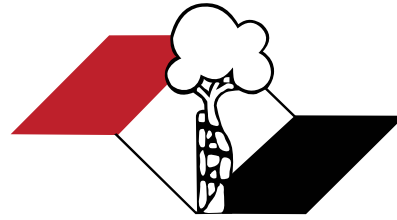


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(Reviewed January 2016)

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Type of Article	Abstract	Number of words	References	Figures	Tables	Maximum number of authors allowed
Original	Structured, up to 200 words	2,500 Excluding abstract, references, tables and figures	20	10	6	6
Update / Review*	Non-structured, up to 200 words	4,000 Excluding abstract, references, tables and figures	60	3	2	2
Editorial*	No abstract	500	0	0	0	1

\*These contributions shall be published at the Editors' criteria, with due replica, when applicable.

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Manuscripts should be sent in .txt or .doc files, double-spaced, with wide margins. Measures should be expressed in the International System (*Système International*, SI), available at <http://physics.nist.gov/cuu/Units> and standard units, where applicable.

It is recommended that authors do not use abbreviations in the title and limit their use in the abstract and in the text.

The generic names should be used for all drugs. The drugs can be referred to by their trade name, however, the manufacturer's name, city and country or electronic address should be stated in brackets in the Materials and Methods section.

**ABBREVIATIONS:** The use of abbreviations should be minimized. Abbreviations should be defined at the time of its first appearance in the abstract and also in the text. Non-standard abbreviations shall not be used, unless they appear at least three times in the text.

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- The full title in Portuguese and English with up to 80 characters. The title should be concise, but informative;
- The full name of each author (without abbreviations); and their institutional affiliations (the units should be presented in ascending order of hierarchy, e.g. department, faculty/institution, university). The names of institutions and programs should be submitted preferably in full and in the original language of the institution or in the English version when writing is not Latin (e.g. arabic, mandarin, greek);

d) The place where the work was performed;

e) Name, address, telephone number and e-mail of the corresponding author.

**ABSTRACT:** The abstract in Portuguese and in English should be structured in cases of original articles and shall present the study's objectives clearly, methods, results and main conclusions and should not exceed 200 words (do not include any reference citations). Moreover, the abstract should include the level of evidence and the type of study, according to the classification table attached at the end of this text.

**KEYWORDS:** The article should include at least three and at most six descriptors in Portuguese and in English, based on the Descriptors of Health Sciences (DeCS) <http://decs.bvs.br/> or Medical Subject Headings (MeSH) of the National Library of Medicine, available at <http://www.nlm.nih.gov/mesh/meshhome.html>

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Link the conclusions with the goals of the study, but avoid statements and conclusions that are not supported by the data, in particular the distinction between clinical and statistical relevance. Avoid making statements on economic benefits and costs, unless the manuscript includes data and appropriate economic analysis. Avoid priority claim ("this is the first study of ...") or refer to work that has not yet been completed.

**CONCLUSION:** The conclusion should be clear and concise, establishing a link between the conclusion and the study objectives. Avoiding conclusions not based on data from the study in question is recommended, as well as avoiding suggest that studies with larger samples are needed to confirm the results of the work in question.

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Authors should make sure that all references are cited in the text. Several citations within a single set of parentheses should be separated by commas without space (<sup>1,5,7</sup>). Where there are 3 or more sequential citations, use a numeric range (<sup>4-9</sup>). Include the first six authors followed by et al. The titles of journals should be abbreviated according to *Index Medicus*.

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## Levels of Evidence for Primary Research Question<sup>a</sup>

(This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK.  
For more information, please visit [www.cebm.net](http://www.cebm.net).)

Types of study				
Level	Therapeutic Studies Investigating the Results of Treatment	Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease	Diagnostic Studies – Investigating a Diagnostic Test	Economic and Decision Analyses – Developing an Economic or Decision Model
I	High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals	High quality prospective study <sup>d</sup> (all patients were enrolled at the same point in their disease with ≥80% of enrolled patients)	Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard)	Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses
	Systematic review <sup>b</sup> of Level RCTs (and study results were homogenous <sup>c</sup> )	Systematic review <sup>b</sup> of Level I studies	Systematic review <sup>b</sup> of Level I studies	Systematic review <sup>b</sup> of Level I studies
II	Lesser quality RCT (eg, < 80% followup, no blinding, or improper randomization)	Retrospective <sup>f</sup> study	Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard)	Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses
	Prospective <sup>d</sup> comparative study <sup>e</sup>	Untreated controls from an RCT	Systematic review <sup>b</sup> of Level II studies	Systematic review <sup>b</sup> of Level II studies
	Systematic review <sup>b</sup> of Level II studies or Level I studies with inconsistent results	Lesser quality prospective study (eg, patients enrolled at different points in their disease or <80% followup)		
		Systematic review <sup>b</sup> of Level II studies		
III	Case control study <sup>g</sup>	Case control study <sup>g</sup>	Study of non consecutive patients; without consistently applied reference "gold" standard	Analyses based on limited alternatives and costs; and poor estimates
	Retrospective <sup>f</sup> comparative study <sup>e</sup>		Systematic review <sup>b</sup> of Level III studies	Systematic review <sup>b</sup> of Level III studies
	Systematic review <sup>b</sup> of Level III studies		Case-control study	
			Poor reference standard	
IV	Case series <sup>h</sup>	Case series		Analyses with no sensitivity analyses
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

<sup>a</sup> A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.

<sup>b</sup> A combination of results from two or more prior studies.

<sup>c</sup> Studies provided consistent results.

<sup>d</sup> Study was started before the first patient enrolled.

<sup>e</sup> Patients treated one way (eg, cemented hip arthroplasty) compared with a group of patients treated in another way (eg, uncemented hip arthroplasty) at the same institution.

<sup>f</sup> The study was started after the first patient enrolled.

<sup>g</sup> Patients identified for the study based on their outcome, called "cases" eg, failed total arthroplasty, are compared with patients who did not have outcome, called "controls" eg, successful total hip arthroplasty.

<sup>h</sup> Patients treated one way with no comparison group of patients treated in another way.

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# CLINICAL OUTCOMES AFTER TWO-STAGE BICRUCIATE KNEE LIGAMENT RECONSTRUCTION

## RESULTADO CLÍNICO APÓS RECONSTRUÇÃO LIGAMENTAR BICRUZADO DO JOELHO, EM DOIS TEMPOS

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### ABSTRACT

**Objective:** To correlate clinical and intraoperative findings with the postoperative evaluation of two-stage bicruciate knee ligament reconstruction. **Methods:** The study was conducted with 25 patients (20 men and 05 women) with mean age of 32.3 years, mean body mass index (BMI) of 26.2, and mean lesion duration of 18.3 months. The treatment consisted of an Inlay reconstruction of the posterior cruciate ligament (PCL) followed by the anterior cruciate ligament (ACL) reconstruction, at least 3 months after the first surgical procedure. Four patients required additional procedures: patellar tendon (02), medial collateral ligament (MCL) (02). **Results:** With an average follow-up of 24.8 months, 60% of the patients scored zero or + at the posterior drawer test, while 40% scored ++; 60% of patients were evaluated as good/excellent according to the Lysholm scale. Only one patient reached the pre-injury Tegner activity level. Injury duration had a negative influence on functional limitation, vitality, and mental health (SF-36). **Conclusion:** Although two-stage bicruciate knee ligament reconstruction improved knee stability and self-assessment, 96% of patients did not recover their pre-injury state. In the 36-item short form survey (SF-36), injury duration was inversely correlated with self-assessment of functional capacity, physical limitation, vitality, and mental health. **Level of Evidence II, retrospective study.**

**Keywords:** Posterior Cruciate Ligament. Knee Injuries. Ligaments. Patient Reported Outcomes Measures.

### RESUMO

**Objetivo:** Correlacionar os achados clínicos e intraoperatórios com a avaliação pós-operatória da reconstrução ligamentar bicruzada do joelho em dois tempos. **Métodos:** 25 pacientes (20 homens e 05 mulheres), média de idade de 32,3 anos, IMC médio de 26,2, tempo médio da lesão de 18,3 meses. O tratamento foi iniciado com a reconstrução INLAY do LCP e, após o intervalo mínimo de 3 meses, foi realizada a reconstrução do LCA. **Procedimentos adicionais em 04 pacientes – tendão patelar (02), LCM (02).** **Resultados:** com seguimento médio de 24,8 meses, o teste de gaveta posterior foi classificado como zero ou + em 60% dos pacientes avaliados e 40% como ++. 60% dos pacientes avaliados como bons / excelentes (Lysholm). Apenas um paciente atingiu o nível de atividade Tegner pré-lesão. A tempo da lesão influenciou negativamente os parâmetros de limitação do funcionamento físico dos aspectos físicos, vitalidade e saúde mental (SF-36). **Conclusão:** a reconstrução bicruzado do joelho, em dois tempos, melhorou a estabilidade do joelho e a avaliação subjetiva, mas 96% dos pacientes não recuperaram o estado pré-lesão. O tempo de lesão apresentou correlação estatística inversa com a avaliação subjetiva da capacidade funcional, limitação dos aspectos físicos, vitalidade e saúde mental no escore S-36. **Nível de Evidência II, Estudo retrospectivo.**

**Descritores:** Ligamento Cruzado Posterior. Traumatismos do Joelho. Ligamentos. Medidas de Resultados Relatados pelo Paciente.

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### INTRODUCTION

Bicruciate knee ligament injury, that is, lesions affecting both the posterior cruciate ligament (PCL) and the anterior cruciate ligament (ACL) simultaneously, is one of the most severe knee joint injuries, occupying a chapter of its own in the universe of knee ligament lesions.<sup>1,2</sup> Considering that, surgeons' knowledge

about the complex anatomy and biomechanics of both ligaments, trauma history and mechanism, and patients' physical demand level plays a vital role in the decision-making process of this condition.

This complex knee ligament injury is a rare injury, mostly associated with high-energy traumas incurring or not in lesions of

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The study was conducted at Exercise and Sports Medicine Group, Department of Orthopedics, Rheumatology and Traumatology  
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other joints, structures, or organs. Meniscal and osteochondral injuries also commonly occur with other peripheral ligament lesions, worsening symptoms, instability, and joint degeneration.<sup>3</sup> Boisgard et al.<sup>4</sup> described four types of bicruciate knee ligament injury mechanisms: the first one concerns a simple plane femorotibial gaping around a perpendicular axis; the second occurs due to femorotibial translation; the third is a combination of simple gaping and knee translation; and the last is a combination of femorotibial gaping and translation, isolated or associated with rotational movements.<sup>5</sup> However, the clinical practice may fail in identifying the mechanism of injury, especially in chronic cases, due to patients underreporting.

From a biomechanical perspective, knee bicruciate injuries affect stability and normal joint kinematics, causing significant clinical repercussions that interfere in individuals' quality of life. Given the complexity of this lesion, specialists indicate a surgical procedure.

Studies approaching the outcomes of bicruciate knee ligament reconstruction on quality of life, symptoms improvement, return

to work and sports practice, as well as subjective and objective assessments of outcomes are still scarce on the literature, thus presenting a topic of substantial interest.

This study aims to correlate clinical and intraoperative data with postoperative evaluation obtained from the Lysholm knee scoring scale, Tegner activity score, and SF-36 questionnaire after two-stage bicruciate knee ligament reconstruction.

## MATERIALS AND METHODS

This retrospective descriptive study analyzed thirty-one (31) patients who underwent two-stage bicruciate knee ligament reconstruction between 2002 and 2010.

### Exclusion criteria

Patients presenting bilateral lesion (n = 1), intra-articular fracture of the lateral tibial plateau (n = 1), and tibial osteotomy (n = 2) were excluded from the study. Two patients were also lost to follow-up, totaling six excluded patients. Therefore, the study comprised 25 patients (Table 1).

**Table 1.** Patients' characteristics, affected knee, mechanism of injury, and associated injuries.

patients	age	gender	BMI	affected knee	mechanism of injury	associated knee injuries			associated injuries
						condral	meniscal	peripheral ligament	
1	17	F	19.9	R	bicycle	----	----	MCL	----
2	21	F	28	R	motorcycle	----	present	MCL / PT	----
3	24	M	25.8	R	motorcycle	present	----	----	femoral fracture (diaphysis)
4w	24	M	25.9	R	motorcycle	present	present	PLC	----
5	24	M	27.9	L	motorcycle	present	present	PLC	----
6	24	M	28	R	bicycle	present	present	----	----
7	25	M	22.4	L	motorcycle	present	present	----	tibial fracture (diaphysis)
8	27	M	26.2	L	sports	----	----	MCL	----
9	28	M	26.4	R	motorcycle	----	----	PT	----
10	28	M	25.2	R	sports	present	----	----	----
11	28	M	25	R	motorcycle	present	----	PCL	----
12	29	M	22.9	L	motorcycle	present	----	----	----
13	29	M	26,2	L	sports	----	present	MCL	----
14	30	M	27.7	R	car	----	----	PLC	clavicle + C2 fracture
15	32	M	26.2	L	motorcycle	present	present	----	tibial fracture (proximal)
16	33	M	26.9	R	sprains	present	present	----	----
17	34	M	24.1	L	motorcycle	----	----	----	----
18	35	M	24	L	motorcycle	present	----	----	forearm fracture
19	35	M	30	L	motorcycle	present	----	PLC	----
20	37	F	18.9	L	car	present	----	----	femoral fracture + face + retine injury
21	41	M	26.9	R	sports	present	present	----	----
22	46	F	30.5	R	sprains	----	----	----	----
23	52	M	28.4	R	motorcycle	present	present	PLC	acetabulum + tibial plateau fracture
24	52	F	34.9	R	sprains	----	----	MCL	----
25	53	M	27.4	L	bicycle	present	present	----	----



## Cases

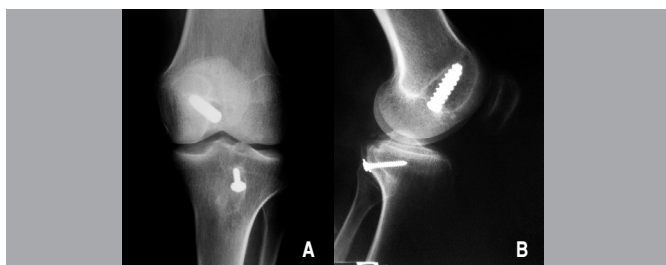
Twenty-five patients were reassessed (twenty men and five women). Among these, mean age was  $32.3 \pm 9.81$  years (17-53), mean body mass index (BMI) was  $26.2 \pm 3.27$  (18.9 – 34.9), and 14 presented the right knee affected whereas 11 presented the left knee.

Regarding the mechanism of injury, car, motorcycle, and bicycle accidents were responsible for 72% of injuries, sports practices for 16%, and falls or sprains for 12%.

Average lesion duration was  $18.28 \pm 29.63$  months (1 – 120), so that all patients had chronic injuries.

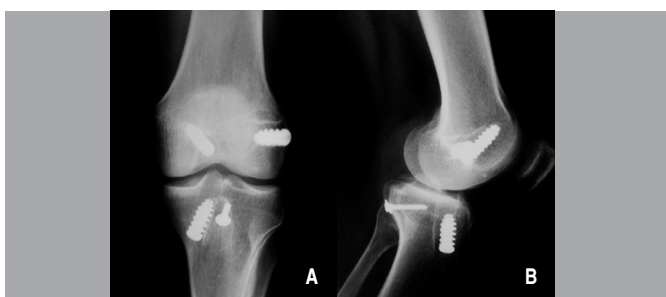
## Surgical technique

Patients' mean age at surgery was 29.4 years (16 – 50). Inlay posterior cruciate ligament (PCL) reconstruction with a central third patellar tendon graft was one of the surgical techniques used. The graft was fixed in the femoral tunnel with a interference screw and in the tibial tunnel with cortical screw and washer (Figure 1). In the postoperative care, the knee remained extended in inguinal-malleolus splint for six weeks.



**Figure 1.** Postoperative radiographs of open Inlay PCL reconstruction: anteroposterior (A) and lateral (B) view of the knee.

After at least 3 months from the first surgical procedure and observing an improvement in the range of motion, patients underwent anatomical outside-in arthroscopic anterior cruciate ligament (ACL) reconstruction using quadruple hamstring grafts and interference screws fixation in both the femur and tibia (Figure 2).



**Figure 2.** Postoperative radiographs of arthroscopic ACL reconstruction: (A): anterior-posterior; and (B) lateral view of the knee.

Four patients with associated lesions in ligaments required additional surgery: two underwent patellar tendon reconstruction using contralateral semitendinosus-gracilis grafts, and two underwent medial collateral reconstruction using contralateral semitendinosus-gracilis grafts.

## Intraoperative findings

Data on meniscal and chondral lesions (grade  $\geq 2$ ) were obtained from medical records. These lesions were prevalent on the medial side of the knee (femoral condyle, medial tibial plateau), patellar surface. For being considered minor injuries, the reports only

contained information on the presence or absence of cartilage damage, without areas measurement.

## Postoperative evaluation

Mean postoperative follow-up was  $24.8 \pm 20.63$  months (9 – 92). Data regarding clinical and radiological assessment was collected, as well as on functional assessment according to the Lysholm scale, Tegner activity score, and the 36-item short form survey (SF-36). Thighs circumference was measured 14 cm above the upper end of the patella. All participants agreed to participate by providing informed consent, and the study was approved by the institution Ethics Committee (CEP no. 963/2010).

## Statistical analysis

Statistical analyses were conducted on the Statistical Package for the Social Sciences (SPSS) 13.0. Numerical and categorical variables were tested using the Mann-Whitney, Spearman, and Wilcoxon tests, with significance level set at  $p < 0.05$ .

Univariate and multivariate linear regression analyses were performed to identify variables influencing participants' quality of life and clinical assessment. In the absence of normality, dependent variables were transformed using stepwise selection. Statistical tests were conducted considering a 5% significance level.

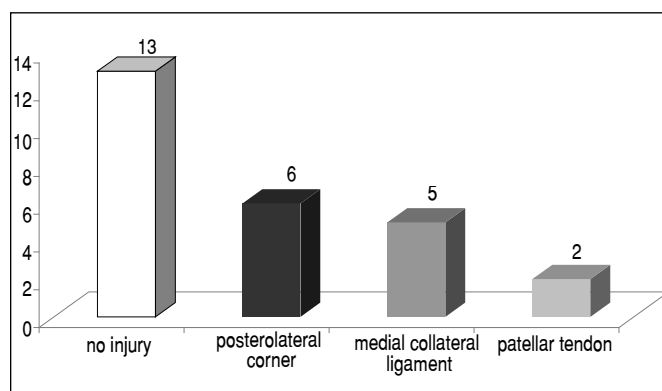
## RESULTS

After treatment completion, all 25 patients fully recovered the range of motion. In 10 patients (40%), the difference in thighs circumference was greater than 2cm when compared to post-operative evaluation.

According to the posterior drawer test, tibialis posterior drawer decreased by at least one level (+ or 0.5 cm). Seven patients (28%) presented a negative posterior drawer, eight patients (32%) showed a 0.5-cm-residual posterior drawer (+/+/+/+), and ten patients (40%) presented a 1-cm-residual posterior drawer (+/+/+/+/+), but none presented residual posterior drawer  $\geq 1.5$  cm (+/+/+/+/+/+) in the operated knee.

Sixteen patients presented chondral lesion (64%), 11 presented meniscal lesion (44%), and 12 associated ligament lesion (48%). Clinical records contain intraoperative findings on chondral injury, but no measurements.

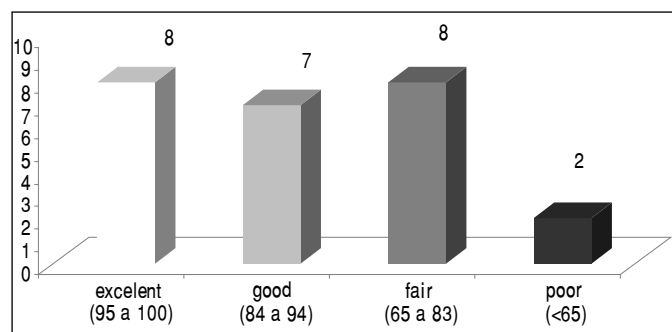
Regarding associated lesions in ligaments, two patients presented patellar tendon injuries (08%), five presented medial collateral ligament injuries (20%) and six patients posterolateral corner injuries (24%) (Figure 3). Patellar tendon reconstruction was performed on two patients and medial collateral reconstruction on other two, but none of the six patients diagnosed with mild posterolateral corner injury was submitted to surgical reconstructions.



**Figure 3.** Distribution of associated ligament lesions in the 25 evaluated cases.

We found no statistical difference among groups regarding age, BMI, presence of associated chondral, meniscal, and ligament lesions, and residual posterior drawer.

According to the Lysholm score ( $83.44 \pm 16.83$ ), eight patients (32%) presented excellent results, seven (28%) presented good results, eight (32%) regular, and two (8%) poor results (Figure 4).



**Figure 4.** Distribution of Lysholm scores of the 25 evaluated cases.

According to the Tegner activity score, the postoperative physical activity level was lower than that reported before the injury (Table 2). However, such change was not statistically significant. Only one patient within our study sample achieved the pre-injury activity level ( $p < 0.001$ ).

**Table 2.** Patients' distribution according to Tegner activity score levels (light, moderate, and high) and Postoperative Tegner deficit (mean values and standard deviation).

Condition	TEGNER (physical activity level)			postoperative Tegner deficit
	light (0 to 3)	moderate (4 to 6)	high (7 to 10)	
pre-injury	7	13	5	$35.56 \pm 18.81$
postoperative	16	7	2	

We found a statistical correlation between the Lysholm scale and Tegner deficit, whereby the higher the Lysholm score, the smaller the physical activity decrease after bicruciate knee ligament reconstruction. Preoperative lesion duration was inversely correlated with physical functioning, physical limitation, vitality, and mental health (SF-36 questionnaire), indicating a negative impact on clinical outcomes. Table 3 shows SF-36 results.

**Table 3.** Mean, standard deviation, and range SF-36 scores for the 25 patients.

SF-36 scores	mean values	SD	range
physical functioning	71	$\pm 21.2$	(30 – 100)
role functioning–physical	60	$\pm 38.9$	(0 – 100)
bodily pain	74	$\pm 25.0$	(22 – 100)
general health	80	$\pm 17.2$	(42 – 100)
vitality	72	$\pm 19.2$	(25 – 100)
social functioning	86	$\pm 17.8$	(37 – 100)
role functioning–emotional	85	$\pm 27.4$	(0 – 100)
mental health	76	$\pm 14.8$	(48 – 100)

We found no statistical correlation between postoperative period and the studied variables, indicating that nine months was enough time to achieve the clinical outcomes.

## DISCUSSION

Although two-stage bicruciate knee ligament reconstruction improved patients' knee stability and self-evaluation, 96% of patients did not achieve the pre-injury physical activity level. Injury period was inversely correlated with self-evaluated physical functioning, physical limitation, vitality, and mental health in the 36-item short form survey (SF-36). Bicruciate ligaments injuries are caused by high-energy traumas, so that associated lesions are commonly observed in these injuries.<sup>3</sup> In our study, 72% of the cases owed to car and motorcycle accidents (Table 1).

The unsatisfactory and inconsistent clinical outcomes resulting from conservative treatments fostered the need for a surgical approach to treat bicruciate ligaments injuries. Yet, no consensus has been reached in the literature regarding the ideal moment for surgery. Whereas Shapiro and Freedman<sup>6</sup> and Harner and Poehling<sup>7</sup> recommend surgery between the second and third week post-injury, Chuang et al.<sup>8</sup> believe that surgery should only be performed once the patient has restored the range of motion.

When evaluating joint mobility after surgical bicruciate reconstruction, Hayashi et al.<sup>9</sup> observed 15% of the patients ( $n = 19$ ) to present motion deficit; for Lo et al.<sup>10</sup>, such condition occurred in 27% of the cases ( $n = 11$ ) and for Hirschmann et al.<sup>11</sup> in 38% ( $n = 24$ ). However, all of our study patients recovered knee range of motion after the two-stage surgery, suggesting that surgical trauma magnitude interferes in postoperative joint mobility.

Hirschmann et al.<sup>11</sup> found 96% of patients in a series of acute and chronic cases to present knee postoperative stability. According to Ohkoshi et al.<sup>12</sup>, 100% of the cases presented residual posterior drawer of less than 0.5 cm. Spiridinov, Slinkard, and LaPrade<sup>13</sup> reported significant improvement in subjective and objective evaluations and knee stability after endoscopic treatment of isolated and combined double-bundle posterior cruciate ligament (PCL) grade-III reconstruction.

Our results show an improvement in knee stability after bicruciate knee ligament reconstruction. Yet, 60% of the patients presented a residual posterior drawer of less than or equal to 0.5 cm. We should also consider that our sample was heterogeneous, with 28% of patients presenting associated injuries such as a bone fracture or patellar tendon rupture.

Lo et al.<sup>10</sup> evaluated 11 patients with bicruciate lesions and found 73% of them to present associated ligament injuries and 27% to present meniscal injuries. Subbiah et al.<sup>14</sup> reported associated ligament lesions in 73% of their study sample, Lustig et al.<sup>3</sup> in 83.4% to 97%, and Fanelli and Edson<sup>15</sup> in 97% of 35 knee dislocation cases. Within our study sample, 48% had associated ligament lesions (Table 1), 16% of which required additional surgical procedure. In turn, 44% of the cases had meniscal injuries.

Corroborating the results reported by Lo et al.<sup>10</sup>, our study recorded no postoperative complications.

In a study conducted with 9 patients with chronic bicruciate lesions, Schofer et al.<sup>16</sup> reported a mean Lysholm score of 74. Hirschmann et al.<sup>11</sup> analyzed 17 cases of acute lesions and 7 cases of chronic injuries and registered a mean Lysholm score of 85 ( $n = 24$ ). Lo et al.<sup>10</sup> obtained a mean score of 88 for 11 chronic patients. In our study, an overall Lysholm score of 83 was classified as regular (Figure 4). A total of 64% of our sample presented chondral lesions, thus achieving poorer subjective Lysholm scores than patients without these injuries ( $82.6 \pm 19.5$  and  $85.0 \pm 11.5$ , respectively). However, we verified no statistical difference between these groups ( $p=0.609$ ). Lustig, Lerayb, and Boisrenoulte<sup>3</sup> reported 42% of their study sample to present chondral lesions.

