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ACTA ORTOPÉDICA BRASILEIRA

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(Reviewed April 2022)

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ACKNOWLEDGEMENTS

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LEVELS OF EVIDENCE FOR PRIMARY RESEARCH QUESTION: Access the following link.

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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.)

Types of study

Level	Therapeutic Studies Investigating the Results of Treatment	Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease	Diagnostic Studies – Investigating a Diagnostic Test	Economic and Decision Analyses – Developing an Economic or Decision Model
I	High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals	High quality prospective study[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[f] 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 inconsis tent 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[g]	Case control study[g]	Study of non consecutive patients; without consistently applied reference ''gold'' standard	Analyses based on limited alternatives and costs; and poor estimates
	Retrospective[f] 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.

SUMMARY

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Original Article

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EFFICIENCY OF DEEP VENOUS THROMBOSIS PREVENTION IN PROXIMAL FEMUR FRACTURES

EFICIÊNCIA DA PREVENÇÃO DA TROMBOSE VENOSA PROFUNDA NAS FRATURAS DO FÊMUR PROXIMAL

João Vitor da Cruz Garcia[1], *Vinicius Takata*[1], *Luis Eduardo Plumacher Diaz*[1], *Francisco Dada Neto*[1], *Marcos Vinicius Felix Santana*[1,2], *Eiffel Tsuyoshi Dobashi*[1,2]

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2. Universidade Federal de São Paulo, Paulista School of Medicine, São Paulo, SP, Brazil.

ABSTRACT

Objective: To determine the efficiency of the deep venous thrombosis (DVT) prophylaxis protocol in postoperative patients due to proximal femoral fractures and to assess any statistical difference between the types of fractures. Methods: A retrospective observational study based on the analysis of patients' medical records who underwent to a surgical intervention due to proximal femoral fractures in 2017 and 2021 at Hospital IFOR – *Rede D'Or São Luiz*. These patients were selected according to previously determined inclusion and exclusion criteria. A total of 99 patients were included divided by sex, age, laterality, length of stay, and death. According to the institutional protocol, was used chemoprophylaxis with low-molecular-weight heparin, associated use of pneumatic compression with compression stockings, and early gait. The DVT diagnosis was determined by clinical evaluation and imaging tests such as venous Doppler ultrasonography and laboratory tests. Results: The protocol was effective in our study. Only one (1.01%) patient developed DVT. Due to the lack of samples, we could not achieve our secondary objective. Conclusion: The institutional protocol is efficient for DVT prophylaxis and essential in these cases. ***Level of Evidence II, Prognostic Study.***

Keywords: Aged. Venous Thrombosis. Femoral Fractures. Diagnosis. Disease Prevention. Multimodal Treatment.

RESUMO

Objetivo: Determinar a eficiência do protocolo de profilaxia contra trombose venosa profunda (TVP) em pacientes de pós-operatório devido à fratura do fêmur proximal e avaliar a diferença estatística entre os tipos de fratura. Método: Estudo retrospectivo observacional a partir da análise de prontuários de pacientes submetidos à intervenção cirúrgica em razão de fratura do fêmur proximal no período de 2017 e 2021 no Hospital IFOR – Rede D'Or São Luiz. Foram selecionados 99 pacientes segundo critérios de inclusão e exclusão determinados previamente, que foram catalogados por: idade, sexo, lateralidade, dias de internação, entre outros. Conforme protocolo institucional, utilizou-se quimioprofilaxia com heparina de baixo peso molecular, associado ao uso concomitante de compressão pneumática e meias elásticas, e deambulação precoce. O diagnóstico de TVP foi determinado por meio de avaliação clínica e exames de imagem, como a ultrassonografia com Doppler venoso e exames laboratoriais. Resultados: A utilização do protocolo se mostrou eficaz neste estudo, havendo apenas um paciente (1,01%) que desenvolveu TVP. Não foi possível atingir o objetivo secundário, pois a amostragem foi insuficiente. Conclusão: O protocolo institucional para a profilaxia de TVP foi eficiente, uma vez que apenas um paciente evoluiu com tal complicação. ***Nível de Evidência II, Estudo Prognóstico.***

Descritores: *Idoso. Trombose Venosa. Fraturas do Fêmur. Diagnóstico. Prevenção de Doenças. Terapia Combinada.*

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INTRODUCTION

Life expectancy of the world population has gradually increased, which has caused a perception that chronic and degenerative diseases among old adults have had remarkable expansion. Osteoporosis is particularly worrisome because of its high prevalence in this population, especially among women. This increased the risk of fractures and the costs associated with this theme, becoming a serious public health problem.[1] Among all the sites with fracture diagnoses, proximal femur has a high frequency and perhaps the greatest impact on morbidity and mortality, estimated at about 6.5 million new cases worldwide by 2050.[2] When we consider the different regions of the world, note that this variable also influences hip fracture incidence. According to the literature, over 60 years and disregarding gender, its frequency ranges from 3 to 0.7/10,000 in Siena, Italy[3] and 122 to 50.1/10,000 in Oslo, Norway.[4] The incidence of fractures gradually

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

The study was conducted at Hospital IFOR, Rede D'Or São Luiz.
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<< SUMÁRIO

varies throughout Europe, with higher incidences in Norway, Sweden, and Denmark, and lower incidences in cities around the Mediterranean Sea.[4,5] In South America, the annual incidence of hip fractures in women over 50 years ranges from 9.4/10,000 in Venezuela to 44.9/10,000 in Chile.[6,7]

The surgeries needed reduce life expectancy of patients suffering from hip fractures by 15% and 20% considering the general population, and the number of deaths in the first six months after the traumatic event is high. The mortality rate ranges from 15% to 50% during the first year of convalescence.[8,9]

After the interventional treatment, adverse complications in this type of fracture included deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE). Before establishing the protocols, the programs that dealt and avoided such adversities––anticoagulants, for example––had an incidence range from 55% to 80%.[10]

Some factors found in the patients' medical history increase the probability of thromboembolism, such as a positive family risk, age over 60 years, cardiomyopathy, chronic edema of the lower limbs, immobilization, obesity, sedentarism, excessive blood loss, blood transfusion, long hospital stay, among others.[11]

The risk is notably higher from the second to third week of postoperative, with 29% of thrombi occurring in the first 12 days and 23% in 22 to 24 days after surgery. Using the Doppler ultrasound examination on the venous system of the lower limbs and contrast venography helps an early diagnosis.[12,13]

Preventive health care of DVT in patients undergoing to an osteosynthesis of proximal femoral fracture is a consensus among all orthopedists. However, due to the scarcity of studies, the literature still lacks a consensus on which medication to use or what would be its ideal time of use.[14] The orthopedic literature indicates vitamin K inhibitors and low-molecular-weight heparins.[15] A systematic review, which compiled 26 studies conducted on 2,600 individuals, found that low-molecular-weight heparin (LMWH) and unfractionated heparin (UFH) effectively reduced DVT. Some reports states that, compared to UFH, LMWH is significantly more effective and safer. A subcutaneous injection of 40 mg once a day is sufficient and effective regarding to the LMWH dose.[16,17]

Mechanical prevention methods, such as using compression stockings, can reduce the occurrence of DVT by more than 50%. The association of methods are considered potential auxiliary measures, such as active and passive kinesiotherapy of the lower limbs and the application of early load.

Therefore, the importance of using preventive methods for DVT is undeniable in patients undergoing hip bone surgery, but the literature lacks a consensus if the combined or individualized use is better. Thus, the main objective of our study is to determine the efficacy of the DVT prevention program used in patients who underwent to a hip osteosynthesis in our institution. Our secondary objective is to compare the DVT rates considering femoral neck fractures, both transtrochanteric and subtrochanteric.

METHODS

This study was approved by the Research Ethics Committee of *Plataforma Brasil* under no. CAAE 51475021.6.0000.5625.

A retrospective and observational study was conducted from analyzing medical records of patients with proximal femoral fractures who underwent to osteosynthesis from 2017 to 2021 at Hospital IFOR Rede D'Or / São Luiz. An investigation protocol was created so that the collected data could be compiled and tabulated with the following information: service number; age at the length of stay; sex; affected side; skin color; body mass index (BMI); fracture; positivity for DVT; and outcome (death).

A strategy was elaborated to search for electronic medical records where the period of investigation was limited stipulated by this research. To locate patients, ICD-10 was used (fracture of femur – S72, fracture of neck of femur – S72.0, pertrochanteric fracture – S72.1, subtrochanteric fracture – S72.2, fracture of femur, part unspecified – S72.9). And age was limited (> 60 years).

A total of 143 eligible medical records were found and after applying the inclusion and exclusion criteria, 99 medical records were included. Among them, 74 (74.75%) were women and 25 (25.25%) were men. Regarding skin color, 79 (79.80%) were White, 10 (10.10%) Black, 7 (7.07%) Yellow, and 3 (3.03%) did not declare. Regarding laterality, 55 (55.56%) fractured the left side and 44 (44.44%) right side (Table 1). And regarding the fracture type, 44 (44.44%) presented transtrochanteric fracture, 49 (49.49%) femoral neck fracture, and 6 (6.06%) subtrochanteric fracture. The average length of stay ranged from 6.10 to 35 days (Table 2). The average BMI of the sample group was 23.5.

Patients from seven studies were included using the following criteria:

1. Patients of both sexes;
2. Age > 60 years;
3. Post-operative care > 6 months;
4. Proximal femoral fractures operated in our service;
5. No history of coagulopathies;
6. No personal history of DVT;
7. Patients included in the institutional DVT prevention protocol.

Non-inclusion criteria were:

1. Patients with incomplete medical records
2. Patients who did not sign an informed consent form for the use of their medical records;
3. Shaft and distal femoral fractures.

Chemoprevention was used as VTE prevention protocol by subcutaneously applying 40 mg of enoxaparin once a day, or subcutaneously applying 5,000 IU of unfractionated heparin every 8 hours associated with mechanical prophylaxis. Chemoprophylaxis was initiated 12 hours before the surgery and maintained 12 to 24 hours after the surgery for 21 to 28 days. Contraindications to pharmacological methods are active bleeding or active peptic ulcer, allergy to heparin, thrombocytopenia, coagulation dysfunction (thrombocytopenia < 100,000/mm^3 or INR > 1.5), uncontrolled systemic arterial hypertension (> 180 × 110 mmHg), persistent renal failure (clearance rate < 30 ml/min), recent intracranial or ocular surgery < 2 weeks, and CSF collected in the last 24 hours.

Compression stockings applied immediately after the surgery is also recommended considering the patient's tolerance, medical release, gait (stimulated on the first postoperative day), supervision of the physiotherapy team. Contraindications of the auxiliary method (intermittent pneumatic compression and compression stocking) are open fractures, severe heart failure, peripheral arterial insufficiency in the lower extremities, and infection or ulcers in the lower extremities.

Table 1. Laterality.

	Right	Left	Overall Total
Neck	24	25	49
Subtrochanteric	3	3	6
Transtrochanteric	17	27	44
Overall Total	**44**	**55**	**99**

Table 2. Length of stay.

	Patients	Time average
Neck	49	5.31
Subtrochanteric	6	9.00
Transtrochanteric	44	6.59
Overall Total	**99**	6.10

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Clinical evaluation and imaging were used to detect DVT. Clinical analysis includes detection of pain in the lower extremities; palpation of the affected area; observation of distal perfusion; palpation of the peripheral pulse, observation of edema; positivity for specific propaedeutic maneuvers such as *Homans*, clubbing, and swollen calf; hyperemia, pallor, or local heat.
In suspicion of DVT, color Doppler ultrasound, MRI, and laboratory tests are used.
Only one patient (1.01%) had a postoperative complication, as Table 3 shows, but he progressed well and did not die. After the osteosynthesis of proximal femur, 2 patients (2.02%) died, but not due to DVT complications.
An informed consent form was made for this study.

RESULTS

Table 1 shows that among 99 patients, only one (1.01%) developed DVT. Table 4 shows that two patients died (2.02%). One was a white woman with a transtrochanteric fracture on the right side, length of stay of 35 days, and BMI 25.3. And the other was white, with a left hip fracture, 89 years, and length of stay of 11 days. Their death was unrelated to DVT.
We could not determine if a relationship between the type of fracture with DVT exist, since the number of patients with this complication was too low to perform a statistical analysis.

DISCUSSION

Proximal femoral fractures highly contribute to increase mortality and functional disability rates, mainly because they occur in patients with previous comorbidities that increase the risk of postoperative complications. Until the third month after surgery, DVT is the most prevalent. This contributes with the death rates, especially when accompanied by pulmonary embolism.

Table 3. Relation between injury site and DVT.

	DEEP VEIN THROMBOSIS		
	No	**Yes**	**Overall Total**
Neck	48	1	49
Subtrochanteric	6		6
Transtrochanteric	44		44
Overall Total	**98**	**1**	**99**

Table 4. Relation between injury site and deaths.

	DEATHS		
	No	**Yes**	**Overall Total**
Neck	49		49
Subtrochanteric	6		6
Transtrochanteric	42	2	44
Overall Total	**97**	**2**	**99**

Still, only some patients with DVT develop full PE symptoms. This subclinical manifestation results from a partial venous obstruction that varies from 10% to 40% of vascular caliber.
We believe that, because of this, a diagnostic underreporting may have occurred, thus justifying the small number of DVT cases in our study.
The literature still lacks a consensus on which drugs are more effective and safer. Some drugs are very effective in reducing VTE incidence, such as Enoxaparin (ENX) and other substances that act on the coagulation cascade, like acetylsalicylic acid (AAS), rivaroxaban (RVX), fondaparinux (FPX), or apixaban (APX). However, these substances have adverse effects and complications, which can increase the risk of bleeding. According to the literature, ENX and AAS have similar bleeding risks and better results for prophylaxis than RvX.
In our data––regardless of skin color and BMI––no patients with a higher length of stay and > 60 years developed DVT.
A patient with femoral neck fracture developed DVT even with the prevention protocol. The patient was a white man, 90 years, BMI 26.3. He was hospitalized for 3 days and, despite thrombosis, did not die. Other participants did not develop DVT. This is probably because of the prophylaxis protocol for DVT of our institution.
Two patients died and both were women. The first was white, 91 years, BMI 25.3, length of stay of 35 days, with a transtrochanteric fracture. The other was white, 89 years BMI 21.7, length of stay of 11 days, with a transtrochanteric fracture. Thrombosis was not the cause of death, which was attributed to other comorbidities––thus, not related to DVT. A late heart disorder and septic shock secondary to urinary tract infection were recognized.
We found that the length of stay ranged from one to 35 days (6.10 days average). This average was lower than most data compared in other studies,[18] which ranged from 10.65 to 42 days. We believe that the multidisciplinary teamwork (physiotherapists, pharmacists, physicians, nurses, and nutrition team), with the correct medicine and physical resources, is essential to a high prevention efficacy. The application of our institutional protocol had an index of 1.01% DVT, which corroborates with the literature whose incidence ranges from 0 to 3%.
We failed to observe a heterogenous distribution when evaluating the different types of proximal femoral fractures. The epidemiological distribution found in the literature is 61.3% for transtrochanteric, 32.7% for cervical, and 6.0% for subtrochanteric fractures. In our study, we found 44.44%, 49.49%, and 6.06% of transtrochanteric, cervical, and subtrochanteric fractures, respectively.
Since only one patient developed DVT, we could not achieve our secondary objective which was to determine whether the type of fracture was significantly related to the onset of DVT.

CONCLUSION

Using thromboprophylaxis is indispensable to prevent DVT after the surgical treatment for proximal femoral fractures. Regarding the efficacy of the institutional protocol, only one (1.01%) patient developed this complication. The deaths of two patients were not related to DVT.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to develop this article. JVCG: literature review, data collection and analysis, article writing; VT: data collection and analysis, article writing; LEPD: literature review and revision of the article to be published; NF: literature review, data collection; MVFS: literature review, research project development; ETD: research project development, data analysis, article review.

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ORIGINAL ARTICLE
ORTHOPEDICS AND TRAUMATOLOGY

CORONAL PLANE GROWTH MODULATION FOR GENU VALGUM IN SKELETAL DYSPLASIA

MODULAÇÃO DO CRESCIMENTO DO PLANO CORONAL PARA GENU VALGUM NA DISPLASIA ESQUELÉTICA

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ABSTRACT

Objective: To investigate the efficiency and rates of correction by hemiepiphysiodesis using 8-plate to manage genu valgum deformity in children with skeletal dysplasia. Methods: Eleven children with skeletal dysplasia (three female, eight male; mean age = 10.5 years; age range = 7–13) who underwent temporary hemiepiphysiodesis using 8-plates for genu valgum deformity were retrospectively reviewed. There were nine bilateral cases and two unilateral cases. The mean follow-up time from the index surgery to the final follow-up was 45 (ranging from 24 to 72) months. Radiographical assessment including preoperative and final follow-up measurements of joint orientation angles and mechanical axis deviation (MAD) were conducted. Results: Deformities were completely corrected in nine lower extremities (45%) and partially corrected in seven extremities (35%). In four extremities of two children with Morquio syndrome, MAD worsened. The correction rate of MAD was 1.25 ± 1.62 mm/mo. Conclusion: Though hemiepiphysiodesis using 8-plate requires a longer treatment period, it seems to be an effective treatment for correction of genu valgum in children with skeletal dysplasia. ***Level of Evidence IV, Case Series.***

Keywords: Bone Dysplasia. Genu Valgum. Growth Plate. Epiphyses. Retrospective Studies.

RESUMO

Objetivo: Investigar a eficiência e as taxas de correção da hemiepifisiodese usando placa-8 no tratamento da deformidade de geno valgo em crianças com displasia esquelética. Métodos: Foram avaliadas retrospectivamente 11 crianças com displasia esquelética (três meninas e oito meninos; idade média = 10,5 anos; faixa etária = 7-13) que foram submetidas à hemiepifisiodese temporária com placa-8 devido à deformidade do geno valgo. Havia nove casos bilaterais e dois casos unilaterais. O acompanhamento médio desde a cirurgia de implante até o acompanhamento final foi de 45 (variação de 24 a 72) meses. Foi feita avaliação radiográfica incluindo medidas de acompanhamento pré e pós-operatórias dos ângulos de orientação da articulação e desvio mecânico do eixo (MAD). Resultados: As deformidades foram completamente corrigidas em nove extremidades inferiores (45%) e parcialmente corrigidas em sete (35%). Em quatro extremidades de duas crianças com síndrome de Morquio, o MAD piorou. A taxa de correção do MAD foi de 1,25 ± 1,62 mm/mês. Conclusão: Embora a hemiepifisiodese com placa-8 necessite de um período de tratamento mais longo, a técnica parece ser um tratamento eficaz para a correção do geno valgo em crianças com displasia esquelética. ***Nível de Evidência IV, Série de Casos.***

Descritores: *Displasias Ósseas. Geno Valgo. Lâmina de Crescimento. Epífises. Estudos Retrospectivos.*

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INTRODUCTION

Genu valgum is a common condition which occurs mostly physiologically as part of normal developmental changes in lower limb alignment in the growth phase (from two to 11 years old). This development-related change usually resolves itself spontaneously.[1,2] In turn, pathological genu valgum, which may be idiopathic or secondary to congenital disorders such as skeletal dysplasia, often leads to progressive displacement of the mechanical axis, with pain and functional limitation – thus requiring surgical intervention.[3]

Skeletally immature children can avoid major surgical procedures, including osteotomy and external or internal fixation, by growth modulation using hemiepiphysiodesis. Hemiepiphysiodesis application can be permanent or temporary.[4] Whereas permanent hemiepiphysiodesis must be used carefully in proper surgical timing to prevent under- or over-correction,[5] temporary hemiepiphysiodesis using several implants has expanded for correcting deformities without the risks from the permanent surgery. Because of its simplicity and ease of application, the 8-plate system for temporary hemiepiphysiodesis has recently replaced transphyseal screws and staples.[6]

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

The study was conducted at Istanbul University, Istanbul Faculty of Medicine, Department of Orthopedics and Traumatology.
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Genu valgum is one of the common orthopedic manifestations of skeletal dysplasia, which is a complex group of conditions that affect bone development.[7] Evidence shows that 8-plates have been effective in correcting idiopathic genu valgum deformity.[1,8,9] However, the literature on the efficacy of this technique in children with skeletal dysplasia is still incipient. The surgery of the pathological physis is also concerning due to potential rebound or risk of permanent growth arrest.[6]

This study sought to determine the efficiency, correction rates, and complications of hemiepiphysiodesis using 8-plate to correct genu valgum deformity in children with skeletal dysplasia.

METHODS

After obtaining approval from the institutional review board, we retrospectively reviewed the medical records of 13 children with several types of skeletal dysplasia who underwent temporary hemiepiphysiodesis using 8-plates (Eight Growth Plate™, TST medical®, Istanbul, Turkey) for genu valgum deformity from 2010 to 2018. Based on the eligibility criteria (Table 1), two patients were excluded (one lost to follow-up; one underwent a corrective lower limb surgery) and the other 11 children (20 extremities; nine with bilateral and two with unilateral genu valgum) were included in the study. Parents were informed that their medical records would be used for scientific purposes only and their written informed consent was collected at the final visit.

The diagnoses of skeletal dysplasia were established by the Department of Medical Genetics (Table 2) and all children were managed by the Department of Pediatric Endocrinology and Metabolic Diseases at our institution.

Radiographic outcome measures

To analyze the genu valgum deformities, anatomical tibiofemoral angle (aTFA), mechanical axis deviation (MAD = 3–17 mm), anatomical and mechanical lateral distal femoral angles (aLDFA = 79–83° and mLDFA = 85–90°, respectively), medial proximal tibial angle (MPTA = 85–90°), and lateral distal tibial angle (LDTA = 86–92°)[10] were measured on the immediate preoperative period and on the final follow-up using orthoroentgenography (anteroposterior full-length weight-bearing radiography).

All measurements were taken by an experienced orthopedic surgeon who was blinded to the clinical information of subjects, thus eliminating inter-observer variability but not intra-observer variability. Orthoroentgenograms were obtained by the well-established, standard technique of using three radiographic exposures centered over the hip, knee, and ankle joints and combining these images into a single film to minimize magnification error.[11] The correction rate was defined by dividing the angular correction value (degree) by the period of treatment with the 8-plate in months.[12] Correction amounts and rates were estimated based on MPTA at the proximal tibia and on LDFAs at the distal femur. Furthermore, the correction rate of MAD was estimated by dividing the amount of MAD correction (mm) by the treatment period in months.[4]

Table 1. Eligibility criteria for inclusion and exclusion of the study participants.

Inclusion criteria	Exclusion criteria
· A diagnosis of skeletal dysplasia; · Radiologically-confirmed genu valgum deformity; · Treated for HES using 8-plates; · A minimum of 12 months of follow-up after the index surgery; · Willingness to participate in the study.	· Lost to follow-up; · A history of lower limb correction surgery; · Unwillingness to participate in the study.

HES: temporary hemiepiphysiodesis.

Table 2. Demographic characteristics of the study participants.

Number of patients (extremities)	11 (20)
Bilateral involvement **Unilateral involvement**	9 2
Gender	8M, 3F
Types of skeletal dysplasia	Achondroplasia→3 X-linked hypophosphatemic rickets→3 Ellis-Van Creveld syndrome→1 Morquio syndrome→4
Mean age at surgery (year)	10.5 (ranging 7–13)
Treatment period (month)	35 (ranging 12–60)
Implant removal	+ => 11 limbs of 6 children – => 9 limbs of 5 children
Follow-up duration (month)	45 (ranging 24–72)

Surgical technique

Surgery was performed based on a standardized procedure after preparation under general anesthesia. After a two-to-three cm incision to center the growth plate, a careful surgical dissection was conducted in the submuscular plane. Anatomic positions for the 8-plates (2-hole 4.5 mm titanium plate) relied on joint orientation angles comprising LDFA, MPTA, and LDTA. Except in one child, the plates were attached to both the tibia and femur since both LDFA and MPTAs were abnormal. In one child with only abnormal LDFA (case 4; Table 2), the plate was attached to the femur only. To attach the plates, a 1.2 mm K-wire was first placed into the physis under the image intensifier; then, the 8-plate (2-hole 4.5 mm titanium plate) was inserted extraperiosteally. Next, 1.6 mm guidewires were carefully introduced into the epiphysis and metaphysis to avoid damaging the periosteum and the perichondrial ring. At the final stage, the plate was fixed to the bone using 4.5 mm fully threaded self-tapping cannulated screws over the guide wires.

Follow-up protocol

All children were encouraged to ambulate immediately post-operation as much as pain allowed. No child received specific physical therapy. Children were monitored every three months and assessed by standing x-rays. Treatment aimed to convert MAD to its opposite side.

The deformity correction was divided into three categories according to Boero, Michelis and Riganti:[9] no correction, partial correction (if MAD improved but did not reach neutral alignment), complete correction (if MAD reached neutral or slight varus alignment). Intra and postoperative complications were observed.

Statistical analyses

The IBM SPSS Statistics software version 20.0 (IBM Corp., Armonk, New York, NY, USA) was used for statistical analysis. A $p < 0.05$ was considered statistically significant. Normality tests were conducted using the Shapiro–Wilk test and histograms. Data were presented as "minimum", "maximum", "range", "arithmetic mean", "standard deviation", and "percentage". Preoperative and postoperative values were compared using a Paired-samples t-test. Correction amounts and rates were compared for distal femoral and proximal tibial physes using the Mann-Whitney U test.

RESULTS

The mean period of treatment with the 8-plate was 35 (ranging from 12 to 60) months. The mean age at the time of surgery was 10.5 (ranging from 7 to 13) years. The mean follow-up time from the index surgery to the final follow-up was 45 (ranging from 24 to 72) months. The mean age at the final follow-up was 13.6

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(ranging from 10 to 17) years. The mean follow-up time after plate removal was 14 ± 7 months (tables 2 and 3).
Table 4 presents measurements of joint orientation angles (aTFA, MPTA, aLDFA, mLDFA, LDTA) and MADs. Only the decrease in aTFA and MAD was statistically significant ($p = 0.005$ and $p = 0.024$, respectively); all other angles improved, albeit insignificantly ($p > 0.05$). Figure 1 shows the box and whisker plot indicating the distributions of angular correction rates at the distal femur (aLDFA, mLDFA) and versus proximal tibia (MPTA).

Deformities were completely corrected in nine lower extremities (45%) and partially corrected in seven extremities (35%) (Figure 2). However, in four extremities of two children diagnosed with Morquio Syndrome, MAD worsened and deformities remained uncorrected (Figure 3). Corrective osteotomy was then performed in these children.
Four limbs of two children (patients no. 8 and 9) with no correction were excluded in correction rate assessment. The correction rates of aLDFA and mLDFA at the distal femur were 0.384 ± 0.5 degree/

Table 3. Demographic and radiographical data of the study participants including preoperative and final follow-up measurements of joint orientation angles and mechanical axis deviation.

Type of Skeletal Dysplasia	Patient No.	Type of Skeletal Dysplasia	Age at Treatment Onset (years)	Site of Plate Insertion: Femur/Tibia	Duration of 8-plate Treatment (months)	Removal of implants (+/–)	Follow-up period (months)	Side	Joint Orientation Angle (°) Angle Initial Angle Final Δ	Mechanical Axis Deviation*** (mm) Initial MAD Final Δ
Achondroplasia	1 – U*	Achondroplasia	7	Both	R = 24	+	24	R	MPTA 100 88 12 aLDFA 73 76 3 mLDFA 82 90 8 LDTA 84 93 9	62 – 10 72
	2 – B**	Achondroplasia	10	Both	R = 36 L = 36	+	48	R	MPTA 95 92 3 aLDFA 83 81 2 mLDFA 90 84 6 LDTA. 89 97 8	35 22 13
								L	MPTA 94 80 14 aLDFA. 83 87 4 mLDFA 87 90 3 LDTA 82 97 15	42 – 21 63
	3 – B	Achondroplasia	9	Both	R = 60 L = 60	+	72	R	MPTA 94 88 6 aLDFA 79 107 28 mLDFA 86 113 27 LDTA 94 95 1	21 – 44 65
								L	MPTA 92 83 9 aLDFA 85 108 23 mLDFA 92 111 19 LDTA 92 87 5	12 – 60 72
X-linked Hypophosphatemic Rickets	4 – U	X-linked Hypophosphatemic Rickets	4.5	Femur	R = 24	+	60	R	MPTA 89 90 1 aLDFA 75 88 13 mLDFA 87 94 7 LDTA 103 79 22	22 8 14
	5 – B	X-linked Hypophosphatemic Rickets	12	Both	R = 60 L = 60	+	72	R	MPTA 96 90 6 aLDFA 85 86 1 mLDFA 90 86 4 LDTA 92 76 16	14 10 4
								L	MPTA 88 90 2 aLDFA 77 79 2 mLDFA 84 85 1 LDTA 91 89 2	19 10 9
	6 – B	X-linked Hypophosphatemic Rickets	9	Both	R = 24 L = 24	-	24	R	MPTA 97 81 16 aLDFA 67 84 17 mLDFA 78 89 11 LDTA 81 84 3	49 – 19 68
								L	MPTA 100 83 17 aLDFA 62 83 21 mLDFA 70 84 14 LDTA 87 75 12	54 – 9 63
Ellis-Van Creveld syndrome	7 – B	Ellis-Van Creveld syndrome	10	Both	R = 12 L = 12	+	48	R	MPTA 100 95 5 aLDFA 59 58 1 mLDFA 76 72 4 LDTA 92 90 2	47 21 26
								L	MPTA 92 91 1 aLDFA 79 87 8 mLDFA 92 94 2 LDTA 98 97 1	5 4 1

Table 3. Demographic and radiographical data of the study participants including preoperative and final follow-up measurements of joint orientation angles and mechanical axis deviation.

