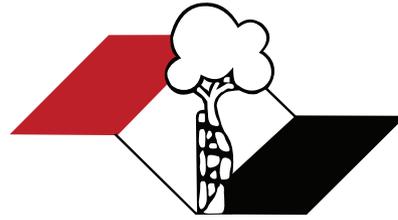


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ACTA ORTOPÉDICA BRASILEIRA

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(Reviewed January 2016)

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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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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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Levels of Evidence for Primary Research Question^a

(This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK.

For more information, please visit www.cebm.net.)

Level	Types of study			
	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 ^d (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 ^b of Level RCTs (and study results were homogenous ^c)	Systematic review ^b of Level I studies	Systematic review ^b of Level I studies	Systematic review ^b of Level I studies
II	Lesser quality RCT (eg, < 80% followup, no blinding, or improper randomization)	Retrospective ^e 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 ^d comparative study ^e	Untreated controls from an RCT	Systematic review ^b of Level II studies	Systematic review ^b of Level II studies
	Systematic review ^b 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 ^b of Level II studies		
III	Case control study ^d	Case control study ^d	Study of non consecutive patients; without consistently applied reference "gold" standard	Analyses based on limited alternatives and costs; and poor estimates
	Retrospective ^e comparative study ^e		Systematic review ^b of Level III studies	Systematic review ^b of Level III studies
	Systematic review ^b of Level III studies		Case-control study	
			Poor reference standard	
IV	Case series ^h	Case series		Analyses with no sensitivity analyses
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

^a A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.

^b A combination of results from two or more prior studies.

^c Studies provided consistent results.

^d Study was started before the first patient enrolled.

^e 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.

^f The study was started after the first patient enrolled.

^g 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.

^h Patients treated one way with no comparison group of patients treated in another way.

ORIGINAL ARTICLES

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HIGH TIBIAL OSTEOTOMY USING A LOCKING TITANIUM PLATE WITH OR WITHOUT AUTOGRAFTING

OSTEOTOMIA TIBIAL ALTA COM PLACA BLOQUEADA DE TITÂNIO COM OU SEM AUTOENXERTO

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ABSTRACT

Objective: To postoperatively evaluate knee scores, radiological assessment results, deficit correction, patellar height change, bone healing time, and weight bearing time in patients undergoing high tibial osteotomy (HTO) with/without autologous iliac bone grafting. **Methods:** This retrospective examination of treated controls from a randomized controlled study included 63 knees of 58 patients aged 46–59 years who underwent HTO with locking open wedge osteotomy plates. The patients were divided into two groups: Group A, HTO with autologous iliac bone grafts ($n = 31$); and Group B, HTO without autologous iliac bone grafts ($n = 32$). Clinical and radiological data were evaluated prospectively at the preoperative consultation and again at 6, 9, and 12 weeks, 6 months, and 1 year after the surgery (and annually thereafter). **Results:** There were no significant intergroup differences in the radiological assessment, deficit correction, patellar height change, bone-healing time, and weight-bearing time at any time after surgery. The knee scores changed positively in both groups ($p < 0.001$). **Conclusions:** There was no difference in the results of patients undergoing HTO with open wedge osteotomy titanium locking plates with or without autografting, and comorbidities resulting from autografts were eliminated with the use of locking plates. **Level of evidence III, Retrospective Study.**

Keywords: Autograft. Healing. Correction. Osteotomy. Bone plate. Tibia.

RESUMO

Objetivo: Avaliar escores de joelho, resultados da avaliação radiológica, correção de déficits, alteração da altura patelar, tempo de consolidação óssea e tempo para apoio de peso no pós-operatório em pacientes submetidos à osteotomia tibial alta (OTA) com ou sem enxerto autólogo de osso ilíaco. **Métodos:** O exame retrospectivo de controles tratados em estudo randomizado e controlado foi realizado em 63 joelhos de 58 pacientes com idade entre 46 e 59 anos submetidos a OTA com placas bloqueadas de titânio em cunha aberta. Os pacientes foram divididos em dois grupos: Grupo A, OTA com enxerto de osso ilíaco autólogo ($n = 31$) e Grupo B, OTA sem enxerto autólogo de osso ilíaco ($n = 32$). Os dados clínicos e radiológicos foram avaliados prospectivamente na consulta pré-operatória e 6, 9 e 12 semanas e 6 meses e 1 ano após a cirurgia (e depois disso, anualmente). **Resultados:** Não houve diferenças significativas quanto a avaliação radiológica, correção de déficit, mudança de altura da patela, tempo de cicatrização óssea e tempo para apoio de peso entre os dois grupos em nenhum momento após a cirurgia. Os escores de joelho mudaram positivamente em ambos os grupos ($p < 0,001$). **Conclusões:** Não houve diferença nos resultados dos pacientes submetidos a OTA com placas bloqueadas de titânio em cunha aberta com e sem autoenxerto, e as comorbidades resultantes dos autoenxertos foram eliminadas com o uso de placas bloqueadas. **Nível de Evidência III, Estudo Retrospectivo.**

Descritores: Autoenxertos. Cura. Correção. Osteotomia. Placas ósseas. Tibia.

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INTRODUCTION

Angular deformities of the knee are a common cause of knee pain. Genu varum and osteoarthritis will increase within the elderly population in most countries along with increases in knee surgeries such as arthroscopy, high tibial osteotomy, and total knee arthroplasty.^{1,2} Jackson³ first described high tibial osteotomy (HTO) in 1958 and

it was further popularized by Coventry.⁴ HTO has become a popular treatment option for varus unicompartmental gonarthrosis, osteochondral lesions, and joint instability in young and active patients.^{5,6} Although many surgical techniques for HTO have been described, including the dome, Ilizarov, medial opening-wedge, and lateral closing-wedge techniques, medial opening-wedge

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Study conducted at the

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high tibial osteotomy (MOWHTO) has become more popular over the past two decades and has a lower rate of complications.⁵⁻⁸ In MOWHTO, different fixation techniques are applied with or without using bone grafts;^{7,9-11} autografts are usually used to fill the osteotomy defect, although allografts (tricalcium phosphate, dicalcium phosphate granules, acrylic cement, or hydroxyapatite) and xenografts have also been used.^{7,11,12} Autogenous bone grafts prolong the operating time and increase morbidity, including severe chronic donor site pain, infection, palpable defects, paresthesias, and increased blood loss.^{7,9,10} Some studies have demonstrated that the bone union rates did not differ significantly with or without a graft in an opening-wedge HTO.^{10,13} However, when grafts or locking plates were not used, a correction deficit and delayed bone union were reported.^{12,14}

Therefore, this study examined differences between patients undergoing MOWHTO with a locking titanium plate with or without autografts by two surgeon's technique, according to knee score, radiological assessment, deficit correction, patellar height change, bone healing time, weight bearing time, and complication rate. Additionally, we evaluated whether bone grafting is necessary or not for HTO.

MATERIALS AND METHODS

Study Design

This retrospective study evaluated 63 knees of 58 patients who had undergone MOWHTO with an open wedge osteotomy (OWO) titanium locking plate (TST Tibbi Aletler, Istanbul, Turkey) (Figure 1) performed at the different medical center by two surgeon's experience (CI and HS) in patients with isolated varus unicompartmental gonarthrosis between December 2011 and September 2014. Group A consisted of 31 osteotomies were operated by the Surgeon CI in which the osseous tibial defect was filled with autologous iliac bone graft. Group B consisted of 32 osteotomies were by the Surgeon HS in which the osseous tibial defect was not filled. Inclusion and exclusion criteria are summarized in Table 1. All patients underwent arthroscopic debridement and assessment before MOWHTO. All patients undergoing HTO were evaluated pre- and postoperatively in terms of range of motion (ROM), Knee Society Score, and Functional Knee Society Score.

Radiological evaluation

Preoperatively, anteroposterior (AP), lateral, and tangential X-rays and magnetic resonance imaging (MRI) of the knee were obtained for patients scheduled to undergo MOWHTO. In pre- and postoperative images, the following measurements were made: the mechanical axis of deviation (MAD), medial proximal tibial angle (MPTA), Insall-Salvati Index (ISI), and Blackburne-Peel Ratio (BPR). The clinical and radiological data were evaluated prospectively at the preoperative consultation and 6, 9, and 12 weeks, and 6 months and 1 year, after the surgery, and then annually. Bone union was



Figure 1. A) Open Wedge Osteotomy titanium locking plate AP. B) Open Wedge Osteotomy titanium locking plate LAT.

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Patients aged <65	Patients aged >65
Isolated medial compartment arthrosis (Ahlbäck grade 1 or 2)	Ahlbäck grade 3 arthrosis and excessive patellofemoral arthrosis
Good patient motivation to comply with postoperative rehabilitation	Poorly patient mentally to comply with postoperative rehabilitation
Range of motion >100°	Range of motion <100°
Absence of knee contractures	Flexion contracture of >10°
Moderate to severe varus malalignment (5-15°)	Varus gonarthrosis requiring >20° correction
Medial joint pain treat to conservative management (analgesics and/or painkillers and physiotherapy for at least 1 year)	Incompatible patient to conservative treatment and poor bone quality (pre-diagnosed osteoporosis)
Stable knees	Laxity of collateral ligament, Anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) insufficiency
BMI < 30 kg/m ²	Previous ACL and/or PCL reconstruction
	Previous bony realignment procedures to the extensor mechanism
	Joint infection and rheumatoid arthritis

evaluated on AP and lateral radiographs. Union at the osteotomy site follows the same process as normal bone healing. Four of the authors (HS, CI, MEI, MU) analyzed the radiological data at every follow-up. In addition, two of the authors (HS, CI) determined when the patients achieved partial and full weight-bearing. The study was approved by the Local Hospital Management Committee. The patients signed the Term of Free and Informed Consent.

Surgical technique

One hour before surgery, 1g cefazolin was administered to all patients intravenously. All patients lay supine under spinal anesthesia. A lower extremity tourniquet was applied in all patients. First, an arthroscopic evaluation was performed and additional intraarticular pathologies were treated using arthroscopic methods. MOWHTO was performed as described elsewhere.¹⁵ The osteotomy incision was made based on the preoperative plan and a titanium locking OWO plate was placed through this osteotomy incision (Figures 2). Under fluoroscopy, the mechanical axis was determined with a metal rod passing through the center of the femoral head and the ankle. The passage of the mechanical axis through the knee was evaluated by arthroscopy. After achieving sufficient correction, the OWO was fixed using a titanium locking plate. In all patients in Group A, an autograft harvested from the contralateral iliac crest was applied on the osteotomy line. All patients underwent prophylactic treatment to protect against deep vein thrombosis for 10 days.

Postoperative Rehabilitation

No external immobilizer was applied in any patient. Patient-controlled anesthesia (PCA) was used to manage the postoperative pain and facilitate the rehabilitation process. On postoperative day 1, active knee ROM exercises were initiated up to 90° as tolerated by the patient. After the second week, rehabilitation exercises were continued freely after ROM of 90° was achieved. One day after surgery, the patients were mobilized, and walking with the aid of a pair of crutches was permitted. For the first 2 weeks, walking with the heels contacting the ground was permitted. Then, partial weight-bearing was allowed as tolerated by the patient. After 6 weeks, full-weight bearing on a crutch while walking was permitted. Three months postoperatively, the patients walked without support.

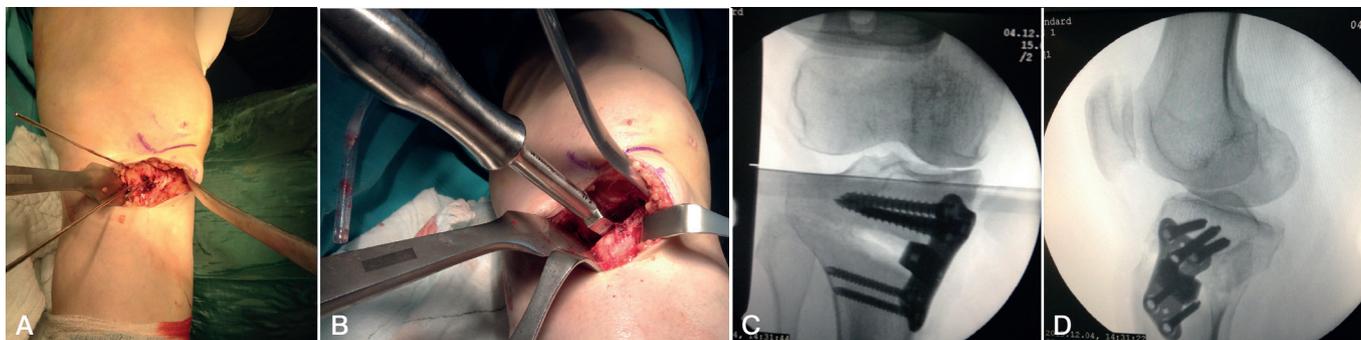


Figure 1. A) Placement of Guide K wires. B) Determination of the size of the Puddu plate to be placed on the osteotomy incision line. C) AP radiogram following perioperative implantation of a plate. D) LAT radiogram following perioperative implantation of a plate.

Statistical Analysis

The data analysis was performed using the Statistical Package for the Social Sciences software, version 20 for Windows (SPSS Inc., Chicago, IL). The data are shown as mean \pm standard deviation for continuous variables, medians (minimum–maximum) for ordinal variables, and frequencies with per cent for categorical variables. Comparisons between groups were performed using one-way ANOVA with post hoc analysis by Tukey's HSD or independent samples t-test and the Kruskal-Wallis tests or Mann-Whitney U test for normally and abnormally distributed data, respectively. The categorical variables between groups were analyzed using the chi-square test. A p value of <0.05 was considered statistically significant.

RESULTS

Clinical results

This study included 58 patients (4 men, 54 women; mean age, 52 years; range: 46–59 years) who were operated on using the MOWHTO method. The patients were followed for at least 1 year. The mean duration of the follow-up was 19.3 months (range: 12–25 months). No significant difference was detected between the groups in the demographic characteristics or size of implants used (Table 2). No significant ($p>0.05$) difference was found between the pre- and post-operative ROM in the patients. The postoperative Knee Society and Functional Knee Society Scores were significantly ($p<0.05$) different when compared with the preoperative scores in both groups (Table 3).

Radiological results

In Groups A and B, full union of the osteotomy line required 11.85 and 12.15 weeks, respectively; the difference was not significant ($p=0.117$). After an average of 6 months, radiological bone union was seen. There was no significant ($p>0.05$) difference in the degree of correction at the first postoperative year between the groups. The X-ray results are summarized in Table 4.

Table 2. Open Wedge Osteotomy plates size.

Plate degrees	Number of knees with group a (n=31)	Number of knees with group b (n=32)	Percentage (%)
10	13	14	42,85
12,5	14	14	44,44
15	4	4	12,69

Table 3. Knee Society Knee Score and Knee Society Functional Score with pre-operatively and post-operatively at one year after surgery.

	KSKS Pre-op.	KSKS Post-op.	KSFS Pre-op.	KSFS Post-op.
Group A	37.9 (0-62)	84.2 (38-100)	45.9 (25-65)	85.5 (40-100)
Group B	38.1 (0-60)	84.9 (40-100)	44.5 (20-65)	88.2 (60-100)

KSKS: Knee Society Knee Score, KSFS: Knee Society Functional Score.

Table 4. The evaluation of X-ray results.

Group	A (N= 31)	B (N=32)	p
Preop MAD	29.6 mm medial	29.3 mm medial	0,885
Early Postop MAD	5.06 mm lateral	5.3 mm lateral	0,388
Postop 1 year MAD	4.9 mm lateral	5.1 mm lateral	0,402
PreopaMPTA	81.3 ^o (77 ^o -86 ^o)	81.8 ^o (76 ^o -87 ^o)	0,459
Early Postop aMPTA	91.1 ^o (87 ^o -97 ^o)	91.4 ^o (86 ^o -97 ^o)	0,757
Postop 1 Year aMPTA	90.5 ^o (86 ^o -97 ^o)	91 ^o (85 ^o -97 ^o)	0,571
Correction degrees of post-operation	10.39 ^o	10.31 ^o	0,817
Correction degrees of post-operation at 12 months	9.97 ^o	9.94 ^o	0,918
Difference of correction degrees	0.42 ^o	0.39 ^o	0,910
Preop ISI	1.05 (0.79-1,22)	1.01 (0.79-1,25)	0,260
Postop ISI	1,12 (0.8-1,35)	1.09 (0.81-1,35)	0,534
Postop ISI at 12. months	1,14 (0.82-1,36)	1,13 (0.84-1,36)	0,854
Preop BPR	0,98 (0.77-1,12)	0,94 (0.75-1,14)	0,094
Postop BPR	0,94 (0.77-1,06)	0,90 (0.75-1,05)	0,099
Postop BPR at 12. months	0,92 (0.76-1)	0,88 (0.75-1)	0,100

MAD: Mechanical axis deviation, aMPTA: Angle between tibial anatomical axis and the articular surface of the proximal tibia and anteroposterior images, ISI: Insall-Salvati index, BPR: Blackburne-Peel ratio.

Complications

None of the patients developed a neurovascular injury, serious infection, or patellar dislocation. Twelve (19%) patients developed various complications: four patients had lateral cortex fractures during the osteotomy procedure (a short-thread cancellous screw was placed through the hole of the plate crosswise at the osteotomy line and the other screws placed in the plate were locking screws; see (Figure 3); three developed deep hematomas in the muscle; three Group A patients had chronic tenderness at the iliac graft harvesting site; and two patients developed lateral plateau fractures while expanding the osteotomy line [after fixing the plate with two spongy screws, the osteotomy line was opened until required correction was achieved (Figure 4); the time to bone union was not different in these patients and no correction deficit developed.

DISCUSSION

MOWHTO, which is a treatment alternative for young and active patients with medial gonarthrosis of the knee, has improved mid- and long-term outcomes with appropriate patient selection and attentive surgery.¹⁻⁵ With MOWHTO technique, no implant is applied at the joint surface, no septic or aseptic loosening is detected (as seen in arthroplasty) and, most importantly, total knee arthroplasty is postponed by preserving the integrity of the patient's own anatomy.^{6-8,16}

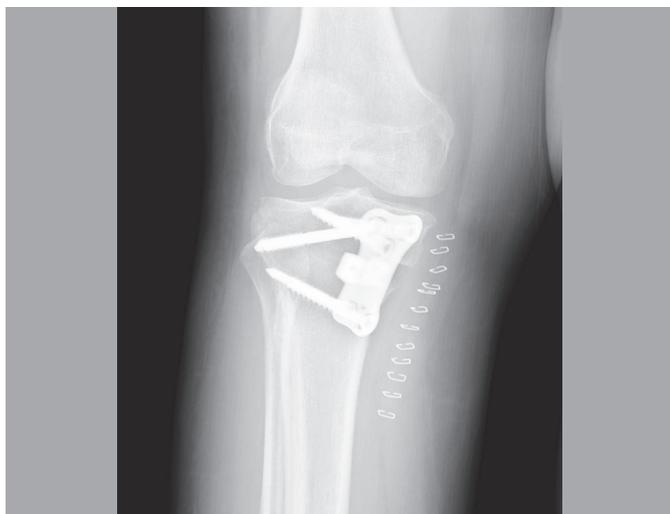


Figure 3. AP radiogram of the patient who developed lateral cortex fracture.



Figure 3. AP radiogram of the patient with lateral plateau fracture.

MOWHTO is associated with stability of the osteotomy in accordance with osteotomy size, an intact lateral cortex, and rigid fixation.¹⁰ Even if these criteria are met, with MOWHTO it is not always possible to achieve the desired state of wellbeing. Serious problems include problematic union of the osteotomy line, unwanted fractures, and under- and overcorrection. Grafting of the osteotomy line is directed at preventing problematic bone union. When a fracture occurs,

union can be problematic and a correction deficit can occur despite rigid fixation. During surgery, the correction should be at least 80° valgus with a tendency towards rigid fixation.^{6,10,12,14-16}

With MOWHTO, although the use of autografts is frequently preferred, this increases the operating time, pain at the donor site, and the risks of iliac wing fracture and inflammation. The disadvantages of allografts, which are being used increasingly, include lower bone formation rates, contagious diseases, and higher costs.^{6,7,9,10}

To prevent correction deficits and accelerate bone healing, Spahn¹⁸ recommends the use of grafts for osteotomy defects > 12°, and tibial size effects on wedge height. In our series, three Group A patients developed chronic pain at the donor site, which was consistent with the literature. We did not observe any significant differences between the groups with and without grafts in terms of union of the osteotomy line or correction deficit. Additionally, the tibial wedge heights of our groups were similar, and was not observed any significant differences between the groups with and without grafts in terms of union of the osteotomy line or correction deficit. Therefore, it is not necessary to risk additional morbidity and potential complications by using grafting in patients who are undergoing MOWHTO with rigid fixation. However, correction degrees of post-operation at 12 months were approximately 10 degrees. It was not than 12 degrees.

Many studies have demonstrated consolidation in patients who underwent MOWHTO with rigid locking plates without using grafts.^{18,19} Correction deficits were reported in cases with lateral cortex fractures when adequate stabilization could not be achieved using conventional Puddu stainless steel plates.^{6,9,10,14,16} We think that the use of an OWO titanium locking plate and a 6.5 mm short-thread cancellous screw inserted through the screw holes in the plate provided additional stabilization of the fracture line.

El-Azab *et al.* demonstrated that closing-wedge HTO and opening-wedge HTO increased the incidences of patella alta and patella baja, respectively.²⁰ In our series, the development of patella baja was seen in patients with MOWHTO. However, there were no significant differences between the pre- and postoperative measurements of the length of the patellar tendon, ISI, and IBR.

Study limitations included its retrospective nature, the performance of the surgeries by different surgeons in the groups with and without graft implantation, the inability to assess the smoking status or number of pack-years of the participants, the wide age range, and the small sample size.

CONCLUSION

In patients undergoing MOWHTO using an OWO titanium locking plate, the use of a graft does not make an additional contribution to the time to bone union or preservation of the correction achieved, while not using a graft avoids the development of additional comorbidities that might occur with an allograft or autograft. We also believe that not using a graft decreases the operating time and costs.

AUTHORS' CONTRIBUTIONS: This manuscript, which describes a multi-institutional study, has four authors. Each author contributed individually and significantly to the development of the manuscript. HS (0000-0003-2221-4731)* and CI (0000-0003-4615-688X)* were the main contributors to the manuscript. HS and CI performed at the different medical centers, followed the patients, and gathered the clinical data. HS, CI, MEI (0000-0002-5385-6182)*, and MU (0000-0003-3139-3583)* analyzed the radiological data at every follow-up appointment. In addition, two of the authors (HS, CI) determined when the patients achieved partial and full weight-bearing. HS and CI performed the statistical analysis. HS, CI, MEI, and MU performed the literature search, reviewed the manuscript, and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

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RANDOMIZED PROSPECTIVE STUDY ON THE TREATMENT OF FEMORO-PATELLAR OSTEOARTHRITIS USING BRACING

ESTUDO PROSPECTIVO RANDOMIZADO DO TRATAMENTO DA ARTROSE FÊMORO-PATELAR PELO USO DE ÓRTESE

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ABSTRACT

Objective: To compare the effect of a brace designed to stabilize the patellofemoral joint to that of a patella-shaped neoprene sleeve with patella cut out in patients with patellofemoral osteoarthritis. **Methods:** Fifty-seven patients with femoro-patellar osteoarthritis were allocated to two groups: patients with femoro-patellar functional brace and those with a neoprene knee with a patellar orifice. Both groups underwent clinical treatment of osteoarthritis and used medications daily 1 month before and up to 3 months after brace placement. They were evaluated with the WOMAC and Lequesne questionnaires and performed five times sit to stand test, Timed Up and Go test, and six minutes walk test immediately before and 1 and 3 months after brace placement. **Results:** Both groups had improved pain, stiffness, and function with no difference between groups. Drug use decreased in both groups in the first month but increased in the third month. Naproxen use was progressively higher in the control group. **Conclusion:** Both knee orthoses improved pain and function and altered drug use only in the first month. Functional knee brace provided analgesia without increased use of naproxen. **Level of Evidence IB, Randomized clinical trial**

Keywords: Osteoarthritis. Orthotic. Patellofemoral Pain Syndrome.

RESUMO

Objetivo: Comparar o efeito de uma órtese destinada a estabilizar a articulação fêmoro-patelar, em comparação com uma de neoprene com orifício para rótula, em pacientes com artrose fêmoro-patelar. **Métodos:** Cinquenta e sete pacientes com artrose fêmoro-patelar foram alocados em dois grupos conforme a joelheira que receberam: órtese funcional fêmoro-patelar e joelheira de neoprene com orifício para patela. Ambos os grupos foram orientados sobre o tratamento clínico da osteoartrite e preencherem o consumo diário de medicamentos um mês antes da colocação das órteses e até três meses depois da colocação das mesmas. Foram avaliados com o questionário de WOMAC e Lequesne e realizaram os testes de senta e levanta, Timed-up-and-go e o teste de caminhada de seis minutos, nos momentos imediatamente antes da colocação da órtese e após um e três meses. **Resultados:** Ambos os grupos melhoraram dor, rigidez e função sem diferença entre os grupos. O consumo de medicamentos diminuiu em ambos os grupos no primeiro mês, aumentando no terceiro mês. O consumo de naproxeno foi progressivamente maior no grupo controle. **Conclusão:** Ambas as joelheiras melhoraram a dor, a função e alteraram o consumo de medicamentos somente no primeiro mês. A joelheira funcional propiciou analgesia sem consumo aumentado de naproxeno. **Nível de evidência IB, Ensaio clínico randomizado.**

Descritores: Osteoartrite. Órtese. Síndrome da Dor Patelofemoral.

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INTRODUCTION

Osteoarthritis (OA) is the most common form of arthritis,¹ with the knee being the primary affected site. Although patellofemoral OA coexists with tibiofemoral OA in up to 65% of patients² and anterior knee pain is equally disabling and painful,³ most studies focus on femorotibial compartments. It has been reported that patellar alignment is correlated with the severity of symptoms and is a radiographic predictor of disease progression.^{3,4} Conservative treatments include oral non-steroidal anti-inflammatory drugs (NSAIDs) and intra-articular administration of corticosteroids

or hyaluronic acid. However, these treatments showed no curative effect on inflammation associated with this condition.⁵ The use of brace is a popular treatment for chronic knee pain because of being widely accessible and relatively inexpensive.⁶ The patellar support provided by knee braces has certain advantages compared to that by a tape, including longer equipment life, lower risk of allergic dermatitis, and similar biomechanical effects, such as increased joint contact area.⁷ Current evidence shows that variations in patellar alignment are widespread and contribute significantly to the progression and symptoms of patellofemoral

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

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OA; thus, it would be highly beneficial to determine whether the extent of poor alignment influences brace efficacy. To date, there is no consensus on the exact contribution and effectiveness of using knee orthoses in improving patellar alignment and pain relief. This study aimed to compare the effect of a brace designed to stabilize the femoro-patellar joint to that of a patella-shaped neoprene brace in patients with femoro-patellar osteoarthritis.

MATERIALS AND METHODS

This study was approved by the Ethics Committee for Analysis of Research Projects (CAPPesq) (number 15016/16 and Clinical Trials registration number NCT02984254). All patients signed an informed consent form after receiving a detailed explanation. This is a randomized prospective study comparing two knee braces for patellofemoral osteoarthritis (PFOA).

The inclusion criteria were as follows: symptomatic PFOA knee OA, absence of axis dislocation, age ≥ 30 years, and clinical treatment for knee osteoarthritis for more than 6 months.

The diagnosis of PFOA OA was made using the clinical criteria of the ACR⁸, i.e., presence of symptoms (pain and sensitivity) in the patellofemoral compartment of the knee, associated with signs of OA according to the K&L classification,⁹ and showing no misalignment. Alignment was examined through panoramic radiography of the lower limbs, tracing the mechanical axis, from the center of the femoral head to the center of the ankle, and the femorotibial angles. Patients with involvement of the femorotibial compartment of the knee or who could not read or understand the consent form or the WOMAC questionnaire were excluded from this study.¹⁰ Patients with grade II and III or morbid obesity were also not included.

The exclusion criteria were as follows: braces used differently from what was requested; abandonment of the study; non-adaptation to the brace; skin and vascular complications due to brace use; failure to report medication use for the month between signing the consent and brace placement.

Procedure: Upon inclusion, the 60 patients were divided into three blocks and allocated to one of the two groups according to the order given by the spreadsheet 6591 created on April 12, 2017, at 8:58:36 in www.randomization.com. Thigh and leg circumferences were measured 15 cm from the center of the patella of the patients included in the study. They started to record their daily use of drugs (paracetamol, dipyrrone, naproxen or other anti-inflammatory drugs, codeine, tramadol, cyclobenzaprine, and other drugs for diabetes, hypertension, etc.). After 1 month, upon delivering the sheet with the medications used in the first month, the patients filled out the questionnaires, performed the function test, and received knee braces following the order of the draw, along with the guidelines for their use:

1. Free Knee: patellofemoral functional brace (Figure 1a) (study)
Technical characteristics: knee brace made of neoprene with upper, lower, and lateral impact absorption system.

