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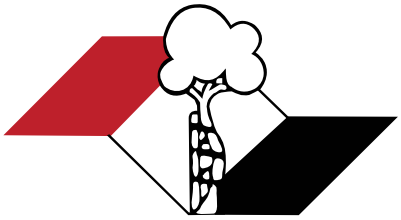

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ACTA ORTOPÉDICA BRASILEIRA

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(Reviewed January 2016)

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Type of Article	Abstract	Number of words	References	Figures	Tables	Maximum number of authors allowed
Original	Structured, up to 200 words	2.500 Excluding abstract, references, tables and figures	20	10	6	6
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CONCLUSION: The conclusion should be clear and concise, establishing a link between the conclusion and the study objectives. Avoiding conclusions not based on data from the study in question is recommended, as well as avoiding suggest that studies with larger samples are needed to confirm the results of the work in question.
ACKNOWLEDGEMENTS
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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 Articles

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ECONOMIC IMPACT OF COVID-19 ON BRAZILIAN ORTHOPEDISTS

IMPACTO ECONÔMICO DA COVID-19 NOS ORTOPEDISTAS BRASILEIROS

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ABSTRACT

Objective: The aim of this study is to assess the economic impact of the new coronavirus (COVID-19) on Brazilian Orthopaedic Surgeons. Methods: The questionnaire was applied to orthopedists and it questions how long they have worked in this area; their monthly financial impact during the pandemic; what sector was impacted the most; if they had or didn't have any financial reserves and how long they would last; if they had any other source of fixed income; and how much time off they had taken from work. It was entirely anonymous and it could only be answered once. Results: About 98% (955 out of 975) of the analyzed orthopedists suffered some monetary impact, 80% had a financial reserves, from which 45% could last for 3 months. Conclusion: There was a direct relationship between the professional experience in this subspecialty and a higher percentage of fixed income, as well as a greater impact on the reduction percentage in the monthly budget and a longer time off the job. ***Level of Evidence IV, Analyses with no sensitivity analyses.***

Keywords: Covid-19. Coronavirus. Monetary Impact. Financial Reserve.

RESUMO

Objetivo: Avaliar o impacto econômico do novo coronavírus (Covid-19) entre ortopedistas brasileiros. Métodos: Questionário aplicado a ortopedistas que aborda o tempo de prática clínica, impacto no orçamento mensal durante o mês inicial da pandemia, setor de maior impacto, presença de outra fonte de renda fixa na área médica ou fora, existência de reserva financeira, previsão de tempo de afastamento e expectativa de retorno às atividades normais. Todo formulário é anônimo e programado para ser respondido apenas uma vez. Resultados: Cerca de 98% (955, entre 975 que responderam ao questionário) dos médicos ortopedistas analisados sofreram algum impacto monetário, 80% tinham reserva financeira, 45% dentre eles com reserva financeira para até 3 meses. Conclusão: Existiu uma relação direta entre o maior tempo de subespecialidade, a maior porcentagem de renda fixa, o maior impacto na porcentagem de redução no salário mensal e o maior o tempo de afastamento. ***Nível de Evidência IV, Análises sem análises de sensibilidade.***

Descritores: *Covid-19. Pandemia de Coronavírus. Sociedade Brasileira de Ortopedia e Traumatologia. Impacto Monetário. Reserva Financeira.*

Citation: Stirma GA, Belangero PS, Pochini AC, Andreoli CV, Ejnisman B. Economic impact of Covid-19 on Brazilian orthopedists. Acta Ortop Bras. [online]. 2021;29(2):61-66. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

On January 30th, 2020, the World Health Organization (WHO) declared the COVID-19 a Public Health Emergency of International Concern. On March 11th, 2020, COVID-19 was characterized as a pandemic. As of August 15th, 2020, 5,488,825 cases of the new Coronavirus were confirmed worldwide, with 349,045 deaths. Brazil has recorded more than 3 million cases and 100,000 deaths to the same date. The Brazilian Ministry of Health reported that the transmission of the disease is already community throughout national territory and the number of cases tends to increase.[1]

The Coronavirus Pandemic disrupted global trade, supply chains and population flow. It depressed asset prices and forced multinational companies to make global impact decisions. The change in the economy has determined the disruption of tourism, flights cancellation and other commercial activities; it caused small businesses to go under, modified commercial relations, exhausted products of basic needs and altered national and international borders.[2]

The rapidly spreading outbreak imposed an unprecedented burden on the effectiveness and sustainability of the health system. The new coronavirus led to an overall increase in visits to clinical emergency and hospitalization numbers, added to the imminent risk of lack of qualified health personnel due to exposure and contagion.[3]

All global and national facts impacted the financial health of the Brazilian medical population. The impossibility of social gathering, the caution with at risk populations and the reduction of unnecessary exposure created the need to cancel elective surgeries and clinical

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

The study was conducted at Universidade Federal de São Paulo, Department of Orthopedics and Traumatology, Centro de Traumatologia do Esporte.
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Article received on 08/16/2020, approved on 10/20/2020.

appointments. The aim of this study is to evaluate the economic impact of the new coronavirus (COVID-19) on Brazilian orthopedists.

MATERIALS AND METHODS

This is a cross-sectional study with an online questionnaire, composed of direct questions and answers, to evaluate the direct financial impact of the COVID-19 pandemic on the life of Brazilian orthopedists. All physicians completed the informed consent form, and the study was approved by the ethics committee of the institution under the number 30606820.3.0000.5505.

The questionnaire (Appendix 1, Table 1) addresses professional experience in the subspecialty, impact on the monthly budget during the initial month of the pandemic, sector of greatest impact (elective surgeries, emergency, outpatient and medical office), presence of another source of fixed income (in the medical area or not), existence of financial reserve, expectations about how long they would stop working and return to normal activities.

The entire form is anonymous and programmed to be answered only once through the Google Forms platform. It was approved by Plataforma Brasil under the number 30606820.3.0000.5505.

The inclusion criterion was being a physician specialized in orthopedics and traumatology. The exclusion criterion was incomplete questionnaires. We performed descriptive statistical analysis of each analyzed parameter with the SPSS program. To compare the quantitative variables, we used the ANOVA test. Differences with $p < 0.05$ were be considered statistically significant.

RESULTS

We obtained 975 complete questionnaires. There was an almost homogeneous division between the professional experience of each physician, 26.1% (254) finished their studies 5 years ago or less, 23.6% (230) from 5 to 10 years ago, 25.4% (248) from 10 to 20 years ago, 14.8% (144) from 20 to 30 years ago and 10.2% (99) have over 30 years of professional experience in the field (Figure 1).

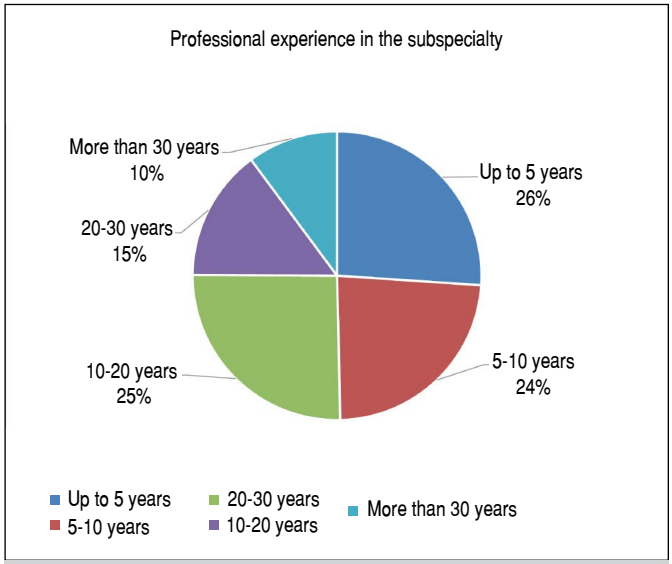

Figure 1. Professional experience in the subspecialty.

The financial impact of the COVID-19 pandemic caused monthly salaries to drop between 50% and 75% for 30 % of the analyzed professionals and between 25% to 50% for 26.1%; 23.6% of the physicians reported a 75% to 99% drop in salary, while only 13.5% reported 1% to 25%; 4.2% reported a 100% drop of their monthly salary and 2.1% reported that their salaries were not affected (Figure 2).

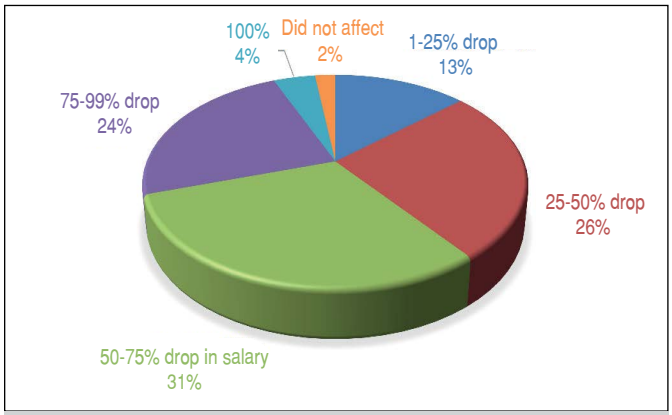

Figure 2. Impact of the pandemic on the monthly budget.

The reasons that reduced physicians' salaries, during the pandemic, were appointments cancellation (90.7%); elective surgeries postponement (85.1%); outpatient (52.9%); decrease in emergency surgeries (20.8%) and shift hours reduction (19.7%) (Figure 3).

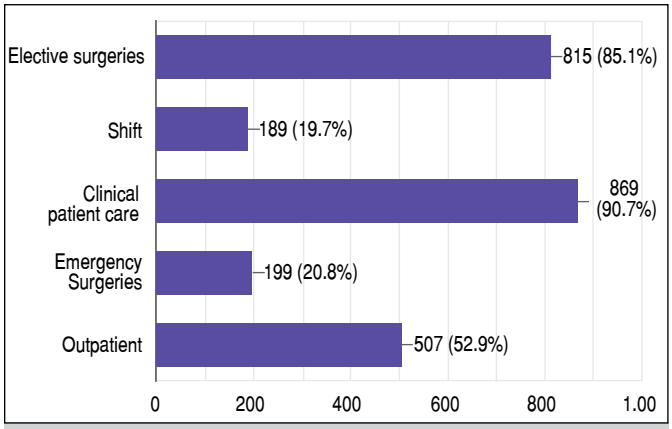

Figure 3. Impact of the cause/pandemic on the monthly budget.

Regarding reduction of shift hours, 66% of the orthopedists claim that shift hours did not change; 9% reported a 12 to 14 hours reduction per month; 7% reported a reduction of 48 hours per month; 7% said 24 to 36 hours per month; 6% reported up to 12 hours of alterations per month and 5% from 36 to 48 hours (Figure 4).

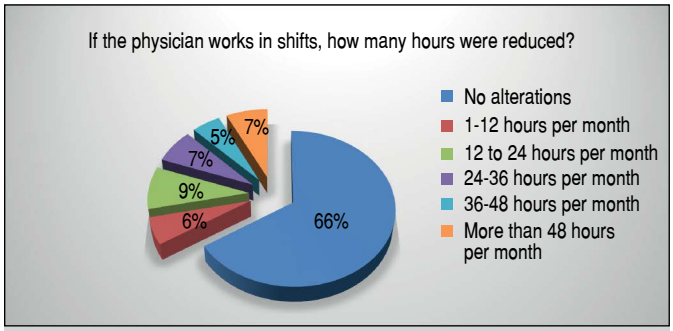

Figure 4. Reduced shift hours per month.

Regarding elective surgeries, 35% of orthopedists reported to have cancelled 5 to 10 surgeries; 31% up to 5; 19% from 10 to 15 surgeries; 7% reported to have cancelled 15 to 20 procedures and 8% more than 20 (Figure 5).

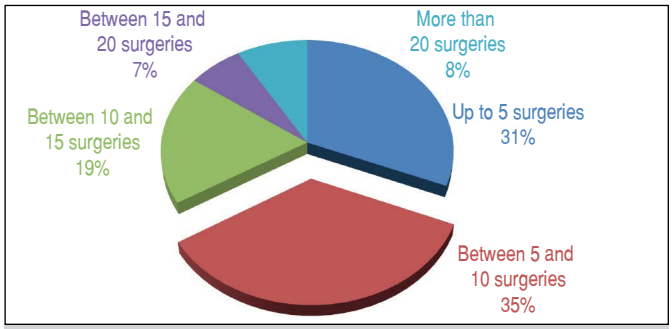

Figure 5. Cancellation of elective surgeries.

Most orthopedists do not have an alternative source of income (80.1%). More than half of the orthopedists (52.3%) have fixed income in the medical field through public tender or registered jobs. Out of the orthopedists with fixed income, 47.5% reported that the received monthly amount corresponds to 1%-25% of their total salary; 32.6% reported that it corresponds to 25% to 50%; 13.2% answered 50% to 75%; only 4.3% and 2.4% said 75% to 99% and 100%, respectively (Figure 6).

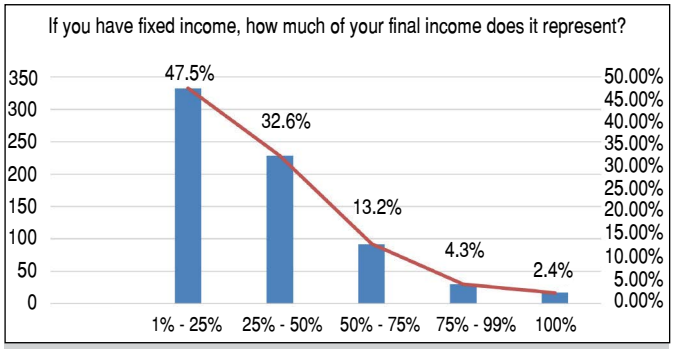

Figure 6. Percentage of fixed income in the monthly salary.

In relation to the time taken away from work, 27% stated that they took more than 30 days away from work since the beginning of social distancing; 26% answered up to 30 days; 24% up to 21 days; 16% up to 14 days; and 7% reported that they did not take time away from work (Figure 7).

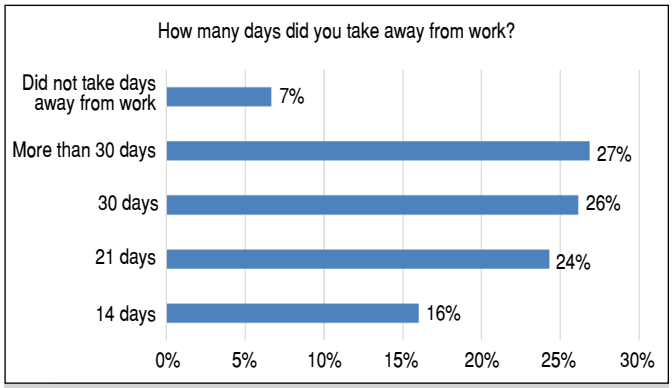

Figure 7. Number of days away from work due to the pandemic.

About 85% of orthopedists had a financial reserve, however, 33% could maintain themselves for only one to three months; 24.7% for three to six months; 18.6% for over one year; 11.8% for up to one month and 11.8% for six to twelve months (Figure 8).

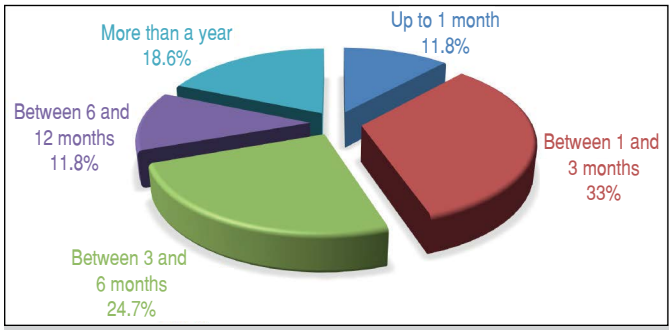

Figure 8. Financial reserve.

The answers about expectation of returning to work activities were 29.6% for return in two months, 25.2% in one month, 23.9% in three months, 16.2% in three to six months, 3.7% in six to twelve months and 1.3% in one year or more (Figure 9).

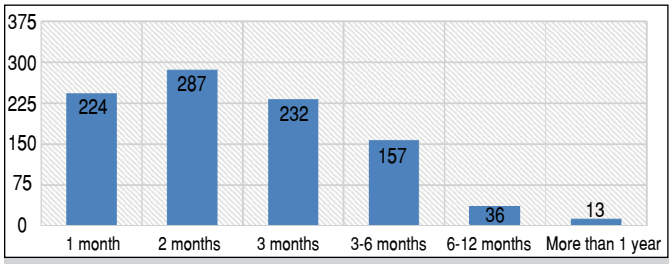

Figure 9. Expectation of return to regular work activities.

DISCUSSION

Public and sanitary measures to contain the new Coronavirus changed the routine and patient care of physicians in Brazil. The impossibility of social gathering, the caution with at risk populations and reduction of unnecessary exposure created the need to cancel elective surgeries, clinical appointments and outpatient consultations, because they may contribute to spreading the disease. In many cases, patients transmitting the virus are asymptomatic, thus, they unintentionally expose everyone in close contact with them. Besides, the precept to cancel elective procedures was to minimize the use of essential items and materials needed for the care of post-surgical patients. Among them are ICU beds and use of personal protective equipment and ventilators.[4] All factors influenced the medical and orthopedic financial health: in this study, 98% of the analyzed physicians suffered some monetary impact. Economists present worrying predictions for the effect of the new coronavirus (COVID-19) on the global financial system.[5] In figures, the most optimistic scenario predicts an impact of − 0.1 percentage points on the national GDP. On the other hand, the extreme scenario indicates − 0.66 percentage points.[6]

Financial education is one of the key factors for economic stability of a population or community. There has never been such an expressive growth in the medical population in Brazil, in such a short period of time. In less than five decades, the total number of physicians increased by 665.8% or 7.7.[7] Thus, the search for financial security and stable jobs are one of the great priorities to which the medical community aspires. The highest percentage of orthopedists with another source of income appears in professionals who have graduated more than 10 years ago ($p = 0.01$) (Figure 10); a proportion that is maintained for public tender or registered jobs. The longer professional experience in the subspecialty, the higher the proportional percentage ($p = 0.0$) (Figure 11).

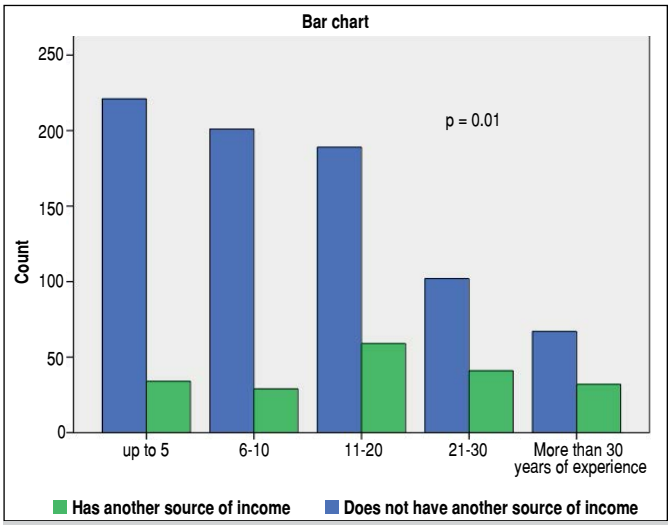

Figure 10. Relationship between another source of income × professional experience.

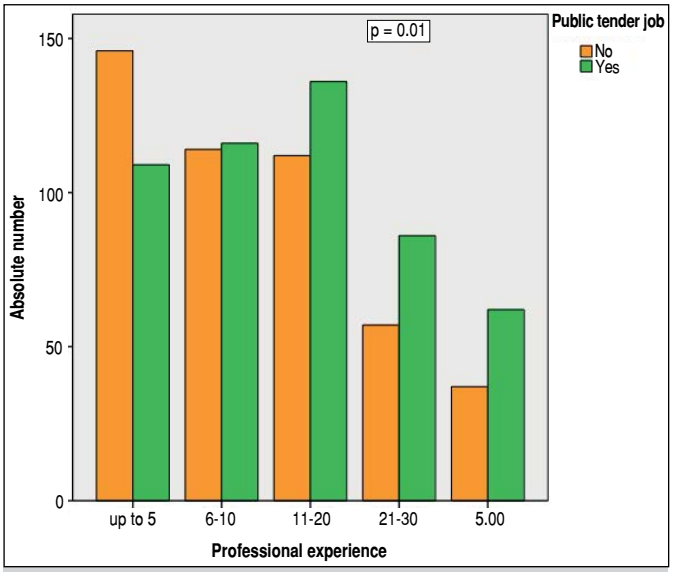

Figure 11. Relationship between public tender job/documented job × professional experience.

The financial literature suggests an emergency reserve of three months for public employees, six months for regular company employees and one year for self-employed workers, without fixed income.[8] Among orthopedists, 80% have a financial reserve – without statistical significance regarding professional experience – however, only around 45% of the entire group had a financial reserve that could last for up to 3 months. Information that clearly shows the need for reflection on medical monetary education for emergency situations and, perhaps, better financial education to achieve economic stability even during times of crisis.

Among orthopedists, the financial impact of the COVID-19 pandemic caused a 50% to 75% monthly salary drop for 30 % of the analyzed professionals, a 25% to 50% drop for 26.1% and 23.6% of the physicians reported a 75% to 99% drop in salary. However, the longer the time of professional experience, the greater the reduction percentage of the monthly salary ($p < 0.01$). That is because orthopedists with longer subspecialty experience have a higher percentage of their monthly income depending on elective surgeries and medical appointments, while those with less experience have the emergency shifts as the largest source of salary. Emergency room shifts have not changed, regarding the number of hours, for 66% of the physicians, up to the moment of this research.

There was a direct relationship between the time of experience and the time they took away from work. Longer time of experience in the subspecialty led to longer time off work ($p = 0.02$). These values were accentuated among physicians with 20 or more years of experience: orthopedists who are probably in the age group – or close to the age group defined by the World Health Organization – considered as risk group for the new Coronavirus.[1]

It is difficult to measure the final impact on the financial health of orthopedists, as the pandemic can extend over a long period and lead to mass layoffs, need for government assistance, work changes and changes in the consumer-company relationship. Therefore, it is necessary to create awareness about the difficulties that not only the medical class will go through, as well as the whole nation.

Our study may be limited because we did not evaluate the geographic distribution of the orthopedists.0 However, we evaluated more than 975 responses, a very significant number compared with the 17,000 orthopedists registered in the Brazilian Society of Orthopedics and Traumatology (SBOT). The questions are simple for such a complex problem, but it would be very difficult to obtain such a large number of responses with a complex questionnaire. Another limitation was that the research was performed at the beginning of the quarantine, so some answers may not be as accurate after some time due to the new conditions brought by the pandemic.

This study showed the financial impact of the new Coronavirus on Brazilian orthopedists. The situation we are experiencing today is unique in recent history. The results presented are relevant to elucidate the current context and they allow the creation of a current panorama of financial difficulties and economic education of our field. Thus, it can serve as guide for decisions of the Brazilian Society of Orthopedics and Traumatology (SBOT).

CONCLUSION

About 98% of the orthopedists analyzed in this study suffered some monetary impact; 80% had a financial reserve, however, only 45% of them could last for 3 months. There was a direct relationship between the longer subspecialty professional experience with the highest percentage of fixed income from public tender or registered job; greater impact on the percentage of monthly salary reduction; and greater time off work during the pandemic of the new Coronavirus (COVID-19).

AUTHORS' CONTRIBUTIONS: GAS: writing of the article, review, intellectual concept of the article and preparation of the entire research project; PSB: review, intellectual concept of the article; ACP: review, intellectual concept of the article; CVA: review, intellectual concept of the article; BE: writing of the article, review and intellectual concept of the article.

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APPENDIX

Questionnaire – Orhtopedics (COVID-19) – Annonymous

Questionnaire about the financial impact on orthopedists

Professional experience in the subspecialty

- ◯ Up to 5 years
- ◯ 5-10 years
- ◯ 10-20 years
- ◯ 20-30 years
- ◯ more than 30 years

Drop (impact) of the budget in the month of the pandemic

- ◯ There was no impact
- ◯ 1-25% drop
- ◯ 25-50% drop
- ◯ 50-75% drop
- ◯ 75-99% drop
- ◯ 100%

If your monthly budget was affected, that happend due to the reduction of (multiple answers are possible)

- ◯ Elective surgeries
- ◯ Shift hours
- ◯ Medical appointments
- ◯ Emergency surgeries
- ◯ Outpatient

If the doctor works in shifts, how many hours were reduced?

- ◯ No reductions
- ◯ 1-12 hours per month
- ◯ 12 to 24 hours per month
- ◯ 24-36 hours per month
- ◯ 36-48 hours per month
- ◯ More than 48 hours per month

Do you have an alternative source of income (other than medicine)?

- ◯ Yes
- ◯ No

Do you have fixed income working in a public tender or registered job?

- ◯ Yes
- ◯ No

If you have fixed income, how much of your final income does it represent?

- ◯ 1% - 25%
- ◯ 25% - 50%
- ◯ 50% - 75%
- ◯ 75% - 99%
- ◯ 100%

How many elective surgeries were cancelled?

- ◯ Up to 5 surgeries
- ◯ Between 5 and 10 surgeries
- ◯ Between 10 and 15 surgeries
- ◯ Between 15 and 20 surgeries
- ◯ More than 20 surgeries

How many days will you take away from work activities?

- ◯ 13/03 to 23/03 – 14 days
- ◯ 13/03 to 03/04 – 21 days
- ◯ 13/03 até 10/04 – 30 days
- ◯ More than 30 days

Do you have a financial reserve?

- ◯ Yes
- ◯ No

If you have a financial reserve, how long can it last?

- ◯ Up to one month
- ◯ 1 to 3 months
- ◯ 3 to 6 months
- ◯ 6 to 12 months
- ◯ More than 1 year

When do you expect to get back to regular work activities?

- ◯ 1 month
- ◯ 2 months
- ◯ 3 months
- ◯ 3-6 months
- ◯ 6 to 12 months
- ◯ more than 1 year

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FUNCTIONAL OUTCOMES OF ARTHROSCOPIC TREATMENT IN 230 FEMOROACETABULAR IMPINGEMENT CASES

FUNCTIONAL RESULT OF ARTHROSCOPIC TREATMENT IN 230 IMPACTS FEMOROACETABULARES

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ABSTRACT

Objective: To analyze the functional outcomes after arthroscopic treatment of femoroacetabular impingement (FAI). Methods: 194 patients (131 males and 63 females), with a mean age of 39 (15-68) years old for men and 43 (16-58) years old for women. The average follow-up was 17 months (2 to 71). 103 patients presented Cam-type FAI, 102 mixed and 25 Pincer. "Unilateral" arthroscopy was performed in 161 cases, "Bilateral" (only once each side) in 46 cases and, "Multiple" (more than one procedure on the same hip) in 23. The female sex was prevalent in the Pincer type FAI (76%), while males were prevalent in Mixed and Cam type, 74.5% and 72.8%, respectively. Results: The mean HHSpre score was 63.7 and 87.1 for HHSpost, i.e. 73.11%. Differences appeared between "mixed" and "unilateral" groups. The complications percentage in this series was 18.7% and 7% progressed to total hip arthroplasty. Conclusion: The arthroscopic FAI treatment improved the postoperative clinical scores of these patients, especially in cases of mixed-type FAI, which presented a higher improvement rate. Insufficient femoral osteoplasty was the main cause for surgical re-intervention, particularly in the initial cases of this series. ***Level of Evidence II, Retrospective study.***

Keywords: Femoroacetabular Impingement. Arthroscopy. Hip. Patient Reported Outcome Measures.

