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Original article

Surgical treatment of avulsion fractures at the tibial insertion of the posterior cruciate ligament: functional result☆

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ABSTRACT

Objective: To objectively and subjectively evaluate the functional result from before to after surgery among patients with a diagnosis of an isolated avulsion fracture of the posterior cruciate ligament who were treated surgically.
Method: Five patients were evaluated by means of reviewing the medical files, applying the Lysholm questionnaire, physical examination and radiological examination. For the statistical analysis, a significance level of 0.10 and 95% confidence interval were used.
Results: According to the Lysholm criteria, all the patients were classified as poor (<64 points) before the operation and evolved to a mean of 96 points six months after the operation. We observed that 100% of the posterior drawer cases became negative, taking values less than 5 mm to be negative.
Conclusion: Surgical methods with stable fixation for treating avulsion fractures at the tibial insertion of the posterior cruciate ligament produce acceptable functional results from the surgical and radiological points of view, with a significance level of 0.042.

Tratamento cirúrgico da fratura avulsão na inserção tibial do ligamento cruzado posterior: resultado funcional

Palavras-chave:
Fraturas ósseas
Ligamento cruzado posterior
Joelho

RESUMO

Objetivo: Avaliar o resultado funcional pré e pós-cirúrgico, de forma objetiva e subjetiva, dos pacientes com diagnóstico de fratura avulsão isolada do ligamento cruzado posterior que foram tratados cirurgicamente.
Método: Foram avaliados cinco pacientes por meio de revisão de prontuários, aplicação do questionário de Lysholm, exame físico e exame radiológico. Para a estatística foi usado nível de significância de 0,10 e intervalo de confiança de 95%.

☆ Work performed in the Department of Orthopedics and Traumatology, Hospital Universitário de Taubaté, Taubaté, SP, Brazil.

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Resultados: Segundo os critérios de Lysholm, todos os pacientes foram classificados como ruins (< 64 pontos) no pré-operatório, evoluíram para média de 96 pontos em seis meses de pós-operatório. Observamos a negativação de 100% da gaveta posterior, uma vez que consideramos negativo o valor menor do que 5 mm.

Conclusão: A fratura avulsão do ligamento cruzado posterior na inserção tibial quando tratada com métodos cirúrgicos e fixação estável produz resultados funcionais aceitáveis do ponto de vista clínico e radiológico para uma significância de 0,042.

Introduction

Knee ligament injuries are frequent topics of health-related research and publications. For some years, studies on the posterior cruciate ligament (PCL) have shared researchers' attention. Avulsion fractures, which are the subject of this study, are among the injuries to the cruciate ligament.

Avulsion fractures of the appendicular skeleton are commonly seen within orthopedic emergency scenarios. Their prevalence is continuing to rise as the population progressively becomes involved in athletic activities[1] and car accidents.[2]

Avulsion fractures consist of detachment of a bone fragment consequent to traction of a ligament, tendon or joint capsule from its point of bone insertion.[1] Although this type of injury is increasing, it is still rare, according to the literature, especially injuries to the PCL, which are sometimes underdiagnosed.[3–5] Avulsion of the PCL may be as much as 10 times less frequent than that of the anterior cruciate ligament (ACL), even in children.[6,7]

The PCL has an important role in the biomechanics of the knee and is fundamental to the stability of this joint because it is the primary restrictor of posterior translation of the tibia in relation to the femur.[2,8–11] The characteristics of the fracture, such as the size and displacement of the bone fragment, the region of the tibia affected and the patient's age, are important information in choosing the treatment and may influence the functional result.

In view of the importance of this topic, the main objective of the present study was to evaluate the functional quality of knees with avulsion fractures of the PCL before and after surgical treatment, in comparison with the literature.

Materials and methods

This was a retrospective observational study on five patients who were evaluated in our department between January 2013 and July 2014. This study had previously undergone analysis by our institution's ethics committee (which is registered with and approved by the Brazil Platform) and was authorized by it.