2. Neoprene knee brace with a patellar orifice (Figure 1b) (control)
Technical characteristics: patella-shaped neoprene knee brace with lateral reinforcement.

All patients attended a half-day course on osteoarthritis and its forms of treatment based on an osteometabolic disease group educational program for patients with knee OA.¹¹

The patients answered the WOMAC and Lequesne questionnaires and performed the five-times-sit-to-stand test (FTSST), Timed Up and Go (TUG), and six-min walk (6MWT) tests.^{10,12-14}

Use of braces: The patients left the hospital with the brace(s) placed in the affected knee(s). They were instructed to use the brace for 2 h on the first day and increase by half an hour per day from the second day, up to a maximum of 12 h/day. These 12 h of use could be continuous or at intervals of not less than 4 h (from the second



Figure 1. A) Functional knee orthosis (Free Knee[®], Salvapé, made of neoprene with Velcro and rubber tubes in the upper, lower, and lateral parts of the patella). B) Neoprene knee orthosis (Knee orthosis with patellar orifice, Salvapé, neoprene, and Velcro).

week) with rest of up to 2 h during the day, replacing the brace. The patients were instructed to sleep without the knee brace(s) and use them when performing physical activities, as long as activities were not performed in water.

Evaluations: The primary objective was to assess pain and stiffness, function, and drug use in the short term. To this end, follow-up evaluations were made before and 1 and 3 months after knee brace placement. Evaluations included the records of medications used daily (along with the number of hours of brace use), the WOMAC and Lequesne questionnaires, and functional evaluations. Radiography without the brace (Schuss view and profile and axial views of the patella) to measure the affected joint spaces and panoramic radiography to measure the internal and external femorotibial angles were performed before inclusion of patients. Age, years of schooling, and weight and height for BMI calculation were also obtained.

Sample calculation: "n" was calculated to obtain a statistical power of 80% and a significance level of 5%. To this end, we considered the standard deviation of the WOMAC variation in the study by Campos et al., who used a similar population of patients with knee OA from the Institute of Orthopedics and Traumatology.¹⁵ The sample size was selected so that it allowed the detection of a 5-point WOMAC variation. Considering eventual dropouts of about 10% of the patients, 26 patients per group was obtained as the recommended sample size.

Statistical analysis

Age and years of schooling were described according to groups using summary measures (means, standard deviations, medians, minimums, and maximums) and compared between groups using Student's t-test and Mann-Whitney test, respectively. Sex was described according to groups using absolute and relative frequencies, and the association was verified using Fisher's exact test.

The scores of the questionnaires were described according to the groups over the evaluation period using summary measures and compared between groups and time-points using generalized estimation equations with normal marginal distribution and identity link function. The same analyses were performed for the drugs used, assuming a negative binomial distribution with identity link function and a first-order auto-regressive correlation matrix between the evaluation periods for all the analyses. The analyses were followed by Bonferroni's multiple comparisons to determine the point at

which significant differences between the groups and evaluation periods occurred.

The results of the questionnaires and function tests were illustrated in graphs showing the mean profile and respective standard errors. The analyses were performed using IBM SPSS for Windows version 20.0, and data were entered in Microsoft Excel 2003. The tests were performed with a 5% significance level.

RESULTS

The study started with 30 patients in each group. One patient in the control group and two in the study group did not attend the session for knee brace retrieval (one patient in the control group asserted that his wife did not inform him, one patient in the study group had a trip, and the other patient did not explain the reason for abandoning the study before knee brace placement). All other patients completed the study.

Table 1 shows the personal characteristics according to groups. The results showed that pain, stiffness, WOMAC and Lequesne scores, and TUG and 6MWT results evolved similarly in both groups in all study periods (Figures 2–9, Table 2), with difference only in FTSTT results between the two groups.

Table 2 shows that pain, stiffness, and WOMAC and Lequesne scores differed throughout the evaluation periods regardless of the group ($p < 0.05$). 6MWT results differed, on average, between the groups independent of the time point of evaluation ($p = 0.026$), and the time of knee brace use differed between the periods evaluated regardless of the group ($p < 0.001$).

Table 3 shows that the WOMAC domains (pain, stiffness, and function) and the WOMAC total score reduced from inclusion to the other periods ($p < 0.05$), except for stiffness, which differed only from the baseline (pre) to the third month ($p = 0.001$). The 6MWT result was, on average, higher in the control group ($p = 0.026$), and brace use was, on average, higher at 3 months than at 1 month ($p < 0.001$).

With regard to the use of drugs (Table 4) for pain control, the combination of naproxen, dipyron, and omeprazole or ranitidine showed a statistically significantly different mean behavior in the groups throughout the evaluation period ($p_{\text{interaction}} \leq 0.05$). The use of paracetamol, codeine, tramadol, and cyclobenzaprine showed a mean difference throughout the evaluation periods regardless of the group ($p < 0.001$). An increase in naproxen use in the first and third months, compared to the initial time point, was observed only in the control group ($p < 0.05$), and in the third month, the control group used, on average, more naproxen than the study

Table 1. Personal characteristics according to groups and results of statistical tests.

Variable	Group		Total	P-value
	Neoprene sleeve (control) (N=29)	Functional brace (study) (N=28)		
Age (years)				0.265
Mean SD	65.3±7.6	63±7.9	64.2±7.8	
Median (min.; max.)	65 (39. 79)	63 (41. 78)	65 (39. 79)	
Sex, n (%)				0.504**
Female	25 (86.2)	22 (78.6)	47 (82.5)	
Male	4 (13.8)	6 (21.4)	10 (17.5)	
Education (years of schooling)				0.828*
Mean SD	7.9±4.1	8.3±6.4	8.1±5.3	
Median (min.; max.)	8 (0. 16)	5 (0. 30)	7 (0. 30)	

Student's t-test; * Mann-Whitney test; ** Fisher's exact test.

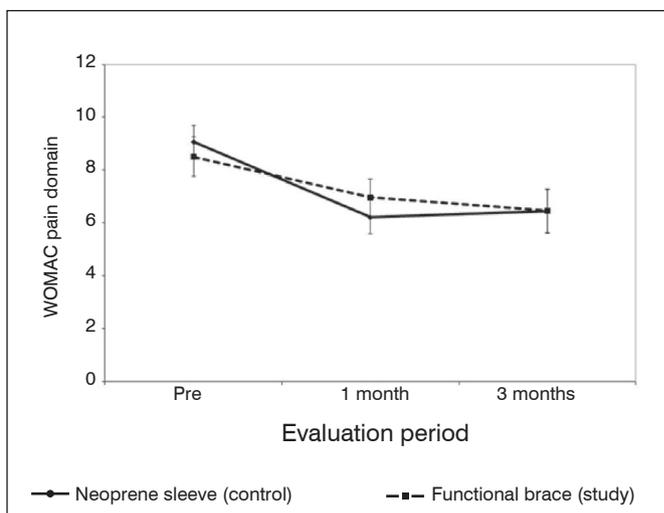


Figure 2. Mean values and respective standard errors of WOMAC pain domain by groups.

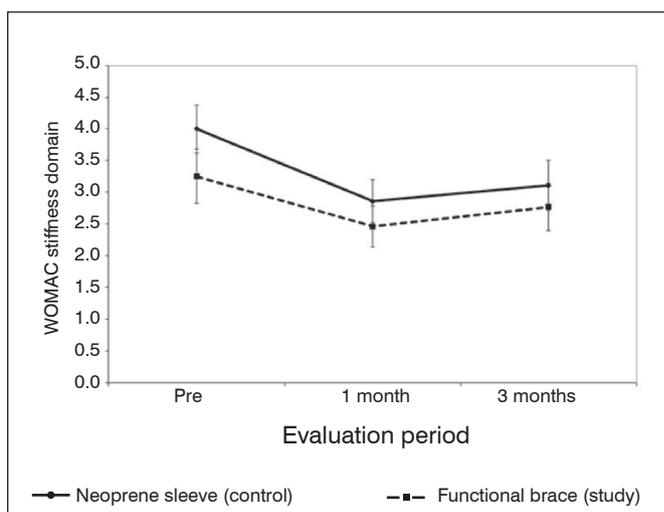


Figure 3. Mean values and respective standard errors of WOMAC stiffness domain by groups.

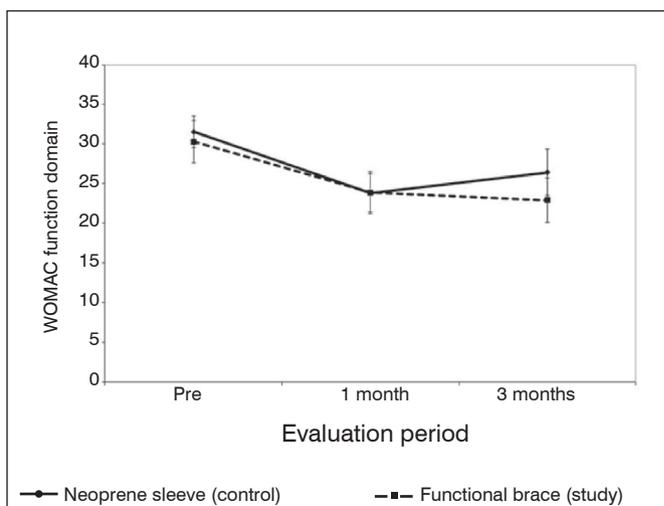


Figure 4. Mean values and respective standard errors of WOMAC function domain by groups.

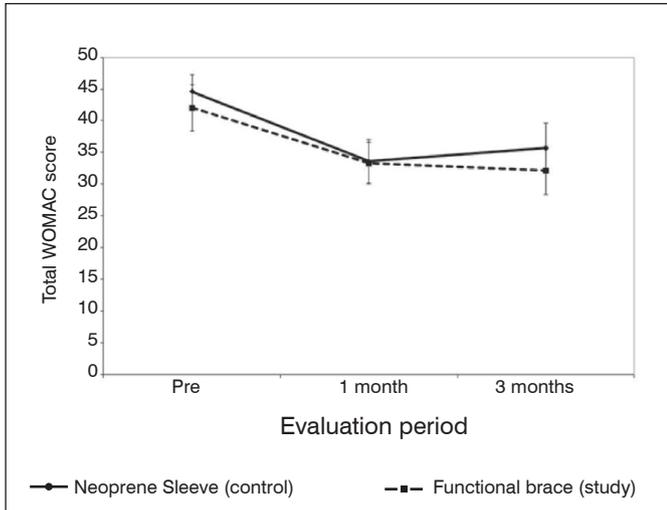


Figure 5. Mean values and respective standard errors of total WOMAC score by groups.

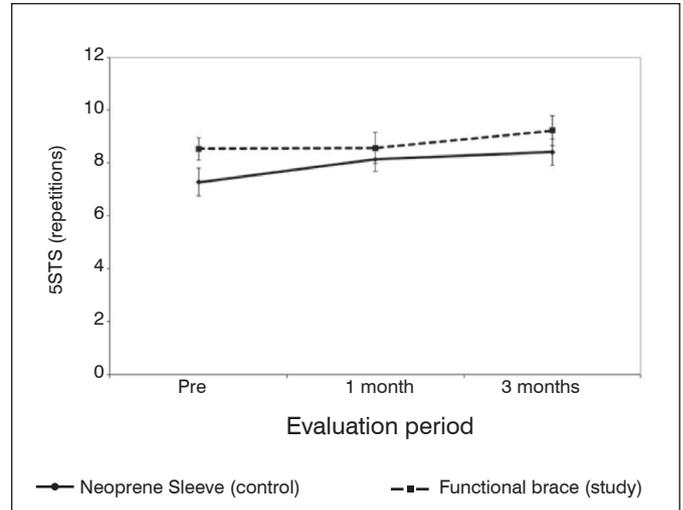


Figure 8. Mean values and respective standard errors of 5STS by groups.

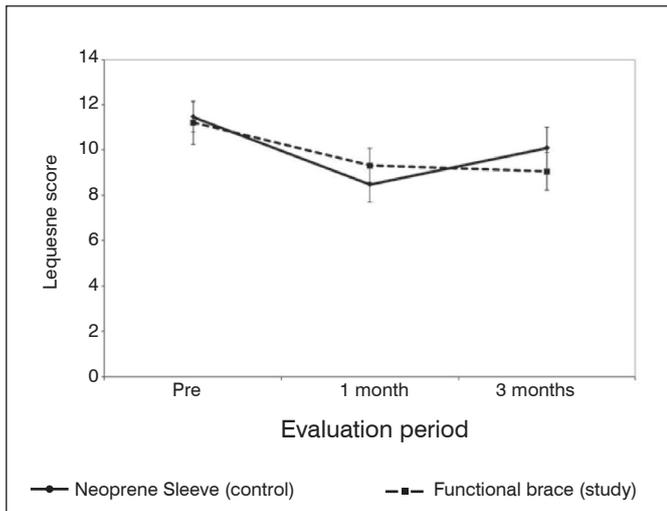


Figure 6. Mean values and respective standard errors of Lequesne scores by groups.

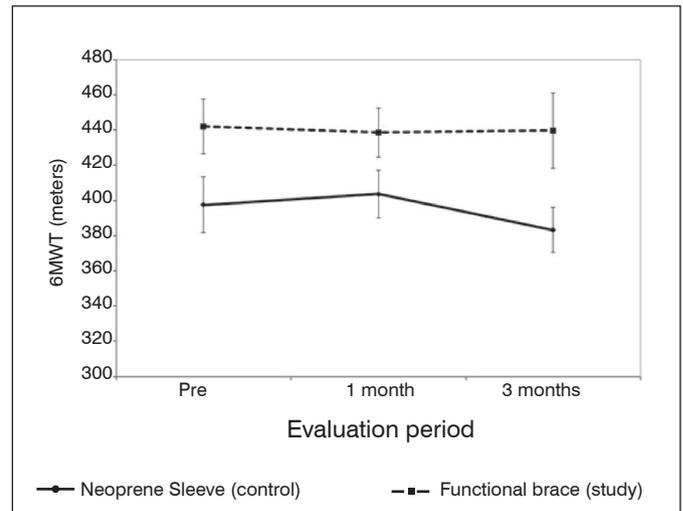


Figure 9. Mean values and respective standard errors of 6MWT by groups.

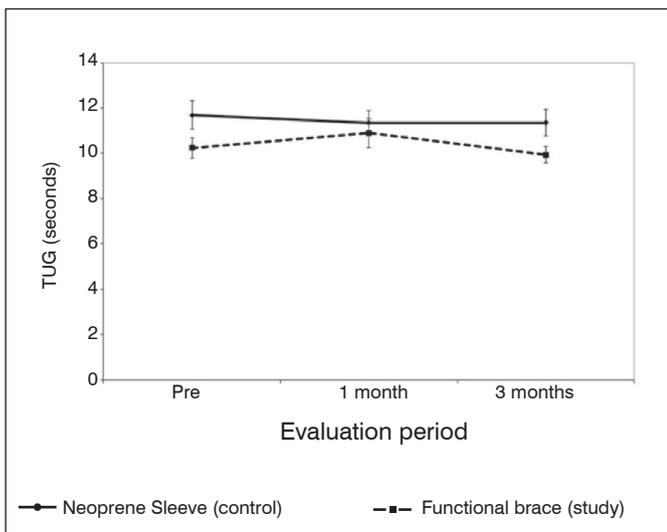


Figure 7. Mean values and respective standard errors of TUG by groups.

group ($p=0.011$) (Table 5). The use of dipyron decreased in the first month and increased in the third month in the study group ($p=0.002$ and $p=0.001$ respectively), and in the first month, the control group used, on average, more dipyron than the study group ($p=0.001$, Tables 4 and 5). The use of paracetamol and codeine increased on average in the third month, regardless of the group ($p<0.05$). Both groups used codeine, but some patients in the control group used tramadol instead of codeine (the study group did not use tramadol). The use of tramadol (only in the control group) decreased in the first month compared to that at pre ($p=0.047$) and increased in the third month, differing from pre and first month ($p=0.002$ and $p<0.001$, respectively). The variation in the use of codeine and tramadol was similar over time and between groups. The use of cyclobenzaprine was lower at the first month than at other periods, regardless of the group ($p<0.05$). The use of omeprazole or ranitidine increased in the third month in the control group ($p<0.05$) and decreased from pre to the first month in the study group ($p = 0.001$), following naproxen use (Tables 4 and 5).

Table 2. BMI, WOMAC domains, and total WOMAC score, and function tests according to groups and evaluation periods and results of comparative tests.

Variable	Group						P _{Group}	P _{Period}	P _{Interaction}
	Neoprene sleeve (control)			Functional brace (study)					
	Pre	1 month	3 months	Pre	1 month	3 months			
BMI							0.329	0.427	0.270
Mean SD	29.5±3.2	29.4±2.8	29.2±2.7	28.5±3.8	28.3±3.7	28.3±4.3			
Median (min.. max.)	30 (20.7. 35.4)	30 (23.4. 34.7)	29 (23.6. 34.2)	29.1 (20.3. 35.2)	28.7 (20.2. 34.5)	27.6 (19.5. 36.2)			
WOMAC pain domain							0.935	<0.001	0.272
Mean SD	9.1±3.3	6.2±3.5	6.4±4.4	8.5±4	7±3.7	6.5±4.2			
Median (min.. max.)	10 (3. 13)	6 (0. 15)	7 (0. 20)	7.5 (2. 20)	7 (1. 14)	6 (1. 14)			
WOMAC stiffness domain							0.223	0.001	0.769
Mean SD	4±2	2.9±1.8	3.1±2.1	3.3±2.3	2.5±1.7	2.8±1.9			
Median (min.. max.)	4 (0. 8)	3 (0. 6)	3 (0. 7)	4 (0. 8)	3 (0. 5)	3 (0. 7)			
WOMAC function domain							0.575	<0.001	0.364
Mean SD	31.6±10.7	23.8±14.4	26.4±15.5	30.3±14.3	23.9±12.8	22.9±14.2			
Median (min.. max.)	34 (8. 49)	25 (0. 52)	26.5 (0. 67)	30.5 (2. 68)	22.5 (2. 54)	20.5 (0. 49)			
Total WOMAC score							0.581	<0.001	0.540
Mean SD	44.6±14.1	33.6±18.3	35.7±20.9	42±19.5	33.3±17.3	32.2±19.4			
Median (min.. max.)	48 (13. 69)	38 (0. 68)	36 (0. 94)	41.5 (4. 96)	33.5 (3. 73)	28.5 (1. 68)			
Lequesne score							0.891	<0.001	0.106
Mean SD	11.5±3.6	8.5±4.2	10.1±4.9	11.2±5	9.3±4	9.1±4.3			
Median (min.. max.)	12.5 (3.5. 17.5)	10 (1. 15.5)	10.5 (0. 22.5)	11.3 (0. 21)	9.3 (1. 16)	10 (0. 16.5)			
TUG (seconds)							0.163	0.504	0.146
Mean SD	11.7±3.4	11.4±2.9	11.4±3.1	10.2±2.4	10.9±3.4	9.9±1.8			
Median (min.. max.)	10.5 (7.8. 20.8)	10.7 (6.8. 19.6)	10.6 (7.8. 19.9)	9.8 (6.5. 16.6)	10.5 (6.6. 24.9)	9.9 (6.7. 13.3)			
FTSTS (repetitions)							0.202	0.164	0.359
Mean SD	7.3±2.8	8.1±2.5	8.4±2.6	8.5±2.3	8.6±3.2	9.2±2.9			
Median (min.. max.)	8 (0. 13)	8 (2. 12)	9 (0. 13)	8 (4. 15)	8.5 (0. 16)	9.5 (5. 17)			
6MWT (meters)							0.026	0.599	0.333
Mean SD	397.4±84.9	403.7±72.6	383.3±68.5	442.1±81.3	438.6±71.7	439.7±108.9			
Median (min.. max.)	419 (223. 517)	415 (224. 486)	398.5 (210. 480)	439 (250. 633)	450 (295. 676)	439 (233. 700)			
Use of knee brace (hours)							0.208	<0.001	0.900
Mean SD		127.2±107.2	270±240.7		191.5±145.6	325±292.2			
Median (min.. max.)		115 (0. 351.5)	257 (0. 828)		147 (0. 429)	259 (6. 924)			

EEG with normal distribution and identity link function

Table 3. Results of comparisons between WOMAC domains and total WOMAC score, Lequesne score, and use of knee brace between the evaluation periods and the 6MWT score between the groups.

Variable	Comparison		Mean difference	Standard error	gf	P-value	CI (95%)	
							Lower	Upper
	Pain	Pre and	1 month	2.20	0.44	1	<0.001	1.15
Pre and		3 months	2.28	0.57	1	<0.001	0.93	3.64
1 month and		3 months	0.08	0.45	1	>0.999	-0.99	1.16
Stiffness	Pre and	1 month	0.96	0.26	1	0.001	0.34	1.58
	Pre and	3 months	0.68	0.32	1	0.107	-0.09	1.45
	1 month and	3 months	-0.29	0.26	1	0.834	-0.92	0.35
Function	Pre and	1 month	7.08	1.43	1	<0.001	3.66	10.49
	Pre and	3 months	6.09	1.88	1	0.004	1.59	10.60
	1 month and	3 months	-0.98	1.46	1	>0.999	-4.48	2.51
Total WOMAC score	Pre and	1 month	9.88	1.84	1	<0.001	5.47	14.28
	Pre and	3 months	9.19	2.44	1	0.001	3.34	15.03
	1 month and	3 months	-0.69	1.88	1	>0.999	-5.20	3.82
Lequesne score	Pre and	1 month	2.44	0.46	1	<0.001	1.33	3.55
	Pre and	3 months	1.71	0.61	1	0.015	0.25	3.17
	1 month and	3 months	-0.73	0.48	1	0.379	-1.86	0.41
6MWT (meters)	Control and	Study	-43.17	19.41	1	0.026	-81.22	-5.12
Use of knee brace (hours)	1 month and	3 months	-137.03	27.53	1	<0.001	-190.99	-83.07

Bonferroni's multiple comparisons

Table 4. Use of drugs according to groups and evaluation periods and results of comparative tests.

Variable	Group						p _{Group}	p _{Period}	p _{Interaction}
	Neoprene sleeve (control)			Functional brace (study)					
	Pre	1 month	3 months	Pre	1 month	3 months			
Naproxen							0.004	<0.001	<0.001
Mean SD	0.8±2.3	2.1±8.7	7.5±28.9	1.7±5	1.1±4.3	2.2±7			
Median (min.. max.)	0 (0. 9)	0 (0. 46)	0 (0. 154)	0 (0. 21)	0 (0. 19)	0 (0. 31)			
Dipyrone							0.073	0.018	0.002
Mean SD	5.7±14.7	8.6±20.8	10.3±22	7.4±23.4	1.7±6.8	8.5±20.9			
Median (min.. max.)	0 (0. 73)	0 (0. 86)	0 (0. 84)	0 (0. 122)	0 (0. 35)	0 (0. 78)			
Paracetamol							0.946	<0.001	0.225
Mean SD	12±22.1	10.9±21.2	25.2±47.5	10.4±21.6	13.4±23.9	23.7±59			
Median (min.. max.)	1 (0. 93)	0 (0. 78)	1 (0. 195)	0 (0. 102)	0 (0. 80)	0 (0. 276)			
Codeïne							0.152	<0.001	0.695
Mean SD	7.3±18.7	6.2±15.2	18.6±41.7	9.8±21.6	9.8±20.7	25.8±46.7			
Median (min.. max.)	0 (0. 81)	0 (0. 57)	0 (0. 172)	0 (0. 102)	0 (0. 76)	1.5 (0. 189)			
Tramadol							#	<0.001	#
Mean SD	1.4±7.2	0.7±2.5	3.6±9.6	0±0	0±0	0±0			
Median (min.. max.)	0 (0. 38)	0 (0. 13)	0 (0. 36)	0 (0. 0)	0 (0. 0)	0 (0. 0)			
Cyclobenzaprine							0.102	<0.001	0.577
Mean SD	4.5±13	2.1±6.8	6.8±16.6	7.6±18.1	4.6±12.7	7.3±19.6			
Median (min.. max.)	0 (0. 61)	0 (0. 26)	0 (0. 63)	0 (0. 61)	0 (0. 54)	0 (0. 77)			
Omeprazole or ranitidine							0.275	<0.001	<0.001
Mean SD	6.4±14	9.7±16.8	17±26.3	12.9±33.6	4.8±20.4	7.5±17.6			
Median (min.. max.)	0 (0. 61)	0 (0. 52)	0 (0. 82)	0 (0. 147)	0 (0. 105)	0 (0. 68)			
Cortisone							#	0.133	#
Mean SD	0±0	0.1±0.4	0.3±1.2	0.1±0.8	0±0	0±0			
Median (min.. max.)	0 (0. 0)	0 (0. 2)	0 (0. 5)	0 (0. 4)	0 (0. 0)	0 (0. 0)			

EEG with negative binomial distribution and identity link function. #, unable to calculate

Table 5. Results of the multiple comparisons of the drugs that showed differences between groups or periods.

Variable	Group/period	Comparison		Mean difference	Standard error	gf	p	CI (95%)	
								Lower	Upper
Naproxen	Control	Pre and	1 month	-1.28	0.49	1	0.131	-2.70	0.15
		Pre and	3 months	-6.66	1.49	1	<0.001	-11.03	-2.28
		1 month and	3 months	-5.38	1.47	1	0.004	-9.68	-1.08
	Study	Pre and	1 month	0.57	0.46	1	>0.999	-0.77	1.91
		Pre and	3 months	-0.50	0.64	1	>0.999	-2.37	1.37
		1 month and	3 months	-1.07	0.53	1	0.674	-2.64	0.50
	Pre	Control and	Study	-0.89	0.47	1	0.866	-2.26	0.48
	1 month	Control and	Study	0.96	0.56	1	>0.999	-0.68	2.60
3 months	Control and	Study	5.27	1.56	1	0.011	0.68	9.86	
Dipyrone	Control	Pre and	1 month	-2.96	1.95	1	>0.999	-8.69	2.76
		Pre and	3 months	-4.69	2.31	1	0.638	-11.47	2.10
		1 month and	3 months	-1.72	2.49	1	>0.999	-9.04	5.59
	Study	Pre and	1 month	5.71	1.51	1	0.002	1.29	10.14
		Pre and	3 months	-1.11	2.26	1	>0.999	-7.73	5.51
		1 month and	3 months	-6.82	1.71	1	0.001	-11.85	-1.80
	Pre	Control and	Study	-1.77	1.89	1	>0.999	-7.33	3.78
	1 month	Control and	Study	6.91	1.74	1	0.001	1.80	12.01
3 months	Control and	Study	1.81	2.64	1	>0.999	-5.93	9.55	
Paracetamol	Both groups	Pre and	1 month	-0.93	1.39	1	>0.999	-4.26	2.40
		Pre and	3 months	-13.25	3.02	1	<0.001	-20.47	-6.02
		1 month and	3 months	-12.32	2.58	1	<0.001	-18.50	-6.13
Codeïne	Both groups	Pre and	1 month	0.60	1.02	1	>0.999	-1.84	3.04
		Pre and	3 months	-13.60	2.80	1	<0.001	-20.30	-6.91
		1 month and	3 months	-14.21	2.49	1	<0.001	-20.17	-8.25
Tramadol	Both groups	Pre and	1 month	0.36	0.15	1	0.047	0.00	0.72
		Pre and	3 months	-1.13	0.33	1	0.002	-1.91	-0.35
		1 month and	3 months	-1.49	0.29	1	<0.001	-2.18	-0.80
Cyclobenzaprine	Both groups	Pre and	1 month	2.44	0.88	1	0.017	0.33	4.56
		Pre and	3 months	-1.03	1.27	1	>0.999	-4.06	2.00
		1 month and	3 months	-3.47	0.97	1	0.001	-5.80	-1.14
Omeprazole or ranitidine	Control	Pre and	1 month	-3.28	1.34	1	0.215	-7.20	0.65
		Pre and	3 months	-10.55	2.83	1	0.003	-18.85	-2.25
		1 month and	3 months	-7.28	2.33	1	0.027	-14.11	-0.44
	Study	Pre and	1 month	8.11	1.96	1	0.001	2.35	13.86
		Pre and	3 months	5.43	2.21	1	0.210	-1.06	11.91
		1 month and	3 months	-2.68	1.07	1	0.184	-5.82	0.46
	Pre	Control and	Study	-6.51	2.84	1	0.328	-14.85	1.82
	1 month	Control and	Study	4.87	2.14	1	0.342	-1.41	11.15
3 months	Control and	Study	9.47	3.58	1	0.122	-1.03	19.96	

Bonferroni's multiple comparisons

DISCUSSION

Patellofemoral OA is a common condition; however, there is little consensus about nonsurgical approaches to its treatment.^{6,16,17} In our study, there was no significant improvement of one group over the other. Previous studies on the efficacy of treatment with patellofemoral braces have reported varied results.^{6,16,18} However, the use of brace is still a common conservative treatment option as it is a noninvasive and low-cost intervention that is widely available, and therefore, it is in the public interest to evaluate its reliability and therapeutic limitations. Since patellar alignment is an important factor in the progression and development of the symptoms of PFOA, a treatment approach that addresses patellar alignment would be logical and of theoretical benefit.^{3,4} Although patellar malalignment has been positively associated with progression of PFOA OA,^{4,18} poor alignment alone may be insufficient to cause pain,^{19,20} and correction of poor alignment does not necessarily reduce the symptoms.^{19,20} The current understanding of the etiology of pain resulting from patellar malalignment is incomplete.^{19,20}

In this study, both groups showed improvement during treatment targeting pain and function, which shows the importance of targeted nonsurgical intervention, such as exercise, education, and the use of knee brace. In the 3-month assessment, although pain was reported to be lower, there was an increase in the use of drugs in both groups. Specifically, the control group showed progressively increased use of naproxen, and consequently the use of gastric protectors, while reporting lesser pain, better function, and using knee braces for a relatively shorter time than the study group. This may indicate a relative superiority of the functional knee brace, with patients using it for more hours and using fewer drugs. Despite

the information provided on diet and daily exercises necessary to complement the treatment, the program was not supervised regarding these variables of clinical treatment. Thus, adherence to the unsupervised program is unknown. Considering that OA is a chronic disease, our results indicate the need for studies with an extended duration of supervised treatment or additional means to ensure adherence to an unsupervised program.