RESUMO

Objetivo: Avaliar os resultados funcionais após tratamento artroscópico do impacto femoroacetabular (IFA). Métodos: Foram selecionados 194 pacientes (131 do sexo masculino e 63 do sexo feminino), com idade média de 39 (15-68) anos no caso dos homens e 43 (16-58) anos para as mulheres. O seguimento médio foi de 17 meses (2 a 71). 103 pacientes apresentaram IFA tipo Came, 102 Misto e 25 tipo Pincer. A artroscopia única foi realizada em 161 casos; a bilateral (somente uma vez cada lado) em 46 casos e a múltipla (mais de um procedimento no mesmo quadril) em 23. O sexo feminino foi prevalente no IFA do tipo Pincer (76%) e o masculino nos tipos Misto e Came, 74,5% e 72,8%, respectivamente. Resultados: A média do escore HHSpré foi de 63,7 para HHSpós de 87,1, ou seja 73,11% Ficaram evidenciadas diferenças nos grupos "misto" e "único". O percentual de complicações desta série foi de 18,7% e 7% evoluíram para artroplastia total do quadril. Conclusão: O tratamento artroscópico IFA melhorou os escores clínicos, principalmente nos casos de IFA do tipo misto, que apresentou maior taxa de melhora, A osteoplastia femoral insuficiente foi a principal causa para reintervenção cirúrgica, particularmente nos casos iniciais desta série. ***Nível de Evidência II, Estudo retrospectivo.***

Descritores: *Impacto Femoroacetabular. Artroscopia. Quadril. Medidas de Resultados Relatados pelo Paciente.*

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INTRODUCTION

Although femorocetabular impingement (FAI) represents one of the most common causes of hip pain in young adults,[1] the first conceptual descriptions of FAI[2] were made in 1991 and, in 2003, Ganz et al.[3] described its clinical implications. Being a relatively recent pathology[4] may contribute to its misdiagnosis by generalist orthopedists, particularly in the initial stages of the disease.

According to the morphological alteration, FAI can be classified as Cam-type, if the alterations appear in the femoral head-neck junction (prominence in the neck-head transition); Pincer, when the alterations are in the acetabulum (acetabular overcoverage of the femoral head); and Mixed, when there is an association between the two previous types.[5] These abnormal anatomical relationships, as well as possible supraphysiological movements[6] (even if morphology is normal),

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

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can produce shear and contact forces between the transition of the head and femoral neck with the acetabulum. The evolution of the disease can lead to labral tears, chondral lesions or a combination of both – chondro-labral transition–and, consequently, hip osteoarthritis. These observations are important, because FAI can affect young adults in their productive age, directly interfering in quality of life.

Although open surgeries are sometimes recommended to treat FAI, minimally invasive procedures are desired objectives in all surgical specialties, due to their lower morbidity and length of hospitalization, which allow a faster process of functional rehabilitation.[7] Within this context, the arthroscopic approach of the hip is an interesting surgical alternative, because it can contemplate the advantages of less surgical trauma, modify the symptomatic picture and thus contribute to slow down the evolutionary process of osteoarthritis.[8,9]

Hip arthroscopy is, however, a procedure with specificities that reinforce the importance of proper surgical preparation, particularly the correct positioning of the patient on the operating table and use of traction.[9] These are essential measures, as they widen the joint space and favor the correct identification of anatomical references and placement of arthroscopic portals. Thus, the arthroscopic approach of the hip combines a series of technical details that are incorporated and improved with technical development and surgical experience.[10,11]

The aim of this retrospective study was to evaluate functional results after the arthroscopic approach of FAI in a series of patients; to correlate the three types of FAI (Cam, Mixed and Pincer) with variables such as age, sex, type of arthroscopic surgery (Unilateral, Bilateral or Multiple) and complications; as well as presenting the acquired experience in the study.

MATERIALS AND METHODS

This retrospective study evaluated 230 arthroscopic hip surgeries that were performed from June 2006 to September 2013. The sample comprised 194 patients – 63 women (32.5%), 131 men (67.5%) (p = 0.3044) – with a mean age of 43 years old (16 to 58) for women and 39 years old (15 to 68) for men (p = 0.5172). The mean follow-up was 17 months (2 to 71). The FAI diagnosis was Cam in 103 patients (44.78%), Mixed in 102 (44.34%) and Pincer in 25 (10.87%). In 70% of the cases (n = 161) a unilateral approach was performed; bilateral (n = 46) in 20%; and multiple in 10% (n = 23) (Table 1).

Table 1. Distribution of the 230 cases according to the different types of femoroacetabular impingement and arthroscopic surgery performed.

	Type of surgery			
Type of FAI (%)	**Bilateral**	**Multiple**	**Unilateral**	**Total**
Cam	18	10	75	103
Mixed	25	12	65	102
Pincer	3	1	21	25
Total	46	23	161	230

Clinical history data, physical and functional examination of the patients were also recorded. In this series, the main reported complaint was hip pain associated with movement limitation, followed by restriction to practice physical activities. The adopted criteria for surgical indication were defined based on clinical and radiographic evaluation. The included patients were diagnosed with FAI, had been submitted to hip arthroscopy and presented up to grade 2 of joint degeneration in the Tönnis classification.[12]

Patients had good general health (ASA I or II), practiced regular physical activities and had no history of previous surgical procedures. The main complaint was progressive and limiting hip pain. The procedures were ambulatory, performed in a standardized way by two surgeons (GML and FLAJr). We excluded patients whose medical records did not allow these analyses – grade 3 of degeneration (Tönnis classification) (Chart 1). The Informed Consent Form was obtained from all patients, and the study was submitted and approved by the Ethics Committee of this service (CAAE: 38413414.1.0000.5404; opinion no.: 980.263).

Chart 1. Tönnis classification.

Degree	Characteristics
Zero	No signs of osteoarthritis or minimal sclerosis.
1	Slight sclerosis of the acetabulum or femoral head, slight narrowing of joint space, subtle osteophytes.
2	Small cysts in the femoral head or acetabulum, increased narrowing of joint space, formation of osteophytes, moderate loss of sphericity of the femoral head.
3	Larger cysts, severe narrowing or obliteration of joint space, severe deformity of the femoral head, avascular necrosis.

Statistical Analysis

Data analysis compared the groups Type of FAI (Cam, Mixed and Pincer) and Type of arthroscopic surgery performed (Unilateral, Bilateral and Multiple). For statistical analysis, a mixed linear model was adjusted, in which the response variable (dependent) was the improvement percentage and the independent variables (age, sex, diagnostic group, type of FAI) acted as second-order interactions between categorical variables. These variables constituted the fixed effects on the adjustment of the model. As some patients were operated more than once, there is statistical dependence between the responses observed in the same patient, so the random factor 'patient' was introduced in the model. The covariance structure used was 'variance components' that were estimated by the restricted maximum likelihood (REML) method, with the approximation of Satterthwaite to the degrees of freedom; and the matrix of variances and covariances of the estimated fixed and random effects was inflated by the method proposed by Prasad-Rao (1990) and Harville-Jeske (1992). For multiple comparison of mean, the significance levels were corrected by the Tukey method to maintain the overall significance level. Residue analysis was performed to verify possible outliers.

RESULTS

The overall functional evaluation of the postoperative global functional (Harris Hip Score – HHS) showed a 73.11% improvement (87.12) compared with preoperative mean values (63.70). This improvement was significant in the final results both for FAI (p = 0.0128) and for surgery (p = 0.0111). Similarly, the analysis of the improvement percentage was significant for 'type of FAI' (p = 0.0197) and 'type of surgery performed' (p = 0.0523).

No significant interactions were identified between the two studied groups (FAI and Surgery) (p = 0.2323) and in the correlation between the levels of each group, the frequency distributions did not differ from each other (p = 0.2485).

Table 2 shows the distribution of mean, minimum and maximum values of age, sex and functional scores of the hip – Harris Hip Score (HHS) (preoperative, postoperative and improvement %) in the various types of FAI, while Table 3 relates these variables to the type of surgery performed (unilateral, bilateral and multiple). Figures 1 and 2 present the analysis of the means of the least squares and standard deviations related to the type of FAI and type of surgery, respectively. Tables 4 and 5 report, respectively,

the various procedures performed and the complications – 43 (18.7%) in the 230 analyzed cases. It is worth mentioning that in 16 (7%) cases unfavorable clinical evolution led to total hip arthroplasty. The residue analyses showed no noteworthy deviations.

Table 2. Distribution of cases in the femoroacetabular impingement type group related to age, sex and hip functional score (Harris Hip Score - HHS) in the 230 evaluated cases.

			functional hip score (HHS)		
Type of FAI (%)	**Mean age (min. and max.)**	**sex (number of cases)**	**preoperative (min. and max.)**	**postoperative (min. and max.)**	**improvement %**
Cam (103)	40.11 (17 to 68)	M75 / F28	63.10 (36.3 to 73.7)	88.78 (15.40 to 100.1)	34.25
Mixed (102)	38.22 (15 to 77)	M76 / F26	64.44 (30.8 to 84.7)	89.42 (10.10 to 100.1)	38.76
Pincer (25)	40.56 (22 to 56)	M6 / F19	63.14 (24.2 to 84.7)	87.38 (18.70 to 100.1)	38.39
	***p*-value**				**p = 0.0378**

*M (male) / F (female)

Table 3. Distribution of cases according to type of arthroscopic hip surgery related to age, sex and functional score (Harris Hip Score – HHS) in the 230 evaluated cases.

			functional hip score (HHS)		
Surgery	**Mean age (min. and max.)**	**Sex**	**Preoperative (min. and max.)**	**Postoperative (min. and max.)**	**Improvement %**
Unilateral (161)	41 (16 to 68)	M108/ F53	63.56 (24.2 to 84.7)	88.47 (10.1 to 100.1)	39.38
Bilateral (46)	36 (15 to 55)	M32/ F14	65.95 (42.9 to 73.7)	89.21 (38.10 to 100.1)	35.26
Multiple (23)	34 (17 to 49)	M17/ F6	60.21 (30.8 to 84.7)	73.51 (15.40 to 100.1)	22.08
	***p*-value**				**p = 0.078**

*M (male) / F (female)

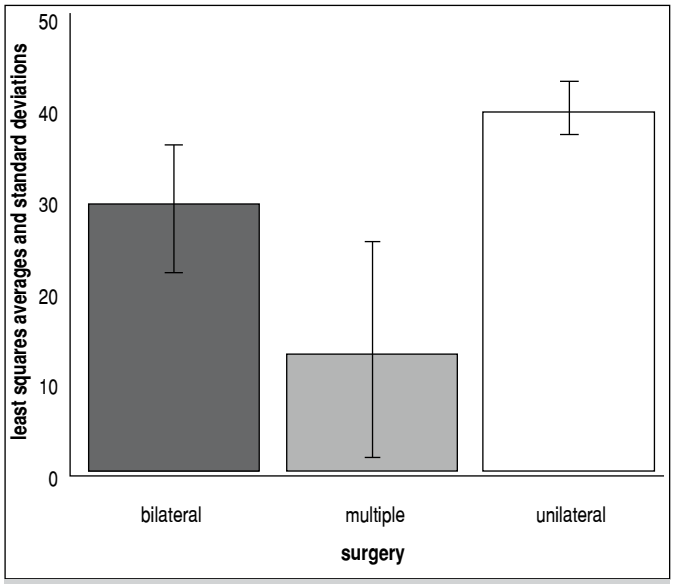

Figure 1. Distribution of the means of the least squares and standard deviations in the type of surgery group.

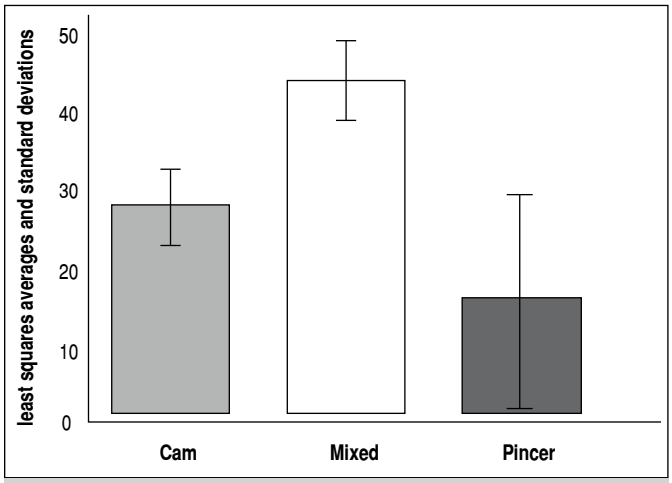

Figure 2. Distribution of least squares and standard deviations in the Femoroacetabular Impingement (FAI) type group.

Table 4. Procedures performed in the arthroscopic surgery, in the 230 cases.

Procedure	total
Labrum stabilization	8
Labral debridement	157
Labral fixation	48
Acetabular osteoplasty	133
Femoral osteoplasty	193
Round ligament debridement	3
Microfracture	20
Loose bodies	8
Others	5
Total	575

Table 5. Number of cases and percentage of postoperative complications.

Complications	number of cases 18.7 %
Capsulitis	3 (6.9%)
Femoral neck fracture	1 (2.3%)
Instability	2 (4.6%)
Skin injury	7 (16.2%)
Neuropraxia	17 (39.5%)
Heterotopic ossification	13 (30.2%)
Total	43 (100%)

DISCUSSION

The most important finding of this study was the confirmation that arthroscopic treatment of femoroacetabular impingement (FAI) resulted in the overall improvement of the preoperative clinical condition of these patients (73.11% of improvement), especially in mixed-type FAI cases; patients submitted to a single intervention (surgery) presented high suspicion in the improvement percentage compared with multiple surgery cases. Insufficient femoral osteoplasty was the main cause for surgical re-intervention, particularly in the initial cases of this series. Since the publications of Smith-Petersen[13] in 1936, and Tönnis and Heinecke[14] in 1999, and subsequently Ganz descriptions,[2,3,5] the bone morphology of the hip has been related to Femoroacetabular Impact. With the advances of the arthroscopic technique, described by Glick et al.,[15] this procedure has become increasingly popular in the orthopedic field.

One commonly used criterion in the surgical treatment of FAI is the classification of the hip joint degenerative state (Tönnis classification).[16]

However, in this study, radiographic classification was not the only parameter, as we also considered data on medical history, clinical examination and functional demand of patients.[15]

Zhang et al.[17] performed a meta-analysis to evaluate the results of arthroscopic and open surgical treatment of FAI. The authors observed that the arthroscopic approach showed significant clinical improvement in the first 3 postoperative months compared with open surgery.

In the interpretation of the final results, the functional evaluation of the hip is fundamental. In clinical practice, the modified Harris Hip Score functional score (HHSm) is a commonly employed method, followed by the Hip Outcome Score (HOS).

In this study, the mean functional scores (HHS) before and after surgery showed no difference in the distribution between the different types of FAI ($p = 0.1381$) and the number of surgical procedures ($p = 0.2485$). Similarly, statistical analysis showed no influence of the variables sex ($p = 0.304$) and age ($p = 0.517$) on the results.

Considering the percentage of functional improvement in the different FAI (Table 2), the mixed type presented the highest significant ($p = 0.0378$) percentage (38.76%) compared with Cam (34.35%), while no differences were detected between Cam vs. Pincer and Mixed vs. Pincer. These findings may, in part, reflect more complex and comprehensive surgical attitudes (femoral and acetabular osteoplasty, for example), commonly necessary in mixed type FAI.

The number of surgical interventions performed and medical history[18] is considered by many authors as factors that can negatively interfere in final results. In this study, the improvement percentage regarding the number of surgical procedures showed high suspicion (marginally significant) for cases of only a single unilateral procedure compared with cases of multiple procedures ($p = 0.078$) while bilateral vs. multiple and bilateral vs. unilateral were not different.

A possible explanation for these findings is that cases of a single surgical approach and the lack of symptomatology in the contralateral hip may have contributed to a better overall evaluation, because the functional hip score (HHS) has an important subjective component, that is, information reported by the patient.

An important aspect to be emphasized is that most of the morphological alterations of the hip occur during childhood, therefore, FAI is a pathology that mainly affects young adults.[4] In this study, a predominance of young male patients with Cam-type IFA was observed, while in Pincer cases (10.87% of all cases) the female sex was prevalent, a fact that is in agreement with the literature (Table 2).[8,19]

Postoperative follow-up time is essential to evaluate the results of the intervention. In this study, the average postoperative follow-up time was 17 months, ranging from 2 to 71 months. The shortest postoperative follow-up time (between 2 and 3 months) occurred in 6.96% of the cases (16 patients), mostly because these patients were from other cities and due to the difficulties inherent to their displacement, they began follow-up in another service, after re-establishment of joint function and postoperative clinical improvement. Even though the literature reports studies in which the analyzed follow-up time was two weeks,[20] considering the minimum follow-up time of 06 months may be more appropriate for results evaluation.

Regarding the distribution of sex and age, Frank et al.[21] reported that women over 45 have worse outcomes, while McCormick et al.[22] concluded that patients under the age of 40 have better evolution (better predictive factor). Even though men were predominant in this study, sex and age did not interfere in the final results.

In these 230 cases, 575 procedures were performed (Table 4), with femoral osteoplasty being the most frequently performed procedure (193 times), followed by labral debridement (157 times) and acetabular osteoplasty (133 times).

Insufficient femoral osteoplasty was the main cause for surgical re-intervention, particularly in the initial cases of this series. In the learning curve of the arthroscopic approach of FAI, the clinical evaluation and the careful interpretation of postoperative radiographs were fundamental for the technical and surgical strategy improvement, unlike the intraoperative interpretations made with the image intensifier.

In the evolution of the surgical approach, the mastery of the labral suture technique was improved with surgical experience and availability of materials with specific designs. In this procedure, the suture technique was consolidated from 2010.

Although the 18.7% complication rate presented in this study is above literature values ,[23] it should be emphasized that this study considered minor complications, that is, small skin lesions, neuropraxias without definitive repercussions and small images of heterotopic ossifications that did not harm the final result (Table 5).

The limitations of this study lie in the fact that it is a retrospective case study, in which a small percentage of patients (6.96%) had minimal follow-up between 2 and 3 months. However, it is important to consider the relevant points of this study, which are expressive serial analyses of FAI cases ($n = 230$), approached by the same surgeons (G.M.L and F.L.A.Jr) in a standardized way; respecting technical criteria established in the current literature.

CONCLUSION

Arthroscopic treatment of femoroacetabular impingement (FAI) resulted in the improvement of postoperative clinical scores of these patients, especially in mixed FAI cases; patients submitted to a single intervention (surgery) presented high suspicion in the improvement percentage when compared with cases of multiple surgery. Insufficient femoral osteoplasty was the main cause for surgical re-intervention, particularly in the initial cases of this series.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. GML: surgery performance, data collection and writing, review; FLAJ: surgery, data collection and writing; SRP: data analysis and writing, review and intellectual conception of the article.

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RESULTS OF TREATMENT OF PLICA SYNDROME OF THE KNEE

RESULTADOS DO TRATAMENTO DA PREGA SINOVIAL (PLICA) PATOLÓGICA DO JOELHO

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ABSTRACT

Objective: The synovial fold is an intra-articular structure found in more than 50% of the knees, which can cause symptoms similar to meniscal injuries. These symptoms are mostly related to hypertrophy of the synovial fold resulting from inadequate physical activity. Conservative treatment with readjustment of sports activity and muscle rebalancing solves most cases. Rare cases require surgical treatment, which is indicated due to the persistence of instability, blockage and pain. We present our experience in the treatment of this pathology. Methods: 58 patients (70 knees), with 62 knees treated conservatively and 8 treated surgically exclusively for the pathological synovial fold. Results: Description of the series and treatment results are reported. Conclusion: The non-surgical treatment of the pathological synovial fold of the knee provided good results within 60 days of rehabilitation program in almost 90% of the patients. Arthroscopic resection of the synovial fold is a surgery that has a longer and laborious rehabilitation period, despite good results in most cases. ***Level of Evidence IV, Case series***.

Keywords: Knee. Synovitis. Synovial Folds.

RESUMO

Objetivo: A prega sinovial é uma estrutura intra-articular encontrada em mais de 50% dos joelhos, que pode provocar sintomas semelhantes aos da lesão meniscal. Esses sintomas estão relacionados, na maioria dos casos, à hipertrofia da prega sinovial decorrente de atividade física inadequada. O tratamento conservador com a readequação da atividade esportiva e reequilíbrio muscular resolve a maioria dos casos. Raros casos demandam tratamento cirúrgico, que é indicado pela persistência de falseios, bloqueios e dor. Apresentamos nossa experiência no tratamento dessa patologia. Métodos: 58 pacientes (70 joelhos), com 62 joelhos tratados conservadoramente e 8 tratados cirurgicamente exclusivamente para a prega sinovial patológica. Resultados: São apresentados descrição da série e resultados do tratamento. Conclusão: O tratamento não cirúrgico da prega sinovial patológica do joelho propiciou bons resultados com 60 dias de programa de reabilitação em quase 90% dos pacientes. A ressecção artroscópica da prega sinovial é uma cirurgia que tem um período de reabilitação mais longo e trabalhoso, apesar do bom resultado na maioria dos casos. ***Nível de Evidência IV, Série de casos.***

Descritores*: Joelho. Sinovite. Pregas Sinoviais.*

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INTRODUCTION

Synovial plica, as it is known in the orthopedics, is called "synovial fold" in the anatomy. Its asymptomatic presence is frequent, and its prevalence can reach 50%, according to *postmortem* and arthroscopic anatomical studies.[1] It is an important cause of diagnostic failure, since it can cause symptoms similar to meniscal injury, usually without a history of trauma, being directly related to inadequate physical activity that can lead to hypertrophy of the synovial fold.
It can be present in several possible locations, the most frequent being the infrapatellar (mucous ligament), followed by the suprapatellar and mediopatellar.[2,3] Medial localization is the most clinically relevant, because its thickening caused by trauma, repetitive exertion and other conditions causes marginal synovial irritation in the femoral medial condyle and patella, causing synovitis and even chondral injury. This clinical situation is known as synovial fold (or plica) syndrome.[4] Magnetic resonance imaging (MRI) helps a lot in its identification, but it often goes unnoticed by the radiologist and should be actively sought according to clinical suspicion (Figure 1).

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

The study was conducted at Instituto Ortopédico Camanho.
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Figure 1. Resonance of the knee showing synovial fold interposed between the articular face of the patella and the medial femoral condyle in axial projection.

Pathological folds cause symptoms such as pain after physical activity, blockages, instability (giving way) and possible effusions. Conservative treatment with the readjustment of sports activity and muscle rebalance is the first-line treatment and solves most cases. Surgical treatment with synovial fold resection is indicated in cases of persistence of mechanical phenomena (instability and blockage) and pain, after a satisfactory program of physiotherapy and adjustments in physical activity.

We describe the evolution of 50 patients (62 knees) treated with physiotherapy and re-education of physical activity and 8 surgically treated patients in the last 10 years.

MATERIALS AND METHODS

Patients treated by the authors in the last 10 years due to pathological synovial fold were included, with a diagnosis made by the clinical presentation and confirmed by magnetic resonance imaging. Ethics committee approval 78967517.0.0000.0068, obtained waiver from the informed consent form.

The most frequent clinical presentation consists of onset of blocking symptoms and pain to the final extension of the knee, with the quadriceps contracted, after a modification of sports activity, even in athletes. Compression of the medial edge of the patella (taking care not to generate increased carytillanous pressure) associated with quadriceps contraction, with the knee in extension causes pain by favoring the clamping of the plica between the patella and the femur.

The cases of patients with synovial folds visualized and treated in other associated surgical procedures and patients that did not undergo an adequate minimum program of 10 physiotherapy sessions were excluded, as well as patients with previous knee surgeries.

We used the Iino classification, since it was the one adopted in our study of incidence of synovial fold in 100 knees (1). Iino published his Japanese language classification, and the synovial fold also came to be known as "Iino's band."[5] type A – a medial synovial thickening, with a cord aspect, which descends through the medial synovial, originating at the level of the upper pole of the patella, to insert itself in the infrapatellar fatty cushion; type B – a strip of synovial membrane with laminar aspect, similar to a "windsurfing sail" and running through the medial synovial, from the infrapatellar cushion to immediately below the suprapatellar pouch, inserting itself in the suprapatellar fold, as a continuation of or close to it; type C – similar to type B, usually larger, wider, thicker and covering part of the medial femoral condyle, scraping against it and the medial articular face of the patella to knee joint movements; type D – rare variety, is a fold with double proximal insertion, forming a "false bucket handle," which can be interspersed with the patellofemoral joint.

Conservative physical therapy treatment consisted of a stretching program and strengthening of specific muscle groups, and re-education for sports activity was based on the skills and physical conditions of the patients. Special attention was paid to the knee joint muscle (articularisgenus) that tensions the capsule and synovial of the knee avoiding its clamping,[6] stimulated in the adequacy of quadriceps extensor function in knee hyperextension exercises. The program has been used for years after satisfactory previous results.[7]

Cases refractory to physical therapy treatment were indicated for surgery if symptoms were maintained for > 3 months. The operation, when necessary, consisted of synovectomy with extensive resection of the synovial fold, performed arthroscopically,[8] using a 4.5 mm or 5.0 mm "shaver" blade.

After surgery, the patients were discharged on the same day of the operation and started rehabilitation within 7 days, aiming at regaining movement and restoring muscle strength.

After treatment, patients were followed up by the authors in evaluations at 2, 4 and 12 months. We analyzed the return of patients to their non-sports activities, the presence or absence of pain, the return of the normal knee range of motion, the presence or absence of blocking sensation, and the recovery of muscle strength as the objective of treatment.

RESULTS

Fifty-eight patients with 12 bilateral cases were included, which determined a n of 70 knees. Age ranged from 14 to 52 years, with a mean of 28.5 and median of 26 years.

The right side was affected in 38 knees (51%), and 38 patients (76%) were female.