Type of Skeletal Dysplasia	Patient No.	Type of Skeletal Dysplasia	Age at Treatment Onset (years)	Site of Plate Insertion: Femur/Tibia	Duration of 8-plate Treatment (months)	Removal of implants (+/–)	Follow-up period (months)	Side	Joint Orientation Angle (˚) Angle Initial Angle	Final Angle	Δ	Mechanical Axis Deviation*** (mm) Initial MAD	Final Δ
Mucopolysaccharidosis type IVA (Morquio syndrome)	8 – B	Mucopolysaccharidosis type IVA (Morquio syndrome)	10	Both	R = 36 L = 36	-	36	R	MPTA	98	104	6	60 91 – 31
									aLDFA	78	59	19	
									mLDFA	83	63	20	
									LDTA	92	80	12	
								L	MPTA	102	106	4	29 85 – 56
									aLDFA	66	56	10	
									mLDFA	71	63	8	
									LDTA	86	78	8	
	9 – B	Mucopolysaccharidosis type IVA (Morquio syndrome)	12	Both	R = 48 L = 48	-	48	R	MPTA	106	110	4	49 37 12
									aLDFA	81	80	1	
									mLDFA	94	86	8	
									LDTA	74	70	4	
								L	MPTA	88	89	1	16 – 11 28
									aLDFA	80	90	10	
									mLDFA	77	94	17	
									LDTA	91	90	1	
	10 – B	Mucopolysaccharidosis type IVA (Morquio syndrome)	13	Both	R = 24 L = 24	-	24	R	MPTA	87	88	1	22 – 16 38
									aLDFA	79	88	9	
									mLDFA	75	91	16	
									LDTA	89	89	0	
								L	MPTA	100	103	3	26 40 – 14
									aLDFA	75	76	1	
									mLDFA	83	80	3	
									LDTA	60	70	10	
	11 – B	Mucopolysaccharidosis type IVA (Morquio syndrome)	8	Both	R = 24 L = 24	+	36	R	MPTA	102	94	8	27 – 10 37
									aLDFA	84	85	1	
									mLDFA	91	93	2	
									LDTA	65	64	1	
								L	MPTA	92	106	14	11 32 – 21
									aLDFA	85	70	15	
									mLDFA	87	78	9	
									LDTA	98	74	14	

U*: unilateral genu valgum; B**: bilateral genu valgum; Δ: difference between preoperative and final follow-up measurements; MAD: mechanical axis deviation; MPTA: medial proximal tibial angle; mLDFA: mechanical lateral distal femoral angle; LDTA: lateral distal tibial angle.

Table 4. Preoperative and final follow-up measurements of joint orientation angles and mechanical axis deviations.

	Preoperative	Final follow-up	Δ	P
aTFA˚	27.4 ± 10	12.6 ± 20	14.8 ± 17.7	*0.005**
MPTA˚	95.6 ± 5.39	92.5 ± 9.10	– 3.5 ± 8.23	0.140
aLDFA˚	76.8 ± 7.76	81.4 ± 13.6	4.65 ± 12	0.076
mLDFA˚	83.8 ± 7.18	87 ± 12.6	3.45 ± 11.4	0.35
LDTA˚	87 ± 10.6	83.7 ± 10.1	– 2.7 ± 9.39	0.177
MAD (mm)	30.5 ± 16.5	8.95 ± 37	22.1 ± 38.1	*0.024**

Δ: difference between preoperative and final follow-up measurements; aTFA: anatomical tibiofemoral angle; MPTA: medial proximal tibial angle; aLDFA: anatomical lateral distal femoral angle; mLDFA: mechanical lateral distal femoral angle; LDTA: lateral distal tibial angle; MAD: mechanical axis deviation. *Significance was defined at $p < 0.05$.

mo and 0.395 ± 0.39 degree/mo, respectively. The correction rate of MPTA at the proximal tibia was 0.297 ± 0.38 degree/mo. Figure 4 presents the box and whisker plot of the distributions of angular correction amounts at the distal femur (ΔaLDFA, ΔmLDFA) versus proximal tibia (ΔMPTA). The correction rate of MAD was 1.25 ± 1.62 mm/mo (Figure 5).

Hardware was removed from six children (ten extremities). Correction with plates was maintained in five children (nine extremities) with open growth plates. No clinical complications such as implant failure, loosening, or infection were observed during follow-up except for undercorrection or overcorrection of the angular deformity.

DISCUSSION

Pathological genu valgum, a well-known component of skeletal dysplasia, causes both cosmetic problems and premature osteoarthritis and must be corrected.[13] Although osteotomies have traditionally been the basis of deformity correction,[3] these procedures have potential drawbacks, including prolonged immobilization, extensive soft-tissue dissection, infection, delayed union, nonunion, and malunion.[3,14] To overcome these drawbacks, temporary hemiepiphysiodesis using the 8-plate has been successfully used in recent years to correct idiopathic genu valgum.[1,8,9] However, to our knowledge, the literature on the correction of genu valgum secondary to skeletal dysplasia with 8-plate is still incipient. Furthermore, since skeletal dysplasia is a rare and heterogeneous group of disorders that particularly affect epiphyseal growth plates, the efficacy of this surgical method in such disorders raises concern.

One major concern is whether the 8-plate treatment can correct genu valgum in children with a pathologic physis as seen in skeletal dysplasia. Our review of the literature shows that few studies[3,4,9,13] involving children with different types of skeletal

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dysplasia have reported different correction rates in the knee. Boero, Michelis, and Riganti[9] compared idiopathic versus dysplasia/syndrome patients and suggested early operation with the 8-plate in the group of children with skeletal dysplasia since this treatment has a longer correction period. Table 4 shows that comparing these studies is difficult due to different definitions of correction rates based on the joint orientation angles (MPTA, LDFA) or MAD as well as heterogeneous patient series and different types of deformity (varus, valgus, and windswept). Nonetheless, our findings seem to corroborate other studies, indicating that this method allows significant correction even though the correction rate would be slower in a pathologic physis than in an idiopathic deformity.

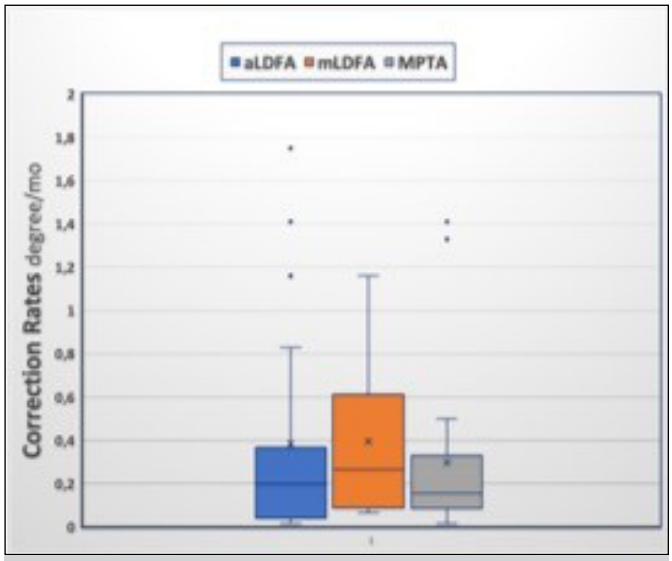

Figure 1. Box and whisker plot showing the distributions of angular correction rates at the distal femur (aLDFA, mLDFA) and versus proximal tibia (MPTA). Horizontal bars represent the median whereas boxes and whiskers show the interquartile ranges and data ranges, respectively.

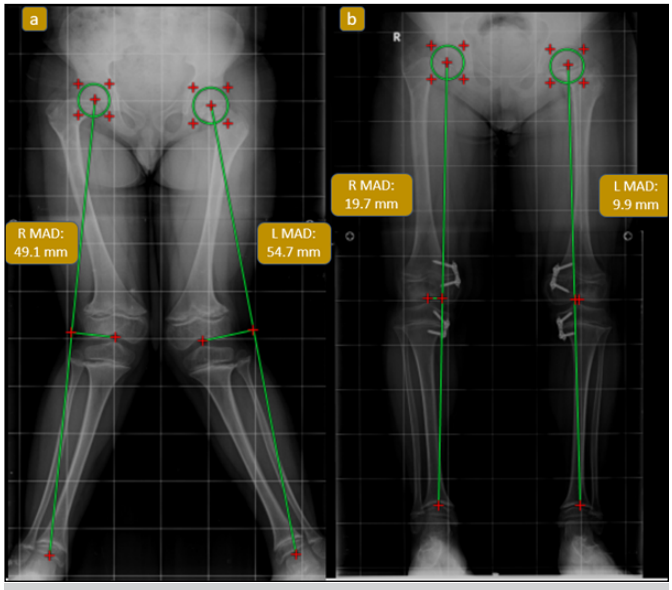

Figure 2. Preoperative (a) and final follow-up (b) orthoroentgenograms of case no. 6 (see Table 3). Observe the complete correction on both sides, with neutral mechanical axis deviation on the left side and slight varus alignment on the right side.

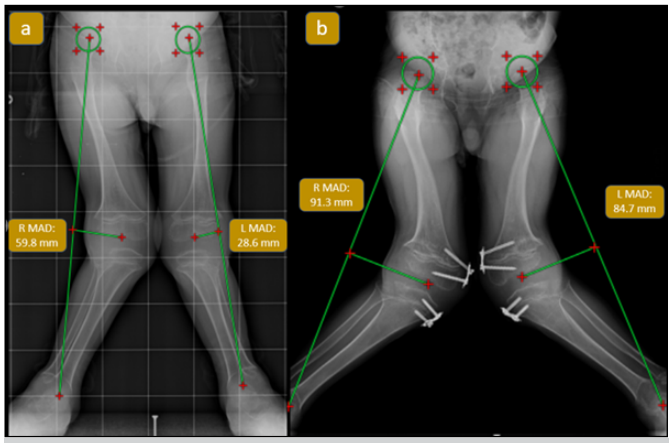

Figure 3. Preoperative (a) and final follow-up (b) orthoroentgenograms of case no. 8 (see Table 3). No correction on both sides, with a worsening of mechanical axis deviations.

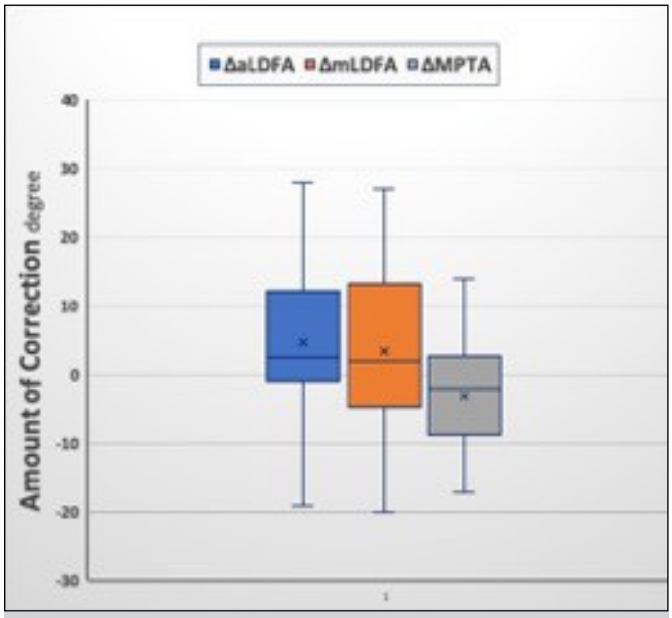

Figure 4. Box and whisker plot showing the distributions of angular correction amounts at the distal femur (ΔaLDFA, ΔmLDFA) versus proximal tibia (ΔMPTA). Horizontal bars represent the median whereas boxes and whiskers show the interquartile ranges and data ranges, respectively.

Figure 5. Box and whisker plot showing the distribution of correction rates of mechanical axis deviation.

Other major concerns of surgery for a pathologic physis include the rebound phenomenon and risk of permanent growth arrest.[6] Some authors[1,3,6] advocate an overcorrection of 5° to 10° (mild varus) in children with risk factors (dysplasia, obesity, etc.) to prevent a possible recurrence. Although some studies[3,9,13] included patients who underwent surgery due to recurrence of genu valgum, none of our patients sustained the rebound phenomenon. However, the short-term follow-up after hardware removal in some of our patients is insufficient to accurately report this phenomenon. Moreover, the pathologic physis was expected to show no tolerance against surgical intervention, with the risk of a permanent physeal arrest and irreversible injury.[15] Recent studies[3,4,9,13] on this issue showed a safe application of 8-plates in skeletal dysplasia. Our observations thus reaffirmed the safe use of the 8-plate for this condition.

We have consecutively performed this technique in children with genu valgum deformity secondary to skeletal dysplasia. Deformities were resolved completely in almost half of the cases (45%), but some achieved partial correction (35%) and required further osteotomies. Nonetheless, as Schroerlucke et al. suggest,[16] even partial correction can be considered a favorable outcome in such cases since it can lead to a technically easier osteotomy with a lower risk of complications.

In four lower extremities of two children with Morquio syndrome, no correction was achieved and MAD and joint orientation angles worsened. This poor outcome can result from several factors, including the timing of surgery. In our case series, cases with partial or no deformity correction presented a higher age at initial treatment than cases with complete corrections. The study by Boero, Michelis, and Riganti,[9] which sought to compare results of 8-plate use between idiopathic and pathological genu valgum, emphasized the importance of age at initial treatment. The authors began to treat pathological deformities earlier (2-13 years old) than idiopathic deformities (8-14 years old), obtaining successful comparable results. Our results support Boero, Michelis, and Riganti's finding that starting treatment at a very young age is reasonable since deformities are minor and correction is rapid.

Another risk factor for treatment failure is the type of skeletal dysplasia since distinct types are associated with different growth rates in the epiphyseal plate. Only two patients from our series presented treatment failure, caused by Morquie syndrome, in which bone growth typically decelerates quickly after the age of three and ends around 11 years old.[13] In a case series including 23 children with genu valgum deformities secondary to Morquio syndrome, Cooper et al.[13] determined that hemiepiphysiodesis using the 8-plate requires a longer time for deformity correction. Similarly to our observations, the authors stated that in children over 11 to 12 years old, deformity correction can fail due to insufficient growth capacity.

This study has limitations and strengths. The major limitations of the study were its retrospective nature, limited sample size, and short-to-mid-term follow-up. Another limitation was the lack of a control group with children with idiopathic genu valgum. Moreover, deformities were assessed only in the coronal plane using long anteroposterior radiographs. As a strength, however, based on the inclusion criteria, none of the children in our cohort had clinically problematic sagittal deformity that could impair the radiographic measurement of coronal alignment. Finally, another strength is that our study population consists of a heterogeneous group of children with several types of skeletal dysplasia. Despite its limitations, our study is one of the few[3,4,9,13] to present results of hemiepiphysiodesis with 8-plates in skeletal dysplasia.

CONCLUSION

Overall, temporary hemiepiphysiodesis using 8-plate seems to be an effective treatment to correct genu valgum in children with skeletal dysplasia, with low complication rates if applied at the right age. Despite having a longer treatment period, this technique can achieve a sufficient amount of correction at both the distal femur and proximal tibia in skeletal dysplasia if started early.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. YS: study design, analysis and interpretation of data, drafting and critical revision of the manuscript; MD: data analysis, drafting and critical revision of the manuscript; AMY, FB, CS: study design, drafting and critical revision of the manuscript.

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ORIGINAL ARTICLE
ORTHOPEDICS AND TRAUMATOLOGY

THE IMPACT OF COVID-19 ON THE PROFILE OF MOTORCYCLE ACCIDENTS ATTENDED AT A TERTIARY HOSPITAL IN CAMPINAS

IMPACTO DA COVID-19 NO PERFIL DE ACIDENTADOS DE MOTO ATENDIDOS EM UM HOSPITAL TERCIÁRIO EM CAMPINAS

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ABSTRACT

Traffic-accidents are a public health problem with repercussions on population morbimortality. Objective: To analyze the impact of the pandemic on the profile of motorcycle accidents assisted at the Tertiary Hospital in 2020. Methods: Cross-sectional, descriptive retrospective study in 2017 and 2020 of 260 medical records of care for motorcycle accidents in the emergency room of the Tertiary Hospital. Statistical analysis of data and their correlations using the chi-square test ($p < 0.05$). Results: Of the 105 medical records in 2017, 83% are men, mean age 29.8 years, and death rate of 3.90%. Fractures in 98.10%, 64.10% exposed and predominantly the tibia (61.90%). Of the 155 medical records in 2020, 91.61% are men, mean age 31.21 years, and no deaths. Fractures in 94.84%, 37.42% exposed and predominantly the tibia (28.57%). Between 2017 and 2020, Infosiga-SP showed a relevant reduction ($p < 0.001$) of deaths in the hospital environment (52.46% to 31.91%). Conclusion: The incidence of motorcycle accidents increased, in-hospital deaths dropped, but the epidemiological profile of accidents at the Hospital remained unchanged. ***Level of Evidence III, Comparative Retrospective Study.***

Keywords: Traffic Accidents. Motorcycles. COVID-19.

RESUMO

Acidentes motociclísticos configuram um problema de saúde pública com repercussões na morbimortalidade populacional. Objetivo: Analisar o impacto da pandemia por COVID-19 no perfil de acidentes motociclísticos atendidos em um hospital terciário em 2020. Métodos: Estudo transversal, descritivo e retrospectivo que analisou 260 prontuários de acidentados de moto atendidos na Urgência e Emergência do Hospital Universitário Terciário em 2017 e 2020. Realizou-se uma análise estatística dos dados e suas correlações pelo teste qui-quadrado ($p < 0,05$). Resultados: Dos 105 prontuários de 2017, 83% são de homens ($p < 0,001$), com média de 29,8 anos, e índice de óbito de 3,90%. Houve fraturas em 98,10% dos casos, sendo 58,10% expostas e predominantemente da tíbia (61,90%). Dos 155 prontuários de 2020, 91,61% são homens ($p < 0,001$), com média de 31,21 anos e sem casos de óbito. Houve fraturas em 94,84%, sendo 37,42% expostas e predominantemente da tíbia (28,57%). Entre 2017 e 2020, o Infosiga-SP mostrou redução significativa ($p < 0,001$) de mortes em ambiente hospitalar (de 52,46% para 31,91%). Conclusão: Houve aumento na incidência dos acidentes motociclísticos e queda nos óbitos intra-hospitalares, mas o perfil epidemiológico dos acidentados no hospital permaneceu inalterado. ***Nível de Evidência III, Estudo Comparativo Retrospectivo.***

Descritores: *Acidentes de Trânsito. Motocicletas. COVID-19.*

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INTRODUCTION

Traffic accidents are part of the set of external causes of morbidity and mortality and are one of the most important problems of public health worldwide.[1] In 2009, a survey on traffic accidents worldwide conducted by the World Health Organization (WHO) revealed that they are responsible for about 1.24 million deaths per year, and 20 to 50 million people survived with sequelae. The study estimated that 90% of all deaths occurred in middle and low income countries, which held only 48% of the world's fleet of vehicles. Moreover, the WHO predicted that would reach around 1.9 million in 2020 deaths if no intervention was performed.[2]

Between 2007 and 2018, the National Traffic Department (Denatran) recorded 395,998 deaths from land traffic accidents in Brazil, which 30% involved motorcycles. The study shows that this percentage relates to the increase in the fleet of motorcycles in this period, which increased from 11 million to 26.7 million.[3]

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

The study was conducted at PUC-Campinas Hospital.
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The Life in Traffic Project Report (*Projeto Vida no Trânsito* - PVT), prepared by the Department of Health Surveillance (DEVISA) in 2017, points to the predominance of deaths resulting from motorcycle accidents in males between 18 and 34 years. Therefore, it showed that the risk factors for accidents are: alcohol intake, speed, lack of qualification, disrespect for traffic signs and conditions related to the vehicle. This report also related the absence of helmet use with increased severity of trauma, raising the probability of death of an individual who suffered an accident.[4] According to the WHO, the use of this safety equipment reduces 70% in the chances of TBI and up to 40% in the chances of death.[5]

Motorcycles are a mean of transport and a working equipment for delivery, transportation and other services.[3] In the context of the SARS-Cov-2 pandemic, several state decrees limited or prohibited face-to-face service in bars, cafeterias and restaurants. As a result, these establishments increased their performance in delivery apps that use motorcycle couriers to deliver food, beverages and products.[6] Between the 1st and 2nd semester of 2020, the Inter-Union Department of Statistics and Socioeconomic Studies (Dieese) observed an increase in 12.2% of unemployed individuals, using the study "Profile of motorcycle couriers and delivery men." However, the transport sector showed an increase of 529,000, suggesting that the unemployed resorted to the delivery service as an alternative income.[7]

Thus, this study aimed to compare the data of the victims assisted in the Emergency Department of a Tertiary Hospital of Campinas due to motorcycle accident in 2017 and in 2020. Moreover, it seeks to evaluate the impact of the pandemic context caused by COVID-19 and the measures taken, such as the implementation or intensification of delivery services through digital platforms, because the possibility of making essential purchases without leaving home became imperative for the entire population.[6]

METHODS

This is a retrospective observational study, conducted at the PUC-Campinas Hospital, founded in 1978, located in the Northwest region of the city of Campinas.

Victims of motorcycle accidents in Campinas (SP) from January to December, 105 in 2017 and 155 in 2020, formed the sample of 260 patients. We analyzed data from medical records listed in the Orthopedics and Traumatology service of the PUC-Campinas Hospital. Individuals that suffered motorcycle accidents with orthopedic surgical management in 2017 and 2020 and were treated in the Emergency Department of the PUC-Campinas Hospital who accepted participate in the study and provided written consent were included in the study. Those injured patients who did not undergo orthopedic surgeries, were not in the driver or rump category and who suffered bicycle accidents were excluded.

The screening of patients who meet the inclusion criteria took place in two stages: via the preparation of a report with all patients hospitalized for surgical procedures in the Orthopedics and Traumatology sector of the Hospital in the "MV System 2000i Hospital Management," and by selecting the medical records of individuals who suffered motorcycle accidents from the list generated by the program. Then, the following information were obtained from medical records of the study population: gender, age, presence of fracture, polytrauma caused by traffic accidents, exposed fracture, affected limb and bone, deaths, trimester, profession, speed of accident and use of helmet (yes, no or incorrect use).

Additionally, the Database called "Traffic Accident Information System of the State of São Paulo" (Infosiga-SP) was used to survey the total quantity and place of death (accident site, hospital or others) in 2017 and 2020, resulting from motorcycle accidents in Campinas. Infosiga-SP's information system gathers information about traffic accidents that occurred in the state of São Paulo notified by the Civil Police, Military Police and Federal Highway Police. The Infosiga-SP was chosen at the expense of the Traffic Accident Occurrence Book of the Municipal Development Company of Campinas (EMDEC), because accidents that occur on highways are not included in their analyses.[8]

From September to December 2020, the data were collected from records by medical professionals and students using a previously prepared form. For data processing and graphing, the Excel program version 16.44 (Build 20121301), which has a tool called pivot table to gather the results and facilitate statistical analysis, was used. The statistical analysis was performed with the assistance of the chi-square test, used to estimate the probability (p-value) of the data to comply with the pattern related to some hypothesis contrary to what we wanted to demonstrate. Thus, we considered our observations statistically significant when the p-value was low ($p < 0.05$).

This study is part of the research project called "Epidemiological Profile and socioeconomic impact of victims of motorcycle accidents in the emergency of a Tertiary Hospital", approved by the Research Ethics Committee of PUC-Campinas according to CAE 88812818.3.0000.5481 and opinion number 2,722,693/2018. The regulatory standards expressed in Resolution No. 196/1996 of the National Health Council were respected.

RESULTS

In the two years, the analysis of medical records at the PUC-Campinas Hospital showed significant bias ($p < 0.001$) for males, from 87 (82.86%) in 2017 to 142 (91.61%) in 2020 (Table 1). The age group from 18 to 29 years old presented higher incidence, with 45.71% and 53.55% for 2017 and 2020, respectively. The mean age was 29.8 in 2017 and 31.2 in 2020 (Table 1).

Moreover, the data showed a high incidence of fracture and poly trauma among victims of motorcycle accidents, with 103 (98.10%)

Table 1. Characteristics of the victims of motorcycle accidents treated at the PUC-Campinas Hospital in 2017 and 2020.

Characteristics of victims	2017			2020			[b]p-value
	n	%	[a]p-value	n	%	[a]p-value	
Gender			p < 0.001			p < 0.001	p > 0.05
Male	87	82.86		142	91.61		
Female	18	17.14		13	8.39		
Age							p < 0.01
0-17 years old	13	12.38		3	1.94		p < 0.001
18-29 years old	48	45.71		83	53.55		
30-39 years old	22	20.95		33	21.29		
40-49 years old	13	12.38		20	12.90		
50-59 years old	5	4.76		13	8.39		
60-69 years old	4	3.81		3	1.94		
Mean age	29-8 years old			31-21 years old			
Most prevalent age group	18-29 years old			18-29 years old			
Age range	6-69 years old			16-67 years old			
Fracture	103	98.10		144	94.84		p > 0.05
Polytrauma	61	58.10		80	51.61		
Open fracture	67	63.81		58	37.42		p < 0.001
Lower limb	94	89.52		117	75.48		p = 0.05
Tibia	65	61.90		44	28.57		p < 0.001
Deaths	4	3.90		0	0.00		p < 0.05

[a]p-value: by chi-square test using the homogeneity of the distributions each year as null hypothesis;
[b]p-value: by chi-square test using the homogeneity of the distributions each year as null hypothesis.

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fractures, 61 (58.10%) of poly traumatic fractures, and 67 (63.81%) of open fractures in 2017 compared to 144 (94.84%) of fractures, 80 (51.61%) of poly traumatic fractures and 58 (37.42%) of open fractures in 2020. In both periods, the most affected bone was the tibia, present in 65 (61.90%) cases in 2017 and 44 (28.57%) cases in 2020. We observed a statistically significant reduction ($p < 0.005$) in deaths between years, from 4 (3.90%) to 0 deaths.

The distribution of motorcycle accidents during the 2017 quarters occurred homogeneously ($p > 0.05$), and it was impossible to affirm a higher concentration in a specific quarter. In 2020, in turn, the data are dispersed heterogeneously ($p < 0.001$), and the second and third quarters concentrated most accidents, with 62 (40.00%) and 57 (36.77%) cases, respectively (Table 2).

The profession of the injured was suppressed in 76 (49%) medical records, but the most prevalent occupations were motorcyclists, with 19 (12%) cases, and self-employed, with five (3%) patients.

Only in 2020, data about the period of the accident, speed and helmet use at the time of impact were collected. The statistical difference ($p < 0.001$) regarding the use of helmets was 11 (7.1%) did not use it, 136 (87.74%) used it and eight (5.16%) used it incorrectly (Table 3). Since $p > 0.05$, the hypothesis that the velocities occurred homogeneously cannot be excluded, therefore, we cannot affirm that some speed range was prevalence (high, moderate and low).

According to Infosiga-SP, the number of deaths between 2017 and 2020 reduced from 61 to 48 fatal victims. Besides, the number of deaths in the hospital environment decreased from 32 (52.46%) to 15 (31.91%), showing statistical relevance ($p < 0.001$) (Table 4).

DISCUSSION

According to the National Survey on Accidents and Violence (VIVA Project), conducted in Brazil in 2017, most victims of motorcycle accidents were young adults, aged 18 to 29 years, and male, as already pointed out by numerous studies conducted in different Brazilian cities.[9-13]

In 2017 and 2020, this study observed the same age and gender profile found in the literature (Table 1). Moreover, it also showed a significant reduction in accidents in the age range 0-17 years old. This fact may be related to the suspension of classes in public and private schools during most of 2020, between March and October, which decreased the circulation of minors and, consequently, their involvement in motorcycle accidents.[14]

The National Household Sample Survey Data (PNAD) in 2008 indicates that males are twice as likely to be involved in motorcycle accidents as females. In 2019, the Brazilian Association of Manufacturers of Motorcycles, Mopeds, Scooters, Bicycles and Similar (Abraciclo) reported that 77.3% motorcycle driver licenses belong to men.[15] Therefore, the greatest involvement of the male population in motorcycle accidents is due to their greater exposure in traffic.

