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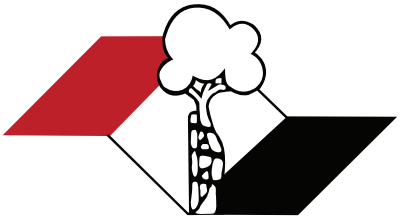

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ACTA ORTOPÉDICA BRASILEIRA

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(Reviewed January 2016)

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

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ACKNOWLEDGEMENTS
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- Writing the article or critically reviewing its intellectual content;
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d) Abstract: Author(s). Title, followed by [abstract]. Journal. Year; volume (supplement and its number, if it applies): page (s).

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g) Electronic material: Author (s). Article title. Abbreviated Journal title [medium]. Publication date [access date followed by the expression "accessed on"]; volume (number):initial page-final page or [approximate number of pages]. URL followed by the expression "Available from:"

Ex.: Pavezi N, Flores D, Perez CB. Proposição de um conjunto de metadados para descrição de arquivos fotográficos considerando a Nobrade e a Sepiades. Transinf. [Internet]. 2009 [acesso em 2010 nov 8];21(3):197-205. Available from: http://periodicos.puc-campinas.edu.br/seer/index.php/transinfo/article/view/501

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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

VOLUME 26–Nº 3–2018

Original Articles

HAND

HIP

KNEE

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ORIGINAL ARTICLE

APPLICABILITY OF RANDOMIZED TRIALS IN HAND SURGERY: SURVEY STUDY

APLICABILIDADE DE ENSAIOS RANDOMIZADOS EM CIRURGIA DA MÃO: ESTUDO TIPO SURVEY

VINÍCIUS YNOE DE MORAES[1], PRISCILA FRANTZ RUFF[1], CARLOS HENRIQUE FERNANDES[1], JOÃO BAPTISTA GOMES DOS SANTOS[1], JOÃO CARLOS BELLOTI[1], FLÁVIO FALOPPA[1]

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ABSTRACT

Objective: To assess the applicability of randomized clinical trials and whether certain factors (surgeon experience/journal impact factor) influence their applicability. Methods: In this survey study we used the Pubmed/Medline database to select 32 consecutive randomized clinical trials published between 2013 and 2015, involving hand surgery (high/low impact). These studies were independently assessed by 20 hand surgeons (with more or less than 10 years of practice) who answered 4 questions regarding their applicability. Agreement was assessed using Cohen's kappa and comparison of proportions via chi-square statistics. P-value <5% constituted statistical significance. Results: A total of 640 evaluations were produced, generating 2560 responses. A weak correlation was observed between less and more experienced respondents (kappa <0.2; range 0.119–0.179). Applicability between the least and most experienced respondents was similar (p = 0.424 and p = 0.70). Stratification by journal impact factor showed no greater propensity of applicability (p = 0.29) for any of the groups. Conclusions: Low agreement was found between the respondents for the applicability of the randomized studies. Surgeon experience and journal impact do not seem to influence this decision. ***Level of Evidence II, Prospective comparative study.***

Keywords: Clinical trial. Evidence-based medicine. Reserch.

RESUMO

Objetivo: Avaliar a aplicabilidade de ensaios clínicos randomizados e se há fatores que a influenciam (experiência do cirurgião/ impacto do periódico). Métodos: Estudo tipo survey. Selecionou-se (via Medline/Pubmed) dentre os anos de 2013 e 2015, 32 ensaios clínicos randomizados consecutivos envolvendo cirurgia da mão (estratificados como alto/ baixo impacto). Estes estudos foram avaliados de forma independente por 20 cirurgiões de mão (mais versus menos de 10 anos de prática), que responderam quatro questões dicotômicas relativas à propensão da aplicabilidade clínicados estudos. A concordância foi avaliada pelo kappa de Cohen e comparação de proporções pelo Qui-quadrado. Constituiu-se como significantes p menores que 5%. Resultados: realizou-se 640 avaliações, envolvendo 2560 respostas. Observou-se baixa concordância entre os avaliadores (menos versus mais experientes): Kappa <0,2; alcance 0,119-0,179. A propensão para aplicabilidade foi semelhante entre os menos e mais experientes (p=0,424 e p=0,70). O mesmo ocorre quando estratificados por impacto da revista, não há maior propensão de aplicabilidade para quaisquer dos grupos (p=0,29). Conclusões: Há baixa concordância entre os avaliadores quanto à aplicabilidade de estudos randomizados. Experiência do cirurgião e impacto do periódico parecem não influenciar nesta decisão. ***Nível de Evidência II; Estudo prospectivo comparativo.***

Descritores: *Ensaio Clínico. Medicina baseada em evidências. Pesquisar.*

Citation: Moraes VY, Ruff PF, Fernandes CH, Santos JBG, Belloti JC, Faloppa F. Applicability of randomized trials in hand surgery: survey study. Acta Ortop Bras. [online]. 2018;26(3):154-7. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The number of published clinical studies has been increasing dramatically, with a challenging volume of information to be evaluated and summarized.[1,2] Scientific journals are largely responsible for disseminating such information, but there is some doubt about the connection between what is published in high-impact journals and its relevance in everyday practice.[3,4]

In an effort to achieve visibility for their findings, researchers suffer from the high methodological requirements necessary for publication in high-impact journals. These transform good clinical questions into studies that do not reflect real practice scenarios, sometimes controlled artificially by the particularities of controlled randomized clinical studies. This is the current criticism of the purism of evidence-based medicine.[5]

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

Work conducted at the Casa da Mão, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.
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Furthermore, a confounding factor can be found in the potential conflict of interest between high-impact journals and external funding by industry or various research sources.[6,7]

Even so, the consensus is that comparative clinical studies controlled by randomization are the best and most reliable for everyday application.[8] There is great doubt, however, correlating high levels of methodological excellence and practical applicability; studies involving hand surgery and orthopedics report that approximately half of randomized clinical studies change treatment paradigms in a north American orthopedists.[9-12]

This study starts from the hypothesis that applying research to daily clinical practice (external validity) is not directly related to the impact or importance of the journal in which the study was published and also not associated with experience gained over time.

The objective of this current study is to verify whether characteristics of the study/periodical (journal impact) are related to the propensity of applicability (feasibility/relevance) of these results in daily clinical practice, using the opinion of physicians (hand surgeons and their experience) as the parameter.

MATERIALS AND METHODS

This study was approved by the institutional review board (CAAE: 55969916.5.0000.5505), and participants signed an informed consent form after explanation of the study.

Strategy for identifying studies eligible for the survey

Randomized clinical trials on treatment involving the topic of hand surgery. Consecutive articles were selected by a survey strategy involving MeSH terms (hand surgery OR hand therapy OR wrist surgery) associated with the filter[10] for randomized clinical trials and limited to the past 4 years (2016–2012).

- 18 studies from high-impact journals[13-18,21,23,26,28,29,32-35,37-39] (defined as Qualis/CAPES A1, A2, B1, AND/OR impact factor above 1.5);
- 14 studies from low-impact journals[19,20,22,24,25,27,30,31,36,40-44] (defined as Qualis/CAPES B2 and lower and/or impact factor below 1.5).

The structured abstracts of these studies were evaluated by: 20 (twenty) physicians:

- 10 hand surgeons with more than 10 years of training;
- 10 hand surgeons/orthopedists with less than 10 years of training.

Verification of applicability/relevance/feasibility

For each study, questions related to applicability/feasibility/clinical relevance were developed, and participants responded during a single session under the supervision of the researcher, who did not influence the responses:

a. Do you consider the topic (clinical research question) relevant/important?
b. Under ideal conditions, would you apply these results in your patients?
c. In everyday clinical practice, is application of these results feasible?
d. Do you consider this methodology appropriate to answer the research question?

These questions were answered categorically *(Yes/No)*. We considered studies which earned more than 75% "yes" responses applicable, study by study.

Analysis of subgroups

The responses were evaluated and categorized according to:

a. Journal impact: low vs. high impact;
b. Surgeon's experience: more or less than 10 years of experience.

Statistical analysis

The numerical data were presented as mean and standard deviations or percentages, and confidence intervals of 95%.

Categorical data were assessed in accordance with 2x2 contingency tables and subsequent inferential analysis by means of the chi-square test. Assessment of interobserver concordance consisted of the Kappa statistic, with the level of concordance standardized according to Cohen. P values lower than 5% were considered significant.

RESULTS

Thirty-two studies were included, and evaluated by 20 hand surgeons, totaling 640 evaluations and 2560 responses.

Applicability/Feasibility/Relevance: high versus low-impact publications

When the study-by-study responses were stratified according to "great chance of applicability" and "low chance of applicability," and "low and high scientific impact publications," no significant difference was seen between the propensity of applicability. (Table 1)

Table 1. Summary of studies with low and high chance of applicability, stratified by journal impact factor.

Journal impact	High chance of applicability	Low chance of applicability
High	187	173
Low	157	123

Chi-square; 1.079; p=0.29.

Concordance: more vs. less experienced

In general, the responses regarding the studies demonstrate low reproducibility and low significance when more experienced surgeons were compared with less experienced surgeons. Of the 32 studies, only four demonstrated statistical significance. (Tables 2 and 3)

External validity: more vs. less experienced

Among the studies, the difference between the proportions of "yes" answers (number of "yes" answers per study), stratified by experience, showed a difference for eight studies (25%). Among these studies, the proportion of "yes" responses was greater among less experienced respondents in five studies. Among the more experienced physicians, the proportion of "yes" responses was higher in three studies, with no difference between the proportions (Fisher's exact test, p=0.70).

When "yes" answers (>75%) were categorized by study, there was no difference between the less and more experienced professionals (less experienced: 37.5% *versus* more experienced: 28%, chi-square = 0.637; p=0.424). (Table 4)

DISCUSSION

The objective of this study was to verify the factors leading to applicability of high-quality clinical research (level I, randomized clinical studies) in the spectrum of hand surgery. It is plausible that in clinical practice, surgeon experience and journal impact are relevant factors for decision-making. More experienced surgeons are expected to be more skeptical about applying new evidence compared to less experienced professionals. The same is also expected in terms of journal impact factor: higher-impact journals are expected to publish studies with greater clinical relevance and external validity. However, the results of this study refute common sense, demonstrating that these factors are not relevant.

With the recent advent of open-access journals that charge for publication, there is a tendency for some studies to migrate to these journals since they offer impartial theoretical assessment and swifter

Table 2. Interobserver agreement stratified by study and potential applicability: more vs. less experienced.