Another limitation of our study is the lack of measurement of improvement in patellar positioning and patellar tilt to assess whether there is real improvement in patellar alignment with the use of knee brace, especially during movement.

CONCLUSION

Both knee braces improved pain and function and altered the use of drugs only in the first month. The functional knee brace provided analgesia without the increased use of naproxen.

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BONE MINERAL DENSITY AND BODY COMPOSITION IN ELDERLY RUNNERS: SIX-YEAR FOLLOW-UP

DENSIDADE MINERAL ÓSSEA E COMPOSIÇÃO CORPORAL DE IDOSOS CORREDORES: FOLLOW-UP DE SEIS ANOS

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ABSTRACT

Objective: To evaluate bone mineral density (BMD) and body composition over a six-year period in elderly long-distance runners. **Methods:** We analyzed the medical records of elderly athletes who were long-distance runners, were participants of the IOT-HCFMUSP Orthogeriatric Group, and had their BMD evaluated between 2001 and 2007; of these athletes, 11 were included in the study. **Inclusion criteria:** athletes should be long-distance runners, should not stop long-distance running during the six-year period, and should have undergone BMD and body composition evaluations. **Body composition** was evaluated using bone densitometry with dual-energy X-ray absorptiometry with a Lunar-DPX device. **Results:** Over the six-year period, body composition remained stable, but there was a significant increase only in the fat percentage ($p = 0.003$). **Conclusion:** Long-distance running may maintain BMD but may lead to an increase in the fat percentage in elderly runners. **Level of Evidence II; Prognostic Study - Investigating the Effect of Patient Characteristics on Disease Outcome.**

Keywords: Bone mineral density. Body composition. Running. Elderly.

RESUMO

Objetivo: Acompanhar a densidade mineral óssea (DMO) e a composição corporal, ao longo de seis anos, em idosos corredores de longa distância. **Métodos:** analisamos os prontuários médicos de um grupo de atletas idosos, corredores de longa distância, participantes do Grupo de Ortopedia do IOT-HC-FMUSP, e reunimos todos os atletas que tiveram a DMO avaliada no ano de 2001 e de 2007, sendo destes, 11 prontuários selecionados. **Critérios de inclusão:** ser corredor de longa distância; não parar de correr ao longo dos seis anos e ter os dois exames de DMO e composição corporal avaliados. **A composição corporal** foi avaliada por meio de densitometria óssea, com uma dupla energia de absorção de raios-X (DEXA), em um aparelho LUNAR-DPX. **Resultados:** Ao longo dos seis anos, a composição corpórea se manteve estável, havendo apenas um aumento significativo na gordura expressa em (%) ($p=0,003$). **Conclusão:** A corrida de longa distância parece conservar a DMO de idosos corredores, porém com aumento de gordura. **Nível de Evidência II; Estudos prognósticos - Investigação do efeito de características de um paciente sobre o desfecho da doença.**

Descritores: Densidade mineral óssea. Composição corporal. Corrida. Idosos.

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INTRODUCTION

Bone mass accumulation starts right from the fetal period and steadily increases through to pregnancy. Bone mineral density (BMD) is the result of a dynamic process for the formation and reabsorption of bone tissue, known as remodeling, which takes place throughout life in cycles, each four to six months in length. BMD maintenance is very important for the prevention of osteoporosis, which, together with other factors associated with age, could lead to a higher occurrence of fractures. Although bone loss is more

evident and more intense in women, men also show some decrease in bone mass with age.^{1,2}

Among the different courses of treatment, physical exercise is still considered the most efficient of the nonpharmacological strategies for the maintenance or increase of BMD. Bone tissue is positively affected by exercises promoting adaptations through stimuli, mainly mechanical, which contribute to bone formation. Therefore, exercise regimes including resistance and impact training are considered as the main nonpharmacological strategies for bone formation and maintenance.³

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

The study was conducted at the Universidade de São Paulo, Faculdade de Medicina, Hospital das Clínicas (HCFMUSP), Department of Orthopedics and Traumatology, Laboratory of Movement Studies, São Paulo, in association with Universidade São Judas Tadeu, Department of Postgraduate Studies in Ageing Sciences, São Paulo, Brazil. Correspondence: Angelica Castilho Alonso, Rua Ovídio Pires de Campos, 333, Cerqueira César, São Paulo, SP 01246-000, Brazil. angelicacastilho@msn.com



As BMD is a measure of bone mineral status, it can also be influenced by various factors such as body composition,³ genetics, hormonal state, exposure to sunlight, eating habits, and lifestyle. BMD is also closely associated with sport practice, which plays an important role in the development and maintenance of lean and bone mass.^{4,5}

In adult athletes, there is evidence that BMD is associated with sport practice during teenage years, and long-term training could lead to an increase in BMD.⁶

The effects of sport practice on BMD vary depending on the sport practiced and the intensity of the impact.⁷ Activities with body overload have the ability to boost the increment in bone mass, as the skeleton self-organizes itself according to the load coming from the specific sport. The involvement of different segments of the body also helps to increase BMD values.⁷

Therefore, the purpose of this study was to evaluate BMD and body composition over a six-year period in elderly long-distance runners.

MATERIALS AND METHODS

This was a cohort study conducted over a six-year period and was developed by the Orthogeriatric Group at IOT-HCFMUSP (CAPESq no. 1167/06) in association with Universidade São Judas Tadeu.

Sample

We analyzed the medical records of elderly athletes who were long-distance runners, were participants of the Orthogeriatric Group of IOT-HCFMUSP, and had undergone BMD evaluation between 2001 and 2007; of these athletes, 11 were selected. The inclusion criteria were that the participants should be long-distance runners, should not stop long-distance running during the six-year period, and should have undergone BMD and body composition evaluations performed by the same physician by using the same machine in the Radiology Department of the IOT.

Evaluation of BMD and Body Composition

Body composition was evaluated using bone densitometry with dual-energy X-ray absorptiometry with a LUNAR-DPX device (Madison Corporation, USA) by trained professionals.

Statistical Analysis

Data were analyzed using SPSS 20 software and presented using means and standard deviations. The Shapiro-Wilk test was used to determine whether the continuous quantitative variables were normally distributed. The paired *t*-test was used to compare dependent samples. Statistical significance was set at 5%.

RESULTS

Over the six-year study period, the subjects maintained the same volume of training, and there was a significant difference only in their age and years of experience (Table 1).

Moreover, BMD was maintained in the subjects (Figure 1 and Table 2), and no statistically significant differences were observed in BMD.

Table 1. Age, running experience, and training volume of elderly long-distance runners over a six-year follow-up period.

	2001	2007	p
Age (years)	65.5(5.2)	71.5(4.9)	≤0.001*
Frequency/week (days)	4.2(0.9)	4.0(0.7)	0.465
km/day	9.9(1.2)	9.3(1.6)	0.258
km/week	43.3(14.1)	38.0(11.3)	0.322
Experience (years)	17.1(4.3)	23.1(4.0)	≤0.001*

Paired *t*-test. *p* ≤ 0.05*. km - kilometers.

In addition, body composition remained constant, but there was a significant increase in only the fat percentage in the subjects (Table 2). In 2001, there was no correlation between the number of training sessions per week and BMD; however, in 2007, there was a significantly positive correlation between the two variables, suggesting that BMD increased when the weekly training load increased. (Figure 2)

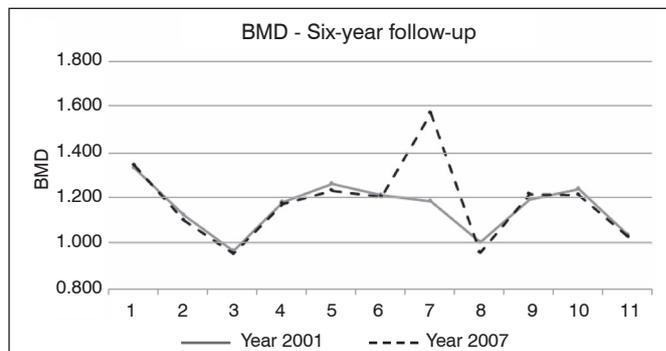


Figure 1. A six-year follow-up of bone mineral density (BMD) levels in elderly long-distance runners.

Table 2. Bone mineral density and body composition in elderly long-distance runners over a six-year follow-up period.

	2001	2007	p
BMD	1.15(0.1)	1.18(0.1)	0.536
Fat (%)	16.7(5.7)	19.0(4.5)	0.003*
Tissue (g)	60762.9(5087.7)	56317.7(16729.3)	0.390
Fat (g)	10255.1(4017.0)	10684.2(4357.6)	0.756
Lean (g)	50507.8(4268.9)	45633.5(13637.2)	0.209
BMC (g)	2709.0(408.9)	2462.1(748.6)	0.206
Total Calcium	1029.0(155.3)	934.9(284.5)	0.204

Paired *t*-test. *p* ≤ 0.05*. BMD - bone mineral density; g - grams; BMC - bone mineral content.

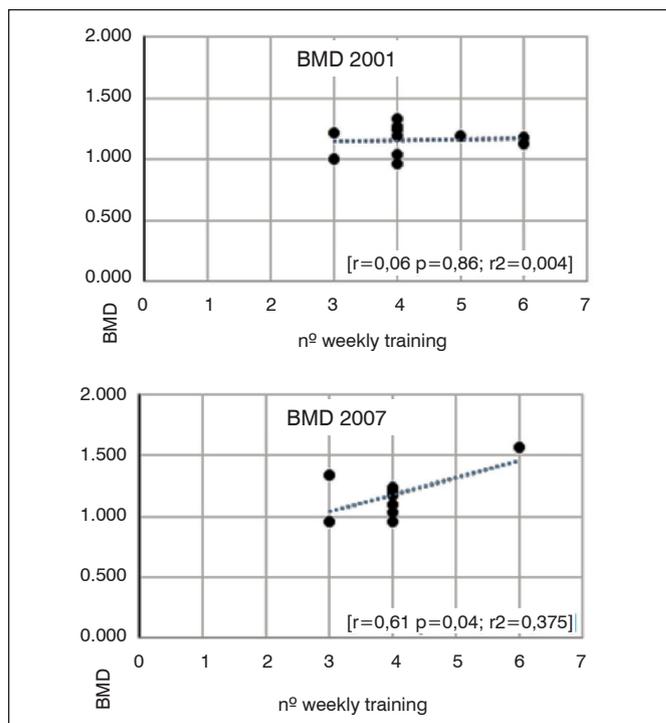


Figure 2. Correlation between bone mineral density (BMD) and the number of weekly training sessions between 2001 and 2007 in elderly long-distance runners.

DISCUSSION

The main finding in the present study was that in elderly long-distance runners, BMD and body composition were maintained, but the fat percentage increased over a six-year period. This suggests that long-distance running seems to have a positive effect on the maintenance of these variables, and it is necessary to increase the stimulus in order to increase BMD.

BMD is reported to decrease with age,³ but in the present study, BMD remained stable, showing just a slight nonsignificant increase over a six-year period. Moreover, none of the athletes showed any signs of osteopenia or osteoporosis in a study by Nowak et al.,⁸ comparing male long-distance runners and male nonathletes. Further, sport practice induced beneficial effects and helped maintain BMD.⁹

Bone mass may be maintained and its decrease may be prevented in athletes who participate in endurance activities such as middle-distance and long-distance running and undergo training for long periods,¹⁰ because the distribution of plantar pressure occurs through a "mata-borrão" movement, in which the body weight of the athlete travels across the entire foot, from the heel to the tips of the toes.¹¹ It should be considered that athletes and people who engage in physical exercise have better bone mass than those who do not engage in physical exercise; this is owing to the mechanical overload on the bone, inducing the formation of osteoblasts, piezoelectric effect, and the same mechanism of traction of the muscles on the bone.³ However, studies have shown that after a certain BMD peak is reached, there is no further improvement in bone mineralization unless there is an increase and modification of the stimulus.¹² Indeed, results of the present study show that only an increase in the stimulus

leads to an improvement of BMD. In contrast, cessation of training leads to worsening of the quantity and quality of bone tissue.¹³ With regard to body composition, we observed an increase in the fat percentage, which is in line with the findings reported by Alonso et al.,¹⁴ who affirmed that body composition changes significantly in elderly individuals, including the increase and redistribution of adipose tissue. This distribution increases progressively within the abdominal cavity and is less pronounced in the limbs.

In the present study, despite the significant increase in the fat percentage over the six-year period, the athletes had low body weight, characteristic of long-distance runners, and the fat percentage was a borderline value of the normal range. In a study performed by Prouteau et al.,¹⁵ low body weight and weight loss were associated with a low BMD level, caused by a decrease in the mechanical load on the skeleton;^{16,17} compared to men with a sedentary lifestyle, runners and cyclists were reported to have a fairly low body weight and inconsistent BMD levels.¹⁸

In the present study, we evaluated the subjects from a gerontological perspective over a six-year period. These elderly athletes may have a reduced risk of osteopenia and osteoporosis because of their healthy lifestyle.^{19,20}

The main contribution of this study is related to understanding the applicability of exercises to BMD. Long-distance running is a good activity for maintaining bone mass; however, it is necessary to increase the stimulus in order to improve BMD.

CONCLUSION

Long-distance running may maintain BMD but may lead to an increase in the fat percentage in elderly runners.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this study. ACA (0000-0002-9644-5068)* was the lead author who analyzed the study data and prepared the manuscript; RCE (0000-0003-2272-5320)* assisted in preparing the manuscript; RAB (0000-0003-3530-3995)* assisted in preparing the manuscript; AML (0000-0002-5741-3418)* assisted in preparing the manuscript; PRSS (0000-0003-1223-5862)* assisted in preparing the manuscript and collecting data; JMDAG (0000-0003-1778-0448)* made the final corrections to the manuscript; LEGL (0000-0002-9738-5466)* was responsible for requesting, collecting, and analyzing the examination results and making the final corrections to the manuscript; RHMP (0000-0002-9896-0493)* prepared the references and was responsible for manuscript submission. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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PROFILE OF PATIENTS WITH OSTEOPOROTIC FRACTURES AND FACTORS THAT DECREASE PREVENTION

PERFIL DE PACIENTES COM FRATURAS OSTEOPORÓTICAS E FATORES QUE DIMINUEM ADERÊNCIA À PREVENÇÃO

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ABSTRACT

Objective: To evaluate the epidemiological profile of patients with osteoporotic fractures compared to patients with osteoarthritis (OA) and identify factors that diminish adherence to secondary prevention. **Methods:** A total of 108 patients with osteoporotic fractures (OF) were compared to 86 patients with OA. **Results:** Patients in the OF group were older ($p < 0.001$); had a lower body mass index ($p < 0.001$); were less literate ($p = 0.012$); were more frequently Caucasian ($p = 0.003$); were less frequently married ($p < 0.001$); experienced more falls, cognitive deficiency, previous fractures, old fracture, falls in the last year, and fall fractures; needed more help and took more medicine for osteoporosis ($p < 0.05$); and showed less pathology in the feet, muscle weakness, less vitamin D intake, and lower Katz & Lawton scores ($p < 0.001$). Factors that increased the chance of nonadherence included older age ($p = 0.020$), falls ($p = 0.035$), cognitive deficiency ($p = 0.044$), and presence of depression/apathy/confusion ($p < 0.001$). **Conclusion:** Patient age, ethnicity, marital status, previous falls, foot pathologies, muscle weakness, previous fractures, use of vitamin D, use of osteoporosis drugs, and lower Katz & Lawton scale score defined the OF group. Factors that increased the chance of nonadherence included older age, sedative use, cognitive disorders, and symptoms of depression/apathy/confusion. **Level of Evidence III, Case-control.**

Keywords: Osteoporotic Fractures. Osteoporosis. Epidemiology. Prevalence. Secondary Prevention.

RESUMO

Objetivo: Avaliar o perfil epidemiológico de pacientes com fraturas osteoporóticas, comparando com pacientes com osteoartrite (OA) e identificar fatores que diminuem a aderência à prevenção secundária. **Métodos:** 108 pacientes com FO foram comparados a 86 pacientes com OA. **Resultados:** Grupo FO era mais velho ($p < 0,001$), com menor IMC ($p < 0,001$), menos alfabetizado ($p = 0,012$), com maior frequência de brancos ($p = 0,003$), menor frequência de casados ($p < 0,001$). Apresentaram mais quedas, deficiência cognitiva, fraturas prévias, fratura antiga, queda no último ano, fraturas por queda. Necessitam de mais auxílio e tomam mais medicamento para osteoporose ($p < 0,05$); apresentaram menos patologia nos pés, fraqueza muscular. Tomam menos vitamina D e menor Katz & Lawton ($p < 0,001$). Tem aumento da chance de não aderência: maior idade ($p = 0,020$), sedativo ($p = 0,020$), quedas ($p = 0,035$), deficiência cognitiva ($p = 0,044$) e presença de depressão/apatia/confusão ($p < 0,001$). **Conclusão:** Idade do paciente, etnia, estado civil, quedas prévias, patologias nos pés, fraqueza muscular, fraturas prévias, uso de vitamina D, uso de medicamentos para osteoporose e a escala Katz & Lawton definem o grupo FO. Aumentam a chance de não aderência: maior idade, sedativos, distúrbios cognitivos e sintomas de depressão/apatia/confusão. **Nível de Evidência III, Estudo de caso controle.**

Descritores: Fraturas por osteoporose. Osteoporose. Epidemiologia. Prevalência.

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INTRODUCTION

Osteoporosis, the most common bone disease,¹ is characterized by a progressive decrease in bone mass that leads to a decrease in bone strength and higher risk of fractures¹ and considered a public health problem responsible for the expenditure of R\$ 290 million from 2008 to 2010 by the Brazilian Unified Health System.² As the Brazilian population ages, the incidence of osteoporotic fractures

(OF) is increasing. The number of proximal femoral fractures is estimated to increase from 80,640 in 2015 to 198,000 in 2040.³ In addition to the economic impact, OF have a great social cost since they are associated with an increased mortality rate, decreased independence,⁴ loss of self-esteem, depression, and distortion of body image.⁵ Although osteoporosis treatment has been available since the 1990s, up to 80% of eligible patients do not receive

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treatment.⁶ This treatment failure is associated with the disastrous socioeconomic consequences of OF, especially proximal femoral fractures. This led to the development of secondary prevention programs⁷ aiming at reducing the incidence of OF, especially proximal femoral fractures.

Although these programs are cost-effective⁸ and capable of reducing mortality rates,⁹ they have not been able to reduce the incidence of new proximal femoral fractures, which may be due to low treatment adherence.^{10,11}

Unfortunately, studies on the epidemiology of patients with OF in Brazil are scarce, which makes it difficult to implement a program to reduce the impacts of osteoporosis.

This study aimed to evaluate the epidemiological profile of the population affected by OF (proximal femoral fractures, proximal humeral fractures, distal radial fractures, and thoracolumbar spinal fractures) treated in an orthopedic tertiary care hospital over a 12-month period with or without a previous diagnosis of osteopenia or osteoporosis and compare this profile with that of patients with osteoarthritis (OA) treated in the same period and identify factors that may decrease the adherence rates of OF patients to a secondary prevention program.

OBJECTIVES

Primary objective

The primary objective of this study was to describe the epidemiological profile of patients with OF treated in a tertiary orthopedic care hospital and identify the possible factors associated with this fracture compared to patients with OA treated during the same period.

Secondary objective

The secondary objective of this study was to describe the characteristics associated with lower adherence rates to a secondary prevention program and the function of patients with OF.

MATERIALS AND METHODS

The Osteometabolic Diseases Group conducted this study upon receiving ethics committee approval (number 76629217.3/0000.0068). All patients signed an informed consent form after having their doubts clarified. The study included all patients admitted in the Orthopedic Institute for treatment of the OF in the period of twelve months and patients with knee OA (only those treated in the osteometabolic diseases group of a tertiary orthopedic care hospital).

Inclusion criteria: Study group (patients with OF): Patients > 45 years of age who had one or more of the following fractures: proximal femur, proximal humerus, distal radius, and thoracolumbar spine. Patients with high-energy fractures were not included.

Control group (patients with OA): Patients > 45 years of age with a clinical and radiographic diagnosis of knee OA isolated or not and with or without comorbidities.

Exclusion criteria: Patients < 45 years of age with suspected or confirmed pathological fractures; non-collaborative patients.

Interventions: The participants answered a questionnaire (Table 1) that was used to collect data such as demographic profile, fracture type, ethnicity, education level, personal history, previous fractures, physical activity level, mobility, place and time of the accident that caused the fracture, use of medications and behavioral measures to treat osteoporosis, and evaluation of functionality according to Katz and Lawton & Brody (12,13). Following the international protocol, all patients in the OF group were referred to a secondary prevention outpatient clinic.⁷

Statistical analysis

We describe the characteristics of the patients using absolute and relative frequencies by groups for qualitative variables and

verified the association using chi-square tests or Fisher's exact test. We calculated summary measurements (mean and standard deviation or median, minimum, and maximum) by groups for quantitative variables and compared the groups using Student's t-test or the Mann-Whitney U-test. In fractured patients, the characteristics were described according to adherence or loss of follow-up and the same tests were performed as previously described. The unadjusted odds ratio of each variable was used to estimate the chance of OF; in the fractured patients, the chance of loss of follow-up was determined with the respective intervals at a 95% confidence level. Multiple logistic regression models were estimated to explain the group of osteoporotic fractures; in the fractured patients, loss of follow-up, selecting the variables that were significant in the bivariate tests and using stepwise backward regression to select the variables with criteria for entry and exit of variables at 5% ($p < 0.05$). SPSS for Windows version 20.0 was used to perform the analyses and the data were entered in Microsoft Excel 2003. The tests were performed using a significance level of 5%.

RESULTS

The results of the questionnaires administered to 108 patients with OF and 86 patients with knee OA (or OA of multiple joints including the knee) are summarized in Table 1.

Table 1 shows that, in isolation, the patients with OF were older ($p < 0.001$) and had a lower mean weight and lower BMI ($p < 0.001$). The frequency of literacy was lower ($p = 0.012$), the frequency of Caucasian race was higher ($p = 0.003$), and the frequency of married individuals was lower ($p < 0.001$) in the OF group.

Patients with OF had more previous falls, cognitive impairment, previous fractures, old fracture (>1 year), fall in the last 12 months, fracture after a fall, needed more help, and took more medication for osteoporosis ($p < 0.05$). They had fewer foot pathologies, muscle weakness, took less vitamin D, and had lower Katz & Lawton's Activities of Daily Living (ADL) and Instrumental ADL (IADL) scores ($p < 0.001$). Table 2 shows that patient age, ethnicity, marital status, previous falls, foot pathologies, muscle weakness, previous fractures, use of vitamin D, use of medications for osteoporosis and Katz & Lawton's IADL explained the occurrence of OF in the patients regardless of the other evaluated characteristics ($p < 0.05$). For each 1-year increase in patient age, the chance of OF increased 8%; Caucasian patients were 6.58 times more likely to have OF than non-Caucasian patients; those who were widowed or single or had another marital status were more likely to have OF than married patients; patients with previous falls were 8.15 times more likely to have OF than those without previous falls; patients with previous fractures were 4.55 times more likely to have OF than those without previous fractures; and patients who used medications for osteoporosis were 27.39 times more likely to have OF than those who did not. The factors that decreased the chance of OF were: foot pathologies (decreased the chance of OF by 91%); muscle weakness (decreased the chance of OF by 92%); use of vitamin D (decreased the chance of OF by 90%); and level of independence on the Katz & Lawton scale (decreased the chance of OF by 38% for each unit increase in scale score).

Table 3 shows that, in isolation, fractured patients who were lost to follow-up more frequently were older ($p = 0.020$), used more sedatives ($p = 0.020$), had more falls ($p = 0.035$), or had cognitive impairment ($p = 0.044$) or depression/apathy/confusion ($p < 0.001$). Table 4 shows that, together, the chance of loss of follow-up increased 10% with each 1-year increase in patient age; the chance of follow-up loss in patients who used sedation was 8.69 times higher than that of patients who did not; and the chance of follow-up loss in patients who had depression/apathy/confusion was 8.50 times higher than that chance of patients who did not have these symptoms.

Table 1. Description of patient characteristics by group and results of the unadjusted analyses.

Variable	Group			OR	95% confidence interval		p
	Control (n = 86)	Osteoporosis (n = 108)	Total (N = 194)		Lower	Superior	
Gender (female), n (%)	68 (79.1)	78 (72.2)	146 (75.3)	0.69	0.35	1.34	0.272
Age (years), mean SD	65 ± 8.9	75.2 ± 11.1	70.7 ± 11.3	1.11	1.07	1.14	<0.001**
Weight (kg), mean SD	73.7 ± 14.2	66.9 ± 13.7	69.9 ± 14.3	0.97	0.95	0.99	<0.001**
Height (cm), mean SD	160.7 ± 7.3	160.7 ± 8.5	160.7 ± 8	1.00	0.96	1.04	0.971**
BMI (kg/m ²), mean SD	28.5 ± 5	26 ± 5.3	27.1 ± 5.3	0.91	0.86	0.96	<0.001**
Education (literate), n (%)	84 (97.7)	95 (88)	179 (92.3)	0.17	0.04	0.79	0.012
Education (school years), median (min.; max.)	8 (0; 30)	8 (0; 18)	8 (0; 30)	0.96	0.91	1.02	0.160£
Ethnicity (Caucasian), n (%)	60 (69.8)	94 (87)	154 (79.4)	2.91	1.41	6.01	0.003
Civil status, n (%)							<0.001
Married	52 (60.5)	34 (31.5)	86 (44.3)	1.00			
Widower	11 (12.8)	42 (38.9)	53 (27.3)	5.84	2.64	12.90	
Single	7 (8.1)	16 (14.8)	23 (11.9)	3.50	1.30	9.39	
Other	16 (18.6)	16 (14.8)	32 (16.5)	1.53	0.68	3.46	
Living with, median (min.; max.)	1 (0; 5)	1 (0; 6)	1 (0; 6)	0.97	0.77	1.23	0.454£
Father or mother with hip fx, n (%)	5 (5.8)	12 (11.1)	17 (8.8)	2.03	0.69	5.99	0.195
Current smoker, n (%)	9 (10.5)	18 (16.7)	27 (13.9)	1.71	0.73	4.03	0.215
Glucocorticoid, n (%)	4 (4.7)	8 (7.4)	12 (6.2)	1.64	0.48	5.64	0.429
Secondary osteoporosis, n (%)	8 (9.3)	6 (5.6)	14 (7.2)	0.57	0.19	1.72	0.316
Alcohol use >3 doses per day, n (%)	5 (5.8)	3 (2.8)	8 (4.1)	0.46	0.11	1.99	0.470*
Sedatives, n (%)	9 (10.5)	9 (8.3)	18 (9.3)	0.78	0.30	2.05	0.611
Previous falls, n (%)	16 (18.6)	56 (51.9)	72 (37.1)	4.71	2.43	9.13	<0.001
Cognitive impairment, n (%)	3 (3.5)	15 (13.9)	18 (9.3)	4.46	1.25	15.96	0.013
Visual impairment, n (%)	38 (44.2)	55 (50.9)	93 (47.9)	1.31	0.74	2.32	0.351
Lower limb impairment, n (%)	15 (17.4)	10 (9.3)	25 (12.9)	0.48	0.21	1.14	0.091
Foot pathologies, n (%)	25 (29.1)	8 (7.4)	33 (17)	0.20	0.08	0.46	<0.001
Change in balance, n (%)	25 (29.1)	33 (30.6)	58 (29.9)	1.07	0.58	2.00	0.822
Muscle weakness, n (%)	35 (40.7)	29 (26.9)	64 (33)	0.54	0.29	0.98	0.042
Altered gait, n (%)	24 (27.9)	29 (26.9)	53 (27.3)	0.95	0.50	1.79	0.870
Postural hypotension, n (%)	14 (16.3)	16 (14.8)	30 (15.5)	0.89	0.41	1.95	0.779
Dizziness, n (%)	20 (23.3)	24 (22.2)	44 (22.7)	0.94	0.48	1.85	0.864
Depression/apathy/confusion, n (%)	13 (15.1)	22 (20.4)	35 (18)	1.44	0.68	3.05	0.344
Diabetes, n (%)	27 (31.4)	35 (32.4)	62 (32)	1.05	0.57	1.93	0.881
SAH, n (%)	52 (60.5)	56 (51.9)	108 (55.7)	0.70	0.40	1.25	0.230
Hypothyroidism, n (%)	19 (22.1)	15 (13.9)	34 (17.5)	0.57	0.27	1.20	0.135
Previous fractures, n (%)	15 (17.4)	48 (44.4)	63 (32.5)	3.79	1.93	7.43	<0.001
Old fracture (>1 year), n (%)	15 (17.4)	50 (46.3)	65 (33.5)	4.08	2.08	8.00	<0.001
Physical activity before fracture, n (%)	30 (34.9)	25 (23.1)	55 (28.4)	0.56	0.30	1.06	0.072
Fear of falling, n (%)	52 (60.5)	67 (62)	119 (61.3)	1.07	0.60	1.91	0.823
Falls in the last 12 months, n (%)	18 (20.9)	58 (53.7)	76 (39.2)	4.38	2.31	8.33	<0.001
Fracture due to fall, n (%)	2 (2.3)	104 (96.3)	106 (54.6)	1092.0	195.2	6107.8	<0.001
Help, n (%)	7 (8.1)	62 (57.4)	69 (35.6)	15.21	6.43	36.02	<0.001
Previous diagnosis of osteoporosis, n (%)	27 (31.4)	35 (32.4)	62 (32)	1.05	0.57	1.93	0.881
Calcium use, n (%)	30 (34.9)	26 (24.1)	56 (28.9)	0.59	0.32	1.11	0.099
Sunbathe 3x week, n (%)	49 (57)	56 (51.9)	105 (54.1)	0.81	0.46	1.44	0.477
Vitamin D use, n (%)	53 (61.6)	32 (29.6)	85 (43.8)	0.26	0.14	0.48	<0.001
Osteoporosis drug use, n (%)	4 (4.7)	15 (13.9)	19 (9.8)	3.31	1.06	10.36	0.032
Katz & Lawton DLA, median (min.; max.)	6 (3; 6)	6 (0; 6)	6 (0; 6)	0.49	0.29	0.82	<0.001£
Katz & Lawton IADL, median (min.; max.)	8 (1; 8)	8 (0; 8)	8 (0; 8)	0.73	0.62	0.86	<0.001£

Chi-square test; *Fisher's exact test; **Student's t-test; £Mann-Whitney's U-test.