From 2017 to 2020, the number of trauma patients due to motorcycle accidents treated by the PUC-Campinas Hospital increased 62%, from 104 to 155 cases (Table 1). The first main cause of this increase is that the Sectoral Coordination of Access Regulation of the Department of Audit and Regulation of the SUS made the PUC-Campinas Hospital a reference for the care of the flow of traumas and "non-covid" pathologies in the city, aimed to adapt the city's hospitals to the demand caused by the pandemic.[16]

The second main cause is the significant increase in the number of deliveries to households due to the restriction of circulation imposed in March 2020 in the city of Campinas.[17] RankMyApp's research showed that the use of delivery apps increased 30% between February and March 2020.[18] Moreover, one delivery app declared 100,000 new restaurant registrations during the pandemic, as well as a 60% increase in orders between 2019 and 2020.[19] According to the Association of Motorcycle Couriers of Applications of Campinas, the number of motorcycle and bicycle delivery men in this period increased 32%, from 5,000 to 6,600.[20] However, the need for greater rigor in filling out the profession in the patient's form is emphasized, since this information was not present in 76 (49%) medical records, so in this research it is impossible to confirm the correlation between the growth of motorcycle accidents and increase of motorcycle boys.

According to Debieux et al.,[21] lower limb injuries represent 53.9% of injuries resulting from motorcycle accidents, and the femur is the most prevalent bone.[22] Lower limbs have a greater susceptibility to affection because they are the most unprotected areas, since usually the safety equipment used provides protection only to the head region.[23] In our sample, although the tibia was the most affected bone (Table 1), there was agreement in both years regarding the predominance of lower limb injury, 89.5% (2017) and 75.48% (2020).

In cases of fatal victims, the most observed injuries are on the head, abdomen, lower limbs and pelvis, as Koizumi[24] points out. This study presents limitation regarding information on deaths,

Table 2. Characteristics of the victims of motorcycle accidents treated at the PUC-Campinas Hospital in 2017 and 2020.

Characteristics of the accident	2017			2020		
	N	%	[a]p-value	n	%	[a]p-value
Quarter			p > 0.05			p < 0.001
First quarter	22	20.95		13	8.39	
Second quarter	27	25.71		62	40.00	
Third quarter	21	20.00		57	36.77	
Fourth quarter	35	33.33		23	14.84	

[a]p-value: by chi-square test using the homogeneity of the distributions each year as null hypothesis;

Table 3. Characteristics of the victims of motorcycle accidents treated at the PUC-Campinas Hospital in 2020 and 2020.

Characteristics of the accident	2020		
	N	%	[a]p-value
Speed			
[b]High	37	23.87%	
[c]Moderate	28	18.06%	p > 0.05
[d]Low	29	18.71%	
Not informed	61	39.35%	
Helmet use			p < 0.001
Yes	136	87.74%	
No	11	7.10%	
Incorrect use	8	5.16%	

[a]p-value: by chi-square test using the homogeneity of the distributions each year as null hypothesis; [b]High 30 km/h; [c]Moderate: between 30 and 60 km/h; [d]Low: 60 km/h.

Table 4. Number and place of deaths resulting from motorcycle accidents in the city of Campinas in 2017 and 2020.

Deaths in the city of Campinas	2017		2020		[a]p-value
	N	%	N	%	
Total	61		48		
Place of death					
Place of accident	28	45.90%	31	63.83%	
Hospital	32	52.46%	15	31.91%	p < 0.001
Others	1	1.64%	2	4.26%	

[a]p-value: by chi-square test using the homogeneity of the distributions each year as null hypothesis. Source: Traffic Accident Information System of the State of São Paulo (Infosiga-SP).

since in 2017 it is known only that they were caused by TCE and polytrauma, while in 2020 it had no data to be collected.[22]
Between 2017 and 2020, despite the increase in the total number of motorcycle accidents seen at the PUC-Campinas Hospital, the number of fatal victims decreased significantly, from 4 (3.9%) to no cases (Table 1). The fact that the Hospital did not have any death may be related to the high rate of correct use of helmet 136 (87.74%) among the injured (Table 3). This decrease associates to the increase in deaths at the accident site and, consequently, a decrease in the hospital environment, with 32 (52.46%) in 2017 and 15 (31.91%) in 2020 (Table 4). However, sample size is an important limiting factor, since we collected epidemiological data already available.
Thus, the main victims were individuals between 18-29 years of age, with most infections in the lower limbs, and predominance of the tibia. Despite the increase in the number of motorcycle accidents between 2017 and 2020, the deaths reduced in Campinas, which may be related to the decrease in the number of deaths in hospitals in general.

CONCLUSION

The analysis between 2017 and pandemic period of 2020 showed an increase in the incidence of motorcycle accidents, but the epidemiological profile of motorcycle victims treated at the PUC-Campinas Hospital was constant: young people between 18-29 years old from the male sex. Despite the decrease in deaths during this period, both in the Hospital and in the city of Campinas, further investigating and evaluate the epidemiological profile of the victims is essential, as well as their injuries, in order to provide adequate basis for the implementation of awareness and prevention measures targeting the most affected groups.

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EPIDEMIOLOGICAL PROFILE AND EVOLUTION OF ANKLE MUSCULOSKELETAL TUMORS

PERFIL EPIDEMIOLÓGICO E EVOLUÇÃO NOS TUMORES MUSCULOESQUELÉTICOS AO NÍVEL DO TORNOZELO

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ABSTRACT

Objective: Characterizing ankle tumors, presenting the epidemiological profile of these lesions. Methods: Retrospective observational case series study to evaluate the results of clinical and/or surgical treatments of patients with ankle tumors whose first visit occurred from 1990 to 2020. The dependent variables were: benign bone tumor, malignant bone tumor, benign soft tissue tumor, malignant soft tissue tumor, and infection. The independent variables were: sex, age; presence of symptoms (pain/local volume increase/fracture), duration of symptoms until treatment, diagnosis, treatment, and recurrence. Results: In total, 70 patients were included—58.5% were women, with a mean age at the time of diagnosis of 21.66 years. Among all cases, 76% were bone tumor, 14% were soft tissue tumor, and 10% were infection. The mean age at the time of diagnosis was 21.7 ± 2.29 years. The overall prevalence of pain was 77.1%. In total, 55.6% patients had a general local volume increase 13.4% had fractures. The mean time from symptoms to treatment was 17.4 ± 4.61 months and the mean diagnosis time was 10.13 ± 0.86 months. Of all cases, 73.44% underwent surgical treatment and 22.64% had recurrence. Conclusion: In this series, ankle tumors corresponded mainly to bone tumors. Benign tumors were the most prevalent type of tumor and the highest occurrence was among young people. ***Level of Evidence IV, Case Series.***

Keywords: Neoplasms. Sarcoma. Ankle. Amputation. Neoplasm Recurrence, Local.

RESUMO

Objetivos: Caracterizar tumores da região do tornozelo apresentando o perfil epidemiológico destas lesões. Métodos: Estudo observacional retrospectivo de série de casos para avaliação dos resultados de neoplasias do tornozelo submetidos a tratamento clínico e/ou cirúrgico em que o primeiro atendimento tenha ocorrido entre 1990 e 2020. As variáveis dependentes foram: tumor ósseo benigno, tumor ósseo maligno, tumor de partes moles benigno, tumor de partes moles maligno e infecção. As variáveis independentes foram: sexo, idade, presença de sintomas (dor/aumento de volume local/fratura), tempo de sintomas até o atendimento, diagnóstico, tratamento e recidiva. Resultados: Foram analisados 70 pacientes, sendo 58,5% do sexo feminino, com média de idade no momento do diagnóstico de 21,66 (21,7 ± 2,29) anos. As neoplasias ósseas correspondem a 76% dos casos, seguidas de tumor de partes moles com 14% e de infecção com 10%. A prevalência geral de dor foi de 77,1%. O aumento geral de volume local ocorreu em 55,6% pacientes e presença de fraturas em 13,4%. A média de tempo de sintomas até o atendimento foi de 17,4 ± 4,61 meses e a média de tempo para o diagnóstico foi de 10,13 ± 0,86 meses. O tratamento cirúrgico ocorreu em 73,44% dos casos e a recidiva em 22,64%. Conclusão: Os tumores ao nível do tornozelo nesta série correspondem majoritariamente a tumores ósseos, com prevalência do benigno e maior ocorrência em jovens. ***Nível de Evidência IV, Série de Casos.***

Descritores: *Neoplasias. Sarcoma. Tornozelo. Amputação. Recidiva Local de Neoplasia.*

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INTRODUCTION

About 3% to 4% of cases of bone tumors affect the ankle, mostly soft tissue tumors,[1] of which about 8% are benign and 5% are malignant.[2] Malignant lesions and especially secondary lesions (metastatic lesions) are extremely rare.[3]

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

The study was conducted at Institute of Pediatrics Oncology (IOP/GRAAC), Universidade Federal de São Paulo.
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Among studies in the literature addressing neoplastic lesions of the foot and ankle, sarcomas of the foot show a distinct biological behavior when compared with the same type of tumor in other skeletal sites. Moreover, knowing incidence and distribution patterns of tumors of the foot and ankle helps in their evaluation, diagnosis, and treatment.[4-6]

The distal anatomy of the lower limb is of great complexity and, along with the rarity of this type of lesion, its diagnosis becomes difficult, especially for general orthopedists.[2] This region is anatomically small, with little muscle and subcutaneous tissue, which prevents neoplastic lesions from growing for long periods unnoticed.[1] The anatomical peculiarity of this region is a challenge to limb-salvage surgery in the context of obtaining broad oncological margins.[7]

Patients with ankle tumors should be evaluated in a systematic and judicious way with a good anamnesis and physical examination, followed by complementary imaging tests to formalize a diagnostic hypothesis and, when necessary, schedule a biopsy.[2,8,9] In general, the initial imaging test is a simple X-ray, but ultrasound and computed tomography may also be necessary. In case of local staging of the lesion, magnetic resonance imaging with contrast remains the best imaging test for diagnostic evaluation and treatment planning.[1]

Inadequate treatment of these lesions can cause a great impairment regarding prognosis and functional outcome of patients. Unplanned resection and local recurrences generally occur with the need for more aggressive approaches.[4]

To the best our knowledge, no study in the Brazilian literature characterizes ankle tumors. Thus, this study aimed to characterize ankle tumors, presenting the epidemiological profile of lesions treated in an oncology reference center in Brazil.

METHODS

This retrospective observational case series study was performed to evaluate the results of ankle musculoskeletal tumors. Data were collected from medical and imaging records of patients and a specific database was constructed for this study with total protection regarding the identification of patients. This study was approved by the institutional Research Ethics Committee and is registered in the Brazil Platform under no. 41308920.9.0000.5505.

Medical records of 101 patients diagnosed with neoplasm of the distal end of the lower limbs, whose first visit occurred from 1990 to 2020, undergoing clinical and/or surgical treatments were analyzed. The inclusion criteria were patients of both sexes, with no age limit, followed up at the institution, with an ankle musculoskeletal tumor, which could be defined as:

i. Bone lesion of the talus;
ii. Bone lesion in the distal fibula to the upper limit of the tibial Heim triangle, including lateral malleolus;
iii. Bone lesion of the distal end of the tibia, defined by the metaphyseal region (upper limit of the Heim triangle) to the articular surface of the distal tibia, including the medial malleolus;
iv. Extraosseous lesion (soft tissue) covering the distal anatomical regions to the upper limit of the metaphyseal region of the distal tibia and in proximity to the distal limit of the talus.

Musculoskeletal infections (osteomyelitis, soft tissue infection) that did a differential diagnosis with musculoskeletal neoplasms in this region were included in the study.

All patients with tumors of lower limbs proximal or distal to the area of interest or lesions with extension by contiguity to the ankle, but an epicenter that was not in the region to be studied were excluded. The lack of patient compliance to participate in the study, at any time, was also considered an exclusion criterion.

All patients were evaluated according to general epidemiological variables: (1) sex; (2) age; (3) presence of symptoms (pain/local volume increase/fracture), (4) duration of symptoms until treatment; (5) diagnosis; (6) treatment; (7) recurrence of the lesion after surgical treatment. In this study, ankle lesions were considered a dependent variable: benign bone tumor, malignant bone tumor, benign soft tissue tumor, malignant soft tissue tumor, and infection.

The differential diagnosis of bone infection was confirmed by culture and/or anatomopathological exam. The studied variables were collected by analysis of medical records. Bone tumors were confirmed by biopsy.

The construction of the database and graph creation was performed using the Excel (Microsoft®) software. For statistical analysis, the SPSS® software (IBM, V21) was used. Descriptive analyses are presented in absolute number (n) and relative frequency (%), mean and standard deviation. The Fisher Exact test was used to compare the relative frequency lower than five. ANOVA was used to compare the means of numerical variables of three or more groups. Epidemiological analyses of the variables studied were performed, with a description of categorical and continuous variables.

RESULTS

In total, 70 patients with ankle lesions were included. Among them, 41 (58.6%) were women and 29 (41.4%) were men. The mean age of patients with ankle tumors at the time of diagnosis was 21.7 ± 2.29 years. A total of 47 (77.1%) patients reported pain, 35 (55.6%) had a local volume increase, and nine (13.4%) had fractures. The mean duration of symptoms until treatment was 17.4 ± 4.61 months (range of 0 to 180 months). The mean diagnosis time was 10.13 ± 0.86 months. In this study, 47 patients (73.44%) underwent surgical treatment. Regarding the side affected by the lesion, 49.23% (n = 32) had its right side affected and 46.15% (n = 30) its left side. Recurrence occurred in 22.64% (n = 12) of the cases (Table 1).

Regarding the prevalence of ankle lesions, benign bone tumors represented 55.71% (n = 39) of cases, malignant bone tumors 20% (n = 14), malignant soft tissue tumors 8% (n = 6), infections 10% (n = 7), and benign soft tissue tumor 6% (n = 4). Figure 1 shows the distribution of diagnoses of ankle lesions. Among benign bone tumors, non-ossifying fibroma was the most prevalent (14%; n = 10), followed by osteochondroma (10%; n = 7), Trevor disease (7%; n = 5), and aneurysmal bone cyst (6%; n = 4). Among malignant bone tumors, osteosarcoma (9%; n = 6) and Ewing sarcoma (6%; n = 4) were the most prevalent. Among malignant soft tissue tumors, synovial sarcoma was the most prevalent (6%; n = 4). Figure 2 presents X-ray images of patients with chondroblastic osteosarcoma, chondrosarcoma, osteomyelitis, and Trevor disease. Table 1 also shows the prevalence and means of ankle lesions according to the variables studied and association information. The local volume increase of lesions was different (p = 0) and benign bone tumors presented an increase greater than other lesions (34.29%; n = 12). Moreover, the mean diagnosis time was also different (p = 0).

DISCUSSION

This study presents essential information and contributions to the field of studies on ankle musculoskeletal tumors. Tumors of the foot and ankle are generally uncommon. However, despite the rarity, orthopedic surgeons must know the epidemiological profile, diagnostic criteria, and therapeutic options of patients, as each tumor varies in presentation, degree of aggressiveness, and natural history of the disease.[2]

In this study, benign bone tumors presented higher prevalence, with no statistical differences between women and men. This type of tumor affected mainly adolescents and non-ossifying fibroma and osteochondroma were the most prevalent diagnoses. This type of tumor presented higher prevalence of pain, local increased volume,

Table 1. Sample characterization, prevalence, and mean/standard deviation of ankle lesions and their association with the studied variables (n = 70).

	Total n (%)	BBT n (%)	MBT n (%)	Benign STT n (%)	Malignant STT n (%)	Infection n (%)	
		39 (55.71%)	14 (20%)	4 (5.71%)	6 (8.57%)	7 (10%)	
Sex							0.082*
Women	41 (58.57%)	22 (53.66%)	12 (29.27%)	1 (2.44%)	2 (4.88%)	4 (9.76%)	
Men	29 (41.43%)	17 (58.62%)	2 (6.9%)	3 (10.34%)	4 (13.79%)	3 (10.34%)	
Age (mean/SD)	21.66 2.29	17.08 1.84	27.31 7.75	42.75 13.87	35 6.06	12.57 6.35	0.064**
Pain							0.852*
No	14 (22.95%)	9 (64.29%)	1 (7.14%)	1 (7.14%)	2 (14.29%)	1 (7.14%)	
Yes	47 (77.05%)	26 (55.32%)	8 (17.02%)	3 (6.38%)	4 (8.51%)	6 (12.77%)	
Local volume increase							0.000*
No	28 (44.44%)	25 (89.29%)	2 (7.14%)	0 (0%)	0 (0%)	1 (3.57%)	
Yes	35 (55.56%)	12 (34.29%)	8 (22.86%)	3 (8.57%)	6 (17.14%)	6 (17.14%)	
Fracture							0.180*
No	58 (86.57%)	34 (58.62%)	11 (18.97%)	4 (6.9%)	5 (8.62%)	4 (6.9%)	
Yes	9 (13.43%)	4 (44.44%)	1 (11.11%)	0 (0%)	1 (11.11%)	3 (33.33%)	
Duration of symptoms until treatment (mean/SD)	17.40 4.61	20.04 6.69	5.78 1.10	72 48	30 6	2.57 0.68	0.539**
Diagnosis time (mean/SD)	10.13 0.86	5.31 0.80	13.85 0.85	16.5 4.79	17.5 0.34	19.57 0.30	**0.000***
Surgical treatment							0.299*
No	17 (26.56%)	13 (26.56%)	3 (17.65%)	1 (5.88%)	0 (0%)	0 (0%)	
Yes	47 (73.44%)	23 (73.44%)	11 (23.4%)	3 (6.38%)	6 (12.77%)	4 (8.51%)	
Affected side							0.230*
Left	30 (46.15%)	14 (46.67%)	5 (16.67%)	1 (3.33%)	4 (13.33%)	6 (20%)	
Right	32 (49.23%)	19 (59.38 %)	8 (25%)	2 (6.25%)	2 (6.25%)	1 (3.13%)	
Both	3 (4.62%)	2 (66.67%)	0 (0%)	1 (33.33%)	0 (0%)	0 (0%)	
Recurrence							0.955*
No	41 (77.36%)	20 (48.78%)	9 (21.95%)	3 (7.32%)	5 (12.2%)	4 (9.76%)	
Yes	12 (22.64%)	7 (58.33%)	3 (25%)	1 (8.33%)	1 (8.33%)	0 (0%)	

BBT: benign bone tumor; MBT: malignant bone tumor; Benign STT: benign soft tissue tumor; Malignant STT: malignant soft tissue tumor; SD: standard deviation; *Fisher exact test; **ANOVA; $p < 0.05$: statistically significant.

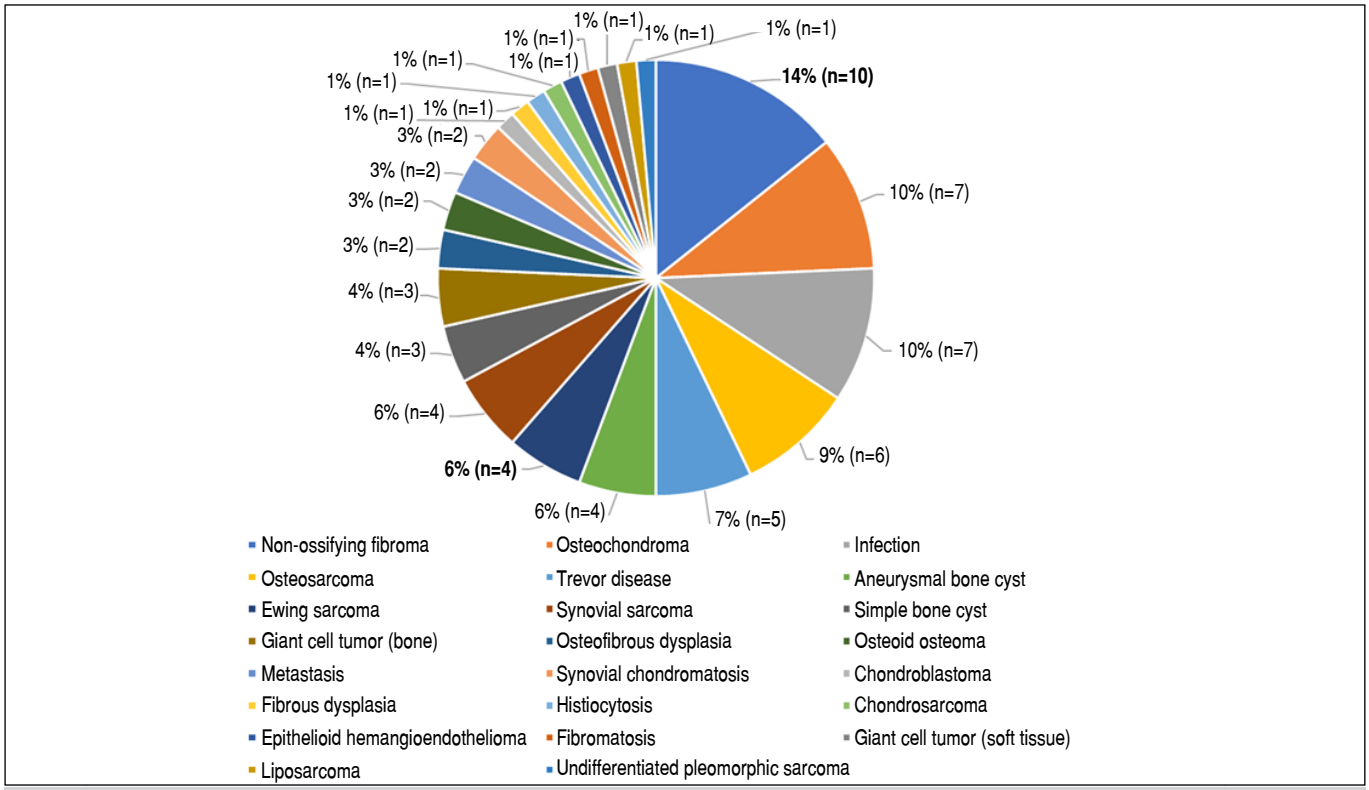

Figure 1. Distribution of diagnoses of ankle lesions.

Figure 2. X-ray images: A) woman, 23 years of age, chondroblastic osteosarcoma; B) man, 63 years of age, grade II chondrosarcoma; C) man, 11 months of age, osteomyelitis; D) woman, eight years of age, Trevor disease.

and recurrence in comparison with other types of tumor. Our findings are in line with other studies.[1,3] Ozdemir et al.[1] reported 1,786 bone and soft tissue tumors, of which 87.2% were benign. Moreover, Chou, Ho, and Malawer[3] reported a prevalence of 60.8% of benign ankle and foot lesions.

Malignant bone tumors were more prevalent among young women (27.31 ± 7.75 years). It was the second type of tumor with the highest prevalence of pain, local increased volume, and recurrence. Osteosarcoma and Ewing sarcomas were the most prevalent diagnoses for this type of tumor. Brotzmann et al.[6] showed that for malignant bone tumors, the first symptoms, such as pain and edema, are nonspecific and often misinterpreted as inflammatory or post-traumatic in nature. The authors also stated that the variety of differential diagnoses explains the long delay in the diagnosis of bone tumors in general, but not the marked difference between foot tumors and those in other skeletal sites.

In our study, 5.71% of the cases were benign soft tissue tumors, with lower prevalence of pain, local increased volume, and risk of fractures. The diagnoses of this type of tumor were synovial chondromatosis (3%), extra-abdominal fibromatosis (1%), and giant cell tumors (1%). In a study by Ruggieri et al.,[10] 189 patients (16.15%) were diagnosed with soft tissue lesions, of whom 91 (48.15%) were non-malignant (pseudotumors or benign tumors).

Malignant soft tissue tumors were more predominant among adult men (mean age of 35 years) and synovial sarcoma (6%), liposarcoma (1%), and undifferentiated pleomorphic sarcoma (1%) were the most prevalent diagnoses. In a study by Toepfer et al.,[4] 78 cases (18.8%) were malignant tumors. Soft tissue tumors showed a malignancy rate (29.2%) higher than bone lesions (13.1%).

In our study, diagnoses of infections were osteomyelitis and infected Charcot osteoarthropathy. Charcot osteoarthropathy is a relatively painless, progressive, and degenerative arthropathy of one or more joints caused by underlying neurological deficits. In contrast to Charcot osteoarthropathy, osteomyelitis is a bone infection that can reach the bloodstream from nearby tissues.[11]

The strength of this study refers to information on the epidemiological profile of ankle lesions. However, this study had limitations, such as its design (case series) and data obtained from a single center, which limits the interpretation at the national level of the findings.

CONCLUSION

In this series, ankle tumors corresponded mainly to bone tumors. Benign tumors were the most prevalent type of tumor and the highest occurrence was among young people. Knowing the epidemiological profile of ankle lesions can help to improve the understanding of the pathology and, consequently, the therapeutic success.

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RADIOGRAPHIC STUDY OF THE MEDIAL JOINT SPACE OF THE HIP IN LEGG-CALVÉ-PERTHES DISEASE

ESTUDO RADIOGRÁFICO DO ESPAÇO ARTICULAR MEDIAL DO QUADRIL NA DOENÇA DE LEGG-CALVÉ-PERTHES

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ABSTRACT

Objective: To evaluate medial joint space in affected and normal contralateral hips in patients with Legg-Calvé-Perthes disease (LCPD). Methods: To compare joint space, femoral head extrusion (FHE), medial space coefficient (MSC) of the hip, and femoral head width (FHW) in affected and normal hips, using 127 radiographs of patients with unilateral LCPD and considering age groups under and over six years old as well as their disease stage. Results: No statistically significant differences were observed regarding MSC between normal and affected hips regardless of disease staging. However, medial joint distance was significantly greater in affected hips than in normal hips. In the necrosis and fragmentation phase, distance from medial space in affected hips was significantly greater than in contralateral normal hips. Comparing only affected hips, MSC and FHW showed statistically significant differences and the group > 6 yo presented higher values. Among normal hips, the group < 6 yo presented a statistically significant difference considering the MSC and FHW. Conclusions: No statistically significant difference was found between the medial joint space of affected and normal hips, except for early stages of the disease (necrosis and fragmentation). The isolated use of radiographic study is insufficient in LCPD and the lack of complementation with other exams, such as magnetic resonance, can delay diagnosis of and onset of treatment for the disease. ***Level of Evidence III, Study of Non Consecutive Patients; without Consistently Applied Reference "Gold" Standard.***

RESUMO

Objetivo: Avaliar o espaço articular medial entre o quadril afetado e o contralateral normal em pacientes com doença de Legg-Calvé-Perthes (DLCP). Métodos: Comparação do espaço articular, da extrusão da cabeça femoral (ECF), do coeficiente do espaço medial do quadril (CEM) e da largura da cabeça femoral (LCF) entre quadris afetados e normais a partir de 127 radiografias de pacientes com DLCP unilateral. Foram consideradas faixas etárias maiores e menores de 6 anos e o estágio evolutivo da doença. Resultados: Na comparação dos lados normal e afetado, independentemente da fase da doença, não se observou diferença estatisticamente significativa quanto ao CEM. Contudo, a distância articular medial no quadril afetado foi significantemente maior que a do quadril normal. Na fase de necrose e fragmentação, a distância do espaço medial dos quadris afetados foi significativamente maior em comparação aos contralaterais. Entre os quadris afetados, o CEM e a LCF apresentaram diferenças estatisticamente significantes, sendo que o grupo com idade > 6 anos apresentou valores maiores. Nos quadris normais, observou-se diferença estatisticamente significante do CEM e da LCF no grupo com idade < 6 anos. Conclusões: Não foi observada diferença estatisticamente significante quanto ao espaço articular medial entre quadril afetado e quadril normal, exceto nas fases iniciais da doença (necrose e fragmentação). O uso isolado do estudo radiográfico mostra-se insuficiente na DLCP, de forma que a falta de complementação com outros instrumentos, como a ressonância magnética, pode retardar o diagnóstico e, consequentemente, o início do tratamento. ***Nível de Evidência III, Estudo de Pacientes Não Consecutivos; sem Padrão de Referência "Ouro" Aplicado Uniformemente.***

Keywords: Legg-Calvé-Perthes Disease. Radiography. Classification. Child.

Descritores: *Doença de Legg-Calvé-Perthes. Radiografia. Classificação. Criança.*

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INTRODUCTION

Since its description in 1910, Legg-Calvé-Perthes disease (LCPD) has always stimulated interest among researchers, being one of the subjects with the most controversies in the orthopedic literature. Considering the aspects of imaging diagnosis, for a long time authors focused on analyzing radiographic aspects. The evolutionary phases of the disease were first described by Waldenström, whose

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classification was later simplified and correlated with Jonsäter's pathological findings.[1] Catterall then systematized the assessment of the involvement of the femoral head (FH) ossification center based on the maximum fragmentation phase. To determine the proportions of the lesion in its initial or necrosis phase, Salter and Thompson showed that the size of the subchondral fracture in the incidence of the head profile could accurately reflect how much the disease affected the proximal femoral epiphysis (PFE).[2] More recently, Herring[3] proposed a classification based on the height of the lateral column of the femoral epiphysis.

Since the growing hip presents a cartilaginous mold that is not visible by plain radiography, only pneumoarthrography (PAG) or Magnetic Resonance Imaging (MRI) would allow early recognizing changes in the shape of the head and femoral extrusion.[4]

The thickness of the hyaline cartilage of the FH, recognized virtually by conventional radiography as joint space, varies according to the growth of children. A reduction of this gap is a direct indication of joint disease and occurs in several arthritic hip disorders.[5] In LCPD, an increase in the joint space, especially in the early stages of the disease, indicates tapering of the articular cartilage of the FH. Less commonly, the occurrence of a chondrolysis, especially in the more severe forms of LCPD, indicates a great reduction of the medial space.

