Functional results and complications of tibial plateau fractures due to high-energy trauma

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Abstract

Introduction: Tibial plateau fractures represent 1% of all fractures. Functional results depend mainly on the patient's knee range of motion, joint stability and pain. The aim of this study was to evaluate functional results, range of motion, postoperative complications and pain in patients who suffered tibial plateau fracture following high-energy traumatism.

Material and Methods: We evaluated a series of 51 patients (averaging 48 years of age) with average follow-up of 42 months. We evaluated range of motion, functional results with KOOS test and pain with visual analogue scale.

Results: Twenty-five patients had Schatzker's type V fractures and, 26, Schatzker's type VI fractures. Patients' average range of motion was 2.4°-120.68°in type V fractures and 1.5°-118.04°in type VI fractures. With respect to pain, there were significant differences (p=0.0403) between the patients with Schatzker's type V and type VI fractures: 50% of the patients with type V fractures did not report pain, whereas 50% of those with type VI fractures reported >2 pain and, 25, >3 pain.

Conclusions: Tibial plateau fractures are still conditions in which results modify patients' life quality significantly. Therefore, they should be warned about the possibility of long-term poor results and the need for multiple surgeries. Moreover, they should be given information about the possibility of not recovering previous levels of sport and working activities.

Key words: Tibial plateau fractures; Schatzker's type V-VI fractures; range of motion; pain; complications.
Level of evidence: IV

Resultados funcionales y complicaciones de fracturas de platillo tibial por traumatismos de alta energía

Resumen

Introducción: Las fracturas de platillo tibial representan el 1% de todas las fracturas. El resultado funcional depende principalmente del rango de movilidad de la rodilla, la estabilidad de la articulación y el dolor. El objetivo de este estudio fue evaluar el resultado funcional, el rango de movilidad, las complicaciones posoperatorias y el dolor en pacientes que sufrieron fracturas de platillo tibial por traumatismos de alta energía.

Materiales y Métodos: Serie de 51 pacientes (edad promedio 48 años), con un seguimiento promedio de 42 meses. Se evaluaron el rango de movilidad, los resultados funcionales con el test de KOOS y el dolor con la escala analógica visual.

Resultados: Veinticinco pacientes tenían fracturas Schatzker tipo V y 26, tipo VI. El rango de movilidad promedio era de 2,4°-120,68° en el grupo de fracturas tipo V y de 1,5°-118,04° en el otro grupo. Respecto del dolor, hubo diferencias significativas (p = 0,0403) en pacientes con fracturas Schatzker tipos V y VI: el 50% de los pacientes con fracturas tipo V no refirió dolor y el 50% de aquellos con fractura Schatzker tipo VI indicó dolor >2 y un 25%, <3.

Conflict of interests: The authors have reported none.

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Conclusiones: Las fracturas de platillo tibial siguen siendo un cuadro en el que los resultados modifican considerablemente la calidad de vida de los pacientes. Por ello, se les debe informar sobre la posibilidad de malos resultados funcionales a largo plazo y múltiples cirugías; como así también que es posible que no recuperen el nivel previo de actividad deportiva y laboral.

Palabras clave: Fracturas de platillo tibial; Schatzker V-VI; rango de movilidad; dolor; complicaciones.
Nivel de Evidencia: IV

Introduction

Tibial plateau fractures represent 1% of all fractures. They usually occur following high-energy direct traumatisms, and are most frequently caused by car crashes, fall from height, sport injuries, and gun-shots.[1]

Low-energy injuries usually cause fracture with unilateral depression, whereas high-energy fractures can cause comminuted fractures with significant bone loss, severe injury of soft tissues and neurovascular damage, what calls for special consideration because they can have an influence on therapeutic options.[2]

The classifications of tibial plateau fractures most frequently used are Schatzker's type VI, V and VI, and the AO's for the highest-energy traumatisms—type C_3.

Open reduction and internal fixation is the treatment method of choice, since it aims at a more anatomic reduction of the fracture (although surgical approaches and the use of one or more plates are debatable); complication rates, however, are high. Over the past few years external fixation has become a popular therapeutic method; it is less invasive, but it does not result in anatomic reduction, nor does it keep long-term reduction.[4] The injury of the articular cartilage that is caused by the fracture can be the most important factor leading to joint post-traumatic degeneration despite anatomic reduction.[5]

Imaging studies asked for in these types of injuries are X-rays and CT scans with 3D reconstruction.