Clinically, all patients complained of pain after sports activity and the sensation of joint blockage. Joint effusion has been reported only by 14 patients.

All patients were first treated conservatively. Of these, 50 patients (86%) improved and did not require surgery, with 12 bilateral cases totaling 62 knees treated by rehabilitation (7). Of this group, 34 were female (68%) and only 5 patients (10%) did not improve within 2 months of rehabilitation. At 4 months and 1 year, all patients were healthy.

Among the 8 patients that did not improve up to 4 months and consequently received surgical indication, all had the unilateral condition, and the right side was affected in 5 cases, and 3 were female (37.5%). Age ranged from 23 to 41 years, with a mean of 26 years.

We could only classify the folds of the operated cases, since they were visualized during arthroscopy, being 6 synovial folds of type C and 2 of type D of Iino.

During arthroscopy, 7 cases (87.5%) presented chondral lesion due to friction, 3 in the medial femoral condyle and 4 in the patella (Figure 2). The exposure of the subcondral bone was not observed in any case.

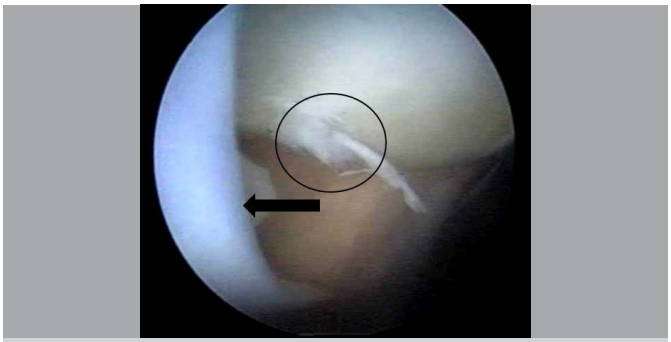

Figure 2. Image obtained arthroscopically of pathological mediopatellar fold (arrow). The medial articular face of the patella with lesion in the area of contact with the fold (circle) is noted.

After 60 days of postoperative evolution, of the 8 operated patients 2 were discharged and 6 (four men) had delayed results represented by pain (in the 6 cases), quadriceps insufficiency (in the 6 cases) and joint limitation (in 3 cases). Of these, 3 patients were discharged with satisfactory treatment before the 6th postoperative month; among these were the 2 type D cases of Iino. Two patients prolonged their rehabilitation up to 6 months with improvement, and 1 patient abandoned our treatment at 5 months still with complaints.

After 1 year, 7 patients completed the evaluation period. Seven were asymptomatic and only one patient (who abandoned treatment at 5 months) complained of lack of strength in the operated limb and maintenance of pain.

Of the 14 patients with joint effusion, 10 were from the conservative treatment group and no longer had the presence of effusion after 1 year of follow-up. Of the 4 patients with joint effusion treated surgically, 3 had a chondral lesion.

DISCUSSION

The main finding of our study is that conservative treatment is most often successful for knee synovial fold syndrome, with 88% resolution of symptoms. Refractory cases showed an improvement of 87.5% with surgical treatment. Only 1 operated patient did not progress satisfactorily after a 12-month follow-up.

The experience of the authors is that most patients improve complaints only with general guidance and stretching, without the need for a structured rehabilitation program. The patients, once oriented, do their stretching and adapt to the sports activity, living well with the synovious folds. The 58 patients included in this study are an exception and required structured physical therapy follow-up. Conservative treatment is a consensus. The surgical indication is exceptional, only in cases that did not obtain results of conservative treatment and with more evident mechanical complaints, representing approximately only 0.25% of all surgeries performed by the authors in the last 10 years.

Most patients are practicing some physical activity. Kang et al.,[9] found the presence of synovial fold of increased size in 38% of soldiers with anterior knee pain. They verified that the clinical examination associated with MRI has high accuracy in the diagnosis of synovial fold, and also report the ultrasound value. We have no experience with the use of ultrasound.

Our group studied in two opportunities the incidence of synovial folds in cadavers, according to each type.[1,10] Older et al.[10] found, in 115 dissections, 47 medial folds (41%), 10 type A of Iino, 29 of type B, 8 of type C and no type D. Joyce III et al.,[11] in 492 dissections of the knees of cadavers, found medial synovial fold in 47% of the times.

In this series, we operated 6 folds of type C of Iino and 2 of type D. Perhaps the rarest types C and D are of worse evolution and present greater need for surgery, but our sample does not allow this conclusion, since it is not possible to correctly classify the fold without arthroscopy in patients treated conservatively.

The occurrence of associated lesions is controversial in the literature. Hardaker et al.,[12] found synovitis and erosion of the cartilage of the condiles in 37 knees and chondromalacia of the patella in 35 out of 53 arthroscopies. In 22 knees, there was the presence of the medial suprapatellar fold; in five, the medial and lateral suprapatellar fold, and in 15, of the medial synovial fold associated with the medial suprapatellar fold. Munzinger et al., found 61 medial synovial folds in 136 arthroscopies.[13] In five, there was chondromalacia of the patella in the contact area of the fold; in three, cartilaginous alteration in the medial femoral condyle; and, in two, alterations in both the patella and the condyle. In another study of 174 medial synovial folds, found in arthroscopies performed by Vielpeau et al., the authors report that 134 patients had patellar chondrosis, 43 had inflammatory chondral lesion in the medial femoral condyle and 14 in the lateral.[14] Cohen et al.,[15] out of 74 arthroscopies of symptomatic medial folds, found 31 associated lesions, of which 13 were articular cartilage injury, seven medial meniscopathies, five lateral and in four anterior cruciate ligament injuries. However, meniscal and ligament injuries do not seem to be related to the presence of the medial synovial fold.

All these authors treated folds concomitant with other knee pathologies. In this series, we include only cases with clinical diagnosis and confirmed by MRI of pathological synovial fold alone, without other associated pathology. We found three femoral and four patellar lesions, without full-thickness lesions. Three of these patients presented joint effusion, a frequent fact in patients with these cartilage lesions.

The expectation with the resection of the plica is to offer rapid improvement and a satisfactory rehabilitation within 60 days. However, it was not effective; the surgery did not offer patients a rapid rehabilitation such as plica cases that responded well to conservative treatment. The presence of pain and difficulty in activating the quadriceps were the major complaints. This limitation occurred in 6 of the 8 (75%) patients operated on the first 2 months. We could not relate this initial difficulty of rehabilitation to any of the demographic data or to associated injuries found due to the small number of cases. As described in the results, only 1 patient had not improved at 1 year, so knee surgeons should not expect a postoperative and rehabilitation as fast as a meniscectomy, for example.

Hufeland and al. operated 35 young patients with synovial plica, with clinical diagnosis and MRI. They report good results, with return of all patients to the activity that preceded the surgery.[16] Wecksträm et al.[17] report experience of 23 patients undergoing arthroscopic surgical resection of synovial plicas. The follow-up was long, above 5 years, and the results were good in 74%.

Schindler, in an extensive literature review, states that the results of the few operated cases are good in 64%. The author's study is based on a meta-analysis of 969 cases of 23 studies. The profile of patients is very similar to ours, with young patients, mean age of 25 years, with a mean follow-up of 26 months.[18] Good results of only 64% are below most knee surgeries, and therefore the origin of pain as being of plica should be considered as an exception, and the surgical procedure should be restricted to cases actually refractory to conservative treatment. Resection of the synovial plica should not be considered a trivial and rapid rehabilitation surgery.

The greatest limitations of our study are its retrospective nature, although all were followed by the senior author and the data are reliable. Moreover, the low number of operated cases made us avoid statistical analyses, and choose to report the experience in these patients descriptively. In any case, our study presents a significant number of cases with synovial plica, interestingly exemplifying what knee surgeons should expect from their specific treatment.

Synovial folds must be further studied, since they may have other functions, perhaps due to its innervation, and not consider them only structures that can impinge in physical activities and as sources of pain. Moreover, a systematization of MRI interpretation may help to better classify them.

CONCLUSION

Non-surgical treatment of pathological knee synovial fold provided good results with 60 days of rehabilitation program in almost 90% of patients. Arthroscopic resection of the synovial fold is a surgery that has a longer and laborious rehabilitation period, despite the good results in most cases.

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ORIGINAL ARTICLE
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FORMULAE DERIVED FROM ANTHROPOMETRIC MEASUREMENTS TO ESTIMATE IDEAL TIBIAL NAIL LENGTH

FÓRMULAS DERIVADAS DE MEDIDAS ANTROPOMÉTRICAS PARA ESTIMATIVA DO COMPRIMENTO IDEAL DA HASTE TIBIAL

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ABSTRACT

Introduction: Ideal Nail Length (INL) provides better outcomes after Intramedullary Nailing (IMN) of Tibia Shaft Fractures (TSF). Intraoperative methods do not allow for preoperative planning. Changing the nail may cause complications. X-rays are commonly used, but displacement or magnification errors may occur. Forearm measurements may be benefical in bilateral TSF. We aim to examine correlations of anthropometric measurements (AMs) and INL and use them to obtain formulae. Materials and methods: Tuberositas Tibia-Medial Malleolus (TM), Tuberositas Tibia-Ankle joint (TA), knee-ankle joint (JJ), and olecranon tip-5th Metacarpal head (OM) distances were evaluated in 76 IMN patients. Correlation analyses were performed and the results used to create formulae. Results: The correlations between INL and TM-left, TM-right, TA-left, TA-right, OM-left, OM-right, JJ-left, JJ-right were 0.81, 0.83, 0.77, 0.77, 0.82, 0.80, 0.90, 0.91 respectively for males; and 0.93, 0.89, 0.88, 0.86, 0.80, 0.82, 0.90, 0.89 respectively for females. AMs show excellent correlation in both sexes ($p<0.0001$). Regression analysis was statistically significant in all formulae. The most compatible correlations in males were JJ-right and JJ-left; and in females, TM-left, TM-right, and JJ-right. Conclusion: The most compatible correlations wth INL were JJ in males, and TM and JJ in females. OM can be used in the presence of bilateral TSF, edema, wounds and obesity. AMs are useful preoperatively. The formulae can be used to ensure INL and reduce errors, time and radiation. Level of Evidence: ***Level I, Testing of previously developed diagnostic criteria on consecutive patients (with the universally applied reference gold standard).***

Keywords: Tibial fractures, Intramedullary nailing, Anthropometry.

RESUMO

Introdução: O comprimento ideal da haste (CIH) proporciona desfechos melhores depois da colocação de haste intramedular (HIM) em fraturas da diáfise da tíbia (FDT). Os métodos dessa cirurgia não permitem o planejamento pré-operatório. A troca da haste pode causar complicações. Em geral, são usadas radiografias, mas podem ocorrer erros de deslocamento ou de tamanho. As medições do antebraço podem ser benéficas nas FDTs bilaterais. Nosso objetivo é examinar as correlações das medidas antropométricas (MAs) e CIH e usá-las para obter fórmulas. Materiais e métodos: As distâncias entre Tuberosidade da tíbia-Maléolo medial (TM), Tuberosidade da tíbia-Articulação do tornozelo (TT), Articulações do joelho e do tornozelo (JT) e extremidade do olécrano-cabeça do 5º metacarpal (OM) foram avaliadas em 76 pacientes com HIM. Foram realizadas análises de correlação e os resultados foram usados para criar fórmulas. Resultados: As correlações entre CIH e TM-esquerda, TM-direita, TT-esquerda, TT-direita, OM-esquerda, OM-direita, JT-esquerda, JT-direito foram 0,81, 0,83, 0,77, 0,77, 0,82, 0,80, 0,90, 0,91 para homens e 0,93, 0,89, 0,88, 0,86, 0,80, 0,82, 0,90, 0,89 para mulheres. As MAs tiveram excelente correlação em ambos os sexos ($p < 0,0001$). A análise de regressão foi estatisticamente significativa em todas as fórmulas. As correlações mais compatíveis em homens foram JT-direita e JT-esquerda; nas mulheres, foram TM-esquerda, TM-direita, e JT-direita. Conclusão: As correlações mais compatíveis com CIH foram JT em homens e TM e JT em mulheres. A OM pode ser usada em FDT bilateral, edema, feridas e obesidade. As MAs são úteis no pré-operatório. As fórmulas podem ser usadas para garantir o CIH e reduzir erros, tempo e radiação. ***Nível de evidência: Nível I, Desenvolvimento de critérios diagnósticos em pacientes consecutivos (com padrão de referência "ouro" aplicado).***

Descritores: *Fraturas da tíbia, Haste intramedular, Antropometria.*

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INTRODUCTION

Tibia shaft fracture (TSF) is the most common long bone fracture with an incidence of 16.9/100.000 per year.[1] Intramedullary nailing (IMN); is the gold standard and most used treatment option for adult TSF.[2] Better outcomes after IMN of TSFs can be achieved by ensuring anatomical reduction and choosing the correct nail length (NL).[3] IMN between 0.5-1 cm distal to knee joint and 1-2 cm proximal to ankle is recommended as Ideal Nail Length (INL) in literature.[4-6] Intraoperative measurements can be made by guidewire method and surgical ruler.[3] On the other hand, these methods do not allow preoperative planning, as a result they may cause prolonged anesthesia and operation time, associated infection and bleeding, and extra radiation exposure of the patient and surgical team. Changing the improper NL during surgery may prolong the duration of surgery and anesthesia and may cause additional complications associated with it. If all NLs are not available for surgery, inappropriate nail placement may be encountered. Therefore, careful preoperative planning is essential for TSF like any orthopedic surgical procedure. Radiographic measurements can be used for preoperative planning. Preoperative radiographic measurement of broken or contralateral tibia can be used but problems due to displacement of fracture or magnification errors may occur. Various anthropometric methods have been used to calculate the appropriate NL in tibia IMN surgery. Although height of the patient was used for this purpose, it is not accepted for tibial nail as a sufficient value alone.[3,7] Distance between Tuberositas Tibia and Medial Malleol (TM), distance between Tuberositas Tibia and Ankle joint (TA), distance between knee joint line and ankle joint line (JJ) were evaluated. In the presence of bilateral tibia fractures, obesity and wounds on tibia; the distance between the olecranon tip point and the 5th Metacarpal head level (OM) was evaluated for preoperative planning of NL. Evaluating these measurements together is important in the presence of multitrauma in particular. However, there are very few studies in the literature where the distances of TM, TA, OM, JJ are used for tibial measurement. Unfortunately, in these studies; cadavers and healthy volunteers were used to examine the consistency of anthropometric measurements (AM) instead of patients suffering from TSF, and the correlations of these AM are leaking in the literature for real TSF patients. Also the present studies do not present a formula to orthopaedic surgeons to reach NL.

In the current study; we aim to examine correlations of AMs with NL, and we aim to obtain formulas to place the ideal nail for TSF to guide orthopaedic surgeons.

MATERIALS AND METHODS

Patients with TSFs treated with IMN between 2015 and 2020 were retrospectively screened. 216 patients who had unilateral IMN, who did not develop fractures on the contralateral tibia and forearm were invited to our hospital by phone. 92 of the invited patients admitted to the hospital. Informed consent was taken from all subjects. The current study was approved by the local ethic committee of hospital with 59/427 decision/protocol number. Patients with a Body mass index (BMI) between 25 and 30 were included to avoid landmark palpation difficulties of obese patients. Patients with another history of trauma to the lower limbs and forearm, patients with soft tissue injuries on the measurement side such as burns that caused scar formation, and patients with limb inequality were excluded from the study to avoid patient's trauma related measurement errors.

As a result of the radiographic evaluation by tibia AP X-ray, the NLs of the patients were evaluated. A radiographic ruler was used and X-ray with %100 magnification from 1 meter distance were taken, and nails terminated 1 cm proximal to the ankle joint and 1 cm below the knee joint were evaluated as INL in guide of literatüre.[3-6] As a result, a total of 76 patients with INL of whom 61 were males and 15 were females were included in the study. TM, TA, OM, JJ of both sides of 76 patients who participated in our study were measured and recorded with their demographic characteristics and fracture sides. TM was measured from the most prominent point on tuberositas tibia to the most prominent point on medial malleolus.[3-4] (Figure 1) TA was measured from the most prominent point on tuberositas tibia to the distal rim of the tibial plafond.[7] (Figure 2) OM was measured as a distance between the olecranon tip to the 5th metacarpal head when the elbow and metacarpophalangeal joints were in 90 degrees of flexexion and wrist was neutral.[6] (Figure 3) JJ was measured as a distance between the point 3 cm medial to patellar tendon's medial edge to tibial plafond's distal rim which is felt as a joint depression at the medial corner [3-7] (Figure 4) This measurement is performed when the knee is flexed, the ankle is dorsiflexed and the leg is in external rotation[5] All measurements were made by authors twice with the same tape measure and average of the values were taken. In our study, the relationship between TM, TA, OM, JJ values and INL was determined. For preoperative planning, it was aimed to reach INL through AM by creating a formula according to the AM values of male and female genders.

Ethics committee approval was received for this study from the Ethics Committee of the hospital (59/427). The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal.

Figure 1. Tuberositas Tibia and Medial Malleol Distance (TM).

Figure 2. Tuberositas Tibia and Ankle joint (TA) Distance.

Figure 3. Olecranon Tip and 5th Metacarpal Head (OM) distance.

Figure 4. Knee Joint and Ankle Joint Line Distance (JJ).

Statistical Analysis

Statistical analysis was performed using SPSS version 22 Chicago: SPSS Inc. Kolmogorov-Smirnov and Shapiro Wilk tests were performed for the evalution of normality. A Student's t-test and Mann Whitney U test were used for the comparison of continuous variables between the groups. Non-parametric Spearman's correlation coefficiency and and Pearson's correlation tests were applied for the correlation analysis of the data. Linear regression analysis was performed for the assessment of evaluation between the AMs and INL (95% CI).

RESULTS

There were 76 patients in the study of whom 15 were female and 61 were male. 9 females and 30 males had left side and, 6 females and 31 males had right side fracture. 39 patients had left tibia IMN and 37 patients had right tibia IMN. There was no statistically significant difference in terms of fracture side (p=0.568). Comparison of the demographic features and AMs of extremities in patient groups are presented in Table 1. All mean AM values and mean NL of male patients were longer than female patients.

Correlation values of left and right TM, TA, OM, JJ values of male patients and NL are presented in Table 2. Correlations between NL of the male patients and TM left, TM right, TA left, TA right, OM left, OM right, JJ left and JJ right were 0.81, 0.83, 0.77, 0.77, 0.82, 0.80, 0.90, 0.91 respectively. According to Table 2, TM, TA, OM, JJ and NL show high correlation in male patients (p<0.0001).

Correlation analysis of TM, TA, OM, JJ values of female patients with each other and NL is presented in table 2. Correlations between NL of the female patients and TM left, TM right, TA left, TA right, OM left, OM right, JJ left and JJ right were 0.93, 0.89, 0.88, 0.86, 0.80, 0.82, 0.90, 0.89 respectively. According to Table 2, TM, TA, OM, JJ and NL values of female patients showed high correlation (p<0.0001). The anthropometric values of the patients and INL were analyzed and the formulas were obtained for preoperative planning. Accordingly, formulas that can be used in male patients are presented in Table 3. Regression analysis was statistically significant in the formulas of male patients (p<0.0001). JJ Right (R^2=0.8284) and JJ Left (R^2=0.8091) values were determined as the most compatible results. (Table 3) The formulas obtained by analyzing the INL through the AM of female patients are presented in Table 4. Regression analysis was statistically significant in the formulas of female patients (TM left, TM right, TA left TA right, and JJ right (p <0.0001); OM left, OM right, JJ left (p<0.001)). (Table 4) In female patients, TM left (R^2=0.8735), TM right (R^2=0.8069), JJ right (R^2=0.8023) gave the most compatible result, respectively.

Table 1. Comparison of the anthropometric measurements (in cm) of the extremities in patient groups.

	Mean SD	Female (n=15) Mean±SD	Male (n=61) Mean±SD	p value
Age	39.38±13.33	40.27±12.27	39.16±13.66	0.776
L/R	39/37	9/6	30/31	0.568
TM Left	33.40±2.00	31.67±1.51	33.82±1.88	<0.0001
TM Right	33.44±2.08	31.69±1.75	33.87±1.94	<0.0001
TA Left	31.71±2.10	30.31±1.86	32.05±2.03	<0.01
TA Right	31.75±2.15	30.27±1.92	32.11±2.05	<0.01
OM Left	34.43±2.22	31.94±2.22	35.05±1.75	<0.0001
OM Right	34.52±2.15	32.00±2.17	35.14±1.65	<0.0001
JJ Left	34.72±2.53	32.47±2.11	35.28±2.32	<0.0001
JJ Right	34.73±2.59	32.40±2.19	35.3±2.37	<0.0001
Nail length	32.11±2.35	29.73±1.98	32.69±2.06	<0.0001

Table 2. Correlation for Nail Length of Males and Females with Anthropometric measurements.

	TM Left	TM Right	TA Left	TA Right	OM Left	OM Right	JJ Left	JJ Right
NL of Males	0.81*	0.83*	0.77*	0.77*	0.82*	0.80*	0.90*	0.91*
NL of females	0.93*	0.89*	0.88*	0.86*	0.80*	0.82*	0.90*	0.89*

TM: Tuberositas tibia-Medial malleol distance, TA: Tuberositas tibia-Ankle Joint distance, OM: Olecranon tip-5th Metacarpal Head Distance, JJ: Knee – Ankle Joint distance, NL: Nail Length, *p<0.0001

Table 3. Regression equations for male subjects according to Antropometric measurements.

MALE (n=61)	Formula	R^2	p
TM Left	= 0.7416*X + 9.583(±2.272)	0.6595	p<0.0001
TM Right	= 0.7832*X + 8.266(±2.223)	0.6930	p<0.0001
TA Left	= 0.7605*X + 7.192(±2.678)	0.5945	p<0.0001
TA Right	= 0.7722*X + 6.866(±2.695)	0.5989	p<0.0001
OM Left	= 0.7065*X + 11.95(±2.039)	0.6857	p<0.0001
OM Right	= 0.6435*X + 14.10(±2.034)	0.6455	p<0.0001
JJ Left	= 1.015*X + 2.106(±2.102)	0.8091	p<0.0001
JJ Right	= 1.047*X + 1.074(±2.032)	0.8284	p<0.0001

TM: Tuberositas tibia-Medial malleol distance, TA: Tuberositas tibia-Ankle Joint distance, OM: Olecranon tip-5th Metacarpal Head Distance, JJ: Knee – Ankle Joint distance, X=Ideal Nail Length

Table 4. Regression equations for female subjects according to Antropometric measurements.

FEMALE (n=15)	Formula	R^2	p
TM Left	= 0.7148*X + 10.41(±2.248)	0.8735	p<0.0001
TM Right	= 0.7968*X + 8.000(±3.222)	0.8069	p<0.0001
TA Left	= 0.8311*X + 5.603(±3.653)	0.7794	p<0.0001
TA Right	= 0.8422*X + 5.224(±4.039)	0.7480	p<0.0001
OM Left	= 0.9095*X + 4.899(±5.478)	0.6531	p<0.001
OM Right	= 0.8993*X + 5.262(±5.212)	0.6702	p<0.001
JJ Left	= 0.8791*X + 6.334(±4.990)	0.6794	p<0.001
JJ Right	= 0.9939*X + 2.847(±4.077)	0.8023	p<0.0001

TM: Tuberositas tibia-Medial malleol distance, TA: Tuberositas tibia-Ankle Joint distance, OM: Olecranon tip-5th Metacarpal Head Distance, JJ: Knee – Ankle Joint distance, X=Ideal Nail Length

DISCUSSION

Anatomical reduction of TSF and ensuring stability with the INL is very important in terms of recovery of the functions. It increases the quality of life, enables to return to social life and work earlier, and it requires meticulous preoperative planning. Proper NL is essential for surgical success.[3] Nails shorter than they should be can result in malrotation, loss of reduction and fixation failure. Extraction of the nail can not be performed when necessary, if nail is too short. NL longer than it should be can distract the fracture site and can result ankle and/or knee joint penetration and patellar tendon impingement. In this sense, NL should start from 0.5-1 cm distal to the knee joint and extend to 1-2 cm proximal to the ankle.[4,8] In our study, we evaluated the nail length starting from 1 cm distal of the knee joint to 1 cm proximal to the ankle joint as the INL.

In the surgery of TSF, all nail sizes should be kept ready in the operating room. Intraoperative guide wire method and radiographic ruler can be used.[3] However, these intraoperative methods do not allow preoperative planning. In cases of emergency conditions, when the appropriate nail is not ready in the operating room, the application of the non-ideal NL to the patient may be faced. Therefore, the surgeon must ensure that the correct NLs are ready by making appropriate preoperative planning.

Intraoperative errors, anesthesia and operative time and radiation exposure of surgical team and patient are reduced by proper preoperative nail planning.[3-7] For this reason, radiographic measurements and AM can be used for preoperative planning such as radiographic templates and patient height.[9-11]

Preoperative radiographic measurement of broken or contralateral tibia can be used. However, the correct length may not be accurately measured due to translation and displacement of broken fragments. Moreover, the magnification of the radiographs does not always reflect the actual length.

It should be taken into consideration that the radiographs of the contralateral tibia may not be taken with equal magnification at an equal distance to each trauma patient under emergency conditions. Splinting and leg positioning may also affect the magnification. The presence of leg length inequalities, past TSF or lower limb deformities limit the use of broken and contralateral tibia to calculate NL.[6]

Using patient height in preoperative planning is not recommended due to low accuracy.[3-7] Since the soft tissue coverage of the tibia is relatively less, it is suitable for various anthropometric methods based on bone and joint landmarks. Therefore; JJ, TM, TA were evaluated preoperatively to have the correct NL ready in the operating room. However, due to the reasons such as obesity, density of subcutaneous fatty tissue, the presence of wounds and lesions on landmarks, fracture of the contralateral tibia, and inability to perform appropriate measurements due to edema of crus pushed orthopedic surgeons to search for landmarks from other parts of the body.[6,12] For these reasons, the OM, in which bone landmarks are easily determined, was used.

Studies using these AM in the literature have obtained variable results in calculating the possible NL. For example, while Venkateswaran et al found 64% accuracy with TM; Colen and Prieskorn stated that TM distance is the most compatible measurement with 71% accuracy (4,5). In contrast, Galbraith et al suggested using the JJ distance for calculating the NL (3). Isaac et al added 11 mm to the TA distance and found the highest correlation with the nail length with 81%, and suggested to use the TA distance in preoperative planning.[7] Venkateswaran et al reported that the subtracting 20 mm from the JJ distance showed the highest accuracy with 86%.[5]

These studies were mostly performed on healthy volunteers and present the AM values of healthy people. In these studies on volunteers, the correlations of AM with each other were evaluated; it is not based on radiographic measurements. The number of cadaver studies using radiographic measurements is limited. In our study, the actual NL was calculated by radiography in real magnification, so there was no need for computed tomography. The average age of the cadaver studies does not meet the age group in which TSFs are common. In addition, AMs made on cadavers may show differences due to positioning differences, palpation differences due to the absence of sense of pain during measurement, and the lack of landmarks due to subcutaneous fatty tissue and atrophy of muscle tissue. Our study is based on AMs of real patients who underwent IMN surgery due to TSF; evaluates the correlation of these values with the INL.

