Treatment of Comminuted Patellar Fracture: Are There Differences between Performing or Not Performing an Eversion?

Tratamiento de la fractura conminuta de patela: ¿existen diferencias entre realizar o no una eversión?

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Abstract

Purpose To compare the clinical, functional and imaging outcomes of two surgical techniques for the treatment of comminuted patellar fractures: with and without eversion.

Methods In a retrospective series of cases of comminuted patellar fractures treated at a single center between 2014 and 2017, with a follow-up $\geq$ 3 months , we performed a comparison between the eversion group and the non-eversion group eversion. The exclusion criteria were partial or total patellectomy, tendon reinsertion, or incomplete rehabilitation. The variables analyzed were age, gender, smoking, diabetes mellitus, the energy of the accident, the fracture type, surgical variables (tension band, screws, wires, knots, circular cerclage), postoperative joint range of motion (ROM), presence of symptomatic osteosynthesis, the scores on the functional scales (of Tegner-Lysholm and of Kujala) at the final discharge, complications (joint stiffness, infection, deep vein thrombosis), and pre- and postoperative computed tomography imaging variables (gap, step-off $>$2mm, intra-articular fixation elements).

Results In total, 20 out of 22 patients, 13 undergoing eversion and 7 not undergoing eversion, met the selection criteria.. The follow-up ranged from 3 to 12 months, and there were no statistically significant differences regarding the demographic variables

Keywords
- patellar fracture
- patellar eversion
- comminuted fracture
- tension band

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between both groups, which makes them comparable. The most remarkable results were the time from admission to final discharge, of 7 months for the patients in the eversion group, and of 5 months for those in the non-eversion group ($p = 0.032$), the proportion of patients with a step-off > 2 mm, with 7.7% for the eversion group and 14.3% for the non-eversion group ($p = 0.016$), and a tendency towards higher scores in the functional scales for the eversion group.

Conclusion The treatment of comminuted patellar fractures with eversion seems to be a viable alternative, given its superior imaging and functional results compared to those of the usual technique.

Resumen

Objetivo Comparar los resultados clínicos, funcionales e imagenológicos de dos técnicas quirúrgicas para el manejo de fracturas conminutas de patela: con y sin eversión patelar.

Métodos En una serie de casos retrospectivos de fracturas conminutas de patela tratadas en el mismo centro entre 2014 y 2017, con un seguimiento ≥ 3 meses , se hizo una comparación entre el grupo con eversión y el grupo sin eversión. Los criterios de exclusión fueron patelectomía parcial o total, reinserción tendínea, o rehabilitación incompleta. Las variables analizadas fueron edad, sexo, tabaquismo, diabetes mellitus, energía del accidente, tipo de fractura, variables quirúrgicas (banda de tensión, tornillos, alambres, nudos, cerclaje circular), rango de movimiento (RDM) articular postoperatorio, presencia de osteosíntesis sintomática, puntaje de escalas funcionales (de Tegner-Lysholm y de Kujala) al alta definitiva, complicaciones (rigidez articular, infección, trombosis venosa profunda), y variables imagenológicos con tomografías computarizadas pre- y postoperatorias (brecha, desnivel articular > 2 mm, elementos de fijación intraarticular).

Resultados En total, 20 de 22 pacientes, 13 con eversión y 7 sin eversión, cumplieron con los criterios de selección. El seguimiento fue de 3 a 12 meses, y no hubo diferencias estadísticamente significativas respecto a las variables demográficas entre ambos grupos, lo cual los hace comparables. Destacaron el tiempo desde el ingreso al alta, con 7 meses para los pacientes con eversión y 5 meses para los sin eversión ($p = 0.032$), la proporción de pacientes con desnivel articular > 2 mm, con 7.7% para los con eversión y 14.3% para los sin eversión ($p = 0.016$), y una tendencia a resultados superiores en escalas funcionales para el grupo con eversión.

Conclusión El tratamiento de fracturas conminutas de patela con eversión parece ser una alternativa viable dados sus resultados imagenológicos y funcionales superiores a los de la técnica habitual.