The most frequently associated complications are: deep infection, articular rigidity, irritation of the superficial peroneal nerve, and compartment syndrome.[6]

Functional results depend mainly on patients' knee range of motion (ROM), joint stability and pain. Just few studies evaluate knee functional results following tibial plateau fracture due to high-energy traumatism.[7] The aim of this study was to assess functional results, ROM, postoperative complications and pain in patients who suffered tibial plateau fracture due to high-energy traumatism, using the Schatzker classification.[8]

Materials and Methods

We analyzed a series of 51 patients (34 males and 17 females averaging 48 years of age) who suffered tibial plateau fracture due to high-energy traumatism between January 2010 and December 2015, with an average follow-up of 42 months.

We used the Schatzker classification for fractures and the Gustilo-Anderson classification for soft tissue injuries.[9]

We assessed ROM with a goniometer, whereas functional results were evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS),[10] which includes symptoms/rigidity, pain, activities of daily-living, sport/recreation activities, and life quality. A score=100 represents a normal knee; between 100 and 91, a mostly normal knee; from 90 to 71, a mildly dysfunctional knee; between 70 and 51, a moderately dysfunctional knee; and from 50 to 20, a severely dysfunctional/osteoarthritic knee. Pain was evaluated using the visual analogue scale (VAS)[11,12] and complications were diagnosed by means of medical history, physical examination and imaging studies.

Inclusion criteria

We included patients between 15 and 75 years old of both sexes without previous surgeries in tibial plateau and Schatzker's types V-VI fractures, with minimal follow-up of 6 months.

Exclusion criteria

We excluded patients with history of tibial plateau surgery, Schatzker's type I-IV fractures and <6-month follow-up.

Statistical analysis

We used tools from descriptive statistics to characterize the sample. We built contingency tables and calculated the chi-squared test outcomes to assess the VAS associations. Moreover, we adjusted the diverse generalized linear models with gamma distribution to estimate the effects of age and detect differences in the classification of fractures and the presence of comorbidities or complications at the time of studying the results in the KOOS scale.

Results

Sixty-nine percent of the fractures (34 patients) occurred due to motorcycle crash; 6% (5 patients), due to

car crash, 23% (11 patients), following fall from height, and 2% (one patient), due to sport activities (football). Thirty-thee fractures occurred in left knees and 18, in right knees. Twenty-five patients suffered Schatzker's type V fractures (2 3A and one 3C Gustilo fractures) and 26, Schatzker's type VI fractures (one 3C Gustilo fracture). In both 3C Gustilo fractures, we verified the injury of the popliteal artery by arteriography; therefore, the Vascular Surgery Department participated in the therapeutic procedure.

With respect to comorbidities, nine patients had high blood pressure, one suffered type 2 diabetes, one patient had myasthenia gravis, one suffered heart failure, and another one had chronic obstructive pulmonary disease. Twelve out of the 51 patients were smokers.

As definite treatment of these fractures, in two patients with Schatzker's type V fractures we used AO tubular devices-like transarticular external fixators (due to soft tissues injury); one patient received a hockey stick-like 4.5 mm locking plate for proximal tibial bone by medial approach, 20 patients were treated with "L" shaped 4.5 mm locking plates for proximal tibial bone by lateral approach, and two with double-plate by medial approach (3.5 mm reconstructive plate) and lateral approach ("L" shaped locking plate). One patient (Case 1) needed an internal gastrocnemius rotatory flap plus skin graft because the patient had suffered open 3C Gustilo fracture (Figures 1-5).

Of the 26 patients with Schatzker's type VI fracture, two received definite treatment with AO tubular devices-like transarticular external fixators due to soft tissues injury; nine, with "L" shaped locking plates by lateral approach; 15 required double 4.5 mm locking plates for proximal tibial bone, and one patient needed an internal gastrocnemius rotatory flap plus skin graft because the patient had open 3C Gustilo fracture.

Figure 1. Case 1. Fifty-one year-old male, with fracture caused by motorcycle crash. Pre-operative X-rays.