Concordance	Kappa	P-value
Vanni et al[13]	-0.032	0.629
Van Heest et al[14]	0.179	0.002*
White et al.[15]	-0.009	0.852
Zaino et al.[16]	-0.021	0.757
Rubin et al.[17]	0.110	0.103
Dundar et al.[18]	-0.114	0.087*
Orlandi et al.[19]	0.060	0.355
Roh et al.[20]	0.012	0.755
Kolbenschlag et al.[21]	-0.027	0.677
Mickelson et al[22]	0.069	0.308
Ekrol et al.[23]	0.000	0.998
McMillan et al.[24]	0.174	0.010*
Costa et al.[25]	0.119	0.046*
Prosser et al.[26]	0.043	0.525
Vermeulen et al.[27]	0.018	0.721
Vermeulen et al.[28]	0.012	0.815
Walenkamp et al.[29]	0.059	0.376
Buijze et al.[30]	0.096	0.066
Paschos et al.[31]	0.023	0.729
Bentohami et al.[32]	0.036	0.593
Gradl et al.[33]	0.000	1.000
Rocchi et al.[34]	0.018	0.752
Yamazaki et al.[35]	0.108	0.107
Gautam et al.[36]	0.062	0.353
Zhang et al.[37]	0.110	0.092
Lindan et al.[38]	0.035	0.597
Østerås et al.[39]	-0.031	0.633
Nam et al.[40]	0.052	0.262
Karlsson et al.[41]	0.019	0.775
Drac et al.[42]	0.150	0.026*
Geetha et al.[43]	0.116	0.073
Koman et al.[44]	0.064	0.321

Table 3. Interobserver agreement stratified by study and potential applicability: more *vs.* less experienced - significant results.

Concordance	Kappa	P-value
Van Heest et al.[14]	0.179	0.002
McMillan et al.[24]	0.174	0.010
Costa et al.[25]	0.119	0.046
Buijze et al.[30]	0.150	0.026

publication. This scenario permits publication of studies with high methodological quality in "open" journals with lower impact and visibility in the area. Our results demonstrate a greater tendency to applicability, when stratified by journal impact or importance.

The applicability of the evidence, as disseminated by the Canadian school, should follow the cycle of evidence, which consists of five stages: 1. formulate the clinical question; 2. look for the best evidence; 3. critical analysis, verify the effects and their applicability; 4. integrate the evidence with the experience, in the clinical setting; 5. evaluate effectiveness and efficiency. This present study

Table 4. Number and percentage of "yes" answers, stratified by experience.

"Yes" answer	More Experienced		Less Experienced		P-value
	N	%	N	%	
Vanni et al.[13]	32	80.0%	34	85.0%	0.556
Van Heest et al.[14]	25	62.5%	31	77.5%	0.143
White et al.[15]	18	45.0%	32	80.0%	0.001*
Zaino et al.[16]	21	52.5%	18	45.0%	0.502
Rubin et al.[17]	28	70.0%	32	80.0%	0.302
Dundar et al.[18]	27	67.5%	31	77.5%	0.317
Orlandi et al.[19]	20	50.0%	21	52.5%	0.823
Roh et al.[20]	33	82.5%	39	97.5%	0.025
Kolbenschlag et al.[21]	17	42.5%	15	37.5%	0.648
Mickelson et al[22]	27	67.5%	25	62.5%	0.639
Ekrol et al.[23]	20	50.0%	26	65.0%	0.175
McMillan et al.[24]	21	52.5%	16	40.0%	0.262
Costa et al.[25]	34	85.0%	24	60.0%	0.012*
Prosser et al.[26]	17	42.5%	16	40.0%	0.820
Vermeulen et al.[27]	14	35.0%	26	65.0%	0.007*
Vermeulen et al.[28]	33	82.5%	37	92.5%	0.176
Walenkamp et al.[29]	35	87.5%	33	82.5%	0.531
Buijze et al.[30]	20	50.0%	32	80.0%	0.005*
Paschos et al.[31]	31	77.5%	26	65.0%	0.217
Bentohami et al.[32]	20	50.0%	23	57.5%	0.501
Gradl et al.[33]	22	55.0%	11	27.5%	0.012*
Rocchi et al.[34]	32	80.0%	22	55.0%	0.017*
Yamazaki et al.[35]	26	65.0%	21	52.5%	0.256
Gautam et al.[36]	23	57.5%	21	53.8%	0.744
Zhang et al.[37]	31	77.5%	35	87.5%	0.239
Lindan et al.[38]	22	59.5%	28	70.0%	0.333
Østerås et al.[39]	32	80.0%	28	70.0%	0.302
Nam et al.[40]	28	70.0%	33	91.7%	0.018*
Karlsson et al.[41]	11	27.5%	16	40.0%	0.237
Drac et al.[42]	18	45.0%	20	50.0%	0.654
Geetha et al.[43]	27	67.5%	31	77.5%	0.317
Koman et al.[44]	14	35.0%	16	40.0%	0.644

systematically created a controlled environment in which we can evaluate stages 2, 3 and 4 of evidence-based medicine in an integrated manner.[3,8]

The results of our study are unprecedented and there is no standard for comparison in the area literature, making our results relevant and groundbreaking. Future studies could consider larger samples and investigate other influencing factors, such as external funding, costs, and specific regional characteristics (related to assistance and economic aspects).

CONCLUSION

In summary, in this study a low concordance was observed between a group of specialized surgeons in terms of applicability of randomized clinical trials. Potentially influencing factors, such as surgeon experience and journal impact factor were not seen to be relevant for this sample.

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ORIGINAL ARTICLE

POSTOPERATIVE RETROSPECTIVE ANALYSIS OF THE TREATMENT OF DUPLICATED THUMB

ANÁLISE RETROSPECTIVA PÓS-OPERATÓRIA DO TRATAMENTO DAS DUPLICAÇÕES DE POLEGAR

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ABSTRACT

Objective: To evaluate postoperative epidemiological and functional factors in patients operated to treat duplicate thumb. Methods: This retrospective case series evaluated 20 patients (23 thumbs) treated from January 2012 to December 2016 at our service. Epidemiological and clinical factors were studied, including Tada score. Results: Of the 34 children who were treated surgically, only 20 appeared for the functional evaluation and were included in the study. Of the operated cases, 60% were Wassel type 4. All evaluated cases had good functional results (Tada score ≥5, mean score: 6.65). The most frequently used surgical technique was resection of the radial thumb with reconstruction of the radial collateral ligament (47.8% of cases). Conclusion: Surgical correction of duplicated thumb yields good results, as long as attention is paid to abnormalities in bones, ligaments, and tendons. ***Level of Evidence IV; Case series.***

Keywords: Thumb/abnormalities. Thumb/pathology. Thumb/physiopathology. Thumb/surgery. Classification. Follow-up studies.

RESUMO

Objetivo: Avaliar os fatores epidemiológicos e funcionais pós operatórios dos pacientes operados por duplicação de polegar. Métodos: Essa é uma série retrospectiva de casos em que foram avaliados 20 pacientes (23 polegares), operados entre janeiro de 2012 e dezembro de 2016, no Hospital Menino Jesus/ SP. Foram estudados fatores epidemiológicos e clínicos, dentre os quais o score funcional de Tada. Resultados: Das 34 crianças operadas, apenas 20 compareceram para avaliação funcional. Dos casos operados, 60% eram Wassel tipo 4. Todos os casos avaliados obtiveram resultado funcional bom (Tada maior ou igual a 5), com score médio de 6,65. A técnica cirúrgica mais utilizada foi a ressecção do polegar radial com reconstrução do ligamento colateral radial, presente em 47,8% das vezes. Conclusão: A correção cirúrgica da duplicação de polegar cursa com bons resultados, desde que se atente para as anormalidades osteoligamentares e tendíneas. ***Nível de Evidência IV; Série de casos.***

Descritores: Polegar/anormalidades. Polegar/patologia. Polegar/fisiopatologia. Polegar/cirurgia. Classificação. Seguimentos.

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INTRODUCTION

Thumb duplication is a common complex deformity[1] more frequent in American and Asian populations. Its occurrence is sporadic[2] with an incidence of 8 per 100,000 live births.[3]

Wassel's classification divides thumb duplications in seven types based on radiologic assessment.[4] However thumb duplications are not restricted to skeletal alterations. They are frequently associated with deficiency of the collateral ligament and tendon abnormalities. Besides systematizing polydactyly, Wassel's classification might guide treatment, which is usually surgical. The objective of surgery is to obtain a thumb with good mobility, adequate size and growth, minimal scarring and nail deformity, and stable interphalangeal and metacarpophalangeal joints.[5,6]

Tada scoring system was developed with the objective of systematizing functional evaluation of thumb duplication. (Table 1) It is a ranked scale, which assesses four basic areas: range of movement, instability, axial deviation and aesthetic perception. Scores higher than five characterize good results, between 3-4 moderate ones, while those under two indicate poor results.

This study aims at assessing postoperative epidemiological and functional factors in patients operated on for thumb duplication.

MATERIALS AND METHODS

This is a retrospective study based on a series of cases. After approval by the ethics committee at Hospital Menino Jesus, São Paulo (CAAE: 62431416.5.0000.5639), patients operated on for

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

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Table 1. Tada score.

Postoperative evaluation			
Score	2	1	0
Range of movement* (IP + MCP)	>70%	50-70%	<50%
Instability	--	Negative	Positive
Axial Deviation	<10º	10-20º	>20º
Esthetic	Acceptable	Little deformed	Very deformed

Evaluation: >5 good; 3-4 fair; <2 poor. * Interphalangeal + metacarpophalangeal: value stands for the percentage of range of thumb contra-lateral normal movement.

thumb duplication in that hospital between January 2012 and May 2016 were invited to an appointment for functional assessment. All parents/guardians were properly informed on the objectives of the study and they signed the informed consent and permission forms. Medical records were reviewed in order to inform on surgical technique employed and anatomical details of each patient. Clinical-surgical photographic and radiographic records of the patients were also examined.

Epidemiological and surgical aspects were assessed. Epidemiological factors analyzed were age at surgery, follow-up period, sex, laterality and pathological background. Clinical factors observed were Wassel's classification, surgical technique employed, Tada score, early and late complications. Dehiscence or wound infection was considered an early complication, while the perception of hypertrophic scar or pulp hypoplasia was considered a late complication.

Thirty-four children were operated on in the period. Only twenty attended the functional assessment, a total of 23 thumbs. All patients were operated by the same surgeon and underwent the same rehabilitation protocol.

RESULTS

In the period between January 2012 and May 2017, 34 children were operated on for thumb duplication at Hospital Menino Jesus, however only 20 attended the functional assessment, resulting in a 58% attendance to the call.

Among the 20 patients assessed, nine are males (45%) and 11 females (55%)

Twenty-three hands were studied, 11 of those were right hands (47%), nine left ones (39%) and three cases were bilateral (13%). Among the three bilateral ones, two were male and both displayed the same classification on both hands (Wassel type 4)

The mean age of the children at the time of surgery was 19 months (range: three to 82 months). The mean follow-up period was 26 months (range: nine to 51 months).

Population distribution according to Wassel's classification is demonstrated in Table 2. Type 4 (Figure 1) is the most frequent deformity affecting 14 thumbs, which corresponds to 60% of the operated thumbs.

None of the patients interviewed has reported comorbidities prior to surgery neither has any of them presented postoperative complications.