These concepts are considered essential for understanding the disease and indicating treatment. The preservation of the spherical form of the FH is known to minimize the risk of secondary degenerative hip osteoarthritis in adulthood.[6]

In the orthopedic literature, few studies discuss the importance of the joint space, especially of its medial aspect of the coxofemoral joint in LCPD observed by radiographic analysis. This study thus aimed to measure medial joint distance in hips affected by unilateral LCPD and compare the values obtained with contralateral hips unaffected by the disease. We also sought to verify if this radiographic parameter is correlated with the extrusion of the PFE or patients' age at the occurrence of the disease.

METHODS

This research project was submitted to the Research Ethics Committee of Plataforma Brasil and approved for execution under no. CAAE 53730316.6.0000.5625.

Patients and/or their guardians signed an informed consent form to participate in the study.

Radiographic images of 127 patients affected by LCPD from the Outpatient Clinic of the Pediatric Orthopedics Discipline of the Department of Orthopedics and Traumatology of EPM-UNIFESP were unilaterally assessed. The material was collected from 1996 to 2008. Of all patients studied, 96 (75.6%) were male and 31 (24.4%) were female. The mean age of patients was 7.3 years (ranging from three to 16 years). Regarding the affected side, 68 (53.5%) had a compromised right hip and 59 (46.5%) had the left hip compromised.

This study's patient inclusion criteria were:

- Patients with unilateral LCPD.
- Adequate and well-defined radiographic documentation.
- Patients not submitted to surgical treatment.
- Skeletal immaturity.

The study's exclusion criteria were as follows:

- Patients with bilateral LCPD.
- Incomplete or poor quality radiographic documentation.
- Patients submitted to surgical treatment.
- Skeletal maturity.

Radiographs were classified according to Waldenström criteria modified by Jonsäter and divided into necrosis, fragmentation, reossification, and definitive phases. Therefore, 55 (43.31%) hips were categorized in the necrosis phase, 42 (33.07%) in fragmentation, 21 (16.53%) in reossification, and nine (7.09%) in the definitive phase (Chart 1).

Parameters used for the study were the relationships of the measurements obtained on pelvis radiographs in the anteroposterior incidence of patients (Figure 1).

The relationships of the medial space, the subluxation of the FH, and the size of the femoral head of both hips were assessed by estimating the following coefficients:

- Coefficient of medial space of the affected hip (CMSA): BD/CD.
- Extrusion of the FH of the affected hip (EFHA): AC/AB
- Width of the FH of the affected hip (WFHA): AD-AC
- Coefficient of medial space of the normal hip (CMSN): EG/EF
- Normal FH extrusion (NFHE): FH/GH
- Normal FH width (NFHW): EH-EF

Methodology for data analysis

A professional specialized in medical statistics evaluated the results using Spearman's correlation coefficient and the nonparametric Wilcoxon and Mann-Whitney test to compare the measurements of normal and affected hips. All tests were applied considering the significance level of 5% and significant values were marked with the symbol (*).

Chart 1. Distribution of the 127 patients affected by Legg-Calvé-Perthes disease according to Waldenström's classification of the evolutionary phases modified by Jonsäter.

Evolutionary phase	Patients	Variable	Minimum	Maximum	Mean	p
Necrosis	55	normal hip affected hip	0.10 0.06	0.50 0.33	0.25 0.22	0.047
Fragmentation	42	normal hip affected hip	0.09 0.08	0.44 0.33	0.21 0.22	0.790
Reossification	21	normal hip affected hip	0.10 0.11	0.85 0.31	0.26 0.21	0.079
Definitive	9	normal hip affected hip	0.11 0.13	0.33 0.34	0.20 0.21	0.767

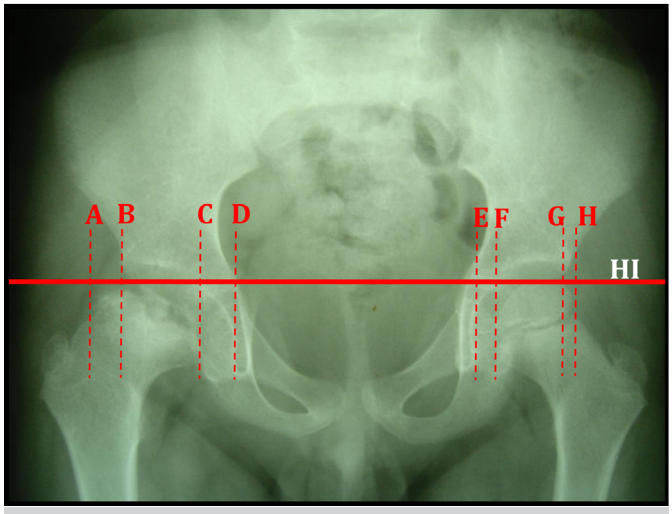

Figure 1. Pelvis radiography showing the references used to estimate the measurements studied in the LCPD.

HILG: Hilgenreiner's line; A: line perpendicular to Hilgenreiner's line crossing the lateral edge of the PFE of the affected hip; B: line perpendicular to Hilgenreiner's line crossing the lateral edge of the affected hip acetabulum; C: line perpendicular to Hilgenreiner's line crossing the medial edge of the PFE of the affected hip; D: line perpendicular to Hilgenreiner's line crossing the medial edge of Köhler teardrop of the affected hip; E: line perpendicular to Hilgenreiner's line crossing the medial edge of Köhler teardrop of the normal hip; F: line perpendicular to Hilgenreiner's line crossing the medial edge of the PFE of the normal hip; G: line perpendicular to Hilgenreiner's line crossing the lateral edge of the normal hip acetabulum; H: line perpendicular to Hilgenreiner's line crossing the lateral edge of the PFE of the normal hip. Measurements obtained from the affected hip: AB: extrusion of the PFE of the affected hip; AC: width of the PFE of the affected hip; CD: medial joint space of the affected hip. Measurements obtained from the normal hip: EF: medial joint space of the normal hip; FH: PFE width of the normal hip; GH: PFE extrusion of the normal hip.

RESULTS

The Wilcoxon test showed no significant differences between normal and affected sides regardless of the evolutionary phase of the disease. However, medial joint distance was significantly higher in the affected hip than in the normal hip ($p = 0.025$*).

Table 1 shows that in the NECROSIS phase, the distances of the medial space of the hips affected by LCPD present no statistically significant difference. The distances of the medial space of the hips of the normal contralateral side also showed no statistically significant difference. Moreover, the distances of the medial space in hips affected by LCPD were statistically significant and higher than in hips of the contralateral side unaffected by the disease ($p = 0.047$*). In the FRAGMENTATION phase, distances of the medial space of the hips affected by LCPD showed a statistically significant difference ($p = 0.001$*). However, no statistically significant differences were found among the hips unaffected by the disease and between the affected and normal sides. In the REOSSIFICATION and DEFINITIVE phases, no statistically significant differences were found among the affected and unaffected hips and between the affected and normal sides.

Table 2 shows the results of the evaluation between the medial space coefficient, FH extrusion, and FH width of the hips affected by LCPD considering the age groups < 6 years and > 6 years after applying the Mann-Whitney nonparametric test. Analysis of the CMSA shows a statistically significant difference among age groups, with the group aged > 6 years presenting significantly higher values ($p = 0.025$*). No statistically significant difference was observed between the two groups regarding EFHA ($p = 0.170$). The groups presented statistically significant differences regarding WFHA, with the group aged > 6 years presenting significantly higher values ($p = 0.012$*). Among unaffected hips, groups presented a statistically significant difference regarding CMSN, with the group aged < 6 years presenting higher values ($p < 0.001$*). The groups also showed a statistically significant difference regarding NFHW, with the group aged < 6 years presenting higher values ($p = 0.006$*). No statistically significant difference was observed between the two groups regarding NFHE, with $p = 0.810$ (Table 3).

Table 1. Comparison of the coefficient of medial space according to disease phase (Wilcoxon parametric test).

Phase	Variable	n	Mean	SD	Minimum	Maximum	P25	Median	P75	p
Necrosis	CD	55	2.04	1.24	0.40	4.00	0.70	2.4	3.00	0.543
	EF	55	2.06	1.05	0.50	4.00	1.00	2.20	3.00	
	Normal side relationship	55	0.25	0.10	0.01	0.50	0.15	0.25	0.30	0.047 (*)
	Affected side relationship	55	0.22	0.06	0.09	0.33	0.17	0.22	0.26	
Fragmentation	CD	42	1.55	1.24	0.40	4.50	0.60	0.80	2.80	0.001 (*)
	EF	42	1.80	1.24	0.40	4.50	1.00	1.05	3.00	
	Normal side relationship	42	0.21	0.09	0.09	0.44	0.15	0.18	0.27	0.790
	Affected side relationship	42	0.22	0.07	0.08	0.33	0.16	0.22	0.27	
Reossification	CD	21	2.25	1.32	0.50	4.00	0.70	2.80	3.40	0.226
	EF	21	2.13	0.98	0.50	3.5	1.10	2.50	3.00	
	Normal side relationship	21	0.26	0.15	0.10	0.85	0.18	0.22	0.30	0.079
	Affected side relationship	21	0.21	0.05	0.11	0.31	0.17	0.20	0.24	
Definitive	CD	9	1.52	1.37	0.40	3.5	0.55	0.70	3.25	0.361
	EF	9	1.68	1.17	0.50	3.7	0.75	1.30	2.90	
	Normal side relationship	9	0.20	0.07	0.11	0.33	0.13	0.18	0.26	0.767
	Affected side relationship	9	0.21	0.08	0.13	0.34	0.15	0.16	0.30	

CD: medial joint space of the affected hip; EF: medial joint space of the normal hip; n: number of cases; SD: standard deviation; p: result of the statistical calculation.

Table 2. Evaluation of the coefficient of the medial space, extrusion of the femoral head, and width of the femoral head of the hips affected by Legg-Calvé-Perthes disease considering the age groups < 6 years and > 6 years after applying the Mann-Whitney nonparametric test.

Variable	Group	n	Mean	SD	Minimum	Maximum	P25	Median	P75	p
CMSA	Up to six years old	41	3.79	1.48	1.39	9.33	2.91	3.56	4.57	0.026 (*)
	Over six years old	65	4.38	1.59	1.88	9.80	3.36	4.05	5.13	
EFHA	Up to six years old	41	38.01	83.33	– 28.00	280.00	4.75	9.45	20.00	0.170
	Over six years old	65	17.37	47.19	– 5.00	290.00	3.78	6.33	13.10	
WFHA	Up to six years old	41	3.68	1.62	2.55	10.66	2.80	3.15	3.7	0.012 (*)
	Over six years old	65	4.19	1.67	2.30	10.33	3.05	3.8	4.93	

Table 3. Evaluation of the coefficient of medial space, extrusion of the femoral head, and width of the femoral head of the normal hips considering the age groups < 6 years and > 6 years after applying the Mann-Whitney nonparametric test.

Variable	Group	n	Mean	SD	Minimum	Maximum	P25	Median	P75	p
CMSN	Up to six years old	41	3.63	1.29	1.18	8.00	2.82	3.30	4.57	< 0.001 (*)
	Over six years old	65	4.53	1.20	1.18	8.00	3.67	4.56	5.00	
NFHE	Up to six years old	41	22.45	59.49	– 6.50	290.00	4.16	6.00	9.68	0.810
	Over six years old	65	15.09	47.34	– 25.00	280.00	3.69	7.00	10.34	
NFHW	Up to six years old	41	3.31	1.42	1.24	8.47	2.35	2.70	4.14	0.006 (*)
	Over six years old	65	4.10	1.62	1.24	10.20	2.70	4.13	5.43	

DISCUSSION

In LCPD, the bone part of the PFE undergoes several alterations in its medullary part, that can be recognized radiographically a few weeks after the disease onset, and in its trabecular arrangement after the onset of ischemia.[7]

Throughout this condition, the PFE could contain viable bone tissue interwoven with the necrotic bone. Therefore, radiographic staging cannot be properly performed during the first weeks after the initial FH infarction[8], postponing treatment.[9]

Our findings showed that in the early stages of the disease, even plain radiography indicated a lateral subluxation of the FH evidenced by the increased medial joint space considering the epiphysis and acetabulum. Flattening the PFE could also increase this virtual radiographic space.

These alterations were recognized statistically in the necrosis and fragmentation phases of LCPD, indicating FH deformity since the initial phases of the disease. Although many authors consider FH extrusion as extremely important to predict the risk of and indicate treatment for degenerative osteoarthritis, our findings showed no direct relationship between this variable and medial joint space. The increase of the medial space was statistically significant in the affected hips.

The extent of the FH deformity in LCPD is considered a determining factor to establish a long-term prognosis. A serial analysis of the radiographs indicates a progressive deformation of the PFE from the early stages of the disease. However, the hyaline cartilage of the FH is damaged a few days after the occurrence of arterial insufficiency, leading to its hypertrophy. Importantly, such structural modification can only be analyzed by an examination that can directly visualize the cartilaginous tissue, as in MRI.[10,11]

Since radiographic analysis is insufficient, assessment of cartilaginous structures should indicate the disease phase and treatment more accurately.[12] Accordingly, the incipient knowledge of changes in the cartilaginous molds of the PFE and acetabulum results in limited conclusions and sometimes equivocal interpretations to radiographic examinations when trying to establish the actual position of the FH in relation to the acetabulum.

The most studied radiographic alterations in LCPD include FH deformation and enlargement, adductor brevis with trochanteric overgrowth, acetabular dysplasia, joint incongruity, and FH extrusion.[13]

Among these, some authors consider that the two most important prognostic radiographic parameters are femoral head deformation and joint incongruity.

However, other authors argue that radiographic examination alone is insufficient to assess the compromised coxofemoral joint, whereas MRI, PAG, or tomography could be useful to show subtle changes in form and phenomena, such as femoroacetabular impingement.[14,15]

Our study found no statistically significant increase in the medial joint space of the affected hip in relation to the normal hip among the evolutionary phases of the disease.

However, our analysis showed that the medial joint space of the affected hips is larger than that of the normal contralateral side. This could be related to the progressive deformation of the femoral head associated or not with PFE extrusion.

Some studies using MRI examinations found an increase in medial joint space.[16] According to these studies, enlargement at an early stage results from a proliferation of PFE chondrocytes without its due endochondral ossification of the secondary nucleus which suffered circulatory damage.[17] This proliferation would also occur in the hyaline cartilage of the acetabulum. Furthermore, this cartilaginous thickening in the active phases of LCPD would be transitory since it does not occur in the more advanced phases of the disease.

Vijayan et al.[5] showed that several patients affected by LCPD undoubtedly had an increased joint space which persisted until skeletal maturity, especially when the hips were classified as belonging to classes III, IV, and V according to Stulberg, Cooperman and Wallensten.[18] The authors also found a relationship regarding the increase in the joint space between the acetabulum and the FH in all its joint extension determined by the magnification of the PFE determined by coxa magna. They also suggested that hypertrophy of the entire proximal femoral complex could cause articular cartilaginous enlargement, being directly related to the poor prognosis of individuals affected by this disease.

Our sample included patients exclusively with skeletal immaturity. Regarding age groups, some authors consider that the age limit for indication of conservative treatment is six years old. We observed that the medial space of the hips affected by the disease was higher in children over six years old, suggesting more severe hip deformity in this age group. Among the hips unaffected by LCPD, the age group under six years old had greater medial space and FH width, which we considered as a physiological condition.

Regardless of our results, we believe that many variables must be researched, even when reporting to radiographic examination. Moreover, further biomechanical, biochemical, and anatomical studies are needed to better understand medial space in LCPD and determine the best treatments and results for the disease after its healing phase.

CONCLUSIONS

Although conventional radiography remains the main instrument for diagnostic aid and follow-up of LCPD evolution, applying this method without other radiological examinations is insufficient, delaying the diagnosis and onset of treatment of the disease.

Accordingly, this study found no statistically significant differences regarding medial space coefficient ($p = 0.087$) among the normal and affected sides regardless of the evolutionary phase of LCPD. In the necrosis phase, however, this relationship was statistically significant (Table 1). In the fragmentation phase, distances of the medial space of the hips affected by LCPD presented a statistically significant difference ($p = 0.001$*).

The hips affected by LCPD also presented a statistically significant difference for CMSA, with the group aged > 6 years presenting significantly higher values ($p = 0.025$*). The groups also presented statistically significant differences regarding WFHA, with the group aged > 6 years presenting significantly higher values ($p = 0.012$*). No statistically significant difference was observed between the two groups regarding EFHA, with $p = 0.170$ (Table 2).

Evaluation of the normal hips showed a statistically significant difference for CMSN among groups, with the group aged < 6 years presenting significantly higher values ($p < 0.001$*). The groups also showed statistically significant differences regarding NFHW, with the group aged < 6 years presenting significantly higher values ($p = 0.006$*). No statistically significant difference was observed between the two groups regarding NFHE, with $p = 0.810$ (Table 3).

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EPIDEMIOLOGICAL STUDY OF SURGICALLY TREATED HUMERAL SHAFT FRACTURES – A 10-YEAR REVIEW

ESTUDO EPIDEMIOLÓGICO DAS FRATURAS DIAFISÁRIAS DO ÚMERO TRATADAS CIRURGICAMENTE – UMA REVISÃO DE 10 ANOS

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ABSTRACT

Most epidemiological studies do not exclusively address fractures treated surgically but include those with conservative treatment. In Brazil, few epidemiological studies address fractures prevalence undergoing surgical treatment. Objective: To assess the prevalence, demographics, and associated injuries of surgically treated humeral shaft fractures. Methods: A retrospective study between 2009 and 2019 with patients undergoing osteosynthesis of humeral shaft fracture. Categorical variables were assessed using Fisher's chi-square or exact test, and non-categorical variables were assessed using the unpaired t-test. A significance level of 5% was adopted. Results: A total of 115 patients were evaluated. Mean age was 37.9 ± 15.6 years, with a male predominance (66.9%) due to car accidents. The most prevalent fracture type was 12 A3. Open fracture prevalence was 11.3%. Radial nerve damage prevalence was 33% and low-energy trauma was twice as likely. Conclusion: Surgically treated humeral shaft fractures were more prevalent in men, young, and related to high-energy trauma, with a transverse line pattern. Fractures secondary to low-energy trauma had a greater association with radial nerve injury. ***Level of Evidence III, Epidemiological, Retrospective Study.***

Keywords: Analytical Epidemiology. Humeral Fractures. Fracture Fixation, Internal. Radial Neuropathy.

RESUMO

A maior parcela dos estudos epidemiológicos não aborda exclusivamente as fraturas tratadas cirurgicamente, mas engloba as de tratamento conservador. No Brasil existem poucos estudos epidemiológicos que versam sobre a prevalência das fraturas submetidas ao tratamento cirúrgico. Objetivo: Avaliar a prevalência, os dados demográficos e as lesões associadas das fraturas da diáfise do úmero tratadas cirurgicamente. Métodos: Estudo retrospectivo conduzido entre 2009 e 2019, com pacientes submetidos a osteossíntese de fratura diafisária do úmero. As variáveis categóricas foram testadas pelo teste qui-quadrado ou teste exato de Fisher, enquanto as não categóricas foram medidas pelo teste t não pareado. Adotou-se nível de significância de 5%. Resultados: Foram avaliados 115 pacientes. A média de idade foi de 37,9 ± 15,6 anos, com uma predominância de pacientes do sexo masculino (66,9%) devido a acidentes automobilísticos. A fratura tipo 12 A3 foi a mais prevalente. A prevalência de fratura exposta foi de 11,3%. A lesão nervo radial ocorreu em 33%, principalmente em traumas de baixa energia. Conclusão: As fraturas diafisárias do úmero tratadas cirurgicamente foram mais prevalentes em homens jovens e relacionadas a traumas de alta energia, com padrão de traço transverso. Fraturas secundárias e traumas de baixa energia tiveram maior associação com lesão do nervo radial. ***Nível de Evidência III, Estudo Epidemiológico, Retrospectivo.***

Descritores: *Epidemiologia Analítica. Fraturas do Úmero. Fixação Interna de Fraturas. Neuropatia Radial.*

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INTRODUCTION

In adults, 1 to 3% of all locomotor system fractures are humeral shaft fractures, and these are the second humerus most frequent fracture location (14 to 20%), less prevalent only when compared to the proximal region.[1-6]

Most epidemiological studies of humeral shaft fractures are European and North American.[4,7,8] Developed countries have a bimodal incidence, with two peaks: young men, related to high-energy trauma, and older women, related to low-energy traumas.[1,7] In Latin America, a multicenter study showed a predominance in

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young men.[8] Thus, the country development degree may influence this epidemiology, since automobile accidents are more prevalent in underdeveloped countries and low-energy traumas predominate in developed countries.[4,8]

Humeral shaft fracture conservative treatment is still the gold standard, since it has high consolidation potential related to good humerus vascularization.[9] Surgical treatment has precise indications, such as open fractures, floating elbow, bilateral humeral fracture, nerve injuries after penetrating injuries or after closed manipulation, polytrauma, and unacceptable angular deviations.[10]

The largest part of epidemiological studies does not address surgically treated fractures exclusively but encompasses those of conservative treatment. Thus, a targeted epidemiological study is fundamental to plan a health system to care for patients.

Brazil shows few epidemiological studies dealing with the prevalence of humeral shaft fractures which underwent surgical treatment.

Objective

To evaluate the prevalence and of humeral shaft fractures surgically treated in a trauma center and its associated lesions and data.

METHODS

A retrospective study was conducted via a survey of humeral shaft fractures medical records surgically treated between 2009 and 2019. Patients still followed up at the outpatient clinic signed na informed consente form. Those discharged by the outpatient clinic were contacted via phone call and provided authorization to have their information used in the study.

Inclusion criteria were age ≥ 18 years, humeral shaft fractures, in which the main trait is outside the Heim square, set up by the AO (Arbeitsgemeinschaft für Osteosynthesefragen), in the humeral proximal and distal segments. The Heim square is a square whose sides have the same length as the widest part of the epiphysis and delimits the ending segments.[11,12] The square was traced using the program Synapse^{R}.

Exclusion criteria were patients undergoing conservative treatment, incomplete information on the medical records (clinical and radiological), and pathological fractures.

Demographic data such as sex, age, injury date, trauma mechanism, affected side, fracture classification (according to the AO), fracture classification as exposed or closed, radial nerve associated lesions, and the surgical treatment method employed were researched.

High-energy trauma was considered as accidents with motor vehicles (motorcycle and car), running over, gunshot wound, limb seizures by machines, and falls from height (scaffolding, bridge). Low-energy trauma was considered as fall from one's own height and sprains.

A statistical analysis was performed to evaluate the central trend data. Categorical variables were assessed by Fisher's exact or Chi-square test, and the non-categorical variables by the unpaired t-test. All analyses were conducted in the program PASW statistics 18.0 (SPSS Inc., Chicago, USA), adopting a 5% significance level ($P < 0.05$).

The research project was approved by the Research Ethics Committee under number 42661820.9.0000.5404.

RESULTS

We found a total of 156 patients with humeral shaft fractures from January 2009 to December 2019. Due to incomplete data (clinical or radiological), we excluded 41 patients.

Their mean age was 37.9 ± 15.6 years, with a male predominance (66.9%), a 2:1 ratio when compared to females. Comparing the mean age between genders, women were older (42.4 years) than men (35.7 years) ($p < 0.05$).

We noticed a higher prevalence of the left limb on the fracture's laterality (56.5%). Table 1 shows the demographic data.

The prevalence of fractures was higher in December, lower in February, and stable in other months (Figure 1).

Fractures were classified according to the AO standards. Simple trait (type A) was the most prevalent (70.4%), especially A3 (transverse). Figure 2 describes fractures frequency types.

Patients mostly presented closed fracture and only 13 of them (11.3%) evolved with open fracture, which were associated with high-energy trauma ($p = 0.02$). Gender or age did not interfere in open fractures prevalence.

Regarding the trauma mechanism, high-energy accidents prevailed (72.2%).

A total of 38 (33%) patients were diagnosed with radial nerve associated lesion, which presented a two fold lower risk of occurring in high-energy trauma (OR 0.5; CI 0.32–0.89; $p < 0.05$). However, no association were found between age, gender, open fracture, and radial nerve injury. Table 2 describes the associated lesions.

Table 1. Demographic data

Characteristic	Values/Occurrence
Age [mean (+ SD)] (years)	37.9 ± 15.6
Sex [No. (%)]	
Male	77 (67)
Female	38 (33)
Laterality [No. (%)]	
Right	50 (43.5)
Left	65 (56.5)

SD: standard deviation.

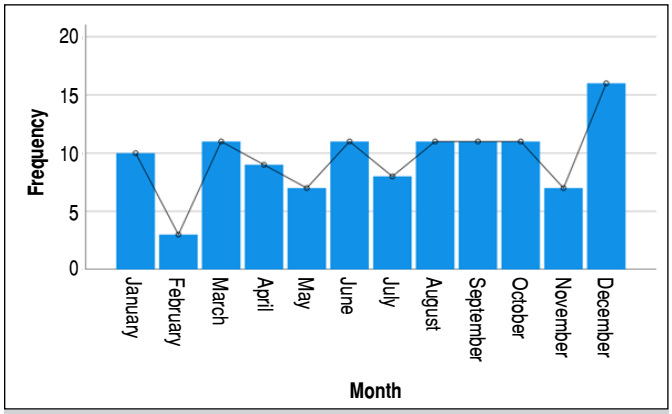

Figure 1. Prevalence distribution per month.

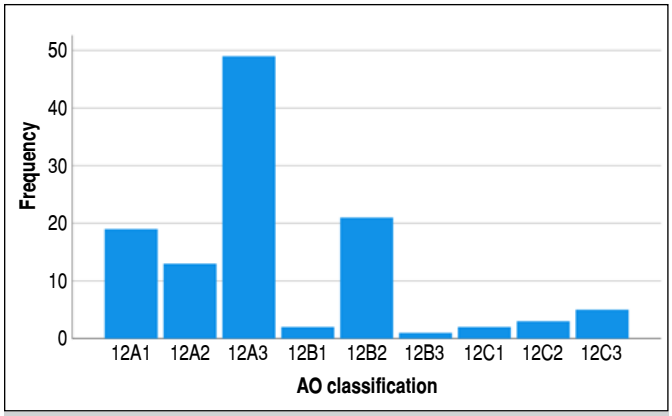

Figure 2. Fractures prevalence according to the AO classification.

The surgeons mostly (73%) used osteosynthesis with DCP plate (dynamic compression plate) via the MIPO technique (minimally invasive plate osteosynthesis), followed by open reduction and internal fixation with DCP plate. Table 3 describes techniques frequencies.

DISCUSSION

The epidemiology of surgical treatment on humeral shaft fractures is little addressed in the literature. Some articles deal with general humeral fractures (concerning several anatomical segments), and on the conservative treatment context.[2,4,7]

The humeral shaft fractures that occur in developed countries have a bimodal distribution with a first peak in young individuals and a second in individuals over 65 years.[1,2,4,7] We did not find this same distribution profile here. Our study showed a high prevalence among young adult individuals, with a mean age of 37.9 years. This difference may be explained because the main epidemiological studies are conducted in European countries since in Brazil, as well as in Asian countries, high-energy traumatic events (car accidents and falls from height), involving young victims are more frequent.[4,8]

The distribution between genders showed a higher prevalence of male patients (66.9%), in an approximate proportion of two men for each woman (2:1). We found a higher mean age in women (42.4 years), as did the literature.[4] The high number of men with humeral shaft fracture is associated with a greater exposure to traumatic events, especially high-energy ones. In women, the occurrence of fractures at an older age may relate to a greater propensity for age-related osteopenia.[2,3]

Involvement of the left arm was greater than that of the right arm, agreeing with some other important studies. However, authors have been unable to reach a consensus[2] on the correlation between affected side and gender, age, associated lesions, type of trait or mechanism of trauma.

Regarding the fracture's distribution throughout the months, our study recorded a considerable increase in December, as well as a significant decrease in February. According to DATASUS data via SIM (*Sistema de Informação de Mortalidade* – Mortality Information System), December presents an increase of approximately 10% in mortality by automobile accidents, as well as a decrease in February.[13] The increased number of humeral shaft fractures recorded in the period reflects its prevalence since they cause most of these lesions in Brazil.[8]

We classified the fractures into groups and subgroups according to the description proposed by the AO.[11,12] Tsai et al.[4] found higher fracture prevalence with simple trait (group A) and a high frequency of subgroup A3 (transverse simple trait).[2,6,7,10,11,14] We achieved the same results; more than 70% of patients presented simple fracture trait (type A) with a higher prevalence of subtype A3 (42.6%).