Imprecise diagnoses, added to these patients' delayed referral to specialized services, contributed to chronic cases within our sample.

Regarding pre-injury activity level, we found this complex lesion to significantly impair patients' quality of life. In a study conducted by Hirschmann et al.<sup>11</sup>, 33% of the patients (n = 8) attained the pre-injury activity level, whereas for Lo et al.<sup>10</sup> this number was 82% (9 out of 11). However, only one of the participants in our study attained the pre-injury activity level (4%) (Tegner score activity = 4) (Table 2). Considering isolated anterior cruciate ligament (ACL) reconstruction, Möller, Weidenhielm and Werner,<sup>17</sup> and Nunez et al.<sup>18</sup> recorded a mean SF-36 score higher than 70. Conversely, Sekiya et al.<sup>19</sup> reported a mean score near 50 in isolated PCL reconstruction, emphasizing that acute and subacute PCL injuries reached better scores than chronic injuries (p = 0,036).

When analyzing bicruciate reconstruction, Schofer et al.<sup>16</sup> and Hirschmann et al.<sup>20</sup> observed a mean physical functioning SF-36 score ranging from 43 to 58 points, whereas in our study mean values were between 60 to 80 points (Table 3).

We also found preoperative injury period to be inversely correlated with the following items of the SF-36 questionnaire: physical functioning, physical limitation, vitality, and mental health. These findings indicate a negative effect of lesion duration on the postoperative outcomes.

Age, BMI, associated ligament lesions, posterior residual drawer, and postoperative follow-up duration were unrelated to postoperative outcomes.

This non-randomized retrospective study was conducted with a heterogenous sample of 25 patients with bicruciate chronic lesions submitted to a two-stage bicruciate knee ligament reconstruction using autograft and performed by the same surgeon. Considering this surgical procedure learning curve, which requires the harvesting of two or more autografts, as well as the surgical trauma and the time-lapse from trauma to surgery, a two-stage bicruciate knee ligament reconstruction could be deemed a realistic strategy.

## CONCLUSION

Although two-stage bicruciate knee ligament reconstruction improved patients' knee stability and subjective evaluation, 96% of the study sample did not achieve the pre-injury physical activity level. Injury period was inversely correlated with self-evaluated physical functioning, physical limitation, vitality, and mental health in the SF-36 questionnaire.

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# CLINICAL OUTCOMES AFTER UNICOMPARTMENTAL KNEE ARTHROPLASTY FOR OSTEONECROSIS OF THE KNEE

## DESFECHOS CLÍNICOS APÓS ARTROPLASTIA UNICOMPARTIMENTAL DO JOELHO NO TRATAMENTO DA OSTEONECROSE DO JOELHO

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### ABSTRACT

**Objective:** Although the mobile-bearing Oxford unicompartmental knee arthroplasty (OUKA) seems an appropriate procedure to treat spontaneous osteonecrosis of the knee (SONK), aseptic tibial component loosening was the leading cause for medial UKA failure. This study aimed to observe short-term and midterm clinical outcomes following OUKA and determine whether tibial lesion affects the procedure clinical and radiographic outcomes. **Methods:** Sixty patients (mean age  $73.1 \pm 6.6$  years) diagnosed with SONK in the medial femoral condyle and treated with OUKA were separated into two groups using T1-weighted preoperative magnetic resonance imaging (MRI): group F (necrotic lesion confined to the femur) and group T (necrotic lesion spread to the tibia). The Oxford Knee Score (OKS), maximum flexion angle (MFA), and radiographic findings (radiolucent line and subsidence) were compared between the two groups using unpaired *t*-test. **Results:** Both groups showed significant improvement in OKS and MFA values at the final follow-up, but without significant differences in the clinical and radiographic outcomes. **Conclusion:** OUKA is a reliable treatment procedure for SONK in the short and midterm. The presence of tibial lesions on preoperative MRI does not affect postoperative radiographic and clinical outcomes. **Level of Evidence IV, Case Series.**

**Keywords:** Knee. Arthroplasty. Osteonecrosis.

### RESUMO

**Objetivo:** Embora a Artroplastia Unicompartmental do Joelho (AUJ) de Oxford pareça ser um procedimento adequado para o tratamento da Osteonecrose Espontânea do Joelho (ONEJ), o afrouxamento asséptico do componente tibial foi a principal causa de fracasso na AUJ medial. Este estudo teve por objetivo observar desfechos clínicos de curto e médio prazo após AUJ, além de determinar se a presença de lesão tibial interfere nos desfechos clínicos e radiográficos do procedimento. **Métodos:** Sessenta pacientes (idade média de  $73,1 \pm 6,6$  anos) diagnosticados com ONEJ no côndilo medial do fêmur e tratados com AUJ foram divididos em dois grupos por meio de imagens ponderadas em T1 obtidas em exames pré-operatórios de ressonância magnética (RM): grupo F (lesão necrótica limitada ao fêmur) e grupo T (lesão necrótica espalhada para a tibia). Os valores obtidos no Oxford Knee Score (OKS) e o ângulo de flexão máxima (AFM), bem como achados radiográficos (linha radiotransparente e subsidência) para cada grupo foram comparados usando teste *t* não-pareado. **Resultados:** Ambos os grupos apresentaram melhoria significativa nos valores de OKS e AFM no último acompanhamento, mas sem diferenças significativas nos desfechos clínicos e radiográficos. **Conclusão:** AUJ é um procedimento confiável para o tratamento de ONEJ a curto e médio prazo. A presença de lesões da tibia, diagnosticada por meio da RM pré-operatória, não afetou os desfechos clínicos e radiográficos no pós-operatório. **Nível de Evidência IV, Série de casos.**

**Descritores:** Joelho. Artroplastia. Osteonecrose.

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### INTRODUCTION

Unicompartmental knee arthroplasty (UKA) seems an appropriate procedure for treating spontaneous osteonecrosis of the knee

(SONK) with unaffected lateral and patellofemoral compartments. Less invasive than other surgical procedures and with positive clinical outcomes, UKA replaces only the affected condyle and

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preserves all major ligaments, including the anterior cruciate ligament (ACL).<sup>1-5</sup> However, a recent systematic review on the use of UKA for the treatment of SONK verified a wide variation in survival rates within the literature, stressing the importance of appropriately selecting patients.<sup>6</sup>

Despite extensive knowledge on SONK affecting the femoral condyle, studies approaching SONK in the tibial plateau are still scarce due to its lower prevalence when compared to the femoral component, comprising only approximately 2% of the cases.<sup>7</sup> Recent studies found tibial component aseptic mechanical loosening and subsidence to be the leading causes of UKA failure.<sup>8-10</sup> A recent research reported the use of Oxford UKA for the treatment of medial tibial plateau osteonecrosis to achieve positive clinical outcomes.<sup>11</sup> However, we found no reports in the literature comparing UKA outcomes for SONK affecting the femoral condyle and the tibial plateau due to the major difference in their incidences. Our hypothesis is that the presence of lesion on the tibial component, verified by preoperative magnetic resonance imaging (MRI), can affect UKA clinical and radiographic outcomes for SONK treatment.

This study sought to observe the short and midterm clinical outcomes of mobile-bearing Oxford UKA for treating SONK and determine whether the presence of tibial lesions in preoperative MRI would affect the clinical and radiographic outcomes of the procedure.

## MATERIALS AND METHODS

### Subjects, clinical data, and surgery

The study protocol was approved by the Ethics Committee of our hospital (No. 2018-79). All patients included in this study signed an informed consent form. Our study group comprised 60 patients diagnosed with SONK affecting the medial femoral condyle, treated in our hospital between 2012 and 2014 with UKA using an Oxford mobile-bearing knee implant (The Oxford Partial Knee, Zimmer Biomet Ltd), and followed up for at least 3 years after surgery. In case of persistent pain and joint collapse with failure of conservative treatment after at least 3 months, surgical treatment was performed. Patients without multicompartiment necrotizing involvement, soft tissue imbalance, ligament involvement, and coronal malalignment greater than 15° underwent UKA. Patients whose outcomes, radiographic evaluation, and knee condition could be measured at the outpatient clinic during the final follow-up were included in the study. Exclusion criteria were knees with fixed flexion greater than 15°, active knee joint infection, and bilateral UKA. Among the 60 patients that participated in the study, 47 were women and 13 men (mean age, 73.1 ± 6.6 years; body mass index, 23.1 ± 3.6 kg/m<sup>2</sup>) (Table 1).

Among patients, the average preoperative coronal plane alignment on standard weight-bearing anteroposterior (AP) radiographs was 7.4° ± 5.1° in varus. All surgeries were performed by the senior author (TH) or by surgeons directly instructed by him.

Surgical procedures were conducted as described in the literature.<sup>12</sup> Before performing UKA, all intact cruciate ligaments and healthy cartilage in unaffected compartments were confirmed. Cemented implants were used in both tibial and femoral sides for all cases. Osteonecrotic lesion was removed as much as possible so that normal bone could be used as base for cement impregnation while avoiding deeper bone cut, thus prioritizing joint-line preservation and soft tissue balance over complete removal of necrotic lesion. After bone cut, eventual large craters were filled with autologous bone graft, harvested from the bone removed during surgery according to a previously reported method.<sup>2</sup>

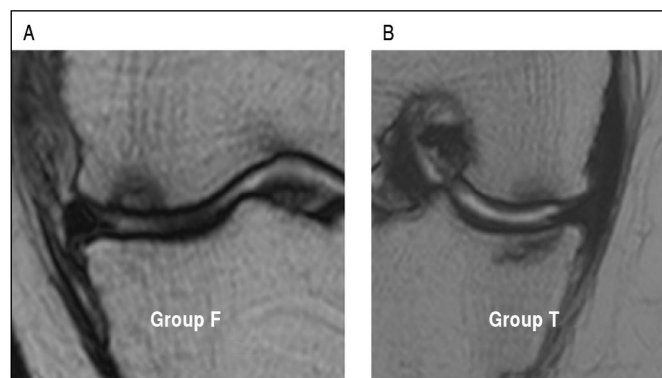
**Table 1.** Patient demographic data.

	Group F (N=34)	Group T (N=26)	p-value
<b>OKS</b>			
preoperatively	23.4±9.2	22.8±9.4	0.65
final follow-up	37.8±8.8	38.3±9.1	0.76
improvement	14.4±6.7	15.5±6.1	0.51
<b>MFA</b>			
preoperatively	109.8±12.9	107.9±12.0	0.88
final follow-up	132.2±11.5	130.7±11.9	0.71
improvement	22.3±6.1	22.8±5.7	0.85
<b>Complications</b>			
Superficial infection	0	1	N.S
Deep infection	1	0	N.S
Tibial plateau fracture	0	1	N.S
Revision cases	1	0	N.S
	Group F (n=34)	Group T (n=26)	p-value
Sex	male 8, female 26	male 5, female 21	NSw
Age	73.4 ± 6.4 y.o	72.7 ± 7.6 y.o	P=0.86
Body mass index	22.7 ± 3.5 kg/m <sup>2</sup>	23.5 ± 3.7 kg/m <sup>2</sup>	P=0.42
Varus deformity	7.6° ± 5.3°	7.1° ± 4.7°	P=0.77
Period from onset to surgery	61.0±9.8 weeks	68.6±11.1 weeks	P=0.66
Follow-up	60.5±9.3 months	56.7±10.4 months	P=0.49

Group F: necrotic lesion confined to the femur; Group T: necrotic lesion spread to the tibia; N.S: not significant.

### Preoperative MRI classification

Patients were separated into two groups using T1-weighted preoperative magnetic resonance imaging (MRI). Whereas in group F the necrotic lesion was confined to the femur, in group T it was spread to the tibia (Figure 1).



**Figure 1.** Preoperative T1-weighted magnetic resonance imaging classification. (A): Group F – necrotic lesion confined to the femur; (B) Group T – necrotic lesion spread to the tibia.

### Clinical outcome

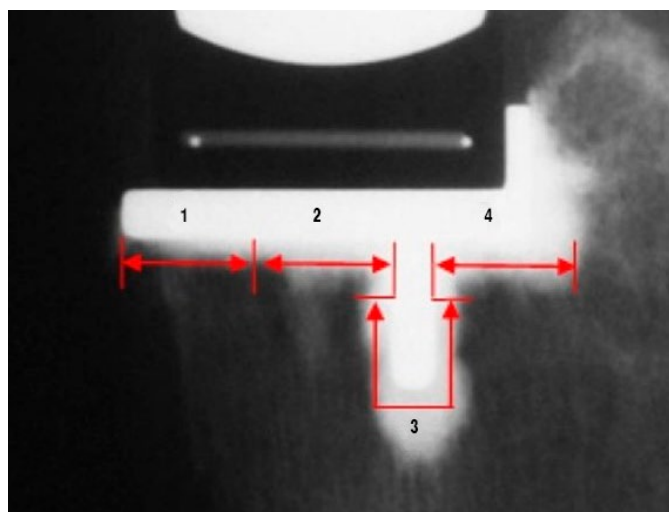
Clinical outcome was measured using the Oxford Knee Score (OKS) – a patient-based questionnaire that allows patients to report functional activity levels and clinical symptoms. OKS has been validated for use in degenerative arthrosis of the knee<sup>2</sup> and received a Japanese translation, which was also validated.<sup>13</sup>

The maximum flexion angle (MFA) was measured using a goniometer, both preoperatively and postoperatively (at the final follow-up), to assess clinical outcome.

Both parameters (OKS and MFA) were compared 2 weeks preoperatively and postoperatively (at the final follow-up) using the paired *t*-test ( $p < 0.05$ ).

## Radiolucent line assessment

Radiolucent line (RLL), that is, the radiolucent interval (measured in millimeters) between the cement and the bone,<sup>14</sup> was assessed using AP radiography at the final follow-up. Radiolucency was evaluated by adjusting the X-ray beam direction parallel to the tibial component and dividing the bone-cement interface into four zones, according to a previously reported method (Figure 2).<sup>15</sup>



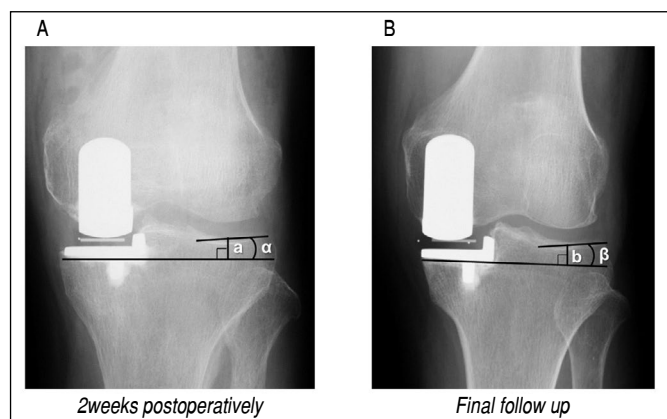
**Figure 2.** Standardized analysis of the tibial bone-cement interface in four zones, according to a previously reported method.

Those with RLLs in 1-3 zones were considered partial RLL, whereas those with RLLs in all 4 zones were considered completed RLL.

## Assessment of tibial component subsidence

The subsidence of tibial component was evaluated according to changes in radiographic parameters from 2 weeks postoperatively to the final follow-up.

Subsidence distance was measured by the height difference between the center of the lateral compartment and the line in contact with the tibial prosthesis lower surface at 2 weeks postoperatively and at the final follow-up. Subsidence angle was measured by the angular difference between the lateral compartment and the line in contact with the tibial prosthesis lower surface at 2 weeks postoperatively and final follow-up (Figure 3).



**Figure 3.** Assessment of tibial component subsidence. The subsidence of the tibial component was evaluated according to changes in radiographic parameters from 2 weeks postoperatively (A); to final follow-up (B). Subsidence distance (mm) =  $b - a$ . Subsidence angle ( $^{\circ}$ ) =  $\beta - \alpha$ .

## Statistical analysis

Results were analyzed using StatView 5.0 (Abacus Concepts Inc., CA, USA). RLL ratios between the groups were compared using Pearson's chi-square test ( $p < 0.05$ ). Clinical outcome (OKS and MFA) and subsidence (distance and angle) at the final follow-up were also compared using unpaired  $t$ -test ( $p < 0.05$ ). All values are presented as mean  $\pm$  standard deviation (SD).

Considering a prespecified significance level at  $\alpha < 0.05$  and assuming a medium effect size (effect size = 0.5) using G power 3, the statistical power analysis performed before the study expected a 0.8 power.<sup>16</sup> The estimated sample size was 54 patients, and  $p < 0.05$  was considered statistically significant.

## RESULTS

### Clinical data

Table 2 shows the clinical data of both groups (group F,  $n = 32$ ; group T,  $n = 28$ ). We found no significant differences regarding age, sex, body mass index (BMI), and follow-up period between groups.

**Table 2.** Clinical outcome for both groups.

	Group F (N=34)	Group T (N=26)	p-value
<b>OKS</b>			
preoperatively	23.4 $\pm$ 9.2	22.8 $\pm$ 9.4	0.65
final follow-up	37.8 $\pm$ 8.8	38.3 $\pm$ 9.1	0.76
improvement	14.4 $\pm$ 6.7	15.5 $\pm$ 6.1	0.51
<b>MFA</b>			
preoperatively	109.8 $\pm$ 12.9	107.9 $\pm$ 12.0	0.88
final follow-up	132.2 $\pm$ 11.5	130.7 $\pm$ 11.9	0.71
improvement	22.3 $\pm$ 6.1	22.8 $\pm$ 5.7	0.85
<b>Complications</b>			
Superficial infection	0	1	N.S
Deep infection	1	0	N.S
Tibial plateau fracture	0	1	N.S
<b>Revision cases</b>	1	0	N.S

Group F: necrotic lesion confined to the femur; Group T: necrotic lesion spread to the tibia; OKS: Oxford knee score; MFA: Maximum flexion angle; N.S: not significant.

### Clinical outcome

OKS and MFA significantly improved in both groups from preoperative to final follow-up, according to paired  $t$ -test. However, we verified no significant differences between both groups.

### Radiographic evaluation (radiolucent line and subsidence)

Table 3 shows radiographic evaluation results. Radiolucent line (RLL) ratios, partial RLL, and complete RLL were not significantly different between groups. Group T shows slightly larger subsidence distance and angle than Group F, but without significant differences.

**Table 3.** Radiographic evaluation for both groups.

	Group F (N=34)	Group T (N=26)	p-value
<b>RLL</b>			
No RLL	18/34 (52.9%)	14/26 (53.8%)	0.79
Partial RLL	8/34 (23.5%)	7/26 (26.9%)	0.53
Completed RLL	6/34 (17.6%)	4/26 (15.3%)	0.55
<b>Subsidence</b>			
Subsidence distance (mm)	0.98 $\pm$ 0.08	1.09 $\pm$ 0.10	0.28
Subsidence angle ( $^{\circ}$ )	0.85 $\pm$ 0.11	1.01 $\pm$ 0.12	0.24

Group F: necrotic lesion confined to the femur; Group T: necrotic lesion spread to the tibia; RLL: radiolucent line.



## DISCUSSION

Oxford mobile-bearing unicompartmental knee arthroplasty (UKA) seems an appropriate procedure to treat spontaneous osteonecrosis of the knee (SONK) regardless of the presence of necrotic lesion on the tibial side besides the femoral side, verified by preoperative magnetic resonance imaging (MRI). To the best of our knowledge, this is the first study to describe the midterm clinical and radiographic outcomes of Oxford UKA in Japanese populations, as well as the impact of tibial lesion on clinical outcomes.

Several authors reported positive midterm outcomes of Oxford mobile-bearing UKA for SONK treatment. A study conducted by Langdown et al.<sup>2</sup> with 29 patients reported a 100% survival rate at a mean follow-up of 5 years. Guo et al.<sup>17</sup> and Zhang et al.<sup>18</sup> also verified a 100% survival rate at short follow-up using a minimally invasive approach. In our study, the survival rate was 96.7%, showing that Oxford medial UKA is an effective technique for the treatment of Japanese patients with SONK in the short and midterm. Despite the positive results, further studies should continue to pursue long-term follow-up, given that several studies conducted with follow-up of over 10 years reported a slightly high revision rate, of approximately 10%.<sup>19,20</sup>

To the detriment of plain radiographs, MRI provides more detailed information for SONK evaluation. Early-stage SONK shows low signal intensity at T1-weighted images, but subchondral areas with high-intensity signals surrounded by low-intensity band-like signals at T2-weighted imaging.<sup>21,22</sup> In this study, we compared the clinical and radiographic outcomes verified by preoperative T1-weighted MRI of two groups: one with condylar necrosis localized on the femoral side (Group F) and one with lesion spreading on the tibial side (Group T). According to the literature, lesions at the femoral condyle and tibial plateau (Group T) co-occur in around 30-40% of all SONK patients<sup>7,23,24</sup> following two patterns. The first occurs in SONK natural course in the femoral condyle, as explained by Koshino et al.<sup>25</sup> After osteonecrosis onset in the femoral condyle with a typical oval shadow in the subchondral area at the weight-bearing portion, the shadow expands and a surrounding sclerotic halo is formed. Then, these changes lead to ipsilateral lesions of the subchondral bone and articular cartilage in

tibial plateau and consequently to osteoarthritis (OA) progression, including osteophytes, osteosclerosis, and joint-space narrowing. The second pattern refers to the occurrence after minor trauma, such as meniscal injury. Mechanical environmental changes after medial meniscus injury may increase contact stresses across the joint, resulting in focal subchondral overload and fracture, and possibly leading to osteonecrosis development on both the femur and tibial side simultaneously.<sup>26-28</sup> Still regarding UKA for Group T, surgeons should also be concerned about tibial component loosening caused by incomplete seating due to poor bone quality, given that aseptic tibial component loosening was reported as the leading cause of failure in medial UKA.<sup>8,29</sup> We found no significant differences in the clinical and radiographic evaluations between groups F and T, suggesting that the presence of necrotic lesion on the tibial plateau in preoperative MRI should not be considered a contraindication for the use of medial UKA for the treatment of SONK. We found no reports in the literature correlating clinical outcome to the extent of the surrounding bone marrow lesions after medial UKA.<sup>30</sup> Yet, to our best knowledge, this is the first study to describe the minimal influence of tibial plateau lesion in preoperative MRI on clinical and radiographic outcomes after the use of Oxford UKA for treating SONK affecting the femoral condyle.

Our study had some limitations, such as the limited sample size and short follow-up period, indicating the need for further long-term research with larger sample size. We also did not perform a histological examination of osteonecrosis, which would be important for differentiate osteonecrosis from insufficiency fracture. Moreover, imaging results are influenced by the onset period in view of its diversity until MRI evaluation. Regardless of the limitations, this study suggests that the presence of tibial side lesions in preoperative MRI is not a predictor of poor outcome in the use of UKA for SONK.

## CONCLUSION

The Oxford medial UKA is a reliable option for treating SONK in the short and midterm. The presence of lesions spread to the tibia in preoperative MRI does not affect the procedure radiographic and clinical outcomes.

**AUTHORS' CONTRIBUTIONS:** Each author contributed individually and significantly to the development of this article. TK: writing of the original draft, formal analysis, investigation; TH: conceptualization, supervision, review, editing; YH: data curation, review, editing.; TF: data curation, review, editing; KO: data curation, review and editing.






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# INCIDENCE OF DEEP VEIN THROMBOSIS IN FLOATING KNEE

## INCIDÊNCIA DE TROMBOSE VENOSA PROFUNDA EM JOELHO FLUTUANTE

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### ABSTRACT

**Objective:** To report the incidence of deep vein thrombosis (DVT) in ipsilateral femur and tibial fractures (floating knee). **Methods:** This is a retrospective, analytical, observational study conducted with the medical records of thirty patients admitted to a trauma hospital between October 2016 and July 2017 with floating knee. **Results:** Patients aged between 21-30 years were the most affected by the condition (36%). Seventeen patients affected the dominant limb (57%); 19 (63%) patients were classified as Fraser type I, 18 (60%) had open (compound) fractures, 16 (53%) tibial fractures, and 8 (26%) femoral fractures. External fixation of the femur and tibia (25 patients = 83%) was the most common emergency treatment. In total, 17% of patients presented deep venous thrombosis ( $p = 0.409$ ). **Conclusion:** Despite antithrombotic prophylaxis, the incidence of DVT in the affected limb of patients with floating knee was high. We found patients with Fraser I fractures, male, and with fractures in the non-dominant limb to present a higher chance of developing DVT. **Level of Evidence III, Comparative retrospective study.**

**Keywords:** Venous Thrombosis. Knee. Trauma. Fractures, Bone.

### RESUMO

**Objetivo:** Relatar a incidência de trombose venosa profunda (TVP) em fratura ipsilateral de fêmur e tíbia (joelho flutuante). **Materiais e métodos:** Realizado um estudo retrospectivo, observacional e analítico por meio da avaliação de prontuários de trinta pacientes admitidos com joelho flutuante em um hospital de trauma durante o período de outubro de 2016 a julho de 2017. **Resultados:** A faixa etária mais acometida foi entre 21 e 30 anos (36%). O acometimento do membro dominante ocorreu em 17 (57%) dos pacientes avaliados. Dezenove (63%) pacientes acometidos foram classificados como Fraser Tipo I. Dezoito (60%) pacientes tiveram fratura exposta, sendo 16 (53%) em tíbia e 8 (26%) em fêmur. O tratamento mais utilizado como urgência foi o de controle de danos com fixador externo em fêmur e tíbia (83%). Observamos trombose venosa profunda em 17% dos pacientes ( $p = 0,409$ ). **Conclusão:** Apesar do uso da profilaxia antitrombótica medicamentosa, houve uma grande incidência de TVP no membro acometido em pacientes com joelho flutuante na população estudada. As fraturas classificadas como Fraser I, pacientes do sexo masculino e o membro não dominante levaram ao aumento da probabilidade do surgimento de TVP. **Nível de Evidência III, Estudo retrospectivo comparativo.**

**Descritores:** Trombose Venosa. Trauma. Joelho. Fraturas Ósseas.

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### INTRODUCTION

Deep vein thrombosis (DVT) is a major complication of lower limb fractures<sup>1</sup> that may incur in death risk, such as for leading to pulmonary thromboembolism.<sup>2</sup> DVT is directly related to high-energy trauma.<sup>3</sup> The routine use of anticoagulants in prophylactic doses, such as low-molecular-weight heparin, is the most common among the protocols to avoid such complication. Despite its high cost, this protocol is effective in preventing DVT, reducing treatment costs and avoiding morbidity with considerable death risk or permanent sequelae.<sup>4</sup>

Described by Blake and McBryde in 1975 as floating knee,<sup>5</sup> ipsilateral fractures of the femur and tibia are associated with high-energy mechanisms of injury,<sup>6</sup> thus implying a greater association with DVT. Fraser classified floating knee injuries into two types. Whereas type I injuries characterize diaphyseal fractures of the femur and tibia, type II affects the knee joint and is subdivided into three other types: IIA, diaphyseal femur fractures and intra-articular fractures of the tibia; IIB: intra-articular fractures of the femur and diaphyseal tibial fractures; and IIC: intra-articular fractures of the femur and tibia.<sup>7</sup>

All authors declare no potential conflict of interest related to this article.