Studies in the literature have made investigations for the calculation of NL by adding or subtracting a fixed value to AM. According to our study, the mean NL varies depending on the gender. In addition, keeping the added or subtracted value constant may increase the margin of error according to the size of the measured anthropometric value. For this reason, creating a formula instead of a constant value can increase the possibility of obtaining the INL.

Depending on the reasons such as wound in the measurement area, presence of trauma-related edema, patient's inability to tolerate manipulations related to fracture pain; one or more of the measured anthropometric values may not be used. Therefore, in our study, we obtained formulas by evaluating the correlations by making all AM from both the right and left sides. In this way, we also ensured the sustainability of preoperative planning in multitrauma patients.

According to our study, AM of the right and the left extremities showed high correlation with INL and are presented in Table 2. In the current study, the highest correlation between AM and NL in male patients was found with JJ similar to Galbraith and Venkateswaran.[6,11] In male patients, TM, OM, and TA followed JJ respectively.

The highest correlation between AM and NL was found in TM and JJ, followed by TA and OM in female patients. Our study also stated that AM can be used as Isaac, Venkateswaran, Colen and Prieskorn indicated.[3,11] In addition, the current study showed that OM can be used with high correlation in cases with bilateral tibia fracture, obesity, skin wounds and lesions, burn scars and edema as Blair stated.[2]

Moreover, our study has provided formulas for real TSF patients treated with INL and unlike other studies, the highest compatible AM that can be recommended by sex are separated.

Accordingly, it has been shown that JJ accuracy is higher in male patients, and TM and JJ accuracies are higher in female patients. We recommend to evaluate AMs simultaneously and to have the INL ready in the operating room before starting the surgery.

In this sense, the current study is the first study aiming to reach the INL by formulas according to the female and male sexes separately and the broken side. Our study includes a high number of cases compared to other studies. However, the number of female patients is relatively less.

The limitation of the current study is the lower case numbers of female patients especially for left side fractures. This study was performed in a single center and gives information of a single race. It may be a guide for multicentric studies in which especially the number of female patients is increased.

CONCLUSION

In our study, the correlation between INL and AM according to the fracture side in male and female patients was examined; found greater compatibility with JJ in male patients and TM and JJ in female patients. The formulas presented by our study in the preoperative evaluation may ensure that INL is available in the operating room and can prevent the operation from starting without having the appropriate NL. By shortening the duration of surgery and anesthesia with preoperative planning, it may reduce associated blood loss, infection risk and radiation dose. Our study is guiding surgeons for multitrauma patients because it contains different AMs. It can be used in preoperative planning as a fast, easy-to-apply method without financial burden.

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RECONSTRUCTION OF UPPER LIMB SOFT TISSUE INJURIES, EXCEPT FOR FINGERTIPS LESIONS

RECONSTRUÇÃO DE LESÕES DE PARTES MOLES DO MEMBRO SUPERIOR, EXCETO LESÕES DAS PONTAS DOS DEDOS

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ABSTRACT

Objective: The main purpose of this work was to evaluate the advantages and disadvantages of reconstructive procedures applied in upper limb soft tissue injuries according to their location. Methods: The study involved 94 male and 22 female patients (116 total) operated between April 2001 and November 2017 due to traumatic injuries in a upper limb. Individuals were evaluated considering their age, sex, etiology, reconstruction area , applied methodology and complications. The finger injuries were excluded. Results: The performed reconstruction procedures include 29 skin grafts; six advancement flaps; seven rotation flaps; 33 pedicled fasciocutaneous flaps, 9 free fasciocutaneous flaps; 5 pedicled muscle flaps; 12 free muscle flaps, three pedicled musculocutaneous flaps; one free musculocutaneous flap; 11 neurovascular free flaps. Conclusion: Reconstructive procedures in the upper limbs are diverse, varying from skin grafting to free flaps. The indication of the best option depends on the type of injurie and the surgeon. The final goal is to reach the best functional result combined with the lowest possible morbidity. ***Level of Evidence IV, Case series.***

Keywords: Upper Extremity. Reconstructive Surgical Procedures. Surgical Flaps. Arm Injuries. Shoulder Injuries. Hand Injuries.

RESUMO

Objetivo: O objetivo deste estudo foi analisar as vantagens e desvantagens dos procedimentos reconstrutivos utilizados em lesões de partes moles do membro superior, conforme sua localização. Métodos: Foram analisados 116 pacientes, 94 do sexo masculino e 22 do sexo feminino, operados entre abril de 2001 e novembro de 2017 em consequência de lesões traumáticas no membro superior. As lesões restritas aos dedos foram excluídas. Foram avaliados quanto à idade, sexo, etiologia, área de reconstrução, método empregado e complicações. Resultados: Os procedimentos de reconstrução realizados incluem 29 enxertos de pele; 6 retalhos por avançamento; 7 retalhos por rotação; 33 retalhos fasciocutâneos pediculados, 9 retalhos fasciocutâneos livres; 5 retalhos musculares pediculados; 12 retalhos musculares livres, 3 retalhos musculocutâneos pediculados; 1 retalho musculocutâneo livre; 11 retalhos livres neurovasculares. Conclusão: Os procedimentos reconstrutivos nos membros superiores são muito variados, abrangendo desde a enxertia de pele até retalhos livres. A indicação depende do tipo de lesão e da escolha do cirurgião. O objetivo final é alcançar o melhor resultado funcional com a menor morbidade possível. ***Nível de Evidência IV, Série de casos****.*

Descritores: *Extremidade Superior. Procedimentos Cirúrgicos Reconstrutivos. Retalhos Cirúrgicos. Traumatismos do Braço. Lesões do Ombro. Traumatismos da Mão.*

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INTRODUCTION

The upper limb consists of four segments: shoulder, arm, forearm and hand and it is in constant interaction with the world and, consequently, it is commonly injured. Unlike many other body parts, critical structures of the hand are located just under the skin, which means that the upper limb soft tissue injuries represent a more difficult reconstructive challenge for the surgeon than similar injuries in other body parts.[1]

Upper limb trauma frequently results in serious injuries that compromise multiple structures, including skin, bones, tendons, nerves and blood vessels, which can threaten or impair limb function.[2] Complex injuries usually appear as a result of burns and traffic accidents, as well as workplace and even home related accidents. Mechanisms of injuries include crushing, avulsion, high pressure, firearm firing, fireworks or a combination of two or more.[3]

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The study was conducted at the Faculty of Medical Sciences and Health, Pontifícia Universidade Católica de São Paulo.
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No evidence suggests that delayed skin covering may lead to a higher rate of flap failure or wound infection. Negative pressure bandages, after serial operatory debriding are useful tools for temporizing wounds before reconstruction.[1] Inappropriate conduct can lead to amputation or permanent disability, which are major causes of emotional impairment. Covering the injury site with appropriate soft tissues prevents the development of contractures and facilitates tendons and joints mobility, essential for the improvement of motor, sensory and aesthetic functions of the upper extremity.[4]

Optimal coverage is stable, durable and able to withstand heavy work demands. It must also preserve joint mobility and present an aesthetically acceptable appearance – however, always prioritizing function.[5] The simplest technique includes direct primary closure, followed by skin grafting, use of local and regional flaps and, finally, transfer of free or pedicled flaps of vascularized tissue.[1]

The aim of this study was to analyze the advantages and disadvantages of the procedures used to repair 116 traumatic injuries with loss of soft tissue in the upper limb, according to the affected segment.

MATERIALS AND METHODS

The study evaluated and reviewed cases of 116 patients (94 male and 22 female) submitted to surgical treatment of injuries with tissue loss of several different segments of the upper limbs, from April 2011 to November 2017. Patients were evaluated regarding age, sex, injury etiology, reconstituted area, reconstruction methods and complications. The mean age of patients was 25.6 years old (ranging from 18 months to 68 years old). Out of the 116 patients, 82 were over 18 years of age and 34 were less than 18 years old by the time of the surgery. All injuries were result from trauma: 51 work-related injuries; 43 traffic accidents; 7 burns; and 15 from other causes.

Injuries that had been primarily reconstructed and those compromising only the fingers were excluded from our evaluation. X-ray images were taken in appropriate positions to confirm or to discard skeletal injuries. In many cases, serial debridations were required until all the devitalized tissue was completely removed. The use of negative pressure treatment of the wounds allowed a stable temporary wound coverage before definitive reconstruction. All available participants adhered to institutional ethical precepts and the project was evaluated by the Ethics in Research Committee and registered in the *Plataforma Brasil* under the CAAE number 83985818.7.0000.5373.

RESULTS

The events involving upper limb segments, from proximal to distal, were shoulder and armpit (3); arm and elbow (15); forearm (20); fist and hand (78). Reconstruction procedures included 29 skin grafts; six advancement flaps; seven rotation flaps; 33 pedicled fasciocutaneous flaps; 26 groin flap;, four posterior interosseous artery flaps; three radial forearm flaps; nine free fasciocutaneous flaps, four of which were parascapular and 5 lateral arm flaps; 12 neurovascular free flaps; seven dorsal foot flaps; two dorsal foot flaps associated with the first commissure; a dorsal foot flap associated with the second toe transfer; a lateral arm neurovascular flap; a radial forearm neurovascular flap; 13 serratus anterior muscle flaps (10 free and 3 pedicled flaps) ; seven latissimus dorsi muscle flaps– two free flaps (one muscular and one musculocutaneous) and 5 pedicled flaps (2 muscular and 3 musculocutaneous) (Table 1).

Table 1. Distribution of the procedures according the affected segment.

	Shoulder and armpit	Arm and elbow	Forearm	Fist and hand	Total
Skin graft	–	4	7	18	29
Advancement flap	–	–	1	5	6
Rotation flap	–	–	3	4	7
Pedicled fasciocutaneous • Groin • Posterior interosseous artery • Radial Forearm			 4 3	26	33
Free fasciocutaneous • Para-scapular • Lateral arm		 4 5			9
Neurovascular free flap		–	–	12	12
Serratus anterior muscle flap	–	–	–	13	13
Latissimus dorsi muscle flaps	3	2	2	–	7
Total	3	15	20	78	

Table 2 describes the causes of complications . Six patients had partial or complete loss of the flap and reconstruction was achieved with skin grafts.

Table 2. Complications that occurred in patients submitted to free and pedicled flaps.

	Bruise	Seroma	Suture dehiscence	Problems in the donor area	Venous insufficiency	Arterial insufficiency	Flap loss	Nervous or vascular injury
Radial forearm flap				Donor area skin graft				
Posterior insterosseous artery flap					Flap loss by por venous insufficiency			
Lateral arm flap			Second intention healing		Parcial flap loss (2 cases)			
Scapular flap		Seroma in one case		Injury to the vascular pedicle (1 case)				
Groin flap		Seroma in 2 cases	In 2 cases	Flap disconnection (2 cases)				
Foot dorsal artery flap				Unacceptable scar (10 cases)	Parcial flap loss (2 cases)			
Serratus anterior muscle flap	In one case	Seroma in 5 cases			Flap loss (1 case)			Long thoracic nerve injury (1 case)
Latissimus dorsi muscle flap		Seroma in 4 cases						
Skin graft							Parcial graft loss (2 cases)	
Rotation flap			In one case					
Advancement flap							Parcial flap loss (1 case)	

DISCUSSION

The hands are coated by a special soft tissue consisting of skin, subcutaneous adipose tissue and fibrous septa. Hand skin is quite different in its palmar face and dorsal side. The palmar skin is hard and thick to support its constant usage and to protect deeper structures.[1,2] It presents low mobility, which difficults the rotation of local flaps in palmar skin injuries.[3] Thus, flaps from other places are frequently preferred for reconstruction.[5] Fasciocutaneous flaps are preferred in aesthetically sensitive areas such as hands. Muscle flaps can be designed to adapt to the contour of the lesions and are of great importance in patients with exposed tendons, as they provide a sliding plane for excursion of the tendon.[2,5]

The selection of a flap depends on the receiving area: its size and deepness; injury mechanism; exposed structures; structures that need reconstruction; contamination; color and texture of tissues that surround the lesion; and the need for recovering sensitivity.[6,7] It is also important to consider that, after debriding, the injured area is larger and deeper than before and the microvascular anastomoses must be placed outside of the injury zone. The morbidity of the donating area must be minimized.[4] The variety of available free flaps allows that the donating place can be individually chosen, according to the preference of the surgeon and based on the characteristics of the donating and receiving areas.[6] In the present study, the recovery of 116 upper limbs that suffered trauma (with or without associated bone lesion) was performed.

The radial forearm flap is commonly used as pedicled flap for the ipsilateral hand and it can also be used as free flap for the opposite hand.[5,6] The radial artery must be included in the flap and it is important to perform the Allen test, to ensure appropriate blood flow towards the hand through the ulnar artery, as a part of the pre-operatory planning.[5,7] Advantages of radial forearm free flap include its reliable anatomy, large vessels, long pedicle and wide versatility. It can be used as a composite flap with long palmar tendon, radius segment or lateral cutaneous nerve of the forearm.[6] The main disadvantage is the need of skin graft to coat the donating area, causing an unpleasant appearance specially for women.[7-9] In this study, the radial flap of the forearm was used in four limbs as a pedicled flap: two to coat the first commissure, one for the back of the hand and one as neurovascular flap for the palm. In another case, it was used as a free flap of the amputated hand, to cover a contralateral lesion (Figure 1). No complications occurred in these five cases.

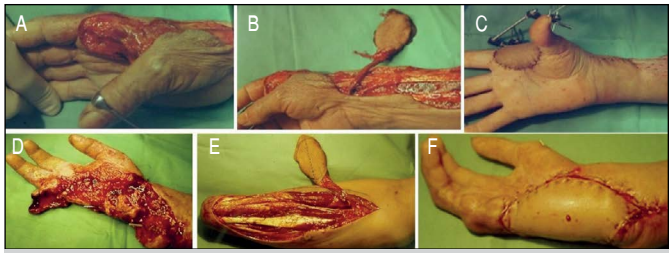

Figure 1 A, B, C. The radial forearm fasciocutanous flap (Chinese flap) to cover tissue losses of the first web space. An external mini fixator was used to maintain the opening of the first web space. **D, E, F.** The radial forearm flap was removed from the limb with amputated left hand and transferred as a free flap to cover tissue loss of the injured right hand.

The posterior interosseous artery flap provides a very fine quality skin to cover skin lesions on the hand. It is a reverse flow flap based on the distal communication between the anterior and posterior interosseous vessels (artery and vein).[10] After complete dissection of the pedicle, it can be rotated distally to reach the wrist and hand – but not the fingers.[10,11] If the pedicle is rotated proximally, it is possible to cover forearm and elbow lesions. The pedicle flap consists of the posterior interosseous artery and vein located between the extensor *carpi ulnaris* and extensor *digitorum* muscles.[10] The vessels that compose the pedicle flap are not frequently chosen as free flaps, once they have very thin caliber that difficulties anastomosis. The use of this flap is not recommended for patients with previous or current injuries in the distal wrist or forearm that could have compromised the communication between vessels.[10,11] They are recommended only in small injuries, once primary closure of the donor area is possible, which makes skin grafting unnecessary. The use of the fascia flap alone provides a thin flap allowing the primary closure of the skin.[1,11] Through such flap. it is exceptionally possible to incorporate a radium bone segment. In this study, flaps of the posterior interosseous artery were performed: two to coat the back of the hand (Figure 2); and one for the first commissure. In these three cases, primary closure was possible , without skin graft. In the fourth case, a fascia flap was performed, however, the flap was lost due venous insufficiency and the resulting area was coated with skin graft.

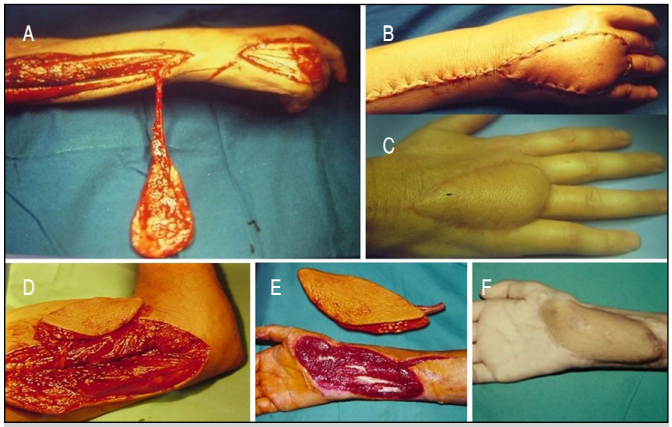

Figure 2 A, B, C. Posterior interosseous fasciocutanous flap to cover tissue loss of the dorsal aspect of the hand. **D, E, F**. The lateral arm flap has the advantage that it can be used as a free flap on the same side of the traumatized hand, so that dissection in both the donor and recipient area is restricted to the injured extremity.

The lateral arm flap receives vascular supply from the posterior radial collateral artery, which is the most calibrated branch of the deep brachial artery. It is located in the septum between the triceps and brachioradial muscles, it branches into the fascia, goes towards the skin of the lateral of the arm and ends up anastomosing with the interosseous recurrent artery, at the level of the lateral epicondyle of the humerus.[12] The flap can be lifted simply as a facia flap, decreasing the morbidity of the donor area. During the lifting of the flap, the radial nerve that lays at the side of the pedicle must be protected from lesions. The posterior cutaneous nerve of the arm – which is a sensitive branch of the radial nerve – goes along the vascular pedicle and sends sensitive fasciculus to the skin of the lateral of the arm, allowing it to be used as a neurovascular flap.[1,6] It can also be a composite flap, incorporating a segment of the humerus or triceps. It has the advantage of presenting a long pedicle with calibrated vessels that allow its use as a free flap at the same side of the traumatized hand, in such way that the dissection – both in the donor and receptor areas – is restricted to the injured extremity.[13,14] When such flap is wider than 7 cm, direct closure of its edges is not possible and skin grafting is required, which causes an unpleasant aesthetic aspect.[2,5,14] In this study, the latera flap of the arm was used as a free flap in five limbs: one of

them as a neurovascular flap to coat the palm of the hand (Figure 3). In two cases a partial loss of the flap occurred due to venous insufficiency; they were solved with skin grafting. In another case a suture dehiscence occurred that healed by second intention.

Figure 3 A, B, C. The scapular flap was designed to cover this deep lesion on the back of the wrist and hand. With this dimension, it is possible to directly close the donor zone. **D, E, F, G**. The pedicled fasciocutaneous groin flap repaired a tissue loss on the back of the hand. The Superficial iliac circumflex artery supplies the flap.

The scapular flap is projected transversely along the spine of the scapula and the para-scapular flap is located obliquely along the lateral edge of the scapula; they are based on transverse and descending branches of the subscapular artery, respectively. It is a fasciocutaneous flap that receives blood supply through the cutaneous branches of the circumflex scapular artery, which originates from the subscapular artery.[14-16] It has a long and reliable pedicle, with low morbidity of the donor area, which can usually be closured primarily.[14] A segment from the scapula can also be included in the flap.[2,6,14] Their disadvantages include the need of a intraoperative lateral positioning and the absence of a defined skin innervation in this region, so it cannot be used as a neurovascular flap.[6,14] In order to obtain larger amount of tissue in extensive reconstructions, it can be associated to muscle flaps from the latissimus dorsi and serratus anterior, in a single common subscapular pedicle.[2,6] Its use has been declined lately due to the advent of the anterolateral thigh flap.[13,17] In the present study, such flap was used in four limbs with extensive injuries involving hand and distal forearm and no complications were observed (Figure 4). In one case, seroma formation seroma occurred, but it was spontaneously solved. In another limb, the vascular pedicle was damaged during dissection and the procedure was aborted and the flap was placed back in its original position.

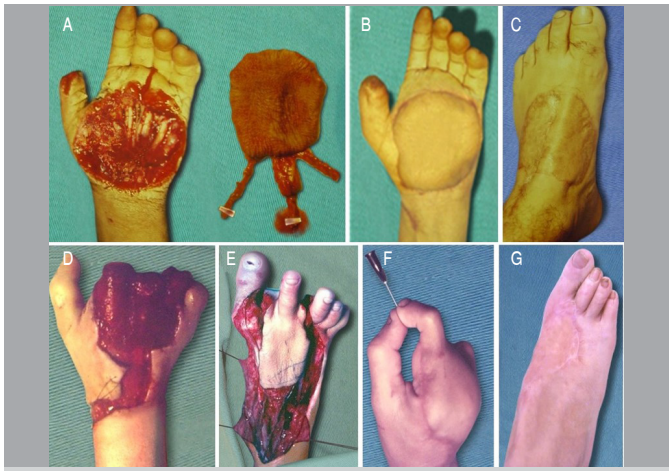

Figure 4 A, B, C. Neurovascular dorsalis pedis fasciocutaneous free flap to cover the palmar aspect of the hand. **D, E, F, G**. Dorsal neurovascular free flap of the foot, associated with the transfer of the second toe.

The groin flap is indicated in the recovery of extensive skin lesions involving the distal third of the forearm, fist and hand,[3,18] once it offers good quality skin for coating. It is an axial flap, thus it has a well-defined, constant and reliable blood circulation. The groin flap has as axis the surface of circumflex iliac artery, originated in the femoral artery–c.a. 2 cm distally from the inguinal ligament. The main advantage of groin flaps is that its use can be planned accordingly to the size of the injury in the upper extremity.[1,13,14] The main disadvantage is the need of a second surgery after three weeks of immobilization, revascularization and flap removal. Once it has a short pedicle, its use as a free flap is not recommended. It can be used as pedicled osteocutaneous flap, in which case the deep iliac circumflex artery must be incorporated into the flap, once it is the main responsible for the vascularization of the attached osseous segment.[1,14,18] Here, the pedicled groin flap was the preferential method for 26 patients with hand and fist injuries. In two cases an osseous segment from the iliac crest was incorporated into the flap to repair osseous tissue loss (Figure 5). In two non-collaborative patients, the flap was removed and placed back in donor area; in another two, the occurrence of seroma was observed, but it was spontaneously solved.

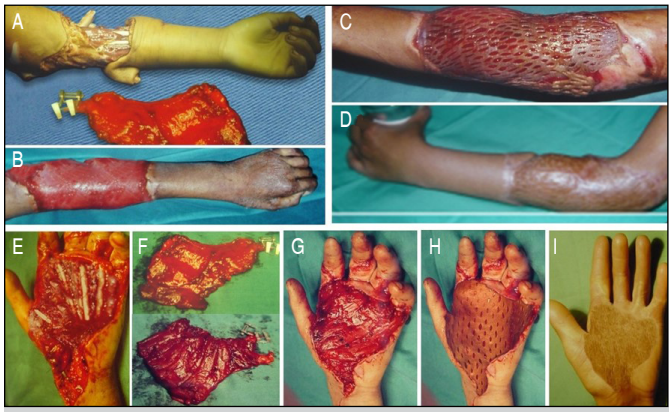

Figure 5 A, B, C. The anterior serratus muscle flap can be used as a free flap, as in this case, in which crushing with open fractures and loss of soft tissues occurred. **D, E, F, G, H, I**. The superficial portion of the serratus muscle was used to cover a lesion of the palm with exposure of the flexor tendons. The portion covered by the fascia is placed in contact with the flexor tendons to prevent their adherence to the musculature, with the bloody muscular area facing the surface, which is grafted with partial skin.

Dorsal foot flap has good quality and its tissue structure is similar to the hand.[19,20] Its main advantage is the good quality restoration of the hand palm surface and fingers sensitivity , besides being a fine flap that generates few volume when placed on the palm surface. It has a relatively long pedicle, reliable vascular anatomy and the potential to include specific vascularized structures, such as tendons. The inclusion of the fibular nerve surface in the flap allows it to be used as a neurovascular flap, while the inclusion of the deep fibular nerve makes it a neurovascular flap of first commissure.[2,20] However, the morbidity in the donor area may be a disadvantage in the use of such flap. Samson et al.[21] recommended that this flap should only be used when there are no other options available. To avoid more serious sequels, the flap should not be extensive and the distal edge must be at least 2 cm proximal to the digital mommissures.[21] In this study, foot dorsal neurovascular flap was used in ten upper limbs: 7 dorsal foot flaps, 2 dorsal foot flaps associated to the first commissure, 1 dorsal foot flap associated to the second toe transfer (Figures 6 and 7) (Table 1).

Partial flap loss was observed by venous insufficiency and in one case required skin graft. The morbidity of the donor area was unacceptable in all limbs.

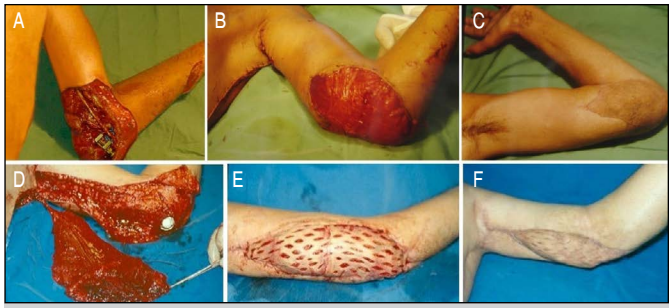

Figure 6 A, B, C. The anterior serratus muscle flap can be used, without the need for microvascular anastomoses, as in this case, in which an extensive injury occurred on the medial surface of the elbow, with associated ulnar nerve damage. **D, E, F**. Transposition of the vascular pedicle flap of the latissimus dorsalis muscle to cover a prosthesis of the elbow joint.

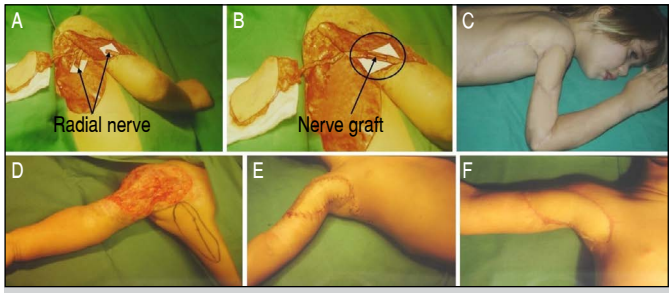

Figure 7 A, B, C. Injury with loss of soft tissue in the axillary region, covered with latissimus dorsalis musculocutaneous flap. **D, E, F**. Injury with loss of soft tissue and lesion of the radial nerve. The sural nerve was grafted and covered with latissimus dorsalis musculocutaneous flap.