Fractures were mostly closed. However, 11.3% of the cases were open fractures, as described by Strohm et al.,[3] who found about 10%.[4] We found a predominance of lesions classified as Gustilo II and III. High-energy traumas favored the occurrence of open fractures, which agrees with the literature.[7]

The association of radial nerve deficit with fracture occurred in 33% of the cases. However, most epidemiological studies show an association of 1.8–18%.[3-6,10,15-17] A selection bias probably occurred relating the hospital's characteristics (high complexity trauma center), which may have interfered in the increased prevalence of cases referred with greater severity soft tissue lesions and high association with radial nerve injury, as in other countries with similar reference centers.[4,18]

We found an association between trauma energy and radial nerve injury which low-energy traumas had two fold higher risk ($p < 0.05$). This association disagrees with the literature, which reports an association between high-energy trauma and radial nerve injury. However, Holstein and Lewis[18] described the distal humeral fracture pattern with a spiral trace that evolves with a greater chance of radial nerve injury,[4,19] and the same, usually, is related to low-energy torsional trauma mechanism.[10]

Conservative treatment is still a choice in the approach of humeral shaft fractures. Regarding surgical treatment, open reduction and internal fixation is still considered the gold standard. However, methods using relative stability (intramedullary rod or osteosynthesis with DCP plate via MIPO technique) with bone biological preservation are increasingly being used.[1,8,9,16]

Thus, our research showed an increasing prevalence of techniques without addressing the fracture focus, especially MIPO. Therefore, a bias occurred, because we started the MIPO technique, which influenced surgeons training and the method choice. According to the latest meta-analyses, the technique shows lower pseudarthrosis rates than conservative treatment, and a better functional outcome for shoulder, especially in the first postoperative year.[8,16]

Our study has weaknesses, mainly concerning the retrospective design. Moreover, a bias might have occurred in the patients' and treatment method selection (MIPO technique). However, to our knowledge, this is the first epidemiological study in Brazil on the humeral shaft fractures surgical treatment.

Table 2. Trauma energy × radial nerve injury.

	Trauma energy		p-value	OR	CI
Radial nerve injury [no. (%)]	High	Low			
Yes	22 (57.9)	16 (42.1)	0.05[(a)]	0.6	0.36–0.99%
No	58 (75.3)	19 (24.7)			
Open fracture					
Yes	13 (100)	0	0.02[(b)]	-	-
No	72 (70.6)	30 (29.4)			

a: Pearson chi-square test; b: Fisher's exact test; OR: odds ratio; CI: confidence interval.

Table 3. Surgical technique frequency.

Technique	Frequency	Percentage (%)
MIPO	84	73
ORIF	22	19.1
Intramedullary rod	6	5.2
External Fixator	3	2.7

MIPO: Minimally invasive plate osteosynthesis; ORIF: open reduction and internal fixation.

CONCLUSION

Surgically treated humeral shaft fractures were more prevalent in men, young, and related to high-energy traumas (car accident), especially in December, and with a transverse trait pattern (AO12A3). Fractures secondary to low-energy traumas were more associated with radial nerve injury.

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INTRA- AND INTER-OBSERVER AGREEMENT OF PROXIMAL HUMERAL FRACTURES CLASSIFICATIONS IN ADULTS

CONCORDÂNCIA INTRA E INTEROBSERVADORES DAS CLASSIFICAÇÕES NAS FRATURAS DO ÚMERO PROXIMAL EM ADULTOS

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ABSTRACT

Objective: Evaluating intra- and inter-observer agreement of the Neer, AO, and AO/OTA proximal humerus fractures classification systems in adults. Methods: In total, 100 X-rays of patients with proximal humerus fractures were selected according to the inclusion and exclusion criteria established in this study. They were evaluated by four evaluators with different levels of expertise. The evaluation was performed at two distinct moments, with an interval of 21 days between each analysis. Images were randomized for the second evaluation by a researcher who did not participate in the image selection process. A Fleiss Kappa test was performed to evaluate intra- and inter-observer agreement. Results: We observed a substantial agreement with k = 0.669, k = 0.715, and k = 0.780 for the Neer, AO, and AO/OTA classification systems, respectively. Conclusion: In the second evaluation, intra-observer agreement improved. In the first evaluation, we obtained values of k = 0.724, k = 0.490, and k = 0.599 for the evaluation of the Neer, AO, and AO/OTA classifications. In the second evaluation, the values k = 0.759, k = 0.772, and k = 0.858. Therefore, the evaluations went from moderate to substantial for the AO classification and from moderate to practically perfect for the AO/OTA classification. The level of inter-observer agreement was substantial (0.61–0.80), with k = 0.669, k = 0.715, and k = 0.780 for the Neer, AO, and AO/OTA classifications, respectively. ***Level of Evidence III, Cross-Sectional Observational Study.***

Keywords: Radiography. Shoulder Fractures. Fractures, Bone. Classification. Observer Variation.

RESUMO

Objetivo: Avaliar a concordância intra e interobservadores entre os sistemas de classificação Neer, AO e AO/OTA nas fraturas do úmero proximal de indivíduos adultos. Métodos: Após a aplicação dos critérios de inclusão e exclusão determinados para a realização deste trabalho, foram selecionadas 100 radiografias de pacientes com fratura do úmero proximal. Estas foram submetidas à avaliação de quatro examinadores com níveis diferentes de expertise. A avaliação foi realizada em dois momentos distintos, com intervalo de 21 dias entre cada análise. As imagens foram randomizadas para a segunda avaliação por um pesquisador que não participou da seleção de imagens. Foi aplicado o teste kappa de Fleiss para verificar a concordância intra e interobservador. Resultados: Na primeira avaliação obtivemos valores de k = 0,724, k = 0,490 e k = 0,599, enquanto na segunda avaliação, os valores k = 0,759, k = 0,772 e k = 0,858 para as avaliações de Neer, AO e AO/OTA, respectivamente. Isso indica que a concordância intraobservador melhorou na segunda avaliação. Conclusões: As avaliações passaram de moderada para substancial para a classificação AO e de moderada para praticamente perfeita para o sistema AO/OTA. O nível de concordância interobservadores foram considerados substanciais (0,61-0,80) com k = 0,669, k = 0,715 e k = 0,780 para as classificações de Neer, AO e AO/OTA, respectivamente. ***Nível de Evidência III, Estudo Transversal Observacional.***

Descritores*: Radiografia. Fraturas do Ombro. Fraturas Ósseas. Classificação. Variações Dependentes do Observador.*

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INTRODUCTION

The treatment of any fracture depends on a detailed evaluation of the extension and characteristics of bone lesions, as well as of the damage affecting adjacent soft tissues. The success of a treatment depends on the anatomical restoration and biomechanics of the involved structures for the reconstruction of the joint.[1]

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The study was conducted at Hospital IFOR, Rede D'Or São Luiz.
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Proximal humerus fractures correspond to about 4% of all lesions affecting a full-grown skeleton and is the most common fracture of the upper limb.[1]

To characterize the types of a proximal humerus fracture, classification systems with multiple objectives, such as defining the severity, treatment, and prognosis of the damage, are systematically used. Classification systems become efficient when they are easily understood, with a simple language, as well as reliable and reproducible, providing a high intra- and inter-observer agreement rate.[2,3]

Neer is a fracture classification system developed in the early 1970s based on the number of parts of the cephalic portion of the humerus, dividing them into two, three, or four parts, which correspond to the involvement and displacement of the greater tubercle, lesser tubercle, head, and shaft.[4,5]

The AO/ASIF[3] group based its methodology on an alphanumeric system that grades the severity of the lesion in increasing order, considering its site, pattern, and involved kinetic energy. For surgeons to make full use of this system, identifying what Müller called the "essence" of the fracture is crucial. This attribute provides a specific identification of bone lesions, which depends on a very accurate description. Each bone or bone region is numbered and these structures are divided by their site and segments. Each bone segment is divided in types, groups, and subgroups, creating a hierarchical organization, in which the morphological complexity of fractures establishes the difficulties inherent to its treatment and prognosis.

In 2018, the AO/OTA Fracture and Dislocation Classification Compendium[6] was published. It was the second review of a first publication made in 1996, as a combination of the efforts of the AO Foundation and the Orthopedic Trauma Association (OTA). This compendium created a standardized and rational methodology to describe all fractures and dislocations, to establish a consistent system of clinical interaction and research. After 20 years of use, this 2018 review presented a series of suggestions aimed at the systematic improvement of the application of this system.

We found in the literature numerous studies that evaluate inter-observer agreement of radiographic classification systems for proximal humerus fractures, but their results were conflicting.[7-9] Most studies showed reasonable or moderate agreement. Moreover, the number of studies evaluating inter-observer agreement of the AO classification was considerably smaller. This lack of studies, especially on the 2018 AO/OTA, stimulated our group to perform this study.

Some authors used other more specialized imaging modalities, such as conventional computed tomography and the use of three-dimensional images to improve the interpretation of proximal humerus fractures.[10,11] However, their results did not improve agreement rates. The current literature suggests that failures of agreement may be related to failures of the classification systems, as well as to the experience of evaluators.[7-9]

Thus, this study aimed to evaluate intra- and inter-observer agreement of the Neer, AO, and AO/OTA proximal humerus fractures classification systems in adults. Moreover, we aimed to observe the differences between different intra-observer analyses.

METHODS

This study was approved by the Research Ethics Committee of the Brazil Platform under no. CAAE 51482521.9.0000.5625.

Patients were selected based on the following inclusion criteria:

1. Adults from 18 to 60 years of age;
2. Patients of both sexes;
3. Patients with two or more incidences of X-ray of the shoulder;
4. Not having previous rheumatic diseases, active or previous infectious diseases in the segment of study, progressive neurological diseases, bone fragility (e.g., osteogenesis imperfecta), pathological fractures, history of chronic use of alendronate, corticosteroids, immunosuppressants, or chemotherapy and radiotherapy agents, osteoblastic diseases, sickle cell anemia, bone dysplasia, active endocrine and metabolic diseases, and bone loss.

Patients were excluded based on the following exclusion criteria:

1. Patients who refused to sign the informed consent form specially prepared for this study;
2. Incomplete and low-quality X-ray.

With the aid of a medical statistician, sample calculation was performed[12] to establish the number of X-rays necessary for this study. A 5% significance level and 80% power were considered. Thus, the minimum number of X-rays would be 95 consecutive cases for the result of the analysis to be statistically significant.

The sample was selected from images stored in the Viewer and Webris programs from December 2018 to January 2020. For the use of data, a prior authorization was obtained from the hospital. All X-rays were selected by a researcher who did not participate in their classification process.

In total, 100 X-rays of patients who met the inclusion criteria were used. For the first evaluation, a file was created to distribute these X-rays. For the second evaluation, a second file was created, in which X-rays were randomly distributed, and delivered to each researcher.

X-rays were classified by four evaluators, with different levels of experience: a first-year resident physician in Orthopedics and Traumatology (evaluator 1), a third-year resident physician in Orthopedics and Traumatology (evaluator 2), an orthopedist with a title of specialist given by the Brazilian Society of Orthopedics and Traumatology (evaluator 3), and a subspecialist in shoulder and elbow surgery (evaluator 4).

To minimize the interpretation bias, evaluators received a prior explanation of the classification systems to be used. Each evaluator received a file with the images of each classification system. The four evaluators performed evaluations independently at two different moments, with an interval of 21 days between each analysis. To preserve confidentiality during analysis, evaluators could not talk to each other about the studied X-rays during the entire evaluation process. Data on patient name, age, sex, fracture time, and trauma mechanism were also not presented. Moreover, evaluators did not have access to the patients' clinical history.

Fracture classification system

In this study, three fracture classification systems were used: Neer, AO, and AO/OTA.

The Neer classification considers that proximal humerus fractures can, in a reproducible way, result in four anatomical segments, with or without additional fracture lines, which are arbitrarily defined as those in which a segment undergoes a translation of at least 1 cm or a minimum angulation of 45°.[4,5] The resulting four-segment classification provides a descriptive proximal humerus fracture classification system, which mainly aims to conceptualize the pathological anatomy of these fractures and the terminology for each category. For displaced fractures, the number of displaced segments and the main displaced segment are considered. Displaced fractures with less than 1 cm of displacement and 45° of angulation are considered non-displaced and commonly called "one-part fractures."[4,5]

The AO classification is an alphanumeric system based on the fracture site and its morphology. It was especially created for fractures of long bones and their respective segments and subsegments.[3] The fracture morphology is described by a specific code representing the fracture pattern, a severity code, and an additional code used in certain types of specific fractures. This classification

system considers the site and presence of impaction, angulation, translation, or comminution of fractures, as well as the presence or absence of dislocation. They are classified as belonging to bone segment 11 (1 for humerus, 1 for proximal segment) and subclassified in types, groups, and subgroups.[3]

Type A fractures are extra-articular unifocal fractures associated with a single fracture line; type B fractures are extra-articular bifocal fractures associated with two fracture lines; and type C fractures involve the humerus head or anatomical neck. Type A fractures are grouped in fractures of the greater tubercle (A1), surgical neck fractures with metaphyseal impaction (A2), and surgical neck fractures without metaphyseal impaction (A3). Type B fractures are grouped in surgical neck fractures with metaphyseal impaction and a fracture of the greater tubercle or lesser tubercle (B1), surgical neck fractures without impaction and a fracture of the greater tubercle or lesser tubercle (B2), and surgical neck fractures with a fracture of the greater tubercle or lesser tubercle and glenohumeral dislocation (B3). Type C fractures are grouped in anatomical neck fractures with mild displacement (C1), anatomical neck fractures with significant displacement (C2), and anatomical neck fractures with glenohumeral dislocation (C3). Each type of fracture is subgrouped according to displacement, valgus or varus angulation of the humerus head, comminution, and presence and direction of the dislocation of the glenohumeral joint.[3]

The 2018 AO/OTA[6] considers the same bone segment and groups of the AO classification, however, the subgroups are more detailed. Fractures of the tubercles belong to group 11A1 and its subgroups are A1.1 (fractures of the greater tubercle) and A1.2 (fractures of the lesser tubercle). Surgical neck fractures belong to group 11A2 and its subgroups are classified as: simple fracture (A2.1), wedge fragment (A2.2), multifragmentary fracture (A2.3), and vertical fracture (A2.4). Extra-articular bifocal surgical neck fractures belong to group 11B1 and its subgroups include B1.1 (greater tubercle) and B1.2 (lesser tubercle). Finally, articular or four-part anatomical neck fractures belong to group 11C1 and its subgroups include valgus-impacted fractures (C1.1) and isolated anatomical neck fractures (C1.2). Anatomical neck fractures involving the metaphysis belong to group C3 and are subclassified in: articular multifragmentary metaphyseal fractures (C3.1), intra-articular multifragmentary metaphyseal fractures (C3.2), and fractures with extension to the shaft (C3.3).[6]

Statistical analysis

The statistical analysis was performed by a professional specialized in health statistics using the IBM® SPSS® software, which offers a specific statistical analysis.

According to Altman,[13] the interpretation of results is a "chance-corrected proportional agreement." Thus, a kappa test using a coefficient of agreement with a value that varies from +1 (perfect agreement) to −1 (complete disagreement), passing by 0 (agreement equivalent to chance), is used. In this study, the Fleiss kappa coefficient was considered the most appropriate considering the multiple evaluators or evaluations and the many categories of the evaluated scales.[14] This method was used to evaluate intra- and inter-observer agreement for each scale.[15,16]

The intervals used as cut-off values were:

1. 0.0–0.2, representing a very low agreement.
2. 0.21–0.40, representing a poor agreement.
3. 0.41–0.60, representing a moderate agreement.
4. 0.61–0.80, representing a substantial agreement.
5. < 0.80, representing a practically perfect agreement.[12,14,17]

RESULTS

Table 1 (intra-observer evaluation) and Table 2 (inter-observer evaluation) present the results obtained.

Table 1. Results of the intra-observer Fleiss Kappa test.

Classification	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4
Neer	0.790 (Substantial)	0.771 (Substantial)	0.844 (Practically perfect)	0.737 (Substantial)
AO	0.730 (Substantial)	0.769 (Substantial)	0.813 (Practically perfect)	0.694 (Substantial)
AO/OTA	0.341 (Poor correlation)	0.760 (Substantial)	0.811 (Practically perfect)	0.706 (Substantial)

Table 2. Results of the inter-observer Fleiss kappa test.

Classification	First evaluation	Second evaluation	First evaluation + second evaluation
Neer	0.724 (Substantial)	0.759 (Substantial)	0.669 (Substantial)
AO	0.490 (Moderate)	0.772 (Substantial)	0.715 (Substantial)
AO/OTA	0.599 (Moderate)	0.858 (Practically perfect)	0.780 (Substantial)

Regarding the intra-observer evaluation, for evaluator 1, the Fleiss kappa index value was k = 0.790 (substantial agreement) for the Neer classification, k = 0.730 (substantial agreement) for the AO classification, and k = 0.341 (poor correlation) for the AO/OTA classification. For evaluator 2, it was k = 0.771 (substantial agreement) for the Neer classification, k = 0.769 (substantial agreement) for the AO classification, and k = 0.760 (substantial agreement) for the AO/OTA classification. For evaluator 3, it was k = 0.844 (practically perfect) for the Neer classification, k = 0.813 (practically perfect) for the AO classification, and k = 0.811 (practically perfect) for the AO/OTA classification. For evaluator 4, it was k = 0.737 (substantial agreement) for the Neer classification, k = 0.694 (substantial agreement) for the AO classification, and k = 0.706 (substantial agreement) for the AO/OTA classification.

The inter-observer correlations were k = 0.724 (substantial agreement) for the Neer classification, k = 0.490 (moderate correlation), and k = 0.599 (moderate correlation). In the second evaluation, the Fleiss kappa indexes were k = 0.759 (substantial agreement), k = 0.772 (substantial agreement), and k = 0.858 (practically perfect) for the Neer, AO, and AO/OTA classifications, respectively.

DISCUSSION

This study evaluated intra- and inter-observer agreement of proximal humerus fractures classification systems, based on the analysis performed by four physicians with different orthopedic experiences. We carefully elaborated this study so that its results could present the understanding and application of each different fracture classification system. In the selection of X-rays, which was made by a researcher who did not participate in their classification process, we sought to resolve the possible biases, allowing an impartial analysis to be performed at two different moments. We performed the second evaluation after randomization of images after three weeks. Considering the results of intra-observer agreement, evaluators 1, 2, and 4 obtained a substantial Fleiss kappa value for the Neer, AO and AO/OTA classifications and evaluator 3 obtained a practically perfect value. For the AO/OTA classification, the less experienced evaluator presented poor correlation index in comparison with the other evaluators, possibly due to the lower ability to interpret images.

This fact can positively influence the agreement of proximal humerus fractures classifications. Although Sidor et al.[18] obtained kappa values of 0.83 when a shoulder surgeon used the Neer

classification, in comparison with residents (k = 0.48), other authors did not support the hypothesis that a greater experience would be equivalent to a better inter-observer agreement.

This finding corroborates the idea that the interpretation skills of residents in Orthopedics with less experience improve when they are guided by subspecialist surgeons. The current practice in the UK, in particular, recognizes it. Increasingly, upper limb trauma is treated by surgeons with maximum experience in this anatomical region even in district general practice.

Regarding the results of the global inter-observer analysis, we could observe a substantial correlation for all classification systems. However, when considering the first and second inter-observer evaluations separately, the results for each classification system improved. The familiarization associated with an improvement in the potential to interpret fractures can be considered a determining factor to justify this result.

However, some opinions does not agree that the Neer classification is sufficiently reliable. The variability in the quality of the X-rays used in previous studies with this evaluation method justifies this fact. This divergence may result from an incorrect positioning of the fractured limb during the X-ray examination, making it difficult to interpret the fracture lines, which can be multiple in comminuted lesions. Obese patients or with too much muscle mass cannot reach the projection of soft tissues and, often by intense pain, the ideal positioning.

The interpretation of the degree of displacement based on the displacement and angulation between fragments can allow this classification to be more consistently applied. It offers treatment options in a systematized way and has the potential to eliminate the poor result of the treatment of this fracture, which remains highly variable.

In 2011, Mahadeva et al.[19] presented kappa mean values of 0.617 to 0.730 in the evaluation of X-rays showing proximal humerus fractures, classifying them according to the Neer classification. Their results are very similar to ours, even considering the difference in experience among evaluators.

However, we found studies that suggest that the results of inter-observer agreement tests are slightly better for the Neer classification system, which would make the categorization of cases more useful in clinical practice.

To date, reducing the number of categories in each classification system have been showing minimal improvements. Moreover, the more advanced imaging modalities failed to significantly improve the inter-observer agreement.

A small number of researchers used the simplified AO classification. Majed et al.[20] simplified the AO classification to three categories and found an inter-observer kappa value of 0.30 in comparison with the value of 0.11 for the 27-category system. Siebenrock and Gerber[21] also found this result. In their study, agreement improved with the three-category system (k = 0.53) in comparison with the nine-category system (the AO classification) (k = 0.42). However, simplifying the complete classification system for nine- or three -category systems presented no substantial improvement.

Considering the variable agreement of all classification systems, unsurprisingly, the management of proximal humerus fractures can be quite varied and challenging.

The agreement of the Neer and AO classification systems improved, but the use of more advanced imaging modalities could not significantly improve inter-observer agreement.

Papakonstantinou et al.[8] observed a moderate agreement for the evaluation of 104 X-rays performed by three orthopedic surgeons with experience of two to 15 years. Siebernrock and Gerber[21] also found a moderate agreement (k = 0.40 for Neer and k = 0.42 for AO) in the inter-observer evaluation while the mean kappa for intra-observer reliability was 0.60 for the Neer classification and 0.58 for the AO classification.

Therefore, some studies, by incorporating computed tomography to adequately evaluate lesions and recognize the different fracture patterns, aimed to resolve the interpretation bias of images and, later, allow the application of the classifications, seeking to improve the levels of agreement. Moreover, the use of routine computed tomography would increase the cost of managing lesions beyond the exposure inherent to their use of patient exposure to an excessive amount of radiation.[9,11,22]

The development of other technologies and software capable of making a customized reproduction of 3D models for the evaluation of proximal humerus fractures improved the understanding and treatment regimen of some patients. The use of 3D models to better understand complex fractures in the pelvis, acetabulum, and tibial plateau was incorporated as an adjuvant diagnostic method to define the schedule of surgical treatments. These models are also useful in teaching and training in the medical field.[11]

They are considered a potential imaging method to improve diagnostic agreement by resident specialists or physicians. Those who use augmented reality presents a substantial diagnostic agreement, thus, it may be a potential option, as well as radiography and tomography. However, a study showed that the use of this resource in a given period of medical experience among different evaluators did not increase diagnostic agreement between the proposed methods. This study showed that the highest inter-observer agreement was among upper-limb surgeons with 3D reconstruction.[9,11,22]

We believe that an appropriate classification system should present a higher possible level of intra- and inter-observer agreement. It should also predict which treatment method and which type of fracture would present the best results, along with lower complication rates. Therefore, a search for a system that met these attributes still exists, as the studies found do not seem to have solved it. However, our results present a substantial agreement index, which shows that the use of the applied systems is satisfactory regardless of the level of experience of evaluators.

Therefore, we understand that an ideal classification system has not yet been found. Indexes show that these lesions have been systematically and similarly treated or, at least, discussed and receiving appropriate treatment.

A weakness of this study was its inability to provide a better classification, with reliability greater than those commonly used. We also did not evaluate the physicians' responses regarding agreement in subgroups when analyzing the AO classification, considering only its general aspects.

As a strength, this study included the AO/OTA classification in the agreement evaluation between the proximal humerus fracture classification systems available. Only one of the studies found presented this evaluation.

CONCLUSION

In the second evaluation, intra-observer agreement improved and we can attribute this increase to the greater familiarization to the classification systems used. In the first evaluation, we obtained the values k = 0.724, k = 0.490, and k = 0.599 for the Neer, AO, and AO/OTA classifications, respectively. In the second evaluation, kappa values were k = 0.759, k = 0.772, and k = 0.858. The evaluations went from moderate to substantial for the AO classification and from moderate to practically perfect for the AO/OTA classification. Therefore, the studied classifications presented substantial intra-observer levels of agreement, by the Fleiss kappa statistical method, with k = 0.669, k = 0.715, and k = 0.780 for the Neer, AO, and AO/OTA classifications, respectively.

Finally, this study significantly contributes to a better understanding of classification systems and their application by orthopedists. However, further studies capable of evaluating agreement between classifications in detail, as well as capable of elaborating a classification with greater intra- and inter-observer reliability, are necessary.

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EPIDEMIOLOGICAL ANALYSIS OF FRACTURES IN THE PREVIOUS PERIOD AND DURING THE QUARANTINE OF COVID-19

ANÁLISE EPIDEMIOLÓGICA DE FRATURAS ANTES E DURANTE A QUARENTENA DE COVID-19

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ABSTRACT

Objectives: Our aim was to compare the epidemiology of surgically treated fractures during the pandemic period with previous years without the pandemic. Methods: This was a retrospective study with data collection that included patients hospitalized and operated for fractures between March 24th and June 23rd in 2018, 2019 and 2020. Results: A total of 879 patients were registered, resulting in a total of 965 fractures. During the COVID-19 pandemic, 234 patients were registered, representing 26.62% of the total, and in the period before the pandemic, 645 patients were registered, 73.38% of the total. Conclusion: We observed a proportional increase in high-energy trauma in the social isolation period and patient's average age. The other changes found in the study had no statistical difference. ***Level of Evidence IV, Case Series.***

Keywords: COVID-19. Pandemics. Aged. Fractures, Bone. Epidemiology.

RESUMO

Objetivos: Comparar a epidemiologia das fraturas tratadas cirurgicamente durante o período de contingência causado pela pandemia com os intervalos respectivos de anos anteriores. Métodos: Foram incluídos todos os pacientes com diagnóstico de fratura em qualquer seguimento do corpo, exceto coluna vertebral e face, que foram internados e operados entre 24 de março e 23 de junho de 2018, 2019 e 2020 em dois hospitais referência para tratamento de trauma na grande São Paulo. Os dados foram obtidos a partir da avaliação retrospectiva de prontuários médicos. Levou-se em consideração epidemiologia das fraturas, mecanismo de trauma e dados demográficos dos pacientes tratados no período de contingência em comparação com a média dos três anos anteriores (período controle). Resultados: Foram avaliados 879 pacientes e 965 fraturas. Durante a pandemia pelo coronavírus foram registrados 234 pacientes, enquanto a média do período controle foi de 322,5 pacientes. Em relação ao mecanismo de trauma, houve um significativo aumento do trauma de alta energia em comparação ao período controle. Conclusão: Verificou-se uma diminuição na incidência de fraturas tratadas cirurgicamente nos hospitais avaliados. No entanto, houve uma elevação na taxa de trauma de alta energia no período de isolamento social. Essa alteração demonstra que mudanças no fluxo das cidades podem impactar na demanda hospitalar e que a pandemia influenciou direta e indiretamente os órgãos de saúde. ***Nível de Evidência IV, Série de Casos.***

Descritores: *COVID-19. Pandemias. Idoso. Fraturas Ósseas. Epidemiologia.*

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INTRODUCTION

Since the first reported case of acute respiratory disease caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), in December 2019, we watched the virus spreading. On March 11, 2020, with the infection increasing in several countries, the World Health Organization has declared that the COVID-19 outbreak is a global pandemic. In Brazil, as well as worldwide, we followed the disease outbreak. On March 24, 2021, the State of São Paulo government decreed a contingency plan, restricting open

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

The study was conducted at Hospital São Paulo and Hospital Municipal de Barueri Dr. Francisco Moran.
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establishments and changing mobility through social distancing, aiming to limit the virus spread.

The epidemiology of fractures is often associated with the patient's age group, gender, and comorbidities, as well as functional profile and type of activity. Moreover, the incidence may follow a seasonal pattern. For example, proximal femur fractures are commoner in women over 60 years and in the winter. The sudden change in the habits of the Brazilian population due to the quarantine probably brought general epidemiological changes, as well as orthopedic traumatic pathologies.

Our study aims to evaluate whether this social alteration, especially in the red phase period enacted by the contingency plan of the State of São Paulo due to the COVID-19 pandemic, influenced the epidemiology of fractures treated by the orthopedic department in two referral hospitals in the State of São Paulo in 2020 compared to the same period in 2019 and 2018. Our hypothesis is that the number of fractures treated surgically would be lower than usual in the mobility restriction period. Proportionally, a decrease would occur in the number of fractures caused by high-energy trauma, due to decreased vehicle flow.

METHODS

In this study, were evaluated patients diagnosed with acute fractures in any part of the body, except for the spine and face, treated surgically in the orthopedics sector of Hospital São Paulo, at the city São Paulo, and the Municipal Hospital of Barueri Dr. Francisco Moran, at the city Barueri, part of the metropolitan area of São Paulo. All patients who entered these services in the red phase period imposed by the contingency plan of the State of São Paulo, from March 24 and June 10, 2020, were included in the study. The control group included all patients treated in the same period in the previous two years, 2018 and 2019.

The Ethics Committee of both institutions approved this study, which was submitted to Plataforma Brasil (opinion No. 45016620.6.0000.5505). Patients list was obtained via hospital admission system. The evaluated data were collected from the medical records via retrospective analysis. The data collected were age, gender, trauma mechanism, fracture anatomical location, date of trauma, and laterality. Regarding trauma energy, all sprains and falls without unevenness were considered low energy. Other traumas were considered high energy.

The diagnoses were reviewed by two independent evaluators. The anatomical location in the long bones was defined as diaphyseal, proximal, and distal, according to the AO classification.