The study was conducted at the Instituto Dr. José Frota.

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This retrospective study aims to investigate the association between deep vein thrombosis (DVT) and ipsilateral fracture of the femur and tibia (floating knee) in patients receiving antithrombotic therapy.

## MATERIALS AND METHODS

This is a retrospective, cross-sectional, analytical study conducted with patients treated at a tertiary referral hospital in Fortaleza – Ceará (CE) Brazil, between October 2016 and July 2017. During this time, 37 patients with floating knee injuries were treated at the hospital. All patients admitted to the hospital and diagnosed with floating knee during the aforementioned period were included in the study. Floating knee was diagnosed based on anteroposterior radiographs (AR) and a profile of the affected limb leg and femur bones.

Patients with prefracture comorbidities that could cause complications (diabetes, thrombophilia, hemophilia, smoking) and with prior history of thromboembolic events were excluded.

After applying the exclusion criteria, 30 patients were eligible to participate in the study.

The following data were collected from patients' medical records: age, gender, affected side, Fraser's fractures classification, mechanism of injury, fracture type (open or closed), fracture treatment at urgent care, definitive fracture treatment, and complications (superficial infection, deep infection, and DVT).

Up from admission, all patients (n = 30) received subcutaneous enoxaparin prophylaxis (40 mg/day) in prevention of thromboembolic events. If they did not present any complications, the treatment was maintained for 2 months during hospitalization, according to the institution's protocol. After clinical complaints (pain and stiffness), DVT was considered and confirmed with direct venous thrombosis visualization using Doppler ultrasound.

Data were stored in the Statistical Package for the Social Sciences (SPSS, NY, USA) version 18.0 and tabulated in Microsoft Excel 2007 (Microsoft, WA, USA), calculating the frequency of each categorical variable. Pearson's chi-squared test was used for variables associations; p-value < 0.05 was considered statistically significant for all analyses.

The study was approved by the Research Ethics Committee under protocol number 2.259.144, and written informed consent was obtained from the institution Medical Record sector.

## RESULTS

Of the 30 patients assessed, 25 (83%) were men and 5 (17%) women. The most affected age range was between 21 and 30 years (36%). Seventeen patients presented injuries affecting the dominant limb (57%).

Most patients were classified as type I fractures according to Fraser's classification; that is, extra-articular fractures of the femur and tibia (Figure 1)

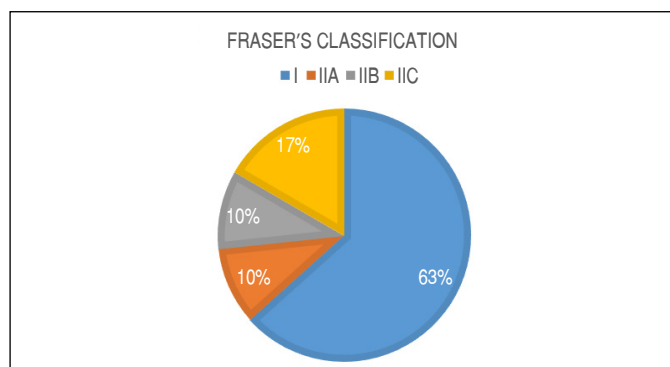


Figure 1. Fraser's classification for the patients studied.

Eighteen (60%) patients had open fractures, 16 (53%) tibial fractures, and 8 (26%) femoral fractures. Regarding the open tibial fractures, five were classified as grade I,<sup>8</sup> seven as grade II, and six as grade IIIa. As for the open femoral fractures, five were graded II and three IIIa.

External fixation of the femur and tibia was the most used emergency treatment (25 patients = 83%), and femur plates and external fixators for the tibia were the most common definitive treatment, used in 7 patients (23%) (Table 1). One patient suffered clinical complications due to severe infection and soft tissue necrosis; venous Doppler ultrasound examination was performed and pointed to the need for suprapatellar amputation (negative for DVT).

The average time for the definitive treatment was 8.14 days, with a maximum of 22 and minimum of 2 days.

Most patients' (70%) injuries were due to high-energy motorcycle accident trauma. (Figure 2) (Table 1)

Fracture consolidation time took on average 19.4 (16-25) weeks for the femur and 16.2 (13-20) weeks for the tibia.

Two cases presented pseudarthrosis of the femur: one treated with an autologous iliac crest bone graft and one with bone transport. Pseudarthrosis of the tibia occurred in three cases, all treated with autologous bone graft and subsequent consolidation.

Fourteen patients (46%) suffered infectious complications, nine (30%) superficial, and five (16%) deep. Superficial infection was treated with oral antibiotic and local care. When *S. aureus* was identified in culture, deep infection was treated with surgical debridement. Patients underwent endovenous antibiotic therapy for 4 weeks and oral therapy for other 2, guided by the antibiogram.

One patient suffered vascular lesion of the popliteal artery at trauma and underwent revascularization 3 hours after. The same patient presented DVT and deep infection.

Four patients presented neurological lesion in the the deep fibular nerve and recovered spontaneously after expectant treatment during outpatient follow-up. All were classified as Fraser's type IIC.

Five patients (17%) were diagnosed with DVT by Doppler ultrasound – cases 3, 5, 7, 11, and 22 in Table 1 (p = 0.409), – four of which in a deep leg vein and one in a deep thigh vein. All DVT cases were identified between the second and fourth week post-trauma.

All five patients affected by DVT were men (p = 0.209), victims of traffic accident (p = 0.372) and treated with an external fixator at emergency care (p = 0.570). Conversion to internal synthesis was precluded in two of these patients due to the severe skin damage (cases 3 and 22), so an external fixator was used as definitive treatment. For the other three cases, definitive treatment consisted either of plate/screw on the femur and external fixator in the tibia; osteosynthesis with retrograde intramedullary nailing of the femur; or plate/screw and external fixator in the tibia.

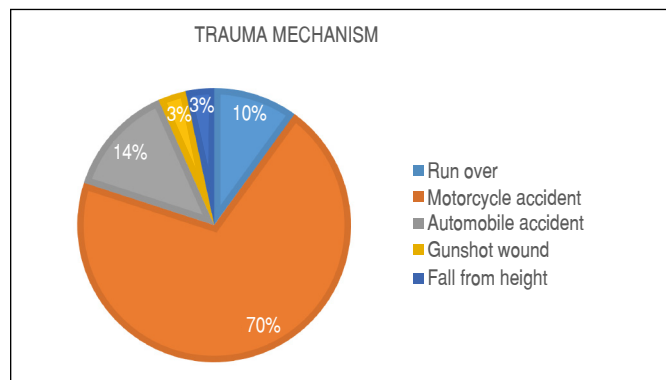
Among patients with DVT, 80% were classified as type I fractures according to Fraser's classification and 20% as type IIC (p = 0.480). All injuries were caused due to high-energy trauma, 60% resulting of motorcycle accident and 40% of automobile accident (p = 0.372).

Four cases were treated with full heparinization (60 mg/day) and one with vena cava filter placement. After DVT diagnosis and treatment, cases converted for internal synthesis underwent surgery upon authorization of the institution vascular surgery team.

**Table 1.** Demographic profile, injury pattern, fixation method, and complications.

Variables	Tibial fractures	Femoral fractures	All patients	p-value
No. of patients (men/women)			30 (26/4)	0.209
Age			34.7 (±12-72 years)	0.452
Trauma mechanism				0,372
MVA			28	
GSW			1	
Fall from height			1	
Affected limb (R/L)			21/9	
Dominant limb			17	0.412
Associated injuries (patients with associated injury)			31 (19)	
Fractures in other bones			11	
TBI			8	
Pelvic injury			3	
Chest trauma			3	
Abdominal trauma			2	
Facial trauma			2	
Spinal injury			1	
Other injuries			1	
Period between admission and first surgery			1.21 days	
Fracture pattern				0.480
Closed	14	22		
Open	16	8		
Type I	2			
Type II	8	5		
Type III				
A	4	3		
B	1			
C	1			
Fixation method at urgent care				0.570
Isolated Ex Fix	1/25	1/25		
Transarticular Ex Fix				
HIM				
Plate	1	1		
Plaster splint	3	3		
Conversion time			8.14 (±2-22 days)	
Definitive fixation method				0.266
External fixator	12	10		
IM Nailing	4	7		
Plate	12	12		
Plaster cast	1			
Amputation	1	1		
Consolidation time	16.2 (±13-20 months)	19.4 (±16-25 months)		
Complications				
DVT	4	1	5	0.409
Infection			14	0.193
Superficial			9	
Deep			5	
Pseudoarthrosis	3	2	5	
Vascular lesion			1	
Neurological lesion			4	

MVA: motor vehicle accident; GSW: gunshot wound; TBI: traumatic brain injury; Ex Fix: external fixator; IM: intramedullary nail; DVT: deep vein thrombosis.



**Figure 2.** Patients with floating knee according to trauma mechanism.

## DISCUSSION

Our results indicate that male patients with fractures classified as Fraser's type I are more likely to develop deep vein thrombosis (DVT) and exhibit high indices of associated injury. Besides other fractures, uncommon injuries of unknown incidence, these patients also present a higher risk for organ damage, possibly leading to death.<sup>9</sup> Most of our study participants were men in their 30s, corroborating a previous study that found a higher prevalence of men (85%) in their 30s (45%) among 238 cases of floating knee.

In our study, most patients with floating knee were victims of high-energy traffic accident trauma, primarily involving motorcycles. These data corroborate those of Rethnam, Yesupalan, and Nair,<sup>10</sup> who likewise found 27 of 29 floating knee cases to result from traffic accidents. Another retrospective study conducted with 172 patients with floating knee found 71.5% to be classified as type I, 8.2% as IIA, 11.2% IIB, and 8.7% as IIC according to Fraser's classification.<sup>11</sup> These findings corroborate ours, since most cases in our study were classified as type I (63%).

Most patients were treated with external fixation at urgent care, possibly due to their severity at arrival, since most were victims of high-energy trauma (Table 1). De Marco, Rozim, and Piedade<sup>12</sup> reported similar results, in which 64.71% of patients with floating knee were treated with external fixation to stabilize fractures at hospital arrival. When studying 125 patients with lower limb fracture, Kapoor et al.<sup>13</sup> found six cases to be positive for DVT. Among the 47 patients with periacetabular fractures, four (8.51%) developed DVT and eight sustained floating knee, two of whom eventually developed DVT. None of these patients received antithrombotic prophylaxis. In our study, the incidence of DVT in patients with floating knee was 17%, even with antithrombotic prophylaxis.

Within our study sample, the analyzed variables (gender, dominant limb affected, Fraser classification, trauma mechanisms, and emergency treatment) were not statistically significant risk factors for patients with floating knee to develop DVT.

According to Donath et al., using fondaparinux in antithrombotic prophylaxis resulted in a higher number of distal thrombotic events than enoxaparin in the context of orthopedic surgery.<sup>14</sup> However, we found no statistical significance for this association.

The early diagnosis and treatment of DVT may play a key role in minimizing complications related to this condition.<sup>15</sup> In our study, the five patients diagnosed by venous Doppler ultrasound exhibited no symptoms of pulmonary thromboembolism.

Considering this is a retrospective study, our main limitation is related to the short follow-up. Using an external fixator at emergency treatment was also a negative factor for promoting a prolonged restriction and immobilization<sup>16</sup> and not verifying the presence of other associated lesions, such as knee ligament injuries. Moreover,



given that the Doppler ultrasound was only used in symptomatic cases, the incidence found may be higher.

Our study comprises a large number of cases of an infrequent lesion with a significant amount of data. In the near future, we plan to conduct a prospective randomized study with a larger number of cases.

## CONCLUSION

Regardless of the use of antithrombotic prophylaxis, the incidence of deep vein thrombosis was high among patients with floating knee. Patients with Fraser type I fractures, male, and with the non-dominant limb affected are more likely to develop DVT.

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# THE NEW INJURIES' RISK AFTER ACL RECONSTRUCTION MIGHT BE REDUCED WITH FUNCTIONAL TRAINING

## O RISCO DE NOVAS LESÕES APÓS RECONSTRUÇÃO DO LCA PODE SER MINORADO COM O TREINAMENTO FUNCIONAL

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### ABSTRACT

**Objective:** The objective of our study was to evaluate if functional training with the Functional Movement Screen (FMS) can reduce the risk of a new injury for patients that underwent an anterior cruciate ligament reconstruction (ACLR). Our hypothesis was that the functional training might reduce the risk of a new injury. **Methods:** Our training protocol consisted of six phases, each one lasting six weeks. It began two months after surgery. The study group was composed of 10 individuals that completed our protocol after ACLR. The control group consisted of 10 people that completed a regular ACLR rehabilitation protocol. The FMS was used to compare the study and control group performance. Patients with a score of 14 or less on the FMS were considered more likely to suffer an injury than those with a score higher than 14. **Results:** The study group average FMS score was 16.6 compared to the control group at 12.3. Functional training for ACLR rehabilitation added a statistically significant benefit ( $p < 0.0002$ ) to reduce the risk of a new injury compared to regular protocol. **Conclusion:** Functional training may be considered an alternative to the regular ACLR rehabilitation to reduce the risk of a new injury before returning to sports. **Level of Evidence III, Case control study.**

**Keywords:** Knee Injuries. Ligaments. Rehabilitation.

### RESUMO

**Objetivo:** Nosso objetivo foi avaliar se o treinamento funcional pode reduzir o risco de nova lesão, após a reconstrução do ligamento cruzado anterior (RLCA), pelo Functional Movement Screen (FMS). Nossa hipótese foi que o treinamento funcional pode diminuir o risco de nova lesão. **Métodos:** O treinamento consistiu de seis fases de seis semanas cada uma. Começou dois meses após a reconstrução do ligamento. O grupo estudo foi composto por 10 indivíduos que completaram o treinamento, após a RLCA. O grupo controle consistiu em 10 pessoas que fizeram o protocolo regular de reabilitação da RLCA. O FMS foi utilizado para comparar o desempenho dos dois grupos. Pacientes com pontuação igual ou inferior a 14 foram considerados mais propensos a sofrer nova lesão em comparação àqueles com pontuação maior que 14. **Resultados:** A pontuação média do grupo estudo foi de 16,6 e a do grupo controle, 12,3. O treinamento funcional adicionou um benefício estatisticamente significativo ( $p < 0,0002$ ) para diminuir o risco de nova lesão, em comparação com o protocolo regular. **Conclusão:** O treinamento funcional pode ser mais uma estratégia a ser incluída na reabilitação regular da RLCA, para diminuir o risco de uma nova lesão, antes de retornar ao esporte. **Nível de Evidência III, Estudo de Caso controle.**

**Descritores:** Traumatismos do Joelho. Ligamentos. Reabilitação.

**Citation:** Gali JC, Fadel GW, Marques MF, Almeida TA, Gali Filho JC, Faria FAS. The new injuries' risk after ACL reconstruction might be reduced with functional training. *Acta Ortop Bras.* [online]. 2021;29(1):21-5. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

In the United States of America, approximately 90% of patients undergoing anterior cruciate ligament (ACL) injury had their ligament reconstructed.<sup>1</sup> After surgery, specific rehabilitation programs are

used to restore joint movement, improve muscle strength and conditioning, and provide a safe return to sports participation. However, the standard anterior cruciate ligament reconstruction (ACLR) rehabilitation is not a guarantee for a return to sports at

All authors declare no potential conflict of interest related to this article.

The study was conducted Faculdade de Ciências Médicas e da Saúde da Pontifícia Universidade Católica de São Paulo - Sorocaba  
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the previous activity level and for continued participation in the desired sport.<sup>2</sup>

After an ACL injury, proprioception and neuromuscular control of the knee are impaired, which may persist subsequently to reconstruction and surgical rehabilitation.<sup>3</sup> On the other hand, inadequate neuromuscular control may be a risk both for the first ACL injury<sup>4,5</sup> and for recurrent instabilities.<sup>6</sup>

The neuromuscular training program has been used to prevent ACL injuries in female athletes<sup>7-9</sup> and to avoid injuries in adolescents and adults.<sup>10</sup> Risberg and Holm<sup>11</sup> suggested that neuromuscular training should be part of the rehabilitation program after ACLR. Wiggins et al., in a systematic review and meta-analysis, proposed that neuromuscular training can help athletes under 25 to return more safely to the sport and reduce the risk of a second injury.<sup>12</sup> Huang et al.,<sup>13</sup> in a systematic review of randomized clinical trials, reported that an ACL injury prevention program had a significant positive effect and reduced the injury rate by 53%.

Closed kinetic chain evaluation has been used to test patients' strength and ability to advance to a more complex functional level.<sup>14</sup> Functional tests, such as single leg and vertical jumping, are generally used to determine knee function after ligament reconstruction.<sup>15,16</sup> However, an objective and accepted method of evaluation is needed to determine how an athlete will develop in the final phase of rehabilitation and if he will have a safe return to sports.<sup>17</sup> Recently, a score  $\leq 14$  measured by the Functional Movement Screen (FMS) was considered a detectable risk factor for injuries in professional soccer players.<sup>18</sup> Using the FMS score, Boyle et al.<sup>19</sup> found that adolescents were at increased risk for lower limb injuries after 9 months of ACLR.

However, there is no concrete way to evaluate neuromuscular control in individuals whose ACL was reconstructed. The objective of our study was to evaluate if our functional training algorithm

can decrease the risk assessment of a new lesion in patients that underwent ACLR, using the FMS scoring system.

## MATERIALS AND METHODS

Informed consent was obtained from all patients participating in the study and the study was approved by our institution's Ethics Committee under the number CAEE: 32800116.0.0000.5373. Inclusion criteria were considered patients that had unilateral primary anatomic ACLR with ischiotibial tendon graft for the treatment of chronic lesions and, to the exclusion, patients with acute lesions, reconstructions with other type of graft than the ischiotibial ones, revision or reconstruction of another ligament associated to ACLR and patients with bilateral lesions. No patient was a professional athlete, but all performed at least 50 hours of sports activities per year.

Immediate total body weight support, with crutches, and full range of motion was allowed for all patients from the first postoperative day. No immobilization was used. The crutches were removed after seven days, as long as there was no claudication.

After that, the patients were divided into two groups, study and control. The study group consisted of 10 individuals that completed the proposed functional training protocol after two months of physiotherapy rehabilitation. In this group, there were eight men and two women, aged between 25 and 53 years, with an average of 37.5 years. Regarding the side, six right knees were and four left knees were treated.

The protocol consisted of a 36-week training period, starting right after the rehabilitation period. This practice was divided in six phases of six weeks each, and the exercises were performed three times a week. It was based on exercises of central stability (paravertebral, abdominal and hip musculature), correction of asymmetries in the lower limbs and neuromuscular deficits to improve neuromuscular control and minimize the risk of future injuries (Table 1).

**Table 1.** Functional Training Protocol.

Phase I: Week 1 to 6	Phase II: Week 7 to 12	Phase III: Week 13 to 18
<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To restore fundamental movement patterns</li> <li>➤ To establish the domain of the hip and knee</li> <li>➤ To adequate movement patterns for physical activities</li> </ul>	<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To emphasize unilateral exercises</li> <li>➤ To minimize limb asymmetries and general deficits (strength, joint stability / mobility and neuromuscular control)</li> </ul>	<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To provide greater range of motion, control and perception in various positions</li> </ul>
<ul style="list-style-type: none"> <li>- Bridge: 20 sec / 8 repetitions</li> <li>- Board: 30 sec</li> <li>- Educational squat: Medium mini-band / 3 kg medicine ball / 10 repetitions</li> <li>- Activation of the plantar arch + lateral displacement: Medium mini-band / 4 m</li> <li>- Educational charge: Stick / 8 repetitions</li> <li>- Root leg activation: 10 repetitions</li> <li>- Adduction with band: Light band / 10 repetitions</li> <li>- Educational land survey: Baton / 10 repetitions</li> <li>- Lunge: 3 kg medical ball / 8 reps</li> <li>- Ankle mobility with knee flexion: 10 repetitions</li> </ul>	<ul style="list-style-type: none"> <li>- TRX bridge: 20 sec / 6 repetitions</li> <li>- Board: 30 sec</li> <li>- One-sided squat: 2 kg medicine ball / 6 repetitions</li> <li>- Unilateral rotational hip mobility with stick: 4 repetitions</li> <li>- Unilateral educational land survey: Baton / 6 repetitions</li> <li>- Side displacement: super band / 4m</li> <li>- Activation of the root leg with light band / 10 repetitions</li> <li>- Bulgarian squat: 3 kg medicine ball / 8 reps</li> <li>- String: 30 sec</li> <li>- Unilateral plyometrics: 20 cm box / 6 repetitions</li> <li>- Pullover with ball: 6 repetitions</li> </ul>	<ul style="list-style-type: none"> <li>- Bridge on the ball: 20 sec / 6 repetitions</li> <li>- Board on the ball: 30 sec</li> <li>- Climb in box: stick / 8 repetitions</li> <li>- Stick and box for hip mobility, semi-kneeling: 20 sec / 5 repetitions</li> <li>- Deadlift: 10kg / 10 repetitions</li> <li>- TRX unilateral hip rotational mobility: 6 repetitions</li> <li>- Front displacement with medium mini-band: 4 meters</li> <li>- Unilateral Lifting with Kettlebell: 4kg / 6 repetitions</li> <li>- Semi-knees anti-rotation with band: 6 repetitions</li> <li>- Side board: 20 sec</li> <li>- Slide: 1 min</li> <li>- Lateral attack with external rotation: stick / 6 repetitions</li> <li>- Plyometric circuit with medium mini-band: 8 repetitions</li> <li>- One in / low knee agility: 3 strides</li> <li>- One in / low knee agility: 3 strides</li> <li>- Treadmill run: 20 min / Lightweight: 50-60% of maximum heart rate</li> </ul>

**Table 1.** Functional Training Protocol.

Phase IV: Week 19 to 24	Phase V: Week 25 to 30	Phase VI: Week 31 to 36
<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To provide the ability to generate power through a highly coordinated and efficient movement between body segments</li> </ul>	<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To maintain the ability to generate power through highly coordinated movements</li> <li>➤ To provide conditions for training and developing specific skills</li> </ul>	<p>Goals:</p> <ul style="list-style-type: none"> <li>➤ To maintain the physical capabilities already acquired</li> <li>➤ To provide optimal conditions for training and developing specific skills without wasting energy</li> </ul>
<ul style="list-style-type: none"> <li>- Slide bridge: 20 sec / 6 repetitions</li> <li>- Slide board: 30 sec / 6 repetitions</li> <li>- Plyometric Squat: 5kg / 10 repetitions</li> <li>- Balance board: 45 sec</li> <li>- Unilateral hip activation in the box: 20 sec</li> <li>- Strong miniband lateral displacement / 4m</li> <li>- Swing Kettlebell: 10kg / 10 repetitions</li> <li>- Hip flexion and alternate knee on TRX: 10 repetitions</li> <li>- Low sequential plyometrics: 5 repetitions / 30-35-40 cm</li> <li>- Agility One in / high knee: 3 passes</li> <li>- Agility Two in / high knee: 3 passes</li> <li>- Agility Half Carioca: 3 tickets</li> <li>- Treadmill Run: 30 min / Light 50-60% HR Max</li> </ul>	<ul style="list-style-type: none"> <li>- TRX bridge: 20 sec / 6 repetitions</li> <li>- TRX unilateral board: 20 sec</li> <li>- TRX unilateral onslaught: 10 reps</li> <li>- Mobility rotational hip stick unstable: 5 repetitions</li> <li>- Sled: 6x10 meters / 50kg</li> <li>- Side board with TRX rotation: 20 sec / 4 repetitions</li> <li>- Pullover Roller: 6 reps</li> <li>- Olympic Weightlifting: 6 reps 5kg / 3 reps 10kg</li> <li>- Side shift + SuperBand squat: 4m / Medium SuperBand</li> <li>- SuperBand lateral plyometrics: 8x each side / Average SuperBand</li> <li>- Agility Half Carioca: 3 tickets</li> <li>- Agility Slalom Jump: 3 passes</li> <li>- Agility Two in Lateral: 3 passes</li> <li>- Cross agility two in: 3 tickets</li> <li>- Cross agility feint: 3 passes</li> <li>- Educational / Running Hopslerlauf: 2x20m</li> <li>- Educational / Running Hopslerlauf Kick: 2x20m</li> <li>- Educational / Side Race Run: 2x20m</li> </ul>	<ul style="list-style-type: none"> <li>- TRX unilateral onslaught: 10 reps</li> <li>- SuperBand crouching lateral displacement: 4m / Medium Superband</li> <li>- Forward and reverse displacement: 6kg / 6 repetitions</li> <li>- Slide adduction: 8 repetitions / 3 kg medicine ball</li> <li>- TRX Hip Flexed Side Plank: 6 reps</li> <li>- Olympic Weightlifting: 10 reps / 5kg</li> <li>- TRX low pullover: 6 repetitions</li> <li>- Sequential Plyometry in Total Flexion: 10x / 40 cm</li> <li>- Educational / Running</li> <li>- Side run with change of direction: 3x30 m</li> <li>- Front / back running: 3x30 m</li> <li>- 360 x swing race: 3x30 m</li> <li>- Diagonal run with spin: 3x10 m</li> <li>- Running field: 30 min / Moderate 60-75% FC Max</li> </ul>

The control group also consisted of 10 people, nine men and one woman, who underwent two months of physical therapy and a regular ACRL rehabilitation protocol, including muscle strengthening, resistance, proprioception, plyometrics and specific training, for six months.<sup>20</sup> The patients were aged between 19 and 46 years, with a mean of 32.1 years. There were five right and five left knees in this group.

