria

- Proximal tibia fracture - AO 41.C
- Patients treated between June 2014 and June 2019.
- Patients older than 18 years old.

Exclusion criteria

- Patients treated in a different hospital.
- Less than 2 years follow-up.
- Incomplete data.

Table 2. Comorbidities present in 12 (42.87%) out of 28 patients in this study.

Patient	Comorbidities
1	Breast cancer
2	Depression, dyslipidemia.
3	Depression, ankylosing spondylitis, acute myocardial infarction, peripheral vascular disease.
4	Type 2 diabetes.
5	Multiple sclerosis, prostate cancer.
6	HBP
7	HBP, asthma
8	HBP, dyslipidemia, type 2 diabetes.
9	HBP, sleep apnea syndrome.
10	Cerebral arteriovenous malformation, Parkinson´s disease, stroke.
11	Sleep apnea síndrome.

HBP – high blood pressure

Fractures were classified as follows: 2 cases (7.41%) as AO41.C1, 4 cases (14.81%) as AO41.C2, and 21 cases (77.77%) as AO41.C3 [Figure 1]. Table 3 summarizes the demographic data, including fracture classification according to Shatzker's classification,[7] Luo's classification,[12] and the SOTA algorithm.[22]

Table 3. Gender, ASA classification, fracture mechanism and type of fracture (according AO/ASIF classification) of 28 patients included: number (N) and percentage (%).

	N (27)	%
Gender (F/M)	16/11	59.26/40.74
ASA		
• I	13	48.15
• II	9	33.33
• III	5	18.52
Fracture mechanism		
• Simple fall	12	42.8
• Traffic accident	10	35.7
• Crush injury	4	14.3
• Fall from height	1	3.6
• Sport accident	1	3.6

Table 3. Continued

AO/ASIF classification		
•AO41.C1	2	7.41
•AO41.C2	4	14,86
•AO41.C3	21	77.78
Schatzker classification		
•V	10	37.04
•VI	17	62,96
Luo Classification		
• II	10	37,04
-L+M	6	
-L+P	3	
-M+P	1	
• III	17	62.96
SOTA Algorithm		
• Two column	10	37.04
-L+M	6	
-L+P	3	
-M+P	1	
• MDD	17	62.96
-MDD-AL	3	
-MDD-PL	8	
-MDD-PM	6	

ASA = American Society of Anesthesiology; AO/ASIF = "Arbeitsgemeinschaft für Osteosynthesefragen" / Association of the Study of Internal fixation; F = female; M = male. SOTA= Spanish Orthopaedic Trauma Association. MDD= Main Deformity Direction

Regarding initial radiographic findings, the mean MPTA at diagnosis was 84.33 ± 3.43 degrees, and the mean posterior slope (PPTA) was 8.12 ± 8.04 degrees. Articular step-off was present in 22 patients, with a mean value of 6.99 ± 4.97 mm. Condylar widening was observed in 27 patients, with a mean value of 7.00 ± 3.98 mm [Table 4].

Table 4. Radiological results in this study.

	MPTA	PTSA	Axis (FTA)	Articular step-off	Condylar widening
Mean	86.00	7.19	6.63	1.04	2.92
SD	2.83	2.76	4.00	1.63	2.17

MPTA = medial proximal tibial angle; PTSA = posterior proximal tibial angle; FTA = femorotibial angle; SD = standard deviation.

Fifty-two percent of patients required external fixation, all due to poor soft tissue conditions. Mean time to definitive surgery in these patients was 9.42 days. In patients who did not require external fixation, the mean time to surgery was 4.54 days. The use of external fixation was not associated with worse clinical outcomes at the end of follow-up (p = 0.56). No cases of compartment syndrome or vascular injury were recorded. Fixation was performed using two plates in 21 patients [Figure 2]. In all cases, a double anterolateral and posteromedial approach was used [Figure 3]. In four patients, fixation was performed with a single plate through the anterolateral approach [Figure 4]. In addition to the medial and lateral plates, a posterior plate was used in two patients, implanted through the posteromedial approach to provide increased posterior support [Figure 5]. Definitive surgery was performed by 7 different surgeons, as shown in [Table 5]. Bioceramics were used in 3 patients (11.11%).