Table 2. Results of the joint model to explain the fracture group by osteoporosis according to evaluated characteristics.

Variable	OR	CI (95%)		p
		Lower	Superior	
Age (years)	1.08	1.03	1.13	0.002
Ethnicity (caucasian)	6.58	1.71	25.00	0.006
Civil status				
Married	1.00			
Widower	4.27	1.22	15.02	0.024
Single	31.35	5.35	183.61	<0.001
Other	6.41	1.50	27.38	0.012
Previous fall	8.15	2.21	30.07	0.002
Foot pathologies	0.09	0.02	0.42	0.002
Muscle weakness	0.08	0.02	0.32	<0.001
Previous fracture	4.55	1.45	14.24	0.009
Vitamin D use	0.10	0.03	0.31	<0.001
Osteoporosis drug use	27.39	3.00	249.99	0.003
Katz & Lawton IADL	0.62	0.47	0.82	0.001

Multiple logistic regression.

DISCUSSION

We found that patients with OF were older, weighed less, had a lower mean BMI, and were more likely to be Caucasian, findings that are in agreement with the results of other studies.^{14,15} However, no great influence of glucocorticoid consumption, alcohol consumption, or smoking was observed as described in the literature.¹⁴ We found a protective relationship against OF in married patients compared to those with other marital statuses (Table 1) as in our previous studies.¹⁵ Patients with osteoporosis had more previous falls, a greater number of falls in the last year associated with bone fragility, old fractures (>1 year), and more previous fractures. The OF group used more medication for the treatment of osteoporosis, needed more help, and had lower Katz & Lawton's ADL and IADL scores. The greater number of falls can be explained by higher age and eventual

Table 3. Description of the characteristics of the fractured patients according to loss of follow-up and result of the unadjusted analyzes.

Variable	Attendance			OR	CI (95%)		p
	Adhere (N = 87)	Loss of contact (N = 14)	Total (N = 101)		Lower	Superior	
Gender (female), n (%)	63 (72.4)	11 (78.6)	74 (73.3)	0.88	0.36	2.11	0.754
Age (years), mean SD	73.8 ± 11	81.2 ± 10.2	74.8 ± 11.2	1.02	0.98	1.06	0.020**
Weight (Kg), mean SD	67.7 ± 13.6	64.1 ± 11.5	67.2 ± 13.4	0.98	0.94	1.02	0.344**
Height (cm), mean SD	160.3 ± 8.5	161.5 ± 8.6	160.4 ± 8.5	1.02	0.95	1.09	0.611**
BMI (Kg/m ²), mean SD	26.5 ± 5.4	24.5 ± 3.5	26.2 ± 5.2	0.91	0.80	1.05	0.190**
Education (literate), n (%)	78 (89.7)	13 (92.9)	91 (90.1)	0.36	0.13	1.03	>0.999
Education (school years), median (min.;max.)	8 (0; 18)	8 (1; 15)	8 (0; 18)	1.01	0.90	1.13	0.653£
Ethnicity (Caucasian), n (%)	76 (87.4)	11 (78.6)	87 (86.1)	0.81	0.26	2.54	0.406
Civil status, n (%)							0.844#
Married	26 (29.9)	5 (35.7)	31 (30.7)	1.00			
Widower	34 (39.1)	6 (42.9)	40 (39.6)	0.70	0.26	1.88	
Single	14 (16.1)	2 (14.3)	16 (15.8)	1.69	0.58	4.95	
Orther	13 (14.9)	1 (7.1)	14 (13.9)	0.36	0.07	1.89	
Living with, median (min.; máx.)	1 (0; 6)	1 (0; 4)	1 (0; 6)	0.95	0.63	1.45	0.815£
Father ou mother with hi fx, n (%)	11 (12.6)	1 (7.1)	12 (11.9)	0.53	0.06	4.47	>0.999
Current somoker, n (%)	17 (19.5)	1 (7.1)	18 (17.8)	0.32	0.04	2.59	0.454
Glucocorticoid, n (%)	6 (6.9)	2 (14.3)	8 (7.9)	2.25	0.41	12.46	0.306
Secondary osteoporosis, n (%)	5 (5.7)	0 (0)	5 (5)	&			>0.999
Alcohol use > 3 doses per day, n (%)	3 (3.4)	0 (0)	3 (3)	&			>0.999
Sedatives, n (%)	5 (5.7)	4 (28.6)	9 (8.9)	6.56	1.51	28.52	0.020
Previous fall, n (%)	42 (48.3)	11 (78.6)	53 (52.5)	3.93	1.02	15.07	0.035§
Cognitive impairment, n (%)	7 (8)	4 (28.6)	11 (10.9)	4.57	1.14	18.41	0.044
Visual impairment, n (%)	46 (52.9)	6 (42.9)	52 (51.5)	0.67	0.21	2.09	0.486§
Lower limb impairment, n (%)	8 (9.2)	2 (14.3)	10 (9.9)	1.65	0.31	8.69	0.626
Foot pathologies, n (%)	6 (6.9)	2 (14.3)	8 (7.9)	2.25	0.41	12.46	0.306
Change in balance, n (%)	25 (28.7)	7 (50)	32 (31.7)	2.48	0.79	7.80	0.130
Muscle weakness, n (%)	20 (23)	6 (42.9)	26 (25.7)	2.51	0.78	8.10	0.184
Altered gait, n (%)	21 (24.1)	6 (42.9)	27 (26.7)	2.36	0.73	7.57	0.192
Postural hypotension, n (%)	12 (13.8)	2 (14.3)	14 (13.9)	1.04	0.21	5.24	>0.999
Dizziness, n (%)	17 (19.5)	5 (35.7)	22 (21.8)	2.29	0.68	7.71	0.179
Depression/apathy/confusion, n (%)	13 (14.9)	9 (64.3)	22 (21.8)	10.25	2.96	35.48	<0.001
Diabetes, n (%)	28 (32.2)	6 (42.9)	34 (33.7)	1.58	0.50	4.99	0.544
SAH, n (%)	45 (51.7)	9 (64.3)	54 (53.5)	1.68	0.52	5.42	0.382§
Hypothyroidism, n (%)	11 (12.6)	3 (21.4)	14 (13.9)	1.88	0.45	7.83	0.406
Previous fractures, n (%)	38 (43.7)	8 (57.1)	46 (45.5)	1.72	0.55	5.38	0.348§
Old fracture (> 1 year), n (%)	40 (46)	8 (57.1)	48 (47.5)	1.57	0.50	4.90	0.437§
Physical activity before fracture, n (%)	24 (27.6)	1 (7.1)	25 (24.8)	0.20	0.03	1.63	0.179
Fear of falling, n (%)	54 (62.1)	10 (71.4)	64 (63.4)	1.53	0.44	5.27	0.500§
Falls int he last 12 months, n (%)	46 (52.9)	8 (57.1)	54 (53.5)	1.19	0.38	3.71	0.766§
Fracture due to fall, n (%)	84 (96.6)	14 (100)	98 (97)	&			>0.999
Help, n (%)	49 (56.3)	9 (64.3)	58 (57.4)	1.40	0.43	4.51	0.576§
Previous diagnosis of osteoporosis, n (%)	29 (33.3)	4 (28.6)	33 (32.7)	0.80	0.23	2.77	>0.999
Calcium use, n (%)	22 (25.3)	3 (21.4)	25 (24.8)	0.81	0.21	3.16	>0.999
Sunbathe 3x week, n (%)	46 (52.9)	7 (50)	53 (52.5)	0.89	0.29	2.76	0.842§
Vitamin D use, n (%)	28 (32.2)	3 (21.4)	31 (30.7)	0.58	0.15	2.23	0.541
Osteoporosis drug use, n (%)	15 (17.2)	0 (0)	15 (14.9)	&			0.121
Katz & Lawton DLA, median (min.; máx.)	6 (0; 6)	6 (3; 6)	6 (0; 6)	0.91	0.59	1.40	0.224£
Katz & Lawton IADL, median (min.; máx.)	8 (0; 8)	5 (0; 8)	8 (0; 8)	0.86	0.70	1.06	0.245£

Chi-square test; *Fisher's exact test; **Student's t-test; £Mann-Whitney's U-test.

Tabla 4. Results of the joint model to explain follow-up loss of fracture patients according to evaluated characteristics.

Variável	OR	CI (95%)		p
		Lower	Superior	
Age (years)	1.10	1.02	1.19	0.012
Sedative use	8.69	1.36	55.45	0.022
Depression/apathy/confusion	8.50	2.19	33.09	0.002

Multiple logistic regression

sarcopenia,^{16,17} and possible sequelae of previous fractures due to pain and changes in alignment reducing the frequency of physical activity, which leads to decreased bone and muscle mass, which predisposes patients to further falls and fractures.¹⁸ Patients with OF had fewer foot pathologies and muscle weakness and took less vitamin D. We believe that this is a bias since the patients in the OA group are currently in outpatient follow-up associated with a holistic multiprofessional educational program for the treatment of OA,¹⁹ which enables these patients to recognize deformities, pathologies, and muscle weaknesses. Moreover, they are actively studied for

vitamin D deficiency. It is worth mentioning that muscle weakness was self-reported; we did not perform functional objective tests. Approximately 14% of patients with OF refused to participate in the secondary prevention program. The variables identified as risk factors for follow-up loss were age, use of sedatives, cognitive deficit, greater number of falls, and presence of depression/apathy/confusion. The greatest number of falls may be associated with the use of sedatives and cognitive disorder, although we cannot confirm this with our data. Using multiple logistic regression, we found that: the chance of follow-up loss increased 10% with each 1-year increase in patient age; the use of sedatives increased the chance of follow-up loss by 8.69 times; symptoms of depression/apathy/confusion increased the chance of follow-up loss by 8.5 times. To improve adherence to the secondary prevention program of this subgroup, patients and their families may need an intensive educational program²⁰ that has already reduced falls, increased the frequency of physical activity, improved adherence to drug treatment, and increased the overall quality of life in patients with osteoporosis.

CONCLUSION

Together, patient age, ethnicity, marital status, previous falls, foot pathologies, muscle weakness, previous fractures, use of vitamin D, use of osteoporosis drugs, and Katz & Lawton IADL scale score define patients with OF. The risk factors for non-adherence to the secondary prevention program are patient age, sedative use, cognitive disorder, and the presence of depression/apathy/confusion.

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COMPARISON OF RADIOFREQUENCY ABLATION AND CURETTAGE IN OSTEIOD OSTEOMA IN CHILDREN

COMPARAÇÃO ENTRE ABLAÇÃO POR RADIOFREQUÊNCIA E CURETAGEM DE OSTEOMA OSTEÓIDE EM CRIANÇAS

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ABSTRACT

Objective: Osteoid osteoma, which is observed in the adolescent and young adult population as benign bone tumors, appears as a single nidus with a diameter < 2 cm and is treated with open surgery. However, technological advances in medicine have made it possible to apply less invasive procedures in surgery. **Methods:** Between 2006–2014, 24 patients < 18 years of age were treated for osteoid osteoma. Patient demographic data, surgical data, complications, and recurrences were noted. **Results:** Twenty-four patients (mean age, 11 [2–18] years) were treated and followed up for a mean 3.58 (range, 1–9) years. Mean patient age in the curettage group was 12.1 (range, 3–18) years. Mean operation length was 69.5 (range, 60–120) minutes. Mean hospital stay was 1.3 (range, 0–2) days. Mean patient age in the radiofrequency ablation (RFA) group was 10.7 (range, 2–17) years. Five patients were female and 8 were male. Mean operation length was 49.6 (range, 20–90) minutes. Mean hospital stay was 0.3 (range, 0–1) days. Mean follow-up time was 1.76 (range, 1–4) years. Mean operation length, hospital stay, and follow-up were significantly shorter in the RFA group. **Conclusions:** Considering reduced costs due to shorter hospitalization periods and the ability to reach anatomically difficult locations, percutaneous procedures are likely to replace the conventional open approach. **Level of evidence: II, retrospective study.**

Keywords: Osteoid osteoma. Hospital stay. Complication.

RESUMO

Objetivo: O osteoma osteoide, tumor ósseo benigno, acomete predominantemente adolescentes e adultos jovens. É descrito como um nicho único menor que 2 centímetros e o tratamento, nas últimas décadas, era realizado por cirurgia aberta. Com os avanços tecnológicos na medicina, os procedimentos menos invasivos tornaram-se o tratamento de escolha. **Métodos:** Entre 2006 e 2014, 24 pacientes com menos de 18 anos foram submetidos ao tratamento de osteoma osteoide. Foram coletados os dados demográficos da população estudada e as informações sobre a cirurgia, complicações e recorrência. **Resultados:** Os vinte e quatro pacientes com média de idade de 11 anos (2-18) foram tratados e o acompanhamento teve média de 3,58 anos (1-9). A média de idade dos pacientes no Grupo curetagem foi de 12,1 anos (3-18). O tempo médio da cirurgia foi de 69,5 minutos (60-120). A média de permanência hospitalar foi de 1,3 dias (0-2). A média de idade dos pacientes no Grupo ARF foi de 10,7 anos (2-17) anos, sendo cinco do sexo feminino e oito do sexo masculino. O tempo médio de cirurgia foi de 49,6 minutos (20-90). A permanência hospitalar média foi de 0,3 dias (0-1). O tempo médio de acompanhamento foi de 1,76 anos (1-4). As médias de tempo cirúrgico, tempo de internação e acompanhamento foram significativamente menores no Grupo ARF. **Conclusões:** Quando a redução de custos promovida pelo menor tempo de hospitalização e a capacidade de atingir locais anatomicamente difíceis também forem considerados, os procedimentos percutâneos provavelmente substituirão a cirurgia aberta convencional. **Nível de evidência II; Estudo retrospectivo.**

Descritores: Osteoma Osteoide. Tempo de internação. Complicações.

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INTRODUCTION

Osteoid osteoma is the third most common bone tumour. It is generally observed in the long bones of the lower extremities, especially in the adolescent and young adult population. Histologically, it is described by a single nidus formed by osteoblasts and endowed with neural and vascular supply. The lesion is typically smaller than 2 centimeters.

The most common symptom is pain, which is discontinuous in the beginning but gradually getting constant. Symptoms increase at night and generally alleviated by oral non steroidal anti inflammatory drugs(NSAİD) medication. Plain radiographs and computer tomography(CT) scan are usually enough for diagnosis.¹⁻⁴ Bone

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

Study was conducted at Uludağ University, School of Medicine, Department of Orthopaedics and Traumatology, Bursa, Turkey.

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scintigraphy, single photon emission CT or magnetic resonance imaging(MRI) may be indicated in some cases.²⁻⁴

Osteoid osteomas tend to regress within 6 to 15 years without treatment. This can be reduced to 2 to 3 years with the use of acetylsalicylic acid and NSAIDs. However, most patients do not comply with long term medication because of gastrointestinal side effects or frustration.³⁻⁵ For years, the alternative to medical treatment had been surgical resection or curettage. Recently, percutaneous interventions such as radiofrequency ablation(RFA), trephine excision, cryoablation and laser thermocoagulation have been introduced.⁴⁻⁶ The aim of this study is to compare the results of conventional surgical treatment with those of RFA in children and adolescents. The participants of the research are signed the Term of Free and Informed Consents. Our article hasn't got ethics committee approval because it isn't compulsory in retrospective studies.

MATERIALS AND METHODS

Twenty four patients under 18 years of age who were treated because of osteoid osteoma between years 2006 and 2014 in our institution were included in this retrospective study. Patients with less than 1 year of follow-up, those who had first presented with recurrence and those with vertebral lesions were excluded. Patient's age, gender, location of the tumour, type of intervention, date, duration, pathological results, hospitalization time, complications and recurrence if any were noted. Patients were grouped into two based on type of treatment; those who had curettage and those who were treated with RFA. Operation length, hospitalisation length, complication and, recurrence and success rates were compared between two groups.

Operative procedure

Patients were placed supine on the radiolucent operating table. Both procedures were performed under general anesthesia with fluoroscopic guidance. Patients were discharged once their postoperative pain was manageable with oral analgesic only. Patients were allowed to mobilize freely.

Following standard soft tissue dissection, site of the bony lesion was exposed. Exact location of the lesion was confirmed with

fluoroscopy. Thin layers of bone were removed tangentially using gauges till nidus was visualized. Nidus and the surrounding reactive tissue were curetted and sent for pathological examination.(Figure 1) For the RFA method, exact location of the lesion was determined prior to a stab incision. The bone was drilled using a 3-4 mm drill bit. RF probe (Cool-tip RF Ablation System, Covidien,USA) was placed inside the bone tunnel created and it was made sure that the probe was inside the lesion. Ablation was performed at 90 C for 6 minutes.(Figure 2)

Descriptive statistics, chi-square and Mann-Whitney-U tests were used to compare variables. Data were analysed with SPSS statistical software (SPSS, Chicago, USA)

RESULTS

Mean age of patients was 11(2-18) years. Eight (33%) of the patients were female and 16(66%) were male. 54.2% of the lesions were in the femur, 29.2% in the tibia and 16.7% in other locations (one in humerus, ulna, calcaneus and fibula each). Mean duration of symptoms till surgery was 7.66(1-24) months. Eleven (45.83%) patients underwent curettage, while 13(54.17%) patients received RFA. Mean age of patients in curettage group was 12.1(3-18) years. Three of them were female and 8 were male. Mean operation length was 69.5 (60-120) minutes. Mean hospital stay was 1.3(0-2) days. Mean follow-up time was 5.72(2-9) years. Mean age of patients in the RFA group was 10,7(2-17) years. Five of them were female and 8 were male. Mean operation length was 49.6(20-90)minutes. Mean hospital stay was 0.3(0-1) days. Mean follow-up time was 1.76(1-4) years. Mean operation length, hospital stay and follow-up was significantly shorter in the RFA group. All data of the patients are outlined on Table 1.

Two patients (18.1%) in the curettage group had recurrence. One of the cases was a 3 years old male child with a lesion in his right proximal femur. He had persistent pain in month 5 after surgery and curettage was repeated once further studies confirmed. Other case was a 13 years old female patient with a lesion in her right proximal femur. She was still symptomatic 1 month after surgery and imaging studies revealed recurring lesion. She was treated

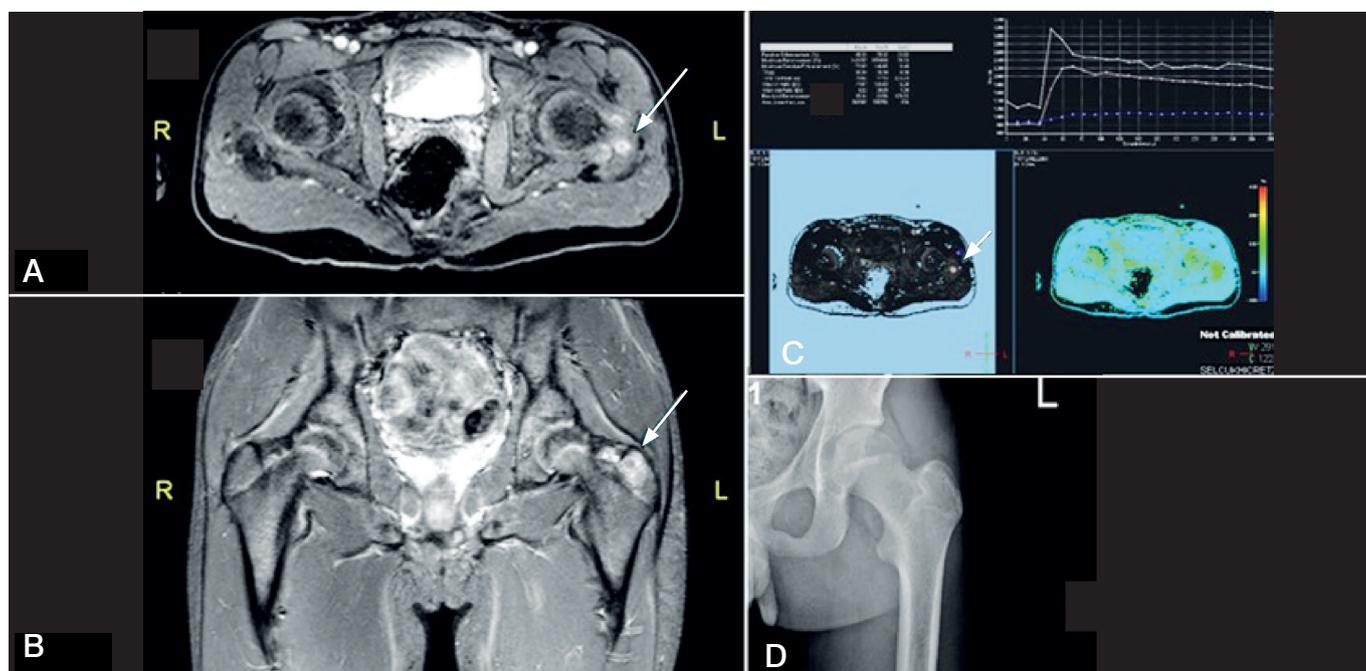


Figure 1. RFA treated 1 year old female patient preoperative (a-b), intraoperative (c), postoperative (d) 1. Year images.

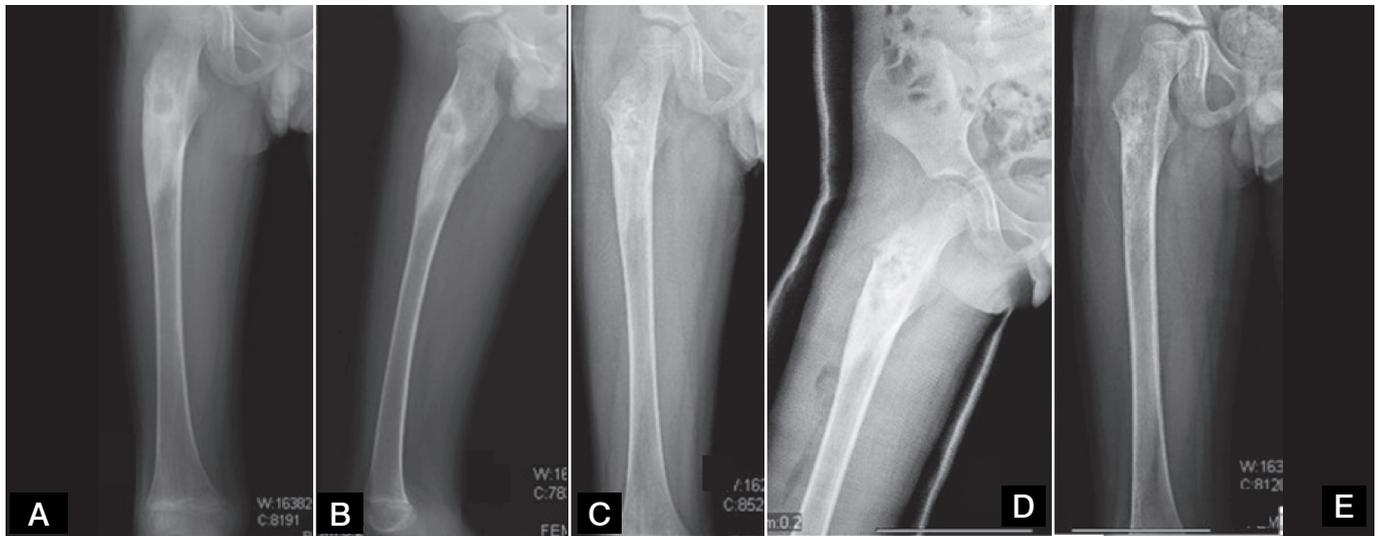


Figure 2. Curettage treated 13 years old male patient preoperative (a-b) early postoperative (c-d) postoperative 15. month(e) images.

Table 1. All data of the patients.

Demographic properties	curettage	Rf	total
Patient	11	13	24
Age(mean)(yr)	12,1(3-18)	10,7(2-17)	11(2-18)
Sex(F-M)	3-8	5-8	8-16
Duration of symptoms (mean)(month)	9,54(5-24)	6,07(1-14)	7,66(1-24)
Operation time(mean)(min)	69,5(60-120)	49,6(20-90)	58,7(20-120)
Length of hospital(mean)(day)	1,3(0-2)	0,3(0-1)	0,75(0-2)
Follow up time(mean)(yr)	5,72(2-9)	1,76(1-4)	3,58(1-9)
Recurrence	2	2	4
Localisation			
Femur	7	6	13
Tibia	1	6	7
Other	3	1	4

with RFA ablation. Both patients remained symptom-free and were considered as cured based on their patient records.

Two of 13 patients (15.3%) in the RFA group had recurrence. One of the cases was a 12 years old female child with a lesion in her left tibial diaphysis that recurred 6 months after surgery. Other case was a 12 years old male patient with a lesion in his left femoral diaphysis which recurred 18 months after surgery. Both patients received 2nd time RFA and no more intervention was necessary. She was still symptomatic 1 month after surgery and imaging studies revealed recurring lesion. She was treated with RFA. Both patients remained symptom-free and were considered as cured based on their patient records.

An eighteen years old patient with a lesion in his calcaneus who was treated with curettage developed wound site infection and needed soft tissue debridement.

DISCUSSION

Technological advances in medicine have made less invasive procedures applicable in the field of surgery. CT, fluoroscopy or MRI guided percutaneous interventions have become alternatives to open surgery in the treatment of osteoid osteoma. Review of recent literature reveals that percutaneous techniques are now

more common than open surgery.⁵⁻¹⁰ We have been using mainly radiofrequency in our clinic for the last four years.