Functional assessment according to Tada score is presented in Table 3. All patients have scored equal or above five, which means a good functional result. The most frequent score was seven (9/23 thumbs) (43%). Mean score was 6.5 (range: five to eight).

Surgical procedures consisted of resection of the radial thumb with reinsertion of the collateral radial ligament (CRL); resection of the radial thumb with reinsertion of CRL associated with metacarpal osteotomy and skin graft; and, Bilhaut-Cloquet procedure. The most used technique was the first, being observed in 47.8% of cases. Distribution of techniques is detailed in Table 4.

Table 2. Distribution of patients according to Wassel's classification.

	Absolute frequency (%)	Relative frequency (%)
Wassel		
I	0	0
II	4	17.5
III	0	0
IV	14	60
V	2	9
VI	1	4.5
VII	2	9
Total	23	100

Figure 1. Clinical photograph of Bilhaut-Cloquet procedure. (A) Clinical aspect and preoperative planning of modified Bilhaut-Cloquet procedure. (B) Preoperative radiographic image. (C) Intra-operative image. (D) Late clinical result.

Table 3. Distribution of patients according to TADA score.

	Absolute frequency (%)	Relative frequency (%)
Tada		
5	2	8.6
6	8	34.7
7	9	39
8	5	17.7
Total	23	100

Table 4. Frequency of surgical techniques used.

	Absolute frequency	Relative frequency (100%)
Technique		
Resection of the radial thumb with reinsertion of CRL	11	48
Resection of the radial thumb with reinsertion of CRL associated with osteotomy of metacarpal head	11	48
Bilhaut-Cloquet	1	4
Total	23	100

CRL: collateral radial ligament.

DISCUSSION

Thumb duplication is included in Swanson's/International Federation of Societies for Surgery of the Hand (IFSSH) classification as a "duplication" and as a malformation/differentiation affecting the radial-ulnar axis of the hand plate within Oberg-Manske-Tonkin (OMT) classification.

Classic etiological theory for thumb duplication is rupture of the ectoderm and necrosis of the preaxial mesoderm during the embryologic period before the eighth week after fertilization.[7] Recent studies have shown the importance of programmed cell death in the formation of the thumb and in the formation of the anteroposterior axis of the limb. The Zone of Polarizing Activity (ZPA) is an area of mesenchyme that contains signs, which guide the development of limb bud development. The sonic hedgehog protein expressed in ZPA is related to the radio-ulnar differentiation. Abnormal expression of this protein and other genes such as Hox genes, bone morphogenic protein and GLI3 gene are also involved in thumb duplication.[8,9]

Reaching good functional and esthetic results is fundamental in the treatment of thumb duplication. Thus, guidelines must be followed in order to achieve the best and most predictable possible results. Wassel's classification works as a guide in standardizing procedures of surgical treatment for thumb duplication. Classical treatment consists of resection of the hypoplastic thumb with the preservation of structures in order to reconstruct the remaining thumb.[10,11]

There is greater risk of postoperative thumb instability in type 2 duplication. Once the deformity is articular, collateral ligaments, capsule and tendons need to be preserved and adequately reinserted in thumb reconstruction. There are three cases of type 2 duplication in the series of cases discussed here. Resection of the hypoplastic thumb was the technique employed to operate on two of them because they were asymmetrically bifid. Modified Bilhaut-Cloquet procedure was used on the third patient.[12] Following this procedure, the surgeon performs an oblique osteotomy on the distal phalange in order to combine the nail bed of the ulnar thumb with the radial osteoarticular structures of the radial thumb. (Figure 2) Good functional and articular results were obtained for the three patients (mean Tada score of 6.3).

There was no thumb duplication type 3 among the cases studied. This type of duplication is treated with resection of the hypoplastic thumb and it presents good prognostic once it does not involve articulating elements.

Type 4 duplication presents higher risk of stiffness and instability.[13] A larger metacarpal head might cause this, requiring the surgeon to perform an osteotomy in order to create better correspondence between the base of the proximal phalange and the metacarpal head.[14,15] There are 14 type 4 duplicated thumbs in the sample studied here. Resection of the hypoplastic thumb with reinsertion of the collateral ligament was performed on nine thumbs (64%), and the osteotomy of the metacarpal head was associated in seven cases (36%). In all cases, good functional results were obtained (mean Tada score of 6.7).

Duplication type 5, as well as type 3, does not involve articulating elements in its reconstruction, hence, there is lower risk of instability. However, unlike in type 3, in type 5 all thenar muscles are inserted into the hypoplastic thumb to be resected. The reinsertion of those muscles in the remaining thumb is a surgical phase to be added in the reconstruction of such cases in order to improve functional results.

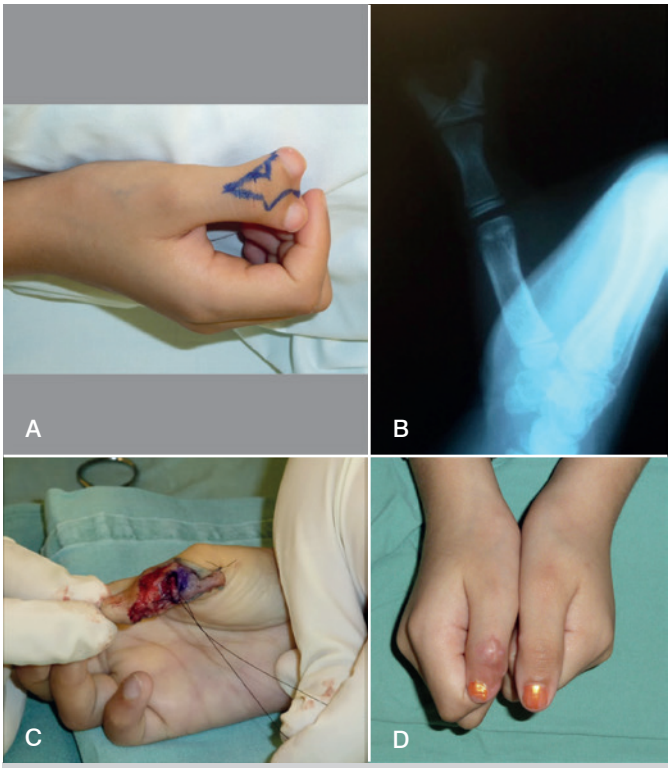

Figure 2. Clinical photograph of Bilhaut-Cloquet procedure. (A) Clinical aspect and preoperative planning of modified Bilhaut-Cloquet procedure. (B) Preoperative radiographic image. (C) Intra-operative image. (D) Late clinical result.

Wasel's type 6 consists of duplication up to metacarpal level. The preservation of articulating structures of the hypoplastic thumb must be combined with the reinsertion of thenar muscles in the reconstruction.[16,17] There was only one such case in this study and it resulted in a good clinical result.

Treatment of type 7 duplication follows the same principles of the previous ones. Despite its greater anatomical complexity, functional and esthetic outcomes are similar to the other types.

Wassel's classification is extremely important in evaluating and guiding the treatment of thumb duplication. However, this classification presents the limitation of considering only the radiographic component of the duplication. Intra-operative findings are varied and might include from cartilage fusion not visible in radiographic images (which changes the type of duplication within Weasel's classification), to tendon abnormalities, enlarged articular surfaces and capsule-ligament laxity.[18] These morphological alterations should be considered in surgical reconstruction of thumb duplication and they are directly involved in the success of the treatment.[19]

CONCLUSION

Surgical reconstruction of thumb duplication presents good esthetic and functional results, since bone and soft tissues morphologic abnormalities are adequately approached. Wassel's classification is useful as a guide in choosing the surgical technique thus providing patients and parents with satisfactory results.

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ORIGINAL ARTICLE

BIOMECHANICAL ANALYSIS OF FEMORAL NECK FRACTURE FIXATION IN SYNTHETIC BONE

ANÁLISE BIOMECÂNICA DA FIXAÇÃO DA FRATURA DO COLO DO FÊMUR EM OSSO SINTÉTICO

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ABSTRACT

Objectives: To analyze the results of biomechanical assays of the fixation of Pauwels type II femoral neck fractures in synthetic bones, using two parallel cannulated screws or three cannulated screws in an inverted pyramid formation. Methods: Ten Brazilian-made synthetic bones were divided into 2 groups. Groups A and B utilized three and two cannulated screws, respectively, after osteotomy in the middle third of the femur, perpendicular to the axis of the femoral neck, simulating a Pauwels type II femoral neck fracture. The resistance of these fixations was analyzed by compression on the axis of the force resulting from hip compression, simulated with a manual hydraulic press. The T-test and post hoc analysis were used to compare the groups, and the significance criterion adopted was $p < 0.05$. Results: In group A, which used fixation with three screws, synthesis failure was seen at a mean force of 526 N. In group B, which used two screws, the mean force was 466 N. The results presented a statistically significant difference ($p = 0.02$). Conclusion: The osteosynthesis of femoral neck fractures in synthetic bone fixated with two screws presented inferior results to fixation with three screws. ***Level of Evidence III; Case-control study.***

Keywords: Bone screws. Femoral neck. Hip fractures.

RESUMO

Objetivos: analisar os resultados dos ensaios biomecânicos da fixação da fratura de colo de fêmur Pauwels tipo II em ossos sintéticos, utilizando dois parafusos paralelos ou três parafusos em formação de triângulo invertido. Métodos: Foram utilizados 10 ossos sintéticos, de uma marca nacional, divididos em dois grupos. Nos grupos A e B foram realizados, respectivamente, fixação com três e com dois parafusos canulados, após osteotomia perpendicular ao colo femoral no seu terço médio, simulando uma fratura do colo femoral Pauwels tipo II. Analisou-se a resistência destas fixações a uma compressão no eixo da força resultante de compressão do quadril, através de uma prensa hidráulica manual. O teste t e a análise "post hoc" foram utilizadas para comparação dos grupos e o critério de determinação de significância adotado foi $p < 0,05$. Resultados: No grupo A, submetido à fixação com três parafusos, observou-se a falha da síntese com uma média de 526 N. Já no grupo B, com dois parafusos, a média foi de 466 N. Os resultados encontrados apresentaram diferença estatisticamente significativa, com $p = 0,02$. Conclusão: A osteossíntese das fraturas do colo femoral de osso sintético com dois parafusos apresentou resultados inferiores à utilização de três parafusos. ***Nível de Evidência III; Estudo caso-controle.***

Descritores: *Parafusos ósseos. Colo femural. Fraturas do quadril*

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INTRODUCTION

Fractures in the proximal third of the femur cause high morbidity and mortality, with many patients dying within two years. Femoral neck fractures are frequently seen in clinical practice, representing 40-50% of proximal femur fractures.[1,2] The average age of patients with these fractures is 75-80 years for women, and slightly lower in men. They commonly occur in patients with multiple comorbidities, and represent high costs for treatment and management.[3-5]

Pauwels classification divides femur neck fractures into three types based on the angle that the fracture forms with the horizontal plane. In type I fractures this angle is 30º, in type II 50º, and in type III 70º. As the fracture becomes more oblique instability also increases, and complications related to fixation and consolidation worsen.[1,5-7]

Surgical treatment reduces the incidences of morbidity and mortality caused by femoral neck fractures. In stable fractures, fixation with screws is often possible, preserving the femoral head. However, unstable fractures are generally treated with total or partial arthroplasty of the hip.[1,2,4-6,8]

In most patients with fractures that are not diverted from the femoral neck, internal fixation is the treatment of choice.[1] These surgeries

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that preserve the femoral head cause less damage to the delicate vascularization of this structure. Consequently, a frequent doubt is whether the use of two cannulated screws instead of three is sufficient to provide stability and consolidate the fracture.[9,10]

The main complications of osteosynthesis in femoral neck fractures are fixation failure and pseudoarthrosis. Pseudoarthrosis is more common and occurs in 6% of cases on average, accounting for 60% of the complications in this type of fracture.[1,5,7,11]

Many studies have compared various types of fixation for unstable fractures,[1,5] but few present the results with analysis of stable fractures and their variables using the classic fixation techniques described in the literature.[9,10]

This study therefore compares the mechanical resistance of femoral neck fixation in synthetic pre-osteotomized bones which simulate a Pauwels type II fracture using two parallel screws and three screws in an inverted pyramid configuration.