Both groups had comparable range of motion, joint stability and trophism of the thigh muscles. FMS was used to compare the performance of the two groups. The study group was assessed immediately after 36 weeks of functional training and the control group was assessed immediately after standard ACRL rehabilitation. The FMS analyzes the quality of seven fundamental movement patterns, applied to verify mobility, stability, neuromuscular and motor control to diagnose limitations and / or asymmetries (Figure 1).



**Figure 1.** Seven tests from Functional Movement Screen.  
Source: <https://lifestyle.fit/entrenamiento/rutinas/fms-test-movilidad-funcional-movement-screen>.

Patients with a score of 14 or less on the FMS were considered more likely to suffer a new injury than those with a higher score.<sup>21,22</sup>

All tests were performed by an experienced and judicious physical educator.

### Statistical analysis

The Mann-Whitney test and Fisher's exact test were used to compare the FMS score, age, gender and affected side of the two groups. The level of significance ( $\alpha$ ) established was 0.05 or 5%.

### RESULTS

There was no statistically significant correlation between age, gender, side involved and FMS score. The average FMS score for the study group was 16.6, for the control group, 12.3. Tables 2 and 3 listed demographic data and FMS scores.

**Table 2.** Age, Gender, Side and FMS Score of Study Group Patients.

Patient	Age	Gender	Side	Score
1	27	M	R	18
2	43	M	R	14
3	37	M	L	16
4	32	F	R	19
5	53	M	R	16
6	34	M	L	16
7	25	F	R	18
8	42	M	R	16
9	45	M	L	15
10	37	F	L	18
	37.5			16.6

**Table 3.** Age, Gender, Side and FMS Score of Control Group Patients.

Patient	Age	Gender	Side	Score
1	38	M	L	13
2	31	M	R	12
3	19	M	R	14
4	26	M	R	13
5	45	M	L	12
6	34	M	L	12
7	46	F	R	11
8	19	M	L	12
9	23	M	L	13
10	40	M	R	11
	32.1			12.3

According to the FMS score, functional training for rehabilitation of knee with ACLR added a statistically significant benefit ( $p < 0.0002$ ) to decrease the risk of further injury compared to the regular rehabilitation protocol.

## DISCUSSION

The results of our study suggest that functional training can be recommended for ACLR rehabilitation programs. Literally, functional means described from the required design; so we can say that this exercise was specially planned for the rehabilitation of ACLR. Functional training combines neuromuscular control, joint mobility and stability, central stability, trunk alignment and lower limb joints. Ageberg and Roos<sup>23</sup> defined neuromuscular control (sensorimotor control) as the ability to produce controlled movement by coordinated muscle activity.

Central stability seeks to strengthen abdominal, paravertebral and gluteal muscles to produce maximum stability in the abdomen and spine. It can be defined as the ability of the lumbopelvic-hip complex to prevent buckling of the spine and return it to balance after disturbance.<sup>24</sup> It provides a stable base for the movement of the extremities and its training uses the central muscles in daily tasks and sports-related activities.<sup>25</sup> Moreover, muscle fatigue alters neuromuscular control, decreases the strength of the central musculature and the capacity of proprioception, which may increase the risk of ACL non-contact injuries.<sup>26</sup>

Unlike traditional muscle strengthening programs, several joints and muscles are exercised in the three planes of movement during functional training, simultaneously challenging the brain and the body. In fact, intervention programs that target multiple load plans are needed to effectively reduce the risk of ACL injury.<sup>27</sup>

In our protocol, the agonist and antagonist muscles are co-activated to maintain the balance of the segments under tension, in static and dynamic situations. Functional training can also provide muscle strength, power and endurance. In this type of practice, the efficiency and quality of the movements are mandatory. The compensatory patterns of patients can also be assessed, and continuous supervision can provide possible adjustments to improve function. Whereas regular muscle strength programs usually work on the sagittal or coronal planes, functional training also works on the transversal plane, where ACL injuries usually occur.

We believe this is the first study that evaluated the response of functional training in individuals with ACLR using the FMS Scoring System. One of the objectives of our protocol was to prevent ACL injury mechanisms (adduction and internal rotation of the hip, knee valgus, external rotation and anterior translation of the tibia and eversion of the ankle).<sup>28,29</sup> More recently, Kiapour

et al., using a cadaveric landing model, proposed that knee valgus collapse is one of the main mechanisms of contactless ACL injuries in falls.<sup>27</sup>

With training exercises, the proposed protocol sought to work the balance between external and internal hip rotators, knee flexors and extensors and ankle invertors and evertors, to obtain dynamic knee stabilization. Thus, the dominance of the quadriceps, which could cause an increase in the ACL tension level and make it more susceptible to injuries,<sup>30</sup> was corrected by dynamic neuromuscular training.<sup>31</sup>

The FMS score was chosen to evaluate the study and control groups, because it analyzes the whole body working together. The test helps to identify deficits in mobility, stability and neuromuscular coordination. To successfully complete the seven fundamental patterns of movement, muscle strength, flexibility, range of motion, coordination, balance and proprioception are required.<sup>18</sup>

Kiesel et al.<sup>18</sup> suggested that a low FMS score is a proven risk factor for injuries in professional soccer players, whereas Bushman et al.<sup>32</sup> considered that, although the low performance of the FMS was associated with a higher risk of injuries, it showed low sensitivity and low positive predictive value for physically active male soldiers. More recently, Bonazza et al.,<sup>33</sup> based on the results of a systematic review and meta-analysis, reported that the FMS has excellent inter- and intra-examiner reliability. They concluded that people with a score  $\leq 14$  on the FMS score are more than twice as likely to suffer a musculoskeletal injury as those with a score  $\geq 14$ .

Our study showed that functional training after ACRL decreased the likelihood of the risk of new injuries when compared with the regular rehabilitation protocol, according to the FMS scoring system. Therefore, the suggested functional training can be a new tool to support the promotion of a safe return to sports activities after ACRL. To reduce the risk of a new ACL injury, patients should continue training at least twice a week, and a longer follow-up is mandatory. Multicenter cohort studies are needed to endorse the efficiency of the proposed protocol in preventing new ACL injuries after rehabilitation.

Our study has some limitations. The main limitation is the small number of participants in each group and the fact that this number was not based on the estimation of the sample size. Since training is demanding and time-consuming, many patients did not have the persistence to complete it. In fact, Slauterbeck et al.<sup>34</sup> reported that, according to the coaches, a compliance with an injury prevention program of at least twice a week is low. The second limitation is the small number of women, two in the intervention group and one in the control group, since the incidence of ACL injuries and the risk of new injury are higher in this gender. On the other hand, our objective was to assess the new risk of new injury for patients that had ACLR using the FMS scoring system. Furthermore, in the general population, the number of men that suffer ACL injuries is greater.

Another limitation was that the tests were performed by only one person, which can increase the chance of subjective influence. However, Bonazza et al.<sup>33</sup> and Teyhen et al.<sup>35</sup> reported that the FMS scoring system showed moderate to good inter-rater reliability, with acceptable levels of measurement error.<sup>33</sup> Finally, other tests were not performed, including the one-leg jump, the vertical jump and isokinetic testing.

## CONCLUSION

Functional training can be included in regular ACLR rehabilitation before returning to sports, with the aim of decreasing the risk of a new injury.



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# COMPARISON BETWEEN CONCENTRATED BONE MARROW ASPIRATE AND CORTICOID IN GLUTEAL TENDINOPATHY

## COMPARAÇÃO ENTRE O ASPIRADO DE MEDULA ÓSSEA CONCENTRADO E O CORTICÓIDE NA TENDINOPATIA GLÚTEA

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### ABSTRACT

**Objective:** To compare bone marrow aspirate concentrate (BMAC) with the standard treatment for gluteal tendinopathies. **Methods:** 48 patients diagnosed with gluteal tendinopathy at a university hospital were selected by a randomized clinical trial and divided into two groups: (G1) bone marrow aspirate concentrate and (G2) corticosteroid injections. **Results:** 40 of the 48 selected patients were monitored for six months and both groups showed better scores. Visual analog scale (VAS) scores and Lequesne index were statistically significant higher in patients submitted to BMAC treatment when compared to standard treatment. Both groups improved their quality of life, without statistically significant difference. **Conclusion:** BMAC constitutes an alternative to gluteal tendinopathy standard treatment, proving to be a safe technique with promising results when combined with multidisciplinary team behavioral therapy. **Level of Evidence II, Randomized Clinical Trial.**

**Keywords:** Tendinopathy. Bone Marrow Cells. Hip Joint. Adrenal Cortex Hormones.

### RESUMO

**Objetivo:** Estudo comparativo entre tratamento com corticóide e aspirado de medula óssea concentrado (BMAC) para o tratamento de tendinopatias glúteas. **Métodos:** O ensaio clínico randomizado selecionou pacientes diagnosticados com tendinopatia glútea e os dividiu em dois grupos: (G1) aspirado de medula óssea concentrada e (G2) injeção de corticosteróide. **Resultados:** Foram selecionados 48 pacientes, dos quais 40 foram monitorados por 6 meses, com melhora nos escores nos dois grupos. Os pacientes que foram submetidos ao tratamento com BMAC tiveram uma melhora estatisticamente significativa nos escores de EVA e nos escores de Lequesne em comparação ao tratamento padrão. Houve uma melhora na avaliação da qualidade de vida em ambos os grupos, sem diferença estatisticamente significativa. **Conclusão:** O aspirado de medula óssea concentrada surge como uma alternativa ao tratamento padrão da tendinopatia glútea, provando ser uma técnica segura e com resultados promissores quando combinada à terapia comportamental de equipe multidisciplinar. **Nível de Evidência II, O ensaio clínico randomizado.**

**Descritores:** Tendinopatia. Células da Medula Óssea. Articulação do Quadril. Corticosteroides.

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### INTRODUCTION

Tendinopathy is a tendon disorder characterized by activity-related pain, local edema, focal tenderness on palpation, and decreased strength in the affected area.<sup>1</sup> Several scientific studies address adult gluteal tendinopathy due to its prevalence. Also known as "hip bursitis," gluteal tendinopathy is often referred to as greater trochanteric pain syndrome (GTPS). GTPS includes several peritrochanteric space disorders of the hip, such as tendinopathy of the gluteus medius and gluteus minimus muscles, snapping hip syndrome, and trochanteric bursitis.<sup>2</sup>

Pathologies affecting the periarticular hip space should be included within differential diagnosis. Traumatic injuries in the direct portion of the rectus femoris muscle incur anterior hip pain and knee extensor strength deficit. Ischiofemoral impingement syndrome is a condition that narrows the proximal femur-ischium space of patients with reduced horizontal offset, causing groin and gluteal pain due to entrapment of the quadratus femoris muscle and surrounding structures. Athletic pubalgia is a syndrome that affects young patients who practice sports regularly, causing groin pain due to a chronic inflammatory process in the pubic symphysis

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The study was conducted at the Complexo Hospitalar Professor Edgard Santos of the Universidade Federal da Bahia, and it is part of the main author's doctoral program at the Universidade Estadual Paulista.

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associated with adductor tendinopathy.<sup>3</sup> Clinical studies show a high prevalence of GTPS, peaking from the sixth decade of life. A cohort study conducted with patients aged between 50 and 79 years found the prevalence of unilateral GTPS to be 15% among women and 6.6% among men and bilateral GTPS to be 8.5% among women and 1.9% among men.<sup>4</sup>

The standard treatment for gluteal tendinopathies consists of an extensive rehabilitation protocol with the use of physical agents (ultrasound, electrical stimulation, and cryotherapy) to relieve pain. Kinesiotherapy is administered to reestablish the function of the muscle group by proper movement, postural realignment, and muscle stretching.<sup>5</sup> For moments of more intense pain, routine analgesics and anti-inflammatories are prescribed. Rest must be proportional, and sports practices must be monitored throughout the recovery process.<sup>5</sup>

Corticosteroids local injection (an invasive method) is often administered to reduce local inflammation and decrease pain, consequently improving the affected hip functional condition. Surgical interventions are reserved for standard treatment-resistant cases and may vary from tendon debridement to tendon reinsertion/footprint.<sup>6</sup>

The challenge for the upcoming years is to change concepts regarding tissue regeneration in a feasible, clinically plausible, and economically viable manner. Surgical practices have shown an increasing interest in bone marrow aspirate concentrate (BMAC) applications and tissue engineering approaches for treating damaged or lost tissues resulting from sports or traumatic injuries<sup>7</sup> due to several factors, including increased familiarity with bone marrow-derived mesenchymal stem cells. Recent techniques such as gene transfer, cell therapy, and application of growth factors show great capacity of becoming effective biological therapies, given that many studies have successfully introduced markers and therapeutic genes in ligaments and tendons.<sup>8</sup>

This study sought to compare the efficacy of BMAC with corticosteroid injection in the treatment of gluteal tendinopathies.

## MATERIALS AND METHODS

### Ethical aspects

This study was developed according to Resolution No. 466/12, which regulates research involving human beings. The research project was submitted to and approved by the Research Ethics Committee of Hospital Universitário Professor Edgard Santos. CAE: 7223631720000049.

### Group of participants

Our study sample comprised 48 patients of both sexes, aged between 18 and 73 years, with clinical and radiological diagnosis of gluteal tendinopathy. These patients' nuclear magnetic resonance (NMR) were analyzed and ultrasound was performed at the outpatient clinic. All patients agreed to participate in the study by signing the informed consent form. Physical therapy treatment protocol, lifestyle changing recommendations, and analgesic treatment were the same for all participants.

### Exclusion criteria

Participants presenting infection at the surgical site or with comorbidities and contraindications for the surgical procedure were excluded.

### Monitoring plan

Monitoring visits occurred before the surgical procedure and one, three, and six months after stem cell-based grafting or corticosteroid injection. To compare condition evolution, Visual Analogue Scale (VAS), and the Lequesne (functional score) and EuroQoL-5D (quality of life score) questionnaires were administered to participants on the day of the procedure and during monitoring visits.

### Randomization

Using a computer-based system, patients were randomized into two groups: bone marrow aspirate concentrate (G1) or corticosteroid treatment (G2).

### Procedures

Stem cells were collected and injected in a surgical center, with the patient under sedation and analgesia and placed in supine position (standard for hip surgery). With the patient under spinal anesthesia and mild sedation, bone marrow aspirate was obtained by inserting a Jamshidi needle 5 cm deep toward the cancellous bone of the anterior iliac crest, so that its tip was located between the inner and outer tables. About 100 mL of bone marrow was aspirated using disposable 10-mL syringes preloaded with anticoagulant. Syringes containing bone marrow aspirates were grouped in sterile surgical grade and their contents transferred to a blood collection bag. An automated and closed system was used to separate and concentrate the fraction of mononuclear cells obtained from bone marrow aspirate (Sepax<sup>®</sup>).

Cell counting and viability assessment were performed using a small cells suspension at the procedure site. Live cells were sampled by anti-CD34 antibody staining and Propidium Iodide incorporation.

### BMAC

Using an ultrasound-guided standard 10-mL syringe, 20 mL of the solution with BMAC was injected in the gluteal tendon footprint (Figure 1).

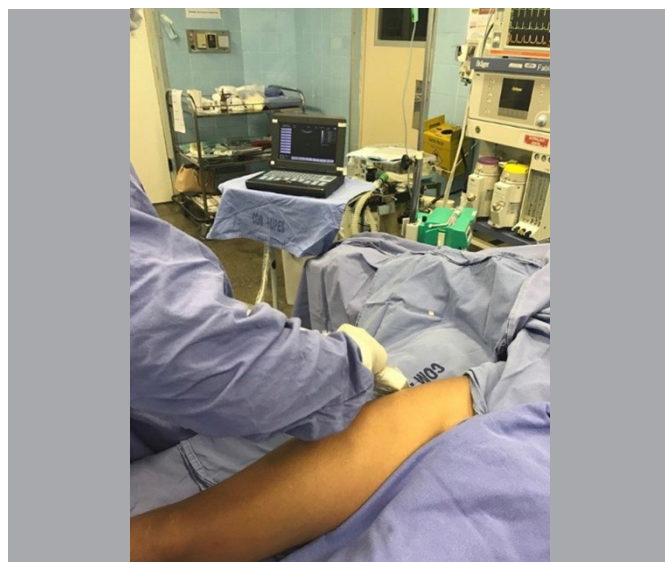


Figure 1. Ultrasound-guided BMAC therapy.

### Corticosteroid injection

Corticosteroid injection was performed in an operating room at the outpatient clinic according to the Health Surveillance norms. After local anesthesia using 2% lidocaine without vasoconstrictor at 2 mL, a solution containing 7 mg of betamethasone associated with 4 mL of 2% lidocaine without vasoconstrictor was injected using a 0.7 x 30 mm needle, guided by ultrasound.

### Data Analysis Plan

Database creation, descriptive analysis, and analytical analysis were performed using the software Statistical Package for Social Sciences (SPSS), version 14.0 for Windows<sup>®</sup>. Data normality was verified using Shapiro-Wilk test, descriptive statistics, and graphic analysis, and the results are presented in tables and graphs. Categorical variables are expressed in absolute and percentage values – n (%).

continuous variables with normal distribution are expressed as mean and standard deviation ( $\pm$ SD) and those with asymmetrical distribution in median and interquartile range (IQR). Significance level was set at 5% for inferential analyses.

## RESULTS

Eight of the 48 evaluated patients were lost to follow-up (16%). Thus, 40 patients were monitored for six months and completed the rehabilitation protocol.

From the 40 participants, twenty (50%) were men and twenty (50%) women. The average age in the bone marrow aspirate concentrate (BMAC) group (G1) was 46.1 years old ( $\pm$  15.2 years old), and in the corticosteroid group (G2) 53.2 years old ( $\pm$  12 years old). Most participants (57.5%) completed high school and only 12.5% of those currently studying got a leave of absence and were receiving the National Institute of Social Security (INSS) benefits. As for comorbidities, 47.5% of the sample presented arterial hypertension and 30% presented *diabetes mellitus*. Depression was highly prevalent among study participants (22.5%) when compared to the overall population of the same age group (4.4%), corroborating the results reported by other studies that demonstrate a strong association between depressive disorders and gluteal tendinopathy (Table 1).

**Table 1.** Comparison of sociodemographic and clinical characteristics.

Variables	BMAC Group (n = 15)	Corticosteroid Group (n = 25)	p-value**
Age (Mean $\pm$ SD)	46,1 $\pm$ 15,2	53,2 $\pm$ 12,0	0,110
Sex	n(%)	n(%)	
Male	10 (66,7)	10 (40,0)	
Female	05 (33,3)	15 (60,0)	
Education			
Primary	04 (26,7)	10 (40,0)	0,451
Secondary	09 (60,0)	14 (56,0)	
Tertiary	02 (13,3)	01 (4,0)	
INSS	04 (26,7)	01 (4,0)	0,056
Comorbidities			
Arterial hypertension	05 (33,3)	14 (56,0)	0,165
Diabetes Mellitus	02 (13,3)	10 (40,0)	0,152*
Depression	05 (33,3)	04 (16,0)	0,255*
Sickle Cell Anemia	00 (0,0)	01 (4,0)	1,000*
Labyrinthitis	00 (0,0)	01 (4,0)	1,000*
Glaucoma	00 (0,0)	01 (4,0)	1,000*
Sports Activity			
Sedentary lifestyle	02 (13,3)	20 (80,0)	< 0,001
Pilates	03 (20,0)	02 (8,0)	
Soccer	05 (33,3)	01 (4,0)	
Water aerobics	03 (20,0)	00 (0,0)	
Gym	02 (13,3)	00 (0,0)	
Walking	00 (0,0)	02 (8,0)	

n: number of participants; SD: standard deviation; INSS: National Institute of Social Security; \*: Fisher's exact test.

Most participants did not practice regular physical activity. At baseline, 55% of the study sample lacked the habit of practicing

regular and guided sports. Among those who did regular physical activity, soccer was the most prevalent (15%). However, all patients reported complying with lifestyle changes recommendations, performing activities at least 3 times a week for 30 minutes. Guided activity entails a warm-up, physical exercise with cardiovascular stimulus, and post-workout stretching. Sex, age, education, INSS, and comorbidities were homogeneous between our study groups.

Comparing VAS scores obtained at baseline and at six-month follow-up, we verified pain to progressively reduce at about 67% in patients treated with BMAC (G1) and at about 34% in patients treated with corticosteroid injection (G2), with statistical significance ( $p < 0.001$ ). At six-month follow-up, the median value was 2 in G1 and 4 in G2, with statistical significance ( $p < 0.01$ ).

The intragroup evaluation regarding the Lequesne questionnaire found G1 to show a 4-point reduction from baseline to six-month follow up, whereas this reduction was of 1.2 points for G2, with statistical significance ( $p < 0.02$ ). The intergroup comparison verified a statistically significant reduction ( $p < 0.03$ ), indicating that BMAC therapy was beneficial.

The quality of life within groups, assessed with by EuroQol 5D, showed statistically significant values in both groups. At six-month follow up, patients treated with BMAC presented an average increase of 0.16 ( $p < 0.002$ ) in EuroQol 5D values, whereas patients treated with corticosteroids presented a 0.11 ( $p < 0.01$ ) increase. We found no statistically significant difference when comparing both groups (Table 2).

**Table 2.** Intergroup and intragroup comparison of the Visual Analogue Scale and the EuroQol 5D and Lequesne questionnaires.

Variables	BMAC Group (n = 15)	Corticosteroid Group (n = 25)	p-value**
VAS	Median (IQR)	Median (IQR)	
Baseline	6.0 (5.0 – 7.0)	6.0 (4.0 – 7.5)	0.619
1st month	3.0 (2.0 – 4.0)	3.0 (2.0 – 5.0)	0.562
6th month	2.0 (2.0 – 3.0)	4.0 (2.5 – 6.0)	0.014
p-value**	0.001	0.001	
EuroQol 5D	Average $\pm$ SD	Average $\pm$ SD	
Baseline	0.52 $\pm$ 0.22	0.50 $\pm$ 0.33	0.752
6th month	0.68 $\pm$ 0.18	0.61 $\pm$ 0.25	0.353
p-value**	0.002	0.016	
Lequesne			
Baseline	8.7 $\pm$ 1.9	8.0 $\pm$ 3.6	0.397
6th month	4.7 $\pm$ 2.1	6.8 $\pm$ 3.3	0.031
p-value**	< 0.001	0.021	

n: number of participants; IQR: interquartile range; SD: standard deviation; VAS: Visual Analogue Scale; \*\*: Intergroup comparison (independent t-test or Mann-Whitney); \*\*\* Intragroup comparison (paired t-test or Wilcoxon).

When calculating the delta values of this study outcomes – obtained by subtracting baseline scores from the six-month follow up – we found VAS scores to present a 3.5-point median reduction in the BMAC-treated group and a 1.6-point reduction in the corticosteroid-treated group, with statistical significance. Likewise, G1 presented a 4-point reduction in the Lequesne index, whereas G2 presented a 1.1-point reduction. We found no statistically significant difference regarding EuroQol 5D values between groups, increasing quality of life by 0.16 in the BMAC group and by 0.12 in the corticosteroid group (Table 3).

**Table 3.** Intergroup comparison of scores variability regarding the Visual Analogue Scale and the EuroQol 5D and Lequesne Index questionnaires.

Variables	BMAC Group (n = 15)	Corticosteroid Group (n = 25)	p-value**
Δ VAS	-3.5±1.5	-1.6±1.8	0.001
Δ EuroQol 5D	0.16±0.15	0.12±0.23	0.590
Δ Lequesne	-4.0±2.0	-1.1±2.3	> 0.001

n: number of participants; VAS: Visual Analogue Scale; \*\* Intergroup comparison (Independent t-test).

## DISCUSSION

Studies addressing tendinopathies are still scarce in the literature, so a limited number of patients is monitored regarding this condition. The first studies on the use of cell therapy in the treatment of tendinopathy were published in 2012. A group of researchers from a sports medicine center in New York published a series of eight cases of patellar tendinopathy treated with bone marrow mesenchymal stem cells. A study conducted in Brazil evaluated 14 individuals. Only case reports are found on the study of gluteal tendinopathy. Several preclinical studies were also developed in other mammalian and *in vitro* species in an attempt to clarify bone marrow aspirate concentrate (BMAC) mechanisms of action in tendinopathies.<sup>9-11</sup> Studies employing corticosteroid injection in the treatment of tendinopathies present a higher proportion of women. In turn, those employing BMAC comprise an equivalent proportion between sexes, like ours. Studies using corticosteroids for gluteal tendinopathy found pain to be higher than 5 (according to VAS scale) in about 40% of patients three months after the procedure.<sup>4,12,13</sup> The literature tends to agree that medication use, physical therapy, or surgical treatment have poor outcomes and few benefits to the patient when performed isolated. For patients with greater trochanteric pain syndrome (GTPS) to achieve a favorable well-being, they must undergo a multidisciplinary treatment involving changing lifestyle habits (regular physical activity, weight loss, muscle strengthening,

and stretching), doing physical therapy, and controlling underlying pathologies and pain (GTPS).<sup>14,15</sup>

Among the different local adjuvant therapies used to treat GTPS, the most common is corticosteroid injection. Using ultrasound for corticosteroids injection in the trochanteric region achieved promising results to the treatment. Long-term studies corroborate the results found in our research: although treatment with corticosteroid injection present positive clinical results at one-month follow-up, a serial evaluation showed that from two to six months after the procedure pain level switch back to values similar to those recorded at baseline. That is, treatment with corticosteroids promote a short-term reduction in pain and inflammation. Corticosteroid injections also pose risks related to inhibition of collagen synthesis and induction of apoptosis, reducing tendon resistance and increasing the risk of rupture.<sup>16,17</sup> BMACs are already being employed in experimental treatments of tendon disorders in different parts of the human body. Treatments for patellar tendinopathy, rotator cuff, and lateral epicondylitis with BMAC have presented positive clinical results.<sup>18,19</sup> GTPS requires a multidisciplinary treatment rather than a specific therapy, entailing comorbidities control, changes in lifestyle habits, and physical therapy.<sup>11</sup> When compared to the standard treatment that uses corticosteroid injection, BMAC showed promising outcomes as a local adjuvant therapy for GTPS.