Patients were only included if they had a final diagnosis of a closed avulsion fracture of the PCL in isolation that had been diagnosed by means of simple radiography and computed tomography (Fig. 1), and if they underwent surgical treatment. There were no sex or age restrictions. Patients were excluded if they were treated conservatively, presented lesions with more than 30 days of evolution, showed pseudarthrosis, or had a diagnosis of intrasubstantial ligament lesions of the PCL or avulsion fracture of the anterior cruciate ligament (ACL).

During the clinical consultations, the patients underwent t subjective evaluations (Lysholm) and objective physical examinations (posterior drawer test) and radiography under stress.

Lysholm divided the results between excellent (95–100), good (84–94), fair (65–83) and poor (64 and under) according to

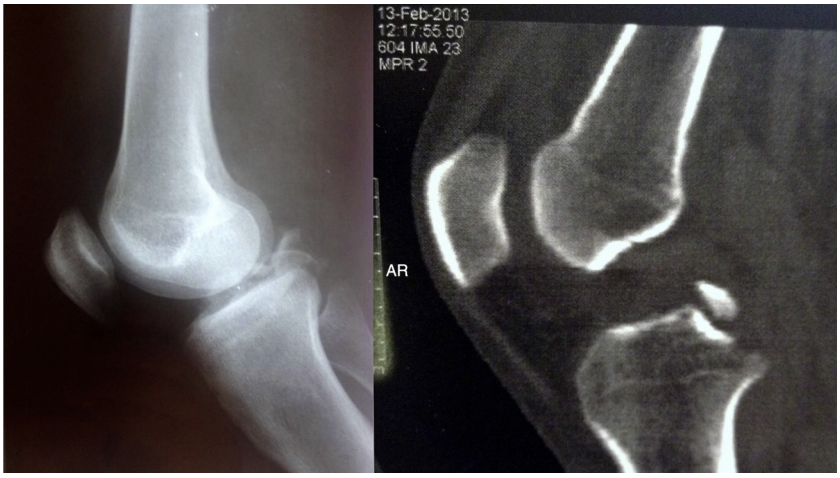

Fig. 1 – Simple radiography and computed tomography before the operation.

Fig. 2 – Technique used for radiography under stress at 80° of knee flexion, using 49 N on the ATT and radiological image.

the sum of the points obtained at the end of the questionnaire, in comparing the situations before and after the operation.[6]

The posterior drawer test was considered to be positive or negative in comparison with the clinical state of the contralateral knee, in the presence or absence of a stop, respectively.

For the radiography under stress, in lateral view, we used patients in horizontal dorsal decubitus, with the limb at 80°, supported only in the heel region, and a force of 49 N (N) applied to the region of the anterior tibial tuberosity (ATT). Following this, the posterior translation of the tibia in relation to the femur was quantified using a ruler: it was considered to be negative or zero when the displacement was less than 4 mm and was graded as one cross (+) if 5–9 mm and as two crosses (++) if greater than or equal to 10 mm, in comparison with each individual's contralateral limb (Fig. 2).[8–10,12]

The following information inherent to the surgical procedure was gathered from the medical files: duration of the operation, osteosynthesis and the surgical access route used. The following complementary information was also gathered: time elapsed between injury and treatment, associated lesions, trauma mechanism, age and sex of the patients (Table 1).

All the patients were positioned in horizontal ventral decubitus, spinal anesthesia was applied, a pneumatic tourniquet was used at the root of the thigh that was to be operated, and a posterior approach to the knee was used at the level of the popliteal fossa. Trickey's route[13] (in S shape) was used on three patients and, for the other two, it was decided to use a reduced incision as described by Burks and Schaffer[14] (in an inverted L shape), as illustrated in Figs. 3 and 4. After the incision had been made, dissection was performed in layers and the vascular-nerve bundle between the medial and lateral gastrocnemius muscles was identified and carefully pushed away. Central and posterior arthrotomy were performed, with identification of the bone fragment avulsed from its tibial bed.