MATERIALS AND METHODS

Ten synthetic proximal femur bones produced in Brazil were used. The bones were produced of rigid polyurethane, with a 7 mm diameter medullary canal and natural curvature. Specimens were divided into two groups, A and B.

Group A consisted of five intact specimens of these synthetic models. Using fluoroscopy, three guide wires were introduced in an inverted pyramid arrangement (with the peak of the pyramid in the lower part of the femoral neck and the other two holes above and parallel to each other, one in the anterior portion of the femoral neck and the other in the posterior portion). After confirmation of proper placement with the aid of guide wires, the holes were drilled with a 4.0 mm bit.

Group B was also comprised of five intact synthetic femur bones. In this group, two guide wires were introduced with a parallel guide, with one wire in the center of the femoral neck in the AP and lateral views and the other vertically parallel below the first.

The guide wires were then removed and an osteotomy was performed perpendicular to the axis of the femoral neck with a bone saw in the middle third of the bone, representing a Pauwels type II fracture, (Figure 1 A and B) after marking with a goniometer to make sure there were no differences between the tested specimens. The osteotomy in group A was fixed with three cannulated 7.0 mm steel screws in the holes which had been drilled previously, in the following order: inferior, anterior and, finally, posterior, as described by Asnis.[12]

In group B, the osteotomy was fixed with two cannulated screws.

In both groups, the holes were drilled prior to completing the osteotomy in the synthetic bones to facilitate anatomical reduction and compression of the fracture.

After the placement of all screws, X-rays were taken in the AP and lateral planes to evaluate fracture reduction and screw position (35 kV, 100 mA, mAs 3.00, time 0.030s). (Figure 2A, B, C and D)

Mechanical testing of the different femoral neck fracture fixation was then performed using axis compression resulting from the hip compression load according to Pauwels. Compression was created using a Contenco I-3001-C model manual digital hydraulic press (São José da Lapa, MG, Brazil). (Figure 3) until the synthesis failed. Failure was considered to occur when the synthetic bone fractured or a shear fracture larger than 5 mm occurred. (Figures 4 A and B)

The statistical method used was the T-test and post hoc analysis to compare the maximum force (N) between groups A and B. The independent mean difference test was chosen due to the due to the small sample size in each group, and statistical significance was established at 5%.

Because this study was not a clinical trial, and investigated mechanical fracture fixation without the use of any medication or human or animal tissue, approval was not required from the institutional review board. Similarly, since the study did not involve humans, the informed consent term was not required.

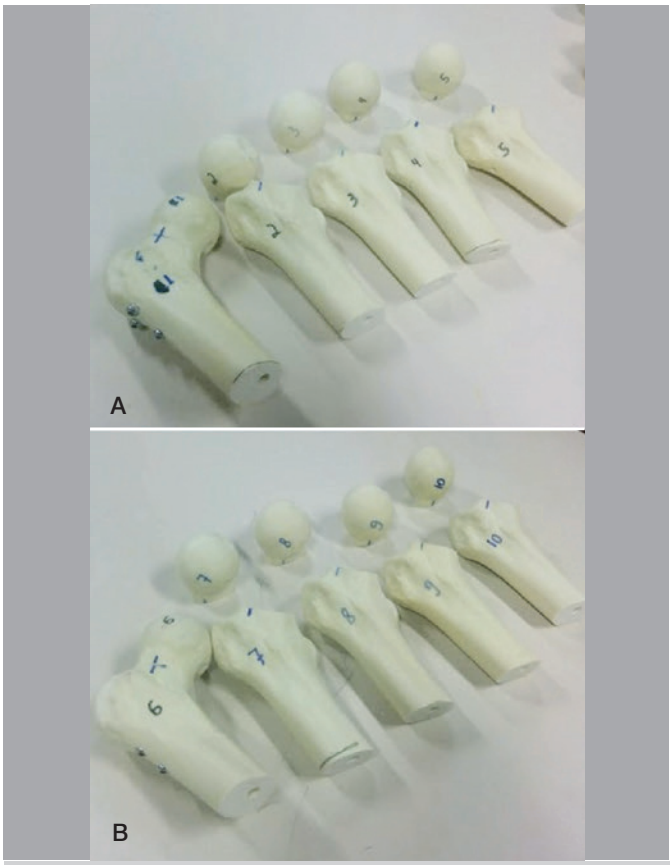

Figure 1. A and B: Samples of group A (fixed with three screws) and B (fixed with two screws).

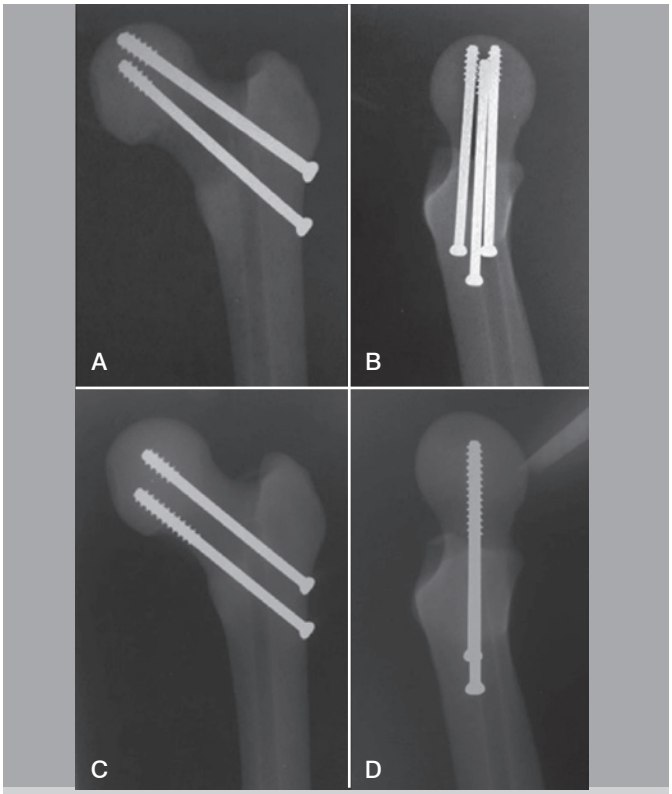

Figure 2. A, B, C and D – Anterior posterior and lateral X-ray confirmation of the correct positioning of the screws in groups A and B, respectively.

Figure 3. Manual hydraulic press used in the tests.

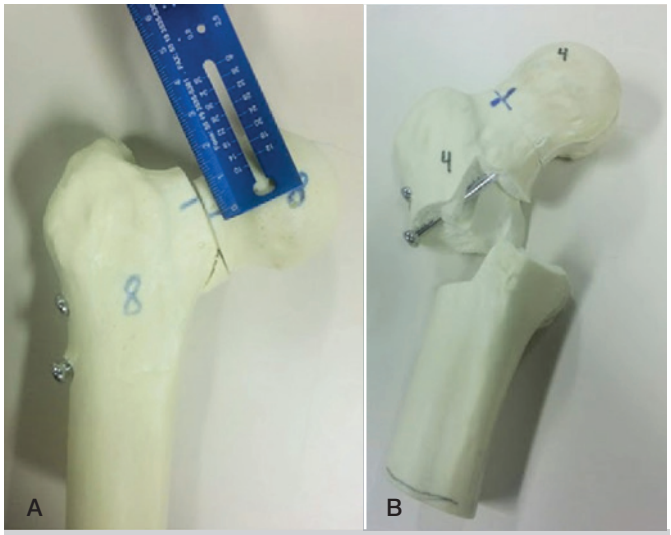

Figure 4. Manual hydraulic press used in the tests.

RESULTS

In group A (osteosynthesis with three screws), five failures were obtained with the applied load of 530, 560, 530, 490, and 520 Newtons (N), respectively, for samples 1–5 (mean 526 N, standard deviation 25 N). In all cases, the fracture occurred in the transtrochanteric region, with the fracture line in the upper-medial region going toward the lower-lateral region, which Tronzo classified as reverse obliquity fracture (type V). There was no shearing in the fracture line which had previously been created in any of the models in this group.

In group B (osteosynthesis with two screws), the load applied until failure was 470, 460, 450, 460, and 490 N for samples 6–10, respectively (mean 466 N, standard deviation 15 N). In three cases failure occurred via transtrocanteric fractures (Tronzo type V) and two were shear failures larger than 5 mm in the previously-created transcervical fracture. (Figures 5A and B)

Table 1 presents the values applied to the models in which fixation failure occurred. According to the mean difference test (T-test), group A sustained a significantly higher load until synthesis failure was reached in comparison with group B ($p = 0.02$). (Figure 6)

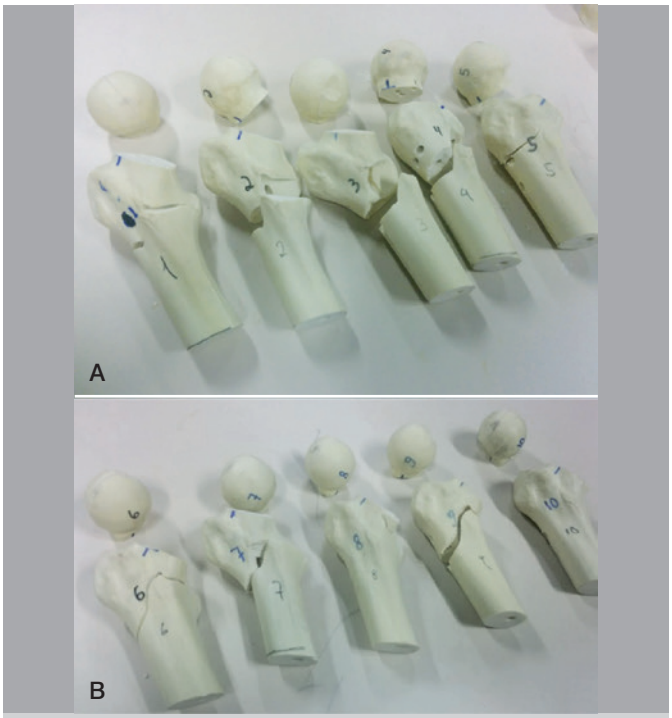

Figure 5. Failures in samples from Group A; B - failures in Group B.