## CONCLUSION

Bone marrow aspirate concentrate (BMAC) represents a promising alternative to corticosteroids in the treatment of hip tendinopathy. When compared to conventional local therapy, BMAC reached statistically significant scores in the Visual Analogue Scale (VAS) for pain and Lequesne algofunctional index. The technique proved to be safe and feasible when administered along with a multimodal treatment involving different areas within health science.

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# CORRELATION BETWEEN FRACTURES AND ABUSE IN CHILDREN: A RETROSPECTIVE ANALYSIS

## RELAÇÃO ENTRE FRATURAS E SUSPEITA DE MAUS TRATOS EM CRIANÇAS: UMA ANÁLISE RETROSPECTIVA

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### ABSTRACT

**Objective:** The aim of this work is to provide evidence for the relationship between suspicion and diagnosis of cases of child abuse and fractures, since, in national literature, studies are still scarce on the subject. **Methods:** Retrospective study involving electronic medical records of a public reference hospital, in a city of the state of São Paulo, in a 8-year period (2010 to 2018). Cases involving children up to 12 years of age were selected when notified as abuse and presenting fractures; data were statistically analyzed. **Results:** Among 83 cases of abuse, 19 patients (20.5%) had 23 different fractures. The victims were mainly boys (68.42%) with a mean age of 5 years old, who suffered physical aggression (79%). The majority had no identified aggressor (52%) and 21% were related to the mother. The fracture patterns found involved, mostly, skull fractures (43.48%) and diaphysary fractures (34.78%). Seven patients (30.43%) had other associated lesions and four patients died (21%). **Conclusion:** Despite the number of cases, it was possible to identify relevant characteristics and patterns. These data indicate that the diagnosis is underestimated and show small epidemiological differences compared with international literature. **Level of Evidence II, Retrospective study.**

**Keywords:** Child abuse. Aggression. Bone Fractures. Child.

### RESUMO

**Objetivo:** O objetivo deste trabalho é fornecer evidências para a relação entre suspeita e diagnóstico de casos de maus tratos e fraturas infantis, dado que, na literatura nacional, os estudos ainda são escassos sobre o tema. **Métodos:** Estudo retrospectivo envolvendo prontuário eletrônico de um hospital público de referência, em um município do estado de São Paulo, num período de 8 anos (2010 a 2018). Foram selecionados casos envolvendo crianças de até 12 anos notificados como maus tratos e apresentando fraturas, sendo os dados submetidos análise estatística. **Resultados:** Dentre 83 casos de maus tratos, um total de 19 pacientes (20.5%) apresentaram 23 fraturas diferentes. As vítimas em 68,42% eram meninos com média de 5 anos de idade que sofreram agressão física (79%). A maioria não teve agressor identificado (52%), sendo 21% relacionado a mãe. Os padrões de fratura encontrados envolveram em sua maioria fraturas de crânio (43,48%) e fraturas diafisárias (34,78%). Sete pacientes (30,43%) tiveram outras lesões associadas e quatro pacientes vieram a óbito (21%). **Conclusão:** Apesar do número de casos, foi possível identificar características e padrões relevantes. Tais dados apontam que o diagnóstico é subestimado e mostram pequenas diferenças epidemiológicas comparativas a literatura internacional. **Nível de Evidência II, Estudo retrospectivo.**

**Descritores:** Maus-Tratos Infantis. Agressão. Fraturas Ósseas. Criança.

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### INTRODUCTION

Child abuse refers to violence committed against children and adolescents in the family, institutional or social environment.<sup>1</sup> One of the first descriptions of orthopedic manifestations directly related to child abuse was performed by Caffey<sup>2</sup> in 1946, describing metaphyseal lesion of long bones in children with multiple injuries, and later coining the term “corner fracture,” which is the fracture through immature metaphyseal bone near the growth plate.<sup>3</sup> In 1962, Kempe et al.<sup>4</sup> introduced the designation “battered child syndrome,” which brought medical attention to the problem of

child abuse and led to the creation of compulsory notification laws. Originally, child abuse was defined as a physical injury inflicted on children by their caregivers. Since then the definition has expanded to include physical neglect, exposure to danger and emotional and sexual abuse.<sup>2,3</sup>

Another important term is non-accidental trauma: action resulting from an act of omission, direct or indirect action that results in harm to the child or impairs his/her health and physical, mental or emotional development.<sup>5</sup>

In addition to being a public health problem, exposure to child abuse is associated with negative long-term consequences, including

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The study was conducted at Universidade Federal de São Paulo, Paulista School of Medicine.

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involvement with the criminal system<sup>6</sup> and recurrent use of mental health services.<sup>7</sup>

The Brazilian Penal Code foresees, in Article 136, the crime of child abuse and since the implementation of the Child and Adolescent Statute, through the Federal Law No. 8069, health professionals are obliged to notify suspected or confirmed cases of abuse against children and adolescents.<sup>8</sup>

Zimmerman et al.<sup>9</sup> reported that 50% of 243 abused children were under the age of one and 78% were under the age of three; 80% of the fractures were due to abuse in children under 18 months<sup>3</sup> and abuse was the third cause of death of 1 to 4-year-old children.<sup>5</sup> Younger children have a higher death rate due to maltreatment.<sup>2</sup> In children under the age of three, 20% of fractures caused by maltreatment are misdiagnosed or attributed to other causes.<sup>3</sup> In addition, fractures may go unnoticed by poorly done or misinterpreted radiographs.<sup>10</sup>

The incidence of fractures in children ranges from 8-12% in the literature.<sup>11</sup> Contusions are the most common injuries, followed by fractures;<sup>10,12</sup> thus, orthopedists play an important role in the recognition and diagnosis of non-accidental trauma,<sup>3</sup> participating in the initial evaluation of these patients. Maltreatment diagnosis can be difficult and requires high suspicion on the part of the professionals.<sup>5</sup> This hypothesis can be ignored as a diagnostic possibility due to intentional change of story to mask abuse, causing misdiagnosis during the initial evaluation of the patient.<sup>13</sup>

When suspicion is raised, radiographic investigation should include anteroposterior incidences and profile of all bones of the appendicular skeleton, skull, chest and lumbar spine with separate cervical spine profile vision and anteroposterior incidences of the thorax, abdomen and pelvis, all in separate films. Oblique incidences of ribs are recommended and very useful. Each x-ray should be analyzed for signs of maltreatment, especially in the presence of specific abuse lesions, such as posteromedial fractures of ribs, corner and scapula fractures, sternum fractures and spinous processes.<sup>14</sup> It is important to note that although numerous studies have described fracture patterns that suggest abuse, there is no pathognomonic pattern and it is impossible to determine whether the child has been abused based solely on radiographies.<sup>5</sup>

To identify child abuse as a cause of fractures, doctors should consider factors such as change in story or inconsistency with the injury, delay in seeking treatment, age of the child, location and type of fracture, as well as the mechanism of trauma involved (fracture of long bones in children under one year old, multiple fractures in different stages of healing, corner fractures, rib and skull fractures) and presence of other injuries (burn injuries and unexplained soft tissue injuries). Even less specific injuries become highly suspicious when a good story is not provided.<sup>14</sup> In view of these findings, the activation and notification of the authorities for the protection of children should be considered at the same time as other causes are investigated.<sup>2,10</sup>

Misdiagnosis, failure to identify the lesion and appropriate intervention increase the risk of progressive and repetitive abuse, with potential permanent consequences for the child and increased morbidity and mortality.<sup>2,5</sup> The rate of new injury in beaten children is around 30 to 50%, and the risk of death is between 5 and 10%.<sup>2,13</sup> If a new injury occurs, it is likely that the caregiver will seek care in a different medical service and the risk of death increases with each new emergency service visited.<sup>2</sup> At the same time, the embarrassment caused to an innocent family accused of abuse can cause conflicts in family dynamics.<sup>7</sup>

We believe that cases of fractures related to child abuse and maltreatment are underestimated by physicians and the injury patterns are poorly known. There are no established protocols to optimize the diagnosis and proper notification of suspected cases. Thus, we aim

to identify the relationship between suspicion and diagnosis of cases of maltreatment and fractures in children, determining the risks and associated factors. We also intend to describe the epidemiological profile of abuse reports related to fractures. In our knowledge, there are no studies of this type involving the Brazilian population.

## MATERIALS AND METHODS

Initially, the study was submitted to the Ethics and Research Committee of hospital São Paulo, Universidade Federal de São Paulo and approved under number 3,521,862. This is a retrospective study involving the review of the care performed by the Orthopedics team of the General Hospital, from 2010 to 2018, and the Free and Informed Consent Form was not applied. Thanks to the work of collecting and organizing of the Hospital Epidemiological Surveillance Center, it was possible to catalog all treated injuries recorded during this period. We identified in electronic medical records of children (from birth to 12 years old) cases reported as maltreatment and abuse. Based on this data, we sought to identify relevant patterns. We cataloged the presence and characteristic of fractures and associated lesions in these diagnoses, as well as the type of aggression and epidemiological data involved.

## RESULTS

The place where the study was conducted is a tertiary hospital in the state of São Paulo, which receives cases of greater complexity. In the 8-year analyzed period, 3106 diseases were identified, notified and registered by the Epidemiological Surveillance Center of the referred hospital. Among them, 83 cases (2.67%) were identified as aggression and maltreatment in children from birth to 12 years of age. We found patients from six different cities. Out of the identified 83 cases, 54 involved physical aggression (65%), 15 cases involved suicide attempts (18%), eight cases were identified as negligence (9.6%), four episodes involved sexual abuse (4.8%) and two cases, abandonment (2.4%). Among these categories, a total of 19 patients (20.5%) presented 23 different fractures.

Among the patients who were victims of fractures, we found 13 boys (68.42%) and six girls (32.58%) with a mean age of five years old (range from 1 month to 12 years old). Only four did not suffer physical aggression (21% versus 79% victims of aggression); three were cases of neglect (15.8%) and there was one case of suicide attempt (5.25%).

The forms of aggression predominantly involved direct body strength (seven cases, 36.84%) and aggression with firearms (five cases, 26.31%), two episodes (10.5%) involving instruments (metal and wood bar), three episodes of fall (15.75%), one suicide attempt, one push and one victim of negligence (5.25% each). Two cases had no elucidated trauma mechanism (children were already abandoned presenting the lesions).

Ten cases had no identified aggressor (52%), four were related to mother (21%), three related to father (15.8%), two to stepfathers (10.5%), one to police officers and one to sister (5.25% each). Two patients had more than one aggressor (mother and stepfather in both cases).

The fracture patterns found involved 10 skull fractures (43.48%), eight diaphyseal fractures (34.78% of which were in the humerus, two in the femur, two in the tibia and one in the forearm), a supracondylar humerus fracture, a palate fracture, a clavicle fracture, a rib fracture and a wrist fracture (adding up 21.74%). Three patients had two or more fractures (15.8%) and, of the total, two fractures were exposed (8.7%). Seven patients (30.43%) had associated lesions; the observed lesions were pulmonary contusion, pneumothorax, subdural/extradural bruises and cerebral edema. Four patients died (21%).

All cases were investigated by the Guardianship Council and public agencies. Two had their custody retained by the guardianship council during hospitalization (10.5%), the others were characterized as maltreatment in a second moment.

## DISCUSSION

Despite the choice of a large tertiary hospital – a reference in a populous region that receives patients from multiple municipalities – in a period of extended temporal analysis and, consequently, covering a large number of patients involved in injuries, we had a relatively small number of cases. This finding is in favor of probable and important diagnostic mistakes and failure to detect cases of child abuse.

The incidence of child abuse is difficult to be determined, even though we find several data and studies discussing the relationship between fractures, maltreatment and their notification in the foreign literature. The Brazilian literature presents few information on the subject. In the United States, more than three million cases of child abuse or neglect are reported annually.<sup>15</sup> Comparing with the Brazilian Institute of Geography and Statistics (IBGE)<sup>16</sup> data and the incidences reported in international studies, the number of cases found in this study is much lower than expected.

It is interesting to note that the nineteen cases reported as suspected maltreatment were afterwards confirmed by public agencies. This suggests that notifications are likely biased, associated with fear of misdiagnosis, so that health professionals probably only reported cases explicitly indicative of abuse.

In an overview, we observed that the type of aggression suffered by most children was physical, followed by suicide attempts (abuse of multifactorial origin) and negligence. Predominantly, the aggressions involved direct body strength or the use of instruments, especially firearms; this may be related to the precarious socioeconomic condition and the social pressures imposed on the population of the cities involved in the study.

Most of the aggressors were not identified, however, mothers were the most identified aggressors, followed by fathers. The aggressions were higher in boys and the average age of the children was five years old. Such data are partly consistent with the literature.

Statistical analyses of internationally reported cases have shown that children are more susceptible to abuse by caregivers when younger and of worse social condition. Abuse is also less likely to be reported when it is emotional rather than physical and when the mother is the main aggressor. However, maltreatment in families with higher purchasing power and social status may be underreported by health professionals, who wish to protect individuals of that social class of the stigma of investigation by public entities.<sup>2</sup> We recall that the population of our study is predominantly poor, SUS users and residents of socioeconomically fragile areas.

Classically, long bone fractures in children under one year of age were considered highly suggestive of maltreatment, as children at this age would be unable to produce trauma with sufficient energy.<sup>17</sup> However, it was later found that this was not true. Kleinman et al. classified the specificity of fractures due to maltreatment in three categories, according to their probability of being abuse-related.<sup>18</sup> Fractures of high specificity are metaphyseal lesions

(corner fracture), ribs in their posterior aspect, scapula, spinous processes and sternum. Those of moderate specificity are multiple (bilateral) fractures at different ages or period, slip fracture through the physis (type I Salter-Harris fracture), vertebral fractures or subluxations, digit fractures and complex skull fractures. Finally, those considered low specificity are clavicle fractures, long bone diaphysis fracture, and linear skull fractures.<sup>18</sup>

Most of the reported fractures involved the skull, mainly the parietal bone. The second most common type of fracture involved long bones. It is interesting to note that the fractures most associated in the literature with maltreatment were not found in this study (except for rib fracture, but we could not define its topographic position).

We believe that it is essential to remember that the diagnosis of maltreatment should never be made only by the study of radiographic patterns,<sup>5</sup> and the findings described reinforce the need to expand clinical investigation on the etiology of lesions even in the presence of less associated types of fractures.

The mortality rate reported in foreign studies for children who were beaten was lower than in our study (5 to 10%<sup>2,5</sup> versus 21%). This finding may point out to the presence of a worse prognosis in relation to severity in children who presented fractures, or the higher notification of severe cases.

For ethical, technical and operational reasons, our data analysis came from cases reported as suspected maltreatment in the hospital. This certainly led to the loss of unreported suspected cases. Among the limitations of this study, we should mention the number of patients found in hospital records referred to as maltreatment, despite the long period investigated. This limits the statistical strength of association of the data. We should also remember the biases inherent to retrospective scientific studies, such as the bias of response selection, inaccuracy and lack of information. We remember, however, that this is a pioneer study: there are no other similar studies in the Brazilian literature involving fractures and child abuse. This is an important initial step to better understand the main characteristics of these complex cases in our reality, to optimize their detection and develop diagnostic, guidance and conduct protocols.

## CONCLUSION

Among the 83 reported cases of maltreatment, a total of 19 patients (20.5%) presented 23 different fractures. Despite the small number of cases, it was possible to identify relevant characteristics and patterns. The victims were mainly boys (68.42%) with a mean age of 5 years old (ranging from 1 month to 12 years old), who suffered physical aggression (79%). The majority had no identified aggressor (52%) and 21% were related to the mother. The fracture patterns found involved, mostly, skull fractures (43.48%) and diaphyseal fractures (34.78%). Seven patients (30.43%) had other associated lesions and four patients died (21%). All cases were investigated by the Guardianship Council and public agencies and definitively characterized as maltreatment. These confirm the hypothesis that the diagnosis is underestimated by health professionals and show small epidemiological differences compared with the international literature. Further studies are needed to better characterize and confirm the patterns found.

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# CLINICAL EVALUATION OF THE TREATMENT OF CLAVICLE FRACTURES: INTRAMEDULLARY NAIL × PLATE

## AVALIAÇÃO CLÍNICA DO TRATAMENTO DAS FRATURAS DE CLAVÍCULA: HASTE × PLACA

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### ABSTRACT

**Objective:** Studies confirm the benefit of surgical treatment for fixation of displaced midshaft clavicle fractures. Plate fixation and intramedullary nail are the two most used techniques. Our study seeks to compare these two surgical techniques. **Methods:** This is a retrospective study, conducted by the evaluation of patients treated for displaced midshaft clavicle fracture with intramedullary nail, and plate and screws. Socioeconomic variables were collected, a visual pain scale questionnaire was applied, the shoulder function was measured using CONSTANT and UCLA scores, and radiography was performed to verify the consolidation and evaluation of the final clavicle shortening. **Results:** Sixty-five patients were evaluated, 36 (55.4%) of which were subjected to clavicle fixation with plate and screws and 29 (44.6%) with intramedullary nail. The median shortening was 0.1mm for plate and 5.8mm for nail ( $p = 0.001$ ). The UCLA score shows an average of 35 in the plate group and 35 in the intramedullary group. The median CONSTANT scores were 96.5 for plate and 95 for nail, without significance. In all groups, 13 (20%) complications were registered, 9 fixed with plate and 4 fixed with intramedullary nail. The most common complication was skin erosion with exposure of the synthetic material. **Conclusion:** The two techniques present satisfactory results for the treatment of displaced midshaft clavicle fractures. **Level of Evidence III, Therapeutic Studies Investigating the Results of Treatment.**

**Keywords:** Fractures, Bone. Clavicle. Fracture Fixation. Bone Plates.

### RESUMO

**Objetivo:** Trabalhos confirmam o benefício do tratamento cirúrgico para fixação de fraturas desviadas do corpo da clavícula. A fixação com placa e haste intramedular são as duas técnicas mais utilizadas. O objetivo deste estudo é comparar as duas técnicas cirúrgicas. **Método:** Estudo retrospectivo realizado por meio da avaliação de pacientes submetidos à fixação com haste intramedular e com placa e parafusos para o tratamento de fraturas desviadas do corpo da clavícula. Neste caso, foram avaliadas variáveis socioeconômicas, aplicado questionário da escala visual da dor, mensurado a função do ombro pelo escore de CONSTANT e UCLA, e realizada radiografia para verificação da consolidação e avaliação do encurtamento final da clavícula. **Resultados:** foram avaliados 65 pacientes, destes 36 (55,4%) foram submetidos à fixação da clavícula com placa e parafusos e 29 (44,6%) com haste intramedular. A mediana do encurtamento foi 0,1mm para placa e 5,8mm para haste ( $p = 0,001$ ). O escore de UCLA apresentou mediana de 35 no grupo placa e 35 no grupo haste. O escore de Constant mostrou mediana de 96,5 no grupo placa e 95 no grupo haste, sem diferença significativa entre os grupos. Ao todo, foram registradas 13 (20%) complicações, 9 do grupo fixado com placa e 4 do grupo fixado com haste. A complicação mais comum foi a erosão da pele com exposição do material de síntese. **Conclusão:** as duas técnicas apresentam resultados satisfatórios para o tratamento das fraturas do corpo da clavícula. **Nível de Evidência III, Estudos terapêuticos – Investigação dos resultados do tratamento.**

**Descritores:** Fraturas ósseas. Clavícula. Fracture Fixation. Placas ósseas.

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### INTRODUCTION

Clavicle fractures represent 2-5% of all fractures in adults.<sup>1-7</sup> They are more common in men in the second decade of life.<sup>3,5</sup> The main mechanisms of fracture are automobile accidents and sports

traumas.<sup>3,7,8</sup> They can be divided according to location, with the clavicle midshaft being the most affected, accounting for 80% of the cases.<sup>2-4,6-10</sup> Furthermore, fractures of the clavicle midshaft tend to be diverted.<sup>4,8,9</sup>

All authors declare no potential conflict of interest related to this article.

The study was conducted at Hospital Ortopédico e Medicina Especializada, Instituto de Pesquisa e Ensino.

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Exposed, diverted high energy fractures, with severe comminution and shortening greater than 2cm are the main indicators of surgical fixation.<sup>11</sup> In these cases, surgical treatment has advantages in consolidation rates, lower shortening rates, lower persistence of pain, earlier return to daily activities, greater mobility and shoulder strength, and better aesthetic satisfaction.<sup>1-4,8,9,12-14</sup> Different techniques have been described for clavicle fixation, among which the two most used are the plate and the intramedullary nail.<sup>1,2,7,8,14,15</sup>

The two fixation techniques have advantages, and plate fixation is considered the gold standard due to its better stabilization when compared with the nail.<sup>1,2,7</sup> The intramedullary nail appeared as an alternative because it is less invasive, since it preserves the adjacent soft tissue, periosteum and vascular integrity at the fracture site. Thus, it presents lower infection rates, better aesthetic results and lower cost.<sup>1,2,5,8</sup>

Few studies have compared the best surgical technique for fixation of clavicle fractures. The objective of our study is to compare the clinical and radiographic results of patients subjected to surgical fixation treatment with intramedullary plate or nail of fractures diverted from the body of the clavicle, since they are the two most used techniques.

## MATERIALS AND METHODS

A retrospective cohort study was conducted, with multivariate analyses of the data obtained by the review of medical records, postoperative clinical reassessment and comparative radiographs of patients subjected to surgical treatment of the clavicle fracture. From January 2011 to August 2017, patients operated for surgical treatment with fractures diverted from the clavicle midshaft fixed with plate and screws or flexible titanium nail were evaluated. The study was conducted in two reference centers, with the same team of surgeons, composed of two shoulder specialists. The volunteers were selected based on the following inclusion and exclusion criteria:

### Inclusion criteria

Individuals aged 18 years or over; fractures of the clavicle midshaft with fixation with plate and screws or intramedullary nail; and at least 6 months postoperatively.

### Exclusion criteria

Fracture of the lateral third; fracture associated with brachial plexus injury; associated lesions in the operated shoulder; patients that were not located or that refused to participate in the study.

In total, 95 patients were operated, 65 contributed to the study, and the main exclusion factor was the loss of patients in the follow-up. The study design was submitted and approved by the local ethics committee on CAAE 70804317.7.0000.0023.

### Evaluation criteria

During the reassessment, sociodemographic, anthropometric and clinical variables were collected. Pain measurement was performed using the visual analog scale. Shoulder function and postoperative patient quality of life were evaluated by the Constant-Murley (CONSTANT) and University of California at Los Angeles (UCLA) scales. On the day of the evaluation, the volunteers were subjected to a new radiography in anteroposterior incidence and ZANCA, comparatively, including the two clavicles. Thus, the consolidation and length of the clavicle, which is its extension from the acromial extremity to the sternal articular face, were evaluated, being measured by two evaluators, using the mean of the values found as the final result (Figures 1 and 2).



**Figure 1.** Radiography with anteroposterior incidence and ZANCA, including comparatively the two clavicles after fixation with plate.



**Figure 2.** Radiography with anteroposterior incidence and ZANCA, including comparatively the two clavicles after fixation with plate.

## Surgical description

In both groups, locoregional anesthesia with brachial plexus block and general anesthesia was used, in addition to antibiotic prophylaxis with cefazolin.

In the group of patients subjected to fixation of fractures with plate and screws, Synthes® precast blocked LCP plates of 3.5 mm stainless steel for clavicle were used. The access route was through upper, horizontal incision, and opening of the muscular fascia. After reduction under direct visualization of the focus, the plate was placed in the upper part of the clavicle and fixed with at least 3 screws in each main fragment. In most cases, the principle of relative stability was used due to the fragmentation of the fracture focus. In some cases, with oblique features and no fragmentation, interfragmented screws with compression of the fracture focus were used.

In the nail group, a medial entry point into the clavicle was used through a 1 cm anterior horizontal incision, laterally to the sternoclavicular joint. The bone entry point was at the lower edge of the medial clavicle, at a point approximately 1 cm lateral to the sternoclavicular joint, performed with a 2.5 mm awl. Each fracture was fixed with only one flexible nail, with a diameter ranging from 2.0 to 3.0 mm, chosen according to the size of the clavicular medullary canal. A reduction was performed either manually or by means of pointed tweezers for percutaneous manipulation of the fragments. When the closed reduction was not achieved, a vertical incision of 2.0 cm was made on the focus and direct fracture reduction. After the nail overtook the fracture focus, it was advanced to the lateral clavicle, piercing the heterolateral cortical. Finally, the nail was cut close to the medial entry point and the fascia was sutured over it. The intramedullary nail was removed at the end of treatment, but the plate was removed only in cases in which they caused discomfort.

## Rehabilitation

The rehabilitation protocol for both groups consisted of immobilization with a sling for four weeks, starting the gain of the range of movements after two weeks, with self-passive exercises. From the fifth week on, the patients were referred to physical therapy to initiate active movement. Muscle strengthening and return to complete activities were allowed after complete fracture consolidation.

## Follow-up period

Initially, the services adopted the exclusive use of fixation with plate and screws in clavicle fractures until January 2015, and the method was completely replaced by fixation with intramedullary nail, regardless of the type of fracture. Thus, the average follow-up period of patients treated with plate was longer than patients treated with intramedullary nail (3 years and 4 months and 1 year and 7 months, respectively).

## Statistical description

The comparison of numerical variables between two groups of synthesis material was performed by the Mann-Whitney test (nonparametric), and for categorical data, the chi-square ( $\chi^2$ ) or Fisher's exact tests were applied. Spearman's correlation coefficient (r) was used for the association between numerical variables.

Significance level was set at 5%. Statistical analysis was processed by statistical software SAS® System, version 6.11 (SAS Institute, Inc., Cary, North Carolina).

## RESULTS

During the period, 95 patients underwent surgery. Of these, 65 were included.

### Epidemiology

Of the 65 volunteers, 36 (55.4%) were subjected to fixation of the clavicle with plate and 29 (44.6%) with intramedullary nail (Table 1).

**Table 1.** Epidemiological profile by group.

Variable	Plate (36)		Nail (29)	
<b>Age (years)</b>				
Mean (range)	37.5 (18 – 69)		37.8 (18 – 75)	
<b>Gender</b>				
Male	33	91.7 (%)	23	79.3 (%)
Female	3	8.3 (%)	6	20.7 (%)
<b>Physical Activity</b>				
Sedentary	9	25.0 (%)	6	20.7 (%)
Moderate	15	41.7 (%)	15	51.7 (%)
active	12	33.3 (%)	8	27.6 (%)
<b>BMI (kg/m<sup>2</sup>)</b>				
median	26.9		24.4	

Men accounted for 86.2% (n = 56) of the patients treated. The main mechanisms of trauma were automobile accidents, followed by sports trauma. The mean age in the fracture event was 37.5±12 years (range 17-75).