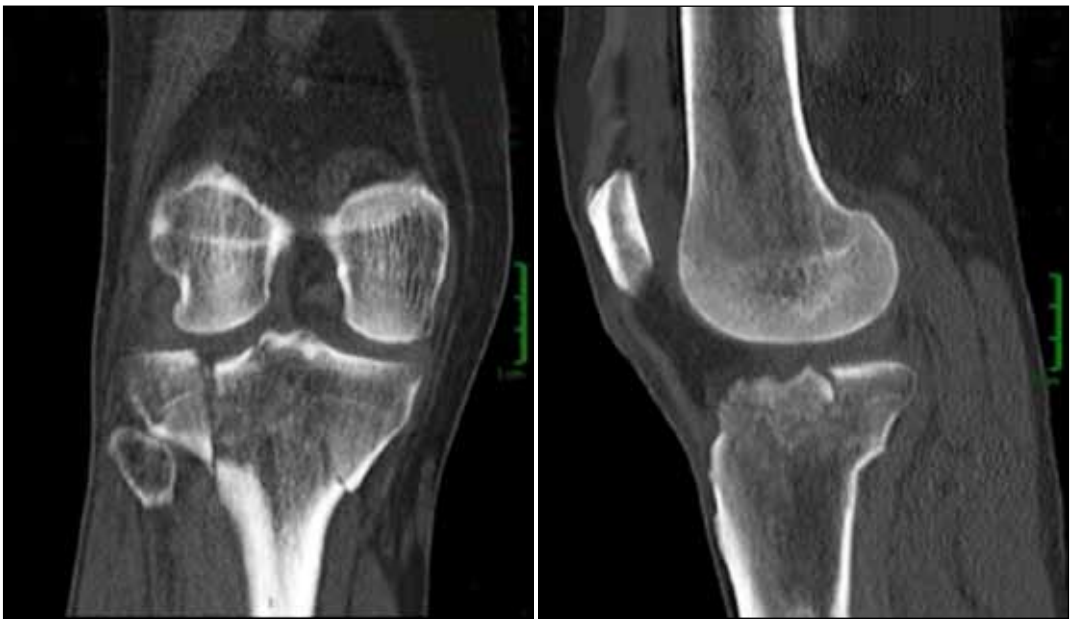

Figure 2. Case 1. Pre-operative CT scan.

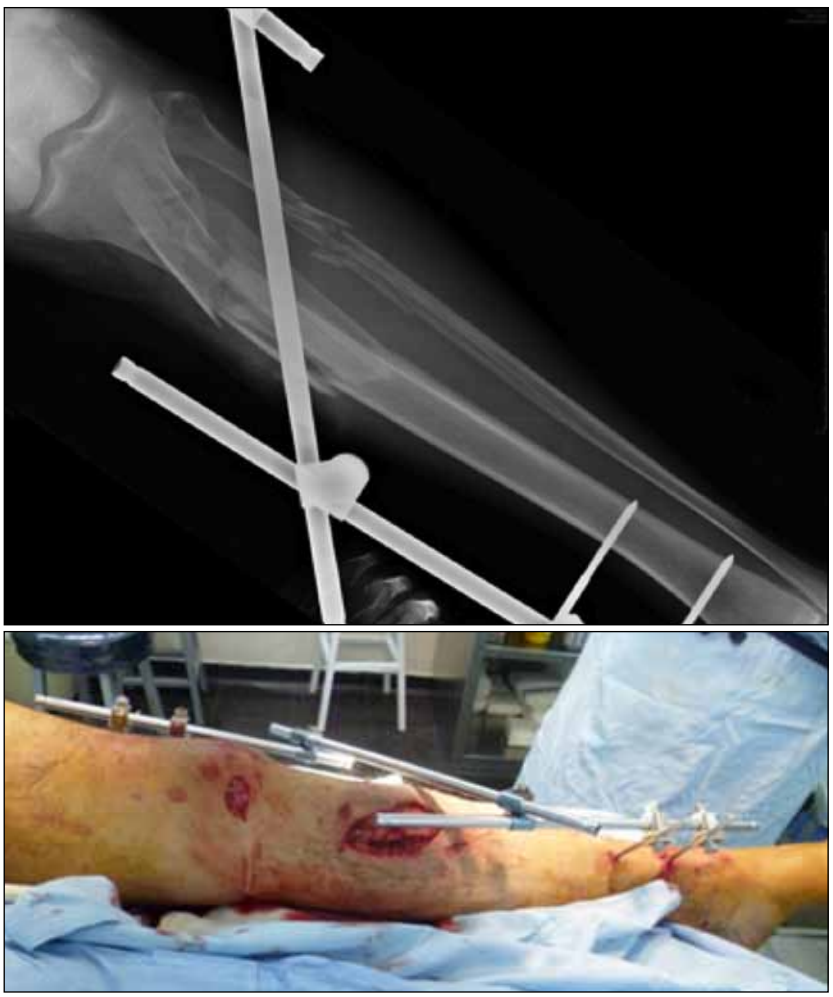

Figure 3. Case 1. Insertion of the external fixation.