Table 1. Distribution of force in Newtons (N) necessary for the failure of the osteosynthesis.

Group A (three screws)	Group B (two screws)
530	470
560	460
530	450
490	460
520	490

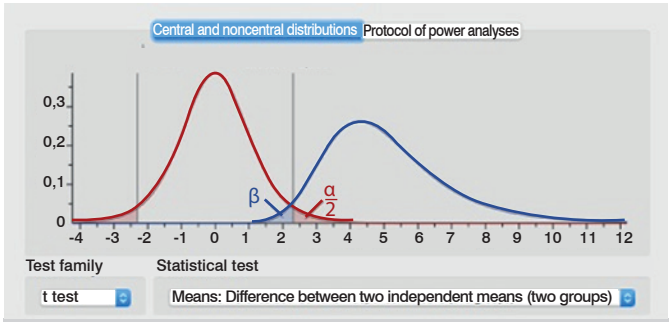

Figure 6. Statistical analysis *T*-test.

DISCUSSION

The main objective in treating femoral neck fractures is to allow the patient to return to normal activity as soon as possible.[5] Therefore, the ideal surgical fixation must be capable of withstanding the forces of weight discharge and restrict movement in the fracture focus during bone consolidation. Secure fixation also reduces the high rates of complications reported in treating this type of fracture.[1]

The synthetic bones were chosen to ensure comparable biomechanical properties between the groups and eliminate some variables.[13] We were consequently able to eliminate some biases inherent to human bones resulting from non-uniform characteristics (bone density, diameter and length) which would complicate the experiment.

Fixation of femoral neck fractures is often recommended with the use of cannulated screws, which have lower surgical morbidity, cause minimal soft tissue damage and limited blood loss, in addition to providing good stability. The widely accepted technique is the placement of three screws at a low angle (typically 135°) in an inverted pyramid arrangement.[14,15] However, patients who undergo surgical treatment of femoral neck fractures continue to exhibit high mortality (20%) and a reoperation rate around 35%.[4]

Selvan et al.[16] defend the traditional configuration of three screws in the inverted pyramid configuration as the most mechanically stable option in comparison with two or three vertical parallel screws. This can be explained by the fact that the clinical outcome is more related to blood supply to the femoral head after fixation than its actual stability.[17,18] The AO-ASIF group[15] also supports the use of three screws, although it does consider fixation with two screws to be an option.

In contrast, Krastman et al.[9] stated that non-diverted femoral neck fractures can be adequately secured with two cannulated screws, and Basile et al.[10] defended the use of only two screws, stating that although this configuration is less stable, it is sufficient for correct treatment of femoral neck fracture, with a 13.3% rate of failure for the technique. Basile et al.[10] also argued that it is difficult to place the implants exactly parallel, and placing the third screw is even more difficult.

In a study using 14 femurs from fresh cadavers, Walker et al.[14] compared the use of two (parallel horizontal) or three (inverted triangle) cannulated screws and concluded that two screws provided adequate fixation, and that no significant advantage was obtained from the addition of a third screw.

In a prospective study with 268 femoral neck fractures, Lagerby et al.[17] compared fixation with two screws (Uppsala technique) and three cannulated screws (Richards technique), and in the first year after surgery found a complication rate of 24% for three screws and 25% for two screws. Revision procedures with prosthetic replacement occurred in 14% and 12% of cases, respectively.

The various studies in the literature do not reach a consensus on the number and optimal positioning of the cannulated screws for fixation of femoral neck fractures. The present study agrees with Selvan and the AO-ASIF group in finding that all failures in the three-screw group occurred from fractures in a different site (the transtrochanteric region), without shear stress in the femoral neck fracture, proving the stability of the synthesis. The samples fixed with two screws demonstrated stabilization in the fracture focus, but two failures resulted from shearing. The difference in the results obtained was statistically significant, allowing us to conclude that fixation with three screws is more stable.

We recognize the limitations of our study. The sample size was small, the fractures were simulated by osteotomy, and there are more technologically advanced means to conduct the proposed tests, in addition to the lack of a control group. The use of synthetic bone instead of cadaver bone does not accurately reflect the anatomy of the femoral trabeculae and its support of force, but these synthetic bones were chosen to ensure that the biomechanical properties were comparable between the groups, eliminating variables.

CONCLUSION

A statistically significant difference was found between the group with Pauwels type II fractures fixed with three screws (group A) and the group secured with two screws (group B) ($p = 0.02$).

Furthermore, no shear failure was seen in transcervical fracture in group A, with all failures occurring due to fractures in the transtrochanteric region, while shear fracture was the source of failure in 40% of the samples in group B.

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ORIGINAL ARTICLE

MENISCAL REPAIR RESULTS COMPARING MRI, ARTHRO-MRI, AND ARTHRO-CT

RESULTADOS DA SUTURA MENISCAL COMPARANDO RM, ARTRO-RM E ARTRO-CT

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ABSTRACT

Objective: To clinically and radiologically evaluate patients who received meniscal suture using the outside-in technique, comparing magnetic resonance imaging (MRI), arthro-magnetic resonance imaging (arthro-MRI), and arthro-computed tomography (arthro-CT) to evaluate the healing of meniscal sutures. Methods: We evaluated eight patients with an average follow-up of 15 months. The evaluation analyzed clinical parameters using the Lysholm and IKDC scores as well as MRI, arthro-MRI, and arthro-CT imaging. Results: At the end of the follow-up period, mean Lysholm score was 89.5 and mean IKDC score was 78.6. In the MRI, signs of meniscal healing were observed in 50% of the cases. The arthro-MRI and arthro-CT showed signs of healing in 75% of cases. There was a positive correlation between arthro-MRI and arthro-CT results in all the cases studied (kappa correlation index=1). Conclusion: Meniscal suture using the outside-in technique presented good or excellent results in 87.5% of our patients. The arthro-CT and arthro-MRI showed the same level of accuracy in detecting healing of the sutured region of the meniscus. ***Level of Evidence IV; Case series.***

Keywords: Meniscus. Knee. Magnetic resonance imaging. Tomography.

RESUMO

Objetivo: Avaliar clinicamente e radiologicamente pacientes submetidos a sutura-meniscal pela técnica outside-in, comparando a Ressonância Magnética (RM), Artro-Ressonância Magnética (Artro-RM) e Artro-Tomografia Computadorizada (Artro-CT), quanto a cicatrização da sutura meniscal. Método: Avaliamos oito pacientes com um seguimento médio de 15 meses, clinicamente e por meio de score de Lisholm e IKDC, e realizamos RM, Artro-RM e Artro-CT. Resultados: A média do score de Lysholm foi de 89.5 e o score médio do IKDC foi de 78,6. A RNM observou sinais de cicatrização meniscal em 50% dos casos, enquanto a artro-RNM e artro-CT evidenciaram sinais de cicatrização em 75% dos casos. Houve uma correlação entre a artro-RNM e a artro-CT em todos os casos. Conclusão: A sutura meniscal pela técnica outside-in apresentou bons e excelentes resultados em 87,5% dos nossos pacientes. A artro-CT e a artro-RNM têm acurácia equivalente na detecção da cicatrização da região suturada do menisco. ***Nível de Evidência IV; Série de casos.***

Descritores: *Menisco. Joelho. Imagem por ressonância magnética. Tomografia.*

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INTRODUCTION

Formerly considered vestigial structures,[1] the menisci are now recognized as vital structures for the biomechanics and integrity of the joint surface of the knee. The known functions of the meniscus include increased femoral tibial joint congruence, joint stability, distribution of the synovial fluid and reduced friction between the joint surfaces, and increased surface area of contact between the femur and the tibia. These factors help reduce contact pressure between the surfaces of the joint, and have a positive effect on joint proprioception.

Despite the satisfactory initial results of meniscectomy for the treatment of patients with meniscal lesion, it was soon observed that this procedure is not without its drawbacks. According to Fairbank,[2] in patients who have undergone meniscectomy, degenerative alterations occur in the joint cartilage of the knee in direct proportion to the quantity of dried meniscus. A knowledge of the function and importance of the meniscus has led to greater emphasis on its preservation, through partial meniscectomies and techniques for repairing the torn meniscus.

The use of techniques to repair the torn meniscus through the use of sutures has been described as far back as the end of the 19th century,[3] with studies on animals from the 1930s.[4] However, the rational use of meniscal suture came with subsequent studies on vascularization of the meniscus. Arnoczky and Warren[1] demonstrated,

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in human corpses, the presence of capillary plexuses covering up to 30% of the meniscus, from its more peripheral portion, inferring the capacity to heal lesions situated in this region. The development of the surgical technique, particularly through arthroscopy, made suture of the meniscus a viable, low risk procedure, which led to a more biological practice with the focus on preserving the meniscus. Various techniques are currently used for meniscal suture.[5] The most common of these is the outside-in technique.[6] Previous studies have demonstrated good or excellent results in more than 90% of patients, using this technique.[7,8]

The objective of this study is to clinically and radiologically evaluate the result of meniscal suture in these patients. The purpose of the radiological study is to evaluate the healing of meniscal lesions after suture, through Magnetic Resonance Imaging (MRI) without contrast medium, or with intrajoint contrast medium (Arthro-MRI), and through Computed Tomography with intrajoint contrast medium (Arthro-CT).

MATERIALS AND METHODS

The study was approved by the institutional review board, protocol (number 806/06), and all individuals were informed about the research purposes and signed written informed consent. We evaluated eight patients submitted to meniscal repair. All patients were male, with an average age of 33.5 years old (range 20 to 48 years old). Meniscus repair was performed by the outside-in technique, with an average follow-up of 40.2 months. (Table 1) The lesion was located in the medial meniscus in all cases. Five patients presented associated lesion of the anterior cruciate ligament, and reconstruction was carried out concomitantly, using autologous patellar tendon graft.

Surgical technique

The outside-in technique was used for the meniscal repair. Before starting the suture, we removed the debris from the edges of the meniscal lesion with a shaver, to promote healing. Next, we took an absorbable suture thread (*vicryl*® nº1) and passed it with a 14 gauge needle from outside to inside through a small incision on the medial side of the knee, perforating the meniscus and the adjacent joint capsule, and going right through the lesion. The suture thread was retrieved from the arthroscopic portal with a grasper. In the same way, we inserted another suture thread approximately 5 mm from the first, tied them outside the portal and retrieved the knot from the medial incision. Then we tied the knot in the capsule, repairing the meniscus to the joint capsule.

In the postoperative program, we emphasized the recovery of muscular strength, total extension, and flexion of up to 90° in the first month. We did not restrict weight-bearing.