The anterior serratus muscle flap is generally used to cover lesions that are not so extensive, it has a long and reliable pedicle, so it is a fine flap that fits well to the back and palm surfaces of the hand and forearm. The serratus muscle begins in the nine first ribs and inserts itself in the medial edge of the scapula, with the function of keeping it in position, avoiding its upper or posterior displacement. It has been of significant importance in reparations of upper limbs lesions.[22,23] No more than the last four attachments can be safely removed. It is innervated by the long thoracic nerve that originates from the roots C5, C6 and C7 of the brachial plexus. The inferior part, with more extensive attachments, receives blood supply through the artery of the anterior serratus muscle, which originates from the thoracodorsal artery, one of the terminal branches of the subscapular artery.[24] The anterior serratus muscle flap can be used as a free flap for extensive lesions of hands and forearms. For the coating of armpit, arms and elbow, only displacement of the flap can be used, without microvascular anastomoses, as its pedicle can reach up to 15 cm, if dissected until its emergence in the axillary artery. It can also be used as a musculoskeletal flap, by inserting its last digits in the costal arches.[25] The flap with the fascia of the serratus muscle cover can also be used. However, it is preferable to associate a muscular portion of at least one centimeter thick with the fascia, to facilitate the venous return. The damage in the donor area is minimal, just a linear scar in the middle axillary line, which is covered by the arm. In this study, the serratus muscle flap was used in 13 limbs: in two as a pediculate flap to coat arm and elbow areas (Figure 6); three free flaps in forearm; and eight free flaps for hands–three for palm and five for the back hand and fist web space (Figure 5). Only one case used the serratus fascia flap, in which total loss of the flap occurred due to venous insufficiency. In four cases presented seroma formation. In another case, injury of the long thoracic nerve was observed.

The *latissimus dorsi* muscle flap, supplied by the thoracodorsal artery is very reliable; it is the largest isolated muscle used to cover large defects in the extremities.[2] As the serratus muscle (scapular or para-scapular), its vascular supply comes from the same pedicle (subscapular artery) and it can be associated to more than one flap with a single pedicle.[14,24] The loss of muscle function at the donor site is compensated by the action of the teres major and pectoralis major muscle, non-athlete patients do not report significant disability due to the removal of the latissimus dorsi muscle, which should be removed from the non-dominant side.[2] The dissection is easy and it presents a long pedicle (8-11 cm) with large caliber vessels. It can be bused as a pedicled flap to repair injuries in shoulders and armpits, simply by flap transposition without vascular anastomoses[26,27] (Figure 7). The occurrence of seroma in donor area is frequent, if draining is not carefully performed. The thoracodorsal artery flap is based on perforating branches of the thoracodorsal artery and it can be used with minimal morbidity at the donor area.[14] Only one segment of the dorsal can be used.[28] In the present study, such flap was used in seven limbs, three as pedicled skin muscle to coat the deltoid area and armpit; two as pedicled flap for arm and elbow; and two for forearm–one musculocutaneous and one muscular. Seroma formation occurred in three cases.

CONCLUSION

The reconstructive procedures on the upper limbs are varied, from skin grafting to free flaps. The indication depends on the type of injury and the choice of the surgeon. The ultimate goal is to achieve the best functional result with the lowest possible morbidity.

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DYNAMIC POSTURAL BALANCE IS MEDIATED BY ANTHROPOMETRY AND BODY COMPOSITION IN OLDER WOMEN

EQUILÍBRIO POSTURAL DINÂMICO É MEDIADO PELA ANTROPOMETRIA E COMPOSIÇÃO CORPORAL EM IDOSAS

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ABSTRACT

Objective: To investigate the relationship between anthropometry and body composition with dynamic postural balance in elderly women with low bone mineral density (BMD). Methods: 45 older women (≥ 60 years), low BMD and nutritional diagnosis of low weight to overweight. For the assessment of body composition, Dual energy X-ray emission densitometry and anthropometric examination were used to measure: body mass (kg), height (cm) and BMI (k/m^2). The assessment of dynamic postural balance was performed by the mini Balance Master Evaluation System clinical test and the computerized Balance Master® System test by the Sit to Stand and Step Up/Over tests. Results: There was a negative correlation between miniBESTest ($r = -0.566$; $p \leq 0.001$) and time to ascend and descend step ($r = -0.393$; $p \leq 0.007$) with fat mass, and positive correlation with miniBESTest ($r = 0.526$; $p \leq 0.001$) and time to go up and down a step with muscle mass ($r = 0.297$; $p \leq 0.04$). As for anthropometric variables, only height showed a positive correlation ($r = 0.296$; $p \leq 0.04$) with the speed in the sit and stand test. Conclusion: Lean mass reduces postural oscillations; in contrast, fat mass negatively interfered with dynamic postural balance in women with low BMD. Height was related to dynamic postural balance, the taller the elderly, the worse their balance. ***Level of Evidence II, Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease.***

Keywords: Aged. Body Composition. Postural Balance. Bone Density.

RESUMO

Objetivo: Investigar a relação da antropometria e composição corporal com o equilíbrio postural dinâmico em idosas com baixa Densidade Mineral Óssea (DMO). Métodos: 45 idosas (≥ 60 anos), baixa DMO e diagnóstico nutricional entre baixo peso e sobrepeso. Para a avaliação da composição corporal utilizou-se a densitometria por emissão de raios x de dupla energia e exame antropométrico para aferir: massa corporal (kg), estatura (cm) e índice de massa corporal (IMC) (k/m2). A avaliação do equilíbrio postural dinâmico foi realizada pelo teste clínico mini Balance Master Evaluation System, pelo teste computadorizado Balance Master® System e pelos testes Sit-to-Stand e Step Up/Over. Resultados: Houve correlação negativa do miniBESTest ($r = -0,566$; $p \leq 0,001$) e tempo de subir e descer um degrau ($r = -0,393$; $p \leq 0,007$) com a massa gorda, e correlação positiva do miniBESTest ($r = 0,526$; $p \leq 0,001$) e tempo de subir e descer um degrau com a massa muscular ($r = 0,297$; $p \leq 0,04$). Quanto às variáveis antropométricas, apenas a estatura apresentou correlação positiva ($r = 0,296$; $p \leq 0,04$) com a velocidade no teste de sentar-se e levantar-se. Conclusão: A massa magra reduz as oscilações posturais. Em contrapartida, a massa gorda interfere de forma negativa no equilíbrio postural dinâmico de mulheres com baixa DMO. A estatura esteve relacionada ao equilíbrio postural dinâmico: quanto mais altas as idosas pior era seu equilíbrio. ***Nível de Evidência II, Estudos prognósticos – Investigação do efeito de característica de um paciente sobre o desfecho da doença.***

Descritores: *Idosos. Composição Corporal. Equilíbrio Postural. Densidade Óssea.*

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INTRODUÇÃO

During the aging process, one of the comorbidities that most affect older women is the decrease in bone mineral density (BMD), osteopenia and osteoporosis. They are characterized by the gradual loss of bone mass and the weakening of bones, making them more fragile and susceptible to fractures[1] due to decreased levels of hormones that act in the process of bone remodeling, mechanical load imposed on the skeleton, inadequate feeding, calcium absorption

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The study was conducted at University of São Judas and developed in partnership with the Laboratory Study of Movement, Orthopedics and Traumatology Institute, Universidade de São Paulo.
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and vitamin D. Studies show an association between lower BMD with lower BMI in young[2] and older men.[3]
Falls are prevalent in older adults; however, in those with osteoporosis and osteopenia, falls can be more disastrous, being related to hip fracture. One in 15 older adults die in the hospital phase, and 30.35% die in one year due to complications resulting from these falls, and fractures.[4]
Several risk factors are associated with falls and fractures, including: increasing age, female gender, osteoporosis, early menopause, sedentary lifestyle, decreased balance, etc., and are considered the major public health problems, affecting mainly older women.[5]
The decrease in the capacity of the postural control system to maintain balance increases postural instability.[6] Changes in the central nervous system (CNS) and peripheral nervous system (PNS) that act directly on the vestibular, visual and somatosensory systems[7] compromise neuromuscular responses, modify postural strategies and cause loss of balance.[8] In aging, these changes are constant and aggravate both static and dynamic stability, generating changes in the support base and center of gravity, associating with the loss of motor and sensory strategies, occurring falls.[9]
Body composition presents significant changes with aging and its increase and redistribution is concentrated more in the abdominal cavity than in the lower limbs, so in overweight older women, a higher prevalence of fat is observed among muscle fibers[10] that are associated with muscle weakness, consequently, decreases balance and leads to falls.[11] In this context, some studies have shown that high levels of visceral fat are associated with lower lean mass, greater frailty, higher frequency of sarcopenia and a higher risk of fractures, besides contributing to functional decline.[12]
Greve et al.[13] correlated body mass index (BMI) with postural balance in unipodal support on an unstable platform. The results showed that the higher the BMI value, the greater the displacement demands to maintain postural balance. Zhang et al.[14] and Sheu et al.[15] stated that a higher fat mass is associated with a lower lean mass, greater fragility and an increased risk of fractures. Regarding body composition, fat mass at adequate levels is a relevant factor for bone biomechanical improvement, since it stimulates osteoblasts and may indicate smaller changes in BMD during the aging process.
Postural balance is multifaceted and it is important to map all possible influences it can suffer, so that programs aiming at preserving falls are better elaborated. Literature is controversial regarding the influences of body composition and postural balance due to anthropometric variables, justifying the need to find reliable parameters that can be used for evaluations and programs to prevent falls.
Thus, the aim of our study is to investigate the relationship between body composition and anthropometry with dynamic postural balance in older women with low BMD.

METHODS

This is a cross-sectional design study conducted at The Universidade São Judas Tadeu (USJT) in partnership with the Laboratory of Movement Study (LEM) of the Institute of Orthopedics and Traumatology and the Laboratory of Bone Metabolism of the Discipline of Rheumatology of the Faculdade de Medicina da Universidade de São Paulo. The study was approved by the Research Ethics Committee of the Faculdade de Medicina of Universidade de São Paulo under protocol number no. 306/15.

Participants

Forty-five older women (age ≥ 60 years), with low BMD and low to overweight nutritional diagnosis classified by BMI (according to the WHO), from nearby communities invited via radio calls and social media, participated in our study. The inclusion criteria were being able to perform independent gait and without pain for at least 100 meters; not presenting injury or trauma in the lower limbs in the last three months; be independent in their activities of daily living; diagnosis of osteoporosis or osteopenia. Although none of the participants was excluded from the study, such exclusion criteria were considered: inability to perform some of the tests; systolic blood pressure equal to or above 160 mmHg and diastolic blood pressure equal to or above 120 mmHg at the time of the test.

Procedures

First, the participants were subjected to anthropometric evaluation to assess body mass (kg), height (cm) and BMI (Kg/m^2) – estimated by the equation BMI = weight/height^2.
For the evaluation of body composition, lean and fat mass were measured by dual energy x-ray absorptiometry (DXA), using aHologic QDR 4500A Densitometry Equipment (Hologic Inc. Bedford, MA, USA, model – Discov).
The evaluation of *dynamic postural balance* was performed through two tests:

1) *Balance Master Evaluation System* (BESTest) miniBESTest adapted version and translated into Portuguese. It is a test with 14 tasks and scores from zero to two points that evaluates balance according to postural responses to external disturbances and verticality. It involves biomechanical restrictions, stability limits, postural responses, anticipatory postural adjustments, sensory orientation and dynamic balance during gait and cognitive effect.[16]
2) *NeuroCom Balance Master®* (N*euroCom International, Inc., Clackamas, OR, USA*) was used to assess functional balance, which includes a computer with a force platform, in which information is recorded via piezoelectricity transducers. Force platform information includes X (± 0.08 cm) and Y (± 0.25 cm) positions of the center of vertical force and total vertical force (± 0.1 N) at a sampling frequency of 100 Hz. In this system, the transducers transmit pressure every 10 ms to the computer, so that the center of gravity of the participant and the dynamic balance over a certain period can be estimated.[17]

The following instruments were used for collecting data:
Sit-to-Stand – the participant was instructed to sit on a backrest bench with her feet apart, knees flexed (90°) and to get up quickly and safely while standing for a few seconds. The test was repeated three times in an interval of 30 seconds. The parameters measured were weight transfer (% body mass), the center of gravity in the balance when the participant was raised within the time used and the speed of balance (%/s).[18,19]
Step Up/Over – a 20 cm step placed on the platform was used in front of the participant and she was instructed to climb with her left leg on the step keeping the trunk upright. Subsequently, she lowered the step with his right leg and then with his left leg leaning on the platform. The test consisted of three attempts with an interval of 10 seconds between each of them and changing the sequence of the sides. The variables analyzed were the survey index, movement time and affect index on both sides. Each participant's movement was recorded in seconds from the initiation of the first step of the first leg with the platform. The lifting index was recorded by the percentage of body mass to be elevated, so that the first leg was brought to the top of the step. The affect index measured the percentage of body mass used to descend on the platform.[18,19]

Statistical analysis

The Statistical Package for Social Sciences (SPSS) software version 20 presented by mean, standard deviation, minimum and maximum. The Kolmogorov Smirnov normality test was applied to verify the normal distribution and the Spearman Test to evaluate the correlation between the tests and the p ≥ 0.05 value was adopted for the significance level. The simple linear regression test was applied to

verify the association between fat and bone mass and miniBESTest. This study was approved by the Ethics Committee from the Faculdade de Saúde Pública of Universidade de São Paulo – FSP/USP (Opinion 306/15). All participants signed an informed consent form.

RESULTS

Forty-five older women with a mean age of 65.4 years and mean BMI of 25.6 kg/m^2 were evaluated. Table 1 shows the characteristics of the study population.

Table 1. Characterization of the population according to age, anthropometry and body composition of older women with low bone densitometry.

Variables	Mean (SD)	Minimum	Maximum
Age	**65.4 (4.26)**	**60.00**	**75.00**
Anthropometrics			
Body Mass (Kg)	62.3 (7.82)	41.50	77.50
Height (cm)	1.55 (0.06)	1.41	1.77
BMI (kg/m^2)	25.63 (2.54)	19.47	30.63
Body Composition			
Lean Mass (Kg)	30.93 (8.83)	14.22	48.43
Fat Mass (Kg)	28.62 (12.61)	23.40	43.85
BMD Lumbar spine (g/cm^2)	0.75 (0.22)	0.00	1.27
BMD Femur neck (g/cm^2)	0.63 (0.08)	0.50	0.86

SD: standard deviation; BMD: bone mineral density.

We observed a negative correlation between the miniBESTest balance test ($r = -0.566$; $p \leq 0.001$) and fat mass; and a positive correlation ($r = 0.526$; $p \leq 0.001$) with lean mass.
Negative correlation between the time of going up and down a step on the left side ($r = -0.393$; $p = 0.007$) with fat mass and positive correlation ($r = 0.297$; $p = 0.04$) with lean mass.
Regarding anthropometric variables, only height showed a positive correlation ($r = 0.296$; $p = 0.04$) with the speed of balance in the sitting and lifting test, as shown in Table 2.

Table 2. Correlation of dynamic postural balance with anthropometry and body composition of old women with low bone mineral density (BMD).

	Body mass (Kg) r (p)	Height (cm) r (p)	BMI (Kg/cm^2) r (p)	Fat mass (kg)* r (p)	Lean body mass (kg) r (p)	BMD Lumbar Spine (g/cm^2) r (p)	BMD Femur neck (g/cm^2) r (p)
miniBESTest	–.113 (0.46)	–.060 (0.69)	–.093 (0.54)	–.566 (p 0.001)*	.526 (p 0.001)*	–.173 (0.25)	.111 (0.46)
Up and down a step							
Time R(s)	–.175 (0.24)	–.118 (0.43)	–.102 (0.50)	–.211 (0.16)	.139 (0.35)	–.149 (0.32)	–.207 (0.16)
Time L(s)	–.199 (0.18)	–.256 (0.86)	–.020 (0.89)	–.393 (0.007)*	.297 (0.04)*	–.159 (0.09)	–.251 (0.09)
Impact R	.095 (0.53)	–.048 (0.75)	.139 (0.35)	.209 (0.16)	–.114 (0.44)	.140 (0.25)	.181 (0.22)
Impact L	.047 (0.75)	.079 (0.59)	–.111 (0.46)	.163 (0.27)	–.163 (0.28)	.080 (0.59)	.131 (0.38)
Sit-to-stand (STS)							
Time (s)	–.106 (0.48)	–.279 (0.06)	.079 (0.60)	–.114 (0.45)	.102 (0.50)	–.016 (0.91)	.074 (0.62)
Balance Speed (º/s)	.130 (0.39)	.296 (0.04)*	–.068 (0.65)	.120 (0.42)	–.055 (0.71)	.017 (0.90)	–.050 (0.74)

Spearman Test *$p \leq 0.05$
R: right side; L: left side; s: seconds; °/s: Degrees per second; STS: sit-to-stand.

In the simple regression analysis, lean mass could predict 17% of the best equilibrium value and fat mass 20% (Figure 1).

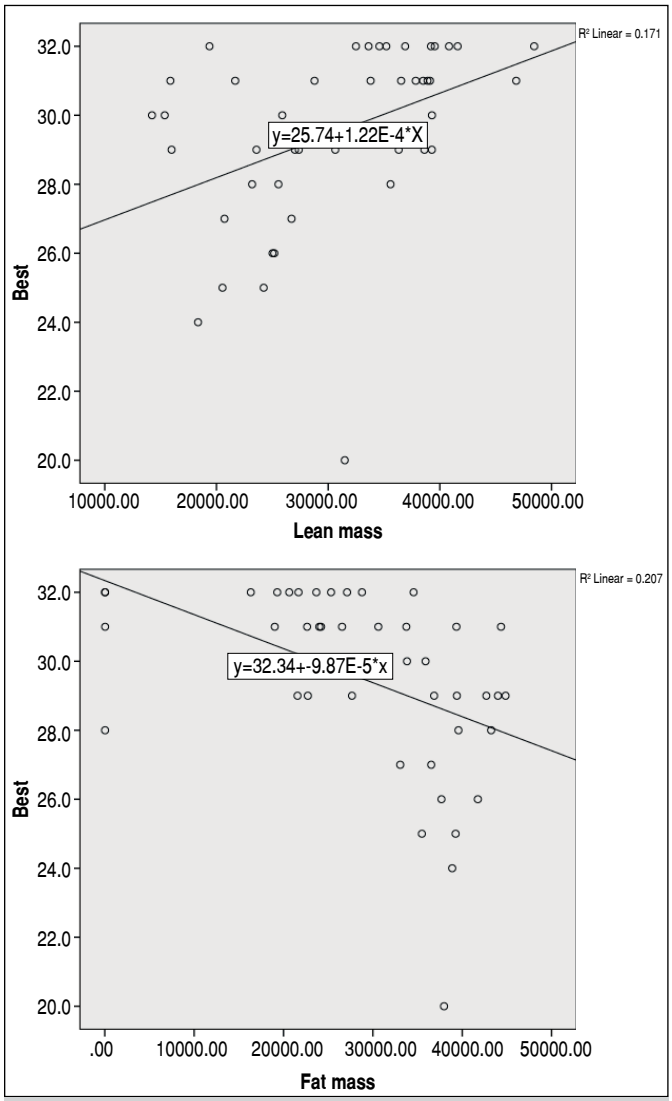

Figure 1. Simple linear regression analysis between balance and lean and fat mass values.

DISCUSSION

The main finding of our study was that fat mass negatively affects dynamic postural balance, whereas lean mass can lead to a preventive effect in women with low BMD. Height acts as an inverted pendulum, taller older adults have higher oscillation speed during postural balance. The miniBESTest, with which the following conditions were tested: a) sensory changes such as vision (open and closed eyes); b) changes of position (sitting to standing); c) different surfaces and support base (unipodal, bipodal, tiptoe, stable and stable surfaces) that stimulate the proprioceptive system; d) walking with changes in head direction to stimulate the vestibular system; e) compensatory anticipation and f) mobility. These conditions help identify postural instability, since the individual relies on sensory information and spatial orientation to minimize situations of sensory conflict that causes imbalance.[16]
In this condition, older women with higher fat mass presented worse performance in balance, and could to explain 20.7% of the test value, in addition to increasing the time of climbing and descending stairs. These results corroborate the study by Carneiro et al.[20], which using the Modified Clinical Test of Sensory Interaction in Balance (CTSIB-M), showed that obese women had lower postural stability

than eutrophic women. Increased fat mass reduces the ability to maintain postural balance in response to external disorders, consequently increasing instability and greater propensity to fall. Moreover, obesity affects the selection of motor strategies used to maintain balance.[17] According to Zhang et al.[14] and Sheu et al.,[15] aging changes the distribution of body fat and is associated with a higher proportion of visceral fat (intra-abdominal) that increases the risk of metabolic diseases, sarcopenia, and functional decline. High visceral fat levels are associated with lower muscle mass, greater frailty and an increased risk of falls and consequently fracture by intramuscular fat infiltration. Another aspect to be discussed is lifestyle, individuals with higher percentage of fat, in general, are more sedentary, consequently presenting lower muscle mass and lower motor ability to maintain postural balance.

On the other hand, the higher the lean mass, the better the performance of postural balance measured by MiniBest. These results can be explained. A more developed and trained musculature, individuals with higher lean mass have a more active lifestyle, with more appropriate diet patterns.[3] The study by Scott et al.[21] showed that the higher muscle density of the leg decreases postural oscillations, suggesting that the increased risk of fractures in sarcopenic obesity can be explained by the low quality of the muscle, which can lead to worsening of postural balance.

Regarding anthropometric variables, the higher the height, the higher the speed of balance in the sit-to-stand test. These findings corroborate previous studies by Alonso et al.[17] and Alonso et al.[22] that state that postural balance can be modeled by the inverted pendulum in the sagittal plane, which increases the oscillations around the ankle joint and the response of the gastrocnemius (ankle strategy). In the frontal plane, the posture is modeled by an inverted double pendulum (hip strategy). The speed of balance is a response to the control of the position of the center of masses.

The limitations of the study are related to the nature of the postural balance, which is multifactorial, and in our study, we evaluated only body composition and anthropometry that can affect balance and consequently lead to falls. However, with the habits of modern life, they often lead to increased global obesity and a sedentary lifestyle aggravates the risk of falls in already vulnerable women.

Therefore, our study clinically proves that not only a motor exercise, but also an association of exercises that promote muscle mass gain and decrease in fat mass is necessary to obtain improvement of postural balance in people with higher fat mass and low BMD.

CONCLUSION

Lean mass reduces postural oscillations and therefore can reduce the risk of fracture. On the other hand, the fat mass negatively interfered with dynamic postural balance in women with low BMD. Height was the only anthropometric variable related to dynamic postural balance, i.e., the higher the older women, the worse their balance.

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REPRODUCIBILITY OF MODIFIED WALDENSTRÖM CLASSIFICATION IN PERTHES DISEASE

REPRODUTIBILIDADE DA CLASSIFICAÇÃO DE WALDENSTRÖM MODIFICADA NA DOENÇA DE PERTHES

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ABSTRACT

Objective: The purpose of our study is to evaluate intraobserver and interobserver reliability of modified Waldenström classification system for Legg-Calvé-Perthes disease and assess the influence of the professional's area of expertise in the assessment. Methods: Twelve evaluators assessed 40 pairs of pelvic radiographs of patients with Legg-Calvé-Perthes disease. After two weeks, a new evaluation was performed by the same evaluators. Kappa and Kendall's W indexes were used to evaluate both intraobserver and interobserver reliability and determine the influence of the evaluators' experience and area of expertise. Results: The average intraobserver kappa value was 0.394, with a reasonable agreement level. The interobserver Kappa value was 0.243 in the first evaluation (95% CI, 0.227-0.259 and $p < 0.0001$) and 0.245 in the second evaluation (95% CI, 0.229-0.260 and $p < 0.0001$). The Kendall's W values obtained for pediatric orthopedists, radiologists and resident physicians were 0.686, 0.630 and 0.529 ($p < 0.0001$), respectively. Conclusion: The modified Waldenström classification presented both moderate and reasonable levels of intraobserver agreement, and reasonable level of interobserver agreement. The evaluators' degree of experience and area of expertise influenced the concordance level found. ***Level of Evidence II, Diagnostic Studies – Investigating a Diagnostic Test.***

Keywords: Legg-Calve-Perthes Disease. Radiography. Osteonecrosis. Child. Hip Joint.

RESUMO

Objetivo: O objetivo deste estudo é avaliar a confiabilidade intraobservador e interobservador do sistema de classificação de Waldenström modificado para a doença de Legg-Calvé-Perthes e avaliar a influência da experiência do profissional na avaliação. Métodos: Doze avaliadores analisaram 40 pares de radiografias pélvicas de pacientes com doença de Legg-Calvé-Perthes. Após duas semanas, nova avaliação foi realizada pelos mesmos avaliadores. Os índices Kappa e Kendall's W foram usados para analisar a confiabilidade intraobservador e interobservador e para determinar a influência da experiência e perícia dos avaliadores. Resultados: O valor médio do kappa intraobservador foi de 0,394, com razoável concordância. O valor de Kappa interobservador foi de 0,243 na primeira avaliação (IC 95%, 0,227-0,259 e $p < 0,0001$) e 0,245 na segunda (IC 95%, 0,229-0,260 e $p < 0,0001$). Os valores W de Kendall obtidos para ortopedistas pediátricos, radiologistas e médicos residentes foram 0,686, 0,630 e 0,529 ($p < 0,0001$), respectivamente. Conclusão: A classificação de Waldenström modificada apresentou níveis moderados e razoáveis de concordância intraobservador e razoável concordância interobservador. O grau de experiência e especialização dos avaliadores influenciou o nível de concordância encontrado. ***Nível de Evidência II, Estudos diagnósticos – Investigação de um exame para diagnóstico.***

Descritores: *Doença de Legg-Calvé-Perthes. Radiografia. Osteonecrose. Criança. Articulação do Quadril.*

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INTRODUCTION

Legg-Calvé-Perthes disease (LCPD) is defined as idiopathic a femoral head osteonecrosis that occurs in childhood. The annual prevalence ranges from 5.1 to 16.9 per 100,000 children between ages 2 and 14 in several regions of the world[1-3] and affects more the boys. The etiology is still unknown, but many theories have been proposed an origin, including trauma, inflammatory process, vascular occlusion, thrombophilia, maternal smoking and Type II collagen mutations. Despite the different theories, most authors agree that it is a multifactorial disease with genetic and environmental factors leading to a common clinical and pathological presentation.[4] Although the etiology remains unconfirmed, the disease key manifestation is the vascular occlusion of the femoral head, causing an ischemic necrosis followed by structural changes that lead to

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The study was conducted at Hospital das Clínicas, Orthopedics and Traumatology Institute.
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sphericity loss and abnormal hip growth. Since the vascular occlusion is temporary, the disease is self-limiting. Nevertheless, once revascularization and reossification occurs, its acknowledgment and management are essential to prevent deformity, which may occur due to the femoral head susceptibility to mechanical load during the necrosis phase, and may evolve to early arthrosis, pain and functional loss of the affected hip.[4]

One of LCPD challenges is to predict the disease course based on symptoms' manifestation. Clinical and radiographic events have been used to establish prognostic factors and indicate therapeutic interventions in a timely manner, aiming at reducing deformation risks.