Figure 4. Removal of external fixation. Internal gastrocnemius rotatory flap plus insertion of locking plate 48 hour after admission.

Figure 5. Case 1. Medial insertion of locking plate, four months after the surgery.

Six patients with Schatzker's type VI fracture required multiple surgeries. One of them underwent knee arthrodesis whereas two patients were subject to knee total arthroplasty (the three of them due to post-traumatic osteoarthritis); another one required supplementation with 3.5 mm reconstruction plate by medial approach due to insufficient osteosynthesis at the first surgical time; one patient suffered infra-patellar amputation due to bone healing failure with methicillin-resistant *Staphylococcus aureus* infection, and another one received an internal gastrocnemius rotatory flap plus skin flap (open 3C Gustilo fracture). Bone healing time was 4 ± 2 months.

In the four patients who received definite treatment with external fixators (2 Schatzker's type V and 2 Schatzker's type VI fractures), decrease in ROM was striking: 5º-90º and 0º-90º in the Schatzker's type V fractures, and 0º-110º and 5º-110º in the Schatzker's type VI fractures.

In the group of the Schatzker's type V fractures, the average ROM was 2.4º-120.68º, with no significant differences (p=0.5131) as compared to the group of the Schatzker's type VI fractures, whose average ROM was 1.5º-118.04º. Due to the classification homogeneity, the distribution of this ROM across

the whole sample had 85º and 110º as P_5 and P_{25} percentiles respectively, and the maximum ROM (130º) as P_{75}, what shows that 75% of the patients did not reach such ideal ROM.

With respect to pain as evaluated by the VAS, there were significant differences between the groups with Schatzker's type V and VI fractures (p=0.0403), because de former had 50% of the patients not reporting pain whereas only 25% of them had a ≥2 score. In the latter this pattern was different, because 50% of the patients reported pain above score=2, whereas in 25% of them the score was >3.

So as to get more accurate results, we grouped the >2-VAS scores in a unique modality, what resulted in a new scale with three categories: 0, 1 and 2 (original ≥2 VAS). The association with the classification of the fracture was highly significant (p=0.0109)—the patients with Schatzker's type VI fracture reported 75% with >2 pain. Figure 6