The patients were evaluated in relation to range of movement, swelling of the joint, crepitation, stability, muscular atrophy, presence of pain in the joint interline, and the McMurray test. The patients were questioned about their level of sports activity compared with before the lesion, and their return to work.

The patients with normal results in the clinical examination, without any complaints about the repaired knee, and who returned to unrestricted activities, were classified as excellent. Patients with pain or swelling in the joint, but without mechanical symptoms and with normal results in the clinical examination were classified as good. Those with persistent pain, swelling of the joint and mechanical symptoms were classified as failures. The patients responded to the Lysholm[9] and subjective IKDC[10] questionnaires.

We carried out the imaging exams on all the patients, who were submitted to Magnetic Nuclear Resonance Imaging (MRI) without contrast or with intrajoint contrast medium (Arthro-RMI), and through Computed Tomography with intrajoint contrast (Arthro-CT). A gadolinium solution (paramagnetic contrast) was used, and non-ionic iodine, administered in the joint by the radiologist, just before the examination. The images were evaluated and drawn up in reports by one of the authors (MBR), a radiologist who specializes in the musculoskeletal system.

RESULTS

Based on the previously established criteria, seven cases were classified as excellent, and one as good. None of the cases were clinically classified as a failure. Mean Lysholm score was 89.5 and mean IKDC score was 78.6. (Table 2) In relation to the physical examination, all the patients presented complete recovery of the range of movement, and a negative result in the McMurray test. All the patients returned to work, and five patients resumed sports without limitations.

Signs of meniscal healing were observed in 50% of the cases in the MRI, characterized by the absence of hypersignal in the meniscus in T2 sequences. The arthro-MRI and arthro-CT showed signs of healing in 75% of the cases, as characterized by the absence of penetration of the contrast medium in the meniscus. (Figures 1 and 2) There was a correlation between the arthro-MRI and the arthro-CT in all the cases (kappa correlation index=1).

DISCUSSION

The success of the meniscal repair is directly related to the indication. We indicate repair in cases of longitudinal, peripheral lesions, within the red zone, preferably severe. However, if the lesion is favorable, we indicate suture, even in chronic cases. When associated with lesion of the ACL, concomitant ligament reconstruction appears to promote healing of the meniscus.[11-14] This was the conduct adopted

Table 1. demographic data of the patients.

Patient	Age (years)	Time (months)	Associated injury	Meniscus	Side
ESPV	20	24	None	Medial	R
RTA	28	6	ACL	Medial	L
AICA	36	7	ACL	Medial	R
DMA	20	12	ACL	Medial	R
MAD	33	7	ACL	Medial	R
MAFL	29	24	None	Medial	R
LAPJ	21	36	ACL	Medial	L
FES	48	14	None	Medial	R

Table 2. Lysholm scores (E=excellent, G=good, R=regular), IKDC score and meniscus healed (H) or not healed (N).

Patient	Lysholm score	IKDC Score	MRI	Arthro-MRI	Arthro-CT
ESPV	94 (E)	86	H	H	H
RTA	90 (G)	80	N	N	N
AICA	89 (G)	69	N	H	H
DMA	95 (E)	89	N	H	H
MAD	94 (E)	86	H	H	H
MAFL	90 (G)	68	N	N	N
LAPJ	65 (R)	62	H	H	H
FES	99 (E)	89	H	H	H

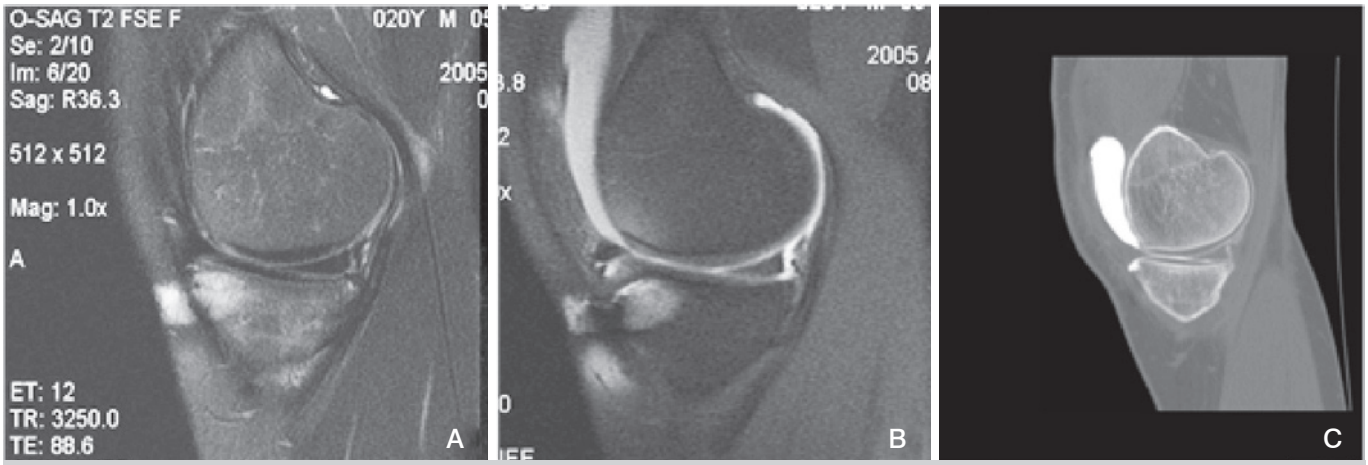

Figure 1. Knee MRI, Arhro-MRI and Arthro-CT after meniscal suture. See the hypersignal in T2 (left) and the penetration of the contrast medium (middle and right pictures).

Figure 2. Hypersignal of the posterior horn of the meniscus (left) in the MRI and absence of penetration of contrast medium (middle and right pictures).

in our patients with unstable knees. Although the small number of patients did not enable any statistically significant conclusion to be drawn in this regard, we observed no differences between the patients with stable knees, and those who underwent reconstruction of the ACL.

The rate of good and excellent results obtained in our study (87.5%) is in accordance with the data reported in the literature.[7,8,13-16] A good clinical result is not always related to complete healing of the meniscus in the area of the lesion, as demonstrated by Horibe et al.[17] The author carried out second-look arthroscopy, evidencing 73% complete healing of the lesion, compared with 93% good clinical results. This data suggests that clinical success does not necessarily imply complete healing of the lesion. We did not propose to carry out postoperative arthroscopy in all the patients for research purposes, as it is an invasive procedure which, although relatively safe, can present complications, and also due to the fact that the majority of our patients obtained good clinical results. We carried out second-look arthroscopy only in one case due to persistence of symptoms. The patient presented hypersignal in the posterior horn of the medial meniscus in the MRI. During surgery, we observed that the meniscus was completely stable, without signs of meniscal lesion. Therefore, in cases where any symptoms persist, a correct evaluation of the *status* of the meniscus can avoid complications and unnecessary procedures. It also provides information to advise the patient of the level of activity that can be carried out following surgery.

The first studies using MRI after meniscal repair were described by Farley et al[18] and Bronstein et al.[19] These authors observe persistent alterations in signal in the area of the lesion, following meniscal suture. In many of these cases, the patients did not have clinical signs of failed healing or new rupture, and many were evaluated through arthroscopy, which demonstrated the presence of healing in the sutured area. The hypothesis proposed was that the persistent area of hypersignal in the region of the meniscal suture was due to the higher water content in the recent repair tissue.[20]

Infiltration of the joint by the paramagnetic contrast can increase the sensitivity and specificity of the exam. In an experimental model using goats, Ritchie[21] demonstrated the 100% accuracy of arthro-MRI for the evaluation of complete meniscal healing, compared with 33% for conventional MRI. The diagnosis of a lesion or failed healing is done by visualizing the penetration of contrast medium at the site of the lesion.

The tomography associated with intrajoint infiltration of contrast (Arthro-CT) may be an alternative to Arthro-MRI. We have considered Arthro-CT particularly useful in cases where there is metallic synthesis material in the joint, to reduce the artefacts of the image presented in the MRI and Arthro-MRI, and also in cases where MRI

is counterindicated, such as in patients with cardiac pacemakers, brain stents and cochlear implants. This study shows that Arthro-CT has the same effectiveness as Arthro-MRI for evidencing the penetration of contrast medium at the site of the meniscal suture, with the advantage that it is lower cost, more widely available and faster to perform than arthro-MRI.

CONCLUSION

Meniscal suture by the outside-in technique presented good or excellent results in 87.5% of our patients. Arthro-CT and arthro-MRI have equivalent accuracy for evidencing whether or not the sutured region of the meniscus had healed.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AMDA (0000-0003-2507-3786)* and MUR (0000-0002-2020-9501)*: drafted the research project, conducted the surgeries, followed the patients, analyzed the data, and wrote the manuscript; MBR (0000-0003-4747-5081)*: evaluated the imaging, reviewed the literature, and drafted and revised the manuscript; AP (0000-0002-8449-7493)* and AH (0000-0001-8645-3956)*: contributed to the intellectual concept of the study and revised the manuscript. *ORCID (Open Researcher and Contributor ID).

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ORIGINAL ARTICLE

NAVIGATED TOTAL KNEE ARTHROPLASTY FOR OSTEOARTHRITIS WITH EXTRA-ARTICULAR DEFORMITY

ARTROPLASTA TOTAL DO GENE NAVEGATIVA PARA OSTEOARTRIA COM DEFORMIDADE EXTRA-ARTICULAR

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ABSTRACT

Objective: It is difficult to achieve proper alignment after total knee arthroplasty (TKA) in patients with extra-articular deformity (EAD) because of altered anatomical axis and distorted landmarks. As of this writing, only case series have been reported with regard to the usefulness of computer-assisted navigation systems for TKA with EAD. This study therefore compared outcomes in TKA with EAD, with and without navigation. Methods: Fourteen osteoarthritis patients with EAD due to previous fracture malunion or operations were assessed. Seven TKAs were performed with navigation (navigation group) and another 7 were performed without navigation (manual group). Clinical and radiographic outcomes were compared before and two years after surgery. Results: The mean postoperative Knee Society function score was significantly higher in the navigation group. No significant difference was found in postoperative range of motion and Knee Society knee score. The rate of outliers in radiographic outcomes tended to be lower in the navigation group. Conclusion: Better clinical outcomes were achieved in cases in which navigation was used. Computer-assisted navigation is useful in TKA for patients with EAD. ***Level of Evidence III; Case control study.***

Keywords: Arthroplasty, replacement, knee. Comparative study.