Regarding follow-up, the mean duration was 49.52 months, with a standard deviation of 19.19 months. No complications were observed in the immediate postoperative period. Regarding the clinical outcomes at the final follow-up, the mean KOOS (Knee Injury and Osteoarthritis Outcome Score) was 53.26 ± 21.92 points [Table 6]. As for the SF-36 scale, at the end of follow-up, the mean Physical Component Summary score was 43.85 ± 11.48 points, and the Mental Component Summary score was 44.07 ± 11.69 points.

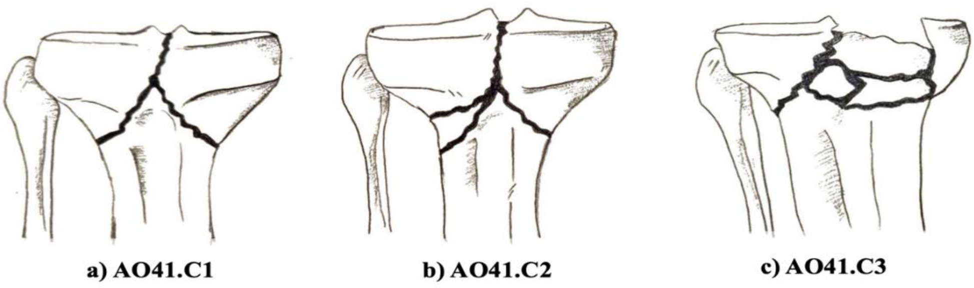

Figure 1. Types of fractures included in this study

Figure 2 (A-H). AP (anteroposterior) (A) and lateral x-rays (B) of a female patient aged 45 diagnosed with a proximal tibial fracture AO 41-C3 after an accidental fall. Note the major articular step-off and comminution, also visible in the computed tomography (CT) (C) and (D). AP (E) and lateral x-rays (F) at the beginning of the weight bearing. The patient presented discomfort in relation to the osteosynthesis material, therefore hardware removal was performed. AP (G) and lateral x-rays (H) at the end of the follow-up, with grade IV arthritic degenerative changes

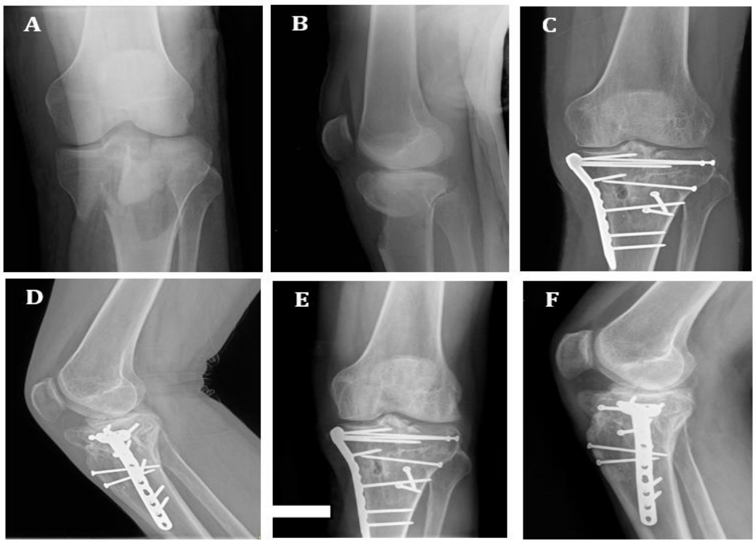

Figure 3 (A-F). AP (anteroposterior) (A) and lateral x-rays (B) of male aged 34 diagnosed with a proximal tibial fracture AO41C-3 following a motorcycle accident. AP (C) and lateral x-rays (D) after synthesis with a medial plate. AP (E) and lateral x-rays (F) on completion of the follow-up