Palabras Clave
- fractura patelar
- eversión patelar
- fractura conminuta
- banda de tensión

Introduction

Patellar fractures correspond to 1% of all fractures.[1] In recent decades, the role of the patella of increasing the lever arm of the quadriceps has been well defined. Its treatment aims at preservation of the bone and of the vascular supply, and at restoration of the joint and of the function of the extensor apparatus. These results have been optimized using the technique of anatomical reduction and fixation.[2] However, certain anatomical characteristics of the patella, such as its extensive articular surface and subcutaneous location, the significant biomechanical requirements of the patellofemoral joint, and the need to obtain complete and early mobility make it continue to be a great challenge.[1–3]

Surgical treatment is indicated in exposed fractures, those that compromise the function of the extensor apparatus, those that present a joint gap greater than 5 mm and/or joint incongruity greater than 3 mm, a group that corresponds to around 30% of the total.[4] Anatomical reduction and stabilization with various types of modified tension band (►**Figure 1**) is the procedure most frequently used.[3] Biomechanical studies have shown that stabilization through the use of a tension band replacing Kirchner needles with cannulated screws (►**Figure 2**) presents adequate resistance to fracture displacement and provides greater stability than the classic configuration,[5] maintaining the theoretical principle of converting the anterior tension forces of the patella generated by the quadriceps in compression at the level of the articular surface.[1–3,5]

Comminuted and displaced fractures of the patella require surgical treatment to obtain better clinical and functional results, which represents a complex scenario in which

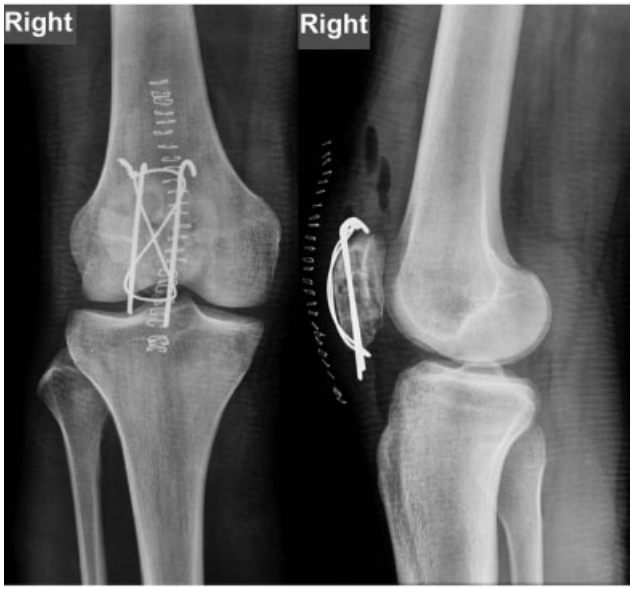

Fig. 1 Anteroposterior (AP) and lateral radiographs showing a patellar fracture treated with the use of a tension band with Kirchner needles + wire loop.

Fig. 2 Radiographs in AP and lateral views showing a patellar fracture treated with the use of a tension band performed with a wire loop through cannulated screws.

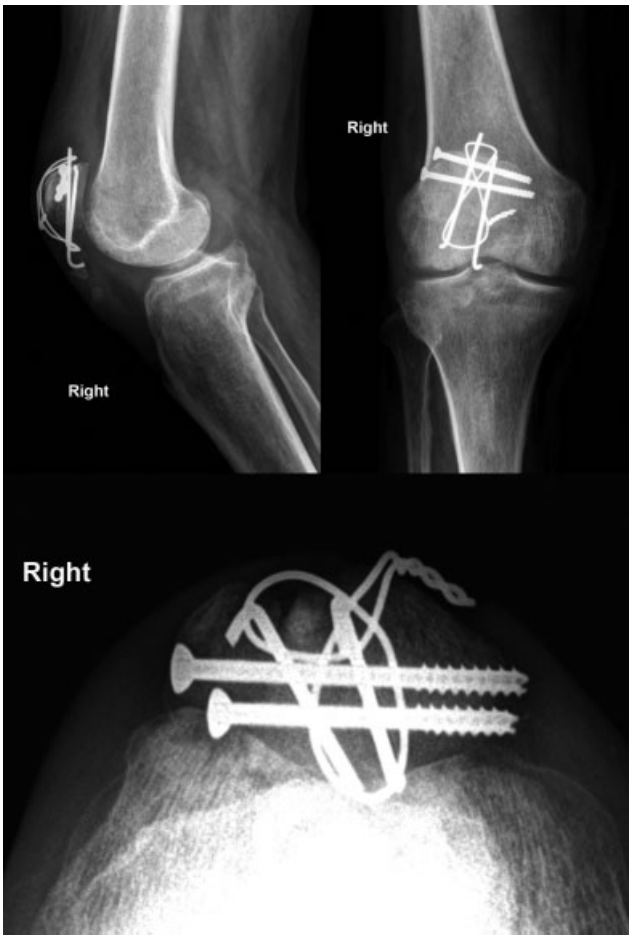

Fig. 3 Radiographs of a right knee with a patellar fracture treated with a tension band with Kirchner needles and cannulated screws. The protrusion of the osteosynthesis elements is visible, which correlates with the symptoms reported by the patient.