Operative length in open surgery is typically longer as it takes time for exposure and wound closure. Need for increased soft tissue dissection and osseous manipulation in open surgery causes more postoperative pain and lengthens hospital stay.^{7,9,11} Lindner has compared percutaneous drilling to conventional methods and stated that hospital stay was shorter with the percutaneous approach.⁹ Similarly, Rosenthal has compared radiofrequency to open methods and reported hospital stay lengths of 4,7 and 0.18 days for open approach and RFA consecutively.⁷ Yildiz have stated that mean hospital stay was 5 days while percutaneous interventions were performed as outpatient procedures.¹²

Main aim of osteoid osteoma treatment is complete excision of the nidus and weaning of symptoms. Complete excision may not always be possible because of lesion's small size and surrounding sclerotic bone, resulting in recurrence. Recurrence is still a major problem despite intraoperative use of advanced imaging techniques. Literature reports 5-25% recurrence with different treatment modalities.^{2,13,14} In our study, recurrence rates were 18,1% for curettage and 15,3% for RFA. Rosenthal has reported recurrence in 9% of cases with open procedures, where as this rate was 12% with RFA.⁷ In his study on conventional treatment of osteoid osteoma, Yildiz had recurrence rate of 5%.¹² Bourgault has conducted a study on CT guided RFA of osteoid osteoma and reported 10.4% recurrence.² Recurrences tend to occur during the first 2 years following surgery.^{2,7,10} Since we have switched mainly to RFA for treatment of osteoid osteoma, follow-up lengths have been shortened. Current literature reports a similar trend with use of less invasive methods, which is disadvantageous to detect recurrence since it can happen during a two year period. Long-term follow ups of RFA need to be analyzed to claim a success, since recurrence can occur in a two year period

Interventions to osteoid osteoma lesions are performed by both orthopedists and radiologists. While radiologists performed procedures under CT and MRI guidance, orthopedists preferred C-arm fluoroscopy and CT.^{1,2,7,11,15} Recurrence rates are similar among different procedures and type of instruments. CT scan is useful because tumor size is small. Disadvantages of CT scan are problems with radiologic suite sterility, radiation, accuracy and increased intra and postoperative complications.¹⁶⁻¹⁸

The main advantage of open procedure is the possibility of histopathological diagnosis. This is not possible with percutaneous interventions. However, several authors conclude that clinical and radiological examination are adequate for diagnosis and pathological essay is not mandatory.^{14,19} This will reduce patient costs also. Nevertheless, histopathological examination is still recommended for lesion on atypical sites.^{20,13}

Most of the studies in the literature are case series of a single type of treatment method. Comparative studies such as ours are extremely rare. In this study, recurrence rates of two different modalities were found to be similar. Operation and hospitalization length were shorter with RFA. When reduced costs due to shorter hospitalization and the ability to reach anatomically difficult locations are also considered percutaneous procedures are likely to replace conventional open approach.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of the manuscript. BS (0000-0003-4071-8052)* and FG (0000-0002-2672-2904)* were the main contributors in the drafting of the manuscript. BS, FG, CE (0000-0001-8259-3695)* and AA (0000-0002-9730-5454)* underwent surgery, followed patients and gathered clinical data. FG, AA and UHG (0000-0002-8151-3371)* evaluated the data of the statistical analysis. FG, UHG and CE performed the literature search, review of the manuscript and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

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COMPLICATIONS AND COST ANALYSIS OF HEMIPELVECTOMY FOR THE TREATMENT OF PELVIC TUMORS

COMPLICAÇÕES E ANÁLISE DE CUSTO DA HEMIPELVECTOMIA PARA O TRATAMENTO DE TUMORES DA Pelve

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ABSTRACT

Objective: Hemipelvectomy is a complex surgery with a high complication rate. Here, we aimed to identify factors related to the onset of complications and calculate their impacts on hospital costs. **Methods:** We evaluated 31 consecutive patients who underwent hemipelvectomy between 1999 and 2015. We assessed the clinical and radiographic data to determine the patients' demographic factors, tumor and surgical characteristics, and complications. The individual hospital stays and financial balances were assessed up to 6 months following the index surgery. **Results:** The overall complication rate was 61% (19/31). Infection was the most prevalent complication (36%). Immediate postoperative death occurred in 5/31 patients (16%); another 5 (16%) died after hospital discharge due to disease progression. Histological grade, previous surgery, and previous radiotherapy were not associated with complications or infection. Acetabular resections, bone reconstruction, and longer operative times were associated with infection, whereas older age, pelvic organ involvement, and comorbidities were associated with immediate postoperative death. Complications and infection were associated with 4.8- and 5.9-fold increases in hospital costs, respectively. **Conclusions:** Acetabular resection and bone reconstruction are important factors that increase short-term complication rates, infection rates, and hospital costs. Mortality was associated with older age and adjacent pelvic tumor progression. **Level of Evidence: IV, case series.**

Keywords: Bone neoplasm, Hemipelvectomy, Patient outcome assessment, Cost analysis, Pelvic neoplasm.

RESUMO

Objetivo: Hemipelvectomia é uma cirurgia complexa associada a alta taxa de complicações. O objetivo foi identificar fatores relacionados a complicações e calcular o impacto sobre os custos hospitalares. **Métodos:** Avaliamos 31 pacientes consecutivos submetidos à hemipelvectomia entre 1999 e 2015. Analisamos dados clínicos e radiográficos para determinar variáveis demográficas, características do tumor e cirurgia, e complicações. A internação hospitalar individual e o balanço financeiro foram calculados até seis meses após a cirurgia principal. **Resultados:** A taxa de complicações foi de 61% (19/31). Infecção foi a complicação mais frequente (36%). Morte pós-operatória precoce foi observada em 5/31 pacientes (16%) e outros cinco (16%) morreram após alta hospitalar devido à progressão da doença. Grau histológico, cirurgia e radioterapias prévias não estiveram associadas com complicações ou infecções. Ressecções acetabulares, reconstruções ósseas e maiores tempos cirúrgicos estiveram associados com infecções, enquanto que mais idade, envolvimento de órgão pélvico e comorbidades estiveram associados com morte precoce. Complicações e infecções apresentaram aumento de 4,8- e 5,9-vezes nos custos hospitalares. **Conclusões:** Ressecções acetabulares e reconstrução óssea são fatores importantes que aumentam as complicações, infecções e custos hospitalares. Mortalidade está associada com maior idade e progressão tumoral intrapélvica. **Nível de Evidência IV, Série de casos.**

Descritores: Neoplasias ósseas. Hemipelvectomia. Avaliação de Resultados da Assistência ao Paciente. Custos e Análise de custo. Neoplasias Pélvicas.

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INTRODUCTION

Primary tumors of the pelvis are complex conditions that may require aggressive treatment. Chondrosarcoma is the most frequent primary tumor of the pelvis, followed by Ewing's sarcoma and osteosarcoma.^{1,2} Pelvic tumors present less favorable prognosis compared to long bone tumors.²

Pelvic tumors are generally large at diagnosis, and the therapeutic decision-making is challenging because of the contiguous neurovascular structures, intestinal tract and urinary tract.^{1,3-5} The proportion of external hemipelvectomies has decreased in recent decades, following the same trend of limb salvage that is applied for the current treatment of long bone tumors.⁶ Despite a considerable decrease in the mortality rate,

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The study was conducted at the Clinical Hospital of the Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto, SP, Brazil.

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which is currently between 0 and 10%, the complication rate remains very high, between 30 to 80%. Wound infection, flap necrosis, reconstruction failures (aseptic loosening, fractures, pseudarthrosis), nerve lesions, thrombosis, viscera injuries and functional disability have been frequently reported.³⁻⁸ Infection is the most common postoperative complication, varying between 20% and 80%.^{3,4} Older age, prolonged operative time, poor flap viability and the type of reconstruction are factors associated with complications.^{1,3,4}

Cost analyses of hemipelvectomy are poorly reported in the literature, and a study detailing the complication rate and costs may provide useful information for specialized oncologic centers. The impact of several factors, such as implant requirements, hospitalization in intensive care units and the characteristics of the complications are of utmost importance to the financial balance. The objectives of this study were to (a) analyze the risk factors that might influence the rate of complications, infection and death and (b) perform a cost analysis of a series of patients affected by pelvic tumors who were treated with hemipelvectomy in a single institution funded by the public health system.

MATERIALS AND METHODS

This is a retrospective study approved by the Institutional Review Board (CAAE: 47355415.0.0000.5440), with waiver of informed consent. We included 31 consecutive patients who underwent hemipelvectomy as index surgical treatment for the treatment of primary pelvic tumors from January 1999 and July 2015. Clinical and imaging data were reviewed from the preoperative up to the first six postoperative months following hemipelvectomy. There were 17 men and 14 women with a median age of 46 years (ranging from nine to 79). We assessed patient demographic characteristics (age and sex), diagnosis (tumor grade and pelvic organ involvement), risk factors (body mass index, hypertension, diabetes, previous radiation therapy, chemotherapy or surgery, and tobacco use), type of surgery (internal or external hemipelvectomy, resection classification, bone reconstruction, pelvic organ reconstruction, operative time, and need for blood transfusion), hospitalization length (ward and intensive care hospitalization days) and final status (resolution of complications, number of reoperations and need for conversion to external hemipelvectomy) (Table 1). We further evaluated the main variables including (a) the presence of complications, which included early death, infection, bowel

fistula, abdominal wall hernia, and renal insufficiency; (b) the presence of postoperative infection, which included deep infection, dehiscence, and flap necrosis; (c) early or late death, and (d) the estimated financial balance. Immediate postoperative death was considered an inpatient event, and late death was considered after the hospital discharge.

The most frequent histological type was chondrosarcoma (seven cases), followed by Ewing's sarcoma (five cases) and osteosarcoma (four cases). Sixteen tumors were classified as high grade. The involvement of pelvic organs occurred in 12 patients, and the bladder was the most frequently affected organ (four cases, 13%), followed by the rectum (three cases, 10%). Seventeen hemipelvectomy were internal, and 14 were external (55% and 45%, respectively). Resections were classified according to the Enneking and Dunham classification.⁹ The most common type was I + II + III (29%), followed by type III (19%) and type II + III (13%). In nine cases (29%), some type of bone reconstruction was required: endoprosthesis alone in two cases, fibular graft in one, and a polypropylene mesh alone in three. The polypropylene mesh was combined with endoprosthesis in two additional cases and with fibular graft in one additional case. The fibular graft was used to reconstruct the pelvic ring. The polypropylene mesh was used to reconstruct the abdominal wall or to attach the endoprosthesis to the remaining bone when hip medialization was performed (Figure 1). The median operative time was six hours, ranging from 1.4 to 22.3 hours. Blood transfusion, with a median of 3 units (1 – 6 units) was needed for 22 patients and

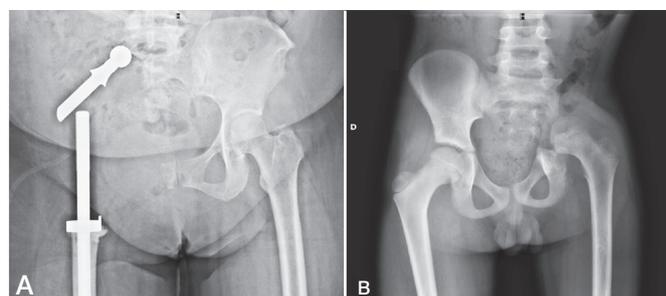


Figure 1. Reconstruction alternatives. Hip medialization technique with a polyethylene proximal femur prosthesis was used to reconstruct a I – IV pelvic resection in an adult patient (A). No bone reconstruction was used after a I + II pelvic resection in a pediatric patient.

Table 1. Medians, ranges and p-values of groups with and without complications, infections and death.

Demographics	General complication			Infection			Death			
	Without (n=12)	With (n=19)	p value	Without (n=20)	With (n=11)	p value	Alive (n=21)	Early death (n=5)	Late death (n=5)	p value *
Age (years)	35 (9-58)	51 (20-79)	.01	45 (27-58)	48 (41-61)	.42	43 (9-71)	65 (48-69)	46 (26-79)	.02
Sex (male)	7 (58%)	10 (53%)	.76	10 (50%)	7 (64%)	.7	11 (52%)	3 (60%)	3 (60%)	.76
Diagnosis										
Histologic grade (high)	11/11 (100%)	12/16 (75%)	.07	15/17 (88%)	8/10 (80%)	.56	15/19 (79%)	3/3 (100%)	5/5 (100%)	.38
Pelvic organ involvement	1 (8%)	10 (53%)	.012	(30%)	5 (45%)	.39	5 (24%)	4 (80%)	2 (40%)	.02
Risk factors										
Weight (kg)	67 (25-90)	77 (33-121)	.15	66 (58-1)	8 (68-80)	.16	68 (25-121)	82 (65-95)	71 (33-99)	.21
Comorbidities	2 (18%)	10 (53%)	.06	7 (37%)	5 (45%)	.64	5 (25%)	4 (80%)	3 (60%)	.02
Previous radiotherapy	2 (18%)	4 (22%)	.80	3 (16%)	3 (30%)	.37	5 (26%)	1 (20%)	0	.77
Previous chemotherapy	7 (64%)	6 (33%)	.11	9 (47%)	4 (40%)	.71	8 (42%)	1 (20%)	4 (80%)	.36
Previous surgery	0	3 (16%)	.18	1 (6%)	2 (18%)	.28	2 (11%)	0	1/5 (20%)	.45
Smoker	0	7 (37%)	.046	3 (19%)	4 (36%)	.31	4 (22%)	2 (40%)	1 (25%)	.42
Surgery										
Internal hemipelvectomy	8 (67%)	9 (47%)	.29	11 (55%)	6 (55%)	.98	16 (76%)	0	1/5 (20%)	.002
At least type II classification	6 (50%)	14 (74%)	.18	10 (50%)	10 (91%)	.02	12 (57%)	4 (80%)	4 (80%)	.35
Bone reconstruction	0	9 (47%)	.005	1 (5%)	8 (73%)	.001	7 (33%)	1 (20%)	1 (20%)	.56
Pelvic organ reconstruction	0	4 (21%)	.09	2 (10%)	2 (18%)	.52	2 (10%)	2 (40%)	0	.090
Operative time (hours)	3 (2-7)	9 (4-23)	.001	5 (3-7)	10 (6-14)	.002	5 (2-23)	8 (6-16)	9 (7-14)	.073
Blood transfusion (units)	2 (0-4)	2 (0-6)	.70	2 (0-3)	1 (1-2)	.48	1 (0-5)	3 (2-6)		.12

Categorical variables are expressed as the count / column total (percentage), and continuous variables are expressed as the median (range). P-values were determined with chi-squared tests for categorical variables and Mann-Whitney U tests for continuous variables. BP = Blood Pressure, ICU = Intensive Care Unit, RS = Brazilian Real.

unnecessary for five patients. We could not retrieve specific details for the other four patients. The median hemoglobin concentration was 10.4 g/dL (5.0 – 15.0) at the beginning and 9.5 g/dL (4.1 – 12.4) at the end of surgery.

A cost analysis was conducted by the institutional financial center for each patient. The expenses of the ward and intensive care unit, operative room (OR), post-anesthesia care unit, medications, surgical implants and blood products were analyzed separately. OR and inpatient daily expenses were estimated from average hospital balances. Medical fees were not included.

For descriptive statistical analysis, the categorical variables were expressed as frequency and percentage, whereas the continuous variables were expressed as median and range. Groups with or without complications or infection, and who were alive or not were compared with chi-squared tests for categorical variables and Mann-Whitney U tests for continuous variables. PASW software version 17 (IBM SPSS, Armonk, USA) was used for data analysis, and p-values > 0.05 were considered significant.

RESULTS

Complications

Complications were found in 19 of 31 patients (61%) (Table 1). Eleven patients had deep infections or flap necrosis, and one of them died due to multiple organ failure. Two patients had abdominal organ herniations, one had renal insufficiency, and another two had bowel fistulizations (one death). Another three patients died due to multiple organ failure.

Higher complication rates were related to older patients ($p=0.01$), pelvic organ involvement ($p=0.01$), tobacco use ($p=0.046$), bone reconstruction ($p=0.01$), and operative time ($p=0.001$).

Infection

Infection was the most common complication (11 of 31; 36%). Deep infection occurred in nine patients (29%) and two patients had flap necrosis and dehiscence (7%) (Table 1). The overall strategy for infection treatment was based on debridement in the operating room and intravenous antibiotics, with a control rate of 89%. In only one of 11 patients, infection could not be controlled within six months after surgery.

The infection rate was significantly high for the longer surgeries ($p=0.002$), when bone reconstruction was needed (Table 2) ($p=0.001$) and when at least the acetabulum was resected (type II hemipelvectomy) ($p=0.023$).

Death

Ten of 31 patients (32%) died within the six-month postoperative period (Table 1). An early mortality rate of 16% (five patients) was observed after a median time of 29 days (13 – 88) after surgery. The late mortality rate, after hospital discharge, was also 16% (five patients) as a consequence of tumor progression.

Early death was significantly high for older patients ($p=0.02$), pelvic organ tumor involvement ($p=0.02$) and patients who underwent external hemipelvectomies ($p=0.034$). Thirteen patients (42%) had prior disease (including hypertension [11 cases] and diabetes mellitus [five cases]), and these comorbidities were associated with early death ($p=0.02$).

Cost analysis

The median postoperative hospital inpatient stay was 15 days and ranged from 2 to 141 days. The presence of complications increased the median hospital stay from 7 days (2 – 22) to 38 days (9 – 141) ($p=0.001$). Specifically, infection increased the median hospital stay from 9 (2-109) to 40 days (10-141) ($p=0.002$).

The median cost was R\$15,517.81 and ranged from R\$3,162.99 to R\$87,970.99. The presence of complications led to a 4.8-fold increase in the median total costs ($p=0.000$), whereas infection led to a 5.9-fold increase in the median total costs ($p=0.001$). The median cost was increased by 2.1 for the early death patients ($p=0.16$) (Table 3). Bone reconstruction with implant usage led to a 5.7-fold increase in the median total cost in relation to non-reconstructed hemipelvectomies. The implant requirement was responsible for only 10% of this increase, whereas hospital stay and surgical costs contributed 26% and 19% to the total cost, respectively.

DISCUSSION

Pelvic bone tumors have varying sizes, affecting different regions, organs and other soft tissues. This large variety of presentations makes challenging the surgical resection, and hampers the comparisons between surgical strategies. Large series with sufficient power to address these issues are quite rare.³ Several techniques are used to reconstruct the disrupted pelvic ring^{5,7,10} and the flail hip joint^{1,11} and are associated with increased infection rates. Although, the surgical reconstruction is based on the disruption of the iliac ring and the support for the affected lower limb,^{12,13} these two factors are not considered by in the Enneking and Dunham classification.⁹ Many aspects of bone reconstruction remain unknown, such as the need for pelvic ring or acetabular reconstruction, the impact of prosthesis or allograft implantation on the infection rate and patients' functionality. Moreover, the prevalence and results of these varying surgical characteristics may have consequences in the hospital costs which were the objectives of this study.

The reconstruction of the pelvic ring is recommended to maintain the limb length and provide mechanical support for the preserved

Table 3. Hospital costs and cost increase for different outcome groups.

	Total	Increase
Complication		
No	7,845.79	
Yes	37,823.73	4.8
Infection		
No	9,131.02	
Yes	54,206.61	5.9
Death		
No	10,264.74	
Early	21,967.08	2.1
Late	30,590.12	3.0
Implant		
Without implant	10,264.74	
With implant	58,890.755	5.7

Table 2. Counts and proportions of implants and transplants used for reconstruction.

	None	Reconstruction	Prosthesis	Prosthesis + mesh	Fibular graft	Fibular graft + Polypropylene mesh	Polypropylene mesh	Total
No infection	19 (86%)	1 (11%)			1			20 (65%)
Infection	3 (14%)	8 (89%)	2	2		1	3	11 (35%)
Total	22 (100%)	9 (100%)	2	2	1	1	3	31 (100%)

Polyp = Polypropylene.

acetabulum.² Iliosacral arthrodesis with autograft, allograft, prosthesis or a combination of the three have been reported.¹³ Apposition of the remaining iliac bone to the sacrum is the easiest reconstruction technique and can be performed when the distance between both bones is small.^{13,14} For larger resections, Müller et al.⁸ suggested the use of megaprosthesis. Hillmann et al.¹² recommended vascularized fibular grafts.¹² It has been suggested that the reconstruction of the pelvic ring provides improved gait scores in comparison with non-reconstruction.¹⁰ For resected acetabulum, the hip support can be restored by arthrodesis,¹⁴ prosthesis, autograft, or hip transposition (Figure 1), improving the pelvic stability, load bearing, and reducing the limb length discrepancy. Prosthetic reconstruction is commonly related to increased loosening and infection rates.^{2,3,13,14} Gebert et al.¹¹ reported good results with a low infection rate of 3 in 17 patients subjected to medialization of the hip with femoral endoprosthesis implantation. Barrientos-Ruiz¹⁵ had 10 wound and 2 deep infections in ten ice-cream-cone prosthesis implantations. Zeifang et al.⁵ suggested that biological reconstruction should be performed in younger patients, providing better longstanding functional results, whereas in older patients, endoprosthetic reconstruction should be preferred because of lower complication rates. Deep infection, flap necrosis and implant loosening are the most frequent complications. The infection rate ranges from 10% to 50% and may demand multiple surgical debridements and soft tissue reconstructive procedures.^{2,3,8,11,12,16} Longer operative time and increased complexity are associated with higher wound infection and flap necrosis rates.⁴ Hip transposition was associated with a infection rate of 29%.¹¹ Angelini et al.³ reported an infection rate of 15% and 26% for non- and reconstructed hemipelvectomy, with a cure rate after one year of 87%. In our study, the rate of infection was 36%, with a resolution rate of 91% in 6 months. Infection was associated with implant use for bone reconstruction. As described by other authors, the histological grade of the tumor, previous surgery and previous radiotherapy were not associated with infections or complications.^{3,4,11} Hospital cost varied enormously. Hospital stay was responsible for almost 53% of costs. Surgery costs corresponded to 27% of costs, and implant cost was responsible for only 4%. The onset of complications and infections caused a 4.8- and 5.9-fold cost

increase, respectively, and prolonged the hospital stay from 7 days to 38 days and 9 days to 40 days, respectively. Similar studies showed that a prolonged hospital stay and the use of expensive medication increased total knee prosthesis revision costs in the United States. Infected and non-infected revisions were 3 to 4 times and two times more expensive in comparison with primary arthroplasties.¹⁷ In the United Kingdom, hospital stays for revisions of infected knee arthroplasties and the associated costs are more than twice as long and three times as high as those of aseptic revisions.¹⁸ The main limitation of this study is the small sample size due to the rarity of pelvic tumors. However, a larger series has shown similar results. Cost analysis is very particular to each country because of different health politics and financial support. Even inside Brazil, regional differences influence the hospital costs. The most important conclusion of our study is that bone reconstruction and the consequent prolongation of the operative time are important factors that increase short-term complication and infection rates and, consequently, hospital stays and costs. All of which can be avoided by performing less complex reconstruction procedures. Further studies should analyze whether complex reconstructions have a better functionality and quality of life that compensate for this high complication rate. In conclusion, age, pelvic organ involvement, tobacco use, bone reconstruction and operative time were associated with complication rate increases in hemipelvectomy surgery. The infection rate was significantly higher for acetabular resections, bone reconstructions and longer operative time. The onset of complications in hemipelvectomy induced a 4.2-fold increase, and the onset of infection induced a 5.9-fold increase in hospital costs.

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SPINE METASTASIS OF INTRACRANIAL HEMANGIOPERICYTOMA: CASE REPORT OF TWO TREATMENTS

METÁSTASE NA COLUNA DE HEMANGIOPERICITOMA INTRACRANIANO: RELATO DE 2 TRATAMENTOS

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ABSTRACT

Objective: To report the use of two techniques (radiosurgery and *en bloc* vertebrectomy) on the same patient for the treatment of two metastases in different sites of the spine arising from intracranial hemangiopericytoma. Intracranial hemangiopericytomas are rare, comprising approximately 2.4% of meningeal tumors and <1% of all tumors of the central nervous system. Metastases to the spine are even rarer: The largest case series reported in the literature has 5 and 7 cases. **Methods:** A 37-year-old man diagnosed with intracranial hemangiopericytoma was referred for a metastatic lesion in T12 and underwent *en bloc* resection using the Tomita technique. **Results:** The disease evolved with a metastasis to T2 treated by radiosurgery with 1600 cGy. The patient died 1,706 days after the *en bloc* resection of T12 and 1324 days after the radiosurgery of T2, and no recurrence occurred in these locations due to progression of the systemic diseases (liver and central nervous system). **Conclusion:** This is the first case reported in the literature in which two different techniques were used to treat metastatic lesions in the spine from an intracranial hemangiopericytoma and is unique for its use of two treatments in the same patient. **Level of evidence: V, case report**

Keywords: Spine. Hemangiopericytoma. Radiotherapy. Neoplasm metastasis. Radiosurgery.

RESUMO

Objetivo: Reportar o uso de duas técnicas (radiocirurgia e *vertebrectomia em bloco*) no mesmo paciente, para o tratamento de metástases de um hemangiopericitoma intracraniano em dois locais da coluna. Hemangiopericitomas intracranianos são raros, consistindo em cerca de 2,4% dos tumores da meninge e menos de 1% de todos os tumores do sistema nervoso central, e metástases para a coluna são ainda mais raras: as maiores séries de casos publicada tinham 5 e 7 casos. **Métodos:** Um homem de 37 anos com diagnóstico de hemangiopericitoma intracraniano foi encaminhado para ressecção em bloco de lesão metastática em T12 com a técnica de Tomita. **Resultados:** A doença evoluiu com metástase em T2, tratada com radiocirurgia (dose de 1600 cGy). O paciente morreu 1.706 dias após a ressecção em bloco de T12 e 1.324 dias após a radiocirurgia de T2, livre de recorrência nessas localizações, devido a progressão sistêmica da doença (para fígado e sistema nervoso central). **Conclusão:** Este é o primeiro caso na literatura no qual duas técnicas diferentes foram usadas pra tratar lesões metastáticas da coluna de hemangiopericitoma intracraniano, único pelo uso de duas técnicas de tratamento no mesmo paciente. **Nível de evidência V, relato de caso.**

Descritores: Coluna Vertebral. Hemangiopericitoma. Radioterapia. Metástase Neoplásica. Radiocirurgia.

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INTRODUCTION

Hemangiopericytomas in the bone are rare and are generally the result of the spread of tumors originating in the soft tissues.¹⁻⁵ In the spine, they have been described both in the epidural space and the bone, accounting for around 0.6% of primary bone tumors of the spine and sacrum.⁶⁻⁸

Intracranial hemangiopericytomas account for around 2.4% of meningeal tumors and less than 1% of all tumors of the central nervous system (CNS). Although common in most malignant neoplasias, metastases to the spine are extremely rare in intracranial hemangiopericytomas.⁸⁻¹²

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

Work conducted at the Department of Orthopaedics and Traumatology, Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HC-FMUSP).

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Metastases to the spine may evolve to spinal cord compression syndrome if not treated.¹²⁻¹⁵ Tomita et al.¹⁶ described a globally recognized technique of posterior-approach *en bloc* resection for the treatment of primary tumors and metastases of the spine, reporting their experience with 20 cases, with pain relief and improvement of neurological deficit in most. Other authors, however, did not achieve the same outcomes when reproducing the technique.²³ There is currently no evaluation and management algorithm available for spine metastases and/or spinal cord compression,^{17,18} nor level 1 evidence for intracranial hemangiopericytomas.¹⁵⁻²⁰ We present our experience with one case of intracranial hemangiopericytoma with asynchronous metastases in non-contiguous vertebrae, treated with two techniques (radiosurgery and *en bloc* vertebrectomy) because of the clinical circumstances of the patient.

MATERIALS AND METHODS

Clinical presentation and examination

The study was approved by the institutional research ethics committee: Comitê de Ética e Pesquisa do Instituto do Câncer do Estado de São Paulo - CEP/ICESP - number 876/2016. All the participants signed the Free and Informed Consent Form.

A 37-year-old male patient with an intracranial hemangiopericytoma diagnosed 8 years ago was referred to our spine surgery clinic (a public, university referral center for cancer) presenting a lytic lesion in vertebra T12 compatible with metastatic disease during staging (Figures 1 and 2), and complaints of back pain without any neurological deficit. The patient had previously undergone two surgeries for a primary resection and for recurrence in the central nervous system (Figures 3 and 4), and two liver surgeries for the resection of metastatic liver lesions.

Interventions

En bloc vertebrectomy of T12

The patient underwent *en bloc* resection of T12 in two stages. In the first surgery, an *en bloc* laminectomy was performed (Figure 5). The patient was positioned lying on the stomach, with appropriately placed cushions. An incision was made in the midline; the paraspinal muscle was dissected from the spinous processes and retracted laterally. Pedicle screws were placed two levels above and two

levels below the lesion (T10, T11, L1, and L2) with fixation of the system using two titanium rods. Resection of the costotransverse joint was performed on both sides, followed by blunt dissection of the pleura, detaching it from the vertebra. Next, resection of the T11 spinous process and its inferior articular processes was performed, making room for the passage of a Gigli saw around



Figure 2. Magnetic resonance imaging (MRI) of the spine in sagittal and axial cuts showing involvement of the T12 vertebra.



Figure 3. Immediate postoperative X-ray showing the *en bloc* resection and reconstruction.

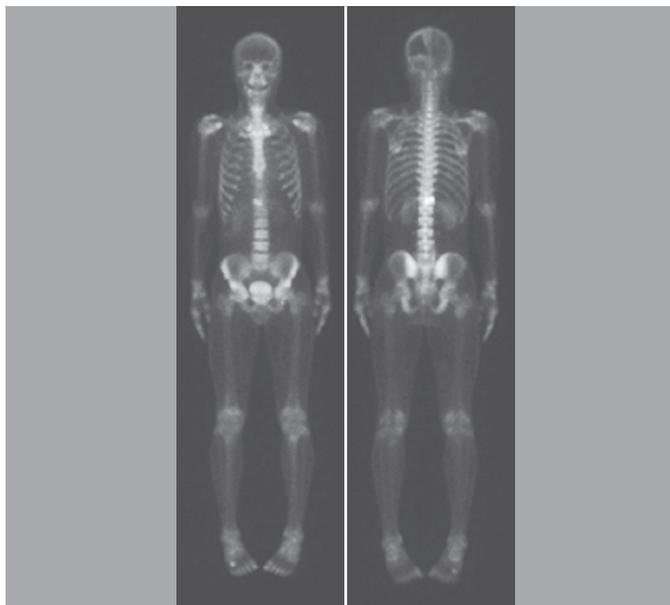


Figure 1. Scintigraphy showing involvement of the T12 vertebra.