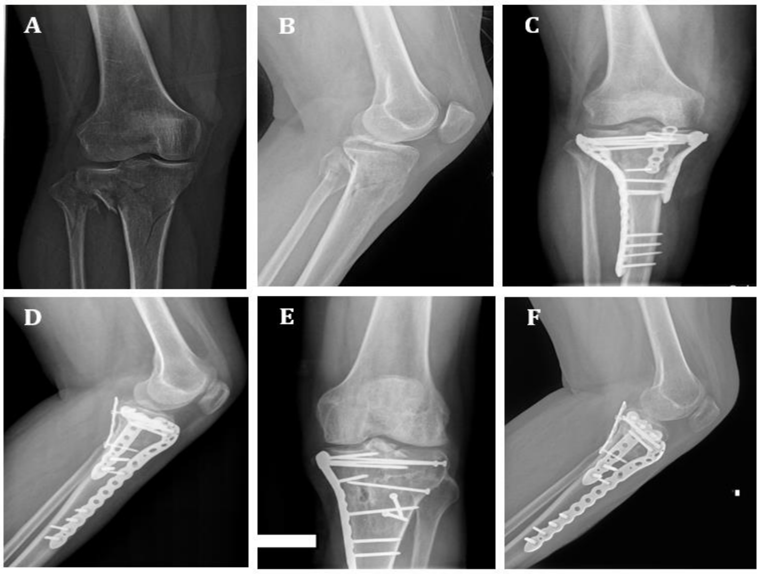

Figure 4 (A-F). AP (anteroposterior) (A) and lateral x-rays (B) of female aged 55, diagnosed with proximal tibia fracture AO 41-C3 after an accidental fall. AP (C) and lateral x-rays (D) following three-plate osteosynthesis. A third posterior plate was used to support the posterior column. AP (E) and lateral x-rays (F) at the end of the follow-up

Table 5. Number of patients treated by each surgeon.

Surgeon	Number of treated patients
1	9
2	6
3	4
4	4
5	2
6	1
7	1

Table 6. KOOS (Knee Injury and Osteoarthritis Outcome Score) and SF-36 (36-Item Short Form Health Survey) from the patients in this study.

	Total KOOS	Symptoms KOOS	Pain KOOS	Daily Living Activities KOOS	Function KOOS	Quality of live KOOS	SF-36 Physical functioning	SF-36 Role limit physical	SF- 36 Role limit emotional	SF-36 energy/ fatigue	SF- 36 emotional	SF- 36 social	SF- 36 pain	SF -36 global health	SF -36 health change
Mean	53.26	58.89	67.56	68.22	30.58	40.30	62.11	62.50	61.89	52.50	60.92	69.23	57.40	58.46	50.00
SD	21.92	19.85	22.37	23.31	29.34	28.48	24.71	36.91	42.36	23.16	22.47	31.67	30.76	17.93	23.45

SD = standard deviation

The physical examination at the end of follow-up showed a mean knee flexion of 118.33 ± 17.17 degrees, with flexion below 90º in 2 patients (7.4%), between 91º and 120º in 15 patients (55.56%), and above 120º in 10 patients (37.04%). Five patients (18.52%) presented with a permanent flexion deformity greater than 10º, with a mean extension of 3.78º ± 6.09º. In three patients, a slightly positive anterior drawer test was identified, and in five patients, slight medio-lateral instability was observed. Three patients presented valgus instability and two presented instability when forced into varus.

Radiological results at the time weight-bearing was allowed showed a mean Modified Rasmussen Score of 14.59 ± 1.73 points. These results were classified as good in 25 patients (92.59%), and satisfactory in 2 patients (7.41%) [Table 4]. Regarding the onset of arthritic changes according to the Kellgren-Lawrence scale, it is noteworthy that all patients exhibited some degree of osteoarthritis. These changes were classified as grade I in 4 patients (14.82%), grade II in 3 patients (11.11%), grade III in 13 patients (48.15%), and grade IV in 7 patients (25.93%).