RESUMO

Objetivo: para pacientes com deformidade extra-articular (EAD), é difícil alcançar o alinhamento adequado após a artroplastia total do joelho (TKA) por causa de um eixo anatômico alterado e marcos distorcidos. Somente foram relatadas apenas séries de casos quanto à utilidade do sistema de navegação assistido por computador para TKA com a EAD até agora. Neste estudo, tentamos comparar resultados em TKA com EAD com e sem navegação. Métodos: Quatorze pacientes com osteoartrite com EAD devido a maluniões ou operações de fratura anteriores foram avaliadas. 7 TKAs foram realizados com navegação (navegação em grupo) e outros 7 TKAs foram realizados sem ele (manual de grupo). Antes e dpois anos após a cirurgia, os desfechos clínicos e radiográficos foram comparados. Resultados: O resultado médio da função Knee Society pós-operatório foi significativamente maior na navegação do grupo do que no manual do grupo. Não houve diferença significativa na amplitude de movimento pós-operatória e na pontuação do joelho na joia. A taxa de outliers em resultados radiográficos tende a ser menor na navegação do grupo do que no manual do grupo. Conclusão: foram obtidos melhores resultados clínicos na navegação em grupo. O sistema de navegação assistido por computador é útil em TKA para pacientes com EAD. ***Nível de Evidência III; Estudo de caso-controle.***

Descritores: *Artroplastia do joelho. Estudo comparativo.*

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INTRODUCTION

Total knee arthroplasty (TKA) is a successful surgical procedure for patients with end-stage osteoarthritis (OA). Achievement of proper alignment and appropriate soft tissue balancing is essential for successful clinical outcomes in TKA. Malalignment caused by improper osteotomy and component positioning leads to poor function, early loosening, and high risk of polyethylene wear.[1] Lonner et al.[2] reported difficulty in achieving proper alignment after surgery in patients with extra-articular deformity (EAD) because of an altered anatomical axis and distorted landmarks.

Computer-assisted surgery has been used for over 10 years to assist in the placement of cutting guides, instruments, and implants, and was developed to overcome some limitations of standard mechanical instrumentation.[3] Several comparative studies have revealed that computer-assisted surgery was effective in TKA to reduce mechanical axis outliers after surgery, and this procedure is now used widely.[4-7] Ishida et al.[8] reported better objective outcomes from use of a navigation system over conventional procedures, including range of motion (ROM) and radiological assessment at 5 years after TKA. With this system, surgeons can even safely operate

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on patients with severe bone deformity in whom conventional instrumentation cannot be used. Especially for cases with EAD, several surgeons have reported the utility of the navigation system for achieving better clinical and radiographic outcomes.[5]
However, nearly all reports on TKA for patients with EAD to date were case series without controls, which are not sufficient to determine the utility of the navigation system.[4-7,9] The current study attempts to clarify the utility of the navigation system.

MATERIALS AND METHODS

Patient characteristics and procedures

From October 2005 to September 2012, 14 patients (4 men and 10 women) with OA and EAD caused by either femoral or tibial trauma or previous leg surgery underwent TKAs at our institution. The study was approved by the institutional review boards of the participating hospitals, and all participants signed the free and informed consent term. The protocol of this study was approved by the Ethics Committee for Human and Animal Research of Graduate School of Medicine Kobe University (Protocol number: 1510). Inclusion criteria were the presence of extra-articular coronal deformity >3° in the femur or tibia. Patients with deformities <3° were excluded. Patient demographic data are shown in Table 1. There were 11 patients with tibial deformities, and the remaining 3 patients had femoral deformities. They were all diagnosed with OA, not with rheumatoid arthritis. Previous fracture malunion caused 4 of the deformities, and the others were caused by previous surgeries such as high tibial osteotomy, Schanz osteotomy, or femoral varus osteotomy. Of these cases, TKAs for 7 patients were performed with computer-assisted navigation systems (navigation group) and TKAs for the other 7 patients were performed without a computer-assisted navigation system (manual group). In the navigation group, 3 patients had an average femoral deformity of 15.1° (range: 28.2° in valgus to 14.5° in varus) and 4 patients had an average tibial deformity of 7.3° (range: 3° in valgus to 12° in varus) in the coronal plane. In the manual group, all patients had tibial deformities, and the average degree of deformity was 9.3° (range, 18° in valgus to 19.4° in varus) in the coronal plane.
All surgeries were performed by two senior authors (TM and KI), and six different types of prostheses were implanted (Zimmer NexGen LPS-Flex in 6 knees, B. Braun Aesculap e-motion in 4 knees, Depuy RP-F in 3 knees, and Stryker Triathlon in 1 knee). Posterior-stabilized (PS) prostheses were used in 8 knees and cruciate-retaining (CR) prostheses were used in 6 knees.

Operative Technique

In the navigation group, the prostheses were implanted with the aid of a CT-free navigation system (Depuy-Brain LAB, Heimstetten, Germany or B. Braun Aesculap, Tuttlingen, Germany). To define the mechanical axis of the tibia, the center of the tibial plateau was identified simply using the tip of the pointer. The anteroposterior direction of the tibia was subsequently defined in the same way after defining the medial and lateral articular surfaces and the anterior contour. Femoral registration consisted of identifying the medial and lateral epicondyles, the articular surface of the medial and lateral condyles, and the anterior sulcus. To define the mechanical axis of the femur, the deepest point of the intercondylar notch was identified simply using the tip of the pointer. The proximal tibial osteotomy was performed with 3° posterior inclination in the sagittal plane. Once the final components were in place, soft tissue balancing was performed to achieve proper collateral ligament tension following the indications of the navigation system.
In the manual group, we used a measured resection technique. The angular deformity and the mechanical axis of the femur were determined by preoperative, weight-bearing, full-length radiographs. The intra-articular resection of the distal femoral bone was made at a 90° angle relative to the mechanical axis.
For the tibial bony cut, an intramedullary rod was used for most cases, while an extra-medullary guiding rod was used in some cases with severe tibial angular deformities. The rotational alignment of the femoral prosthesis was set at 3° of external rotation in relation to the posterior condylar axis, and anterior and posterior femoral bony resections were performed with posterior referencing. The proximal tibial osteotomy was performed perpendicular to the long axis in the coronal plane. For the sagittal plane of the tibia, 3° of posterior inclination in PS-TKA and 7° of posterior inclination in CR-TKA were targeted.

Clinical and Radiological Measurements

Before and 2 years after surgery, clinical and radiological evaluations were performed in both groups. To assess clinical outcomes, the maximum knee extension and flexion angle, Knee Society knee score (KSKS), and Knee Society function score (KSFS) were evaluated.[10] To assess radiological outcomes, the Hip-Knee-Ankle (HKA) angle was measured before and 2 years after the operation in weight-bearing radiographs (a 320mA, 0.03-s exposure at 80-100kV, depending on soft tissue thickness). Component angles, including the femoral component angle in the coronal plane (cFCA), tibial component angle in the coronal plane (cTCA), femoral component angle in the sagittal plane (sFCA) and tibial component angle in the sagittal plane (sTCA), were measured to assess the accuracy in implantation of the prostheses 2 years after surgery (Figure 1) In addition, the ratio

Table 1. Demographic data of for navigation and manual groups.

Characteristics	Group	
	navigation	manual
Sex (male/female (% male))	1/6 (14.3%)	3/4 (42.9%)
BMI (kg/m (mean SD))	25.5 4.4	27.7 4.6
Age at time of TKA (years (mean SD))	75.0 4.2	72.0 6.0

BMI, body mass index; TKA, total knee arthroplasty; SD, standard deviation.

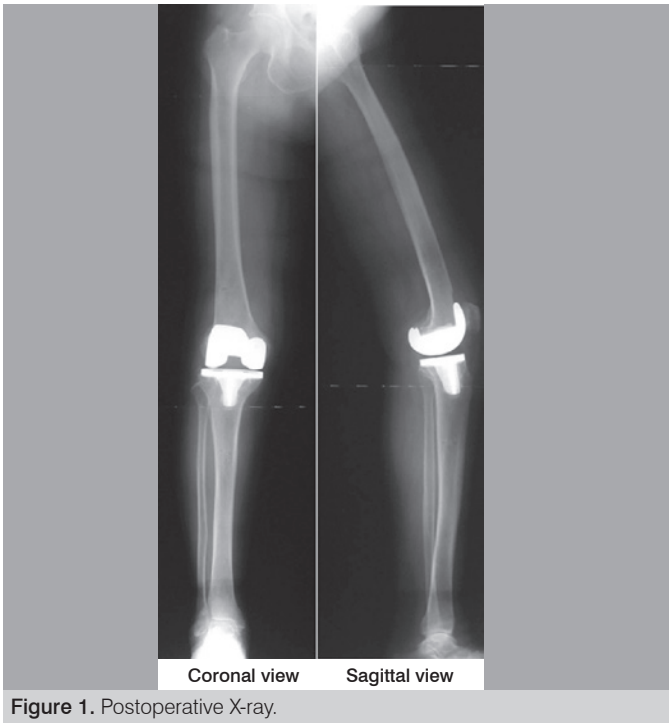

Figure 1. Postoperative X-ray.

of patients with proper alignment in each. radiological assessment category (HKA angle, 180±3°; cFCA, 90±2°; cTCA, 90±2°; sFCA, 87±2°; sTCA for the navigation group and PS-TKA in the manual group, 87±2° and sTCA for CR-TKA in the manual group, 83±2°) were compared between the groups. All radiological measurements were performed by three independent observers. Intra- and inter-observer reliability was almost perfect for both groups.

Statistical analyses

All statistical analyses were performed using Microsoft Excel (Microsoft Japan Inc. Tokyo, Japan). The differences in the 2 groups were analyzed using a chi-square test and a non-paired, two-tailed Student's t-test, which assumed equal dispersion. $P < 0.05$ indicated statistical significance.

RESULTS

The clinical results are shown in Table 2. The extremes of ROM improved on average from –5.7-107.9° to –2.9-127.1° in the navigation group, whereas it improved from –8.8-100.0° pre-operatively to –0.8-115.7° post-operatively in the manual group. KSKS improved from 58.9±9.2 points before surgery to 93.3±6.9 points at the last follow-up in the navigation group, while it improved from 47.0±18.4 points to 93.7±4.1 points in the manual group. There were no significant differences between two groups in ROM and KSKS. KSFS improved from 56.6±10.8 points before surgery to 93.3±5.9 points at the last follow-up in the navigation group, while it improved from 49.7±27.8 points to 73.6±15.4 points in the manual group. Postoperative KSFS in the navigation group was significantly better than in the manual group.

The radiological results are shown in Table 2 and 3. HKA angle improved from 10.6° pre-operatively to 0.3° post-operatively in the navigation group, while it improved from 9.3° to 0.7° in the manual group. No significant difference was shown in the rate of patients with outliers in HKA angle between 2 groups. (Table 2 and Figure 2) At 2 years post-procedure in the navigation group, the average values for cFCA, cTCA, sFCA and sTCA were 90.6°, 89.8°, 87.5° and 85.1°, respectively. In the manual group, the average values for cFCA, cTCA, sFCA and sTCA were 92.0°, 88.2°, 85.4° and 84.2°, respectively. There was no significant difference between the two groups for each component angle. (Table 3) The rates of patients with outliers in each component angle were: cFCA, 14.3% in the navigation group and 28.6% in the manual group; cTCA, 0.0% in the navigation group and 28.6% in the manual group; sFCA, 14.3% in the navigation group and 42.9% in the manual group; sTCA, 14.3% in the navigation group and 42.9% in the manual group. There was no significant difference between the two groups in the rate of patients with outliers in each component angle, although the rate of outliers in the navigation group tended to be lower than in the manual group. (Table 3 and Figures 3, 4)

There were no complications related to the use of the computer-assisted navigation system in the navigation group (such as pin-site infection or fracture).