None of the bone fragments were small enough to impede fixation with rigid material, which would have required transosseous suturing or binding. In these five cases, the principles of absolute stability, anatomical reduction and compression of the fracture focus with rigid synthesis (one or more screws with washers) were used, as can be seen in Fig. 5. We respected the growth plate even in cases of small fragments.

During the postoperative period, a plaster-cast splint extending from the thigh to the malleolus was used, without

Fig. 3 – Left: Trickey's route; and right: Burk's route.

Table 1 – Data relating to the description of the cases: sex, age, injury mechanism, presence of injury on the anterior face, duration of the surgery, time elapsed since injury, pre and postoperative range of motion, side injured, Lysholm result, radiograph under stress, incision and complications.

Patient	01	02	03	04	05
Sex	M	M	M	M	M
Age (years)	21	15	46	31	48
Injury mechanism	Motorcycle	Bicycle	Motorcycle	Motorcycle	Motorcycle
Injury on anterior face (lower leg or knee)	Yes	No	Yes	Yes	No
Duration of operation (in minutes)	40	35	55	40	30
Time elapsed between injury and surgery (in days)	22	06	07	21	16
Postoperative range of motion–flexion (right/left)	125°/145°	130°/120°	140°/140°	135°/135°	145°/135°
Preoperative range of motion–flexion (right/left)	Locked at 40°/preserved at 145°	Preserved at 130°/locked at 10°	Locked at 20°/preserved at 140°	Preserved at 135°/locked at 15°	Preserved at 145°/locked at 20°
Knee injured	Right	Left	Right	Left	Left
Lysholm questionnaire (before/after)	Poor (0)/Excellent (95)	Poor (25)/Excellent (99)	Poor (27)/Excellent (97)	Poor (25)/Excellent (95)	Poor (2)/Good (94)
Relative distances tibia–femur on radiograph under stress (right/left), in millimeters	3/0	0/1	2/0	0/2	0/1
Skin incision	Trickey	Trickey	Trickey	Burks	Burks
Postoperative complications	None	None	Dehiscence of suture	None	None

weight-bearing. The patients returned to the outpatient clinic in the second week for the stitches to be removed and for the plaster cast to be exchanged for a brace, so as to allow the start of passive mobilization and cryotherapy. After one month had been completed, a radiographic control was performed in order to progressively release the patients for weight-bearing and definitive removal of the immobilization. From the second month onwards, the patients were authorized to begin the work of muscle strengthening. In the third month, they returned to work and in the sixth month, after a clinical and radiological reevaluation, they were given a medical discharge.

The statistical methodology comprised the Wilcoxon test with a significance level of 0.10 and 95% confidence interval.

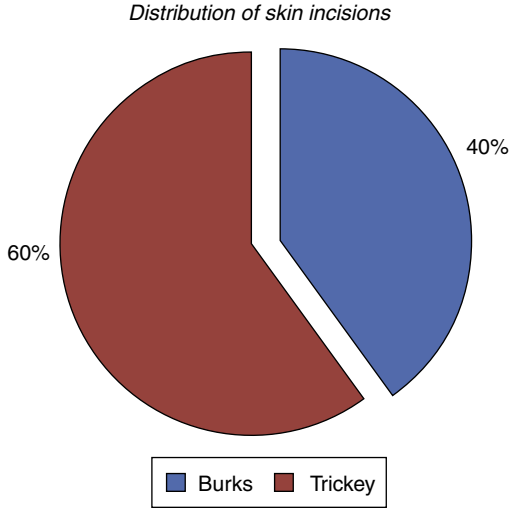

Fig. 4 – Illustration of the distribution of the incision in the skin.

Results

We started the results by doing a complete descriptive analysis according to age, duration of the surgical procedure and the time elapsed between injury and surgery (Table 2). It should be noted that 100% of the patients were male.

Table 2 – Complete description for age, duration of operation and time elapsed from injury to surgery.