Clavicle shortening and shoulder function:

Clavicle shortening is given by the difference between the length of the unfractured side and the fractured side. Its median was 0.9mm (range -3.5 - 14) in the plate group and 5.8mm (range -0.8 - 14.4) in the nail group (p = 0.001) (Figures 1 and 2). The median CONSTANT scores were 96.5 (range 80 - 100) in the plate group and 95 (range 79 - 100) in the nail group, whereas the UCLA score had a median of 35 (range 21 - 35) for plate and 35 (interval 29 - 35) for the nail. Based on Spearman's score, there was no association between clavicle shortening and shoulder function by CONSTANT score (r = 0.009) and UCLA (r = 0.045) (Table 2).

**Table 2.** Shortening rate and shoulder function – Plate × Nail.

	Plate (n = 36)	Nail (29)	p valor	r
Median Shortening (mm)	0.9 (-3.5 – 14)	5.8 (-0.8 – 14.4)	0.001	
Median CONSTANT Score	96.5 (80 – 100)	95 (79 – 100)	0.66	0.009
Median UCLA SCORE	35 (21 – 35)	35 (29 – 35)	0.23	0.045

### Shoulder shortening and function stratified by the type of fracture

By Robinson's rating, 36 (55.3%) patients had type 2B1 and 28 (43.0%) fracture type 2B2. Of the fractures 2B1, 17 (48.5%) were fixed with plate and 18 (51.4%) with nail, whereas among fractures 2B2, 18 (64.2%) were fixed with plate and 10 (35.7%) with nail.

When analyzing the fixation method stratified by the type of fracture, we observed that the median shortening of fractures in group 2B1 was 1.3 mm (interval -1.1 – 10) for plate and 5.5 mm (interval 0.9 - 13.9) for nail. Thus, 2B1 fractures present significantly lower shortening when fixed with plate (p = 0.018). In the 2B2 fracture group, a median of 0.75 mm (range -3.5 – 14) for plate and 9.75 mm (range -0.8 – 14.4) for the nail was observed, with shortening in the plate group significantly lower (p = 0.029).

The 2B1 fractures fixed with plate presented a mean CONSTANT score of 95.2 (interval 82 – 100) and an average UCLA score of 35 (range 35-35). When fixed with nail, the mean CONSTANT score was 95.3 (range 79 – 100) and the mean UCLA score was 34.6 (range 29 – 35). The two fixation methods for 2B1 fractures do not present significant difference compared to the score of CONSTANT (p = 0.7) and UCLA (p = 0.17).

In the 2B2 fractures fixed with plate, similar values were observed in the scores, and the mean CONSTANT score was 93.6 (interval 79 – 100) and the mean UCLA score, 34.3 (interval 21 – 35). The same was observed in fixation with nail, with mean CONSTANT score of 93.9 (range 86 – 100) and average UCLA of 34.8 (range 21 – 35). The two techniques showed no significant difference in UCLA (p = 0.68) and CONSTANT (p = 0.94) (Table 3) scores.

**Table 3.** Shortening and function of the shoulder stratified by the type of fracture.

	2B1 (n = 36)			2B2 (n = 29)		
	Plate (n = 17)	Nail (n = 19)	p valor	Placa (n = 19)	Nail (n = 10)	p valor
Median Shortening (mm)	1.30 (-1.1 – 10)	5.50 (0.9 – 13.9)	0.018	0.75 (-3.5 – 14)	9.75 (-0.8 – 14.4)	0.029
Median CONSTANT Score	98 (82 – 100)	100 (79 – 100)	0.70	95 (80 - 100)	94 (86-100)	0.94
Median UCLA SCORE	35 (35 – 35)	35 (29 - 35)	0.17	35 (21 -35)	35 (33 -35)	0.68

### Pain

Patients operated with nails have a tendency to have more intense/moderate pain in the immediate postoperative period compared to patients operated with plate and screws (p = 0.062). Most patients in both groups evolved without pain; however, when pain remains present, the tendency is to be in patients fixed with plate and screws (p = 0.93) (Table 4).

**Table 4.** Pain distribution.

	Plate (n = 36) %		Nail (n = 29) %		P valor
<b>Immediate postoperative pain</b>					
Absent	6	16.7	6	20.7	0.062
mild	16	44.4	9	31.0	
Moderate	7	19.4	13	44.8	
Intense	7	19.4	1	3.4	
<b>Current pain</b>					
Absent	30	83.3	28	96.6	0.093
mild	6	16.7	1	3.4	

### Patient satisfaction

Patients treated with nail have a tendency of greater aesthetic satisfaction with the scar when compared with the plate group (p = 0.93) (Table 5).



**Table 5.** Aesthetic satisfaction of the surgical scar.

Physical/aesthetic discomfort	Plate (n = 36) %	Nail (n = 29) %	p valor
Yes	6 16.7	1 3.4	0.093
No	30 83.3	28 96.6	

### Complications

In total, 13 (20%) complications of surgical treatment were registered. In the group fixed with plate, nine (25%) presented complications: seven presented major complications (plate loosening, plate breakage and skin erosion with plate exposure) and two minor complications (delayed consolidation and discomfort at the surgical site). In the group fixed with nail, there were four (13.7%) complications. Of these, three complications were major (skin erosion with nail exposure, deep infection and pseudoarthrosis) and one minor (prominent synthesis). However, there was no significant difference between the groups ( $p = 0.45$ ) (Table 6).

**Table 6.** Complications.

	Plate (n) %	Nail (n) (%)
<b>Major complications</b>	<b>7 19.44</b>	<b>3 10.34</b>
Prosthesis loosening	2 5.55	
Break of the synthesis material	1 2.77	
Skin erosion with synthesis material exposure	4 11.1	1 3.44
Deep Infection		1 3.44
Pseudoarthrosis		1 3.44
<b>Minor complications</b>	<b>2 5.55</b>	<b>1 3.44</b>
Consolidation delay	1 2.77	
Surgical site infection	1 2.77	
Outstanding synthesis		1 3.44

### Follow-up period

In our service, plate treatment was replaced by intramedullary nail, resulting in a longer average follow-up period for patients treated with plate compared to patients treated with intramedullary nail (3 years and 4 months and 1 year and 7 months, respectively).

### DISCUSSION

Our study compared the result of surgical treatment by fixation with plate and screws and intramedullary nail of diverted fractures of the clavicle midshaft. For such purpose, 65 volunteers were reevaluated clinically and radiographically after a minimum period of 6 months of follow-up, which were divided according to the fixation used – plate or nail.

The epidemiological profile of our study was similar to that found in other studies.<sup>3,5,7,8</sup> Men were the most affected, accounting for 86.2% ( $n = 56$ ), and the most vulnerable age group was 29 to 49 years. The main mechanisms of trauma were automobile accidents, followed by sports trauma.

The main complications of plate treatment are loosening or failure of the synthesis material, paresthesia at the incision site, injury of neurovascular structures, pseudoarthrosis, discomfort at the surgical site due to the presence of plate and refracture after plate removal.<sup>3,7,16,17</sup> On the other hand, the main disadvantages of nail use are nail migration, skin irritation and the frequent need for removal.<sup>17</sup>

In our study, the complication rate was 20%, being similar to other studies.<sup>18-21</sup> In a meta-analysis conducted by Wang et al.,<sup>17</sup> the frequency of postoperative complications was similar in both forms of fixation. Based on our results, the group fixed with plate presented the highest number of complications ( $n = 9$ ), but without significant

difference when compared with the group fixed with nail ( $n = 4$ ). Skin erosion with the exposure of the synthesis material was the main complication ( $n = 5$ ), being observed in 4 cases in the group fixed with plate and in 1 case in the group treated with nail.

In a meta-analysis performed by Wijicks et al.,<sup>22</sup> the infection in the treatment using plate presented a rate lower than 10% in 9 articles analyzed, and in 2 articles rates higher than this value were found. In our study, we did not observe any case of deep or superficial infection in the group fixed with plate. However, we had one case (3.44%) of skin erosion with exposure of the nail that evolved with deep infection. The approach adopted was the removal of the nail, the debridement of the lesion and antibiotic therapy, evolving with complete consolidation and resolution of the infectious condition. Govindasamy et al.<sup>15</sup> had a rate of 5.6% of superficial skin infection in patients treated with nail, and oral antibiotic treatment was recommended in these cases.

Problems at the site of implantation of the plate, generating necrosis of the skin, may have outcomes that require debridement, removal and revision of fixation. Its rate in the literature ranges from 10 to 53%.<sup>22</sup> In our study, the rate of skin erosion with plate exposure was 11.1% ( $n = 4$ ) in the group fixed with plate and screws. All patients were treated with plate removal and necrotic tissue debridement. In a single case, 3 weeks after surgery, the fracture was not yet consolidated, and the plate was replaced by the nail, with subsequent consolidation.

Zlowodzki et al.<sup>23</sup> conducted a systematic review with 2,144 patients treated surgically and conservatively, and the pseudoarthrosis rate of 5.9% in conservative treatment, 2.5% in plate surgical treatment and 1.6% with nail were found. In radiographic analysis, we observed only one case of pseudoarthrosis (1.53%), in a 75-year-old patient, victim of fall to the ground with consequent fracture of the right clavicle and left proximal humerus. She was subjected to surgical treatment of the two fractures in the same procedure, performing fixation with intramedullary nail of the clavicular fracture (Figure 3).

**Figure 3.** X-ray confirming pseudoarthrosis.

Although the relationship of clavicular shortening with shoulder dysfunction is controversial in the literature, Matsumura et al.,<sup>24</sup> demonstrated that clavicle shortening leads to decreased lateral rotation of the shoulder and posterior inclination of the scapula during elevation, and these anatomical changes may have symptomatic repercussions for the patient. On the other hand, Rasmussen et al.,<sup>25</sup> in a retrospective study with 136 patients with conservative treatment, concluded that shortening of 20mm or more is not associated with shoulder dysfunction.

In our study, when comparing the shortening of patients fixed with plate and nail, a median shortening of 0.9 mm (interval -3.5 - 14) was observed in the plate group and 5.8 (interval -0.8 - 14.4) in the nail group ( $p = 0.001$ ). If we stratified by the type of fracture, the greatest shortening of the 2B1 fractures was 10 mm for plate and 13.9 mm for nail, and of 2B2 fractures, the largest shortening was 14 mm for plate



and 14.4 mm for nail. When relating shortening with shoulder function, using CONSTANT and UCLA scores, we conclude that there was no reduction in shoulder function. Thus, the plate and intramedullary nail present satisfactory results regardless of the type of fracture. Andrade-Silva et al.<sup>26</sup> conducted a prospective study, in which they compared 26 patients subjected to the treatment of clavicle fractures with intramedullary nail and 33 subjected to plate and screw fixation, including both simple fractures and complex fractures in both groups. There were no significant differences between the groups at the time of consolidation, functional scores or complication rate. Plate fixation presents greater damage to the soft tissue adjacent to the fracture due to its invasive nature.<sup>1,2</sup> However, in our study, when pain was present, the group of patients treated with plate presented a tendency ( $p = 0.062$ ) to lower moderate/severe pain in the immediate postoperative period compared to patients treated with nail. Eden et al.<sup>27</sup> performed the pain evaluation of 102 patients and found that in the immediate postoperative period, the treatment with plate and nail presented similar pain values. However, the patients operated with nail evolved with less pain compared to patients operated with plate. In our series, we observed that patients from both groups tended to evolve without pain. On the other hand, cases that evolved with pain were more likely to have undergone fixation with plate ( $p = 0.93$ ).

In a meta-analysis performed by Zhang et al.,<sup>28</sup> the hypertrophic aspect of the scar of patients treated with plate and nail was evaluated. The group fixed with nail presented hypertrophic scar rate of 2.3%, whereas the rate in the group fixed with plate was 15.7%. Regarding the aesthetic satisfaction of our patients, the group treated with a nail showed greater satisfaction with the aesthetic aspect of the scar, since the treatment with plate results in larger scars. Our study presents as main limitations the fact that it is a retrospective research and for this reason, the groups present different follow-up time, which makes the comparative evaluation of the groups difficult. Another limitation is the limited number of patients evaluated. The realization of new prospective studies with long-term follow-up will be important for more definitive conclusions on the best form of surgical treatment of these fractures so common and important in orthopedic practice.

## CONCLUSION

Treatment with plate and screws or intramedullary nail for fractures diverted from the clavicle midshaft does not present important differences in consolidation indices, functional scores or patient satisfaction index. Although the treatment with nail presented greater shortening of the clavicle, there was no association with the reduction of shoulder function. Thus, according to functional scores, both techniques present satisfactory results for the treatment of this type of fracture.





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# TREATMENT OF RECURRENT ANTERIOR SHOULDER DISLOCATION WITH BRISTOW-LATARJET PROCEDURE

## TRATAMENTO DA LUXAÇÃO ANTERIOR RECIDIVANTE DO OMBRO PELA TÉCNICA DE BRISTOW-LATARJET

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### ABSTRACT

**Objectives:** To describe the clinical and radiographic results of patients with traumatic recurrent anterior shoulder dislocation treated with the Bristow-Latarjet procedure. **Methods:** Retrospective case series including 44 patients (45 shoulders) who underwent the Bristow-Latarjet procedure. The graft was fixed “standing” in 84% of the shoulders, and “lying” in 16%. **Results:** The follow-up was  $19.25 \pm 10.24$  months. We obtained 96% of good results, with 2 recurrences presented as subluxation. Graft healing occurred in 62% of cases. The graft was positioned below the glenoid equator in 84% of the cases, and less than 10 mm from its edge in 98%. The external rotation had a limitation of  $20.7^\circ \pm 15.9^\circ$ , while the internal rotation was limited in  $4.0^\circ \pm 9.6^\circ$ . The limitation of rotation and the position of the graft (“standing” or “lying”) did not correlate with graft healing ( $p > 0.05$ ). Bicortical fixation was positively correlated with healing ( $p < 0.001$ ). **Conclusion:** The Bristow-Latarjet technique is indicated for the treatment of recurrent anterior dislocations and subluxations of the shoulder. It is a safe treatment method, which can be used in people with intense physical activity. Limiting shoulder mobility does not prevent patients from returning to their usual occupations. **Level of Evidence IV, Case series.**

**Keywords:** Shoulder Dislocation. Joint Instability. Orthopedic Procedures. Tendon Transfer. Coracoid Process.

### RESUMO

**Objetivos:** Descrever os resultados clínicos e radiográficos do tratamento da luxação anterior recidivante traumática do ombro pela técnica de Bristow-Latarjet. **Métodos:** Série de casos retrospectiva, incluindo 44 pacientes (45 ombros) submetidos à técnica de Bristow-Latarjet. O enxerto foi fixado “em pé” em 84% dos ombros, e “deitado” em 16%, utilizando 1 parafuso metálico. **Resultados:** O seguimento foi de  $19,25 \pm 10,24$  meses. Obtivemos 96% de bons resultados, sendo 2 recidivas sob a forma de subluxação. A consolidação ocorreu em 62% dos casos. O enxerto foi posicionado abaixo do equador da glenoide em 84% das vezes, e a menos de 10 mm da sua borda em 98%. A rotação externa apresentou limitação de  $20,7^\circ \pm 15,9^\circ$ , enquanto a rotação interna  $4,0^\circ \pm 9,6^\circ$ . A limitação das rotações e a posição do enxerto (“em pé” ou “deitado”) não se correlacionaram com a consolidação do enxerto. A fixação bicortical correlacionou-se positivamente com a consolidação. **Conclusões:** A técnica de Bristow-Latarjet está indicada para o tratamento da instabilidade anterior recidivante do ombro. É um método de tratamento seguro, que pode ser utilizado em pessoas com atividade física intensa. A limitação da mobilidade do ombro não impede os pacientes de voltarem às suas ocupações habituais. **Nível de Evidência IV, Série de casos.**

**Descritores:** Luxação do Ombro. Instabilidade Articular. Procedimentos Ortopédicos. Transferência Tendinosa. Processo Coracoide.

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### INTRODUCTORY NOTE

Dr. Arnaldo Amado Ferreira Filho defended his doctoral dissertation in 1984, but the results were never published in scientific journals, and the dissertation is not available on digital platforms. Thus, although he is a pioneer of Shoulder and Elbow Surgery in Brazil, and his knowledge has been fundamental for subsequent generations of orthopedists, the citation of his results in articles and dissertations

was very difficult. The objective of this study is to describe the clinical and radiographic results of the treatment of recurrent anterior shoulder dislocation using the Bristow-Latarjet technique, based on Dr. Arnaldo Amado Ferreira Filho's doctoral dissertation, carried out in 1984. The essay intended to be the most accurate to the original, making minimal adaptations and respecting the author's writing style and the formatting of the usual text at the time.

All authors declare no potential conflict of interest related to this article.

The study was conducted at Hospital das Clínicas.

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## INTRODUCTION

The great mobility of the shoulder requires precise and complex integrated mechanisms of sliding and dynamic stabilization whose vulnerability is the price paid by man in order to be able to fully enjoy it. Traumas and predispositions of various natures can break this functional harmony, causing the loss of joint congruence whose recurrence is studied in the area of scapular instabilities.

Numerous surgical techniques have been proposed for the treatment of recurrent anterior dislocation of the shoulder and, among them, the bone block by pedicled graft of the coracoid process near the anterior edge of the glenoid described by Latarjet<sup>1</sup> and Helfet stands out.<sup>2</sup> This study describes the clinical and radiographic results of the treatment of recurrent anterior shoulder dislocation by the Bristow-Latarjet technique.

## MATERIALS AND METHODS

This study sample is composed of 44 patients, with documentation referring to 45 shoulders. The mean age at the time of surgery was  $23.74 \pm 7.16$  and in the first episode of dislocation  $18.81 \pm 5.15$ . In total, 38 patients (86%) were male, six of them (14%) presented epilepsy, and 35 (80%) had traumatic dislocations. The number of recurrences was one to five for nine patients (20%), six to 10 for 11 patients (24%) and higher than 10 in 25 (56%) patients. A total of 36 patients (82%) practiced sports, eight (18%) at the amateur competitive level, 28 (64%) as recreational activity and most patients practiced more than one modality.

### Clinical examination

Our patients were examined many days after the dislocation episodes and – as always happens in these cases – the clinical examination gave us little information. None of the patients presented pain on palpation or movement, alteration of muscle trophism, peripheral neurovascular injuries or alterations in joint mobility. All patients presented a positive apprehension test and three (7%) presented ligament laxity according to Carter and Wilkinson<sup>3</sup> criteria modified by Beighton and Horan.<sup>4</sup>

### Radiographic examination

Radiographs were performed at anteroposterior incidences in external and internal rotation of  $60^\circ$  and lateral view. We could observe the posterolateral injury of the humeral head in 43 shoulders (96%) and periarticular calcifications in five (11%).

### Intraoperative findings

The described anatomopathological injuries refer to 38 (84%) of the 45 operated shoulders, since in seven medical records the precise information was not found. We observed two cases (5%) of partial rupture of the upper edge of the subscapularis tendon and loose bodies in nine shoulders (24%). The joint capsule was redundant in all cases, and there was capsule-periosteal disinsertion at the level of the neck of scapula and glenoid labrum injury in 37 cases (97%). Marginal fracture of the glenoid edge was observed in two cases (5%), while variable erosion and eburnation of the scapular neck were observed in 37 shoulders (97%).

### Surgical technique

The general anesthesia was applied by tracheal inhalation and intravenous infusion. The patients were positioned in horizontal supine position with a cushion placed under the scapular region of the side to be operated.

Operative times:

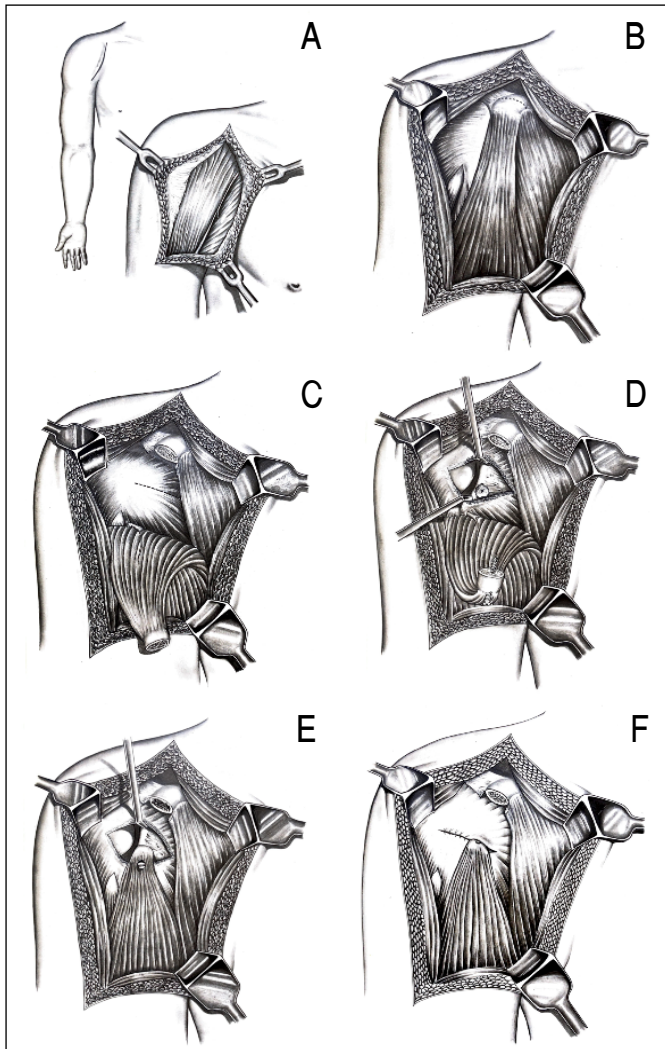
1. Deltopectoral incision about eight cm long, from the lower edge of the clavicle.

2. Identification of the cephalic vein in the deltopectoral groove and displacement of the cephalic vein in the medial direction along with a narrow parallel band of fibers of the deltoid muscle in order to protect it.
3. Exposure, via transdeltoid, of the coracoid process with the insertions of pectoralis minor, coracoacromial ligament, conjoint tendon, and muscle bellies of the short biceps and the coracobrachialis.
4. Osteotomy of the coracoid process about two cm from its apex with chisel and hammer and release of the bone fragment by sectioning the fibers of the pectoralis minor and the coracoacromial ligament inserted on it.
5. Hemostasis of the bloody area remaining from the coracoid process with bone wax.
6. Dissection of the coracobrachialis muscles and the short biceps in the caudal direction to the lower edge of the subscapularis muscle without exceeding it, to avoid the risk of injury to the musculocutaneous nerve that, about six cm below the coracoid process, penetrates into the muscular belly of the coracobrachialis muscle.
7. Perforation of the pedicled bone graft obtained, from its base to its apex (graft "standing"), with a quadrangular sectionawl to ease screw passage. When the coracoid process is narrow with a small cross-section area insufficient to contain the screw, the perforation should be performed in a transverse direction, in the smallest diameter (graft "lying") as described by Latarjet.<sup>1</sup>
8. Inspection of the subscapularis muscle and opening of the subscapularis muscle at the level of its median part, with an incision parallel to its fibers initiated near the lesser tubercle of the humerus. The incision extending from the tendon to the muscular belly should be long enough to allow a good separation of its edges and easy access to the underlying scapulohumeral joint. As the joint capsule is always adhered to the entire extension of the tendon, it was opened simultaneously with the opening of the tendon, then prolonging the capsular incision parallel to the muscle belly.
9. Careful exploration of joint structures.
10. Identification of the passage site of the humerus head, marked by capsule-periosteal disinsertion and erosion of the glenoid edge.
11. Excision of the glenoid labrum or its remains and the reactional scar tissue existing in the neck of scapula, near the edge of the glenoid, in order to clean the area where the graft will be placed. The neck of scapula is most often white and irregular as a consequence of the friction caused by the head of the humerus.
12. Cruentation, without chopping the cortical, with scalpel, curette or chisel, for graft placement.
13. Perforation of the neck of scapula, with electric punch and drill diameter, a graduation below that normally used, also transfixing the posterior cortical, as parallel as possible to the plane of the articular surface. The distance between the screw fixation hole and the glenoid edge should allow, after graft fixation, a perfect continuity between the graft and the plane of the articular surface.
14. Verification, with the appropriate meter, of the neck of scapula width to allow the choice of a screw of sufficient length to transfix the posterior cortical.
15. Firm fixation of the graft to its place, with the available screw, preferably cancellous screws, taking care that the edge of the graft is in continuity with the edge of the glenoid, and it should not exceed it or be away from it. When placed "standing," the coracoid process was fixed with its posterior-inferior face, slightly concave, facing the head of the humerus. A washer can be used to increase the support area of the screw over



- the graft, strengthening its pressure resistance and avoiding friction between the head of the humerus and the screw. In 38 shoulders (84%) the graft was fixed “standing” and in seven shoulders (16%) “lying”; the washer was used nine times.
16. With the arm in external rotation, the joint capsule and the subscapularis muscle were sutured with separated stitches.
  17. Suture of the deltoid muscle with separate stitches.
  18. Closure of the surgical incision with separate stitches in the subcutaneous cellular tissue and skin.
  19. Immobilization

The main operative times are shown in Figure 1.



**Figure 1.** Surgical technique: A: Deltopectoral approach; B: Coracoid process and osteotomy site (dashed line); C: Osteotomy performed, with coracobrachialis muscles and short head of the biceps folded together with the graft, and incision site in the subscapularis muscle (dashed line); D: Exposure of the neck of scapula and head of the humerus, with the place for the graft prepared and coracoid process transfixed by the screw on its longitudinal axis; E: Graft fixed near the edge of the glenoid; F: suture of the subscapularis muscle laterally to the graft.

### Postoperative

Thoracobrachial bandage was maintained for 21 days, with weekly changes for inspection of the surgical wound and patient' hygiene.

The stitches were removed on the 10th day. The patients were medicated exclusively with analgesics. The length of hospital stay ranged from two to 13 days, with an average stay of three days. On the 22nd day, rehabilitation was initiated, which consisted of passive pendulum exercises followed by isometric and isotonic active exercises aimed to strengthening muscle and restoring joint mobility. From the 90th day on, the return to sports activities was both allowed and also encouraged.