Although magnetic resonance imaging is currently more sensitive and accurate in assessing the extension degree of existent necrosis,[5] radiography remains as the most affordable and used examination. There is still no consensus about the use of radiography to predict the natural course of the disease, and several radiographic rating systems have been used and modified to establish prognostic factors and guide interventions.

In 1922, Waldenström[6] proposed a classification system based on four LCPD radiographic stages: I – initial or avascular stage; II – fragmentation stage; III – reossification or healing stage; and IV – healed stage.

The three most important subsequent classifications were intended to indicate a prognosis and were described in the fragmentation phase: Salter and Thompson,[7] Catterall[8] and Herring et al.[9,10]

However, none of these classifications ensure a prognostic value for a specific patient. Moreover, they present conflicting results in both inter and intraobserver evaluations.[11-17] In 2003, a study by Joseph et al.[13] proposed a new classification, which was meant to be a modified and updated version of the classification proposed by Canale et al.,[14] which became known as "modified Waldenström classification" (1972). This classification seems to be very reproducible,[13,15] according to the authors, and it should be routinely applied to study the evolution of Legg-Calvé-Perthes disease.

In the modified Waldenström classification, the stages are: IA, IB, IIA, IIB, IIIA and IIIB and IV. The stage IA is the sclerotic phase with no loss of epiphyseal height, while IB presents both sclerosis and epiphyseal height loss. In stage IIA, the epiphysis begins to fragment, and one or two vertical fissures can be seen. In stage IIB, this fragmentation is at advanced stage, but without lateral bone formation at the fragmented epiphysis. In stage IIIA, there is evidence of new bone formation at the peripheral necrotic region, but still without a normal texture and it covers less than a third of the epiphyseal region. In stage IIIB, the forming bone texture is normal and covers over a third of the epiphyseal region. In stage IV, there is no more avascular bone.[13]

The new classification system includes the disease evolution and helps to identify the onset of epiphyseal, metaphyseal and acetabular events related to the prognosis worsening. The authors argue that the understanding of these aspects may help determine how any treatment could alter the illness natural course.[13,15]

Therefore, the purpose of our study is to evaluate intraobserver and interobserver reliability of the modified Waldenström classification system for Legg-Calvé-Perth disease. Secondly, it aims at assessing if different results are obtained when the evaluation is performed by professionals of two different areas of expertise (Pediatric Orthopedics and Radiology) with diverse work experience (assistants, interns, and resident physician) from our institution.

MATERIALS AND METHODS

Institutional Review Board approval from our institution were obtained (number of the decision: 1.967.830).

In total, 12 evaluators participated in our study, four pediatric orthopedists with over five years of work experience, four skeletal muscle radiologists and four orthopedics and trauma residents. The evaluators attended an introductory lecture of approximately 10 minutes on the aspects of the disease and its classification stages. Each evaluator received a table (Appendix 1) to be filled during the evaluation and an appendix containing the classification to be used. After the delivery of the material, 40 pairs of anteroposterior and frog-leg pelvic radiographs were presented to the evaluators, (Figure 1) distributed randomly according to the different disease stages.

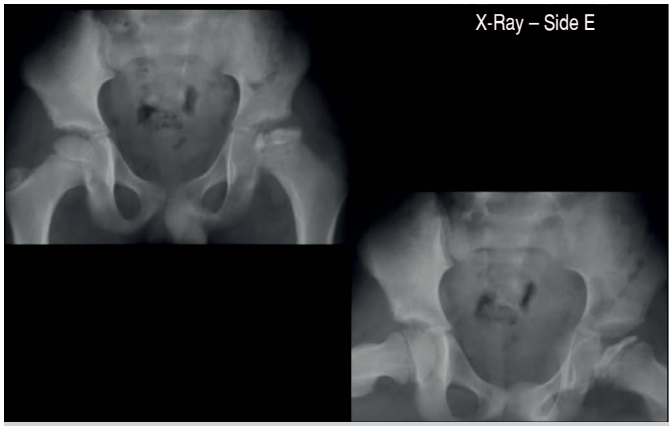

Figure 1. Slide presentation model of radiographic examinations in anteroposterior and frog-leg views.

After 2 weeks, a new evaluation was performed in the same way and following the same criteria of the first one. The same radiography pairs were randomly assigned; however, they followed a different order from the first evaluation.

The statistical analysis was performed by using Kappa index (Table 1).[18]

Table 1. Correlation between K values and concordance level.

Kappa index	Concordance level
< 0.00	No concordance
0.00-0.20	Minimal concordance
0.21-0.40	Reasonable concordance
0.41-0.60	Moderate concordance
0.61-0.80	Substantial concordance
0.81-1.00	Perfect concordance

To check agreement level regarding the different areas of expertise and work experience, a new statistical analysis was performed using Kendall's W test.[19]

RESULTS

The intraobserver evaluation obtained an average Kappa value of 0.394, with 95% confidence interval and with a reasonable agreement level. All pediatric orthopedists, one radiologist, and one resident physician presented a moderate agreement level. The other participants, that is, three radiologists and three resident physicians, presented Kappa values between 0.21 and 0.40, with a reasonable agreement level. Table 2 shows the results of Kappa indexes and confidence intervals regarding the twelve participants.

Table 2. Kappa values and the correlation with the concordance level in intraobserver evaluation of twelve evaluators.

Evaluators	95% CI	Kappa	Concordance Level
Pediatric orthopedics			
1	0.274 to 0.607	0.441	Moderate
2	0.338 to 0.700	0.518	Moderate
3	0.260 to 0.615	0.437	Moderate
4	0.343 to 0.700	0.521	Moderate
Radiologist			
1	0.236 to 0.591	0.413	Moderate
2	0.197 to 0.555	0.376	Reasonable
3	0.133 to 0.475	0.304	Reasonable
4	0.195 to 0.565	0.380	Reasonable
Residents			
1	0.127 to 0.497	0.312	Reasonable
2	0.293 to 0.661	0.477	Moderate
3	0.098 to 0.458	0.278	Reasonable
4	0.102 to 0.444	0.273	Reasonable

The interobserver evaluation obtained a Kappa value of 0.243 among all twelve evaluators in the first evaluation (95% CI, 0.227-0.259 and $p < 0.0001$) and Kappa value = 0.245 among the twelve evaluators in the second evaluation (95% CI, 0.229-0.260 and $p < 0.0001$). The two evaluation levels of inter-evaluative concordance were considered reasonable.

A new statistical analysis was performed using Kendall's W test to compare the influence of the area of expertise and work experience on the interobserver evaluation. Figure 2 shows the results referring to each of the three groups studied.

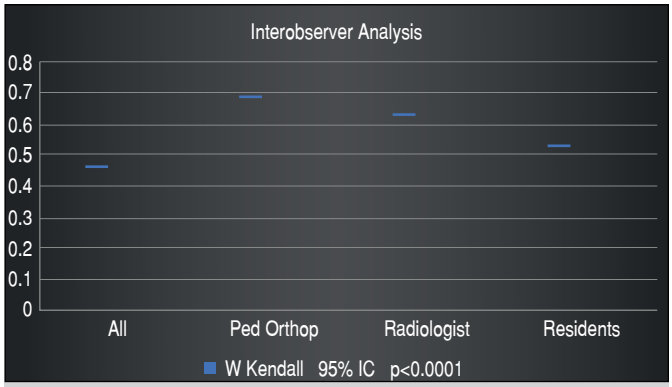

Figure 2. W Kendall values for interobserver agreement evaluation.

DISCUSSION

Legg-Calvé-Perthes disease can be defined as a juvenile form of idiopathic osteonecrosis of the femoral head, since it affects children aged between 2 and 14. It is considered the most common form of femoral head osteonecrosis, with prevalence ranging from 5.1 to 16.9 per 100,000 children in several regions of the world.[1-3] Since the first reports of this unique condition, made approximately 100 years ago by Legg, Calvé, and Perthes, several studies have been published on its etiology, epidemiology, natural history, radiographic classifications and treatment. Despite the increase in research related to Legg-Calvé-Perthes disease, it remains one of the most controversial conditions in pediatric orthopedics.

Current treatment for Legg-Calvé-Perthes disease is focused on obtaining and maintaining a good hip movement amplitude by restricting femoral head movement in the acetabulum. It is believed that, by following this treatment, the femoral head will be congruent with the acetabulum, reducing residual problems.

However, the difficulty of correlating the degree of femoral head lateral subluxation with the final residual deformity raises controversy on what would be the most effective treatment for patients with the disease. The available procedures range from non-surgical interventions, including physical therapy, orthoses and plaster cast to surgical interventions, such as: proximal femoral varus osteotomy, pelvic osteotomy,[14] and arthrodiastasis. Studies suggested that surgical containment may benefit a certain age group of Legg-Calvé-Perthes patients. These studies, however, did not address the relevant question on the best time to intervene with surgical treatment. Understanding the natural history of the disease and identifying the pathology stage affect both treatment decisions and outcome.

Monitoring the disease evolution by radiographic examinations is essential for therapeutic decision-making. Studies with other imaging methods, such as arthrography and MRI[5] were also proposed; however, the difficulty of conducting these serial examinations interferes with the evolutionary monitoring of the pathology.

Therefore, some radiographic classifications were proposed to determine the disease severity and relate it to the final prognosis. Three main classification systems were proposed by Catterall,[8] Salter and Thompson[7] and Herring.[9,10]

Despite the relevance of these classification systems to estimate the disease severity, it also requires a reliable classification system to determine the disease stage, since the intervention time may have a material effect on the treatment results.

The Waldenström classification is the only classification for staging Legg-Calvé-Perthes disease. Thorough its course, the disease produces characteristic radiographic changes in the femoral epiphysis that were subdivided into four temporal stages [6]: necrosis, fragmentation, reossification and residual stage.

Joseph et al.[13] modified Waldenström classification system and subdivided the first three stages into early (A) and late (B). Joseph et al.[13] proved that children surgically treated until the stage of early fragmentation IIA have a greater chance of presenting spherical and congruent femoral head and acetabulum in the residual stage when compared with those surgically treated in later stages of the disease. Therefore, they defended the use of modified Waldenström classification system to guide treatment decision-making. In this study, the modified classification showed solid interobserver and intraobserver reliability (Kappa = 0.72 and 0.71, respectively) [13]. Hyman et al.[15] also obtained a substantial and almost perfect interobserver and intraobserver agreement in several stages of their study. Twenty evaluators, all highly experienced pediatric orthopedists, evaluated 40 pairs of AP and frog-leg pelvic radiographs. Together with the images, the evaluators were provided data, such as patients' age, gender and time of symptom onset.

In both inter and intraobserver evaluation of our study, a slightly lower agreement level was obtained when compared with previous studies. The intraobserver evaluation obtained moderate and reasonable agreement levels, with Kappa value ranging from 0.273 to 0.521, whereas the interobserver analysis obtained a reasonable agreement level in the two evaluations, with Kappa values of 0.243, in the first evaluation, and 0.245, in the second one. Considering that our study involved the same number of radiographs and participants of other studies,[13,15] we attributed the agreement difference to two main factors.

The first factor is related to the evaluators' varied work experience and area of expertise in our study, which was greater than in Hyman et al.[15] and Joseph et al.[13] studies. In the latter two studies, only pediatric orthopedists with prior classification knowledge and highly experienced were assigned as evaluators. We divided the

evaluators in three groups to assess the influence of this factor on the results: experienced pediatric orthopedists, skeletal muscle radiologists, and orthopedics and trauma residents. The intraobserver analysis showed that in, the group of experienced pediatric orthopedists, four observers showed moderate concordance, with kappa ranging from 0.441 to 0.521, whereas the muscle skeletal radiologists' group presented Kappa ranging from 0.304 to 0.413 and only one observer showed moderate concordance, and the resident physicians' group, in which only one observer presented moderate concordance level, with Kappa values of 0.273 and 0.447 among observers. We used Kendall's W test in the interobserver evaluation to estimate the agreement difference among the three groups. The Kendall's W concordance coefficient indicates the degree of ordinal association assessments made by several evaluators when assessing the same samples. Kendall's W values can range from 0 to 1, and the highest Kendall value refers to the strongest association. In our study, Kendall's W coefficient results were higher for experienced pediatric orthopedists (W = 0.686) when compared with the skeletal muscle radiologists (W = 0.630) and the orthopedics and trauma residents (W = 0.529). Therefore, we can say the evaluators' degree of experience and area of expertise influences the agreement level found for the modified Waldenström classification.

The second factor is related to the fact that, unlike the other studies, our study does not provide extra data, such as age, gender and time of symptom onset. We believe that only acetabular and femoral changes presented in AP and frog-leg pelvic radiographs should be enough for the assertive classification of the disease. However, considering that this is an evolutionary classification, with progressive radiographic changes, and the Legg-Calvé-Perthes disease natural history already described by some studies, the time of the disease onset should be considered and may have influenced the increased level of intra and interobserver concordance. The effect of the presence of such data on the evaluation, however, has not been studied and its inclusion should be considered in future studies on classification description.

Although intraobserver and interobserver agreement levels of our study are lower than those presented in previous literature, we believe that our findings show that Waldenström classification is reproducible and it is the best current option for the evolutionary monitoring of Legg-Calvé-Perthes disease. Prior knowledge of the classification, experience in treating patients diagnosed with Legg-Calvé-Perth and additional data, such as the time of disease onset, gender and age, can increase the level of intraobserver and interobserver concordance.

Our study has one limitation: the absence of a clear gold standard for staging each of the cases, which could not be obtained due to the difficulty of determining the stage of each case, despite the large experience of the pediatric orthopedists' group. We decided not to rank the answers, as it was done in Hyman et al.,[15] as early stages (up to stage IIA) and late stages (after stage IIB), because we believe that it is important to distinguish all stages of the disease evolution.

CONCLUSION

The modified Waldenström classification presented a moderate and reasonable level of intraobserver agreement. The interobserver agreement level was considered reasonable in the two evaluations. The evaluators' degree of experience and area of expertise influenced the agreement level among the different groups studied. The concordance level among pediatric orthopedists with over five years of experience was higher than the one between muscle skeletal radiologists and orthopedics and trauma residents.

Prior knowledge of the classification, experience in the disease treatment, and additional data, such as gender, age, and time of the disease onset, probably play an important role on the classification agreement level, adding the need for further studies to confirm this hypothesis.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. FGC: study conception and design, bibliographic review, writing of the article, result interpretation, article review and approval of the final version; PMG: article review and approval of the final version; BSFM: data collection, result interpretation and approval the final version; NBM: result interpretation, article review and approval of the final version; RG: study conception and design, article review and approval of the final version.

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APPENDIX 1

Modified Waldenström classification – Date: ___/___/___
Did you receive any orientation about the classification? ___Y ___N

1. What is your degree of experience?
a) Orthopedic Assistant ( ) How long? ____
b) Orthopedic Resident
c) Radiologist
2. Classify the radiographs below:

1 Ia Ib IIa IIb IIIa IIIb IV	21 Ia Ib IIa IIb IIIa IIIb IV
2 Ia Ib IIa IIb IIIa IIIb IV	22 Ia Ib IIa IIb IIIa IIIb IV
3 Ia Ib IIa IIb IIIa IIIb IV	23 Ia Ib IIa IIb IIIa IIIb IV
4 Ia Ib IIa IIb IIIa IIIb IV	24 Ia Ib IIa IIb IIIa IIIb IV
5 Ia Ib IIa IIb IIIa IIIb IV	25 Ia Ib IIa IIb IIIa IIIb IV
6 Ia Ib IIa IIb IIIa IIIb IV	26 Ia I1b IIa IIb IIIa IIIb IV
7 Ia Ib IIa IIb IIIa IIIb IV	27 Ia Ib IIa IIb IIIa IIIb IV
8 Ia Ib IIa IIb IIIa IIIb IV	28 Ia Ib IIa IIb IIIa IIIb IV
9 Ia Ib IIa IIb IIIa IIIb IV	29 Ia Ib IIa IIb IIIa IIIb IV
10 Ia Ib IIa IIb IIIa IIIb IV	30 Ia Ib IIa IIb IIIa IIIb IV
11 Ia Ib IIa IIb IIIa IIIb IV	31 Ia Ib IIa IIb IIIa IIIb IV
12 Ia Ib IIa IIb IIIa IIIb IV	32 Ia Ib IIa IIb IIIa IIIb IV
13 Ia Ib IIa IIb IIIa IIIb IV	33 Ia Ib IIa IIb IIIa IIIb IV
14 Ia Ib IIa IIb IIIa IIIb IV	34 Ia Ib IIa IIb IIIa IIIb IV
15 Ia Ib IIa IIb IIIa IIIb IV	35 Ia Ib IIa IIb IIIa IIIb IV
16 Ia Ib IIa IIb IIIa IIIb IV	36 Ia Ib IIa IIb IIIa IIIb IV
17 Ia Ib IIa IIb IIIa IIIb IV	37 Ia Ib IIa IIb IIIa IIIb IV
18 Ia Ib IIa IIb IIIa IIIb IV	38 Ia Ib IIa IIb IIIa IIIb IV
19 Ia Ib IIa IIb IIIa IIIb IV	39 Ia Ib IIa IIb IIIa IIIb IV
20 Ia Ib IIa IIb IIIa IIIb IV	40 Ia Ib IIa IIb IIIa IIIb IV

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REPRODUCIBILITY OF S2-ALAR ILIAC SCREW MORPHOMETRIC ANALYSIS

REPRODUTIBILIDADE DA ANÁLISE MORFOMÉTRICA DO PARAFUSO S2-ASA DO ILÍACO

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ABSTRACT

Objective: To evaluate the reproducibility of a S2-alar iliac (S2AI) screw parameters measurement method by inter and intraobserver reliability. Methods: Cross-sectional study, considering computed tomography exams. Morphometric analysis was performed by multiplanar reconstructions. Screw length, diameter and trajectory angles were the studied variables. To analyze the measurements reproducibility, intraclass correlation coefficient (ICC) was used. Results: Interobserver reliability was classified as strong for screw shortest length (ICC: 0.742) and diameter (ICC: 0.699). Interobserver reliability was classified as moderate for screw longest length (ICC: 0.553) and for screw trajectory angles in the axial plane for the longest (ICC: 0.478) and for the shortest lengths (ICC: 0.591). Intraobserver reliability was interpreted as excellent for screw shortest (ICC: 0.932) and longest lengths (ICC: 0.962) and diameter (ICC: 0.770) and screw trajectory angles in the axial plane for the screw longest (ICC: 0.773) and shortest lengths (ICC: 0.862). There were weak interobserver and strong intraobserver reliabilities for trajectory angle in sagittal plane, but no statistical significance was found. Conclusion: Inter and intraobserver reliability of S2AI screw morphometric parameters were interpreted from moderate to excellent in almost all studied variables, except for the screw trajectory angle in the sagittal plane measurement. ***Level of Evidence IV, Diagnostic Studies – Investigating a Diagnostic Test.***

Keywords: Spine. Sacroiliac Joint. Sacrum. Tomography. Reproducibility of Results.

RESUMO

Objetivo: Avaliar a reprodutibilidade, por meio da concordância inter e intraobservador, de um método de aferição dos parâmetros sacropélvicos do parafuso S2-asa do ilíaco (S2AI). Métodos: Estudo transversal, considerando exames de tomografia computadorizada. A análise morfométrica foi feita por meio de reconstruções multiplanares. As variáveis estudadas foram: comprimento, diâmetro e ângulos de trajetória do parafuso S2AI. Para análise da reprodutibilidade das medidas, utilizou-se o coeficiente de correlação intraclasse (ICC). Resultados: A confiabilidade interobservador foi classificada como forte para o menor comprimento (ICC: 0,742) e diâmetro (ICC: 0,699). Em relação ao maior comprimento (ICC: 0,553) e aos ângulos de trajetória axial para o maior (ICC: 0,478) e para o menor comprimento (ICC: 0,591), a confiabilidade interobservador foi classificada como moderada. A confiabilidade intraobservador foi excelente para o menor (ICC: 0,932) e maior comprimentos (ICC: 0,962), diâmetro (ICC: 0,770) e ângulos de trajetória axial (ICC: 0,773 - maior comprimento; ICC: 0,862 - menor comprimento). Houve confiabilidade interobservador fraca e intraobservador forte para o ângulo de trajetória sagital, porém sem significância estatística. Conclusão: A correlação inter e intraobservador dos parâmetros morfométricos do parafuso S2AI mostrou-se de moderada a excelente em quase todas as variáveis estudadas, exceto para o ângulo de trajetória sagital. ***Nível de Evidência IV, Estudos diagnósticos – Investigação de um exame para diagnóstico.***

Descritores: *Coluna Vertebral. Articulação Sacroilíaca. Sacro. Tomografia. Reprodutibilidade dos Testes.*

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INTRODUCTION

Long instrumentation in the spine, which includes the sacrum, requires additional pelvic fixation in order to minimize the high failure rates when the S1 pedicular screw is used alone distally.[1-4] In this context, several techniques of spinal pelvic fixations were described to add stability and rigidity to instrumentation, including transiliac bars, iliac screws and sacroiliac screws.[5-8]

Relatively newer, the S2-alar Iliac screw (S2AI) technique has been developed and has been recognized as a viable sacropelvic fixation option.[1,9] The minor dissection necessary for the insertion

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The study was conducted at Hospital das Clínicas of the Ribeirão Preto School of Medicine, Universidade de São Paulo.
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of this screw; the less prominence of the implant, with consequent lower rates of dehiscence and infection of the surgical wound; and the elimination of the need for modular connectors, since the entry point of the S2AI screw is in line with proximal fixation, are some of the benefits in relation to other techniques.[1,7,9-12]
Although the literature has suggested anatomical parameters for the use of the S2AI screw,[3,4,10,11] there are gaps concerning the reliability of these findings. The aim of this study is to evaluate the reproducibility, through the analysis of inter and intraobserver agreement, of a way of evaluating the sacropelvic parameters necessary for the safe insertion of the S2AI screw.

MATERIALS AND METHODS

The research project was approved by the Research Ethics Committee of the institution, including the exemption from the informed consent form, with process no. 788/2019 (CAAE: 08968219.4.0000.5440).
This is a cross-sectional observational study, considering computed tomography (CT) of the pelvis. Inclusion criteria were the 100 most recent pelvis CTs in the institution's archive, patients over 18 years of age and of both sexes. Of these consecutively selected tests, 66 were met by the exclusion criteria because they had undergone previous surgery in pelvic or lumbosacral region and/or pathologies affecting the sacropelvic segment (fracture, tumor, infection, congenital anomaly, ankylosing spondylitis), totaling n = 34 cases, of which 18 are male and 16 female, whose age ranged from 18 to 86 years, with a mean of 52.11 years, median of 57.5 years and standard deviation (SD) of 18.56 years. The tests were performed on the multislice computed tomography devices of the institution (Philips® Big Bore 16, Netherlands and Toshiba® Aquilion 64, Japan), with field of view protocol (FOV) 500 mm, 120 kV, milliamperage (mA) varying according to patient weight, cutting thickness and reconstruction interval of 1 mm.
The CTs were downloaded in digital imaging and communications in medicine (DICOM) format, and the images were transferred to Horos® software, version 1.1.7. The images were analyzed in a bone window (window level between 300 and 350 HU) and reconstructed in multiplanar models, using the Multiplanar reformatting (MPR) 3D function. The reslicing tool was used to obtain minute anatomical alignment. The variables studied were the following morphometric parameters of the S2AI screw: longer length (LL), shorter length (SL), diameter (DIAM), axial plane trajectory angle (ATA) for the longer length (ATALL), ATA for the shorter length (ATASL) and trajectory angle in the sagittal plane (STA) (Table 1).

Table 1. S2AI screw variables analyzed in this study.

S2AI screw parameter	Abbreviation
shorter length	SL
longer length	LL
diameter	DIAM
axial trajectory angle for the shorter length	ATASL
axial trajectory angle for the longer length	ATALL
sagittal trajectory angle	STA

The methodology for evaluating the exams was performed as follows: Initially, a multiplanar reconstruction was performed from the median cut of the sagittal plane, with inclination of the axis of the series of axial sections (Figure 1), to find the image, in the axial oblique plane, in which the Vertebra S2 and the anteroinferior iliac spine are seen in the same section (Figure 2). Then, in the oblique coronal reconstruction, the longitudinal axis was adjusted in the center of the pelvis, and the line representing the oblique axial cut, at the midpoint between the foramens of S1 and S2. After that, the STA was measured in relation to the S1 plateau (Figure 3) and the entry point of the S2AI screw was demarcated in the oblique axial reconstruction. The point of entry considered was the midpoint of the posterior cortical of the sacrum between the foramens of S1 and S2.[3,13] Still in the oblique axial plane, the LL and the SL of the screw were measured (Figure 4), tangentially the internal and external corticals of the iliac, respectively; the largest viable DIAM of the screw, which corresponds to the smallest measure of the virtual space between the inner and outer tables of the iliac (Figure 4); and the ATAs (ATALL and ATASL) in relation to the anteroposterior line, perpendicular to the horizontal line of the pelvis (Figure 5). Knowing that the diameter of the implants is determined by the measurement of the internal screw size, 3.75 mm (half of the diameter of the chosen implant (7.5mm)) was subtracted medially and laterally so that the screw threads do not violate the iliac bone corticals (Figure 6). Linear parameters were measured in millimeters and angular parameters were measured in degrees.

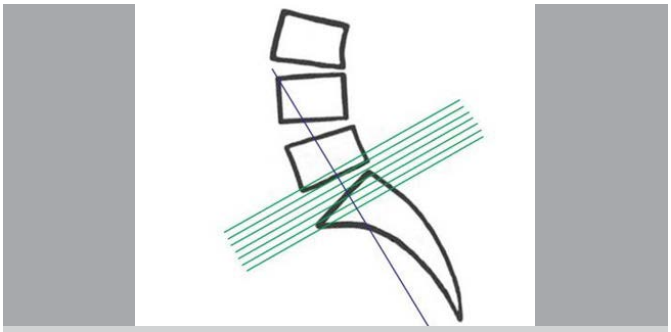

Figure 1. Inclination of the axis (blue) of the series of axial cuts (green), performed to obtain Figure 2.