Description	Age (years)	Duration of operation (min)	Time elapsed between injury and surgery (days)
Mean	32.2	40	14.4
Median	31	40	16
Standard deviation	14.7	9.4	7.6
CV	46%	23%	53%
Min	15	30	6
Max	48	55	22
N	5	5	5
CI	12.9	8.2	6.6

CV, coefficient of variation; Min, minimum value; Max, maximum value; N, sample size; CI, confidence interval.

Fig. 5 – Radiography of synthesis in an adolescent, parallel to the growth plate, thus preserving it.

The Wilcoxon method allowed us to consider that there was a statistically significant difference ($p = 0.042$) from the Lysholm result before the surgery, of 15.8 points (poor), to an average of 96 points (excellent). There was a single case of a good result (94 points) after the surgery, in which the patient lost one point (out of five points) in relation to squatting, because of slight asymmetry when flexed for squatting (10°), in comparison with the contralateral limb (Fig. 6 and Table 3).

A comparison was made with the mean posterior translation of the tibia in relation to the femur on radiographs under stress, with three reference values in millimeters (zero, one and five), given that all cases were at the limit for zero crosses or negative (Table 4).

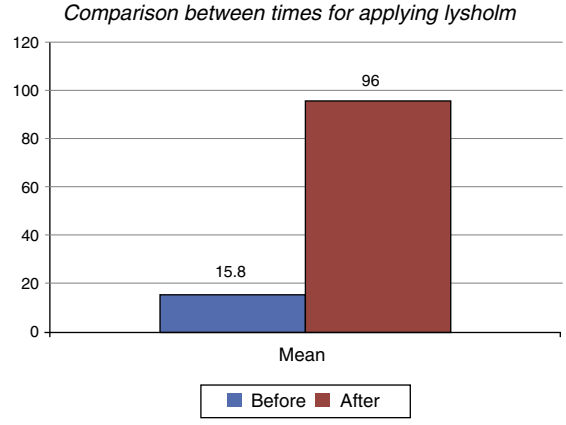

Fig. 6 – Illustration comparing times for applying Lysholm.

Table 3 – Comparison between times when Lysholm was applied.

Lysholm	Before	After
Mean	15.8	96
Median	25	95
Standard deviation	13.6	2
Min	0	94
Max	27	99
N	5	5
CI	11.9	1.8
p value	0.042	

CV, coefficient of variation; Min, minimum value; Max, maximum value; *N*, sample size; CI, confidence interval.

Table 4 – Comparison between radiograph under stress and reference values.

	Radiograph under stress
Mean	1.80
Median	2
Standard deviation	0.84
Min	1
Max	3
N	5
CI	0.73
p value (0)	0.009
p value (2.5)	0.621
p value (5)	0.001

CV, coefficient of variation; Min, minimum value; Max, maximum value; *N*, sample size; CI, confidence interval.

Table 5 – Distribution of the injury mechanism.

Injury mechanism	*N*	%	*p* value
Motorcycle	4	80%	0.058
Bicycle	1	20%	

We found that the mean for radiographs under stress was 1.80 mm and that this mean was statistically difference from zero and from five, but was considered to be equal to the value of 2.50 and less than 5 mm, which is the value for one cross (+) of posterior translation of the tibia in relation to the femur, which would indicate some degree of instability of the joint (Table 4).

We also concluded that there were significant different with regard to the distribution of postoperative complications, injury mechanism (Table 5) and posterior drawer test (Table 6). Regarding postoperative complications, 80% did not present any, while 20% presented complications, and this was a significant difference ($p = 0.058$). The complication observed

Table 6 – Distribution of the drawer test.

Drawer test	*N*	%	*p* value
Negative	5	100%	0.002
Positive	0	0%	

was dehiscence of the skin, which evolved well and without any infection before healing. Neither side was more predominantly affected (0.527; non-significant).