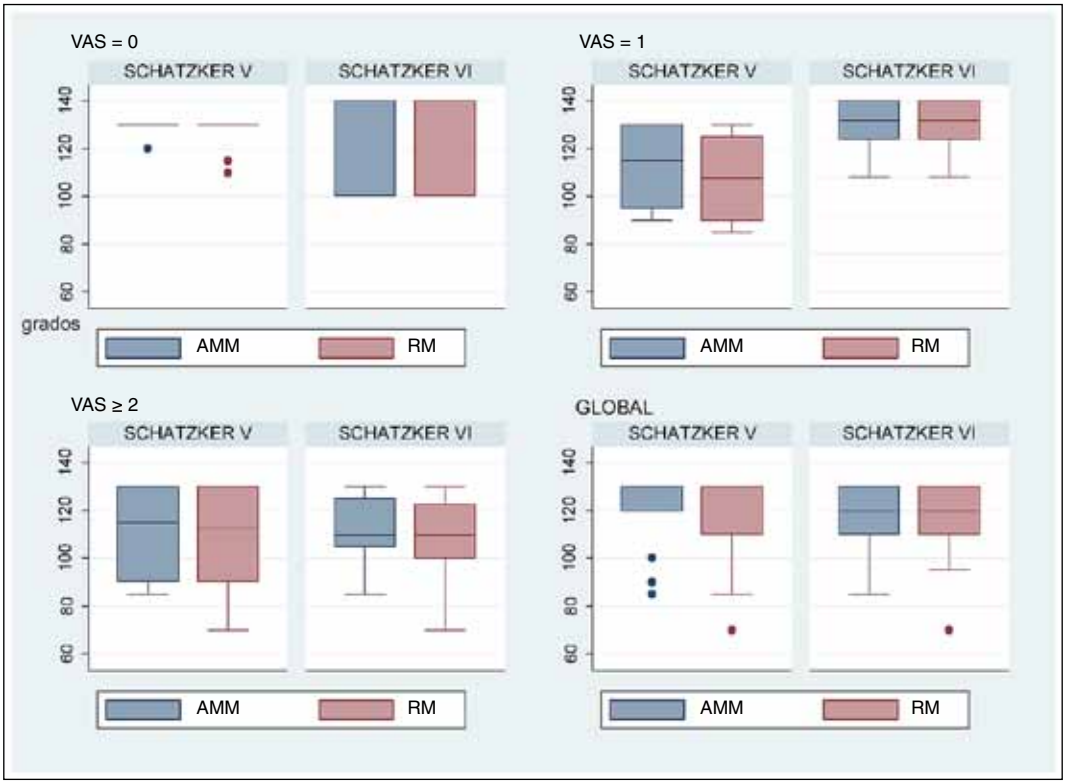

Figure 6. Box diagrams of range of motion (ROM) and maximal mobility amplitude (MMA) based on the classification of the fracture and the visual analogue scale.

shows the distribution of the ROM, what shows, mainly in VAS=0 (no pain), different behaviors in maximal mobility amplitude and total ROM.

Seventy-eight percent of the patients suffered no complications. On the other hand, 45% of the patients (5) who did suffer complications underwent dysbasia (2 of them requiring arthroplasty); 27% of them (3), non-union; 9% of the patients (one case), cellulitis; and 18% of them (2 cases), chronic osteomyelitis (one caused by Gram-Negative bacilli and the other one caused by methicillin-resistant *Staphylococcus aureus*). The presence of complications, as shown afterwards, conditioned the patients' functional results (Table 1).

Functional assessment by the KOOS scale proved significant differences neither between sexes (p=0.849) nor between the fracture classifications (p=0.883); the averages and the standard deviations of this integrated indicator were: 75.33 ± 22.53 (Schatzker's type V fracture) and 72.30 ± 16.45 (Schatzker's type VI fracture). Disaggregated by item, global average figures were as follow: 80.11 (pain), 78.02 (activities of daily living), 35.98 (sport/recreation activities), 69 (life quality), and 73.39 (symptoms/rigidity).

We grouped the patients in three by age so as to facilitate the analysis: 20-40, 41-60 and 61-75 years old, what resulted in an average KOOS score of 79.88%, 73.35% and 57.62%, respectively. The KOOS differed as the patients' high blood pressure status did (p=0.0706; 65.65 ± 7.55 and 78.38 ± 3.1-average ± standard deviation with and without high blood pressure respectively); on the other hand, with respect to age (p=0.07), the KOOS decreased 0.74 per additional year of age.

Figure 7 and Tables 2 and 3 illustrate the behavior of the KOOS score in relationship with some of these covariables.

Lastly, the presence of complications conditioned this scale score, decreasing it highly significantly (52.1 ± 12.4 and 81.7 ± 16.4 with and without complications, respectively) (Figure 8), although there were no differences as compared with other comorbidities such as diabetes (p=0.481), toxic habits (p=0.524).

Both the KOOS and the VAS scales were used in March 2016 with a 5-year follow-up in the former and an 8-month follow-up in the latter.

Discussion

Tibial plateaus are one of the main surfaces that bear the body weight, and the treatment of tibial plateau fractures is most important. However, optimal treatment is still controversial and results are poor.