the use of the aforementioned fixation is insufficient in most cases, which implies the use of more and different elements of osteosynthesis. This is associated with a greater possibility of implant breakage and migration, generating discomfort and eventually loss of reduction.[1] (►**Figure 3**).

It is essential to consider the biomechanics of the bone and the fixation method to be used; in the case of the patella, the angle between the force vector of the quadriceps and that of the patellar tendon determines that, in flexion, the patella bends, separating the fragments,[1] which is neutralized by the tension band that converts these forces into compressive forces at the level of the fracture, the variant performed using cannulated screws being the most stable.[15]

The treatment by eversion of the patella enables a direct view of the articular surface to be obtained, as well as the control and correction eventual step-offs in it, making the use of intraoperative fluoroscopy unnecessary[7] (►**Figure 4**).

On the other hand, conventional management, without patellar eversion and requiring the use of fluoroscopy, has the benefit of being comparatively less interventional, since the patella is less manipulated; and with the shorter surigcal time and fewer procedures performed, there is a lower potential of surgical risks.

The objective of the present work is to compare the functional and imaging results in the management of comminuted patellar fractures treated surgically by using a modified tension band with and without eversion. Our hypothesis is that the management of these fractures through eversion would yield better functional and imaging results and fewer complications than the treatment without eversion.

Material and method

We performed a retrospective evaluation of a surgical series of 20 patients with a diagnosis of comminuted patellar fracture, treated in the same center between January 2014