When asked, 100% of the patients stated that they were satisfied with the functional result for their knee after the treatment. None of them had sequelae or symptoms that caused any limitations or incapacity in relation to their physical, professional and daily activities. Even in one of the cases, in which the patient was a professional within athletics and a physical education teacher, there was no residual incapacitating limitation. This patient is now participating in competitions at professional level.

Discussion

Posterior cruciate ligament injuries are uncommon and, when they occur, they are generally combined with other knee ligament injuries. Injuries to the PCL alone account for approximately 3% of acute knee injuries.[9]

Some authors have reported a mean incidence of three cases of avulsion fractures of the ACL per 100,000 and that cases of avulsion of the PCL are even rarer, possibly as much as ten times less frequent, even in children.[6,7]

The PCL is the strongest of the cruciate ligaments and is the primary restrictor of posterior translation of the tibia during knee flexion. When it is injured, posterior subluxation occurs and this causes changes to the pressure in the femoropatellar joint, with consequent chronic pain and degeneration of the joint cartilage.[8,15]

Previous studies[8,9] observed that the posterior translation of the tibia is greater with increasing degrees of knee flexion on radiographs under stress, at 10°, 20°, 60° and 80°. Stäubli and Jakob[8] agreed that the normal posterior deviation in millimeters was on average 3.7 ± 2.1 on the intact side and 10.4 ± 2.4 when injured (significance of $p < 0.001$).[8,9] This information ensures greater credibility for our objective evaluation of function using radiographs under stress at 80°.

Although there is still no consensus regarding the primary repair in PCL injuries, it is now clear that the best results in cases of avulsion fractures are obtained after stable fixation. Serial studies have consistently demonstrated satisfactory results through fixation, and uniformly poor results from non-surgical methods.[6,8,13,16,17]

The commonest injury mechanism is motorcycle accidents, followed by injury against the panel and being run over, among others.[3,17] We observed that there was one case of a bicycle accident, while all the others involved motorcyclists (Table 5). In around 90° of the cases, the injury is caused by an impact on the anterior face of the flexed knee. In some cases, injury to the anterior region of the knee is present, such as lacerations or cutting-bruising skin wounds (observed in 60% of the cases in this study), as illustrated in Figs. 7 and 8. Other injuries may be associated with these, such as fractures of the patella, ipsilateral femur, carpal bones or rib arches.[3]

Independent of the route, technique or material used, avulsion fractures of the PCL should be treated surgically, as suggested by Veselko and Saciri[16] and by others.[2,3,17] The best technique to apply is still a matter under discussion, but it should be the one with which the specialist surgeon is most familiar or for which the conditions and structure for applying it are the best,[6,8,12,13,16,17] given that the arthroscopic and open techniques are equally reliable.[18]

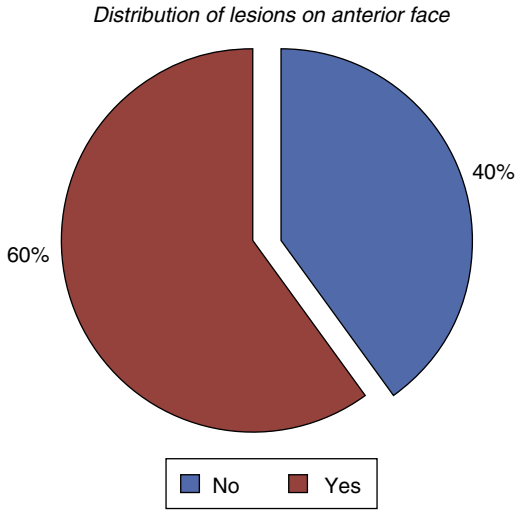

Fig. 7 – Illustration of the lesion distribution on the anterior face.

Fig. 8 – Image of extensive cutting-bruising wound and suturing in the anterior region of the lower leg.

Conclusion

Bone-ligament injury of the PCL causes pain and impairs function, with limitation of the range of motion, in association with knee instability. Surgical treatment produces subjectively

and objectively satisfactory results, with complete functional restoration.

Conflicts of interest

The authors declare no conflicts of interest.

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