Statistical analysis

A comparative analysis was performed between groups of patients treated during the COVID-19 quarantine and patients treated in the same period in 2019 and 2018. Data with continuous variables were analyzed using the t-test and categorical data were analyzed using Fisher's test.

RESULTS

During the study period, 879 patients were recorded. Some patients presented more than one fracture at the time of the incident, totaling 965 fractures. During the COVID-19 pandemic, 234 patients were recorded. In the control interval, 645 patients were recorded: 311 in 2019 and 334 in 2018. Table 1 shows patient's demographic data, trauma mechanism, and fracture's location. Tables 2 and 3 show the same data, but from Hospital Municipal de Barueri Dr. Francisco Moran and Hospital São Paulo, respectively.

Patients mean age was higher in the COVID period. It is statistically significant when we analyze only the Hospital São Paulo, with a 50.27 mean age in the COVID period against 42.87 in the non-COVID period. The number of female patients was the lowest in both periods: 74 (32%) in the Coronavirus period and 216 (33%) in the non-Coronavirus period.

Table 1. Sample characterization and fracture prevalence in each period in both hospitals.

	COVID n (%)	Not COVID n (%)	p
Number of patients	234	645	
Age (mean/SD)	43.09 ± 1.44	40.05 ± 0.84	0.06
Sex			0.62
Female	32%	33%	
Male	68%	67%	
Trauma energy			0.047
Low	34%	43%	
High	66%	57%	
Fracture location			0.43
Hand	9.43%	9.71%	
Feet	4.53	6.00%	
Proximal humerus	3.02%	2.43%	
Diaphyseal humerus	2.64%	2.71%	
Distal humerus	3.40%	4.57%	
Scapula	0.38%	0.00%	
Clavicle	1.51%	1.71%	
Proximal radius	5.28%	4.86	
Diaphyseal radius	7.17%	3.71%	
Distal radius	5.28%	7.43%	
Proximal femur	13.21%	12.86%	
Diaphyseal femur	6.79%	5.71%	
Distal femur	3.02%	1.43%	
Patella	1.89%	2.71%	
Tibial plateau	5.28%	4.43%	
Diaphyseal tibial	8.30%	9.71%	
Distal tibial	3.40%	3.29%	
Ankle	12.45%	15.29%	
Pelvis	1.13%	0.29%	
Acetabulum	1.89%	1.14%	
Number of fractures			0.113
1	88.89%	92.86	
2	8.97%	6.05%	
3	2.14%	0.77%	
4	0.00%	0.32%	

In both periods occurred a high-energy trauma predominance. When these two intervals were compared, there was an increase in the percentages of High Energy trauma from 57% in the non-Coronavirus period to 66% in the Coronavirus period, and the difference was statistically significant ($p = 0.047$). Comparing them show an increase in the high-energy trauma percentages, going from 57% in the non-Coronavirus to 66% in the Coronavirus period. The difference is statistically significant ($p = 0.047$).

During the pandemic period, scapula, proximal humerus, proximal radius, diaphyseal radius, proximal femur, diaphyseal femur, distal femur, tibial plateau, tibial distal, pelvis, and acetabulum fractures increased, but without statistical significance (Table 1).

DISCUSSION

This study delivered interesting information on the epidemiological change of fractures due to the quarantine. We observed a fall in incidence and fractures, and a proportional increase in high-energy trauma.

First, we expected a decrease in high-energy trauma, which are mostly caused by traffic collision. We believed that this type of

Table 2. Sample characterization and fracture prevalence in each period at the Hospital Municipal de Barueri Dr. Francisco Moran.

	COVID n (%)	Not COVID n (%)	p
Number of patients	151	448	
Age (mean/SD)	39.15 ± 1.72	38.8 ± 0.96	0.85
Sex			0.91
Female	31%	31%	
Male	89%	69%	
Trauma energy			0.043
Low	31%	42%	
High	69%	58%	
Fracture location			0.44
Hand	13.33%	12.29%	
Feet	6.06%	6.25%	
Proximal humerus	4.24%	1.88%	
Diaphyseal humerus	3.03%	2.50%	
Distal humerus	4.85%	3.96%	
Scapula	0.00%	0.00%	
Clavicle	1.21%	2.08%	
Proximal radius	4.24%	5.21%	
Diaphyseal radius	7.88%	3.54%	
Distal radius	7.88%	9.58%	
Proximal femur	9.09%	11.04%	
Diaphyseal femur	4.24%	5.00%	
Distal femur	2.42%	1.04%	
Patella	1.82%	2.71%	
Tibial plateau	6.06%	3.54%	
Diaphyseal tibial	5.45%	8.75%	
Distal tibial	4.24%	3.33%	
Ankle	13.94%	16.88%	
Pelvis	0.00%	0.00%	
Acetabulum	0.00%	0.42%	
Number of fractures			0.7
1	92.1%	94.2%	
2	6.6%	4.7%	
3	1.3%	0.9%	
4	0.0%	0.2%	

Table 3. Sample characterization and fracture prevalence in each period in both hospitals.

	COVID n (%)	Not COVID n (%)	p
Number of patients	83	197	
Age (mean/SD)	50.27 ± 2.42	42.87 ± 1.68	0.015
Sex			
Female	31%	39%	
Male	69%	61%	
Trauma energy			0.51
Low	40%	44%	
High	60%	56%	
Fracture location			0.39
Hand	3%	4.09%	
Feet	2%	5.45%	
Proximal humerus	1%	3.64%	
Diaphyseal humerus	2%	3.18%	
Distal humerus	1%	5.91%	
Scapula	1%	0.00%	
Clavicle	2%	0.91%	
Proximal radius	7%	4.09%	
Diaphyseal radius	6%	4.09%	
Distal radius	1%	2.73%	
Proximal femur	20%	16.82%	
Diaphyseal femur	11%	7.27%	
Distal femur	4%	2.27%	
Patella	2%	2.73%	
Tibial plateau	4%	6.36%	
Diaphyseal tibial	13%	11.82%	
Distal tibial	2%	3.18%	
Ankle	10%	11.82%	
Pelvis	3%	0.91%	
Acetabulum	5%	2.73%	
Number of fractures			0.132
1	83.1%	89.9%	
2	13.3%	9.1%	
3	3.6%	0.5%	
4	0.0%	0.5%	

trauma would significantly decrease due to the social isolation implemented in the state of São Paulo, since the number of vehicles in the streets drastically decreased.

In the *Companhia de Engenharia de Tráfego* (The Trafic Engineering Company - CET) annual report of the State of São Paulo,[1] we observed a decrease in traffic collision traumas in 2020, but an increase in the absolute number of fatal victims, thus indicating a significant increase in trauma severity. This data compares with our results on the patient's profile.

Moreover, we also observed an increase in distal tibial, diaphyseal tibial, tibial plateau, and scapular fractures, which are usually related to high-energy trauma mechanisms (Figure 1).

In a similar study conducted in China by Zhu et al.,[2] an increase in low-energy fractures highlighted proximal femur fractures within this group, mostly happening in the residential environment. We also found this datum. Although low-energy trauma was lower than in the other periods, proximal femur fracture was higher between older adults. This may justify by the confinement situation, which is similar to cold periods when the incidence of proximal femur fracture in older adults increases.

The difference between our and Zhu et al.[2] study is possibly due to the restrictive measures imposed by each government. China adopted considerable transportation restrictions. Only health workers and administrative state members were allowed to transit, which resulted in a population isolated at home, leaving the highways and roads free. In contrast, São Paulo restrictions were lighter. Furthermore, closing the commerce increased the delivery-service demand, which is usually made by motorcyclists in Brazil. This raised the number of motorcyclists in the streets. Data from Infosiga SP[3] showed a 45.5% increase in traffic accidents with motorcyclists during the pandemic and a 13.5% increase in deaths.

From what our data suggested, we found that hospitals differed. Hospital São Paulo, despite offering quaternary reference service, finds that users' spontaneous search constitutes its main demand. According to the Instituto Brasileiro de Geografia e Estatística (Brazilian Statics Institute - IBGE),[4] 20.3% of the population near the hospital is over 60 years. In contrast, Hospital Municipal de Barueri Dr. Francisco Moran receives patients transferred from the entire city of Barueri, in which only 7.18% of the population is over 60 years. The percentage of older adults with proximal femur fractures differs in each hospital. At the first hospital, the number

of fractures were 20% and 16.82%, respectively, in the COVID-19 period and in previous years (Figure 3). Considering the same period, the number of fractures at the second hospital was 9.09% and 11.04% (Figure 2).

Furthermore, at Hospital São Paulo, hand and wrist bones fractures are mostly referred to an associated service, reducing the occurrence of these kind of fractures in this study.

CONCLUSION

Over time, the epidemiology of fractures changes as people change their lifestyle. Our study shows that the change imposed by the contingency plan on COVID-19 significantly changed the epidemiological profile of fractures surgically treated by the orthopedics sector of two hospitals in São Paulo. This demonstrates that the pandemic affected the health system directly and indirectly.

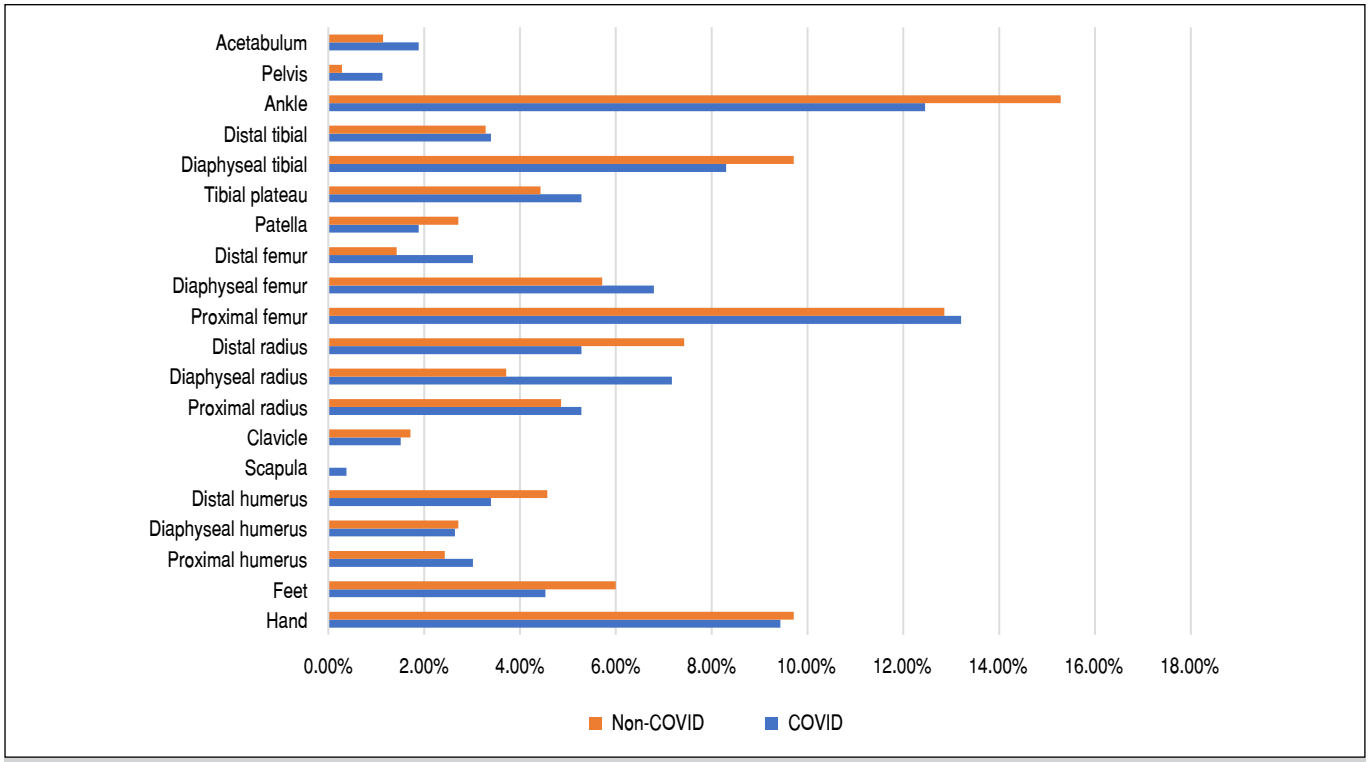

Figure 1. Comparative graph of fractures in both hospitals between the COVID and non-COVID groups.

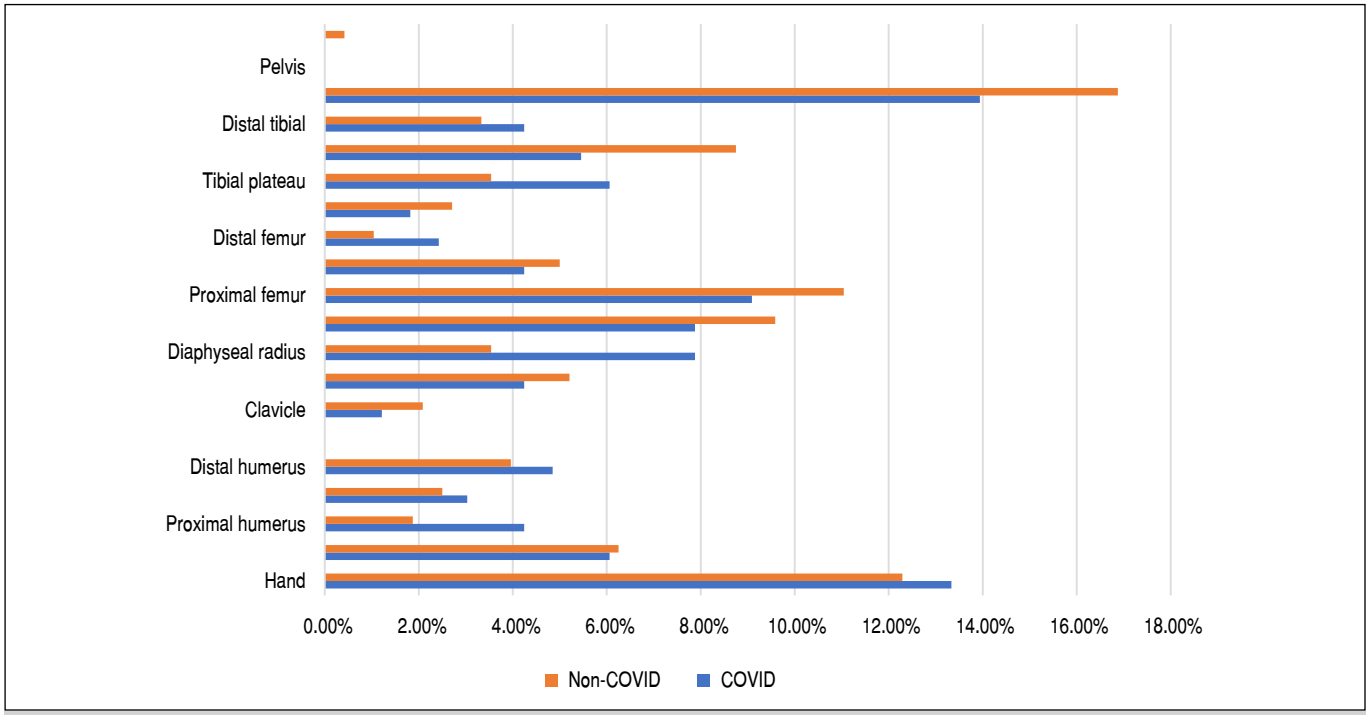

Figure 2. Comparative fractures graph between COVID and non-COVID groups at Hospital Municipal de Barueri Dr. Francisco Moran.

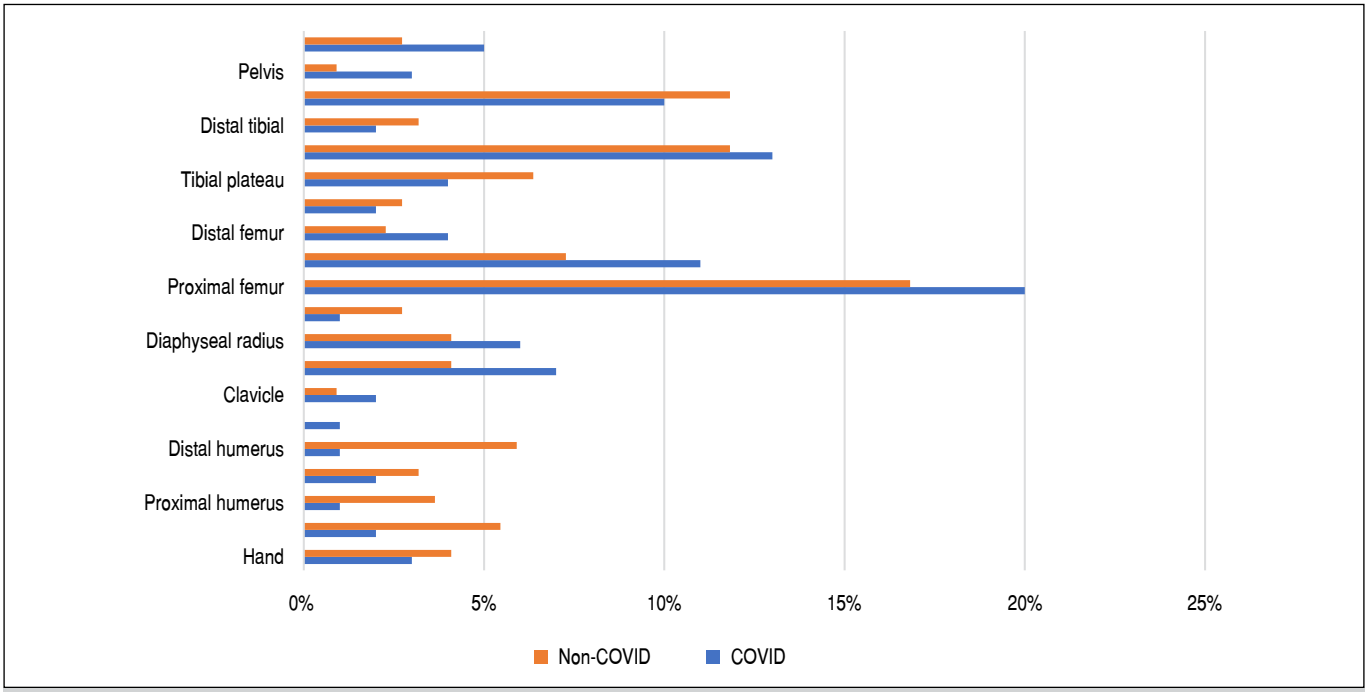

Figure 3. Comparative fractures graph between the COVID and non-COVID groups in both hospitals.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to develop this article. VCS, BS, GMRB, RKD, JL, TPCG, LFMA: study design, data collection, writing, and manuscript review.

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EPIDEMIOLOGY OF PROXIMAL FEMUR FRACTURE IN OLDER ADULTS IN A PHILANTHROPICAL HOSPITAL IN SÃO PAULO

EPIDEMIOLOGIA DA FRATURA DO FÊMUR PROXIMAL EM IDOSOS EM UM HOSPITAL FILANTRÓPICO DE SÃO PAULO

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ABSTRACT

Objective: To evaluate the age and anthropometry profile of patients with a diagnosis of fracture of the proximal femur in older adults admitted to a philanthropic hospital in São Paulo. Methods: Retrospective observational cross-sectional study. All patients older than 59 years with femoral fractures diagnosed and hospitalized between January, 2019 and April, 2020 were included. The analysis of the 85 medical records resulted in the data collected in the present study. Anthropometry, age, sex, ethnicity, presence of comorbidities and mechanism of trauma of these patients were considered in this study. Most traumas, as expect, presented low energy mechanisms. Results: Prevalence of 3:1 in females, aged between 60-104 and mean of 78.5 years, with an increased risk in patients over 80 years. The body mass index (BMI) between 16.53 and 39.80 with an average of 24.16 kg/m^2. Being 89.4% cases of fall from own height. Conclusion: Proximal femur fractures in older adults occur more often in women, with a mean age of 78.5 years, normal BMI range, whose main trauma mechanism is fall to ground level. The most prevalent injury is transtrochanteric fracture, with a mean of 70.5% and the most performed treatment is internal fixation with cephalomedullary nail, with a mean of 66.1%. ***Level of Evidence VI, Descriptive Epidemiological Study.***

Keywords: Causality. Epidemiology. Femoral Fractures. Aged.

RESUMO

Objetivo: Avaliar o perfil de idade e antropometria dos pacientes com diagnóstico de fratura do fêmur proximal em idosos admitidos em um hospital filantrópico de São Paulo. Métodos: Estudo retrospectivo, observacional, transversal. Foram incluídos todos os pacientes com fratura do fêmur proximal e idade superior a 59 anos, internados em um hospital filantrópico de São Paulo entre janeiro de 2019 e abril de 2020. A análise dos 85 prontuários levantados resultou na coleta de dados antropométricos, idade, sexo e etnia, doenças associadas e uso de medicações, além de dados relacionados ao mecanismo de trauma. Como esperado, a maioria dos traumas apresentou mecanismo de baixa energia. Resultados: Houve predominância de 3:1 do sexo feminino, com idade entre 60 e 104 e média de 78,5 anos, havendo um risco maior para pacientes acima dos 80 anos. O índice de massa corpórea (IMC) foi de 16,53 a 39,80, com média de 24,16 kg/m2. Quanto ao mecanismo do trauma, 89,4% dos casos foram de queda da própria altura. Conclusão: Fraturas do fêmur proximal em idosos ocorrem mais em mulheres, com idade média de 78,5 anos, IMC na faixa normal e queda ao nível do solo como principal mecanismo de trauma. A lesão mais prevalente foi a fratura transtrocanteriana, com média de 70,5%, e o tratamento mais realizado foi a fixação interna com haste cefalomedular (66,1%). ***Nível de Evidência VI, Estudo Epidemiológico Descritivo.***

Descritores: *Causalidade. Epidemiologia. Fraturas do Fêmur. Idoso.*

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INTRODUCTION

A striking characteristic of the Brazilian and world age pyramids is the widening of their apex, older individuals (over 60 years), according to UN data.[1] The Brazilian Institute of Geography and Statistics (IBGE) estimates that the older population in Brazil corresponded to approximately 5.0% of the population in 1950; while in 2010, they already represented approximately 10.0%.[2] In addition, the projections for 2020 were confirmed, and today this population corresponds to about 13.0% of all Brazilians, totaling almost 28 million people.[2]

Contrary to what can be observed in young patients, the traumas most associated with proximal femur fractures are those of low energy, and some of the numerous related factors are advanced age, osteoporosis and osteopenia, sarcopenia, low calcium intake and vitamin-D deficiency, genetic predisposition.[3-5]

Studies have shown that osteoporosis is the most relevant factor in fractures of the proximal third of the femur, as well as the higher incidence of falls.[6] Approximately one third of white women over the age of 65 have osteoporosis.[7] Studies estimate

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

The study was conducted at the Department of Orthopedics and Traumatology of Santa Casa de Misericórdia de São Paulo School of Medical Sciences, "Pavilhão Fernandinho Simonsen".
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that 6,000,000 individuals worldwide will suffer proximal femur fractures in the year 2050.[8]
Other studies have shown that 2.1% of patients with proximal femur fractures die during hospitalization and 11.0% after four months.[9]
Advanced age, comorbidity number, male gender, and cognitive impairments are four factors closely related to mortality.[10]
The high cost these fractures generate for the healthcare system due to prolonged hospitalization time, possible complications, morbidity and mortality, and hospitalization in intensive care, as well as rehabilitation for prolonged periods must be considered.[11]
This study aims to evaluate the epidemiological profile of proximal femur fractures in older adults, studying the causes of trauma and the physical characteristics of patients with this type of injury who were hospitalized in the Department of Orthopedics and Traumatology "Fernandinho Simonsen Pavilion" of Irmandade da Santa Casa de Misericórdia de São Paulo between January 4, 2019 and April 25, 2020.

METHODS

This is a retrospective cross-sectional observational study.
The inclusion criteria were all patients with a proximal femur fracture, whether they were transtrochanteric fractures, femoral neck fractures, or subtrochanteric fractures, and age over 59 years, who were hospitalized in the Department of Orthopedics and Traumatology "Pavilhão Fernandinho Simonsen" of Irmandade da Santa Casa de Misericórdia de São Paulo in the period between January 4, 2019 and April 25, 2020.
Patients under 60 years of age were excluded.
Information was collected from this patient group by studying their medical records, obtaining anthropometric data, age, gender and ethnicity, associated diseases and use of medications, type of fracture, trauma mechanism, type of treatment performed, and classification of the fracture.
The analyses by age group were divided into five-year intervals to better estimate the collected data and to facilitate comparison with previous studies.[3]
Body mass index (BMI) was estimated in all patients to analyze the possible existence of a more susceptible group, and the interval between 18.5-24.9 was considered normal, as well as ethnicity, cause of fracture, previous use of medication, and other associated comorbidities.
For cause analysis, the patients were divided according to trauma mechanism. Accidents involving an external impact factor, such as automobile accidents and falls from higher than ground level, were considered high-energy traumas, while falls from ground level and patients who sought care after a few days of trauma (treatment was sought due to the pain, and trauma was then verified) were considered low-energy traumas.
AO Classification was used for fracture analysis.
The types of implants used for surgical treatment were: cephalomedullary nail, DHS, total hip arthroplasty, and non-conventional endoprosthesis.
Statistical analysis involved the quantification of descriptive data by mean and standard deviation for continuous variables and the use of percentage for categorical variables using the SPSS Statistics 21 software.
The study was submitted to and approved by the Research Ethics Committee of the institution, verified opinion No. 4.869.579.

RESULTS

We identified 85 medical records with a proximal femur fracture diagnosis between January 4, 2019 and April 25, 2020.
Regarding age, we observed a mean of 78.5, covering patients aged 60 to 104 years, and distribution among patients aged 60-64 years of 9.4%; 65-70 years, 17.6%; 71-75 years, 10.5%; 76-80 years, 16.4%; and over 80 years, 45.88% (Figure 1).
Regarding sex, 22 were male (25.9%) and 63 were female (74.1%) (Table 1).
Average hospitalization time was 14 days. There was a predominance of white people (72.2%).
The ethnicity distribution found 60 Caucasian patients (72.2%), 19 mixed-race patients (22.8%), and four Asian patients (4.8%) (Figure 2).
Regarding trauma mechanisms, we observed the main one to be falls from one's own height in 76 cases (89.4%), followed by falls from higher heights in four cases (4.7%) (Table 2) (Figure 3).
Regarding type of fracture, we estimated 60 cases of transtrochanteric fractures (70.5%), followed by 21 cases of femoral neck fracture (24.6%), and four cases of subtrochanteric fractures (4.7%) (Table 3).
Regarding Body Mass Index (BMI), we found normal range predominance in 58 patients (68%), overweight in 19 patients (22%), grade 1 obesity in four patients (4.7%), and grade 2 obesity in 4 patients (4.7%), and no cases were observed in patients with higher obesity degrees (Figure 4).
The patients were questioned about their comorbidities. Systemic arterial hypertension was the most prevalent, with 47 cases (32.1%); followed by type 2 diabetes mellitus, with 21 cases (14.3%); Alzheimer's disease, with nine cases (6.1%); cerebrovascular accident

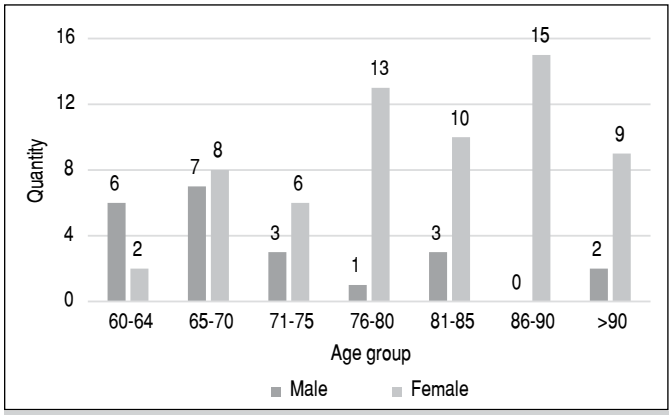

Figure 1. Case number distribution.

Table 1. Descriptive data.

Characteristics	Total
Sample size	85 (100%)
Age (years old)	78.5 (± 10.5)
Weight (Kg)	61.4 (± 12.2)
Height (m)	1.59 (± 9.1)
Body Mass Index (BMI)	24.16 (± 5.06)
Hospitalization days	14.9 (± 10.2)
Sex	
Female	63 (74.1%)
Male	22 (25.9%)
Race	
White	60 (72.2%)
Mixed-race	19 (22.8%)
Asian	4 (4.8%)
Laterality	
Right	34 (40%)
Left	51 (60%)

Kg: kilograms; m: meters.

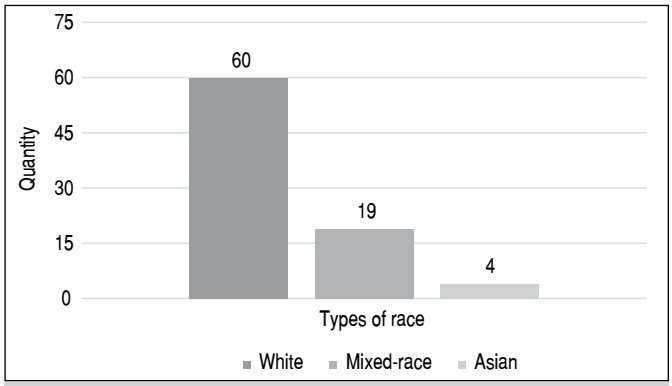

Figure 2. Phenotypical characteristics.