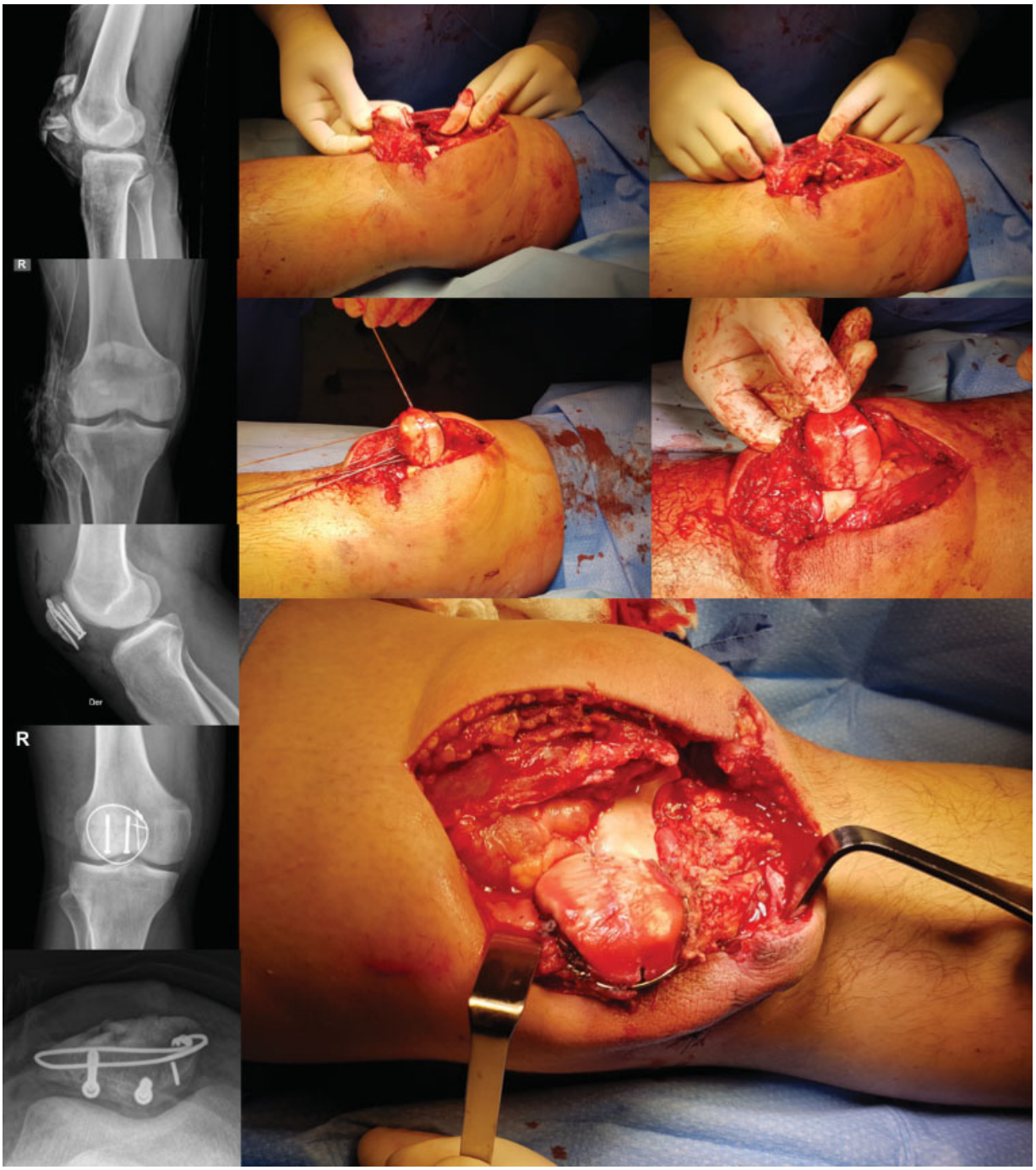

Fig. 4 Clinical imaging correlation of exposed right patellar fracture with significant joint comminution and sequence of patellar eversion technique and circular cerclage fixation associated with tension band with fiber tape super suture (Arthrex, Inc.), with 3.5-mm cannulated screws (DePuy Synthes, West Chester, PA, US)

and April 2017, subject to workers' compensation. All patients underwent open reduction and internal fixation using a tension band. The cohort was divided into 2 groups: 1 of cases, composed of 13 patients with unilateral comminuted patellar fracture undergoing eversion, and a control group consisting of 7 patients with unilateral comminuted patellar fracture treated without eversion.

The recording of the evaluated variables was carried out in the electronic clinical records of our hospital (Medisyn 3.0, – Tisal S.A., Santiago, Chile) from the moment of admission and in each of the evaluations, until discharge. The information recorded in this system was retrieved and systematized in a database using Excel (Microsoft Corp. Redmond, WA, US), version 2015, and submitted to a subsequent statistical analysis using the STATA (StataCorp. LLC, College Station, TX, US) software, version 14.0.

For the inclusion of patients in this cohort, the following criteria were used: diagnosis of comminuted patellar

fracture, complete pre- and postoperative imaging studies (radiography and computed tomography [CT]), surgical management with definitive osteosynthesis with tension band through cannulated screws, and complete treatment carried out in the same hospital center. Patients with: incomplete studies, loss to follow-up, those who underwent total or partial patellectomy, tendon reattachment, and those with previous injuries to the patella or incomplete rehabilitation were excluded.

The rehabilitation consisted of the use of an immobilizer with full discharges for at least three weeks. Progressively, the increase in the range of motion (ROM) in flexion and quadriceps activation with motor kinesiotherapy three times a week, walking with two poles and guided daily home exercises, were authorized until a minimum time of twelve weeks was completed.

The following groups of variables were recorded and analyzed: demographics (age, gender, smoking, diabetes mellitus); those related to the accident (bone exposure, energy involved, number of major fragments in the fracture and Arbeitsgemeinschaft für Osteosynthesefragen [AO] classification of the fracture); surgical variables (type of tension band, diameter of screws and wires, knots and circular cerclage); those pertaining to the clinical evaluation (joint ROM and presence of symptomatic osteosynthesis); the score on the functional scales (Tegner-Lysholm and Kujala) applied at discharge; the complications (joint stiffness, superficial and deep infection, deep vein thrombosis [DVT] and nonunion); and the evaluation of imaging results by postoperative radiography and CT (gap and joint step-off before and after surgery, and intra-articular fixation elements). This last revision was carried out by a radiologist subspecialized in musculoskeletal imaging.

To determine the normality of the distribution of the sample, the Shapiro-Wilk test was performed. In the statistical analysis, parametric *t*-Test and non-parametric Chi-squared and Man-Whitney U tests were carried out according to the distribution, using the STATA software, version 14.0. Values of $p < 0.05$ were considered significant.