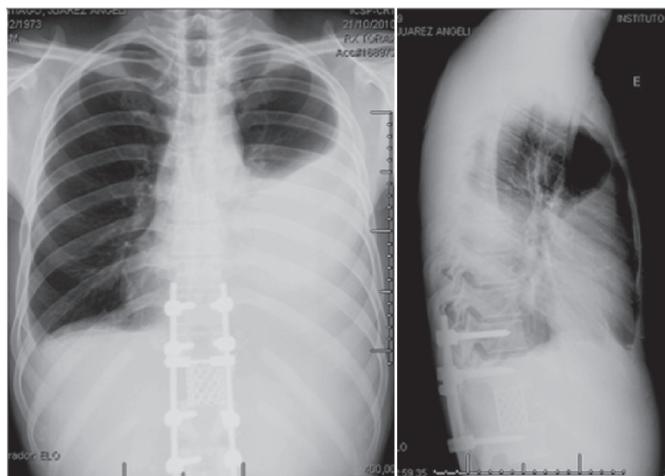


Figure 4. Chest radiograph showing left lung opacity resulting from the chylothorax profile.

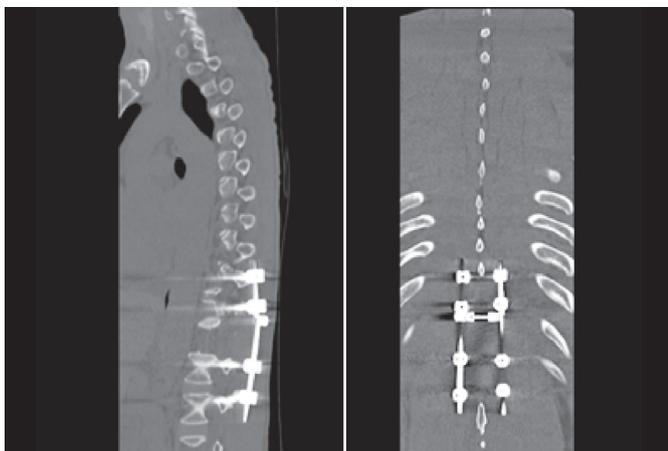


Figure 5. Rod breakage from pseudoarthrosis 14 months after reconstruction.

the pedicles through the intervertebral foramen. After transection of both the pedicles, the posterior elements of T12 were removed in a single block. Temporary fixation was accomplished with two titanium rods. The patient presented no major complications during the postoperative period, only mild pain at the site of the surgical approach, treated with analgesics.

In the second surgery, transection of the ribs was performed at the level of the lesion (T12) and the level immediately above (T11) about 4 cm from the costotransverse joint, with ligation of the nerve roots and the segmental arteries of the same levels. We performed blunt dissection around the vertebral body, detaching it from the pleura, creating a plane between the anterior structures (pleura, aorta) and the vertebral body. We passed the Gigli saw through the space created, performing an osteotomy through the inferior terminal plate of the cephalic vertebra and the superior vertebral plate of the caudal vertebra. Once free, the vertebral body was rotated and removed *en bloc*. We placed an anterior reconstruction cage with a graft from the costectomy. We ended with the final fixation of the system. We also performed ligation of the thoracic duct using metal clips. An accidental injury to the pleura occurred during its detachment from the vertebral body and was repaired. During the entire procedure, we maintained the fixation of the system on at least one side, to reduce the neurological risk.

About two months postoperatively, the patient presented significant respiratory discomfort and was hospitalized for pleural effusion (empyema) and diagnosed with chylothorax (Figures 6). He underwent chest drainage for treatment and was put on a lipid restricted diet for two weeks, without any other complications (Figure 7 and 8). One year and six months following surgery, he underwent revision for symptomatic pseudoarthrosis of the T11-L1 arthrodesis, and made good postoperative progress (Figure 9).

Radiosurgery of T2

In the meantime, the patient presented a new metastatic lesion in T2 (Figure 10), about a year after the first surgery. As the disease was progressing, with new lesions of the liver and the CNS, it was decided to perform radiosurgery on the new lesion with a single dose at 1600 cGy, with no complications.

RESULTS

The patient remained free from recurrence at the sites where the two treatment modalities were performed, until his death, at 1,706 days after the *en bloc* resection of the lesion in T12, due to the progression of liver disease and clinical complications.

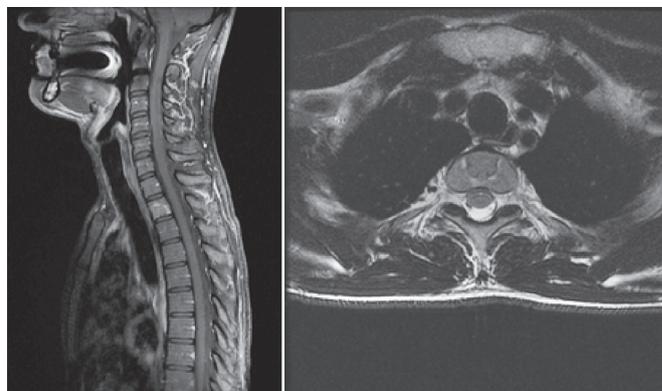


Figure 6. Magnetic resonance imaging (MRI) showing the lesion in T2.

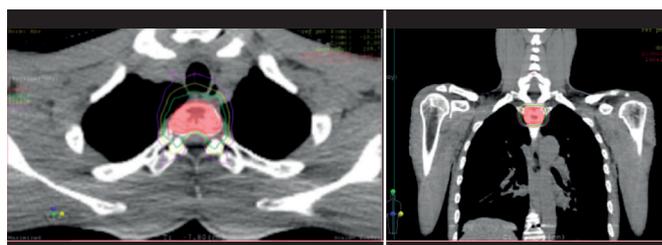


Figure 7. Radiation treatment plan showing isodose curves sparing the spinal cord. Prescription isodose of 16Gy depicted in red.

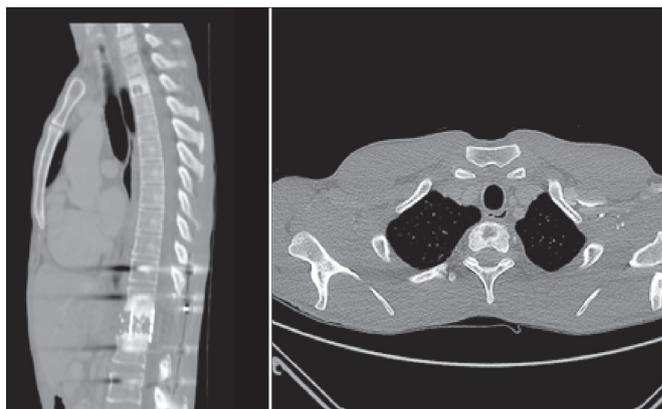


Figure 8. One month after radiosurgery of T2; 12 months following vertebrectomy and reconstruction.

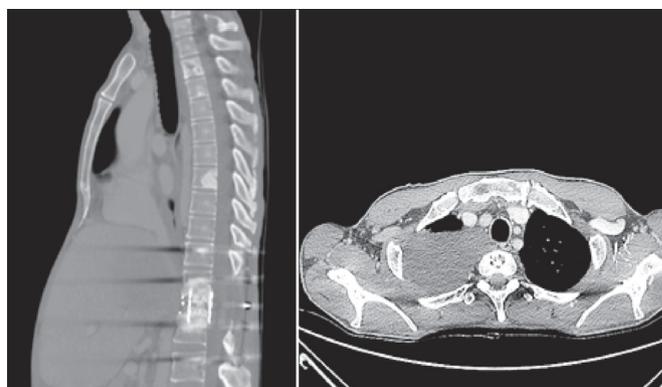


Figure 9. Final follow-up computed tomography (CT) of the T12 lesion 45 months following original surgery; 24 months after revision (consolidation of pseudoarthrosis); and 30 months following radiosurgery.

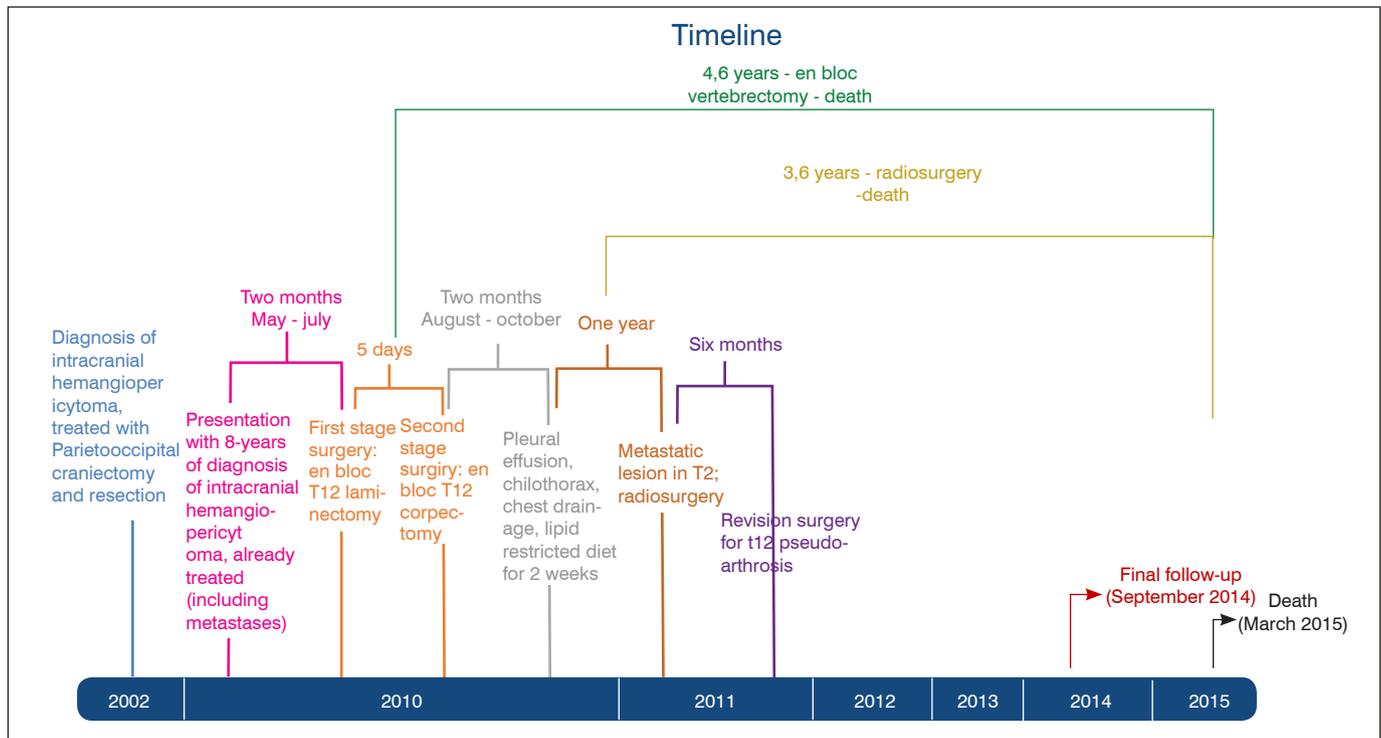


Figure 10. Timeline.

DISCUSSION

The management of hemangiopericytomas remains controversial, with no level 1 recommendation.¹⁻⁵ Surgical treatment is the central pillar in the treatment of these tumors.² There are no guidelines that indicate the ideal resection margins of metastases, which is even more problematic in the spine, where the margins are often bordered by vital structures.²⁻⁶ In the experience reported, we achieved disease-free margins using the posterior approach *en bloc* resection technique described by Tomita et al.,¹⁶ without any significant neurological damage, and without any motor or sphincter function loss. It is a highly demanding technique with potential risks, and its use is only recommended for patients with metastases without paraspinal extension.¹⁷

Chemotherapy plays a purely palliative role in the treatment of hemangiopericytoma, with poor results reported in the literature.¹⁸ Stereotactic radiosurgery (gamma-knife, cyber-knife), has promising results¹⁸ and radiosurgery can also increase survival and the time free from local recurrence,¹⁹ but does not reduce the risk of distant metastases, which cause significant morbidity and mortality.

En bloc resection is a high-risk procedure, with an average duration of 12.1 hours, average bleeding of 3.7 liters, and a complication rate of 36.3% reported in the literature.²⁰ Our patient had two significant postoperative complications: a profile of chylothorax and symptomatic pseudoarthrosis. Although it did not affect patient survival time, it resulted in higher morbidity, with two additional hospitalizations and a third surgery in addition to the two planned ones.

In the lesion of T2, radiosurgery with a single dose of 1600 cGy was chosen, obtaining a good response with 1324 days of follow-up free

from local recurrence and without complications from the procedure. Although no complications were observed in our case, up to 20% of patients can develop a profile of transient pain postoperatively²⁰ and 20% may develop fractures of the vertebrae submitted to SSR, making the proper selection of patients and the proper use of the technique important, since these fractures are observed in patients with lytic spine lesions affecting more than half of the vertebral body. Exaggerated radiation (> 20 cGy) also influences this complication.²⁰

CONCLUSION

This is the first case reported in the literature in which two different techniques were used to treat metastatic lesions of the spine from intracranial hemangiopericytoma, unique because the two forms of treatment were used in the same patient. We observed survival free from recurrence for 1706 days, longer than that reported from the original technique (522 days),¹⁶ and comparable to the more recent literature (1873 days in patients with disseminated metastases).¹⁷ In our opinion, both techniques can be effective if executed with precision and discretion, observing the main determinants of success of the treatment, the extent of the disease, and presence of spinal instability, and the neurological and oncological components.

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AUTHORS' CONTRIBUTIONS: All authors contributed individually and significantly for this study development as follows. FFA (0000-0002-0746-265X)*: manuscript writing, critical revision and data collection (surgeries); DKN (0000-0001-7895-4830)*: data collection (from surgeries), statistical analysis, critical revision of the manuscript; WGJT (0000-0001-9036-629X)*: data collection (from surgeries), data analysis and manuscript writing; RMM (0000-0001-5958-5646)*: data collection (imaging evaluation) and critical review of the manuscript; AFC (0000-0002-7797-5274)*: study design and planning, provision of administrative resources, manuscript writing and revision; TEPBF (0000-0002-7969-7845)*: study design and planning, data collection (from surgeries), manuscript writing, statistical analysis and review. All authors reviewed the final version to be published and are responsible for its contents. *ORCID (Open Researcher and Contributor ID).

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DOES SURGEON SPECIALIZATION CHANGE THE PROXIMAL HUMERAL OSTEO-SYNTHESIS APPROACH?

A ESPECIALIZAÇÃO MUDA A ESCOLHA DA VIA DE ACESSO PARA A OSTEOSSÍNTESE DE ÚMERO PROXIMAL?

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ABSTRACT

Objective: To evaluate the choice of surgical approach among Brazilian orthopedists and whether shoulder surgery specialty training or duration of experience influences the decision-making. **Methods:** A questionnaire on the preferred approach and complications was administered to orthopedic surgeons with and without shoulder specialization training. The chi-square test or Fisher's exact test was applied. **Results:** We interviewed 114 orthopedists, 49 (43.0%) traumatologists, 36 (31.5%) specialist surgeons, and 29 (25%) shoulder surgery specialist residents. In cases of fracture without dislocation, specialized training and duration of experience did not influence the approach used (primarily deltopectoral). In cases of fracture/dislocation, 97.2% of the specialists versus 82.1% of the traumatologists opted for the deltopectoral approach ($p = 0.034$). In cases of fractures/dislocation, 92.5% of surgeons with more than 5 years of experience and 78.7% with less than 5 years of experience opted for the deltopectoral approach ($p = 0.032$). **Conclusion:** Specialization in shoulder surgery did not influence surgeons' approaches to manage fractures without dislocation. In cases of fracture/dislocation, shoulder surgery specialization training and duration of experience were associated with selection of the deltopectoral approach. **Level of Evidence V, Expert opinion.**

Keywords: Shoulder Fractures. Humeral head. Shoulder joint. Osteosynthesis.

RESUMO

Objetivo: Avaliar a via de acesso de escolha entre os ortopedistas brasileiros e se a formação de especialista em cirurgia do ombro e/ou tempo de experiência influenciam nessa decisão. **Métodos:** Realizou-se questionário entre ortopedistas, com e sem especialização em ombro, sobre qual a via de acesso preferida e as complicações observadas. Aplicou-se o teste do qui-quadrado ou o teste exato de Fisher. **Resultados:** Foram entrevistados 114 ortopedistas, 49 (43,0%) traumatologistas, 36 (31,5%) cirurgiões especialistas e 29 (25%) residentes de especialização em cirurgia do ombro. Nas fraturas sem luxação a formação especializada e o tempo de experiência não influenciaram na escolha (maioria deltopeitoral). Na fratura/luxação, 97,2% dos especialistas optaram pela deltopeitoral, comparado com 82,1% dos traumatologistas ($p=0,034$). Nas fraturas/luxação, cirurgiões com experiência superior a 5 anos optaram pela deltopeitoral (92,5%) e aqueles com menos de 5 anos optaram pela via deltopeitoral (78,7%) ($p=0,032$). A diminuição do arco de movimento (ADM) foi a complicação mais relatada. **Conclusão:** A especialização em cirurgia do ombro não influenciou na escolha nas fraturas sem luxação. Na fratura/luxação, a especialização e o tempo de experiência associaram-se à escolha da via deltopeitoral. A complicação mais frequente foi a diminuição do ADM, principalmente entre os cirurgiões do Ombro. **Nível de Evidência V, Opinião de especialistas.**

Descritores: Fraturas do úmero proximal. Fraturas do ombro. Cabeça do úmero. Osteossíntese.

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INTRODUCTION

Increased life expectancy and high-energy trauma increase the incidence of proximal humeral fractures. Most of these fractures are treated conservatively. However, fractures with dislocation may require surgical treatment.^{1,2} When possible, osteosynthesis is the option of choice in fractures with surgical indications in young and elderly patients.¹

Two approaches are used in the osteosynthesis of proximal humeral fractures. The deltopectoral approach is easier to perform and less close to the axillary nerve.³ The anterolateral approach is performed between the anterior and middle deltoid portions and features better exposure of the lateral region of the humerus. It can be performed in an extended manner by isolating and directly observing the axillary nerve or using the minimally invasive plate osteosynthesis (MIPO)

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

The study was conducted at the Universidade Estadual de Campinas (UNICAMP), Department of Orthopedics and Traumatology, Shoulder and Elbow Group, Campinas, São Paulo, Brazil. Correspondence: Plínio de Almeida Martins de Souza, HC-UNICAMP, Department of Orthopedics and Traumatology, Rua Tessália Vieira de Camargo, 126, Barão Geraldo, Campinas 13083-970, SP, Brazil. plinio.ams@gmail.com

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technique, in which the axillary nerve is indirectly protected. Thus, although the anterolateral approach provides better access to the greater tuberosity and the lateral face of the humerus, the axillary nerve must be directly or indirectly protected.^{4,5}

There are several international studies on osteosynthesis of proximal humeral fractures with blocked plates. The main studies included patients treated using the deltopectoral and lateral anteroposterior approaches and the MIPO technique. The extended anterolateral approach was used in few studies because surgeons tend to avoid manipulating the axillary nerve.^{6,7} However, no study in the Brazilian literature to date has investigated whether experience (training time) or shoulder surgery specialization can influence the choice of approach to treat osteosynthesis of proximal humeral fractures. Thus, this study aimed to investigate Brazilian orthopedic surgeons' choice of approach for osteosynthesis of proximal humeral fractures and to evaluate whether shoulder surgery specialist training influences this decision.

MATERIALS AND METHODS

A questionnaire was administered to orthopedists at two instances: in the Brazilian Congress of Orthopedic Trauma - Brasília/DF in 2017 to orthopedists without shoulder surgery specialization training (identified as traumatologists) but with the title of specialist by the Brazilian Society of Orthopedics and Traumatology in the closed meeting in 2017 - Trancoso/Bahia (meeting only among specialists with a title recognized by the Brazilian Society of Shoulder and Elbow Surgery); and among orthopedists who completed the shoulder surgery specialization in 2016 (shoulder residents). The project received approval from the local research ethics committee (number 90910818.7.0000.5404).

The questions were: How long has the surgeon been performing osteosynthesis of proximal humeral fractures (less than 5 years, between 5 and 10 years, and more than 10 years)? In fractures of the proximal humerus (without dislocation), what would be the preferred approach. In fractures associated with dislocation of the proximal humerus, what would be the preferred approach? Which implant is used in osteosynthesis of proximal humeral fractures? Which are the main complications observed in the postoperative of proximal humeral fractures? Questionnaires that were not fully answered were excluded. The chi-square test or Fisher's exact test was used to compare the answers among the different professionals. All analyses were performed using PASW Statistics 18.0 (SPSS Inc., Chicago, IL, USA), using a significance level of 5% ($P < 0.05$). All participants signed an informed consent form before completing the questionnaire.

RESULTS

Among the 114 interviewed orthopedists, 49 (43.0%) were traumatologists, 36 (31.5%) were shoulder surgery specialists, and 29 (25%) were shoulder surgery specialist residents.

For fractures without dislocation of the humeral head, 81.6% of the respondents preferred the deltopectoral approach. Shoulder surgery training did not influence the choice of approach, which was mostly deltopectoral (Table 1). Duration of professional experience also did not interfere with the choice of approach (Table 2).

In cases of fractures associated with humeral head dislocation, most shoulder specialists opted for the deltopectoral approach. Considering the resident shoulder specialists and the shoulder surgery specialists (97.2%), more professionals chose the deltopectoral approach compared to traumatologists (82.1%) ($p = 0.034$) (Table 3). There was an association between the chosen approach and the surgical experience in the treatment of proximal humeral fractures. A total of 92.5% of the surgeons with more than 5 years

of experience opted for the deltopectoral approach, while 78.7% of the surgeons with less than 5 years of experience opted for the deltopectoral approach ($p = 0.032$) (Table 4).

Residents who recently specialized in shoulder surgery primarily chose the deltopectoral approach, especially when the fracture was associated with dislocation (86.2%). In the absence of dislocation, 79.3% of them chose the deltopectoral approach.

The locked plate was the implant of choice among professionals regardless of the surgeon's training and experience duration (Table 5). The decrease in shoulder range of motion was the most commonly reported complication, especially by shoulder specialists (Table 6).

Table 1. Approach used according to training type for fractures without dislocation.

	n	Preferred approach		p
		Anterolateral	Deltopectoral	
Traumatologist	49	10 (20.4%)	39 (79.6%)	0.698
Shoulder surgeon	36	5 (13.9%)	31 (86.1%)	
Shoulder resident	29	6 (20.7%)	23 (79.3%)	
Traumatologist	49	10 (20.4%)	39 (79.6%)	0.635
Shoulder surgeon or resident	65	11 (16.9%)	54 (83.1%)	
	114	21 (18.4%)	93 (81.6%)	

Table 2. Approach used according to duration of surgical experience for fractures without dislocation.

	n	Preferred approach		p
		Anterolateral	Deltopectoral	
Up to 5 years	47	9 (19.1%)	38 (80.9%)	0.170
Between 5 and 10 years	21	1 (4.8%)	20 (95.2%)	
More than 10 years	46	11 (23.9%)	35 (76.1%)	
Up to 5 years	47	9 (19.1%)	38 (80.9%)	0.867
More than 5 years	67	12 (17.9%)	55 (82.1%)	
Up to 10 years	68	10 (14.7%)	58 (85.3%)	0.213
More than 10 years	46	11 (23.9%)	35 (76.1%)	
	114	21 (18.4%)	93 (81.6%)	

Table 3. Approach used according to training time for fractures associated with dislocation.

	n	Preferred approach		p
		Anterolateral	Deltopectoral	
Traumatologist	49	10 (20.4%)	39 (79.6%)	0.059
Shoulder surgeon	36	1 (2.8%)	35 (97.2%)	
Resident	29	4 (13.8%)	25 (86.2%)	
Traumatologist	49	10 (20.4%)	39 (79.6%)	0.047
Shoulder surgeon or resident	65	5 (7.7%)	60 (92.3%)	
	114	14 (12.3%)	100 (87.7%)	

Table 4. Approach used according to duration of surgical experience for fractures associated with dislocation.

	n	Preferred approach		p
		Anterolateral	Deltopectoral	
Up to 5 years	47	10 (21.3%)	37 (78.7%)	0.090*
Between 5 and 10 years	21	1 (4.8%)	20 (95.2%)	
More than 10 years	46	4 (8.7%)	42 (91.3%)	
Up to 5 years	47	10 (21.3%)	37 (78.7%)	0.032*
More than 5 years	67	5 (7.5%)	62 (92.5%)	
Up to 10 years	68	11 (16.2%)	57 (83.8%)	0.276**
More than 10 years	46	4 (8.7%)	42 (91.3%)	
	114	15 (13.2%)	99 (86.8%)	

*Chi-square test, Fisher's exact test. †A case with two approaches was included.

Table 5. Most commonly used implants according to preference or availability.

	n	Implants for normal use		p
		Used locked plates (other implants)	Did not use locked plates	
Traumatologist	49	43 (87.8%)	6 (12.2%)	0.844*
Shoulder surgeon	36	33 (91.7%)	3 (8.3%)	
Resident	29	26 (89.7%)	3 (10.3%)	
	114	102 (89.5%)	12 (10.5%)	

Table 6. Most frequently reported complications.

	n	Most observed complications		p
		Decreased range of motion	Another complication	
Traumatologist	49	42 (85.7%)	7 (14.3%)	0.064*
Shoulder surgeon	36	34 (94.4%)	2 (5.6%)	
Shoulder resident	29	29 (100%)	0 (0.0%)	
	114	105 (92.1%)	9 (7.9%)	

Other complications frequently observed: osteonecrosis of the humeral head (n = 5), europraxia (n = 2), others unspecified (n = 1), does not follow the postoperative period (n = 1).

Axillary nerve neuropraxia was the most frequently reported complication (n = 3), all of whom performed the deltopectoral approach. No surgeon who performed the anterolateral approach, regardless of specialization, mentioned axillary nerve neuropraxia as a frequent complication.

DISCUSSION

Osteosynthesis of proximal humeral fractures is the option of choice for elderly patients when adequate fracture stabilization is possible and in cases of a low risk of avascular necrosis of the humeral head.¹ It is also the option of choice in young patients.⁸ The surgeons preferred the deltopectoral approach, a result that corroborates with the literature.^{3,9} The preference for the deltopectoral approach among international surgeons is due to the exposure provided and the avoidance of dissection of the axillary nerve, which is necessary for the anterolateral approach.¹⁰ However, some authors

have already demonstrated safety of the anterolateral approach as well as the low chance of axillary nerve injury.¹⁰⁻¹² Moreover, this approach facilitates exposure of the lateral humeral surface and identification of major tuberosity fractures that are subsequently dislocated.¹⁰

The anterolateral approach makes medial exposure of the shoulder difficult and should be avoided in fractures with dislocations.¹⁰ Thus, this study showed that shoulder surgery specialization training time longer than 5 years led to the more frequent selection of the deltopectoral approach than the anterolateral approach. Thus, specialization and longer experience positively influenced the appropriate choice of approach.