Table 2. Injury mechanisms.

Characteristics	Total
Fall from one's own height	76 (89.4%)
Fall from other heights	4 (4.7%)
Automobile accidents	1 (1.1%)
Unknown	3 (3.5%)
Other	1 (1.1%)

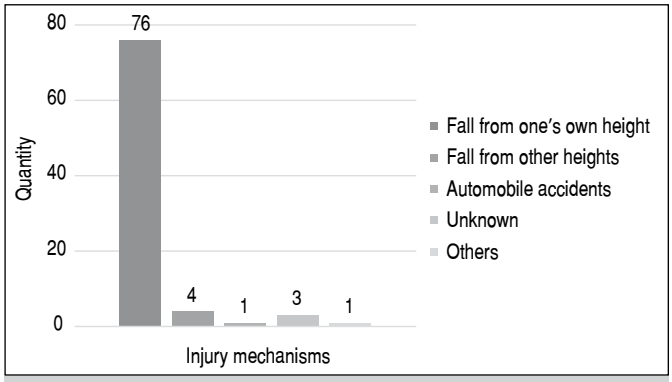

Figure 3. Injury mechanisms.

and smoking, with seven cases each (4.7%); acute myocardial infarction and osteoporosis, with five cases each (3.4%); and other comorbidities, with 37 cases (25.3%) (Table 4).

Of the 80 cases we evaluated in relation to the type of treatment, 77 (96.25%) underwent surgical procedures and only three (3.75%) were treated conservatively.

The surgical procedures performed were: cephalomedullary nail, with 51 cases (66.23%); hip sliding screw, with 12 cases (15.5%); hip arthroplasty, with eight cases (10.3%); cannulate screw, with three cases (3.8%); non-conventional endoprosthesis (NCEP), with two cases (2.5%); and we had one case of untreated evasion (Table 5) (Figure 5). Fractures type 31A (71.4%) were predominant, followed by fractures type 31B (25%), fractures type 32A (2.3%), and fractures type 32B (1.1%) (Table 6).

DISCUSSION

We observed a predominance of proximal femur fracture among female patients (3:1) and a mean age of 78.5 years. These values are like those found in similar studies, with a prevalence between women and men ranging from 1.3:1 to 3.8:1 and with ages ranging from 72 to 80 years for women and 63 to 77 years for men.[4,5,12,13] The difference between the sexes is partly explained by the lower female bone density after menopause.[14]

Table 3. Diagnosed injuries.

Characteristics	Total
Transtrochanteric fracture	60 (70.5%)
Femoral neck fracture	21 (24.6%)
Subtrochanteric fracture	4 (4.7%)

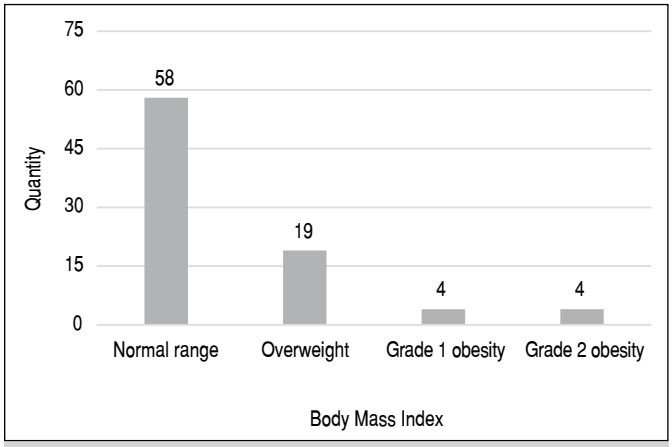

Figure 4. Distribution of participants by body mass range.

Table 4. Comorbidities found.

Comorbidities	Total
Systemic arterial hypertension (SAH)	47 (32.1%)
Type 2 diabetes mellitus (DM)	21 (14.3%)
Alzheimer's disease	9 (6.1%)
Cancer	8 (5.4%)
Cerebrovascular accident (CVA)	7 (4.7%)
Smoking	7 (4.7%)
Acute myocardial infarction (AMI)	5 (3.4%)
Osteoporosis	5 (3.4%)
Others	37 (25.3%)

Table 5. Types of materials used in surgical treatment.

Surgical procedure	Total
Cephalomedullary nail	51 (66.1%)
DHS	12 (15.5%)
Total hip arthroplasty	8 (10.3%)
Cannulated screw	3 (3.8%)
NCEP	2 (2.5%)
Total	76 (100%)

DHS: dynamic hip screw; NCEP: non-conventional endoprosthesis.

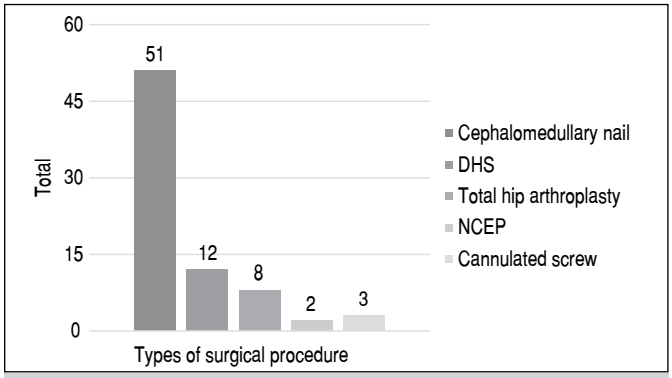

Figure 5. Surgical procedures.

Table 6. AO Classification.

AO Classification		Quantity
3.1.A	3.1A1	24 (28.5%)
	3.1A2	32 (38%)
	3.1A3	4 (4.76%)
Total		60 (71.4%)
3.1.B	3.1B1	12 (14.2%)
	3.1B2	3 (3.5%)
	3.1B3	6 (7.1)
Total		21 (25%)
3.2.A	3.2A1	1 (1.1%)
	3.2A1	1 (1.1%)
Total		2 (2.3%)
3.2.B	3.2B3	1 (1.1%)
Total		1 (1.1%)
Total		**84 (100%)**

Corroborating other studies, considering males, the percentage of cases varied in different age groups, with a decrease in fracture incidence from 70 years of age (Figure 1).

Our study verified a mean body mass index (BMI) of 24.16 (± 5.06) (with no significant difference between men and women), against the mean of 22.6 found,[3] demonstrating maintenance of the patient's physical pattern in recent years and that fractures occurred mostly in patients with BMI within the normal range (68%). Other authors also observed this.[12,15,16] Different factors can explain this occurrence: older individuals with higher BMI generally present a greater amount of muscle and fat tissue, with increased stress in the bone, leading to lower mineral loss[15] and, in addition, fat excess and greater musculature, present due to load excess, can act as a cushion for the pelvis, softening traumas in the region.

Mixed-race patients showed a lower frequency (22.8%), significantly lower than in the Caucasian population (72.2%), but higher than the values of Black/mixed-race cases found in the literature.[3,4] This difference possibly occurs due to greater bone mass accumulation in the Black/mixed-race population, which should be related to a greater renal reabsorption of calcium and resistance to the bone action of parathyroid hormone (PTH);[17] according to some studies, Black individuals also have lower levels of osteocalcin, the bone fraction of alkaline phosphatase and urinary hydroxyproline.[14,18]

In total, 89.4% of the fractures happened due to low-energy traumas, a result higher than the 73.5% found in the literature,[4] but like that found by Hungria Neto, Dias, and Almeida,[3] of 87.3%. Considering only cases related to low-energy trauma, we noted a predominance of cases in which patients suffered the fall while walking or just standing still, but mostly in orthostatic position.

Regarding comorbidities, most of the patients included in the study already have diagnosed diseases and continuous use of medications for them. Hypertension and diabetes mellitus are the predominant diseases. We believe that osteoporosis is less reported due to the disease's subdiagnosis among the analyzed patients.

This study lacked assessment of daily physical activity, including a control group. However, the literature[15,19,20] shows a retrospective history of low daily physical activity in individuals with proximal femur fractures compared to individuals in the group without the same fracture. Authors found that, in both sexes, an increase in physical activity, such as walking, climbing stairs, and working at home and in the garden, is a protective factor for proximal femur fractures.[19] This is due to increased muscle strength, resulting in a greater load on the bones and, consequently, an increase in bone mineral density, in addition to muscle mass itself acting as local protection against trauma.

Of the patients whose fractures occurred due to low-energy traumas, we observed that a considerable number of accidents could have been avoided, since they were falls from their own height. For such purpose, simple and economical epidemiological measures that guide and instruct the older population to get up cautiously (whether from bed in the morning, from a chair, or when leaving the car), use of handrails when going down stairs, and more support mechanisms for them (support bars in the bathroom, corridors, and stairs), can reduce the incidence of proximal femur fractures, bringing great benefits to the older population's quality of life, in addition to a great reduction in morbimortality and socioeconomic costs for the Unified Health System and supplementary health system of this progressively frequent condition, with the increase of the older population.

Undoubtedly, the evolution of medicine, considering prevention, screening, and treatment, contributes significantly to an increased life expectancy and a change in the age constitution of the population. However, it also increases the incidence of diseases typically related to aging and its consequences, such as proximal femur fractures.

CONCLUSIONS

The study showed that proximal femur fractures in older adults occur more frequently in women, with a mean age of 78.5 years, normal BMI range, and whose main trauma mechanism is fall at ground level. The most prevalent type of injury is transtrochanteric fracture, with a mean of 70.5%, and the most performed treatment is internal fixation with cephalomedullary nail, with a mean of 65%.

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GRAFTS FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: SYSTEMATIC REVIEW AND META-ANALYSIS

ENXERTOS PARA RECONSTRUÇÃO DO LIGAMENTO CRUZADO ANTERIOR: REVISÃO SISTEMÁTICA E METANÁLISE

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ABSTRACT

Objective: This study proposes to systematically review the literature and compare data on (1) function, (2) pain, (3) return to sport, and (4) complications after anterior cruciate ligament (ACL) reconstruction with quadriceps tendon autograft (QT) and hamstring tendon autograft (HT). Methods: In June 2021, a systematic review of the EMBASE, MEDLINE/PubMed, Cochrane Central Register of Controlled Trials, and LILACS databases was performed, based on PRISMA guidelines. The search strategy included the keywords: "Previous Cruciate Ligament Reconstruction," "ACL reconstruction," "quadriceps tendon autograft," "quadriceps graft," "Hamstring-Tendon Autografts." Meta-analyses were performed using Review Manager software (RevMan Web). Results: There were no significant differences between the two groups regarding function according to Lysholm score (MD 3.01; CI-0.30, 6.33, p = 0.08), the presence of pain (RR 0.89; CI-0.57, 1.39, p = 0.60), and re-rupture (RR 0.60; IC-0.19, 1.88, p = 0.38). Conclusion: QT and HT autografts show comparatively good results in ACL reconstruction without significant differences regarding function, pain, and rupture after surgical intervention. ***Level of Evidence II, Systematic Review of Level II Studies.***

Keywords: Anterior Cruciate Ligament. Hamstring Tendons. Quadriceps Muscle. Tendons.

RESUMO

Objetivo: Revisar sistematicamente a literatura e comparar dados sobre função, dor, retorno ao esporte e complicação após a reconstrução de ligamento cruzado anterior (LCA) com autoenxerto do tendão do quadríceps (TQ) e autoenxerto do tendão dos músculos isquiotibiais (TF). Métodos: Em junho de 2021, foi realizada revisão sistemática das bases de dados EMBASE, MEDLINE/PubMed, Cochrane Central Register of Controlled Trials e LILACS, baseada nas diretrizes do Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A estratégia de pesquisa incluiu as palavras-chave: "Anterior Cruciate Ligament Reconstruction", "ACL reconstruction", "quadriceps tendon autograft", "quadriceps graft" e "Hamstring-Tendon Autografts". As metanálises foram realizadas usando o software Review Manager (RevMan Web). Resultados: Não houve diferenças significativas entre os dois grupos com relação à função pelo escore de Lysholm (MD 3,01; IC-0,30, 6,33, p = 0,08), presença de dor (RR 0,89; IC-0,57, 1,39, p = 0,60) e re-ruptura (RR 0,60; IC-0,19, 1,88, p = 0,38). Conclusão: Os autoenxertos de TQ e TF apresentam resultados comparativamente bons na reconstrução do LCA sem diferenças significativas com relação à função, dor e ruptura após a intervenção cirúrgica. ***Nível de Evidência II, Revisão Sistemática de Estudos de Nível II.***

Descritores: *Ligamento Cruzado Anterior. Tendões dos Músculos Isquiotibiais. Músculo Quadríceps. Tendões.*

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries are the most common ligament injury to occur in the knee after twisting and rotation, especially during sports activity.[1,2] ACL injury compromises neuromuscular control and proprioceptive acuity of the knee and may contribute to an increased risk of a secondary injury.[3]

After an ACL lesion, the treatment goals are for the patient to return to sports and daily activities without further damage.[1,2] Treatment may be conservative (physiotherapy or medications) or surgical, with ACL reconstruction using autograft.[1,2,4,5] The choice of treatment depends mainly on factors such as age, sex, level of activity, degree of injury or concomitant lesions and degree of instability.[1,2,5]

The choice of graft for ACL reconstruction remains a subject of interest among orthopedic surgeons since the ideal graft has not yet been found and this remains a prevalent research topic.[6,7] Autologous grafts of the hamstrings (TF) and patellar tendon (PT) are the most commonly used for ACL reconstruction.[8] However, as the use of quadriceps tendon (QT) as grafts increases, so does its interest as a topic of scientific

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research.[6,8] For these reasons, QT grafts have been proposed as a promising alternative to common grafts in ACL injury surgery.[8]
Despite technical advances in ACL reconstruction surgery, there is still a need to improve postoperative results and understand which type of grafts result in lower failure rates and risk of complications and which results in better function, less pain, and shorter return time to sport.[6,8] Therefore, the objective of this systematic review and meta-analysis is to compare the available evidence on (1) function, (2) pain, (3) return to sport, and (4) complications after reconstruction of the anterior cruciate ligament with autograft of the quadriceps tendon (QT) and hamstring tendon (HT).

METHODS

A systematic review was conducted, in June 2021, based on the recommendations of The Cochrane Handbook of Interventions Reviews[9,10] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA. A review protocol was published in the International Prospective Register of Systematic Reviews (PROSPERO CRD42021260308).

Data sources and research

One of the researchers (T.N.A.) developed the protocol and defined the research strategies for the databases EMBASE, MEDLINE/PubMed, Cochrane Central Register of Controlled Trials, and LILACS. Data were collected on June 10, 2021. Subsequently, the reference lists of eligible studies were analyzed.
To conduct the search for intervention studies, a strategy was developed with the acronym PICO that focuses on population, intervention, comparison, and outcomes.[11] Thus: P = adults over 18 years of age with complete anterior cruciate ligament injuries; I = quadriceps tendon autograft; C = hamstring autograft; and O = the primary outcome of interest includes pain, function, and re-rupture. Secondary outcomes were: return to sport and complications.

Identification of studies

To search the studies within the databases, the following combinations of keywords were used with the Boolean operators AND and OR:
1 - "Anterior Cruciate Ligament Reconstruction" [Mesh] OR "ACL reconstruction";
2 - "quadriceps tendon autograft" OR "quadriceps graft";
3 - "Hamstring-Tendon Autografts."

Inclusion criteria

Inclusion criteria were as follows: (1) studies performed with humans; (2) adults without previous surgical procedures for anterior cruciate ligament injury; (3) aged over 18 years; (4) randomized clinical trials and cohort studies; (5) clinical studies on ACL reconstruction using quadriceps tendon autograft, single- or double-bundle reconstruction, with or without bone block (quadriceps autograft without bone plug); (6) studies comparing the results of quadriceps tendon autograft versus hamstring autograft (femoral biceps, semitendinosus, and semimembranosus); (7) all procedures were primary ligament reconstructions performed for acute symptoms or chronic ACL deficiency, with or without meniscus injury; (8) articles in English, Spanish, or Portuguese; (9) published between January 2000 and June 2021. Case reports, expert opinion, registration of clinical trials, reviews, unpublished data, animal or in vitro experiments, and studies conducted on human cadavers were excluded, in addition to studies with less than 12 months of follow-up and studies investigating results after reconstruction of other ligaments.

Data extraction

The stages of the screening of the articles were performed using Rayyan software.[12] Analysis of titles and abstracts and the full reading were performed by two researchers (T.N.A. & J.B.M.C.) independently; any divergences were resolved among the members of the research team. After reading the articles, the following information was collected: author, year, and place of publication; study design and follow-up time of the intervention; details about ACL injury, intervention (QT autograft versus HT); measures of outcomes or results.

Evaluation of the quality and risk of bias

The quality of the studies was evaluated for each outcome investigated using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE – https://gradepro.org/).[13,14] The quality of the evidence was classified into four categories: high, moderate, low, or very low.[13,14] The risk of bias in the included studies of the meta-analysis was performed using the ROBINS tool for Risk of Bias in Randomized Trials and Risk of Bias in Non-Randomised Studies.

Statistical analysis

We calculated the risk ratio and mean difference with a 95% confidence interval using the random effect model. Heterogeneity was classified based on the values of I^2: 25%, low heterogeneity; 50%, moderate heterogeneity; and 90%, high heterogeneity.[10] All statistical analyses were performed with the Review Manager (RevMan Web) software.

RESULTS

Searches in the three databases resulted in 350 articles, and two additional articles were retrieved by manual search in Google Scholar. After removing 59 duplicates, we read 39 articles in full, of which 13 were included[8,15-26] (Figure 1). Supplementary Material 2 shows the list of excluded articles and their respective justification.
Table 1 shows the characteristics of the included studies. Four randomized clinical trials[15,18,23,26] and nine cohort studies[8,16,17,19-22,24,25] were included. Studies were conducted in Romania,[15,25] Germany,[8,17,18] Denmark,[23] Mexico,[26] Switzerland,[16] Australia,[19] Korea,[20] Austria,[21,22] and Turkey.[24] A total of 879 adults with anterior cruciate ligament injury participated in this study. Of these, 422 underwent ACL reconstruction with QT autograft and 457, with HT autograft.

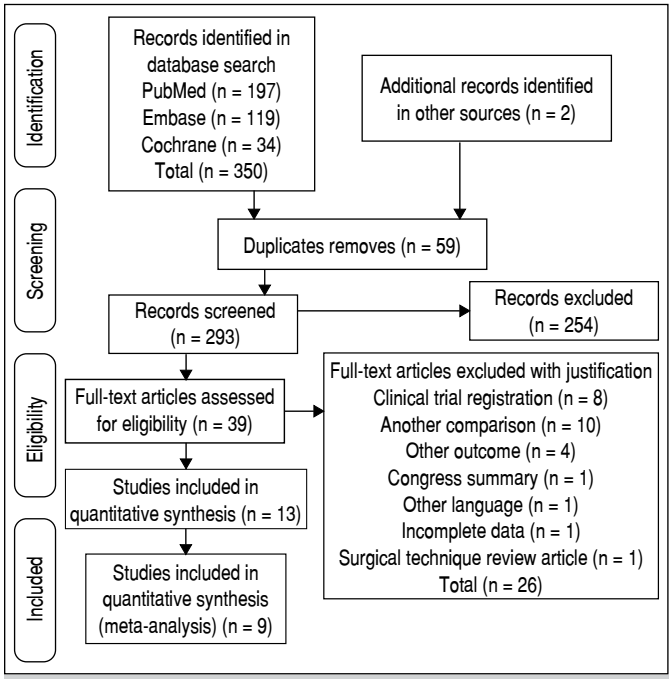

Figure 1. Flowchart of the screening of the articles.

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Table 1. Characteristics of the studies on quadriceps tendon autograft versus hamstring autograft for anterior cruciate ligament reconstruction.

Author, year	Type of study and follow-up	Sample size/ sex/age (years)	Surgical technique	Intervention/ placebo or control	Outcomes	Adverse events or complications	Approval of the ethics committee
CLINICAL TRIALS							
Buescu et al.,[17] 2017 Romania	Parallel randomized clinical trial Average follow-up: 0–48 h	N = 48 Male: 45 Female: 3 Age: 28.35 ± 7.19	Anatomical arthroscopic reconstruction of the ACL in single-bundle	(1) QT (n = 24 patients). (1) HT (n = 24 patients).	Pain: VAS – patients who required complementary analgesia (n/%) (1) QT 0-1 2h: 12 (50%) QT 25-48 h: 4 (16.66%) (2) HT 0-1 2h: 18 (75%) HT 25-48 h: 9 (37.50%) (p = 0.002).	None	Yes
Horstmann et al.,[18] 2022 Germany	Randomized, controled clinical trial Follow-up: 2 years Evaluation: 3, 6, 12, and 24 months after surgery.	N = 51 Sex: Male/Female (1) QT: 21/3 (2) HT: 12/15 Age: (1) QT:24.1 ± 3.6 (2) HT:32.7 ± 11.4	Press-fit fixation techniques without implant.	(1) QT (n = 24 patients). (1) HT (n = 27 patients).	Functional results by Lysholm: (1) QT Preoperative: 72.3 ± 13.2 QT two years postoperatively: 90.4 ± 11.9 (2) HT Preoperative: 60.4 ± 18.5 HT two years postoperatively: 83.5 ± 17.4 p < 0.131 Return to sport (in days): (1) QT: 82.1 ± 45.6 (2) HT: 95.2 ± 45.5 p < 0.131	Yes	Yes
Sinding et al.,[23] 2020 Denmark	Randomized, controled clinical trial Follow-up: 1 year	N = 85 Sex: Male/Female (1) QT: 25/17 (2) HT: 23/20 Age: (1) QT:28.7 ± 6.4 (2) HT: 28.3 ± 6.2	ACL Reconstruction	(1) QT (n = 42 patients). (1) HT (n = 43 patients).	Function: When comparing the two groups of patients with autograft, 4%-11% less muscle strength was observed during knee extensor at 0 degrees/s (isometric, MVIC) and 60 degrees/s (concentric dynamics) in QT vs. HT, along with knee extensor 4% lower RFD200ms. Functional Capacity (single leg hop distance – SHD): There was no difference in SHD between HT and QT.	NR	Yes
Vilchez-Cavazos et al.,[26] 2020 Mexico	Randomized clinical trial Follow-up: 2 weeks and 1, 3, 6 and 12 months.	N = 28 Sex: Male/Female (1) QT: 11/2 (2) HT: 12/3 Age: (1) QT: 30.64 ± 8.71 (2) HT: 28.60 ± 6.74	ACL Reconstruction	(1) QT (n = 14 patients). (1) HT (n = 14 patients).	Functional results by Lysholm (median and interquartile range): (1) QT baseline: 75.0 (61.5-83.5) QT 12 months: 95.0 (91.0-100.0) (2) HT baseline: 61.0 (37.0-74.0) HT 12 months: 98.0 (90.0-100.0) Pain (VAS) (median and interquartile range): (1) QT baseline: 3.0 (1.5-7.0) QT 12 months: 0.0 (0.0-1.5) (2) HT baseline: 4.0 (3.0-7.0) HT 12 months: 0.0 (0.0-1.0)	NR	Yes
OBSERVATIONAL STUDIES							
Akoto et al.,[8] 2019 Germany	Retrospective cohort study Follow-up: 12 months	N = 82 Male: 64 Female: 18 Age: (1) QT: 29 ± 10 (2) HT: 28 ± 10	Isolated ACL reconstruction	(1) QT (n = 41 patients). (1) HT (n = 41 patients).	Functional results by IKDC scores: (1) QT: 86.4 ± 14.2 (2) HT: 86.7 ± 10.9 p = 0.9 Functional tests (One-Leg Hop test): (1) QT: 96.2 ± 8.5 (2) HT: 95.5 ± 8.5 p = 0.8	Graft failure: (1) QT: n = 3 (2) HT: n = 4 Contralateral ACL rupture: (1) QT: n = 1 (2) HT: n = 2 Infection: (1) QT: n = 1 (2) HT: n = 2	Yes

Table 1. Characteristics of the studies on quadriceps tendon autograft versus hamstring autograft for anterior cruciate ligament reconstruction.

Author, year	Type of study and follow-up	Sample size/ sex/age (years)	Surgical technique	Intervention/ placebo or control	Outcomes	Adverse events or complications	Approval of the ethics committee
Cavaignac et al.,[16] 2017 Switzerland	Cohort study Average follow-up: 3.6 6 0.4 years, and the minimum follow-up was 3 years	N = 86 Male: 45 Female: 41 Age: (1) QT: 32.1 ± 8 (2) HT: 30.9 ± 9	Isolated ACL reconstruction	(1) QT (n = 45 patients). (1) HT (n = 41 patients).	Functional results by Lysholm: (1) QT: 89 ± 6.9 (2) HT: 83.1 ± 5.3 p < 0.05 Pain: (1) QT: 90 ± 6.8 (2) HT: 86 ± 7.2 p = 0.23	QT group, there was 1 re-rupture In the HT group, there were 2 cases of graft rupture.	Yes
Häner et al.,[17] 2016 Germany	Cohort study Average follow-up: 24 months	N = 51 Sex: Male/Female (1) QT: 17/8 (2) HT: 18/8 Age: (1) QT: 35.9 ± 10.4 (2) HT: 35.8 ± 13.1	ACL Reconstruction homologous autograft (HT and QT)	(1) QT (n = 25 patients). (1) HT (n = 26 patients).	Functional results by Lysholm: (1) QT: 88 (2) HT: 78.1 p = 0.06 Pain: When kneeling (1) QT: 7 (2) HT: 11 When squatting (1) QT: 7 Climb stairs (1) QT:4 (2) HT: 4 In squats (2) HT:8	No rerupture occurred during postoperative follow-up. No early superficial or meniscal infection. Lesion was found in either group.	Yes
Johnston et al.,[19] 2021 Australia	Cohort study Follow-up: 6 months	N = 111 Sex: Male/Female (1) QT: 29/8 (2) HT: 58/16 Age: (1) QT: 20.0 (15-34) (2) HT: 20.5 (15-32)	Arthroscopy-assisted ACL reconstruction with femoral tunnel perforated via anteromedial portal	(1) QT (n = 37 patients). (1) HT (n = 74 patients).	Previous knee pain: (1) QT: 67% (2) HT: 63% p = N.S. Active knee flexion amplitude while standing (p < 0.001), active knee flexion amplitude measured in lateral decubitus (p < 0.001), and passive knee flexion amplitude (p = 0.016) in the HT Group when compared with the QT group.	NR	Yes
Lee et al.,[20] 2016 Korea	Cohort study Follow-up: 2 years	N = 96 Sex: Male/Female (1) QT: 44/4 (2) HT: 44/4 Age: (1) QT: 31.1 (17-57) (2) HT: 29.9 (17-58)	ACL Reconstruction	(1) QT (n = 48 patients). (1) HT (n = 48 patients).	Lysholm scores: (1) QT Preoperative: 70.2 ± 9.6 QT final follow-up: 92.1 ± 8.7 (2) HT Preoperative: 69.4 ± 18.0 HT final follow-up: 88.4 ± 11.9 p = 0.30 The recovery of flexor muscle strength was better in the quadriceps group (86.6% vs. 92.2% at 60 degrees/s, p = 0.22; 87.1% vs. 99.6% at 180 degrees/s, p = 0.01).	NR	Yes
Ortmaier et al.,[21] 2021 Austria	Retrospective cohort study Follow-up: 12 months	N = 45 patients Sex: Male/Female (1) QT: 17/8 (2) HT: 12/8 Age (average): 33.4 years	ACL Reconstruction homologous autograft (HT and QT)	(1) QT (n = 20 patients). (1) HT (n = 25 patients).	Knee pain (VAS): Subjective assessments of pain during and after sports worsened significantly for almost all parameters with no significant difference between pre- and postoperative groups. Rate of return to sports was 91.3%.	NR	Yes

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Table 1. Characteristics of the studies on quadriceps tendon autograft versus hamstring autograft for anterior cruciate ligament reconstruction.