Table 1. Characteristics of patients and complications

Patient	Age	Sex	Schatzker	Complications	Range of motion	Visual analogue scale
1	45	M	VI	-	0°-110°	3
2	40	M	VI	-	0°-120°	4
3	50	M	VI	-	0°-110°	2
4	53	M	VI	-	0°-110°	1
5	43	M	V	-	5°-100°	2
6	48	F	V	-	0°-130°	2
7	47	F	V	-	5°-90°	1
8	37	M	V	-	0°-130°	0
9	59	M	V		0°-130°	0
10	61	M	V	Dysbasia	0°-130°	5
11	75	F	V	-	0°-130°	0
12	37	M	V	-	0°-130°	0
13	38	M	VI	-	5°-130°	2
14	52	M	VI	-	0°-110°	3
15	72	F	V	-	0°-90°	2
16	51	M	3C Gustilo V	-	0°-100°	3
17	24	M	V	-	0°-130°	2
18	39	M	V	-	10°-130°	1
19	35	M	V	-	0°-130°	0
20	55	M	V	-	0°-130°	1
21	49	M	V	Dysbasia	5°-120°	0
22	50	M	V	Non-union	0°-130°	0
23	45	F	VI	-	5°-110°	4
24	66	M	VI		0°-130°	1
25	39	F	VI	Dysbasia	0°-0°	2
26	48	F	3C Gustilo VI	Chronic osteomyelitis	0°-100°	2
27	40	M	VI	-	0°-130°	5
28	57	M	V	-	0°-130°	0
29	22	F	V	Non-union	0°-130°	0
30	43	M	V	-	15°-85°	3
31	69	M	VI	Cellulitis	5°-100°	2
32	39	M	VI	-	0°-110°	2
33	22	F	VI	Dysbasia	0°-130°	2
34	50	M	V	-	5°-100°	1
35	46	M	3A Gustilo V	-	0°-120°	0
36	49	F	VI	Chronic osteomyelitis	0°-130°	0
37	57	M	VI	-	0°-0°	5
38	57	M	VI	-	0°-120°	1
39	54	F	VI	-	0°-120°	1
40	63	F	V	-	10°-120°	0
41	45	F	V	-	0°-130°	0
42	38	F	VI	Non-union	0°-130°	0
43	61	M	VI	-	15°-85°	3
44	42	M	VI	-	0°-130°	1
45	43	F	VI	Dysbasia	0°-130°	1
46	52	F	V	-	0°-130°	0
47	43	M	VI	-	0°-120°	1
48	58	F	VI	-	5°-100°	2
49	36	F	VI	-	0°-130°	1
50	30	F	VI	-	0°-120°	0
51	74	M	V	-	0°-120°	1

F = female, M = male.

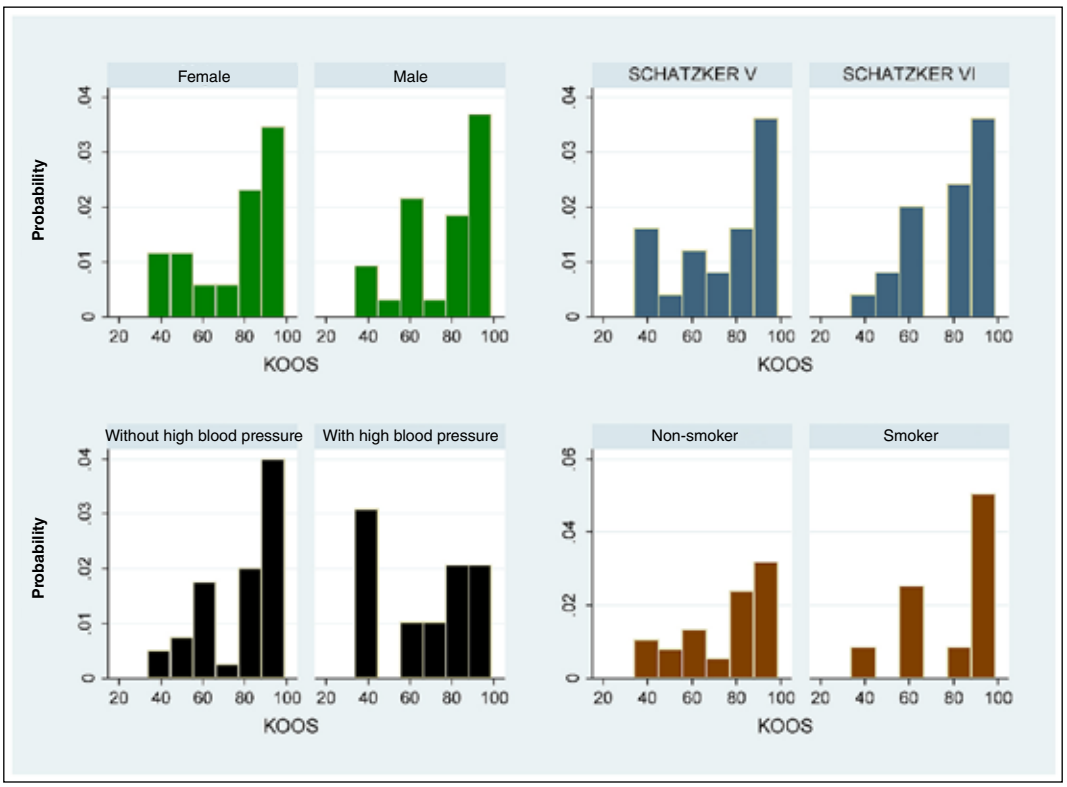

Figura 7. Histogram of the KOOS scale based on sex, fracture classification, blood pressure status and smoking habit.