### Evaluation criteria

#### Criteria based on clinical data

1. Joint stability. Joint stability was assessed by recurrence of dislocation (being considered recurrence both episodes of dislocation and subluxation) and by the seizure test. The result was categorized as good (no recurrence and negative apprehension test), regular (no recurrence and positive apprehension test) and bad (with recurrence).
2. Presence of spontaneous, palpation-related or movement-related pain
3. Presence of alteration in muscular trophism
4. Presence of vasculonervous lesions
5. Limitation of active joint mobility. The amplitude of external rotation, internal rotation, and abduction was measured, and the respective limitations were estimated.
6. Capability to practice sport The result was considered good (when the performance continued to be the same or became better) or bad (when the performance became worse).
7. Patients' opinion regarding the treatment performed. It was considered as good (when patients were satisfied) or bad (when they were not satisfied).

#### Criteria based on radiographic data

The criteria used by Hovelius et al.<sup>5</sup> were largely adopted, and the following items were considered:

1. Behavior of the bone graft, observing whether there was resorption of the graft and healing of the graft in the neck of scapula.
2. Measurement of separation, in mm, between the unconsolidated grafts and the neck of scapula, classified as fibrous union ( $\leq 5$  mm) and small ( $\leq 15$  mm) or large migration ( $\geq 15$  mm)
3. Measurement of the distance, in mm, between the graft and the edge of the glenoid, classified as  $< 10$  mm and  $\geq 10$  mm.
4. Position of the graft in relation to the equator of the glenoid, considered as above the equator, at the equator, or below it.
5. Cortical fixation of the screw and stability of it, observing whether there was transfixation of the posterior cortical and displacement of the screw from its initial position.
6. Loosening of the graft by partial resorption without screw displacement.
7. Injury to the head of the humerus by impact against the screw.
8. Postoperative osteoarticular lesions.

### Statistical Analysis

The relationship between rotation limitation and graft consolidation was analyzed by Student's *t*-test. The limitation of external rotation was also correlated with the postoperative follow-up time by regression analysis. By Fisher's test, they were confronted:

- a. consolidation of the graft and its position (“standing” or “lying”);
- b. loosening of the graft and its position (“standing” or “lying”);
- c. graft consolidation and cortical screw fixation (mono or bicortical);

d. screw displacement and cortical screw fixation (mono or bicortical).

## RESULTS

The patients had a mean follow-up time of  $19.25 \pm 10.24$  months, ranging from nine to 84 months. Follow-up time was longer than 12 months in 36 cases (76%).

### Clinical analysis

Regarding joint stability, we obtained 96% of good results (43/45) and 4% of bad results (2/45). The two cases of recurrence occurred as subluxation. One of the patients presented subluxation four years after surgery, after a sudden movement caused by an electrical discharge. The patient did not suffer any restriction in their activities, latter returning to soccer and swimming practice. Another patient presented subluxation 18 months after surgery, as a result of a violent trauma during a rugby match, with two other episodes in the following days, one sleeping with shoulder in abduction and maximum external rotation, and another playing capoeira. There were no other episodes after, remaining asymptomatic for two years. He regularly practices swimming and capoeira but has quit rugby. The apprehension test was negative on all shoulders, including those who suffered recurrence.

Three patients complained of persistent pain (6.7%). The first one had little intense pain at movements, the second persistent pain on palpation and movements, and sometimes spontaneous pain. The third, in addition to pain similar to the previous one, complained of crackling and limitation of the range of motion, preventing the patient from exercising the usual occupations.

We observed mild muscle hypotrophy in five patients (11%), mainly in the deltoid and biceps muscles, with no apparent decrease in muscle strength.

No patient presented local or distance vasculonervous changes. The limitation of external rotation ranged from  $0^\circ$  to  $70^\circ$ , with an average of  $20.7^\circ \pm 15.9^\circ$ . The internal rotation presented an average limitation of  $4.0^\circ \pm 9.6^\circ$ , ranging from  $0^\circ$  to  $40^\circ$ .

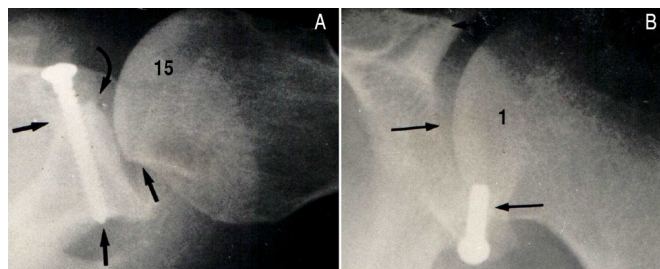
Out of the 36 patients (37 shoulders) who practiced sports, 32 (89%) presented good result and four (11%) bad results.

According to the patients' opinion, 41 (93%) presented good result and three (7%) bad. The three patients declared that they were dissatisfied with the surgery, since they presented persistent pain when moving the operated shoulder.

### Radiographic analysis

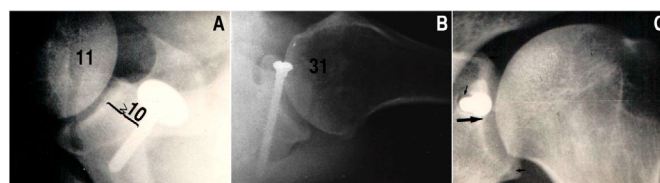
The graft consolidated in 28 shoulders (62%), absence of consolidation in 16 (36%), and absorption in one (2%). Out of the 16 grafts that did not consolidate, in 10 the screw was displaced along with the graft and in six there was no displacement of the screw, but the graft developed a central area of absorption. In 14 (31%) shoulders there was fibrous union, in one small migration and in another large migration.

The graft was fixed at a distance greater than 10 mm from the edge of the glenoid in only 1 shoulder (2%). In three shoulders (7%) the graft was positioned above the equator of the glenoid, in four (9%) at the equator and in 38 (84%) below it. Bicortical fixation was obtained in 38 shoulders (84%), and in seven of these the screw exceeded the posterior cortical more than five mm. In total, 10 screws (22%) were displaced, and an osteolysis of 1 mm or more was observed around them. In two shoulders (4%) the screw was bumped with the head of the humerus because it was fixed excessively oblique. In Figure 2, we observed cases with correct positioning of the graft and screw.



**Figure 2.** Radiographs demonstrating adequate positioning of the graft and screw. A: Graft near the edge of the glenoid, consolidated, with adequate size and angulation screw; B: Graft positioned below the equator of the glenoid.

In Figure 3, we exposed some errors of surgical technique (medialized graft, oblique and long screw, and graft positioned above the equator of the glenoid).



**Figure 3.** Errors of the surgical technique: A: medialized graft; B: oblique and long screw; C: graft positioned above the equator of the glenoid.

In Figure 4, we highlight some of the complications visualized by radiography (absence of consolidation, osteolysis around the screw and displacement of the screw).



**Figure 4.** Surgical complications. A: absence of consolidation; B: osteolysis around the screw; C: screw displacement.

### Statistical analysis

The limitation of external and internal rotation did not correlate with graft consolidation ( $p = 0.852$  and  $p = 0.512$ , respectively). Similarly, the position of the graft ("standing" or "lying") did not correlate with bone consolidation or graft loosening ( $p = 0.884$  and  $p = 0.391$ , respectively). Bicortical fixation presented a statistically significant correlation with consolidation ( $p < 0.001$ ) and with lower screw displacement index ( $p = 0.003$ ). The limitation of external rotation is correlated with the follow-up time, decreasing over time ( $p < 0.05$ ).

### Complications

We observed one case (2%) of subcutaneous hematoma (drained on the fifth postoperative day), persistent pain in one case (2%), probably caused by a reaction to the screw; by removing it, the pain disappear and two cases (4%) of humeral head injury by impact against the screw that was placed excessively oblique, exceeding the edge of the glenoid. Joint pain, abduction limitation, and joint crackling decreased considerably after screw removal in both patients.



## DISCUSSION

The presence of 80% of traumatic cases in our series does not differ from what is reported in the literature.<sup>5-7</sup> Similarly, the prevalence in young adults – with most of the first episodes happening until the age of 20, and predominantly in males – is also presented by other authors.<sup>5,7</sup> The practically equal occurrence between dominant and non-dominant side – observed in this study – is described by Hovelius et al.,<sup>5</sup> but this results disagree with Hill et al.,<sup>7</sup> where shoulder dislocation is more frequent on the dominant side. Out of our patients, only 7% had ligament laxity, a small incidence compared to the 24% of Hill et al.<sup>7</sup> On the other hand, the incidence of epilepsy (14%) is higher than those of other authors, who report 1 to 7%.<sup>5,7</sup>

We found capsular and labral disinsertions in 97% of the shoulders. This high incidence is described by other authors, ranging from 66% to 99%.<sup>6-10</sup> Lesions of the subscapularis muscle can be observed as looseness or structural lesions.<sup>6,10,11</sup> De Palma et al.<sup>11</sup> found this condition on all shoulders, while McLaughlin<sup>10</sup> and Rowe et al.<sup>6</sup> in only 8% and 10%, respectively. We believe that the disparity of opinions lies in the subjectivity of the evaluation. In our series, we did not quantify the subscapularis laxity, but only the structural injuries, found in 5% of the cases. The eburnation of the neck of the scapula is observed in 21 to 87%<sup>6,9,12</sup> of the cases, and the glenoid edge may be fractured in 13-44% of the cases.<sup>6-8</sup> In our series, we observed eburnation of the neck of scapula and erosion of the glenoid edge in 97% of cases, and glenoid edge fracture in 5%. Loose bodies were found in 20% of the shoulders, and the presence of this finding ranges from 2 to 31% in the literature.<sup>6,7,11,12</sup>

The posterolateral injury or “typical defect,” as it was previously called, or Hill-Sachs lesion, as English-speakers authors insist on calling it, has an incidence ranging from 45% to 100% of cases.<sup>6-8</sup> Perhaps the reasons for such discordant results are the need for special incidences in small lesions, which require a broad surgical approach, unnecessary in most surgical techniques for their exposure. We observed the injury as a radiographic finding in 96% of the shoulders and only few times we were able to palpate it during the surgical process.

Several original surgical techniques, or their variations, have been proposed for the treatment of recurrent anterior shoulder dislocation. De Palma et al.<sup>11</sup> grouped the surgeries into five categories: tendon-ligament and labial plastics, tendon transfers, bone blocks, corrective osteotomies, and tendon-suspensions. The dynamic blocking function of the coracoid process, originally considered a static bone block,<sup>1,11</sup> started to be valued,<sup>13,14</sup> at the expense of transplanted muscles and being complemented by the fixation of the lower half of the subscapularis. In addition to these actions, recalls D'Angelo,<sup>15</sup> the graft fills the bone failure in the anterior edge of the glenoid, increases the area of articular surface, and prevents the posterolateral lesion from engaging on the glenoid failure.

In most cases, we did not put the graft in its smallest diameter (“lying” because we considered that the graft resists less to the compression force. Similarly, we do not pierce the graft *in situ*, as most authors do,<sup>5,13,14</sup> because there is a risk of miss-positioning the drill. Perhaps this is the reason for the high incidence (7 to 14%) of intraoperative fractures reported by other authors,<sup>5,7</sup> complications that do not exist in our series. We also did not shorten the subscapularis muscle, as other surgeons did.<sup>1,13</sup>

Mostly, postoperative pain is associated to problems directly related to the screw or graft.<sup>16</sup> The screw may be protruding beyond the edge of the glenoid, for it was placed obliquely in relation to the articular surface, and in these conditions, it collides against the humeral head, harming it, a fact observed in two of our patients. The loose, excessively long, dislocated or fractured

screw can also be a cause of pain, a fact that occurred in one of our patients. Any postoperative painful manifestation should be investigated carefully.

The limitation of external rotation is recognized by many as one of the significant factors that prevent recurrence of dislocations and some surgical techniques deliberately aim to achieve it. It is observed in virtually all statistics, even when procedures are not intended to obtain it. Although the Bristow-Latarjet technique is not based on the limitation of external rotation, it has been observed in a good percentage of operated shoulders. Only 16% of the cases in our series presented normal external rotation, and we observed an average of 20° of limitation, similar to that described by Hovelius et al.<sup>5</sup> but higher than other authors.<sup>7,14</sup> Possibly, this difference originates from the external rotation evaluation technique. Practically all authors perform this technique with the arm at 0° and 90° of abduction, without fixing the scapula and the spine, or with the patient in supine position with the arms in abduction of 90° and the palm of the hands placed on the nape. In our opinion, these are not the appropriate techniques, because they allow the movement of the scapula and spine, which improves the patient's performance. For this reason we evaluated not only the external rotation, but also the internal rotation, with the patient in horizontal ventral decubitus with the arm in abduction and the elbow flexed, both in 90°, fixing with one of the hands the scapula and the spine.

Abduction limitation has not been frequently reported in the literature, although it has been described by some authors.<sup>5,7</sup> From our sample of patients, 7% had abduction limitation, and in two patients, the cause was attributed to the impact of the head against the screw. The limitation of internal rotation is also little reported, ranging from 3° to 13°.<sup>5,7</sup> We found this result in 20% of the patients, with a mean limitation of 4°, a result that we attributed to the examination technique aforementioned. For us, the fusion or not of the graft in the neck of scapula did not influence the limitation of both rotations, a finding similar to Nielson and Nielsen.<sup>17</sup>

Bristow-Latarjet surgery, like some other surgical procedure, has led to a worsening of the performance of throwers athletes whose dominant shoulder was compromised.<sup>7,14</sup> Out of four patients who were impaired, two had limitation of external rotation, and two of internal rotation and abduction. Three patients chose to quit the most violent modalities, without, however, quitting other sports. Comparing our results with those in the literature is difficult, not only because of our small number of competitive athletes, but also because we have treated few practitioners of throwing sports.

We observed graft fusion in the neck of scapula in 65% of the cases, a result similar to those of Hovelius et al.,<sup>5</sup> with 52%. Hill et al.<sup>7</sup> reported 96% consolidation, a result that may be related to the use of less accurate radiographic techniques. Bicortical fixation significantly influenced screw stability in the same way as graft fusion, results that confirm the opinion of Hovelius et al.<sup>5</sup> The graft consolidation in the neck of scapula is achieved by firmly fixing the screw, that must be placed parallel to the plane of the articular surface, reach the posterior cortical exceeding it a few millimeters and the screw head must have the sufficient diameter to allow an ideal compression. A small washer can be used to meet this requirement.

For Bristow-Latarjet surgery achieve success, the graft cannot be exclusively consolidated, but it has to be correctly positioned on the anterior face of the neck of scapula, near the edge of the glenoid and below the equator. We observed that in 86% of the shoulders, the graft was placed below the equator, and in 98% of them, it was positioned less than 10 mm from the equator edge. This location is considered as the best by Hovelius et al.<sup>5</sup>

However, the placement of the graft at or above the equator did not affect stability.

Recurrences have been reported in almost all series of treatment of recurrent anterior dislocation of the shoulder, ranging from 0.7%<sup>18</sup> to 11%,<sup>19</sup> but some authors did not report them.<sup>13,17,20</sup> Notably, Hill et al.<sup>7</sup> and Hovelius et al.,<sup>5</sup> with 6 and 7% of subluxations, did not consider them as recurrences, and we do not agree with this statement. Our series demonstrated 4% recurrence, related to violent trauma.

## CONCLUSION

The Bristow-Latarjet technique is indicated for the treatment of traumatic and non-traumatic anterior shoulder dislocations and subluxations. It is an easy and safe method that can be used in people who have great physical activity. The limitation of shoulder mobility observed in many cases does not prevent patients from returning to their usual occupations, as well as, in most of them, from playing sports with performance equal to that before the operation. The limitation of external rotation tends to decrease over time.

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# EPIDEMIOLOGY OF ANTERIOR CRUCIATE LIGAMENT INJURY IN SOCCER PLAYERS IN THE BRAZILIAN CHAMPIONSHIP

## EPIDEMIOLOGIA DAS LESÕES DO LIGAMENTO CRUZADO ANTERIOR EM JOGADORES DE FUTEBOL DO CAMPEONATO BRASILEIRO

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### ABSTRACT

**Objective:** To evaluate and collect epidemiological data on injuries of the anterior cruciate ligament of the knee in professional soccer players of the Brazilian Championship. **Methods:** Transversal study, with information extracted from the online data platform [www.transfermarkt.com.br](http://www.transfermarkt.com.br) (Transfermarkt GmbH & Co. KG), with 5 seasons (2015 – 2019) of the Brazilian championship series A and B being analyzed and revised by 3 researchers. **Results:** 52 injuries of the anterior cruciate ligament were detected, with a mean age of 26,3 years, time off due to injury of  $244.5 \pm 31.6$  days, regardless of the division. Forwards and defenders had the highest incidences of injury without statistically significant difference, but they had greater chances than goalkeepers, left/right backs and midfielders. **Conclusion:** The incidence of injury to the anterior cruciate ligament of the knee in professional football players in the first and second divisions of the Brazilian soccer championship between 2015 and 2019 is 0.414 per 1,000 hours of play, a value similar to described in the literature. The incidence of the injury varies according to the player's field position, being the forwards and defenders the most injured players. **Level of Evidence II, Retrospective study.**

**Keywords:** Soccer. Athletes. Anterior Cruciate Ligament. Epidemiology.

### RESUMO

**Objetivo:** Avaliar dados epidemiológicos das lesões do ligamento cruzado anterior do joelho em jogadores profissionais de futebol do Campeonato Brasileiro. **Métodos:** Estudo transversal, com informações extraídas da plataforma de dados on-line [www.transfermarkt.com.br](http://www.transfermarkt.com.br) (Transfermarkt GmbH & Co. KG), sendo analisadas 5 temporadas (2015 – 2019) do campeonato brasileiro séries A e B por 3 pesquisadores. **Resultados:** Detectamos 52 lesões do ligamento cruzado anterior, com idade média de 26,3 anos, tempo de afastamento devido a lesão de  $244,5 \pm 31,6$  dias, independentemente da série. Atacantes e zagueiros apresentaram maiores incidências de lesão sem diferença estatisticamente significativa entre eles, porém apresentaram maiores chances que goleiros, laterais e meio campistas. **Conclusão:** A incidência da lesão do ligamento cruzado anterior do joelho em atletas de futebol do campeonato brasileiro série A e B entre 2015-2019 é de 0,414 por 1.000 horas de jogo, semelhante ao descrito em literatura. A incidência da lesão depende da posição tática do jogador, com atacantes e zagueiros sofrendo mais lesões em relação as outras posições. **Nível de Evidência II, Estudo retrospectivo.**

**Descritores:** Futebol. Atletas. Ligamento Cruzado Anterior. Epidemiologia.

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### INTRODUCTION

Created in England in 1863, soccer is the most popular sport in the world. In Brazil, that is not different. With 662 professional teams, Brazilian soccer is responsible for producing great players on an international level.

The Brazilian Football Confederation (CBF) estimates that only in the first six months of 2019 there was movement of 213 million euros in sales of athletes abroad.<sup>1</sup>

In this scenario, it is not difficult to understand that the entire absence of a professional player, even for only a few days, results in high

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costs for a team. The costs increase in cases of injuries that cause long time off, as in the case of the anterior cruciate ligament injury, in which player's time off can vary between nine and 12 months.<sup>2-4</sup> Since soccer is a sport that requires abrupt changes of direction at high speeds, sudden decelerations and high contact, it predisposes the athlete's knee to high axial loads combined with pivot movements,<sup>5-7</sup> representing high risk for anterior cruciate ligament injury.<sup>8-11</sup> And, in addition to the prolonged time away from the sport after three years of injury, only 65% of players return to their pre-injury level.<sup>12</sup> Therefore, preventive programs for the anterior cruciate ligament injury in professional soccer are necessary. Thus, studies on this subject are essential to understand the frequency and severity of these injuries within an actual population of professional soccer players.<sup>12-17</sup> In this context, study aims at evaluating epidemiological data on anterior cruciate ligament injuries of the knee among players participating in the major soccer league in Brazil, the Brazilian National Soccer Championship.

## MATERIALS AND METHODS

This transversal descriptive study was approved by the Research Ethics Committee of the Universidade Federal de São Paulo in the opinion number 1,660,701.

The information in this study was extracted from the public access online data platform [www.transfermarkt.com.br](http://www.transfermarkt.com.br) (Transfermarkt GmbH & Co. KG), in which professional information, market value, statistical and injury data of soccer players from the main soccer club leagues in the world can be found. The published data are periodically reviewed and updated, with validity and accuracy of the injuries recorded in the Transfermarkt online database.<sup>18</sup>

The online data platform was accessed and five seasons (2015 – 2019) of the Brazilian Soccer Championship first and second divisions were analyzed and reviewed by three researchers.

In each season of the Brazilian Championship, both in first and second divisions, 20 teams with varied squads participate, playing with each other twice, counted 38 rounds, totaling 380 matches and 12,540 hours played per season.

For the investigation of previous cruciate ligament injuries in soccer players in the Brazilian championship, the players enrolled in the Brazilian championships first and second divisions between 2015 and 2019 were surveyed for the existence of this injury in the period studied. All players that had the anterior cruciate ligament injury identified were analyzed for age at the time of the injury, tactical position in the team, season at the time of the injury (cold or hot warm) and time off due to injury.

The incidence of the anterior cruciate ligament injury was defined as the new cases divided by the total of players in a given time. The incidence of injury for 1,000 played hours was also analyzed according to Fifa's incidence formula.

$$\text{Incidence} = \frac{\text{number of injuries}}{\text{played hours}} \times 1000$$

SPSS V20, Minitab 16, and Excel Office 2010 software were used. For quantitative variables, descriptive analysis was performed. The comparison of continuous variables was analyzed by the *t*-student test. To characterize the distribution and relative frequency of qualitative variables, we used the Two Proportions Equal Test, analysis of statistical confidence intervals defined as 95% and P-value defined as less than or equal to 0.05.

## RESULTS

We identified 52 previous cruciate ligament injuries on first and second division soccer players in the Brazilian championship

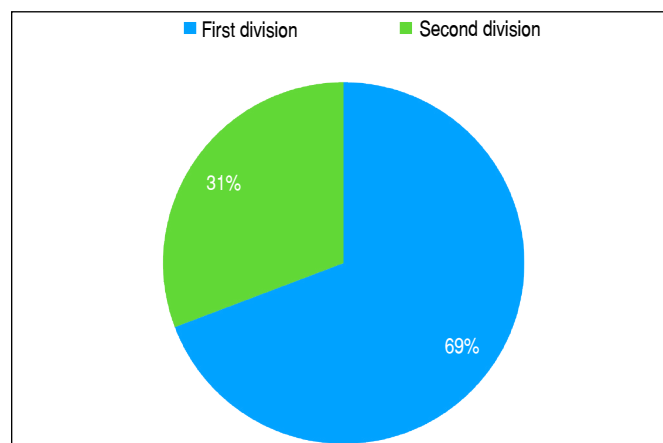
between the seasons 2015 and 2019, a total of 8,121 players and 125,400 played hours. The overall incidence found was 0.0064%, with an average of 10.4 injuries per season added to the A and B series. There were 0.26 team injuries per season, corresponding to approximately 1 injury per team every 4 seasons.

The incidence of injury per 1,000 hours played in first and second divisions was 0.414. Performing the stratification of the incidences between first and second division, we observed a 0.574 incidence in the first division, against 0.255 in the second throughout the studied period (95%CI, *p*-value 0.005, OR 2.13), showing 2.13 times more chances players get injured in first division than in the second (Table 1).

Figure 1 shows the proportion of injuries in the first and second divisions.

**Table 1.** Statistical analysis of samples

	Injuries	Hours	Incidence	<i>p</i> -value	Odds Ratio
General	52	125,400	0.414		
First Division	36	62,700	0.574	0.005	2.13 (1.18 to 3.85)
Second Division	16	62,700	0.255		
	32	84,018	0.380	0.401	1.60 (0.92 to 2.80)
	20	41,382	0.483		
Forward	25	125,400	0.199	Ref.	8.36 (2.52 to 27.69)
Goalkeeper	3	125,400	0.0239	<0.001	Ref.
Left/right Back	3	125,400	0.0239	<0.001	Ref.
Midfielder	4	125,400	0.0318	<0.001	1.33 (0.30 to 5.96)
Central defender	17	125,400	0.135	0.216	5.68 (1.66 to 19.38)



**Figure 1.** Proportion of injuries in First and Second divisions.

Regarding the time when the injury occurred – warm (spring and summer) and cold seasons (fall and winter) – a higher incidence was observed during the warm seasons, 0.483 against 0.380 during the cold seasons. However, this difference is not statistically significant, considering the confidence interval of 0.92 – 2.8. Since the Brazilian championship starts in April and ends in December, the number of hours played in each season is different, having 84,018 hours being played in the coldest seasons of the year, whereas 41,382 hours were played during the warmest seasons (Table 1). Figure 2 illustrates the distribution of injuries that occurred throughout the Brazilian championship calendar.



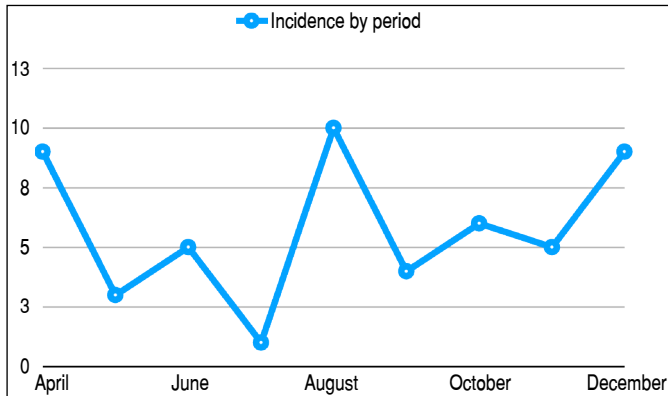


Figure 2. Distribution of injuries throughout the Brazilian Championship.