Most residents who recently graduated from shoulder surgery specialized also opted for the deltopectoral approach, which shows a tendency of training centers to teach this approach to surgeons. Most surgeons chose to use a blocked plate. The blocked implant is the option of choice in the osteosynthesis of proximal humeral fractures since most cases are osteoporotic patients or those with comminuted fractures. Blocked implants provide greater biomechanical stability.¹ Osteosynthesis also has a lower rate of complications than arthroplasty, especially reverse osteosynthesis. Moreover, in cases of failure after osteosynthesis, conventional or reverse arthroplasty is still possible with little functional difference and similar complication rates compared to those for primary reverse prosthesis in fracture treatment.¹³

The complication most commonly reported by the respondents was decreased range of motion, especially by shoulder surgery specialists, a finding that corroborates with the literature. Decreased range of motion, function, and shoulder strength are frequent complications after proximal humeral fractures, especially in cases of comminuted/Neer IV fractures and cases of osteonecrosis with joint penetration by screws.^{3,14,15}

Axillary nerve neuropraxia was poorly reported by surgeons. Furthermore, despite being much feared in the anterolateral approach, no respondent who performed this approach reported that axillary nerve lesion was the more frequent complication. The literature also shows that regardless of the technique used (MIPO or direct exposure) performed with the anterolateral approach, there is little chance of nerve injury.^{16,17}

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EFFECT OF SUBSCAPULARIS TEARS ON FUNCTIONAL SCORES OF PATIENTS UNDERGOING ROTATOR CUFF REPAIR

INFLUÊNCIA DA LESÃO DO SUBSCAPULAR NOS ESCORES FUNCIONAIS DE PACIENTES SUBMETIDOS A REPARO DO MANGUITO ROTADOR

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ABSTRACT

Objective: To evaluate the influence of partial- and full-thickness upper third subscapularis tendon tears on the functional scores of patients undergoing arthroscopic rotator cuff repair. **Methods:** Patients who underwent arthroscopic rotator cuff repair were divided into three groups according to the subscapularis tendon condition: intact, partial-thickness tear, or full-thickness upper third tear. Functional scores were compared among groups. Second, the influence of biceps and infraspinatus tears on the scores was tested using multivariate regression analysis. **Results:** We evaluated 307 shoulders in 297 patients. Full-thickness upper third subscapularis tears presented significantly worse scores than intact tendons. Partial-thickness tears had scores that did not differ significantly from those of the other groups. Patients with full-thickness upper third tears presented a greater rate of injured and unstable biceps tendons. The multivariate analysis showed that biceps and infraspinatus tendon tears did not influence the scores or the intergroup comparison. **Conclusion:** Full-thickness upper third subscapularis tendon tears presented worse functional scores than intact subscapularis tendons among patients undergoing posterolateral rotator cuff repair. Patients with full-thickness subscapularis tears were more likely to suffer biceps tears, but this fact did not influence functional scores. **Level of Evidence I; Clinical randomized trial**

Keywords: Rotator cuff, Arthroscopy, Injury .

RESUMO

Objetivo: Avaliar a influência das lesões do terço superior do tendão subescapular nos escores funcionais de pacientes submetidos ao reparo artroscópico do manguito. **Métodos:** Divisão em três grupos, conforme condição do tendão subescapular: intacto; ruptura de espessura parcial ou ruptura do terço superior de espessura total. Comparamos escores funcionais. Em seguida, a influência das lesões do bíceps e do infraespinhal nos escores foi testada através de análise de regressão multivariada. **Resultados:** Avaliamos 307 ombros em 297 pacientes. Rupturas subescapulares no terço superior de espessura total apresentaram escores significativamente piores aos pacientes com tendão intacto. Rupturas de espessura parcial apresentaram escore sem diferença significativa em relação aos demais. Pacientes com rupturas do terço superior de espessura total apresentaram maior taxa de lesão e instabilidade tendínea do bíceps. Análise multivariada mostrou que as rupturas tendíneas do bíceps e infraespinhal não influenciaram os escores. **Conclusão:** Pacientes com lesão do terço superior de espessura total do tendão do subescapular apresentaram escores funcionais piores do que pacientes com tendão intacto submetidos ao reparo artroscópico posterossuperior do manguito. Pacientes com rupturas do subescapular com espessura total foram mais propensos a apresentar rupturas do bíceps, sem influenciar escores funcionais. **Nível de Evidência I, Estudo clínico randomizado.**

Descritores: Manguito Rotador. Artroscopia. Lesão.

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INTRODUCTION

Rotator cuff tendinopathy is the main reason to visit a specialized shoulder outpatient clinic,¹ and 20% of the population have a tear in these tendons.² The number of surgeries for cuff tear repair is growing^{3,4} causing high economic impacts.⁵ Among the tendons affected, the subscapularis tendon has received less attention in the orthopedic literature.⁶ Around 1% of all rotator cuff tears affect isolately the subscapularis tendon,^{7,8} while more than half

of patients with supraspinatus tears also present associated subscapularis tears.^{9,10}

The biomechanical importance of the subscapularis tendon has been described. Tears affecting 50% of the tendon extension result in increased anterior-superior glenohumeral translation.¹¹ The chances of pseudoparalysis occurring in massive rotator cuff tears are higher in tears affecting the entire tendon.¹² Meanwhile, clinical research focusing solely on the evaluation of massive rotator cuff tears has

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The study was conducted at the Universidade de São Paulo, Hospital das Clínicas do HCFMUSP, Faculdade de Medicina, Instituto de Ortopedia e Traumatologia, Grupo de Ombro e Cotovelo, São Paulo, SP, Brazil.

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not observed any statistical difference between patients with and without subscapularis tears¹³.

The majority of tears affecting the subscapularis, either partial-thickness or full-thickness, involves only the upper third of the tendon.¹⁴ The clinical repercussions of this type of lesion have not yet been described in the literature. The aim of this study was to evaluate the influence of an upper third tear of the subscapularis on preoperative functional scores, according to the American Shoulder and Elbow Surgeons (ASES) scale¹⁵ in patients undergoing arthroscopic posterolateral rotator cuff repair.

METHODS

Study Design and Setting

This was a retrospective cohort study that compared the functional scores of three groups of patients according to the subscapularis tendon characteristics evaluated arthroscopically: intact tendon, partial-thickness tear, or full-thickness upper third tear. The patients included underwent arthroscopy for the treatment of rotator cuff tears from January 2013 to May 2017 and had their shoulder function analyzed one week before surgery according to the American Shoulder and Elbow Surgeons (ASES) scale. All patients had undergone preoperative magnetic resonance imaging (MRI), without the use of intraarticular contrast, in a 1.5T device. Patients with isolated tear of the subscapularis, rotator cuff arthropathy, moderate or severe glenohumeral arthrosis according to Samilson and Prieto,¹⁶ and previous shoulder surgery were not included.

Variables analyzed

The following patient-related variables were registered: age, sex, side affected, smoking, diabetes, work-related problems and previous trauma. The tear-related variables included: subscapularis tendon condition (intact, partial-thickness tear, full-thickness upper third tear); supraspinatus and infraspinatus tendons conditions (intact, partial bursal tear, partial articular tear or full-thickness tear); retraction of the supraspinatus and infraspinatus tendons, according to the classification proposed by Boileau et al.¹⁷ (Stage I - minor retraction; Stage II - moderate retraction; Stage III - severe retraction; Stage IV: massive tear); the long head of the biceps tendon condition and stability; and degree of fatty degeneration of the subscapularis, supraspinatus and infraspinatus muscles, according to Fuchs et al.¹⁸ All the tear-related variables were determined by arthroscopic inspection, with the exception of muscle fatty degeneration.

The functional evaluations were performed one week before the surgical procedure, according to the ASES scale (0 to 100 points)¹⁵. This scale includes both a pain component ranging from 0 to 10 points, accounting for 50% of the overall score, and a functional component based on patient-responses for ten daily living questions, accounting for the other 50%.

Magnetic resonance imaging

The MRI exams were performed in a 1.5 Tesla Magneto, through a dedicated shoulder coil. The shoulder image acquisition protocol included coronal oblique proton density weighted images (RT/ET, 2,800/38; FOV 14 cm; slice thickness 3.5 mm; interslice gap 0.4 mm; matrix 320 x 256), axial, oblique coronal and oblique sagittal T2-weighted fat saturated images (RT/ET, 3,400/50; FOV, 14 cm; slice thickness, 3.5 mm; interslice gap 0.4 mm; matrix, 256 x 256) and oblique sagittal T1-weighted images (RT/ET, 780/15; FOV 14 cm; slice thickness 3.5 mm; interslice gap 0.4 mm; matrix 320 x 256). No intraarticular or intravenous paramagnetic contrast (gadolinium) was used.

Arthroscopy

The procedures were performed under general anesthesia combined with interscalene block. The patients were placed in the beach chair position, and the conventional portals (posterior, anterior and lateral) were used. With the 30° arthroscope positioned in the posterior portal, the appearance of the subscapularis tendon was inspected using the lever-push maneuver¹⁹ in all cases. Through the anterior and anterolateral portals, the tendinous insertion was palpated, using a probe where necessary. In cases where the visualization of the subscapularis was restricted by the biceps tendon, due to instability or partial tear, it was debrided and tenotomized. The other variables described previously were inspected in standardized form.

Statistical analysis

Continuous variables were tested for normality using the Kolmogorov-Smirnov test, and the homogeneity was evaluated using the Levene test. Continuous variables were presented as means and standard deviation, and the categorical variables as absolute values and percentages. The functional results were compared between the groups using ANOVA with Bonferroni's post-hoc test. Preoperative clinical variables presenting differences with a p value < 0.1 were analyzed using multivariate regression analysis to test their association with ASES scores, excluding possible confounding factors. The analysis was performed using the software SPSS version 21.0, with a level of significance of 5%.

RESULTS

We performed 453 rotator cuff repairs during the period analyzed in the study. The following patients were not included in the analysis: open surgeries (54), isolated subscapularis tear (5), reoperations (3), subscapularis tears affecting more than the upper third (40) and those without preoperative clinical information (44). The final cohort comprehended 307 shoulders from 297 patients.

The patient-related variables did not present any difference between the groups (Table 1). Likewise, there were no statistically significant differences regarding the supraspinatus and infraspinatus tears characteristics (Table 2). Patients with a full-thickness subscapularis

Table 1. Patient-related variables divided according to the study groups.

	Intact Tendon (n=122)	Partial Tear (n=131)	Full-thickness tears (n=54)	Overall (n=307)	p
Age (n sd)	55,2 ± 7,9	57,1 ± 8,7	55,4 ± 8,5	56,1 ± 8,4	0,164
Sex [n (%)]					
Male	59 (48,4)	51 (38,9)	18 (33,3)	128 (41,7)	0,123
Female	63 (51,6)	80 (61,1)	36 (66,7)	179 (58,3)	
Side [n (%)]					
Right	84 (68,9)	96 (73,3)	40 (74,1)	220 (71,7)	0,671
Left	38 (31,1)	35 (26,7)	14 (25,9)	87 (28,3)	
Smoking [n (%)]					
Smoker	15 (12,3)	21 (16,0)	5 (9,3)	41 (13,4)	0,508
Former smoker	17 (13,9)	19 (14,5)	6 (11,1)	42 (13,7)	
No	90 (73,8)	91 (69,5)	43 (79,6)	224 (73,0)	
Diabetes [n (%)]					
Yes	18 (14,8)	14 (10,7)	8 (14,8)	40 (13,0)	0,575
No	104 (85,2)	117 (89,3)	46 (85,2)	267 (87,0)	
Work-related problems [n (%)]					
Yes	28 (23,0)	20 (15,3)	7 (13,0)	55 (17,9)	0,184
No	94 (77,0)	111 (84,7)	47 (87,0)	252 (82,1)	
Traumatic tear [n (%)]					
Yes	8 (6,6)	8 (6,1)	6 (11,1)	22 (7,2)	0,460
No	114 (93,4)	123 (93,9)	48 (88,9)	285 (92,8)	

Table 2. Tear-related variables divided according to the study groups.

	Intact tendon (n=122)	Partial tear (n=131)	Full-thickness tear (n=54)	Overall (n=307)	p
Supraspinatus tear					
Bursal partial tear	8 (6,6)	9 (6,9)	3 (5,6)	20 (6,5)	0,262
Articular partial tear	6 (4,9)	2 (1,5)	2 (3,7)	10 (3,3)	
Full-thickness tear	108 (88,5)	120 (91,6)	49 (90,7)	277 (90,2)	
Supraspinatus retraction					
Stage I	48 (39,3)	48 (36,6)	16 (29,6)	112 (36,5)	0,942
Stage II	38 (31,1)	47 (35,9)	22 (40,7)	107 (34,9)	
Stage III	21 (17,2)	23 (17,6)	11 (20,4)	55 (17,9)	
Stage IV	15 (12,3)	13 (9,9)	5 (9,3)	33 (10,7)	
Fuchs classification (supraspinatus)					
I	100 (82,0)	102 (77,9)	40 (74,1)	242 (78,8)	0,566
II	16 (13,1)	21 (16,0)	8 (14,8)	45 (14,7)	
III	6 (4,9)	8 (6,1)	6 (11,1)	20 (6,5)	
Infraspinatus tear					
Intact	101 (82,8)	100 (76,3)	32 (59,3)	233 (75,9)	0,063
Bursal partial tear	0 (0,0)	2 (1,5)	1 (1,9)	3 (1,0)	
Articular partial tear	4 (3,3)	3 (2,3)	2 (3,7)	9 (2,9)	
Full-thickness tear	17 (13,9)	26 (19,8)	19 (35,2)	62 (20,2)	
Infraspinatus retraction					
Stage I	105 (86,1)	113 (86,3)	41 (75,9)	259 (84,4)	0,051
Stage II	10 (8,2)	9 (6,9)	7 (13,0)	26 (8,5)	
Stage III	7 (5,7)	7 (5,3)	6 (11,1)	10 (6,5)	
Stage IV	0 (0,0)	2 (1,5)	0 (0,0)	2 (0,7)	
Fuchs classification (infraspinatus)					
I	106 (86,9)	107 (81,7)	44 (81,5)	256 (83,7)	0,438
II	11 (9,0)	16 (12,2)	9 (16,7)	36 (11,7)	
III	5 (4,1)	8 (6,1)	1 (1,9)	14 (4,6)	
Longe head of the biceps tear					
Intact	77 (63,1)	66 (50,4)	13 (24,1)	156 (50,8)	<0,001
Partial tear < 50%	29 (23,8)	33 (25,2)	17 (31,5)	79 (25,7)	
Partial tear > 50%	11 (9,0)	20 (15,3)	13 (24,1)	44 (14,3)	
Auto-tenotomized	5 (4,1)	12 (9,2)	11 (20,4)	28 (9,1)	
Long head of the biceps stability					
Stable	94 (77,0)	75 (56,5)	11 (20,4)	179 (58,3)	<0,001
Unstable	20 (16,4)	31 (23,7)	19 (35,2)	70 (22,8)	
Dislocated	3 (2,5)	14 (10,7)	13 (24,1)	30 (9,8)	
Not applicable	5 (4,1)	12 (9,2)	11 (20,4)	28 (9,1)	
Fuchs classification (subscapularis)					
I	113 (92,6)	118 (90,1)	49 (90,7)	280 (91,2)	0,502
II	6 (4,9)	8 (6,1)	5 (9,3)	19 (6,2)	
III	3 (2,5)	5 (3,8)	0 (0,0)	8 (2,6)	

tear presented a greater rate of injured and unstable biceps tendons than patients with an intact or a partial-thickness tear of the subscapularis ($p < 0.001$) (Table 2).

Patients with full-thickness upper third subscapularis tears (34.2 ± 19.8) presented significantly worse ASES scores than patients with an intact tendon (42.3 ± 18.2 ; $p = 0.025$) (Table 3). Patients with a partial-thickness tear presented a $39.8 (\pm 18.7)$ mean score, with no statistically significant difference compared to the other groups. The multiple regression analysis included subscapularis tears, infraspinatus tears, and biceps tears as independent variables to test

their association with the ASES scores (dependent variable). There were no statistically significant association between infraspinatus and biceps characteristics with functional scores, whereas subscapularis tears were associated with a worse ASES score (Table 4).

Table 3. Correlation between type of subscapularis tears and ASES scores.

Group	ASES (mean sd)
Intact tendon(n=122)	42,3 18,2
Partial tear(n=131)	39,8 18,7
Full-thickness tear (n=54)	34,2 19,8
Overall (n=307)	39,8 18,9

p Global=0.030. Post-hoc Bonferroni's test: Without tears vs Full-thickness tear $p=0.025$. Remainder $p>0.05$.

Table 4. Multiple regression analysis for control of confounding factors.

	Coefficient	Confidence interval 95%		p
		Lower	Upper	
Subscapularis tear	-1,113	-1,929	-0,296	0,008
Long head of the biceps tear	0,170	-0,562	0,902	0,648
Long head of the biceps stability	-0,575	-1,348	0,197	0,144
Infraspinatus tear	-0,01	-0,944	0,925	0,984
Infraspinatus retraction	0,569	-1,907	3,046	0,651

DISCUSSION

The subscapularis is the largest rotator cuff muscle, and is very important in the balance of forces of the glenohumeral joint.²⁰ Despite this fact, it was long neglected in the orthopedic literature, being named "forgotten tendon".²⁰ Isolated subscapularis tears are rare, representing 1% of all tears.^{7,8} However, their presence associated with supraspinatus tear are observed in more than 50% of arthroscopic rotator cuff repairs.^{9,10} Furukawa et al.¹⁴ observed subscapularis tear in 69% of their series, the majority consisting of partial- (35%) or full-thickness upper third tears (25%). MRI presents low sensitivity in the detection of these tears, especially in partial-thickness ones, which makes difficult the adequate diagnosis and treatment.¹⁰ In massive tears, the involvement of more than 50% of the tendon extension results in poorer function and increases the chance of pseudoparalysis.¹² However, there is a lack of data in the literature on the clinical impact of the most frequent tears, which affect only the upper portion of the tendon.

Our results demonstrate that patients with a full-thickness upper third tear of the subscapularis present significantly poorer functional results, based on the ASES scale, than patients with an intact tendon. The mean functional scores of patients with full-thickness tears were 8.1 points lower than the scores of patients with intact tendons. Patients with partial-thickness tears of the subscapularis performed worse than patients with intact tendons and better than patients with full-thickness tears, but the differences did not reach statistical significance. In contrast to our findings, Park et al. did not observe any difference in the ASES scores between patients with intact subscapularis tendons (44.4 ± 20.1), those with involvement of the upper half of the subscapularis (38.9 ± 19.7) and those with involvement of the entire subscapularis tendon (43.1 ± 26.7). In comparison to our study, their series included a smaller number of subjects (92 patients) and analyzed only massive rotator cuff tears with pseudoparalysis. Furthermore, their study did not evaluate the influence of partial-thickness tears. To our knowledge, our study is the first to evaluate the influence of upper third subscapularis tendon tears on preoperative functional scores among patients undergoing arthroscopic posterolateral rotator cuff repair. These data provide further evidence on the clinical relevance of upper third subscapularis tears.

We should emphasize that the difference of 8.1 points, although statistically significant, did not reach the minimum clinically important difference, which has been found to be 12 points for the ASES scale.²¹ Nevertheless, we could demonstrate that subscapularis tears influenced directly the functional scores of patients presenting baseline impaired scores due to posterosuperior rotator cuff tears. The ASES scale has been used in previous studies analysing subscapularis tears.^{13,22} The scale is the second most widely used for evaluation of rotator cuff tears, and was used in 59% of studies in journals with greatest impact²³, presenting high reliability, validity and sensitivity to detect significant clinical differences.²⁴ On the other hand, for the analyses of subtypes of rotator cuff tear it may not present sufficient sensitivity. We stress that the ASES scale does not have a specific domain for strength, and even scales that do include this evaluation, such as the Constant-Murley and the UCLA scales, do so only for elevation strength, focusing on the supraspinatus tendon.

The groups compared in this study presented significant differences with regard to the presence of biceps tears. This result was expected, given the anatomical proximity between the upper portion of the subscapularis tendon, the medial pulley, and the long head of the biceps. The association between subscapularis tears and involvement of the biceps tendon has already been described.^{9,10} The lack of association between biceps tears and the ASES scores, found in the multiple regression analysis, excluded the influence of biceps tears as confounding factors in the subscapularis analysis. Similarly, infraspinatus tendon tears, which presented a trend to be higher in patients with full-thickness subscapularis tears, were not associated with the ASES scores, and did not influence the comparison between the groups.

Our study had some limitations. We evaluated only patients in the preoperative period with refractory shoulder pain, and our findings cannot be safely transposed to the population with asymptomatic tears. The groups were unbalanced regarding the rate of injured and unstable biceps tendons, what could have influenced the comparison between the groups. However, multiple regression analysis showed no influence of this variable on functional scores. Although partial-thickness subscapularis tears did not influence functional scores, this study did not evaluate tears evolution and risk factors for tear progression. Therefore, we cannot set specific recommendations on the management of partial tears. The strengths of the study included the novelty of the research, the large casuistic and the use of arthroscopy to define the study groups, considered the gold standard diagnostic method.²⁵ Furthermore, the inclusion of only upper third subscapularis tears enhanced the study internal validity. In conclusion, we could demonstrate that the functional scores of patients undergoing posterosuperior rotator cuff repair are directly influenced by the presence of full-thickness upper third subscapularis tears. Additionally, patients with full-thickness subscapularis tears presented a higher rate of biceps tears and biceps instability, but this fact did not influence functional scores. Partial-thickness tears did not affect the clinical results significantly. The clinical relevance of full-thickness upper third subscapularis tears in association with posterosuperior rotator cuff tears was demonstrated, and these data can help surgeons during decision making on the repair of subscapularis tears.

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EFFECTS OF SAGITTAL BALANCE DIFFERENCES ON SPONDYLOLISTHESIS

EFEITOS DAS DIFERENÇAS DO EQUILÍBRIO SAGITAL NA ESPONDILOLISTESE

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ABSTRACT

Objectives: This study aimed to compare the lumbar lordosis (LL) and spinopelvic parameters of patients with stage 1–2 spondylolisthesis to those of the normal population and demonstrate the importance of these parameters in sagittal balance. **Methods:** The lumbosacral parameters on the lateral radiographs of a total of 125 patients were retrospectively compared. Lumbosacral parameters including pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis angle (LLA), L5 incidence (L5I), L5 slope (L5S), and sacral table angle (STA) were compared between groups. **Results:** Comparison of the parameters between groups revealed no sex-based differences ($p > 0.05$). **Conclusions:** Abnormal sagittal spinopelvic parameters are commonly examined for their effects on the development of spondylolisthesis and should be used in routine practice. We found that the low SS values in our study, unlike those of other similar studies, may be a compensatory mechanism developed to reduce pain and maintain sagittal balance. **Level of Evidence II; retrospective study.**

Keywords: Spondylolisthesis. Lumbar vertebrae. Lordosis.

RESUMO

Objetivo: Nosso objetivo é comparar os valores dos parâmetros de LL e espinopélvicos de pacientes com espondilolistese estágios 1 e 2 com a população normal e mostrar a importância desses parâmetros com relação ao balanço sagital. **Métodos:** As radiografias laterais de um total de 125 pacientes foram avaliadas comparativa e retrospectivamente quanto aos parâmetros lombossacrais. Os parâmetros usados para a avaliação foram IP, InP, IS, ângulo de lordose lombar (ALL), incidência de L5 (In-L5), inclinação L5 (I-L5) e ângulo do platô sacral (APS). **Resultados:** Os parâmetros lombossacrais IP, InP, IS, ALL, incidência de L5, I-L5 e APS foram comparados entre os grupos controle e espondilolistese. Quando cada parâmetro foi comparado entre homens e mulheres para avaliar o efeito do sexo nos grupos espondilolistese e controle, não houve diferença significativa entre as medidas de ambos os sexos ($p > 0,05$). **Conclusões:** Os parâmetros sagitais espinopélvicos anormais são usados comumente no presente por seus efeitos sobre o desenvolvimento da espondilolistese e devem fazer parte da prática de rotina. Segundo as avaliações, os baixos valores de IS em nosso estudo, que diferiram de estudos similares, podem ser um mecanismo de compensação desenvolvido pelos pacientes para reduzir a dor e manter o equilíbrio sagital. **Nível de Evidência II; Estudo retrospectivo.**

Descritores: Espondilolistese. Vértebras lombares. Lordose.

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INTRODUCTION

The humans are the only living creatures which have lordotic lumbar curvature and lumbar lordosis (LL) is one of the most important parameters to be examined in sagittal balance evaluations due to its variability.¹ Lumbar lordosis, which varies depending on the shape and the position of the pelvis and the relationship between sacral slope (SS) and pelvic tilt (PT), is thought to be the main mechanical cause of the degenerative diseases of the spine.²

The loss of the LL is an expected finding with the changes in the center of gravity in the aging spine and degenerative disc diseases, which cause spondylolysis, spondylolisthesis, and collapse on

discs. With the activation of the other compensatory mechanisms accompanying the loss of lumbar lordosis, the thoracic, thoracolumbar and sacral angles would change. The two basic variables affected in the compensation mechanisms are pelvic tilt (PT) and SS with the change of LL in degenerative processes. The term pelvic incidence (PI) is equal to the sum of the two variables, PT and SS.¹ In the classification of the spinal study group, spondylolisthesis was classified as six types, and spinopelvic parameters which were assessed using the angle of the shifting, PI, SS, PT and sagittal vertical line of C7 were taken into account when evaluating these types. In this classification, low-grade spondylolisthesis was

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

The study was conducted at Abant İzzet Baysal University, İzzet Baysal Training and Research Hospital, Bolu, Turkey.

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classified as meyerding stage 0-2, shift below 50%; while high-grade spondylolisthesis as meyerding >3 and shift >50%. Today, this classification is commonly used.³

Abnormal PI and spinopelvic parameters play essential roles in the development and progression of many spinal diseases including spondylolysis, spondylolisthesis and various other spinal pathologies.⁴ Recent studies showed that pelvis morphology or PI and its orientation significantly affect the sagittal spinal geometry of LL especially, both in healthy and diseased states.⁵⁻⁶ Because PT and SS are variable parameters that are affected by the position, pelvic and other sagittal parameters should be assessed withstanding lateral radiographs.¹

Our aim in this study is to compare the values of the LL and spinopelvic parameters of patients with stage 1-2 spondylolisthesis to the normal population and to show the importance of these parameters regarding sagittal balance.

MATERIALS AND METHODS

This retrospective study was approved by the ethics committee of Bolu Abant Izzet Baysal University (20187/119). Participants were signed the informed consent form. Among the patients who referred to the neurosurgery outpatient clinic with the complaints of lumbar pain and sciatalgia between 2016 and 2017, seventy-five patients who had no spinal pathology detected with direct radiography (DR) and lumbar magnetic resonance imaging (MRI), and fifty patients with spondylolisthesis were included. The lateral radiographs of a total of 125 patients were evaluated comparatively and retrospectively concerning the lumbosacral parameters.

The exclusion criteria were undergone spinal surgery, lumbar infection, tumor, hip joint disease; the inclusion criteria were the age of 18-70 years and the presence of the lateral radiography which was optimal for the lumbosacral parameter measurement.

A single senior radiologist obtained all lumbosacral parameters on the lateral radiographs obtained on the standing patients via the hospital PACS (imaging) system. The parameters we used for the evaluation were PI, PT, SS, lumbar lordosis angle (LLA), L5 incidence (L5I), L5 slope (L5S) and sacral table angle (STA). PI was the angle between the vertical line passing through the middle point of the superior sacral end plate and the line connecting the femur head axis to this mid point; PT was the angle between the vertical line passing through the femur head axis and the line connecting the femur head axis to the sacral end plate midpoint; SS was the angle between the superior sacral end plate and the horizontal line; LLA was the angle formed by the intersection of the vertical lines from

each of the parallel lines which were drawn from the upper-end plates of the first lumbar vertebrae and the sacral vertebra ; L5I was the angle between the line perpendicular to the middle point of the superior L5 end plate and the femur head axis; L5S was the angle between the upper-end plate of the L5 vertebrae and the horizontal line and the STA was the angle between the superior end plates of the sacrum and the line of the posterior sacrum edge (Figure 1). Statistical analysis showed normal distribution in patient and healthy groups and independent sample T-test was performed for the comparison. It was considered significant when the P value was below 0.05. Independent sample T-test was used to assess the gender effect for each parameter, ANOVA test was used to assess the age effect.

RESULTS

A total of 125 patients, 50 with spondylolisthesis and 75 normal, included in the study ranged between the age of 18-70 years, with a mean age of 49 years. The spondylolisthesis group consisted of 12 males and 38 females and the healthy group consisted of 38 males and 37 females.

Lumbosacral parameters including PI, PT, SS, LLA, L5 incidence, L5S and STA values were compared in healthy and spondylolisthesis groups. Grade 1 listhesis was detected in 43 patients, and grade 2 listhesis was detected in 7 patients in the listhesis group, and when they were compared regarding the lumbosacral parameters, there was no significant difference.

PI, PT, LLA, L5I, L5S values were significantly higher, and STA was significantly lower in the patient group ($p < 0,05$). There was no significant difference in SS values between the two groups (Table1). When each parameter were compared between males and females to assess the gender effect in patient and healthy groups, there was no significant difference between males and females in the measurements. When the healthy and patient groups were divided into three subgroups as 18-39 years, 40-59 years and over 60 years old to evaluate the effect of the age; it was found that there was no significant difference between all age groups in all parameters in both groups.