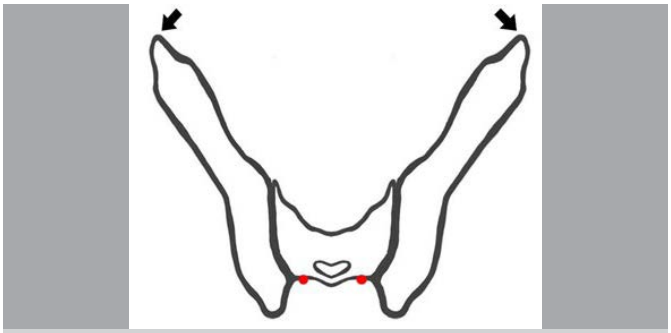

Figure 2. Cut into the oblique axial plane where the entry point of the S2AI screw (red dots) and the anteroinferior iliac spine (arrow) are in the same plane.

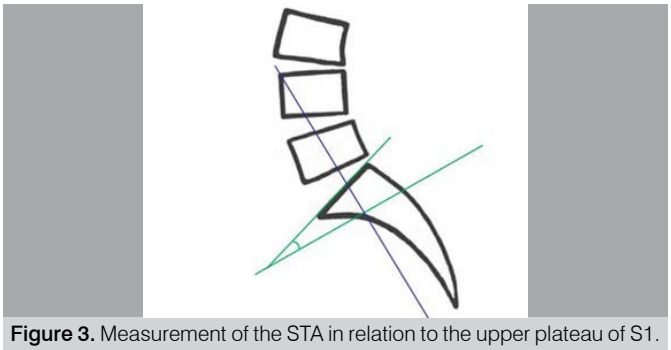

Figure 3. Measurement of the STA in relation to the upper plateau of S1.
STA: sagittal trajectory angle

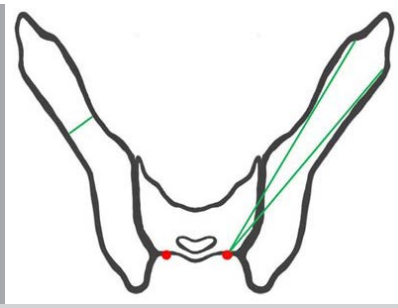

Figure 4. Measurement of LL and SL of the S2AI screw, tangentially with the internal and external corticals of the left ilium, respectively. On the right, we can see the measurement of the largest viable DIAM of the S2AI screw, which corresponds to the smaller thickness of the virtual space between the corticals or ilium.
LL: longer length; SL: shorter length; DIAM: diameter.

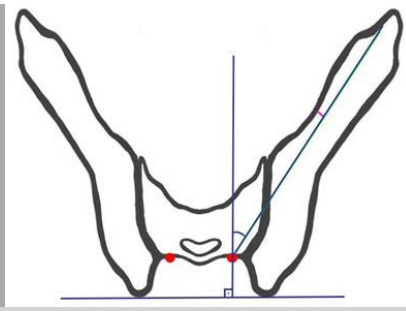

Figure 5. Measurement of the ATA in relation to the anteroposterior blue line of the sacrum, perpendicular to the horizontal line of the pelvis.
ATA: axial trajectory angle.

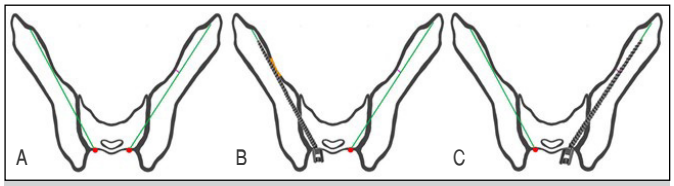

Figure 6. A) LL demarcations of the S2AI screw tangent to the medial cortical of the right iliac bone and with medial subtraction of half the diameter of the implant in the left iliac bone; B) S2AI screw inserted following the planning carried out on the right: Note the violation of the medial cortical of the iliac (orange). C) S2AI screw inserted following the planning carried out on the left: There is no violation of the corticals of the ilium.
LL: longer length

All tomographies were analyzed by two researchers. Reseacher 1, orthopedist and master's student, performed the evaluation of the tomographies in two moments with monthly interval. Researcher 2, medical student in the 5th year, evaluated the exams in a single moment, two weeks after having undergone a training period with researcher 1, which consisted of a class and three shifts of analysis of the images, following a *checklist,* with weekly intervals.
The data were tabulated and analyzed in the Microsoft Excel software®version 15.29 and the results were shown in average, maximum and minimum values, SD and confidence interval (CI), considering confidence level of 95%. For the purpose of analyzing the reproducibility of the measurements, through inter and intraobserver agreement, the data were imported into the IBM SPSS *Statistics*® version 25 software and the intraclass correlation coefficient (ICC) was used, with the following interpretation: < 0.4: weak; from 0.4 to 0.6: moderate; from 0.6 to 0.75: strong; from 0.75 to 1.0: excellent. The results were considered statistically significant when $p < 0.05$.

RESULTS

In the 34 exams evaluated, LL measurement ranged from 86.8 to 137.5 mm, with an average of 108.9 mm (95%CI: 104.96 – 113.01 mm) and SL, from 73.7 to 117.6 mm, with an average of 98.1 mm (95%CI: 94.62 – 101.72 mm). The measurement of DIAM ranged from 9.2 to 21.2 mm, with a mean of 13.8 mm (95%CI: 12.75 – 14.91 mm). Regarding ATALL, we observed an average of 38.1º (95%CI: 36.12 – 40.06º) and an average variation in relation to ATASL of 3.3º (95%CI: 2.79 – 3.92º). The ATS ranged from 4.8 to 10.2º,with an average of 7.1º (95%CI: 6.61 – 7.53º).
The LL measurement of the S2AI screw showed moderate interobserver reliability (ICC: 0.553 – 95%CI: 0.231 – 0.832) and excellent intraobserver reliability (ICC: 0.962 – 95%CI: 0.829 – 0.992). The interobserver reliability found for the SL of the screw was classified as strong (ICC: 0.742 – 95%CI: 0.480 – 0.872) and intraobserver reliability, as excellent (ICC: 0.932 – 95%CI: 0.690 – 0.986).
The DIAM of the S2AI screw showed strong interobserver reliability (ICC: 0.699 – 95%CI: 0.387 – 0.851) and excellent intraobserver reliability (ICC: 0.770 – 95%CI: 0.096 – 0.954).
Regarding ATAs, there was moderate interobserver reliability for ATALL (ICC: 0.478 – 95%CI: 0.040 – 0.739) and also for ATASL (ICC: 0.591 – 95%CI: 0.382 – 0.909). On the other hand, the intraobserver reliability found was excellent for both ATALL (ICC: 0.773 – 95%CI: 0.235 – 0.958), and ATASL (ICC: 0.862 – 95%CI: 0.068 (0.974).
There was weak interobserver reliability (ICC: 0.249 – 95%CI: -0.141 – 0.364) and strong intraobserver reliability (ICC: 0.610 – 95%CI: 0.209 – 0.918) for the STA, but these differences did not present statistical significance ($p > 0.05$).
The results of the study are summarized in Tables 2, 3 and 4.

Table 2. Morphometric parameters of the S2AI screw measured from multiplanar reformations of the CTs.

Measurement	S2AI screw parameter	Mean SD
mm	SL	98.1 ± 10.55
	LL	108.9 ± 11.97
	DIAM	13.8 ± 3.21
degrees	ATASL	41.1 ± 6.43
	ATALL	38.1 ± 5.85
	STA	7.1 ± 1.36

SL: shorter length; LL: longer length; DIAM: diameter; ATASL: axial trajectory angle for the shorter length; ATALL: axial trajectory angle for the longer length; STA: sagittal trajectory angle.

Table 3. Interobserver reliability of S2AI screw parameters.

S2AI screw parameter	ICC (95%CI)	*P*
SL	0.742 (0.480 – 0.872)	$p < 0.001$
LL	0.553 (0.231 – 0.832)	$p < 0.001$
DIAM	0.699 (0.387 – 0.851)	$p < 0.001$
ATASL	0.591 (0.382 – 0.909)	$p < 0.05$
ATALL	0.478 (0.040 – 0.739)	$p < 0.05$
STA	0.249 (0.141 – 0.364)	$p < 0.740$

SL: shorter length; LL: longer length; DIAM: diameter; ATASL: axial trajectory angle for the shorter length; ATALL: axial trajectory angle for the longer length; STA: sagittal trajectory angle.

Table 4. Interobserver reliability of S2AI screw parameters.

S2AI screw parameter	ICC (95%CI)	P
SL	0.932 (0.690 – 0.986)	$p < 0.001$
LL	0.962 (0.829 – 0.992)	$p < 0.001$
DIAM	0.770 (0.096 – 0.954)	$p < 0.05$
ATASL	0.862 (0.068 – 0.974)	$p < 0.002$
ATALL	0.773 (0.235 – 0.958)	$p = 0.003$
STA	0.610 (0.209 – 0.918)	$p < 0.101$

SL: shorter length; LL: longer length; DIAM: diameter; ATASL: axial trajectory angle for the shorter length; ATALL: axial trajectory angle for the longer length; STA: sagittal trajectory angle.

DISCUSSION

In this study, in which the analysis was performed by means of multiplanar tomographic reconstructions with precise anatomical realignment, values similar to those described in the literature in relation to lengths, LL and SL, and DIAM of the S2AI screw were found, since, in a review article, Wu et al.[10] report that the diameter of viable implants ranges from 6.5 to 8.5 mm and the length from 65 to 120 mm. In an asian evaluation, Kwan et al.[3] suggested that screws between 85 and 120 mm in length are potentially safe based on the study population, with no gender difference. The lateral safety trajectory, i.e., the ATA, was estimated from 39.3° ± 3.1 to 50.4° ± 6.1 in men and from 39.5° ± 3.1 to 50.2° ± 5.9 in women, and the length range of the screw within this safety trajectory was 85 mm ± 22.2 to 122.6 mm ± 11.4 and 86.4 mm ± 22.7 to 122.2 mm ± 11.9 for men and women, respectively.[3]

Regarding the values found for implant trajectory angles, the findings of this study differ from the international literature regarding STA. Chang et al.,[9] when evaluating 20 tomographies of the pelvis of adolescents who are closely mature, indicate approximately 40° of ATA and also 40° of STA to find the ideal pathway of the S2AI screw, with the potential to minimize the prominence of the implant and simplify the technique for obtaining pelvic fixation, which is very discrepant to the finding of 7.1° ± 1.36 found in this study. This author, however, did not detail which parameters were used to obtain this STA result. Elder et al.[11] recommend a similar ATA, from 30 to 45°, and a relatively lower STA, between 20 and 45°. In another study, in which the insertion by minimally invasive technique of the S2AI screw was performed in cadavers, lengths of 90 mm, on average, were possible, ranging from 69 to 120 mm. The mean ATA was 42° and the STA was also higher, around 29°.[4]

Based on this discrepancy of values found in relation to the STA, the main responsible factor could be the lack of detail of the measurement technique adopted in these publications.[3,4,9,10,11] The soil was probably used as a parameter, which may increase the risk of failure, since the patient's positioning and the deformities presented can mask the angular value in relation to the soil, making it unreliable. In addition, we questioned, in an accessory way, about the presence of possible bone anatomical variations of the pelvis of Brazilian individuals. Thus, it is clear the importance of the detailed description of the technique used in the measurement of anatomical parameters, since the comparison of the results becomes unfeasible with different measurement techniques. In this study, measurements were made in an attempt to suggest the upper plateau of S1 as a parameter for the measurement of STA, but the results found do not indicate that this is an ideal parameter for the planning of craniocaudal angulation of the S2AI screw, since both interobserver and intraobserver reliability did not present statistical significance. This study has limitations that deserve to be mentioned: First, this is a study with a small number of tests evaluated; second, the absence of deformity in the selected cases; and, finally, limited clinical application. However, this is the first study in which the inter and intraobserver reliability analysis of the results of the morphometric parameters of the S2AI screw measured by a specific technique was performed.

CONCLUSION

The inter- and intraobserver correlation of the results of the morphometric parameters of the S2AI screw measured by a specific technique was moderate to excellent in almost all variables studied, except for the measurement of the trajectory angle in the sagittal plane.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. MDSP: Data collection and analysis, literature review and writing of the article; LAF: acquisition of exams and data collection; LKI: acquisition of exams and data collection; CFPSH: development of the research project, supervision, review of the article and study orientation.

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SCLEROTHERAPY WITH 75% HYPERTONIC GLUCOSE TO TREAT DORSAL SYNOVIAL CYSTS OF THE WRIST

TRATAMENTO DO CISTO SINOVIAL DORSAL DO PUNHO COM ESCLEROTERAPIA UTILIZANDO GLICOSE HIPERTÔNICA 75%

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ABSTRACT

Objective: To evaluate the cure rate for dorsal synovial cysts of the wrist with aspiration and percutaneous sclerotherapy using 75% hypertonic glucose. Methods: We enrolled 45 patients older than 18 years with untreated dorsal synovial cysts of the wrist. They underwent percutaneous aspiration and sclerotherapy with 75% hypertonic glucose 75%. A maximum of two procedures were conducted for each cyst at a 4-week interval. We analyzed age, sex, affected side, history of previous trauma, wrist goniometry, grip strength, wrist pain by the visual analogue scale, complications, and hand function questionnaire scores. Results: We evaluated 45 patients (30 female, 15 male, mean age 38.2 years with 47 cysts). Four weeks after the first procedure, 72.3% cysts were palpable and visible. At 24 weeks after the first procedure, 57.4% cysts evolved to cure and 42.6% persisted. Conclusion: Treatment of dorsal synovial cyst of the wrist with aspiration and percutaneous sclerotherapy using 75% hypertonic glucose achieved a 57.4% cure rate after 24 weeks. ***Level of Evidence IV, Case series***

Keywords: Ganglion Cysts. Conservative Treatment. Sclerotherapy. Suction. Wrist.

RESUMO

Objetivo: Avaliar o índice de cura do cisto sinovial dorsal do punho, com aspiração e escleroterapia percutânea utilizando glicose hipertônica 75%. Métodos: Foram selecionados pacientes maiores de 18 anos, portadores de cisto sinovial dorsal do punho, sem tratamento prévio. Foram submetidos a aspiração e escleroterapia percutânea com glicose hipertônica 75%. Foi realizado no máximo dois procedimentos em cada cisto, em um intervalo de 4 semanas. Foram analisados idade, gênero, lado acometido, história de trauma prévio, goniometria, força de preensão, dor no punho pela escala visual analógica, complicações e os escores dos questionários funcionais. Resultados: Foram avaliados 45 pacientes com 47 cistos, houve perda de seguimento de 3 pacientes (3 cistos). A média de idade foi de 38,2 anos. Na quarta semana após o primeiro procedimento, tivemos cura em 23,4% cistos, 4,3% cistos apresentavam-se palpáveis porém não visíveis e 72,3% cistos se apresentavam palpáveis e visíveis. Os cistos visíveis e palpáveis foram submetidos ao segundo procedimento. Após 24 semanas do primeiro procedimento, 57,4% cistos foram curados e 42,6% cistos apresentaram persistência. Conclusão: O tratamento do cisto sinovial dorsal do punho com escleroterapia percutânea utilizando Glicose Hipertônica 75%, proporcionou cura de 57,4% após 24 semanas. ***Nível de Evidência IV, Série de casos***

Descritores: *Cistos Glanglionares. Tratamento Conservador. Escleroterapia. Sucção. Punho.*

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INTRODUCTION

The synovial cyst is a benign soft tissue tumor mostly found in the dorsal topography of the wrist.[1] It is more common between the 2nd and 4th decade of life and in the female gender.[2] The cyst may be asymptomatic or cause local pain that is exacerbated with wrist movement.[1]

The diagnosis is usually made by clinical examination and confirmed with ultrasound.[1]

There are numerous forms of treatment of the synovial cyst of the dorsal wrist: observational, aspiration of the cyst fluid, aspiration of the cyst fluid with corticosteroid infiltration, aspiration of cyst fluid and sclerotherapy, transcutaneous electrocautery and surgical treatment, which can be conducted openly or arthroscopicly.[1-5] Open or arthroscopic surgical treatment has a cure rate of 70 to 100%.[6] However, it is invasive and has a higher rate of complications.[7,8] Conservative treatment has a cure rate of 20 to 30%.[7] Few sclerosing agents have been studied for the treatment of dorsal synovial cyst of the wrist. There are only three published studies, two of which were case series and one was a randomized study. The first case series used a 2 cc solution of hypertonic serum associated

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

The study was conducted at the Department of Hand and Upper Limb Surgery at the Universidade Federal de São Paulo.
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with 1 cc of 1% lidocaine, resulting in cure for all patients. The author did not report complications after three days.[9] The second case series used 3% polydocanol, with a cure rate of 96%. The authors reported complications such as pain, edema and paraesthesia.[10]
The randomized study compared the use of hyalurocynal, triamcinololine and sodium tetradecyl sulfate in the treatment of synovial cyst in the wrist. He used the Single Dart technique, performing this procedure monthly, at most 3 times. It showed a recurrence rate of 25%, 20% and 35% respectively.[8]
Hypertonic glucose 75% is considered a safe sclerosingagent.[11,12] The reported complications consist of edema, local urticaria that improved after 15 minutes of infiltration, transient glycemic elevation in patients with insulin resistance, transient neurological alteration that usually ceases within 2 hours in patients with migraines and arrhythmias.[11]
We believe that research into sclerosing substances that increase the cure rate will be useful for conservative treatment.
Our primary objective was to evaluate the healing index of the dorsal synovial cyst of the wrist with aspiration and percutaneous sclerotherapy using hypertonic glucose 75%.

MATERIALS AND METHODS

This study is a case series, prospective, longitudinal, interventionist, approved by the Research Ethics Committee, conducted in a university hospital.
Female and male patients aged 18 years or older and less than 60 years of age with dorsal synovial cyst of the wrist were included. Exclusion criteria were a previous history of treatment, refusal of consent and diagnosis of Diabetes Mellitus.
The diagnosis of the dorsal synovial cyst of the wrist was made by clinical examination and complemented by ultrasound.
The pre-procedure data collected were age, affected side, gender and previous history of wrist trauma. The following characteristics were evaluated: the intensity of pain in the wrist, by the visual analog scale (VAS); wrist goniometry; the grip strength, by the mean JAMAR dynamometer; and applied the Quick Dash and Brief Michigan Hand Questionnaire.[13,14]
Patients were evaluated before the procedure and in the fourth, eighth, twelfth and twenty-fourth week after the procedure.
The procedure was performed by the single dart technique.[8]
We started with local anesthesia, by means of a 1% lidocaine injection with a 26-gauge needle in the subcutaneous proximal region of the cyst. In the same region, we introduced an 18-gauge needle, punctured the cyst and aspirated the synovial content. Next, a solution containing 3 ml of hypertonic glucose 75% and 0.5ml of Lidocaine 1% was injected to perform cyst sclerotherapy. If the patient presented pain or discomfort, paracetamol was prescribed.
In the fourth week after the procedure, the patient was asked about complications, the presence of pain or paraesthesia on the back of the wrist and if the patient observed hyperemia and edema.
Regarding the criterion of cure of the cysts, we reevaluated all and distributed them into three groups: healing group (non-palpable and non-visible cyst); palpable and non-visible cyst group and palpable and visible cyst group. In the palpable and visible group, another procedure was conducted by the same technique.
In the eighth and twelfth weeks, the intensity of wrist pain was analyzed and the groups reclassified.
In the twenty-fourth week, all cysts were reevaluated and the groups reclassified, pain intensity was analyzed, wrist goniometry was performed, grip strength was measured and the Quick Dash and Brief Michigan Hand Questionnaire were applied.[13,14]
All these data were added to a spreadsheet.

Statistical method

The statistical methods used were: paired Student's t-test and two-proportion equality test, with significance level less than 0.05.

RESULTS

We treated 50 cysts in 48 patients between October 2017 and February 2018 and followed them for 24 weeks. Three patients were lost during the follow-up, totaling 47 cysts. Age ranged from 18 to 60 years, with a mean of 38.2 years. Among these, 15 were women and 45 men. Regarding the side, 24 were on the left side and 23 on the right. Only three (8%) patients reported previous trauma to the affected wrist.
In the fourth week after the first procedure, we had a cure of 11 (23.4%) cysts, two (4.3%) cysts were palpable but not visible and 34 (72.3%) cysts were palpable and visible. Those palpable and visible were subjected to the second procedure.
Table 1 shows the evolution of cysts in terms of cure in different periods.

Table 1. Evolution of cysts at 24 weeks.

Order	4w	New procedure	8w	12w	24w	Order	4w	New procedure	8w	12w	24ww
1	PV	Y	PNV	PV	PV	26	PV	Y	PNV	PNV	PNV
2	PV	Y	PNV	PNV	CURE	27	PV	Y	PV	PV	PV
3	PV	Y	CURE	CURE	CURE	28	PV	Y	PV	PNV	CURE
4	PV	Y	PV	PV	PV	29	PV	Y	PNV	CURE	CURE
5	PV	Y	CURE	CURE	CURE	30	LOST FOLLOW-UP				
6	PV	Y	PV	PV	PNV	31	PV	Y	PV	PV	PV
7	PV	Y	CURE	CURE	CURE	32	PV	Y	PV	PV	PV
8	CURE	N	PNV	CURE	PNV	33	PV	Y	PNV	CURE	CURE
9	PNV	N	PNV	PNV	CURE	34	CURE	N	CURE	CURE	CURE
10	PV	Y	PV	PV	PV	35	PV	Y	CURE	PV	PV
11	PV	Y	PV	CURE	CURE	36	PV	Y	PNV	PNV	CURE
12	CURE	N	PNV	PNV	CURE	37	PV	Y	PNV	CURE	CURE
13	PV	Y	PNV	PNV	CURE	38	PV	Y	PNV	CURE	CURE
14	CURE	N	PNV	PNV	PNV	39	PV	Y	PV	PNV	CURE
15	PV	Y	PV	PV	PNV	40	PV	Y	PV	PV	PV
16	CURE	N	CURE	CURE	CURE	41	PV	Y	PV	PV	PV
17	PV	Y	PV	PV	PV	42	PV	Y	PV	PV	PV
18	CURE	N	PNV	PNV	PNV	43	CURE	N	CURE	CURE	CURE

Table 1. Evolution of cysts at 24 weeks.

Order	4w	New procedure	8w	12w	24w	Order	4w	New procedure	8w	12w	24ww
19	CURE	N	CURE	CURE	CURE	44	PV	Y	PV	PV	PV
20	PV	Y	PV	PNV	CURE	45	CURE	N	PNV	CURE	CURE
21	PV	Y	PV	PV	PV	46	PV	Y	PV	CURE	CURE
22	PV	Y	PV	PNV	CURE	47	CURE	N	CURE	CURE	CURE
23	LOST FOLLOW-UP					48	PNV	N	CURE	CURE	CURE
24	LOST FOLLOW-UP					49	PV	Y	PV	PV	PV
25	CURE	N	PNV	CURE	CURE	50	PV	Y	CURE	CURE	CURE

After 24 weeks of the first procedure, 27 (57.4%) cysts evolved for healing and 20 (42.6%) cysts showed persistence. Among those who persisted, six (12.8%) cysts were palpable and non-visible and 14 (29.8%) cysts were palpable and visible (Figure 1).

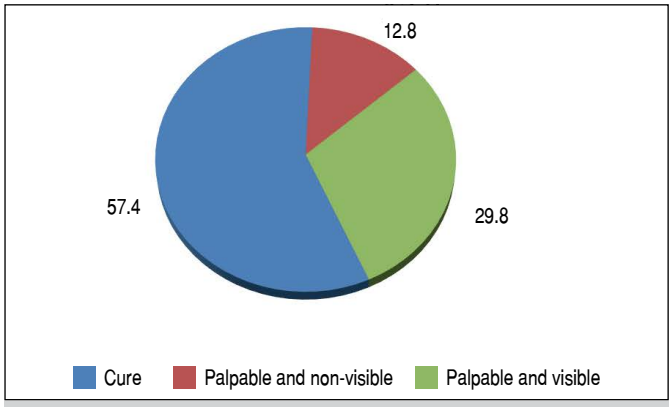

Figure 1. Cure rate at 24 weeks.

When we evaluated the evolution of pain caused by the cyst at different times, there was a significant decrease in the healing group, and in the palpable and non-visible group. There was no difference in the palpable and visible group (Figure 2). Only 10% of patients used analgesics.

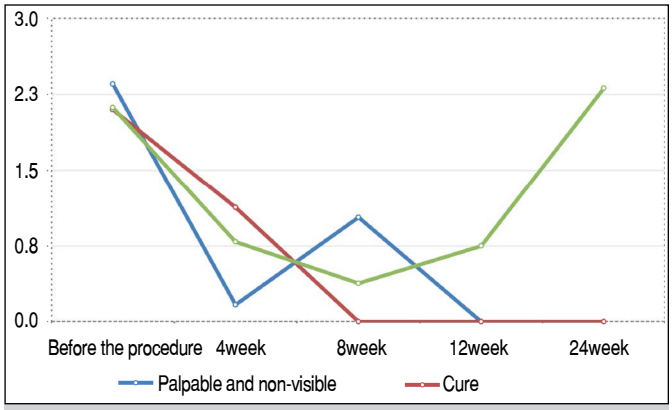

Figure 2. Evolution of the pain symptom caused by the cyst at different evaluation times.

There were no differences in grip strength and cuff range of motion when compared the pre-procedure and 24 weeks after procedure moments.
Regarding complications of the procedure, nine (19%) patients reported pain, 46 (97%) patients reported edema and 45 (95%) reported hyperemia and one (2%) patient presented superficial skin ulceration. No patient required a procedure to treat complications (Figure 3).

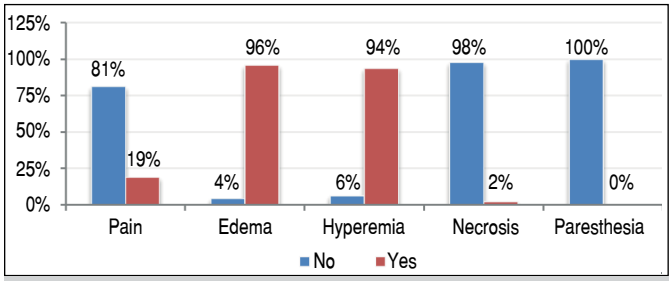

Figure 3. Distribution of complications.

In the evaluation of the Quick DASH questionnaire, when we stratified by groups, for the cured there was a significant decrease in the scores, but it was not significant in the palpable and non-visible groups and in the palpable and visible group (Table 2).
In the evaluation of the Brief Michigan Hand Questionnaire, when we stratified by groups, there was a significant increase in the scores for the healing group and for the the palpable and non-visible group, and not significant increase for the palpable and visible group (Table 2).