Table 2. KOOS results based on type of fracture

KOOS scale						
Patients	**Total**	**Symptoms/ rigidity**	**Pain**	**Activities of daily living**	**Sport/recreation activities**	**Calidad de vida**
Total = 50	**73.78%**	73.39%	80.11%	78.02%	35.98%	69%
24 Type V Schatzker*	**75.33%**	74.85%	82.29%	80.74%	40.41%	75.52%
26 Type VI Schatzker	**72.30%**	74.86%	78.09%	78.50%	33.26%	67.5%

*One patient with Schatzker's type V fracture passed away two years after the treatment due to other causes, and the sample ended up made up of 24 patients.

Table 3. Results of the KOOS scale by age group

KOOS scale						
Age group	**Total**	**Symptoms/ rigidity**	**Pain**	**Activities of daily living**	**Sport/recreation activities**	**Life quality**
20-40 (20 patients)	**79.88**	86.96	85.47	86.97	63.75	78.75
41-60 (23 patients)	**73.35**	71.82	78.62	77.17	28.91	70.92
61-75 (7 patients)	**57.62**	56.63	67.46	68.27	9.28	55.35

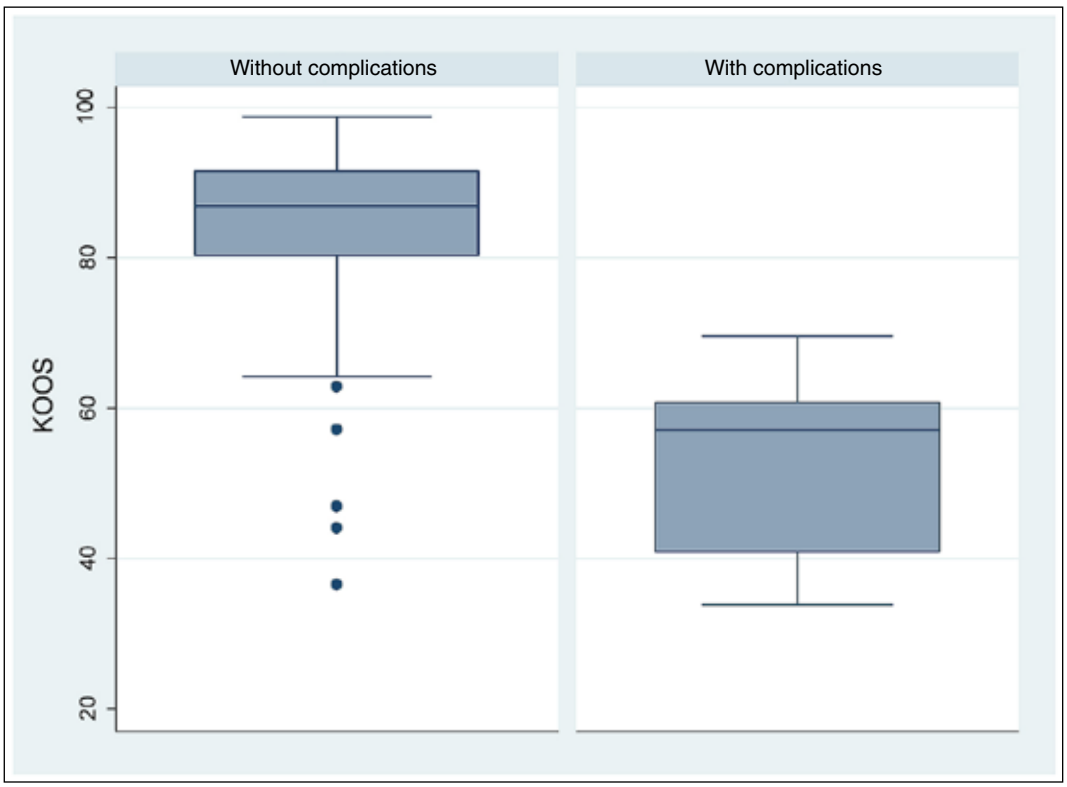

Figure 8. Box diagrams of the KOOS scale based on the presence of complications.