DISCUSSION

In our study, there was a significant relationship between the development of spondylolisthesis, and the horizontal and retrovert position of the pelvis due to the increase in PI and PT values and the increased LLA, increased L5I and low STA values as the

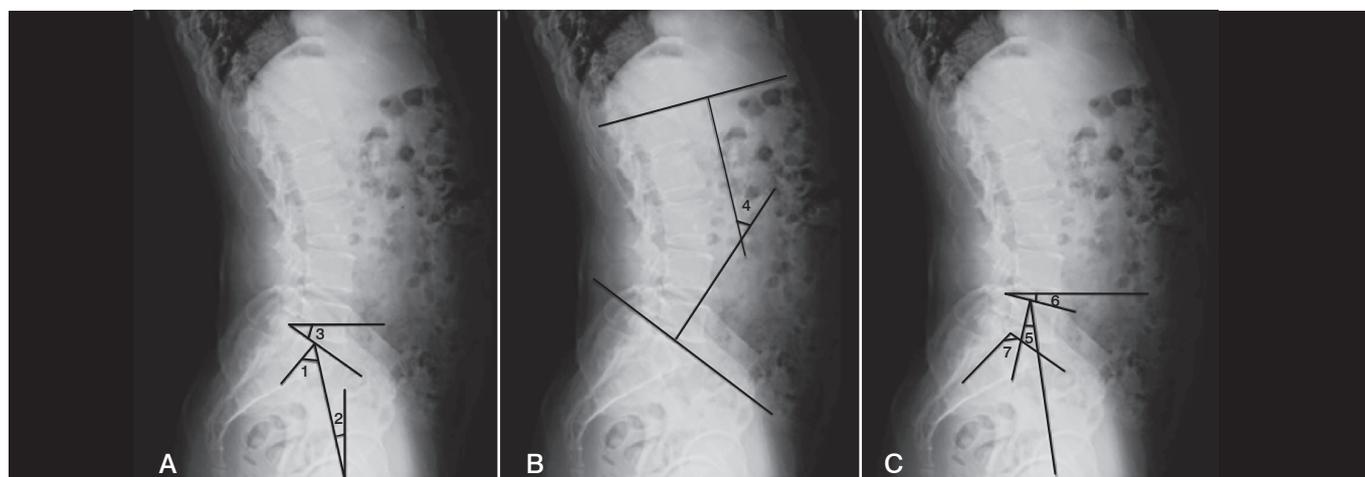


Figure 1. Sagittal lumbosacral parameters (a) 1:PI, 2:PT, 3:SS, (b) 4:LLA, (c) 5:L5I, 6:L5S, 7:STA.

Table 1. Lumbosacral parameters.

Lumbosacral parameters	in all parameters in both groups. Spondylolisthesis group	Normal group	*P value
Pelvic incidence	55 12,8	46 11,2	<0,001
Pelvic tilt	18,6 11,5	14,7 8,01	0,042
Sacral slope	37,7 13,32	34,8 7,9	0,134
Lumbar lordosis angle	52,9 13,3	48,2 11,8	0,042
L5 incidence	29,8 11,8	22,2 9,4	0,001
L5 slope	22,8 11,13	17,1 7,2	0,002
Sacral table angle	97,4 5,4	99,92 4,3	<0,004

Values are expressed as mean(SD). Significant differences of p values are emphasized in bold. *p<0.05 was accepted as statistically significant.

compensatory mechanisms. For this reason, spinopelvic parameters should be included in our routine practice.

In the last decade, the interest in sagittal balance and the researches into parameters related to sagittal balance has been increasing, especially relevant to scoliosis and other spinal deformities. Sagittal lumbosacral parameters have an essential role in the radiological evaluation of lumbar spinal pathologies such as spondylolysis, degenerative lumbar spondylolisthesis, and lumbar disc herniation, and developed the term of pelvic incidence (PI).^{7,8,9}

Whitesides et al. found that PI increased from 41.8° in normal adolescents to 64.5° in adults with isthmic spondylolisthesis, and there was a statistical correlation between sacral slope and PI values in spondylolisthesis patients.⁹ In the case of decreased PI values, the pelvis forms a vertical position, while the increase of the PI values causes the pelvis to form a horizontal position, and the force distribution of the secondary gravity on the vertebra varies regarding this.¹ It is known that the change in this force distribution increases the probability of spondylolysis, and the higher PI values found in the spondylolisthesis group in our study showed parallelism with the literature. Duval-Beaupere et al. also suggested that PI is effective in the formation of isthmic spondylolisthesis, and the larger PI and sacral slope could lead spine to shift.⁷ These findings suggest that PI is the primary etiologic factor in spondylolisthesis. In the study of Frederickson et al., spondylolysis was considered as pre-spondylolisthesis.^{10,11} In our study, the mean PI value was found to be 55 in the spondylolisthesis group, and it was significantly higher than the normal group (Table1).

PT, another parameter in our study, is a postural parameter that reflects the compensatory ability of the pelvis on the sagittal balance. Labelle et al. showed a correlation between the increase in the severity of spondylolisthesis and PI, SS, PT and lumbar lordosis.¹² Low PT values were associated with pelvic anteversion, and high values were associated with retroversion, and retrograde and horizontal placement of the pelvis was associated with the advanced stage spondylolisthesis.¹³ In our study, the PT values of the patients with grade 1 and two spondylolisthesis were found to be significantly higher than the healthy group.

PI is equal to the sum of PT and SS. Since PT has a narrow range of angles, usually between 10-15 degrees, it has been found that when pelvic incidence increases, the sacral slope increases more than pelvic tilt.¹⁰ The relationship between lumbar lordosis (LL) and sacral slope (SS) was first noted by Stagnara.¹⁴ The greater the SS, the greater the LL becomes (the dynamic waist). On the contrary, when the LL gets flattened (the static waist), the SS becomes

horizontal. Roussouly et al. reported that high PI values in low-grade developmental spondylolisthesis (Meyerding 0-2) accompany high SS values (> 40 degrees),¹¹ Dissimilar to the literature, we found that there was no change in SS when the PI was increased in our study. This result suggests us that with the unchanging SS as a result of the increase of PI, LL and PT, sagittal balance is tried to be maintained in a relatively compensatory manner.

Lumbar lordosis angle is the angle formed by the intersection of the vertical lines from each of the parallel lines which were drawn from the upper-end plates of the L1 vertebra and the S1 vertebra in the lateral lumbar radiography, and it has been reported to be correlated strongly with spinal instability.^{15,16} In the literature, it was reported that as PI values increased, LLA also increased to maintain the sagittal balance, and sacrum formed a horizontal position secondary to this increase.¹ In our study, PI and LLA values were found significantly higher in the listhesis group in accordance with the literature.

Roussouly et al., who described the term L5I for the first time, stated that L5I is associated with isthmic lumbar spondylolisthesis.^{11,12,13} In our data, L5I values were significantly higher in the spondylolisthesis group compatible with the other parameters.

In the study conducted by Yukawa et al. thoracic kyphosis and LL showed no significant change between 20 and 60 years of age, but both of them decreased significantly over 70 years of age in Japanese society. PT increases with age, while SS decreases with age.¹⁷ In many other studies to evaluate sagittal spinopelvic parameters, lumbosacral parameters were shown to remain relatively constant throughout life after skeletal maturation.¹⁸ Kim et al. found that there was no significant difference in PI, PT, and SS values between young and old males.¹⁹ Similarly, in our study, there was no significant difference between lumbosacral parameters in terms of age and gender in both healthy and diseased patients.

Inoue et al. showed a significant decrease in STA values of the patients with spondylolysis and spondylolisthesis.²⁰ Whitesides et al. found that individuals with lower STA had a higher probability of developing a pars defect than PI, and that the relation of the STA and the lumbar spondylolysis was stronger. They found that low STA values predisposed to spondylolysis by an increase in shear force resulting in producing more mechanical stress in pars interarticularis.⁹ A more vertical sacral table (i.e. a lower STA value) means that there is higher shear stress on the disc and therefore a greater tendency to shift forward in the upright position. In our study, we found that low STA values increased predisposition to spondylolisthesis in accordance with the literature.

CONCLUSION

Abnormal sagittal spinopelvic parameters; such as the horizontal and retrovert position of the pelvis due to the increase in PI and PT values obtained by the direct radiographs in standing position, increased LL angle, increased L5I and low STA values as of the compensatory mechanism; are the spinopelvic parameters which are commonly used nowadays for their effects on the development of the spondylolisthesis and should take place in the routine practice. It was assessed that low SS values in our study, which were different from other similar studies, may be a compensation mechanism developed by patients to reduce pain and maintain the sagittal balance.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. YD (0000-0002-0767-6359)* performed the surgeries and contributed to the study concept and design; ZD (0000-0003-1996-1568)* analyzed the data and conducted the radiological analysis; ED (0000-0002-0202-8555)* performed the statistical analysis and contributed to the study's intellectual concept. *ORCID (Open Researcher and Contributor ID).

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NORMATIVE ISOMETRIC HIP MUSCLE FORCE VALUES ASSESSED BY A MANUAL DYNAMOMETER

VALORES NORMATIVOS DA FORÇA ISOMÉTRICA DOS MÚSCULOS DO QUADRIL PELA DINAMOMETRIA MANUAL

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ABSTRACT

Objective: Hand-held dynamometry is a quantitative and accessible means of determining the isometric force of muscle groups. **Methods:** A total of 52 women aged 20–29 years with no complaints of hip pain who were sedentary or sporadically active and had a body mass index of 18.5–24.99 kg/m² were included. All participants underwent bilateral assessments using hand-held dynamometry of the flexor, extensor, adductor, and abductor muscles as well as the internal and external rotator hip muscles. All hip movements were measured. All contraction data collected by the dynamometer are expressed in kilograms, normalized according to body weight, and expressed as percentages. **Results:** The flexor muscles exhibited an isometric muscle force of 38.54% of body weight versus a muscle force of 27.04% for the extensor muscles, 16.89% for the adductors, 16.85% for the abductors, and 17.09% for the external rotators, and 23.82% for the internal rotators. **Conclusion:** Standardization of isometric strength values according to body weight proved feasible. This result is important for clinical practice since it allows the establishment of patterns of normality and criteria for discharge, return to sports, or assessment of the impact of injuries in terms of loss of muscle strength. **Level of evidence: III, Development of diagnostic criteria on consecutive patients (with universally applied reference “gold” standard).**

Keywords: Hip. Muscle strength dynamometer. Muscle strength.

RESUMO

Objetivo: Determinar valores da força dos músculos do quadril em mulheres jovens, normalizados pela porcentagem do peso corporal. **Métodos:** Incluídas 52 mulheres entre 20 e 29 anos, sem queixas algicas no quadril, consideradas sedentárias ou irregularmente ativas e com IMC entre 18,50 e 24,99 kg/m². Todas participantes foram submetidas a avaliação bilateral por dinamometria manual para músculos flexores, extensores, adutores, abdutores, rotadores internos e externos do quadril, os valores foram expressos em forma de porcentagem do peso corporal. **Resultados:** Não foi encontrada diferença estatística na força entre lados dominante e não dominante. Os músculos flexores apresentaram força muscular isométrica correspondente a 38,54% do peso corporal, já extensores apresentaram 27,04%. Os adutores com 16,89% e abdutores com 16,85% do peso corporal, não apresentando diferença estatística entre eles. Os rotadores externos atingiram 17,09% do peso corporal e rotadores internos chegaram a 23,82%. **Conclusão:** Mostrou-se possível a padronização e obtenção dos valores de força isométrica em relação ao peso corporal. Para prática clínica este resultado é importante por possibilitar conhecimento de padrões de normalidade e utilizar estes dados como critérios de alta, retorno ao esporte e avaliação da repercussão de diversas lesões na perda de força muscular. **Nível de evidência III, Estudo de pacientes não consecutivos sem padrão de referência “ouro” aplicado uniformemente.**

Descritores: Quadril. Dinamômetro de Força Muscular. Força Muscular.

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INTRODUCTION

Assessment of muscle force face of parameters of normality can provide criteria for hospital discharge for operated patients or even for the return to sport. Assessing muscle force, however, may not always be straightforward, since numerous techniques exist, each with its own inherent particularities.¹

A hand-held dynamometer is one of the electronic means of assessing muscle force.¹⁻³ The method of quantifying the force of the hip muscles, particularly when the assessment is always performed by the same examiner. When this criterion is not observed, the reproducibility of the method becomes questionable. Factors such as patient positioning and compensation from other muscles further

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The study was conducted at the Physical Therapy Department of Irmandade da Santa Casa de Misericórdia de São Paulo, SP, Brazil.

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affect the comparability of results. Also, inadequate positioning of the patient or compensation of movements during the test are factors which can hamper inter-examiner comparability.^{4,5}

Studies have described methods for dynamometer fixation, reducing the risk of examiner bias, thereby increasing the reliability of this approach for measuring muscle force.⁶⁻⁸ However, normative values for many muscle groups are lacking. Furthermore, the majority of studies report results based on linear regression calculations, hampering the clinical application of the data obtained.⁹⁻¹¹

In order to determine normative values, body weight, age, sex, and physical fitness should be taken into account when analyzing the data obtained, given the large disparity in values found between men and women, young and older adults, or athletes and sedentary individuals. However, the ease and convenience in applying the test justify the need for predictive values for athlete and non-athletes.⁹⁻¹¹ Therefore, the objective of the present study was to determine values of hip muscle force in young women, with normal percentage of body weight.

MATERIALS AND METHODS

Main outcome measures

All hip movements were measured. All contraction data collected by the dynamometer were expressed in kilograms and normalized according to body weight and expressed as percentages.

Design

This cross-sectional study was conducted by the physiotherapy research team at a tertiary hospital with a public service located in São Paulo city after approval by the Research Ethics Committee under protocol number: 25567913.0.0000.5479.

Setting

Sampling was performed by agreement, all participants were recruited in the course of physical therapy at a university and evaluated in a physiotherapy research laboratory, where they initially answered an evaluation assessment about their health history and physical activity practice, after responding to the questionnaires the participants were submitted to manual dynamometry with two evaluators.

They were duly informed about the procedures to be performed and signed the Free and Informed Consent Form. Recruitment and data collection was performed between March 2015 and January 2016

Participants

Participants that met the following criteria were included: aged 20-29 years, To avoid the selection of participants with different body composition, we only included participants with body mass index of between 18.50 and 24.99 kg/m², and classified as sedentary or sporadically active according to the International Physical Activity Questionnaire (IPAQ), which determines the type and amount of regular physical exercise practiced by participants.¹² The IPAQ questionnaire was used for selecting sedentary participants or those with minimal physic activity only, excluding athletes or those with regular physical activity. Therefore, only participants with the same pattern of muscle strength were selected.

Participants were excluded if they had pain or previous injury on the hip or lumbar spine, as were those who had rheumatic, heart, lung, neurological conditions or severe limitations in range of movement, which were reported during the completion of the assessment about the health history, without an additional specific physical examination.

Interventions

Data were collected on age, weight, height and dominant leg of the participants, who all answered the IPAQ questionnaire¹³ and

were subsequently submitted to muscle force testing performed in physiotherapy research laboratory located in São Paulo city. A hand-held dynamometer was used, along with an examination table, a fixation belt and a triple suction cup device. The hand-held dynamometer (MICROFET 2, Draper, USA) was attached to the limb under test using a rigid belt secured to the wall by a suction cup for dynamometer fixation. The movements requested for the assessment were adduction and abduction, flexion and extension, as well as internal and external rotations of the hip. All dynamometry measures collected by the dynamometer were expressed in kilograms. The positioning used for placement of the dynamometer was as described by Thorborg et al.¹⁴

Patients first performed two low intensity contractions to learn the movements requested during the test. This was followed by five maximal voluntary isometric contractions performed for five seconds each, to evaluate the strength of the muscle groups involved.

Rest intervals of 15 seconds were allowed between contractions to prevent muscle fatigue during the test. The examiner explained the test and then monitored it avoiding compensations. Standardized instructions were given to the participants assessed, requesting that they exert maximum force throughout the test, while another examiner recorded the data obtained. Verbal stimuli were given during the test in order to encourage maximum muscle performance by participants. Three verbal stimuli were standardized for each muscle contraction performed. All the tests were carried out bilaterally, starting with the non-dominant side, and the highest force value of the five contractions attained was recorded. The anatomical landmarks used as a reference for dynamometer placement are listed in Table 1.

Strength values obtained in kilograms from dominant and non-dominant sides for the muscles tested in all participants were converted to values proportional to individual body weight.

To estimate the mean muscle strength in women aged 20 to 29, the sample size was calculated. The data was generated from the first 10 individuals collected during the pilot study and used some statistical assumptions. It was assumed that the data distribution would be symmetric (Normal), a 95% confidence interval (then $Z = 1.96$) and with a margin of error of 3 units. The standard deviation of muscle strength in the population is unknown, but through the first 10 individuals tested in this study it was estimated that the standard deviation of hip muscle strength ranged from 4 to 10 units. To estimate the sample size, considered the highest standard deviation to obtain the most conservative sample size, requiring 45 patients for the study, and considering possible deletions of up to 15% throughout the study, we recruited 52 subjects.

Data analysis was performed using version 22.0 of the SPSS software for Macintosh computers. Values obtained for normal distribution

Table 1. Anatomical landmarks for the dynamometer placement for hip strength measurement.

Movement	Dynamometer position
Flexion in sitting position	5 cm above the upper border of the patella
Extension in prone position	5 cm above the medial malleolus, at the triceps surae
Abduction in supine position	5 cm above the proximal border of the lateral malleolus
Adduction in supine position	5 cm above the proximal border of the medial malleolus
Medial rotation in sitting position	5 cm above the proximal border of the lateral malleolus
Lateral rotation in sitting position	5 cm above the proximal border of the medial malleolus

muscle groups were submitted to Kolmogorov-Smirnov test and for comparison between the left and right sides we used the t-student tests for paired samples and the Wilcoxon test Signed Rank Test. (Figure 1) A p-value lower than 5% ($p \leq 0.05$) was considered statistically significant.

RESULTS

A total of 52 participants were evaluated in this study with bilateral analysis of the hip strength, with a total of 104 hips analyzed, as depicted in Figure 2. Demographic and anthropometric data of the participants are shown in Table 2.

Mean peak isometric torque, along with confidence interval, standard deviation and p-values are shown in Table 3, confirming the absence of statistically significant difference between dominant and non-dominant sides. Given the absence of statistical difference between the values for dominant and non-dominant sides, these values were pooled together to yield normative values, independently of the side evaluated. Reference values for the muscle groups

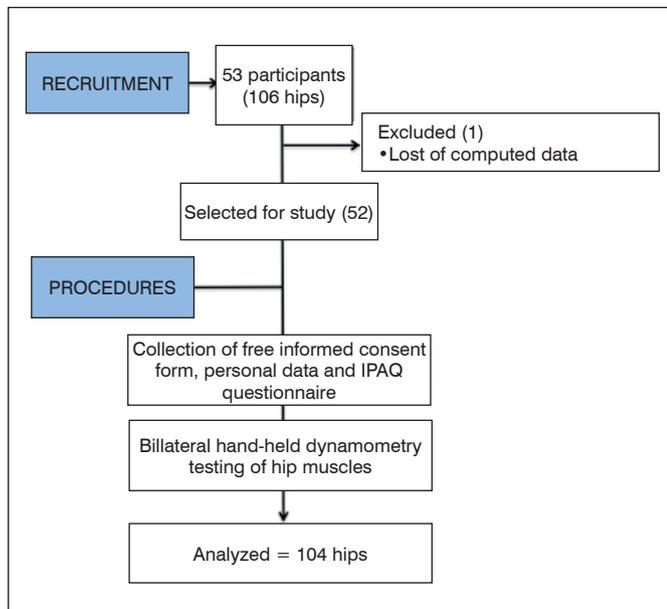


Figure 1. CONSORT diagram showing the flow of patient participants through the trial.

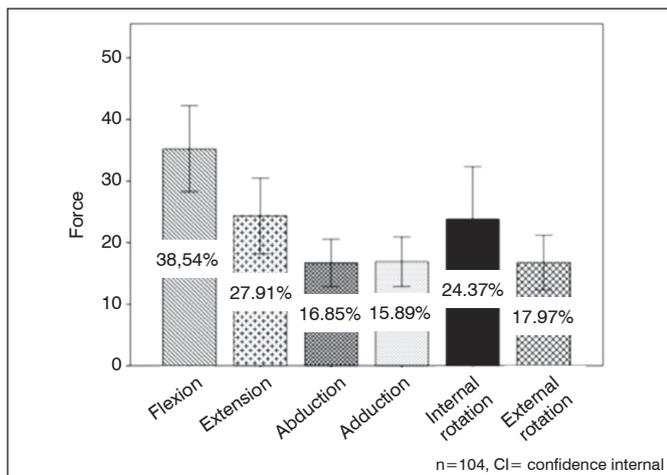


Figure 2. Mean force attained for all hip movements of the 104 joints included in the study, in relation to body weight.

Table 2. Characteristics of participants according to age, weight, height and body mass index (BMI).

	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m ²)
n = 52	22.17	58.40	1.62	22.25
SD	2.08	6.49	5.57	1.97

SD = standard deviation.

studied, together with confidence interval, standard deviation and p-values, are given in Table 4.

The flexor muscles exhibited the highest peak isometric torque, followed by the extensors and internal rotators. The adductor, abductor and external rotator muscles had similar values, as depicted in Figure 2.

Based on the values obtained, the agonist/antagonist relationship can be determined, where flexors were found to be stronger than extensors ($p < 0.01$), the internal rotators stronger than external rotators ($p < 0.01$) while abductors did not differ significantly to adductors ($p = 0.96$) (Figure 3).

DISCUSSION

The determination of normative values for hip muscle force using hand-held dynamometry can yield reference data for the assessment, treatment and discharge criteria of patients with lower limb injuries^{11,13,14} This study explored a practical and reproducible method of normalizing testing to facilitate clinical practice.

Numerous studies reporting linear regression calculations, and even normalizing values for body weight, have been published for some hip muscle groups. However, studies in the literature assessing the force of all the groups are scarce, especially those normalizing values based on body weight.^{9,11,15,16}

In the present study, all the muscle groups of the hip were assessed and their absolute values expressed based on percentage of body weight, facilitating the clinical use of dynamometry. Using this approach, professionals could assess loss of muscle strength, normalizing values obtained without the need for complex equations such as regression calculations and those adopted in other studies,^{8,11} in which values are expressed in absolute form, precluding their use as normative values.

The greater reliability conferred by using a fixation belt during hand-held dynamometry compared with resistance offered by the examiner was reported in 1991. Values reported by studies using hand resistance are often called into question owing to the numerous factors influencing the reliability of data collection. In addition, the values obtained using a dynamometer with belt-fixation are higher than those measure by hand resistance, highlighting the inability of examiners to collect maximum isometric force without the aid of external resources.^{6,8,16} Therefore, the results of the present study cannot be compared against values of studies which have not employed external belt-fixation.

In the literature review, only one study was found that assessed all movements of the hip with the same placement parameters as the present study.¹³ These assessments however, were performed without the use of fixation belts and data were expressed as absolute values. This was the case because the primary aim of the study in question was normalization of the positions of the tests, and not to determine the normative value of muscle forces.¹³

The assessment protocol applied in the present study used the highest of five contractions of each muscle group as a reference. This form of analysis was chosen, as opposed to calculating the average value of contractions, in order to make the assessment faster and more clinically reliable. Indeed, the literature has shown no statistical difference between using the highest value obtained among contractions and the mean of muscle contractions.¹³

Table 3. Mean force of hip muscles for flexors, extensors, adductors, abductors, internal and external rotators in relation to body weight of the 52 participants in the study.

Muscle group	Dominant side	95% CI	Standard deviation	Non-Dominant side	95% CI	Standard deviation	P
Flexors	38.44%	36.35- 40.52%	7.50%	38.64%	36.47 - 40.81%	7.79%	0.768
Extensors	27.91%	26.08 -29.75%	6.60%	26.17%	24.43 - 27.91%	6.25%	0.004
Abductors	17.22%	15.95 - 18.49%	4.56%	16.47%	15.43 - 17.52%	3.75%	0.172
Adductors	17.33%	16.10 - 18.56%	4.42%	16.45%	15.44 - 17.47%	3.63%	0.015
Internal rotators	24.37%	21.97 - 26.77%	8.61%	23.28%	20.94 - 25.62%	8.40%	0.121
External rotators	17.97%	16.44 -19.50%	5.50%	16.21%	14.99 - 17.43%	4.38%	0.003

n = 52; CI = confidence interval.

Table 4. Mean, confidence interval and standard deviation of muscle force in relation to body weight.

Muscle group	Normative value	95% CI	Deviation
Flexors	38.54%	37.06 - 40.02%	7.61%
Extensors	27.04%	25.79 - 28.30%	6.46%
Abductors	16.85%	16.03 - 17.66%	4.17%
Adductors	16.89%	16.11 - 17.68%	4.05%
Internal rotators	23.82%	22.18 - 25.47%	8.48%
External rotators	17.09%	16.12% - 18.07%	5.03%

n = 104, CI = confidence interval.

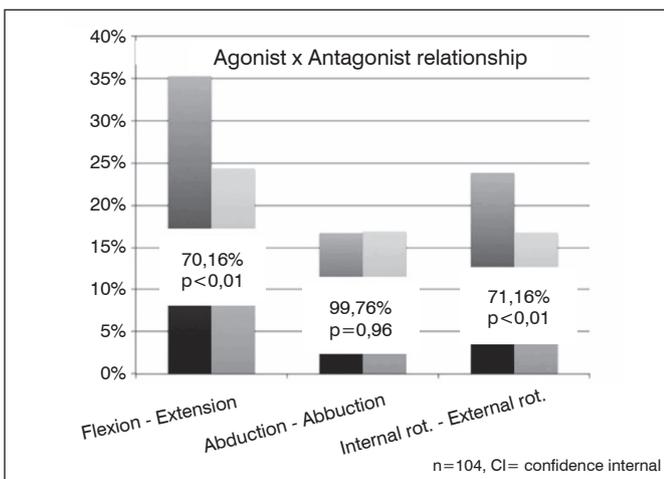


Figure 3. Values of muscle difference found between agonists and antagonists for the 104 hip joints included in the study.

The inclusion of women aged 20-29 years having BMI within normal limits was to establish the normative values for this specific population, given the large variation in data found according to age and sex in previous studies.^{11,16}

Since the literature suggests that muscle strength declines with age, this study centered on assessing young women, serving as initial reference values for comparisons with older age groups.¹⁰ Another factor influencing the choice of age group was the lower incidence of hip injuries in younger adults, facilitating data collection in individuals with healthy hips. Women whose body mass index lay within normal values were recruited due to the large variation in peak torques which can occur in women who are under or overweight, a factor which could lead to bias in the equation converting absolute values to percentage of body weight.

In the studies of van der Ploeg et al.,¹¹ Andrews et al.,⁹ and Bohannon,¹⁶ normative values of maximum voluntary isometric muscle contraction were obtained for a range of muscle groups, including hip muscles. These studies however, only included flexor and abductor muscles. The present study focused on assessing the muscle groups involved in flexion, extension, abduction, adduction,

internal rotation and external rotation of the hip, thereby establishing reference strength values of these muscles and determining the relationship between agonists and antagonists.

The values obtained for hip flexion were significantly higher than data reported by Andrews et al.⁹ We believe this disparity can be explained by the difference in age group of the populations studied of 50-79 years in the cited study versus 20-29 years in the present investigation. Previous studies have also cited a decline in muscle strength with advancing age.¹⁰

No normative values are available for hip extensors, hampering comparisons of the present study results. In the study by Thorborg et al.,¹⁴ the aim of the study was not to determine a predictive value, and yet marked differences can be seen between the force of flexor and extensor muscles, with extensors having lower peak isometric torque, akin to results found in the present study.

The values obtained in the evaluation of abductors were significantly lower than those found by Andrews et al.,⁹ and Bohannon.¹⁶ The main factor to be considered to justify this difference is placement of the dynamometer which, in both studies, was positioned laterally to the femoral condyles. By contrast, the distal position was used in the present study, where the literature suggests greater reliability can be attained with this latter placement.¹⁷ The fact that no external fixation belt was used may have contributed to the difference in values, although this hypothesis was not explored in the present study.

The force values of hip abductors were very similar to those obtained in adductors, contrasting with results found in previous studies using isokinetic dynamometry.¹⁸ However, the muscle contractions used in the cited assessment had different characteristics according to position to those performed in the present study.

Studies which employed the same protocol for positioning participants and dynamometer showed no statistical difference in force between hip adductor and abductor muscles. The values reported cannot be compared between the studies since the data were expressed in absolute values as opposed to percentage of body weight in the present study.^{8,14}

The values found in the present study for mean peak torque of internal rotators were greater than for external rotators, whereas the study of Thorborg et al.,¹⁹ reported higher values for external than internal rotators with the hips placed in a neutral position.

The proposed explanation for this difference may be the positions of the participants, who were placed in a prone position with neutral hip position and knees flexed at 90 degrees. By contrast, in the present study participants were placed in a sitting position on the table with knees and hips flexed at 90 degrees. In another study conducted by Thorborg et al.,¹⁴ in which hips were assessed in the same position as the present study, higher values of peak isometric torque were obtained for internal rotators than external rotators, mirroring the results of the present study.

In order to reproduce muscle force tests using hand-held dynamometry, placement of the dynamometer must be carried out carefully. Another limitation of the study is the collection of values only for women between 20 and 29 years with normal BMI, precluding their

use in groups with different gender, body weight and age bracket to those studied. This study should prompt further analysis of other groups with different demographic profiles to those investigated, given that the potential of dynamometry normalized by body weight as an additional resource in clinical practice has been shown.

CONCLUSION

The standardization of isometric strength values in relation to body weight has proven to be feasible, but there is a need of more studies done with people with different ages and genres. The

values obtained in this study can be applied as standard only for people with the same profile.

The result is important for clinical practice, allowing patterns of normality to be established and used as criteria for discharge, return to sport or assessment of the impact of different injuries in terms of loss of muscle strength.

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