A comparison was made between patients with incipient arthritic changes (grades 1 or 2) and those with advanced arthritis (grades 3 and 4). No significant differences were found in clinical scoring scales between these two groups, specifically in the KOOS (58,43±23.57 vs. 51,45±21,65, p = 0.479), Physical Component Summary (46,78±10.3 vs 41.57±11.83, p = 0.311), or Mental Component Summary (45,91±12.24 vs 42.58±11.6, p = 0.524). No differences in extension deficit were noted either (3.57 ± 7.48 vs. 3.85 ± 5.75, p = 0.919), nor in the degree of flexion (133.42 ± 12.95 vs. 113.05 ± 15.41, p = 0.004) [Table 7]. The main complication was discomfort related to the plates, which required removal in 15 patients (55,56%). One patient also required a high tibial corrective osteotomy due to poor fracture union in valgus alignment [Figure 6].

Table 7. Relationship between arthritic changes and clinical-functional outcomes.

Degree of osteoarthritis (K-L)	KOOS (mean ±SD)	PCS (mean ±SD)	MCS (mean ±SD)	Degrees of joint mobility in extensión (mean ±SD)	Degrees of joint mobility in flexion (mean ±SD)
I o II	58,43±23.57	46,78±10.3	45.91±12.24	3.57±7.48	133.43±12.95
III o IV	51,45±21,65	41.57±11.83	42.58±11.6	3.85±5.75	113,05 ± 15.41
p	0.479	0.311	0.524	0.919	**0.004***

K-L = Kellgren-Lawrence; KOOS = Knee Injury and Osteoarthritis Outcome Score; SD= standard deviation; PCS = Physical Component Summary; MCS = Mental Component Summary. * = statistically significant

Figure 5 (A-K). AP (anteroposterior) (A) and lateral x-rays (B) of a female patient aged 50 diagnosed with a proximal tibial fracture AO 41-C3 after crushing. Axial (C) and AP computed tomography (CT) images (D) showing major comminution and collapse of the articular surface and lateral (E) and medial damage (F). AP (G) and lateral x-rays (H) after osteosynthesis with a lateral plate. AP x-ray (I) on weight bearing 18 months postoperative showing articular collapse with major arthritic changes, which is why a proximal tibial osteotomy was performed. AP (J) and lateral x-rays (K) after 3 years of follow-up

There were no significant differences in the clinical or functional outcome of patients based on the type of fracture according to the Schatzker classification or the Luo classification. Also, patients with posterior column involvement showed no worse outcome compared to patients without posterior column involvement. There were also no statistically significant differences based on the use of bioceramics [Table 8].

Table 8. Relationship between Luo's and Shatzker classifications, posterior column involvement and the use of bioceramics and clinical-functional outcomes.

	KOOS (mean ±SD)	PCS (mean ±SD)	MCS (mean ±SD)	Degrees of joint mobility in extension (mean ±SD)	Degrees of joint mobility in flexion (mean ±SD)	Arthrosis (n of I/II vs n of III/IV)
Shatzker						
• V	51.50±27.76	41.92±13.40	43.41±15.64	4.00±6.58	114.70±13.70	4 / 6
• VI	54.29±18.56	43.50±10.63	43.46±9.05	3.65±5.99	120.47±18.99	3 / 14
• p	0.756	0.737	0.991	0.410	0.888	0.201
Luo						
• II	57.50±25.26	42.94±11.88	41.41±14.85	5.90±7.02	117.40±19.09	1 / 9
• III	50.77±20.10	42.90±11.64	44.64±9.56	2.53±5.31	118.88±16.53	6 / 11
• p	0.452	0.992	0.497	0.833	0.169	0.148
Posterior column involvement						
• Yes	56.33±21.47	42.47±11.67	42.24±16.47	3.33±6.06	124.00±20.77	6 / 15
• No	52.38±22.49	43.04±11.74	43.79±10.35	3.91±6.24	116.71±16.23	1 / 5
• p	0.705	0.917	0.780	0.844	0.370	0.557
Bioceramics						
• Used	34.33±15.95	36.23±10.29	40.97±13.51	8.33±10.41	108.33±7.64	0 / 3
• No	55.63±21.65	43.75±11.56	43.75±11.66	3.21±5.43	119.58±17.71	7 / 17
• p	0.114	0.294	0.704	0.174	0.294	0.277

KOOS = Knee Injury and Osteoarthritis Outcome Score; SD= standard deviation; PCS = Physical Component Summary; MCS = Mental Component Summary.