The therapeutic aims in tibial plateau fractures are to get anatomic reduction with articular coherence and stable fixation for early mobilization, and to avoid complications such as infection, non-union and post-traumatic osteoarthritis.

Our series includes 51 patients with Schatzker's types V and VI tibial plateau fractures, with an average follow-up of 42 months.

The study incorporates data about functional results such as knee ROM, articular stability, post-operative pain and association with comorbidities, consumerism habits and complications in a group of patients with tibial plateau fracture secondary to high-energy traumatism.

Based on a sample of considerable size, we report that the average ROM does not differ accordingly to the fracture classification (Schatzker's types V or VI): it is about 1.95°-119.36° and it is associated neither with comorbidities nor with smoke. Other important findings were a considerable decrease in percentages in the KOOS scale in the elder patients and that, in the vast majority of the cases, the patients' return to sport/recreational activities after fracture healing is the variable associated with the worst results. Pain, as evaluated by the VAS, differs in relationship with the fracture classification and it is more severe in Schatzker's type VI fractures.

Upon analyzing our results, the evidence this study provides us with is valuable also if we take into account the size of the sample, because at the time of matching it with other pieces of research, there are just few giving out results that are based on samples of sizes similar to ours. Moreover, we verified that the patients with complications suffered more pain as evaluated by the VAS and had a smaller ROM.

With respect to the presence of complications, our sample had a good performance, similarly to other works. Working with a smaller sample, Luo et al.[3] reported 21% of complications (dysbasia, wound superficial infection, among others). A study carried out by Spagnolo,[13] although associated with much less evidence than ours (18 patients with Schatzker's type VI fracture) showed that after a 24-60 month follow-up, approximately 40% of the patients reported complications (superficial infection, non-union and irritation of soft tissues by osteosynthesis material).

Although the patients' complication rates were 23%, this was enough to condition the functional results tendency, because the patients' average scores in the KOOS scale decreased significantly, but the presence of comorbidities such as diabetes and toxic habits had no influence on results.

Phistkul et al.[6] analyzed 37 patients with Schatzker's types V and VI tibial plateau fractures, and reported an average ROM of 112º (ranging from 70º to 140º), with average extension of 10º-20º and average flexion of 85º-130º; their results were poorer as compared to our series of cases.

In our study, results were similar to Cho et al.'s,[14] who got an average ROM of 2.5-122.5 in the 10 analyzed patients and a score of 2.2 in the VAS, although the number of patients was low.

While analyzing functional results with the KOOS scale, van Dreumel et al.[15] evaluated 40 patients with Schatzker's types V and VI fractures and average scores were 81.93% for type V fractures (symptoms/rigidity: 92.86%; pain: 97.22%; activities of daily living: 91.18%; sport/recreational activities: 52.50%; life quality: 62.50%) and 85.63% for type VI fractures (symptoms/rigidity: 96.43%; pain: 90.63%; activities of daily living: 92.65%; sport/recreational activities: 90.00%; life quality: 81.25%), differently from our study, where we got worse results in Schatzker's type VI fractures as compared to Schatzker's type V fractures.

We chose the KOOS scale because it is more suitable to the parameters to be evaluated, it is independent from the patient's age and it can be applied to patients of whichever age, although we know that there are other tests such as the Lyshom, the Oxford Knee Score and the Knee Society Score, which are more useful at the time of evaluating ligament surgeries and knee arthroplasty.

We believe that the strength of our study is the size of the sample together with the follow-up and our decision to use the KOOS scale in functional results, because it covers different aspects that we were able to associate with the VAS score.

On the other hand, one of our study weaknesses was that it was a series of cases with retrospective analysis that took neither surgical techniques nor radiographic results into account.

Conclusions

Tibial plateau fractures are still a condition in which results modify patients' life quality significantly. Therefore, they should be warned about the possibility of long-term poor results and the need for multiple surgeries. Moreover, they should be given information about the possibility of not recovering previous levels of sport and working activities.

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