Analyzing the incidences segmented according to the players' tactical position, we found a higher incidence of the studied injury in forwarders, 25 injuries in total, representing a 0.199 incidence per 1,000 hours played. Thus, for statistical significance ( $p$ -value), we chose to use the incidence of injury in forwarders as a reference (0.199 injuries every 1,000 hours played). The difference between the incidence of injury between forwarders and defenders showed no statistical significance ( $p$ -value = 0.216), but between goalkeepers, laterals and midfielders a statistically significant difference was observed ( $p$ -value < 0.001). To determine the odds ratio (Odds Ratio) between the incidences of injuries in the different tactical positions, we chose to adopt the reference value (0.0239 injuries every 1,000 hours played) of the position with the lowest incidence, goalkeepers and backs, with three injuries each, representing 0.0239 injuries per 1,000 played hours. Thus, forwarders had 8.36 times more chances of injury compared to goalkeepers and defenders, and defenders, 5.68 times more chances than goalkeepers. Midfielders, in turn, had 1.33 times more chance to present injuries when compared with goalkeepers and defenders, but this value does not present statistical significance, considering the 95% confidence interval (0.30 to 5.96) in this comparison (Table 1). Figure 3 shows the incidences of injuries according to the players' tactical position.

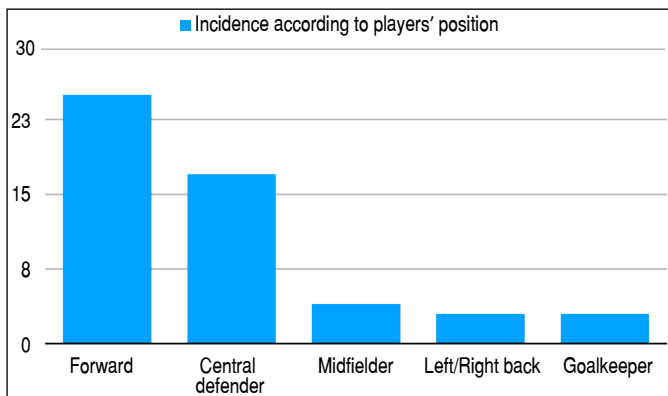


Figure 3. Incidence of injuries according to the players' position.

The average age of the players that suffered the injuries was 26.3 years, with no difference with statistical significance between players in the first and second divisions ( $p$ -value = 0.749). The mean number of days off due to the anterior cruciate ligament injury between the players of first and second divisions ( $p$ -value = 0.492) was similar, observing that the mean time off in both divisions was  $244.5 \pm 31.6$  days. It can also be affirmed

that the variation regarding the time of withdrawal in first division low (Coefficient of Variation < 50%), reflecting a greater homogeneity of data. On the other hand, the same cannot be said for the time off in second division, which presents Coefficient of Variation > 50% (Table 2).

Table 2. Age distribution of injuries and time off.

Division		Mean	Median	Standard Deviation	VC	Min	Max	N	CI	P-value
Age at the injury	Both	26.3	26	4.8	18%	19	36	52	1.3	0.749
	First Division	26.5	26	4.9	19%	19	36	36	1.6	
	Second Division	26.0	26	4.8	19%	19	33	16	2.4	
Time off	Both	244.5	214	116.4	48%	97	800	52	31.6	0.492
	First Division	252.0	219	112.6	45%	150	800	36	36.8	
	Second Division	227.6	188	126.7	56%	97	651	16	62.1	

## DISCUSSION

The age profile of players with anterior cruciate ligament injuries found in our study is similar to the profile of players found in the literature. The average age of 26.3 years found is similar to the 25.2 years reported in a European cohort study with the main European leagues<sup>19</sup> and to the 25.0 years found in professional players of Qatar.<sup>16</sup>

Likewise, the  $244.5 \pm 31.6$  days off is similar to the period observed in previous studies.<sup>2-4</sup> This similarity also occurred between the first and second divisions. There may be many explanations for such a difference, from biological factors inherent to graft healing and integration and to standardization of rehabilitation protocols. Previous studies claim that the highest incidence of anterior cruciate ligament injury in soccer occurs in defenders.<sup>20-23</sup> Contrary to the literature, we observed a higher incidence of injuries among forwarders, but with no statistically significant difference compared to defenders ( $p$ -value = 0.216). This result can be explained, since the aforementioned studies consider both right/left backs and central defenders as defenders. In our study, these two tactical positions were stratified. We can consider that forwarders and defenders presented the highest incidence of injury (0.199 and 0.135, respectively), since these are tactical positions that, not coincidentally, require abrupt changes of direction at high speeds, sudden decelerations and high contact, predisposing the knee to high axial loads combined with pivot movements, a common trauma mechanism of the injury studied.<sup>5-7</sup> Goalkeepers, in turn, can be considered more "jumpers", left/right backs, more "runners" midfielders tend to orbit the midfield at lower speeds. Finally, the 52 injuries found in our study over five seasons, in a universe of 8,121 players and 125,400 played hours, showed an incidence of 0.414 injuries per 1,000 played hours, with an average of 10.4 injuries per season in first and second divisions combined, 0.26 injuries per team per season, corresponding to approximately one injury per team every four seasons. Such results are consistent with those observed in the literature. A study by Alberto Grassi, published in Sport Health in 2019.<sup>24</sup> showed 0.421 injuries per 1,000 hours played in the first division of the Italian championship, and Waldén et al.<sup>12</sup> obtained slightly lower results than those found in our study (0.309 injuries), in the main European leagues, which can still be considered close.

We notice a big difference when analyzing the incidences of injury in the first and second divisions of the Brazilian



championship separately. In the first division, the incidence found is 0.574, whereas in the second, 0.255. The low incidence of injuries in the second division ends up reducing the general average of injuries in Brazilian players, making the final product of the incidences of both series of the Brazilian championship equivalent to that found in the literature. However, this discrepancy masks an increased incidence of injuries in the first division of the Brazilian championship compared to the literature, to the detriment of a lower incidence in the second division. This increased incidence of injuries in the first division is a phenomenon that can be explained by the intense schedule of matches in the major teams in the country, since these players tend to play in matches of different competitions at the same period, especially when representing their national teams. This is not an exclusive routine of the main Brazilian teams, also happening in Europe; however, the Brazilian teams may not be equally prepared for this intensity of matches, both from the point of view of the extension of the squad, and the technical and physical preparation due. This is a hypothesis that could explain the discrepancy of this data with international literature. However, the low incidence of injury in the second division has yet to be clarified. One hypothesis is the underreporting of injuries and the loss of

follow-up of players that present these injuries in this soccer segment. The second division Brazilian soccer presents less investment, and, consequently, health care. In this context, we assume that a player suffering a previous cruciate ligament injury may not have the injury diagnosed or reported.

## CONCLUSION

In short, we can conclude that the incidence of anterior cruciate ligament injury of the knee in professional soccer players of the Brazilian championship first and second divisions between 2015 and 2019 is 0.414 for every 1,000 hours of play, a figure similar to that described in literature. The average age at the time of injury and 23.6 years and time off due to injury is  $244.5 \pm 31.6$  days, regardless of the division. Forwards and defenders presented the highest incidence of injury, without statistically significant difference; however, they presented higher chances than goalkeepers, left/right backs and midfielders. All the epidemiological data cited in our study can be used by teams and professionals related to soccer to implement measures that can contribute to the prevention and faster recovery of injuries in professional athletes.

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# EPIDEMIOLOGY OF ORTHOPEDIC INJURIES IN JIU-JITSU ATHLETES

## EPIDEMIOLOGIA DAS LESÕES ORTOPÉDICAS EM ATLETAS PRATICANTES DE JIU-JITSU

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### ABSTRACT

**Objective:** This study aims to identify the epidemiology of orthopedic injuries in jiu-jitsu practitioners. **Methods:** Ninety-six jiu-jitsu practitioners aged between 18 and 45 years, male and female, answered a questionnaire addressing personal data and history of injuries related to the sport during the last 24 months. **Results:** In the period cover, 85% of the sample presented injuries related to the practice of jiu-jitsu, with an average of 60 days of absenteeism from sports practice. Fingers, shoulders, and knees were the joints most affected by orthopedic injuries. **Conclusion:** Orthopedic injuries are quite prevalent among jiu-jitsu practitioners, often distancing athletes from the sport. **Level of Evidence IV, case series / cross sectional study.**

**Keywords:** Athletic Injuries. Martial Arts. Epidemiology.

### RESUMO

**Objetivo:** Este estudo tem como objetivo identificar um perfil epidemiológico das lesões ortopédicas presentes em praticantes da modalidade jiu-jitsu. **Métodos:** 96 praticantes de jiu-jitsu, entre 18 e 45 anos, de ambos os sexos, responderam a um questionário que abordou dados pessoais e histórico de lesões relacionadas à prática do esporte nos últimos 24 meses. **Resultados:** 85% da amostra apresentou lesão relacionada à prática do jiu-jitsu no período abordado, com média de 60 dias de absenteísmo da prática esportiva. Os locais mais acometidos por lesões ortopédicas foram: dedos, ombros e joelhos. **Conclusão:** As lesões ortopédicas são bastante prevalentes na prática do jiu-jitsu, muitas vezes afastando os atletas de sua prática. **Nível de evidência IV - série de casos / estudo transversal.**

**Descritores:** Traumatismos em Atletas. Artes Marciais. Epidemiologia.

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### INTRODUCTION

Jiu-jitsu originated during feudal times in Japan as an art based on throwing, hitting, kicking, striking, choking, twisting members, and immobilizing the opponent. However, only after the second half of the 16th century jiu-jitsu began to be practiced and taught in a systematized manner. Many Japanese migrated to the West after World War I, especially to Brazil, spreading jiu-jitsu throughout the country; since then, jiu-jitsu has been a widely spread and practiced martial art. Currently, jiu-jitsu is worldwide known as Brazilian jiu-jitsu and represented by the International Brazilian Jiu-Jitsu Federation (IBJJF). Athletes are divided according to belts (graduation), age group, and weight. Fighting time is determined based on combatants' belt and category. Within the adults category (18 to 29 years), fighting time ranges from 5 to 10 minutes according to belt. In the Master category, fighting time is 5 minutes regardless of belt. In jiu-jitsu, the goal is to finish the fight using projections, chokes, twists, and immobilizations, often with joint blockage, which may result in various types of lesions, predominantly orthopedic.<sup>1-5</sup>

These fights are characterized by unexpected, fast, repetitive, and high-intensity effort movements, subjecting joints and muscles to an intense overload. Added to the large number of competitions and training intensity, these factors incur in many musculoskeletal injuries.<sup>5</sup> Many epidemiological studies in the world literature investigate injuries suffered in various martial arts, such as judo, karate, taekwondo, and mixed martial arts (MMA). However, studies associating injuries with jiu-jitsu practice are still scarce. Studies show that the incidence of musculoskeletal injuries associated with jiu-jitsu practice is similar to that found for other martial arts, and that knees, elbows, and other joints commonly subjected to the torsional mechanism are the most common injury sites.<sup>2,3,5</sup>

Studies that assess various modalities epidemiology and compare injuries incidence among them on competitions such as the Olympics and high school and university championships are fairly common in the literature.<sup>6-9</sup> And, although these studies do not include jiu-jitsu, they serve as basis for comparing the epidemiology of other modalities, including fights as judo and wrestling.<sup>2-7,10-12</sup>

All authors declare no potential conflict of interest related to this article.

The study was conducted at the Universidade Federal de São Paulo, Paulista School of Medicine, Sports Traumatology Center. Correspondence: Alexandre Pedro Nicolini, Rua Estado de Israel, 636, São Paulo, SP, Brazil, 04022001. [apnicolini@uol.com.br](mailto:apnicolini@uol.com.br)

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Musculoskeletal injuries account for about 80% of sports injuries. Thus, the number of orthopedic injuries has increased alongside the exponential increase in sports practice by the general population (including at age groups extremes).<sup>12-14</sup>

Many are the categories attributed for sports injuries, such as: those that lead to the interruption of sports practice and/or competitions, those that lead to a decrease in activity level, or those that require treatment, whether surgical or non-surgical. Injuries may be classified according to their severity, absence period from sports practice, length of treatment, nature of the injury, and injury profile (type),<sup>13-15</sup> indicating that understanding sports injuries helps to predict and prevent future injuries.<sup>8,15</sup>

Most musculoskeletal injuries are minor contusions, sprains, and muscle injuries (54%) that entail but a short absence from activities.<sup>12-16</sup>

This study aims to identify the epidemiology of orthopedic injuries in jiu-jitsu practitioners. Epidemiological studies are extremely important for establishing literary data, developing preventive methods, comparing sports modalities, and even implementing or changing rules.

## MATERIALS AND METHODS

### Study design

This is a questionnaire-based cross-sectional study conducted with jiu-jitsu practitioners over 18 years old. The questionnaire (Appendix 1) collected personal data and history of orthopedic injuries related to the sport in the last 2 years through questions addressing the number of injuries, affected site, whether injuries occurred during training or competition, and the treatment received. This project was approved by the Ethics and Research Committee of the Universidade Federal de São Paulo – UNIFESP (opinion no: 52533815.2.0000.5505).

All participants signed the informed consent form. Data was collected using the Referred Morbidity survey, tested by Pastre et al.<sup>17</sup> and validated for the modality at stake.

### Participants

Male and female jiu-jitsu practitioners for at least 12 months, from different training centers in the Metropolitan Region of São Paulo from October to December 2019, and over 18 years of age were considered eligible for the study.

### Inclusion criteria

Male and female jiu-jitsu practitioners for at least 12 months, aged between 18 and 45 years, and with a minimum training frequency of twice a week were included in the study.

### Exclusion criteria

Individuals outside the stipulated age range, practicing jiu-jitsu for less than 12 months and less than twice a week, who had recently undergone surgical procedure and returned to the practice within 1 year of the evaluation were excluded from the research.

In total, 96 practitioners answered the questionnaire, 82 males and 14 females.

## RESULTS

The initial analysis concerns participants' data (Table 1).

Regarding gender, 85% of the participants were male and 15% female. The sample average age was 27.65 ( $\pm$  1.42).

As for athletes' graduation, we observed the following distribution:

**Table 1.** Representativeness of graduation.

Belts	Athletes	
White	25	26%
Blue	25	26%
Purple	16	17%
Brown	9	9%
Black	21	22%
Total	96	100%

Table 2 show practitioners' training frequency, with an average frequency of 3.56 training sessions/week ( $\pm$  0.31).

**Table 2.** Description of weekly training frequency.

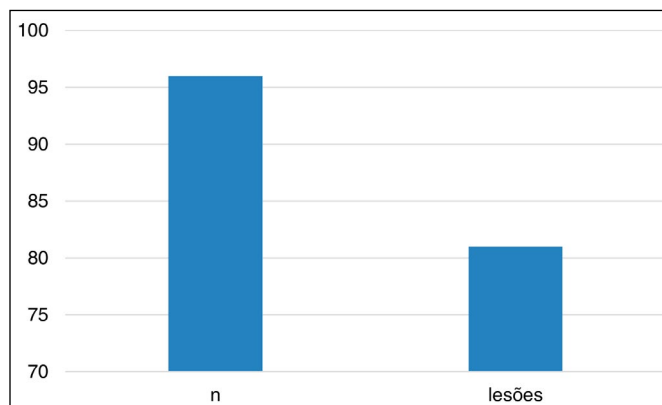
Frequency training sessions/week		
2	26	27%
3	17	18%
4	13	13%
5	18	19%
6	7	7%
7	3	3%
8	3	3%
9	4	4%
10	4	4%
11	1	1%
Total	96	100%

Table 3 shows the results of competitions annual frequency.

**Table 3.** Yearly number of competitions.

Competitions frequency	n	%
Not reported	25	26%
None	19	20%
1	10	10%
2	14	15%
3	1	1%
4	5	5%
5	5	5%
6	5	5%
8	4	4%

Eighty-one participants (84% of the sample) suffered some type of orthopedic injury in the last 2 years (Figure 1), totalizing 229 injuries. Of these, 69 were male (84%) and 12, female (86%).

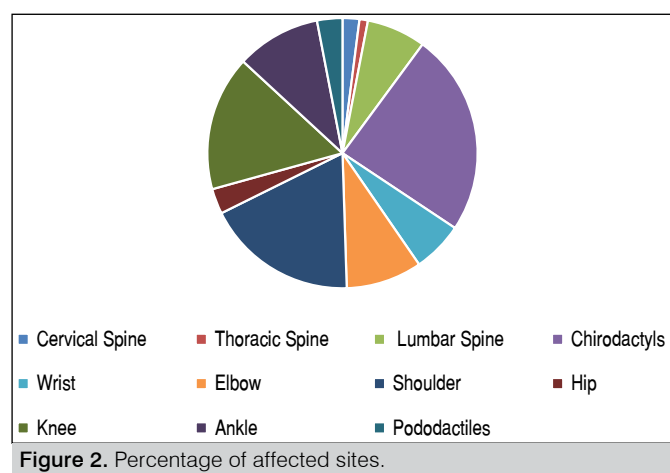


**Figure 1.** Number of participants who reported orthopedic injuries.

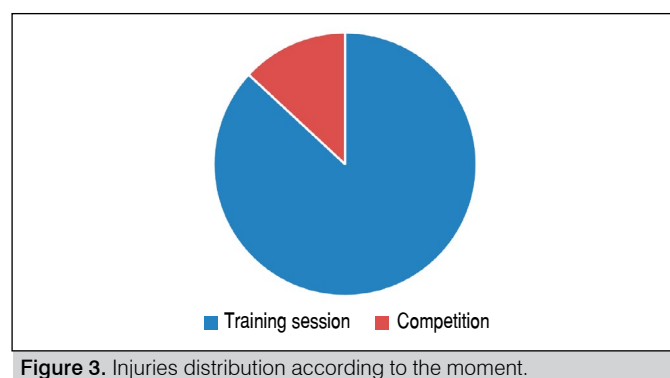
With that, we analyzed the moment at which injury occurred and which anatomical region was affected. Regarding affected site, we found the following distribution (Table 4):

Site	Male	Female	Total
Cervical spine	4	2	6
Thoracic spine	2	1	3
Lumbar spine	12	5	17
Chirodactyls	44	11	55
Wrist	11	2	13
Elbow	16	5	21
Shoulder	37	4	41
Hip	7	0	7
Knee	32	5	37
Ankle	19	3	22
Pododactiles	5	2	7
Total	189	40	229

Chirodactyls were the most injured site during jiu-jitsu practice, with 24% of total injuries, followed by shoulder, knee, and ankles (Figure 2).



Regarding the moment of injury, practitioners reported whether it occurred during training or competition, and injuries during training were more common than those occurred during competitions, as shown in Figure 3.



After investigating lesions and most affected anatomical regions, we studied treatment approaches. The first variable concerned the search for medical intervention.

Only 65% of the practitioners who got injured in the last 24 months sought medical attention. Among the 35% who did not, 21% reported self-treatment (Figure 4).

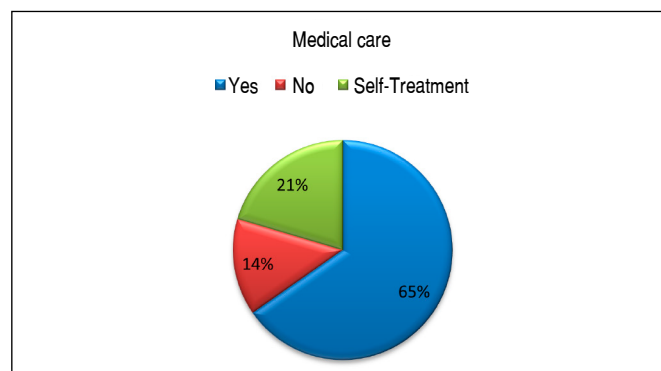


Figure 4. Search for medical care.

As for received medical treatment, we obtained the following distribution (Table 5):

Performed procedure	n
Surgery	4
Immobilization	11
Physical therapy	21
Medication	18

Table 6 shows data on subjects who performed self-treatment.

Treatment	n
Immobilization	7
Physical therapy	5
Medication	12

Average absenteeism period was 63.33 ( $\pm$  4.48) days among men and 58.63 ( $\pm$  8.40) among women.

Regarding post-injury return to sports, 22% of practitioners reported returning at the same or higher level than pre-injury, 60% reported returning at a level lower level, and approximately 18% did not inform.

## DISCUSSION

Among the 96 practitioners who answered the questionnaire, 13 men and two women reported having suffered no injury during jiu-jitsu practice in the last 2 years, whereas 81 participants had at least one orthopedic injury – a significant percentage. These injuries incur long periods of sport absence and loss of training, physical fitness, and even financial resources for professional athletes.

In our sample, chirodactyls, shoulder, knee, ankle, elbow, and lumbar spine were the most affected sites, which may be explained by the movements mechanics and strikes inherent to jiu-jitsu. Chirodactyl injuries are quite common due to kimono grips, strikes, and blocks. Shoulder and elbow injuries are due to falls and armlocks, which may place the elbow in hyperextension positions and/or adduction-abduction stress. Knee injuries are quite common after falls, opponents' falls over one's knee, "guard pass," and in kicking/tripping someone.<sup>2</sup> Cervical spine is usually compromised after choke and post-fall direct trauma,<sup>18</sup> whereas ankle injuries usually occur after "foot lock." Pododactile injuries are also common after torsional trauma on the mat.<sup>2</sup>

Epidemiological studies are required to understand the mechanisms of injury, most prevalent injuries, most affected anatomical regions, as well as treatments received and absenteeism length related to the practice of jiu-jitsu. This enable better preventive and treatment conducts for reinserting the athlete into sports practice



in a more agile manner, without functional impairments and with low risk of recurrence. Given this is a questionnaire-based study and athletes/patients may lack the knowledge on injury type, we did not evaluate this variable.

Injuries suffered during training were more prevalent than those suffered at competitions, which is justified by the greater number of practicing hours during the week and even greater during training sessions (one or more hours), whereas competition fights last from 2 to 10 minutes. The longer the exposure/practice time within the same session, the greater the risk of injury.<sup>9,16</sup> Some authors explain that competition injuries tend to differ from those suffered during training, given that in competitions athletes often seek victory by submission. Such submission may result in injuries, especially when the opponent does not "hit" by surrender.<sup>19</sup>

Epidemiological studies approaching injuries in the practice of jiu-jitsu are still scarce in the literature. Scoggin et al.<sup>2</sup> conducted one of the most important studies on the subject, assessing injuries suffered during a jiu-jitsu championship between 2005 and 2011. The authors reported an incidence of 9.2 injuries per 1000 fights, with a high prevalence of orthopedic injuries (78% of injuries). They also found elbow to be the most affected site, which may be explained by the bar movement, quite common in the sport.

Kreiswirth et al.<sup>3</sup> evaluated 951 athletes during a jiu-jitsu championship and reported 62 injuries, 40 of which in joints. They found black belt athletes to present a higher incidence of injuries, most commonly affecting the knees, elbows, and ankles.

In a retrospective study conducted with medical records and charts, Stephenson and Rossheim<sup>5</sup> found 39,181 injuries between 2008 and 2015 related to the practice of jiu-jitsu, judo, and mixed martial arts (MMA) in the United States. The authors found sprains to be the most common type of injury in jiu-jitsu and, corroborating our findings, injuries occurred predominantly during training. Head, hands, shoulder, and feet were the most common affected sites.

McDonald et al.<sup>19</sup> conducted a similar questionnaire-based study and obtained 166 answers from jiu-jitsu practitioners. They found

hands and fingers, feet, elbows, and shoulders to be the most common affected sites, corroborating our results.

When comparing jiu-jitsu with other fighting modalities, a study addressing injuries caused by judo found chirodactyls and knees to be the most common affected sites, similar to our findings.<sup>19</sup> Petrisor et al.<sup>4</sup> conducted a questionnaire-based study with 70 jiu-jitsu practitioners to establish the epidemiology of injuries suffered in the sport. In line with our findings, they reported 91% of injuries to occur during training and a high prevalence of injuries in the neck, fingers/hand, knees, shoulders, and elbows.

Regarding post-injury moment, participants mostly reported seeking for medical care (65%) and receiving non-surgical treatment, including immobilization, rest, physical therapy, and medication. We found injury-related absenteeism period to be two months on average, indicating minor to moderate injuries with short and medium treatment duration. However, even short absence periods can incur loss of technique and physical fitness.

This study aims to provide a better understanding about the types of musculoskeletal injuries jiu-jitsu practitioners are exposed to and their implications. These data may help coaches and athletes to develop better techniques and educational methods to prevent and mitigate lesions.

Considering this is a questionnaire-based study, our data may not reflect the totality of injuries, since minor injuries often go unnoticed or are forgotten by patients. Moreover, participants did not report lesion type, constituting a limitation for this study. Prospective studies closely monitored by a healthcare professional may advance knowledge on this subject.

## CONCLUSION

The prevalence of orthopedic injuries among jiu-jitsu practitioners is quite high (84%). Chirodactyls, shoulder, elbow, knees, and ankles are the most affected sites, and injuries occur more frequently during training. Most practitioners receive non-surgical treatment and remain absent from sports practice for 2 months on average.

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**APPENDIX 1**  
**QUESTIONNAIRE**

NAME:

AGE:

DOMINANT LIMB:            RIGHT ( )            LEFT ( )

BELT:                      WHITE ( )            BLUE ( )            PURPLE ( )            BROWN ( )            BLACK ( )

WHAT IS YOUR WEEKLY TRAINING FREQUENCY?

WHAT IS YOUR COMPETITION FREQUENCY DURING THE YEAR?

DO YOU PRACTICE ANY OTHER SPORT? YES ( )            NO ( )

IF SO, WHICH ONE?

HAVE YOU SUFFERED ANY INJURIES WHILE PRACTICING JIU-JITSU IN THE LAST 2 YEARS?    YES ( )            NO ( )

LESION SITE:

	TRAINING	COMPETITION	OTHER
CERVICAL SPINE	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
THORACIC SPINE	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
LUMBAR SPINE	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
FINGER	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
WRIST	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
ELBOW	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
SHOULDER	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
HIP	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
KNEE	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
ANKLE	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )
PODODACTILES	R ( ) L ( )	R ( ) L ( )	R ( ) L ( )

DID YOU LOOK FOR MEDICAL CARE?            YES ( )            NO ( )

RECEIVED TREATMENT:

SURGERY ( )            PHYSICAL THERAPY ( )            IMMOBILIZATION ( )            MEDICATION ( )

FOR HOW LONG WERE YOU ABSENT FROM SPORTS PRACTICE?

ONCE YOU RETURNED TO THE SPORT PRACTICE, WERE YOU AT THE SAME LEVEL AS BEFORE THE INJURY?