Discussion

Bicondylar tibial plateau fractures remain a challenge for surgeons. The aim of treatment is to achieve a stable joint, restore its axis, and, whenever possible, restore the articular anatomy to the greatest extent, all while preserving soft tissue coverage. Various techniques to achieve this goal have been described, including the use of definitive external fixation, open reduction with plate fixation, and percutaneous fixation techniques.[5,34]

Open reduction and fixation can be performed through different approaches, although such approaches are limited, and none alone provides full visualization of the entire articular surface.[35,36] The use of a singular anterior approach for fixation with a dual plate has been extensively discussed in the literature. Initially, very high complication rates were reported with the use of such approaches, ranging between 40% and 90%.[37,38] However, subsequent studies have demonstrated comparable complication rates with the use of a double approach and a modified anterior approach.[39] More recently, Dobelle et al, despite not finding differences in complication rates, have determined that the use of a double approach allows for better anatomical restoration of the fracture.[40]

At our institution, we prefer the use of separate approaches for adequate visualization of the fragments while trying to minimize damage to the soft tissue. To reduce soft tissue-related complications, sequential treatment, involving the attachment of external fixation followed by osteosynthesis at a later stage, has proven to be an effective strategy in these types of fractures, reducing infection rates and soft tissue complications.[41] In many cases, this results in a delay of definitive surgery, which is performed, on average, after 7 days in cases where no external fixation is used[16] and approximately 15 days[41,42] in patients who have been managed with sequential treatment. Definitive surgery is performed when the skin fold reappears, and the blisters re-epithelialize.

In our cohort, the time to definitive surgery was shorter than in the published studies, being 9.42 days for patients who required external fixation and 4.54 days for those who did not. This may be because, in our case, we not only opted for external fixation in high-energy trauma patients (who likely need more time for soft tissue to be in suitable conditions for surgery), but also in low-energy trauma patients who showed evident worsening of soft tissue after 12 hours of observation (it is likely that, given the energy of the trauma, recovery occurred more quickly). Furthermore, the early application of external fixation may be a factor that facilitates faster soft tissue recovery.

Although external fixation reduces the rate of surgical wound infection in high-energy trauma patients, it continues to be associated with deep infection rates between 7.6% and 13.9%,[41,43] with rates even higher in patients where the pin insertion sites overlap with the approach for definitive surgery.[44] In our series, there were no cases of surgical wound infection. The use of external fixation did not correlate with worse functional outcomes (p=0.340), nor was there any correlation between time to surgery and functional outcome (Pearson's r= -0.118, p=0.558).

Bicondylar tibial plateau fractures appear to significantly affect the lives of our patients, leading to a decline in their quality of life compared to the general population, as highlighted by Timmers et al in their study.[17] They concluded that patients with tibial plateau fractures report up to 2 to 3 times more impairments in each domain of the EuroQol questionnaire. This is also evident in the KOOS scale, where we obtained a mean score of 53.26 points. Other studies have evaluated clinical outcomes using this scale, reporting better results than those obtained in our series.[17,18,19,45] However, when comparing the results obtained across the different sections in studies that detail these scores, it is evident that the differences are mainly due to poorer scores in our patient group in the quality of life and sports activities sections.