Results

The eversion group consisted of 13 patients: 2 women and 11 men, with an average age of 41.8 years (range: 21 to 70 years). The non-eversion group consisted of 7 male patients, with a mean age of 38.7 years (range: 24 to 59 years). In each group, there was only 1 smoker, and none of the 20 patients declared to have diabetes mellitus. No statistically significant demographic differences were found.

In the eversion group, 8 patients (62%) presented high-energy trauma, and 3 (23%) presented exposure of the fracture. In the non-eversion group, 3 patients (42%) had high-energy trauma, and only 1 (14%) had an open fracture. No significant differences were found between both groups regarding these variables.

In both groups, the median number of major fragments per fracture was 3, and the most frequent AO classification was 34-C3, present in 54% of the eversion group and in 71% of the non-eversion group. There were no significant differences between the two groups in terms of the characteristics of the fracture.

Regarding the surgical technique, in the eversion group, the 2 types of tension band used were screws and wires in 9 patients (69%), and screws and fibertape (Arthrex, Inc., Naples, FL, US) in 5 patients (39%); while in the non-eversion group, the 2 types used were screws and wires in 3 patients (43%), and needles and wires in 4 patients (57%). When analyzing the diameter of the screws and wires, no significant differences were found between the groups. Circular cerclage was performed in all patients in the eversion group, and in none of the patients in the non-eversion group. In all patients in whom wires were used, one knot was made. ►**Table 1** shows the summary of the most relevant patient characteristics.

The mean joint ROM in flexion and extension was of 122° and 0° in the eversion group, and of 118° and 0° in the non-eversion group, with no statistically significant differences. Regarding complications, there were five adverse events (four mobilizations under anesthesia [MUA] and one infection of the operative wound) in the eversion group, and two adverse events (one MUA and one infection of the operative wound) in the non-eversion group, with no statistically significant differences. The fact that in none of the groups nonunion as a complication was observed stands out. The average functional results of the eversion group were: Tegner-Lysholm – 89.8, and Kujala – 85.6, versus 73.2 and 69.0 respectively for the non-eversion group; there were no statistically significant differences between the groups. Regarding the time from surgery to discharge to return to work, it was of 7 months for the eversion group, and of 5 months for the non-eversion group, a statistically significant difference ($p = 0.032$). The evaluation of the imaging results using CT showed that, with a *p*-value of 0.016, there were significant differences when analyzing the joint step-off between the groups, with a higher number of step-offs in the non-eversion group. However, when analyzing the gap at the joint level, there were no significant differences. In both groups, the absence of fixation elements in an intra-articular location was observed. The summary of these results is shown in► **Table 2**.

Discussion

In total, 1% of all fractures affect the patella, and, despite the fact that it is a small percentage, its location, extensive joint surface, and function determine the presence of significant functional sequelae if it undergoes inadequate treatment. It is essential to consider the biomechanics of the segment/bone and the fixation method to be used; in the case of the patella, the angle between the force vector of the quadriceps

Table 1 Demographic and surgical characteristics of the patients with comminuted patellar fracture operated with and without patellar eversion