Table 2. Comparison of moments for Quick DASH and Brief Michigan Hand Questionnaire by group.

		Quick DASH.		Brief Michigan		
Week		Mean	P-value	Mean Week		P-value
Cure	0	7.12	0.010	0	85.2	<0.001
	24	0.35		24	99.5	
Palpable and non-visible	0	6.04	0.136	0	85.0	0.035
	24	1.50		24	95.1	
Palpable and visible	0	8.34	0.733	0	84.2	0.072
	24	9.56		24	88.8	

DISCUSSION

We had three follow-up losses, an acceptable number in the literature.[15] We followed 45 patients, a number comparable to other studies related to the theme such as those by Suen et al.[6] and G. Mackie et al.[16]
Diabetic patients were excluded due to the risk of hyperglycemia by hypertonic glucose use, although it is a concern only when larger volumes are used.[11,12]
Paramhans et al.,[1] Kuliński et al.[2] and Dogo et al.[9] also found a higher incidence of cysts in women.
Paramhans et al.[1] and Hernández Espinosa et al.[10] also presented prevalence of wrist dorsal cysts in young adults.
Kuliński et al.,[2] in 2017, also reported no predilection on the affected side of the sore cysts of the wrist.
Chatterje et al.[8] and Berghoff and Amadio[17] also used the same method for the diagnosis of dorsal cyst of the wrist, with clinical examination and ultrasound examination.

The conducted procedure method, called *single dart*, was chosen because it was described in the literature as causing fewer complications.[8,13]

Otu et al.[18] and Chatterje et al.,[8] in their research on synovial cyst of the wrist, also followed-up for 24 weeks.

Regarding the treatment options described in the literature, simple aspiration presents great variation in the recurrence rate, from 15 to 69%.[19,20]

Aspiration and infiltration with corticosteroids present recurrence rates of 33 to 58%, which may lead to skin hypopigmentation.[21]

The mechanism of action of sclerosing substances occurs by the cell lesion, altering the water balance by means of the cell gradient, dehydrating and denaturizing the cell membrane.[22]

Hyperosmotic sclerosing agents, such as hypertonic glucose and sclerosing detergents such as polydocanol and tetradecyl sulfate, are the safest and most effective used for medical procedures.[16]

For a sclerosing agent to be considered ideal, it must be able to produce tissue obliteration and not cause complications.[16]

Using hypertonic serum, in aspiration and sclerotherapy of the cyst, Dogo et al.[9] reported no recurrence of the synovial cyst. Mackie et al.[16] used sodium tetradel disulfate with a recurrence rate of 94%. Hernández Espinosa et al.,[10] using polydocanol, presented a recurrence rate of only 3.6%.

Chatterje et al.[8] in 2014, published recurrence rates of 20%, 31% and 35%, respectively, using triamcinolol, hyaluronidase and sodium tetradecyl sulfate.

In our study, we had 57.4% cure in 24 weeks. Of the six patients after 6 months that were in the group palpable and non-visible cysts, five (84%) refused surgical treatment because they did not report pain and there was no aesthetic complaint. These results were not part of the healing group, if added, they would increase the cure rate to 68%.

After 4 weeks, we found a cure rate of 23.4%. With the second procedure, we increased the cure rate to more than 50%. Chatterje et al.,[8] in his randomized study, reported to have conducted up to three procedures, but not informing the number of procedures in each cyst.

In our study, complications using hypertonic glucose 75% were frequent, but with low morbidity. No complications required a specific treatment and influenced the pain intensity assessed by VAS. The ulceration found in one patient in our study may have been caused by a procedure error with infusion of the sclerosing agent into the subcutaneous tissue or by extravasation of the sclerosing agent out of the cyst. We found reports of skin ulceration in 1% of patients treated with hyaluronidase and in 5% of patients treated with sodium tetradecyl sulfate.[8]

Chatterjee et al.[8] reported wrist stiffness with the use of triamcinolol, hyaluronity and sodium tetradecyl sulfate. We had no wrist stiffness when comparing the cuff range of motion after 24 weeks.

Dogo et al.,[9] using hypertonic serum, reported that 20% of their patients needed analgesics for severe pain. In our study, only 10% of the patients used the prescribed analgesic, showing an advantage over other sclerosing agents, since pain is a factor of discomfort and treatment interruption. Regarding wrist pain, as assessed by VAS, we noticed that in the healing groups and in the palpable and non-visible group, there was a significant improvement in pain, evolving to absence of pain at 8 and 12 weeks, respectively. However, in the palpable and visible group, pain remained present even after 24 weeks, showing that pain is directly related to the presence of the cyst.

In the healing group, there was a significant improvement in the Quick Dash and Brief Michigan functional questionnaires. This improvement was mainly due to pain, which was the main complaint of patients.

In the palpable and non-visible group there was significant improvement only in the Brief Michigan functional questionnaire, which was also due to the appearance of the hand, not addressed in the Quick Dash questionnaire.

As limitations of our study, we cite the short follow-up period, since recurrences can be observed for up to 2 years after aspiration.

CONCLUSION

The treatment of dorsal synovial cyst of the wrist with aspiration and sclerotherapy with hypertonic glucose 75% is a new tool for conservative treatment of the cyst, with a cure rate of 57.4% at 24 weeks after the procedure.

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WEIGHT-BEARING CONE BEAM CT SCANS AND ITS USES IN ANKLE, FOOT, AND KNEE: AN UPDATE ARTICLE

TOMOGRAFIA COMPUTADORIZADA COM CARGA EM TORNOZELO, PÉ E JOELHO: UM ARTIGO DE ATUALIZAÇÃO

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ABSTRACT

Imaging plays a key role in the preoperative diagnosis, surgical planning, and postsurgical assessment of the foot, ankle, and knee pathologies. Interpreting diagnostic imaging accurately is crucial for the clinical practice of orthopedic surgeons. Although among the most used imaging modalities, radiographic assessments are amenable to errors for various technical reasons and superposition of bones. Computed tomography (CT) is a conventional imaging procedure that provides high-resolution images, but fails in considering a truly weight-bearing (WB) condition. In an attempt to overcome this limitation, WB cone beam CT technology has being successfully employed in the clinical practice for the past decade. Besides economically viable and safe, the WB cone beam CT considers WB conditions and provides high-quality scans, thus allowing an equitable and correct interpretation. This review aims to address extensive description and discussion on WBCT, including imaging quality; costs; time consumption; and its applicability in common foot, ankle, and knee, conditions. With this technology increasing popularity, and considering the extensive literature on medical research, radiologists and orthopedic surgeons need to understand its potential applications and use it optimally. ***Level of Evidence III, Systematic review of level III studies.***

Keywords: Tomography, X-Ray Computed. Orthopedics. Weight-Bearing. Foot. Ankle Joint. Knee Joint.

RESUMO

Os exames de imagem são essenciais no diagnóstico, planejamento cirúrgico e avaliação pós-cirúrgica das patologias que envolvem pé, tornozelo e joelho. A interpretação acurada utilizando as tecnologias de diagnóstico por imagem disponíveis é crucial para os cirurgiões ortopédicos na sua prática clínica. Embora as radiografias convencionais estejam entre as modalidades de diagnóstico por imagem mais utilizadas, elas estão sujeitas a erros por várias razões técnicas e sobreposição de estruturas ósseas. Apesar de a tomografia computadorizada (TC) fornecer imagens de alta qualidade, ela falha em não considerar a carga corporal fisiológica. A TC de feixe cônico com carga vem sendo utilizada com sucesso desde a última década, superando a limitação da TC convencional. Além de ser econômica e segura, possibilita a aquisição de imagens de alta resolução, com carga, permitindo, assim, uma interpretação correta e equiparável. O objetivo principal dessa revisão é proporcionar uma discussão e descrição ampla de TC com carga, incluindo qualidade de imagem, custos financeiros, tempo consumido em exames, e suas aplicações em patologias comuns do pé, tornozelo e joelho. A TC com carga vem crescendo em popularidade, e é tema de um número extenso de pesquisas científicas, sendo necessário que radiologistas e cirurgiões ortopédicos entendam suas aplicações para melhor uso futuro. ***Nível de Evidência III, Revisão sistemática de Estudos de Nível III.***

Descritores: *Tomografia Computadorizada por Raios X. Ortopedia. Suporte de Carga. Pé. Articulação do Tornozelo. Articulação do Joelho.*

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INTRODUCTION

Diagnostic imaging provides important information complementary to physical examination, besides aiding in the preoperative planning and postoperative evaluation of the treatment, thus being essential for the orthopedic workup in the foot, ankle, and knee. Radiographs are typically the initial examinations and they should be preferably performed in a weight-bearing (WB) condition to evaluate bone alignment and joint space[1]. Although common and widely used nowadays, radiographs provide two-dimensional (2D) images of three-dimensional (3D) structures, requiring several assumptions and considerations regarding patient positioning, magnification, and image distortions.[2]

Misalignment between the X-ray source and patient positioning may lead to significant varied assessments.[3-6] Systematic reviews on imaging options for distal tibiofibular syndesmosis and subtalar joint (SJ) found conventional radiography to be the most frequently used imaging modality, but raised concerns about its diagnostic reliability.[7,8] A literature review highlighted the limitations of conventional radiography techniques in providing scans that reflect the complexity of hallux valgus (HV) in 3D, such as sectorized and limited information in different planes, superimposing structures, image magnification, and misalignment between X-ray source and patient positioning.[9]

Studies reported variations in the measurements of coronal alignment of knee joint performed in WB condition and supine position, which may significantly impact the outcomes after total knee arthroplasty or revision surgery if disregarded.[10,11]

Radiographic assessment is the most common test for diagnosing knee osteoarthritis (OA). However, even when performed under optimal acquisition conditions, it is inaccurate and not sensitive enough.[12] The lack of sensitivity and specificity for detecting OA-associated articular cartilage damage, as well as the poor sensitivity to record variations in follow-up imaging are some of the limitations of radiography. Variations in knee positioning during image acquisition may influence the quantitative measurement of various radiographic parameters, including joint space narrowing.[13]

For offering enhanced bone visualization, computed tomography (CT) is preferable to radiography regarding measurements associated with patellar instability and patellofemoral alignment. However, CT is performed in non-WB supine position, with the knee at full extension and the quadriceps muscles relaxed, imposing a limitation for the technique.[14]

Weight-bearing CT (WBCT) technology combines the benefits of highly detailed CT imaging, enabling a multiplanar and 3D visualization, with WB considerations, thus providing accurate measurements at a comparatively lower dose of radiation exposure.[15] This review discusses WBCT technology and its applicability, costs, time consumption, and imaging quality of ankle, foot, and knee alignment and their associated pathologies. We conducted a literature search for studies published between 2000-2020 in PubMed and ScienceDirect databases, and relevant studies were retrieved and included in this review. No constraints were imposed on the type of studies included.

Technology and system description

WBCT employs cone-beam CT (CBCT) technology. Although initially used in dental radiology, the small and compact design with high-quality images of the extremities under WB conditions has gained increasing attention over the past decade.[16,17] Different from conventional multidetector CT (MDCT), which emits a fan-shaped X-ray beam that traces multiple spiral paths (helical CT) around the patient lying on the moving table,[18] WB CBCT uses a smaller gantry composed of an X-ray tube emitting a pyramid-shaped X-ray beam (the 'cone') and a large detector panel (Figure 1).[18,19] Imaging is performed with the patient standing at the center of the machine with the X-ray source and the imaging detector at different sides. This tube-detector system executes a single rotation around the patient,[18] whereby the scan obtains fully volumetric data from multiple projections acquired over a 220° arc in about 18-20 s, with less radiation exposure time (< 10 s).[18,19] A computer with installed software acquires the data from multiple projections, reconstructs them within 20-120 s, and creates 3D and multiplanar images using algorithms.[19] Reconstructed images comprise hundreds of slices (> 600 in some machines) of a submillimeter thickness (0.2 mm), which are uploaded to a picture archiving and communication system (PACS) as a standard digital imaging and communications in medicine (DICOM) CT image stack. These can be further used for multiplanar reformations or volume reconstructions with any DICOM-compatible radiology workstation software (Figure 2).[19] The software also enables creating digitally reconstructed radiographs in multiple standard projections (such as Anterior-Posterior, oblique, and lateral views).[17]

Figure 1. Weight bearing LineUp® cone-beam computed tomography (CT; CurveBeam, Philadelphia, PA, USA). Patient positioning for ankles and feet scan. The patient stands at the center of the machine, with the X-ray source and image detector at opposing sites. The tube-detector system executes a single rotation around the patient. Curved arrows represent the tube-detector system rotational movement. For knee scanning, the gantry raises to the appropriate level and performs a single rotation (not shown).

Figure 2. Software user interface, Cubevue® (CurveBeam, Warrington, PA, USA) for foot and ankle. The upper-left window represents the volumetric reconstruction, which may be tailored by the user. The remaining windows are multiplanar reconstructions provided by the software. The user can likewise tailor these images and perform measurements.

Several models of WB CBCT devices are available. Whereas some are restricted for imaging of the foot and ankle, others contain a mobile gantry to scan the knees. These devices acquire images not only in WB conditions, but also in seating and even in monopodal WB position.

Radiation dose, imaging time, and cost-effectiveness

The radiation dose used in WBCT is lower than that of conventional multidetector CT, but higher than that of conventional radiography. Yet, radiographs radiation doses may increase or even equate to those of WBCT depending on additional radiographic series performed, WBCT field of view (FOV), and whether imaging is conducted in a single or both feet.[18,20] The radiation dose to an organ or tissue is calculated based on the equivalent dose, and its expression in units ($J.kg^{-1}$) equals the absorbed dose, referred to as sievert (Sv). Whereas for a single-exposure radiograph of the foot the radiation dose is 0.001 mSv, for a WB CBCT of the foot/ankle it is 0.01/0.03 mSv, and 0.07 mSv for a conventional CT of the ankle. In the US, the average background radiation/year is 3.0 mSv.[17]

A study evaluated 11,009 WBCT scans performed by a pioneer institution to investigate radiation dose, time spent, and cost-effectiveness in comparison with WB radiograph series and conventional CT without WB. The authors found that WBCT was more cost-effective, generating an overall increase of 51.12 Euros per patient in the institution profit, as well as a 10% decrease in the yearly average dose and a 77% decrease in time spent with WBCT when compared to the radiograph/CT group.[21]

Foot and ankle

WBCT provides high-quality images and diagnostic accuracy, facilitating the assessment of complaints related to bone alignment in the foot and ankle,[22] such as distal tibiofibular syndesmosis (TFS), SJ, peritalar subluxation, subtalar instability, hindfoot alignment (HA) and associated pathologies, pes cavus and planus, hallux valgus (HV), and pedography. WBCT imaging have also been successfully employed in postoperative evaluation, such as calcaneal osteotomy and HV correction procedures, and in developing customized medical devices.[15,23]

Studies reported a positive correlation between HA measurements performed using WBCT and clinical measurements.[24,25] Burssens et al. proposed an evaluation method for HA on WBCT, which combined the talocalcaneal axis and the anatomical axis of the tibia in the coronal plane. The authors found a good correlation with the anatomical tibial axis obtained by full leg radiography, suggesting that the short end of the tibia included in the WBCT imaging can be used to determine HA.[24] Conversely to previously described constitutional valgus measured by radiographic methods, the WBCT method presented a more neutral hindfoot configuration in a population without suspicion of hindfoot pathology.[26] By using the WBCT data to create 3D images, Burssens et al. found a good correlation between measurements performed in 2D and 3D images.[27]

Lintz et al. described an efficient 3D biometric and semi-automatic method for calculating HA based on the torque acting on the ankle joint stemming from body weight and ground-reaction forces.[28] Instead of the tibia axis, this method uses the forefoot as a reference and measures the offset between the hindfoot-to-forefoot midline and talus, the foot-ankle offset (FAO), with five 3D-points or coordinates – the first and fifth metatarsal head WB point, the calcaneus WB point, and the centermost and highest talus in the coronal and sagittal planes. "Foot length" was established by a line extending from the calcaneus to the midpoint between the first and the fifth metatarsal heads. Between the ground projection of the centermost and highest talus point and the "foot length" line, the "F" perpendicular point of intersection was determined. The FAO is measured as a percentage of the distance between the ground projection of the centermost and highest talus point and F divided by the 'foot length' (Figure 3). When compared to 2D methods, the 3D approach to calculate HA using FAO is less susceptible to errors related to projection, rotation, and the operator. Lintz et al. found a mean FAO value of 2.3% ± 2.9% in normal cases, – 11.6% ± 6.9% in varus cases, and 11.4% ± 5.7% in valgus cases.[28]

By comparing differences in the distal TFS position, evaluated by the distal fibula displacement in relation to the incisura using WBCT and non-WBCT (NWBCT), a study found a statistically significant external rotation and lateral and posterior translations of the fibula on WB.[29] Another study also determined TFS differences in asymptomatic patients using CT in WB and non-WB (NWB) conditions. Except for the medial clear space, which was significantly lower on WB images, the author found no statistically significant differences in measurements evaluating fibular diastasis, rotation, and translation relative to the incisura.[30] According to the author, some conflicting results may be explained by the inclusion of patients presenting post-traumatic conditions that may affect syndesmotic measurements or the use of different imaging equipment.[30] A cadaveric study simulating WB and NWB conditions by load application found no statistically significant difference in the diagnosis of incomplete syndesmosis injuries, but observed a significant benefit for complete injuries.[31] However, torque application (external rotation of the foot and ankle) might have been change this scenario, as observed by other cadaveric studies that demonstrated its benefits in diagnosing TFS injuries, including incomplete ones.[32,33] A study conducted with healthy volunteers investigated the dynamics of the distal tibiofibular joint and the talus through WBCT performed in a neutral position and on internal and external rotation of the ankle on WB.[34,35] In the neutral position, the distal fibula was located primarily in the anterior aspect of the incisura (88% of the subjects). During external rotation of the talus, it shifted to the posterior aspect in 40% of the subjects, but did not assume the posterior position in any of the cases during internal rotation.[34] Between the internal and external rotation of the ankle, the distal fibula showed a 1.5 mm motion and a 3° rotation,[34] whereas the talus showed a 10° rotation in the ankle mortise.[35] WBCT was used to establish normal TFS reference values and threshold values for suspected TFS injuring.[36] The study also found men's Fibulae to be significantly more laterally translated.[36]

Figure 3. Foot-Ankle Offset (FAO) measurement using the Torque Ankle Lever Arm System (TALAS®; CurveBeam, Warrington PA, USA) with Cubevue® software in a patient with pes planovalgus. In this example, the measured FAO is positive, indicating that the center of the ankle joint is positioned medially to the bisecting line of the foot tripod (valgus alignment). Five points (coordinates) are established using the multiplanar reconstruction – the first metatarsal head WB point (M1), fifth metatarsal head WB point (M5), ground projection of the centermost and highest talus point (T), M1–M5 equidistant point (E), and a CE line point (foot length) crossed by a perpendicular line that includes T. FAO is measured as a percentage of the TF distance divided by the CE distance (foot length). Using this system, FAO measurement is fast and straightforward.

Del Rio et al. conducted a prospective study assessing the syndesmotic area of 39 patients with ankle instability following acute injury and syndesmotic instability verified by arthroscopy and compared with the contralateral uninjured ankle using WBCT in WB and NWB conditions. The authors found unstable ankles to present a significantly greater diastasis in WB when compared to NWB and to uninjured ankles in WB. Uninjured ankles showed a slight syndesmosis widening, but significantly less pronounced than unstable ankles.[37]
Colin et al. studied the morphology of the posterior facet of the ST joint in 59 asymptomatic subjects using WBCT images and found most of them to be concave (88%), opposed to the 12% that were flat (12%) on coronal plane images.[38] The subtalar vertical angle (SVA) was adopted to analyze the orientation of the posterior facet of the SJ. SVA was calculated on the coronal plane, by intersecting a line connecting the medial and lateral border of the posterior facet of the SJ with a vertical line perpendicular to the floor, using a cut in the middle of the SJ as reference. Values lower than 90º determined varus configuration, and those greater than 90º were determined valgus configuration. Although SVA values changed according to the localization on facet (anterior, middle, and posterior), 90% of the subjects presented a valgus orientation.[38] SJ orientation may pose a compensatory factor in ankle osteoarthritis, as osteoarthritic varus ankles show a more valgus-oriented posterior facet of the SJ[39] and a more severe internal rotation of the talus.[40]
This review will adopt the nomenclature of Progressive Collapsing Foot Deformity (PCFD) instead of adult acquired flatfoot deformity (AAFD), according to recent consensus[1]. A prospective study conducted by de Cesar Netto et al. evaluated 20 patients with PCFD using WBCT in WB and NWB conditions and found a statistically significant difference between them, except for the calcaneal inclination angle (one of the nineteen measurements performed). This result indicates the complexity of the three-dimensional deformity and alterations involving the coronal, axial, and sagittal planes.[41] Investigators of different expertise levels found WBCT measurements of flexible PCFD to be reliable.[41,42] Likewise, WBCT was also employed for assessing peritalar subluxation in the context of flexible PCFD, indicating that patients presenting with such condition showed a statistically significant increase in the "uncoverage," implying peritalar subluxation, as well as incongruence of the middle facet of the SJ in relation to the opposing calcaneal articular surface.[43]
Using WBCT, Collan et al. evaluated 10 patients with HV deformity in WB and NWB situations and measured 2D and 3D hallux valgus angles (HVA), intermetatarsal angles (IMA), first metatarsal bone pronation, and first proximal phalanx pronation angles. WB measurements for 2D and 3D HVA, IMA, and proximal phalanx pronation were higher than those found in the control group. The authors also observed a tendency for slight rotation of the first metatarsal bone, but without significant difference among study groups.[44] Another study comparing HV patients with healthy controls using simulated WBCT conditions reported significant dorsiflexion, supination, and internal rotation of the first tarsometatarsal (TMT) joint in those affected with HV.[45] Hypermobility was also shown to continue along the first ray, involving the first metatarsophalangeal, naviculocuneiform, and talonavicular joints.[46]
A prospective study conducted by Conti et al. used pre- and post-surgical WBCT images and WB radiographs to evaluate foot width reduction in 31 feet with HV following a modified Lapidus procedure combined with a modified McBride and Akin osteotomies in most cases. Both WB and WBCT showed a significant reduction in bony and soft tissue foot and no increase in foot width post-surgery.[47]
Lintz et al. performed a retrospective study with a cohort of patients who underwent TAR and had postoperative follow-up WBCT scans to determine the association between periprosthetic cysts and residual malalignment of the hindfoot after total ankle replacement (TAR). The total cystic volume was positively correlated with residual malalignment, measured by the absolute FAO values, with the varus alignment presenting a more medially positioned cyst and the valgus alignment a laterally positioned cyst.[48]

Knee

Regarding knee evaluation, WBCT has been mostly used in individuals with OA and patellar instability, and for evaluating joint alignment by measurements analogous to radiography and tomography. When compared to NWBCT, WBCT presented significant differences.
In patients with OA, WBCT has shown a significant reduction in the medial tibiofemoral compartment joint space width[49,50] and increased meniscal extrusion when compared with NWBCT.[49] Regarding asymptomatic patients, the above measurements increased in WB and NWB conditions.[49]
WBCT-based 3D color-coded maps of the medial tibial subchondral area based on tibiofemoral joint space widths showed that patients with larger surface areas and narrow joint space width (< 2.0 mm) reported greater functional limitations, based on specialized questionnaires. Although the study found a trend for these patients to report greater pain severity was observed, it was not statistically significant.[51]
When compared with NWBCT, WBCT showed good interrater reliability and significant differences in the assessment of patellofemoral alignment. Imaging performed under full weight-bearing condition at 30° knee flexion showed statistically worse values in tilt angle, congruence angle, and distance between the tibial tubercle and the center of the trochlear groove (TTTG offset) of patients with acute or chronic patellar instability when compared to routine methods.[52]
A local study used a dynamic CT setting with muscle action across the knee range of motion to assess pre- and post-operative patellofemoral tracking in patients with patelar instability. However, WB condition was unfeasible in this examination.[53] Although paramount for understanding and planning corrections in patellofemoral pathologies, replicating WB conditions was not really possible before the advent of WBCT.
Likewise, a study predominantly conducted with OA patients evaluated knee joint alignment using WBCT and NWBCT in fully extended positions using two musculoskeletal radiologists.

Both radiologists observed a significant decrease in TTTG offset, but only one found a decrease of the patellar tilt angle. Both radiologists also recorded a significant difference in femorotibial rotation, changing from external rotation of the tibial plateau to the femoral condyles on NWBCT to internal rotation on WBCT.[50] Given that conventional NWBCT may overestimate TTTG offset due to the supine position in which images are acquired, and thus with relaxed muscles, this is a key information for pre-surgical planning. A study conducted with healthy volunteers with progressive knee flexion angles (0°, 30°, 60°, and 120°) using WBCT enabled the assessment of tibiofemoral and patellofemoral rotations, patellofemoral distance, TTTG, and tibiofemoral contact points. Although the measurements performed at 120° flexion were conducted without WB conditions due to technical limitations, the study reached excellent interreader agreement for most measurements.[54] The internal rotation of the tibia relative to the femur increased alongside the increase of flexion angles, whereas patellofemoral rotation tended to decrease from external to almost horizontal position. TTTG and patellofemoral distance likewise decreased. The tibial tuberosity was observed medially to the trochlear groove at 120° flexion. To establish contact points of the tibiofemoral joint, the authors divided the medial and lateral tibial plateaus from anterior to posterior, into ≤ 30%, 31%-60%, 61%-90%, and 91%-100%. The results show that the contact point of the tibiofemoral joint was far anterior (≤ 30%) on the medial side at 0° flexion, shifting posteriorly during flexion (61%-90% at 120° flexion) and never found at the far posterior (91%-100 %). However, regarding the lateral side, the contact point was central (31%-60%) at 0° flexion for most volunteers, gradually shifting to posterior during flexion and located more posteriorly than on the medial side (91%-100%).[54]

CONCLUSION

WBCT is a novel technology that can be used to evaluate feet, ankles, and knees in various circumstances, such as normal alignment, pathologies, and for postoperative follow-up.[25] Although a relatively new technology, several institutions worldwide have published articles addressing WBCT over the past decade. To improve imaging segmentation, 3D technology has been incorporated to the imaging technique.[9,16,17] Besides being safe and incurring low radiation exposure, WBCT may also be financially attractive to institutions when compared to conventional radiography and CT scans. This review explained WBCT applicabilities to different locations and pathologies, as well as the various measurements it can provide in relation to other imaging modalities. Studies found WBCT to provide reliable and accurate measurements. Given the broader understanding and growing popularity of WBCT within the literature, musculoskeletal radiologists and orthopedic surgeons must comprehend its features, strengths, uniqueness, and applicability in routine clinical practice.

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