It is important to highlight the work of Evangelopoulos et al[18], which included 22 patients with a mean follow-up of 67 months. They obtained a similar result in terms of symptoms (62.3 points) but better scores for pain and self-care (80 points). Additionally, Van Dreumel et al,[45] in their study including 96 patients with a one-year follow-up, of whom 28 had bicondylar fractures, reported better clinical outcomes on the KOOS scale: 81.93 for patients with Schatzker type V fractures and 85.63 for those with Schatzker type VI fractures. These authors also assessed the presence of osteoarthritis on the X-rays taken at the one-year follow-up and, like us, found it to be a common occurrence (60% in bicondylar fractures), although its development did not correlate with worse functional outcomes. The lower percentage of patients with arthritic changes in their study compared to ours is likely due to the fact that we assessed the X-rays earlier in the follow-up.[45]

Other authors have also reported the incidence of arthritic changes on X-ray, with incidences up to 93%, without finding any relationship between these changes and the functional outcome.[18,19] However, in certain studies, such as Timmers et al[17] after 6 years of follow-up, up to 22% of patients required conversion to total knee arthroplasty. Our rate of discomfort related to osteosynthesis hardware, which required hardware removal, was 55.56%. In previous publications on tibial plateau fractures, regardless of whether they are unicondylar or bicondylar, this rate ranged from 6% to 40%.[15,45,46] The need for osteosynthesis hardware removal is more frequent in bicondylar fractures, particularly in patients with a lower BMI (body mass index) and in cases with bicortical screw protrusion.[15,47] Our results are in line with the idea that current implants remain too bulky for an anatomical region where soft tissue coverage is scarce.[45]

The functional outcome in our patients was generally good, with a mean extension deficit of 3.78º ± 6.09, and only 5 patients presenting a flexion contracture greater than 10º. The mean flexion achieved was 118.33 ± 17.17, similar or slightly better than in previously published studies.[16,19] Regarding radiographic outcomes, we obtained good results in 92.59% of the treated patients. Other studies have evaluated outcomes using this scale: Kumar et al obtained similar results, with 85.3% of patients achieving good or excellent outcomes[16], and Vasiliadis et al reported good or excellent results in 85.9% of their patients.[20]

However, it is noteworthy that despite achieving anatomical reduction of the fracture in most cases, the majority of our patients showed radiographic signs of osteoarthritis within the first year of follow-up, highlighting the significant cartilage damage associated with these injuries.

This study has several limitations. Firstly, it is a retrospective study based on the review of clinical records and radiographs, selecting only those patients with complete data at the end of follow-up. This means a high rate of loss to follow-up, probably involving those patients who had good clinical outcomes and discontinued their check-ups due to being asymptomatic. Secondly, the retrospective design also resulted in a smaller sample size. This makes comparisons between subgroups difficult, for example based on the different categories of the SOTA algorithm. Thirdly, the follow-up period, approximately four years, is relatively short, meaning that although many patients already showed advanced osteoarthritic changes radiographically, some may develop more severe clinical symptoms over time.

Finally, we must highlight that the study includes patients treated with different numbers and configurations of plates, and patients with diverse baseline characteristics such as age, comorbidities, injury mechanisms, and fracture patterns, without having a sufficiently large sample in each subgroup to conduct a proper comparative analysis. In addition, patients were treated by several surgeons, without a single treatment algorithm, which makes it difficult to link the type of approach and placement of the plates to the final clinical outcome.

The performance of prospective clinical studies with larger sample sizes and longer follow-up periods would help to overcome these limitations.

Conclusion

Bicondylar tibial plateau fractures remain a challenge for surgeons, often leading to significant loss of function and the development of arthritic changes on radiographs, even when good fracture reduction and union rates are achieved. According to our results, the presence of severe posttraumatic degenerative changes on radiographs is not associated with worse clinical or functional outcomes.

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Iris E. Blasco-Smaranda MD [1]
Sarah Mills-Gañán MD [2]
María J. Minotta-Quebradas MD [2]
Patricia Crespo-Lastras MD [2]
Juan C. Rubio-Suárez MD [2]
E. Carlos Rodriguez-Merchan MD, PhD [2]

1 Department of Orthopedic Surgery, Getafe University Hospital, Getafe, Madrid, Spain

2 Department of Orthopedic Surgery, La Paz University Hospital, Madrid, Spain

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