	Subject	Gender	Age	High energy	Exposition	No. of major fragments	AO Classification	Type pf tension band	Screws (diameter)	Wire (diameter)	Circular cerclage
With eversion	1	Male	70	No	No	3	34-C2	Screws and wire	3.0 mm	1.0 mm	Yes
	2	Male	35	No	No	4	34-C3	Screws and wire	4.3 mm	1.2 mm	Yes
	3	Male	21	Yes	Yes	2	34-C3	Screws and fibertape	3.5 mm	–	Yes
	4	Male	33	Yes	No	3	34-C3	Screws and wire	4.0 mm	1.2 mm	Yes
	5	Male	33	Yes	Yes	3	34-C3	Screws and wire	4.0 mm	1.6 mm	Yes
	6	Male	31	Yes	No	3	34-C2	Screws and wire	4.0 mm	1.2 mm	Yes
	7	Male	29	Yes	No	3	34-C3	Screws and wire	4.0 mm	1.2 mm	Yes
	8	Male	22	Yes	No	3	34-B1	Screws and fibertape	3.0 mm	–	Yes
	9	Male	49	No	No	3	34-C3	Screws and wire	3.5 mm	1.2 mm	Yes
	10	Female	54	No	No	2	34-A2	Screws and fibertape	3.5 mm	1.2 mm	Yes
	11	Male	70	Yes	No	3	34-C3	Screws and wire	3.5 mm	1.2 mm	Yes
	12	Female	66	No	No	2	34-C2	Screws and fibertape	4.0 mm	–	Yes
	13	Male	31	Yes	Yes	3	34-C2	Screws and fibertape	4.5 mm	1.2 mm	Yes
Without eversion	14	Male	36	Yes	No	3	34-C3	Needles and wire	–	1.2 mm	No
	15	Male	24	Yes	No	3	34-C3	Screws and wire	3.5 mm	1.0 mm	No
	16	Female	59	No	No	3	34-C3	Needles and wire	–	1.2 mm	No
	17	Male	42	No	No	2	34-C2	Needles and wire	–	1.5 mm	No
	18	Male	42	No	No	2	34-C1	Needles and wire	–	1.2 mm	No
	19	Male	36	Yes	Yes	4	34-C3	Screws and wire	3.5 mm	1.2 mm	No
	20	Male	32	No	No	3	34-C3	Screws and wire	4.0 mm	1.2 mm	No

Table 2 Comparison of results between patients with patellar fracture operated with and without patellar eversion

	Parameter	With eversion	Without eversion	*p*-value
Imaging (computed tomography)	Joint gap	1 (7.7%)	0 (0.0%)	0.509
	Joint step-off	**1 (7.7%)**	**1 (14.3%)**	**0.016**
Complications	Joint stiffness	4 (30.8%)	1 (14.3%)	0.516
	Infection	1 (7.7%)	1 (14.3%)	0.299
Joint range	Maximum flexion	118°	122°	0.072
	Maximum extension	0°	0°	0.463
Functional assessment	Lysholm	89.5	73.2	0.124
	Kujala	85.6	69.0	0.160
Time	**From surgery to discharge to return to work**	**7 months**	**5 months**	**0.032**

and that of the patellar tendon determines that, in flexion, the patella bends, separating the fragments,[1,6] which is neutralized by the tension band that converts these forces into compressive forces at the level of the fracture, with the variant performed using cannulated screws being the most stable.[6,8] Treatment by eversion of the patella enables the direct visualization of the articular surface to be obtained, as well as the control and correction of eventual step-offs of the latter, making the use of intraoperative fluoroscopy unnecessary[7] (►**Figure 4**). Patellar eversion is a technique that makes it possible to dispense with fluoroscopy, a favorable situation, with the understanding that its use in the evaluation of the articular surface is not entirely reliable, since it depends on the characteristics of the equipment, the operator, and an adequate technique.[8,9] In the present review, we did not find significant differences between the two groups of patients in this surgical series in terms of the clinical aspects evaluated. Regarding the evaluation of the imaging results, we observed a greater number of patients with joint step-off in the non-eversion group, without a clinical correlation; therefore, we consider both surgical alternatives acceptable. The group of patients treated by patellar eversion presents slightly superior results in terms of functional scales, and even when these are not statistically significant, they could favor this therapeutic alternative. Among the limitations of the present work are the small sample size and the short follow-up, so we cannot associate differences in terms of clinical and functional results between the different groups studied. The development of posttraumatic osteoarthritis in fractures with joint involvement is a frequent complication that can lead to functional alterations,[10] which can be evidenced in evaluations when the follow-up is prolonged. Based on this, we propose the performance of a prospective study with a longer follow-up, in order to determine if there are significant differences with greater impact.

Among the strengths of the present work, we can mention that it is the first work at the national level to compare both techniques, and that we have shown that this technique can be useful not only to shorten the recovery times of each patient but also to potentially provide precise indications of its safe use.

Conclusion

Comminuted patellar fracture is a difficult entity to manage, and it is associated with significant functional sequelae if it is not properly evaluated, studied and managed. The treatment with patellar eversion seems to be a viable alternative in the management of these fractures, and its imaging results and the time until discharge to return to work are significantly superior to those of the usual technique. We hope that studies with a longer follow-up and a larger sample size can demonstrate the safety and reproducibility of this technique.

Ethical Responsibilities

Protection of people and animals: the authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of the data: the authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent: the authors declare that no patient data appear in this article.

Conflict of Interests

The authors have no conflict of interests to declare.

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