Author, year	Type of study and follow-up	Sample size/ sex/age (years)	Surgical technique	Intervention/ placebo or control	Outcomes	Adverse events or complications	Approval of the ethics committee
Runer et al.,[22] 2018 Austria	Prospective cohort study Follow-up: 6, 12, and 24 months after surgery.	N = 80 patients Sex: Male/Female (1) QT: 23/17 (2) HT: 23/17 Age (average): (1) QT: 34.6 ± 11.0 (2) HT: 34.4 (± 11.0)	ACL Reconstruction homologous autograft (HT and QT)	(1) QT (n = 40 patients). (1) HT (n = 40 patients).	Lysholm scores: (1) QT Preoperative: 94.7 ± 8.2 QT final follow-up: 93.4 ± 7.5 (2) HT Preoperative: 94.1 ± 9.9 HT final follow-up: 93.4 ± 8.7 Pain (VAS): (1) QT Preoperative: 0.90 ± 1.1 QT final follow-up: 0.6 ± 1.0 (2) HT Preoperative: 0.8 ± 1.0 HT final follow-up: 0.8 ± 1.2	During the QT graft collection process, no joint capsule opening or patellar fracture was observed. Postoperatively, no major quadriceps bleeding or hematoma was reported or observed. None of the QT patients reported tenderness, numbness, or irritation at the graft collection site. Rerupture: Over the 2 years of follow-up, one graft rupture occurred in the HT group, while no further ruptures were recorded in the QT group (n.s.). The re-rupture occurred as a result of the player's contact during a football game.	Yes
Sofu et al.,[24] 2013 Turkey	Retrospective cohort study Follow-up: 37.6 months	N = 44 patients Sex: Male/Female (1) QT: 21/02 (2) HT: 21/0 Age (average): (1) QT: 26.8 (2) HT: 28.6	ACL Reconstruction homologous autograft (HT and QT)	(1) QT (n = 23 patients). (1) HT (n = 21 patients).	Lysholm scores < 64 (poor): (1) QT Preoperative: 22 (95.6%) QT final follow-up: 1 (4.3%) (2) HT Preoperative: 19 (90.5%) HT final follow-up: 0 (0%)	NR	Yes
Todor et al.,[25] 2019 Romania	Retrospective cohort study Follow-up: 24 months	N = 72 patients Sex: Male/Female (1) QT: 26/13 (2) HT: 23/10 Age (average): (1) QT: 30.64 ± 8.71 (2) HT: 28.60 ± 6.74	ACL Reconstruction homologous autograft (HT and QT)	(1) QT (n = 39 patients). (1) HT (n = 33 patients).	Lysholm scores: (1) QT Post-operative: 89.20 ± 9.97 (1) HT Post-operative: 91.33 ± 6.65 p = 0.299	In both groups, there were no readmissions or reoperations due to complications. There was one patient in the QT group with a lateral difference of 5 mm in the KT-1000 test and was considered a failure. No patient in the HT group had a difference of more than 3 mm. 5 patients in the QT group (12.82%) reported an unsatisfactory aesthetic appearance of the suprapatellar incision and 8 patients in the HT group (24.24%) reported mild numbness in the anteromedial face of the leg.	Yes

VAS: visual analog scale; QT: quadriceps tendon; HT: hamstring tendons; NR: not reported; IKDC: International Knee Documentation Committee.

RESULTS

Function

Ten studies showed results on knee function after QT autograft and HT autograft.[8,16-18,20,22-26] ACL reconstruction with QT autograft presented clinical outcomes similar to those of the HT autograft in terms of stability and knee function.[8,17,23,26] Of the studies included, only one demonstrated that the autograft of the quadruple tendon of the HT is superior to the autograft of the QT in arthroscopic ACL reconstruction surgery.[24]

Furthermore, one year after ACL reconstruction, it was found that the autograft of HT led to impairments of the extensor and flexor bilateral muscle strength, while the autograft of QT resulted in more pronounced impairments only in the extensor bilateral muscle strength. The functional capacity reported by the patient was not affected by the type of autograft.[23]

We conducted a meta-analysis of six studies with data on knee function analyzed by the Lysholm score.[16-18,20,22,25] The meta-analysis results indicated that there were no differences in knee function between the QT autograft and the HT autograft (MD 3.01; CI-0.30, 6.33, $p = 0.08$), and there was evidence of moderate heterogeneity among the studies ($I^2 = 70\%$, $Chi^2 = 16.53$). Figure 2 presents the Funnel plot results for the Lysholm score.

Pain

Eight studies showed results on the presence of pain after ACL reconstruction surgery.[15-17,19,21,22,24,26]

Vilchez-Cavazos et al.[26] reported that no significant differences were observed regarding pain between the groups of QT and HT autograft, in the pre and postoperative periods. However, Buescu et al.[15] reported that the percentage of individuals who required supplementary analgesics was 38% higher in the group with HT autograft, when compared with the group with QT autograft. In the study by Ortmaier et al.,[21] the subjective assessments of pain during and after sports activity reported a significant worsening in almost all parameters with no significant difference between pre- and postoperative groups.

We performed two meta-analyses on the differences in pain after ACL reconstruction with QT and HT autograft. In the first meta-analysis conducted with four studies that contained data on the total amount of pain, the result indicated that there were no differences between the groups analyzed after intervention (RR 0.89; CI-0.57, 1.39, $p = 0.60$) and there was low evidence of heterogeneity among the studies ($I^2 = 36\%$, $Chi^2 = 4.68$).[15,17,19,24] Additionally, the other meta-analysis with mean and standard deviation of the presence of pain after reconstruction also indicated that there were no differences between the groups analyzed after intervention (MD 1.63; CI-2.45, 5.72, $p = 0.43$)[16,17] (Figure 3).

Return to sport

Two studies reported data on return to sport.[18,21] Horstmann et al.[18] indicated that the time of return to sport was 82 days in the QT autograft group and 95.2 days in the HT autograft group, and there were no differences between the groups. Furthermore, the study by Ortmaier et al.[21] reported that the rate of return to sports was 91.3% and there were no significant differences ($p \geq 0.05$) in the number of sports modalities and in the time of return to sport between groups.

Complication and adverse events

Table 1 shows information on adverse events or complications reported in the studies. Horstmann et al.[18] conducted a randomized controlled trial with a 2-year follow-up period. The authors reported that in the HT group, there was one graft delay, which was treated with revision ACL reconstruction with QT. There was also residual anteromedial instability of the knee, which was treated with the reconstruction of the medial collateral ligament of the knee and revision of the ACL graft. In the QT autograft group, there was one early infection, which was treated with antibiotic transplant retention and arthroscopic lavage and three ACL graft retentions, which were treated with ACL graft revision (two revision reconstructions with thigh tendon graft and a healing response).

Cavaignac et al.[16] described that in the QT autograft group, there was one re-rupture after a new sports injury (contact sport) after 3.7 years of follow-up. There were three reoperations: one for a cyclops lesion (at 5.7 months), one to remove the femoral screw (at 13.1 months), and one for a grade 3 medial condyle cartilage lesion (microfracture at 25.2 months). In the HT group, there were two cases of graft rupture. One patient was re-operated at 15.3 months for arthroscopic arthrolysis.

Akoto et al.[8] reported that the graft failure rate was 7.3% in the QT autograft group and 9.8% in the HT autograft group and there was no statistical difference between the groups. Furthermore, no statistical difference was found between the two groups in terms of infection, contralateral rupture of the ACL or lesions associated with meniscus and cartilage. During the 2-year follow-up, in a cohort study, none of the patients with QT autograft reported tenderness, numbness, or irritation at the graft collection site.[22]

Re-rupture

One study reported cases of contralateral ACL rupture[8] and two studies reported graft re-rupture.[16,22] The meta-analysis of the three studies showed no differences in rupture following QT or HT autograft (RR 0.60; CI-0.19, 1.88, $p = 0.38$), and there was no evidence of heterogeneity among the studies ($I^2 = 0\%$, $Chi^2 = 0.28$). Figure 4 shows the results of rupture following QT or HT autograft.

Quality assessment

Table 2 shows the analysis of the methodological quality of the studies. Figure 5 shows the bias risk analysis for both randomized and non-randomized studies.

DISCUSSION

This systematic review included 13 studies, nine of which were included in the meta-analysis comparing the reconstruction of ACL rupture with QT autograft and HT autograft. The total sample of adult participants was 879. The main finding of this systematic review and meta-analysis is that there were no statistically or clinical differences between the two reconstructions in relation to functionality (Lysholm score),[16-18,20,22,25] pain (VAS),[15,17,19,24] and rupture following reconstruction.[8,16,22] In addition, there were no differences between the groups regarding rates of graft failures and infections.[8]

Although there is another meta-analysis on functional results between reconstruction for ACL rupture with QT autograft and HT autograft,[27] our review included a greater number of studies and with new results. Moreover, our review has the differential of presenting meta-analysis results on pain and re-rupture between the two interventions.

The systematic review and meta-analysis mentioned above was published in February 2019.[27] The authors compared the QT Autograft versus HT and patellar tendon (bone-tendon-bone) autograft.[27] They concluded that the QT autograft had comparable clinical and functional results and graft survival rate when compared with the patellar tendon (bone-tendon-bone) and HT autograft. The QT autograft, however, showed significantly less pain at the site of collection than the patellar tendon autograft

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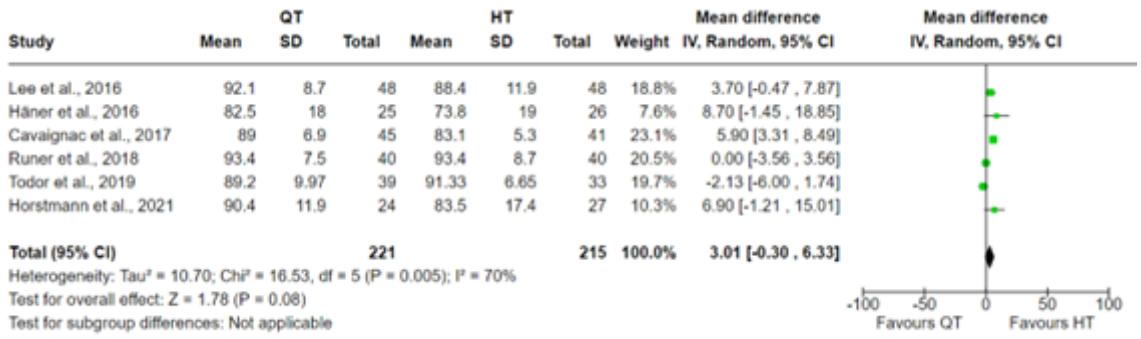

Figure 2. Funnel plot showing the mean difference in Lysholm scores between quadriceps tendon and hamstring tendon autografts.

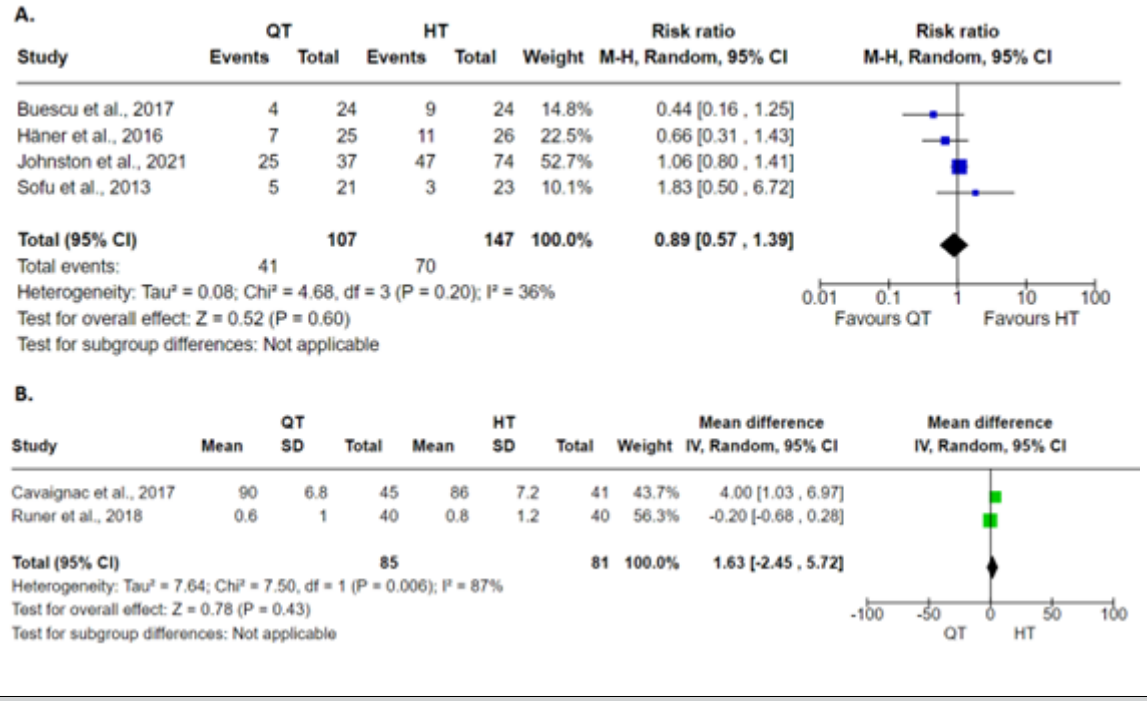

Figure 3. Funnel plot showing the proportion of risk (A) and mean difference (B) of pain after surgical intervention for reconstruction with autografts of the quadriceps tendon and hamstring tendon.

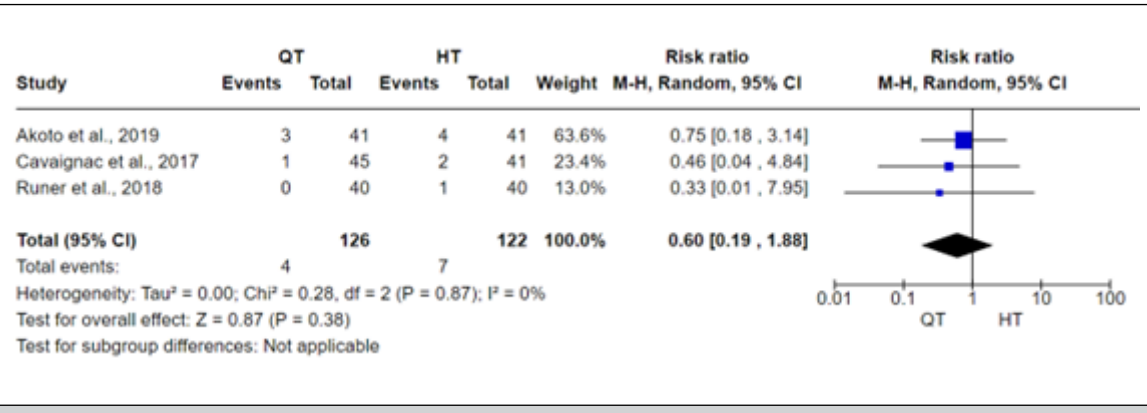

Figure 4. Funnel plot showing the proportion of risk of ruptures after surgical intervention for reconstruction with autografts of the quadriceps tendon and hamstring tendon.

Table 2. Quality assessment.

Summary of findings:						
Quadriceps tendon autograft compared with hamstring tendon autograft for anterior cruciate ligament reconstruction						
Patient or population: anterior cruciate ligament reconstruction **Setting:** **Intervention:** Quadriceps tendon autograft **Comparison:** hamstring tendon autograft						
Outcomes	**Anticipated absolute effects* (95% CI)**		**Relative effect (95% CI)**	**Nº of participants (studies)**	**Certainty of the evidence (GRADE)**	**Comments**
	Risk with hamstring tendon autograft	**Risk with Quadriceps tendon autograft**				
Function follow-up: mean 3 years	The mean function was **89.43**	mean **85.59 higher** (0 to 0)	-	436 (6 RCTs)	⊕⊕⊕◯ MODERATE	There were no differences in knee function between quadriceps tendon autograft and hamstring autograft (p = 0.08).
Pain follow-up: range 48 Years to 24 months	383 per 1.000	**341 per 1.000** (218 to 533)	RR 0.89 (0.57 to 1.39)	254 (4 RCTs)	⊕⊕⊕◯ MODERATE	There were no differences in pain between the groups analyzed after the intervention (p = 0.60).
Return to sport follow-up: median 2 years	The mean return to sport was **82.1**	mean **95.2 higher** (0 to 0)	-	51 (1 RCT)	⊕⊕⊕⊕ HIGH	There were no significant differences (p < 0.131) in time to return to sport between groups.
Complications – Re-rupture follow-up: range 12 months to 3 years	11 per 1.000	**0 per 1.000** (0 to 0)	no estimates	371 (5 observational studies)	⊕⊕◯◯ LOW	There were no differences in rupture following quadriceps tendon autograft and hamstring autograft (p = 0.38).
***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).						
CI: Confidence interval; RR: Risk ratio						
GRADE Working Group grades of evidence **High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect **Moderate certainty:** We are moderately confident in the estimated effect: The true effect is likely to be close to the estimated effect, but there is a possibility that it is substantially different **Low certainty:** Our confidence in the estimated effect is limited: The true effect may be substantially different from the estimated effect **Very low certainty:** We have very little confidence in the estimated effect: The true effect is likely to be substantially different from the estimated effect						

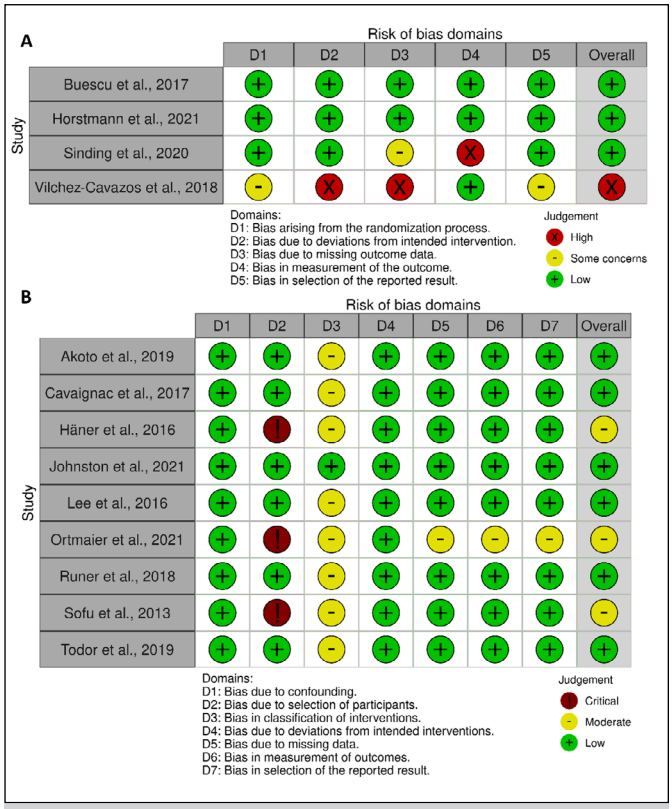

Figure 5. Assessment of the risk of bias from (A) randomized clinical trials and (B) non-randomized trials.

(bone-tendon-bone) and better functional results than the HT autograft.[27]

Another recent systematic review and meta-analysis of randomized clinical trials was performed to compare autografts of the patellar tendon (bone-tendon-bone) with HT autografts. The authors also identified that no recommendation can be made on the optimal choice of graft when using, as a primary metric, the return to baseline level of physical activity and/or participation in sports.[28]

When comparing autograft and synthetic graft interventions in participants with ACL injury, a recent systematic review concluded that patellar tendon autografts (bone-tendon-bone) were associated with better results regarding ACL integrity and stability in the pivot shift and Lachman tests, better degrees of IKDC function, and lower complication rates than synthetic grafts.[29]

As a strength of this review, we highlight the development of a comprehensive research strategy and the accuracy in the selection of studies. As possible limitations of our study, we highlight the heterogeneity between the studies, identified by the presentation of the different outcomes, methods of comparison, and intervention and follow-up period for ACL reconstruction. The evidence is not very robust according to the evaluation of methodological quality, this is mostly due to the small sample size in most of the studies. Thus, we highlight the importance of conducting future research, including high-quality clinical trials and cohort studies, with large sample size and follow-up time; these will help in deciding the best surgical intervention. In future updates to this review, the addition of evidence from ongoing studies and new robust studies should help inform on the optimal treatment for anterior cruciate ligament

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injuries. These studies should not only evaluate and report results that are important for patients with ACL rupture but should also consider factors such as standardization of interventions, period of follow-up, and assessment methods of pain, functions, and complications that create additional challenges in the design, conduction, and interpretation of clinical trials and cohort studies.

CONCLUSION

We found evidence that there is no difference in the postoperative period of surgical treatment of ACL reconstruction with QT autograft and HT autograft regarding the results of function, pain, and re-rupture. Therefore, one technique is not superior to another considering functionality, pain, and ruptures after ACL reconstruction.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. TNA, JBMC, LBD: conception, data collection, data analysis for the work, writing of intellectual work, final approval of the manuscript.

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SUPPLEMENTARY MATERIAL 1.
SEARCH STRATEGIES USED IN DATABASES.

Databases	*Search Strategy*
MEDLINE/PubMed *06/10/2021*	Search: ((((Anterior Cruciate Ligament Reconstruction) OR (ACL reconstruction)) AND (quadriceps tendon autograft)) OR (quadriceps graft)) AND (Hamstring-Tendon Autografts) Filters: from 2000 – 2021 ***Total: 197***
EMBASE *06/10/2021*	1 (Anterior Cruciate Ligament Reconstruction or ACL reconstruction).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] 16283 2 (quadriceps tendon autograft or quadriceps graft).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] 156 3 anterior cruciate ligament/ or anterior cruciate ligament reconstruction/ or tendon graft/ or Hamstring-Tendon Autografts.mp. or hamstring/ or hamstring tendon/ 30642 41 and 2 and 3 ***Total: 119***
Cochrane Central Register of Controlled Trials *06/10/2021*	(Anterior Cruciate Ligament Reconstruction OR ACL reconstruction) AND (quadriceps tendon autograft OR quadriceps graft) AND (Hamstring-Tendon Autografts) ***Total: 34***

SUPPLEMENTARY MATERIAL 2.
EXCLUDED ARTICLES AND REASON FOR EXCLUSIONS.

Number	Title	Reason for exclusion
1	Hamstring tendon autograft versus quadriceps tendon autograft for anterior cruciate ligament reconstruction: a randomised controlled trial [Internet]. Hoboken: Cochrane Central Register of Controlled Trials (CENTRAL); 2018 [accessed on 2022 Oct 24]. Available from: https://trialsearch.who.int/Trial2.aspx?TrialID=ACTRN12618001520224	1
2	A randomized controlled trial comparing the outcomes of quadriceps autograft vs. hamstring autograft in acl reconstruction [Internet]. Hoboken: Cochrane Central Register of Controlled Trials (CENTRAL); 2019 [accessed on 2022 Oct 24]. Available from: https://trialsearch.who.int/Trial2.aspx?TrialID=ACTRN12619001396112	1
3	Cristiani R, Mikkelsen C, Wange P, Olsson D, Stålman A, Engström B. Autograft type affects muscle strength and hop performance after ACL reconstruction. A randomised controlled trial comparing patellar tendon and hamstring tendon autografts with standard or accelerated rehabilitation. Knee Surg Sports Traumatol Arthrosc. 2021;29(9):3025-3036.	2
4	Feller JA, Webster KE. A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. Am J Sports Med. 2003;31(4):564-73.	2
5	Gupta R, Kapoor D, Kapoor L, Malhotra A, Masih GD, Kapoor A, Joshi S. Immediate post-operative pain in anterior cruciate ligament reconstruction surgery with bone patellar tendon bone graft versus hamstring graft. J Orthop Surg Res. 2016;11(1):67.	2
6	Comparing two surgical techniques for anterior cruciate ligament (ACL) reconstruction [Internet]. Hoboken: Cochrane Central Register of Controlled Trials (CENTRAL); 2020 [accessed on 2022 Oct 24]. Available from: https://trialsearch.who.int/Trial2.aspx?TrialID=ISRCTN55542036	1
7	A double blind randomized comparative study of two autografts in arthroscopic ACL reconstruction [Internet]. SICOT 40th Orthopaedic World Congress; 2019; Muscat. Hoboken: Cochrane Central Register of Controlled Trials (CENTRAL); 2019 [accessed on 2022 Oct 24]. Available from: https://www.cochranelibrary.com/central/doi/10.1002/central/CN-02072196/full	4
8	Kondo E, Yasuda K, Miyatake S, Kitamura N, Tohyama H, Yagi T. Clinical comparison of two suspensory fixation devices for anatomic double-bundle anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2012;20(7):1261-7.	3
9	Martin-Alguacil JL, Arroyo-Morales M, Martin-Gómez JL, Lozano-Lozano M, Galiano-Castillo N, Cantarero-Villanueva I. Comparison of knee sonography and pressure pain threshold after anterior cruciate ligament reconstruction with quadriceps tendon versus hamstring tendon autografts in soccer players. Acta Orthop Traumatol Turc. 2019;53(4):260-5.	3
10	Anterior cruciate ligament-reconstruction: quadriceps tendon or hamstrings tendon? A prospective randomised controlled trial [Internet]. Bethesda: NML; 2019 [acessed on 2022 Oct 24]. Available from: https://clinicaltrials.gov/show/NCT02173483	1
11	Comparative study of anterior cruciate ligament reconstruction (quadriceps versus hamstring tendon) [Internet]. Bethesda: NML; 2018 [acessed on 2022 Oct 24]. Available from: https://clinicaltrials.gov/ct2/show/NCT02832791	1
12	Recovery of soccer players after anterior cruciate ligament reconstruction [Internet]. Bethesda: NML; 2021 [acessed on 2022 Oct 24]. Available from: https://clinicaltrials.gov/ct2/show/NCT04742868	1
13	Setuain I, Izquierdo M, Idoate F, Bikandi E, Gorostiaga EM, Aagaard P, et al. Differential effects of 2 rehabilitation programs following anterior cruciate ligament reconstruction. J Sport Rehabil. 2017;26(6):544-55.	2
14	Tashiro T, Kurosawa H, Kawakami A, Hikita A, Fukui N. Influence of medial hamstring tendon harvest on knee flexor strength after anterior cruciate ligament reconstruction. A detailed evaluation with comparison of single- and double-tendon harvest. Am J Sports Med. 2003;31(4):522-9.	2

Number	Title	Reason for exclusion
15	Wipfler B, Donner S, Zechmann CM, Springer J, Siebold R, Paessler HH. Anterior cruciate ligament reconstruction using patellar tendon versus hamstring tendon: a prospective comparative study with 9-year follow-up. Arthroscopy. 2011;27(5):653-65.	2
16	Yoo SH, Song EK, Shin YR, Kim SK, Seon JK. Comparison of clinical outcomes and second-look arthroscopic findings after ACL reconstruction using a hamstring autograft or a tibialis allograft. Knee Surg Sports Traumatol Arthrosc. 2017;25(4):1290-7.	2
17	Chen CH, Chen WJ, Shih CH. Arthroscopic reconstruction of the posterior cruciate ligament: a comparison of quadriceps tendon autograft and quadruple hamstring tendon graft. Arthroscopy. 2002;18(6):603-12.	2
18	Chen CH, Chen WJ, Shih CH, Jiang CC. Quadriceps tendon-patellar bone autograft for arthroscopic anterior cruciate ligament reconstruction. Journal of Surgical Association Republic of China. 1998;31(3):166-72.	5
19	A study comparing two grafts for treatment of knee instability [Internet]. Hoboken: Cochrane Central Register of Controlled Trials (CENTRAL); 2019 [acessed on 2022 Oct 24]. Available from: https://trialsearch.who.int/Trial2.aspx?TrialID=CTRI/2017/03/008098	1
20	Is quadriceps tendon a better choice than hamstring tendons for repairing anterior cruciate ligament lesion? [Internet]. Hoboken: Cochrane Central Register of Controlled Trials; 2019 [acessed on 2022 Oct 24]. Available from: https://trialsearch.who.int/Trial2.aspx?TrialID=ISRCTN12967309	1
21	Ouabo EC, Gillain L, Saithna A, Blanchard J, Siegrist O, Sonnery-Cottet B. Combined anatomic anterior cruciate and anterolateral ligament reconstruction with quadriceps tendon autograft and gracilis allograft through a single femoral tunnel. Arthrosc Tech. 2019;8(8):e827-34.	6
22	Sanada T, Iwaso H, Fukai A, Honda E, Yoshitomi H, Inagawa M. Anatomic anterior cruciate ligament reconstruction using rectangular bone-tendon-bone autograft versus double-bundle hamstring tendon autograft in young female athletes. Arthrosc Sports Med Rehabil. 2021;3(1):e47-55.	2
23	Shibata Y, Matsushita T, Araki D, Kida A, Takiguchi K, Ueda Y, et al. Prediction of quadriceps strength recovery after anterior cruciate ligament reconstruction with a hamstring autograft: decision tree analysis. J Orthop Sci. 2019;24(2):301-5.	3
24	Fischer F, Fink C, Herbst E, Hoser C, Hepperger C, Blank C, Gföller P. Higher hamstring-to-quadriceps isokinetic strength ratio during the first post-operative months in patients with quadriceps tendon compared to hamstring tendon graft following ACL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2018;26(2):418-25.	3
25	Shaieb MD, Kan DM, Chang SK, Marumoto JM, Richardson AB. A prospective randomized comparison of patellar tendon versus semitendinosus and gracilis tendon autografts for anterior cruciate ligament reconstruction. Am J Sports Med. 2002;30(2):214-20.	2
26	Martin-Alguacil JL, Arroyo-Morales M, Martín-Gomez JL, Monje-Cabrera IM, Abellán-Guillén JF, Esparza-Ros F, et al. Strength recovery after anterior cruciate ligament reconstruction with quadriceps tendon versus hamstring tendon autografts in soccer players: a randomized controlled trial. Knee. 2018;25(4):704-14. (e-mail sent to authors)	7

[1]Clinical trial record; [2]Another comparison; [3]Another outcome; [4]Summary of congress; [5]Another language; [6]Article of revision of surgical technique; [7]Incomplete data - deleted after contact with authors.