Table 2. Clinical results and radiological results for Hip-Knee-Ankle angle in navigation and manual groups.

Characteristics		Group		P value
		Navigation	Manual	
Maximum extension angle (degrees (mean (range)))	Preop	–5.7 (–10-0)	–8.8 (–30-0)	0.20
	Postop	–2.9 (–5-0)	–0.8 (–10-0)	0.70
Maximum flexion angle (degrees (mean (range)))	Preop	107.9 (90-125)	100.0 (90-120)	0.30
	Postop	127.1 (110-140)	115.7 (90-135)	0.15
KSKS (mean SE)	Preop	58.9±9.2	47.0±18.4	0.15
	Postop	93.3±6.9	93.7±4.1	0.89
KSFS (mean SE)	Preop	56.6±10.8	49.7±27.8	0.55
	Postop	93.3±5.9	73.6±15.4	0.008*
HKA angle (degrees (mean SE))	Preop	10.6±8.9 in varus	9.3±6.7 in varus	0.76
	Postop	0.3±2.3 in varus	0.7±4.1 in valgus	0.31
Rate of patients with outliers (% (patients with outlier/ all patients))	Preop	71.4 (5/7)	85.7 (6/7)	0.51
	Postop	0.0 (0/7)	28.6 (2/7)	0.13

* means statistically significant. Abbreviations: KSKS, Knee Society knee score; KSFS, Knee Society function score; HKA, Hip-Knee-Ankle; SE, standard error. Outlier of HKA angle was defined as outside of 180±3°. P<0.05 was considered statistically significant.

Table 3. Radiological results for each component angle and rate of patients with outliers in each component angle in navigation and manual groups.

		Group		P value
		Navigation	Manual	
cFCA (degrees)		90.6±1.4	92.0±2.3	0.20
cTCA (degrees)		89.8±1.5	88.2±2.9	0.22
sFCA (degrees)		87.5±1.9	85.4±3.9	0.21
sTCA (degrees)		85.1±1.8	84.2±1.8	0.37
Rate of patients with outlier (% (patients with outlier/all patients))	cFCA	14.3 (1/7)	28.6 (2/7)	0.51
	cTCA	0.0 (0/7)	28.6 (2/7)	0.12
	sFCA	14.3 (1/7)	42.9 (3/7)	0.24
	sTCA	14.3 (1/7)	42.9 (3/7)	0.24

Definition of outlier in each component angle: cFCA, 90±2°; cTCA, 90±2°; sFCA, 87±2°; sTCA, 83±2° (CR-TKA in manual group) or 87±2° (Navigation group and PS-TKA in manual group). All radiological data were shown as mean±SE. Abbreviations: cFCA, femoral component angle in the coronal plane; cTCA, tibial component angle in the coronal plane; sFCA, femoral component angle in the sagittal plane; sTCA, tibial component angle in the sagittal plane; TKA, total knee arthroplasty; CR, cruciate-retaining; PS, posterior-stabilized. P<0.05 was considered statistically significant.

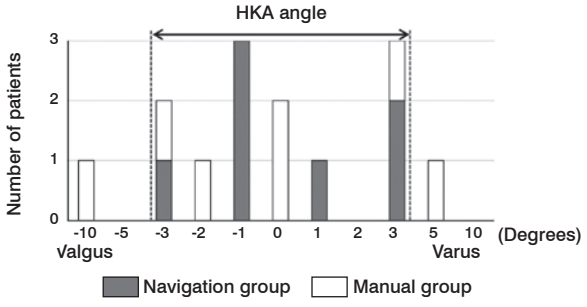

Figure 2. Hip-Knee-Ankle (HKA) angle for each group.

DISCUSSION

This comparative study attempted to estimate the effectiveness of navigation systems in TKA with EAD. The most important finding was that using navigation systems in TKA with EAD was somewhat beneficial for achieving better clinical results (KSFS), while using the systems showed no significant positive effect in other clinical results and radiological results.

Although there are still arguments about alignment accuracy, additional operative time and cost efficiency,[2,3] the benefits of using navigation systems in routine TKA have recently been reported by many researchers.[11-14] Though some authors reported good clinical and radiological outcomes of TKA in EAD using navigation

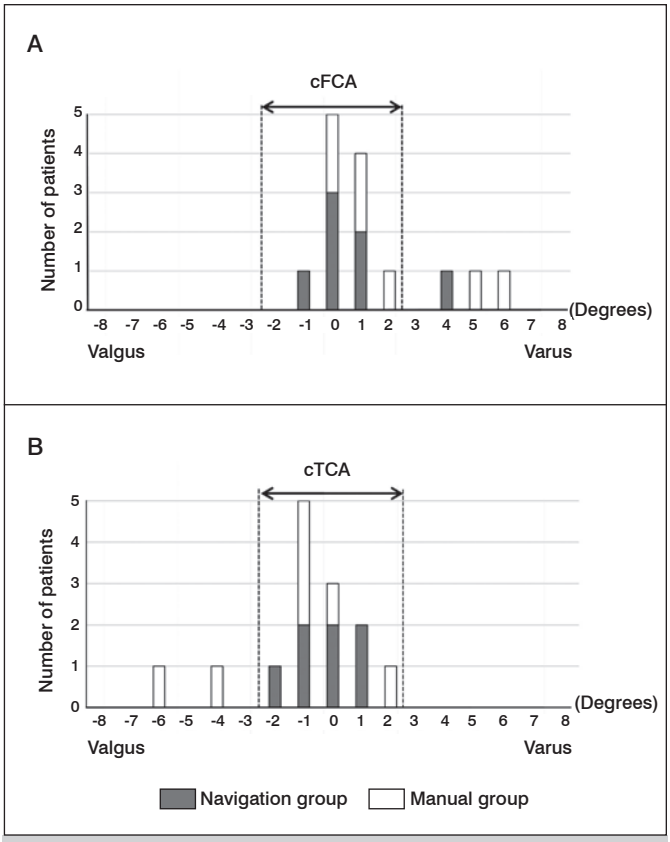

Figure 3. Femoral component angle in the coronal plane (cFCA) and tibial component angle (cTCA) in the coronal plane of each group.

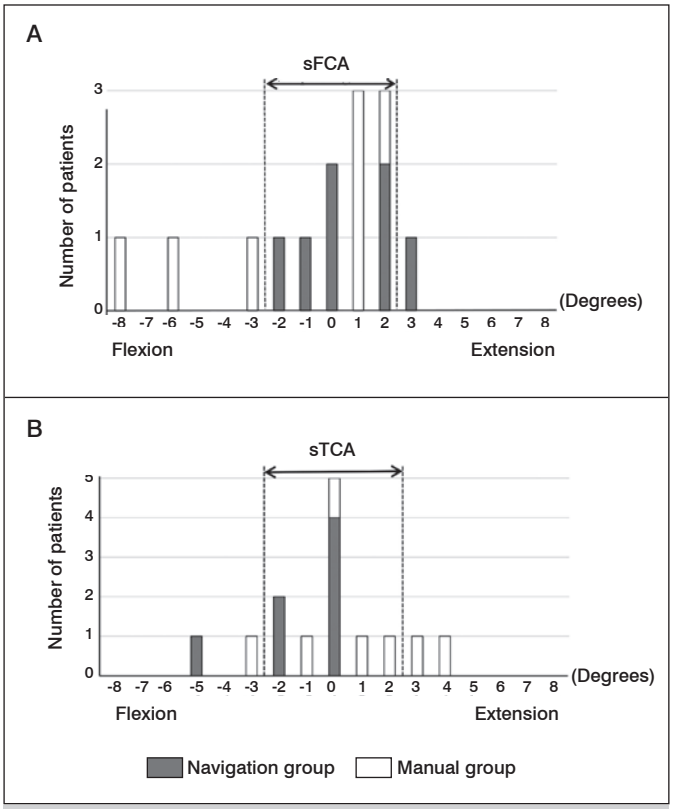

Figure 4. Femoral component angle in the sagittal plane (sFCA) and tibial component angle (sTCA) in the sagittal plane for each group.

systems,[4-7, 9,15] the number of patients in these reports were small and there has been no comparative study with the conventional technique. Klein et al.[6] described a case series comprising 5 patients who underwent TKA with navigation systems, and reported good postoperative radiological outcomes including the mechanical axis of the lower extremity. Fehring et al.[4] described the use of navigation systems for TKA in patients with EAD and reported acceptable postoperative mechanical axis in 9 of the 10 cases. Additionally, Bottros et al.[5] described the use of navigation systems for TKA in 7 patients (9 knees) with EAD, and reported the effectiveness of navigation systems. Conventional mechanical alignment guides for TKA restored the mechanical axis using anatomical femoral and tibial shape. On the other hand, navigation systems can establish the mechanical axis regardless of the shape of the femoral and tibial shaft. From this point of view, using navigation systems could be beneficial in TKA with EAD to recreate the correct mechanical axis when femoral or tibial deformities are present. Furthermore, in cases of TKA with retained previous hardware or bony sclerosis from previous surgery, surgeons could consider navigation systems, since it may be difficult to use standard surgical instrumentation such as intramedullary rods. In addition, using navigation systems may reduce blood loss and potential risk from intramedullary rods.[13] We assume that a slightly better knee flexion angle in the navigation group (125.7° in the navigation group vs. 115.7° in the manual group) is part of the reason for better postoperative KSFS outcomes achieved in the navigation group, although the results were not statistically significant (P=0.15). Increased knee flexion may lead to better KSFS as deep knee flexion is needed to climb/descend stairs, which is one of the components of the KSFS. Devers et al.[16] stated that increased knee flexion after TKA may lead to restoration of normal knee function and improved functional ability such as stair-climbing. Furthermore, Ritter et al.[17] found that increased knee flexion was associated with better outcomes for stair-climbing. Finally, Meneghini et al.[18] showed that knee flexion >125° was beneficial for stair-climbing. These studies could support our current results. In our study, the rate of radiological outliers in all component angles tended to be slightly lower in the navigation group than the manual group, although no significant difference could be found between the groups because the sample size was so small. As for coronal alignments, previous studies showed that using navigation systems could contribute to fewer outliers in coronal alignment,[14] and these studies are consistent with our current results. With regard to sagittal alignment, Matsumoto et al.[19] described desirable sagittal femoral component implantation leading to favorable physiological joint condition and better postoperative ROM in TKA, which could also support our results. This study has several limitations. First, the population size (14 patients) was small. Larger-scale studies are needed to prove our current results. We should have investigated with more than 64 patients in each group (with power=0.8, □=0.5). Second, the follow-up period (2 years) was relatively short; a longer follow-up is necessary to verify the results. Third, the operations were not performed by a single surgeon, although the technique was well-standardized among all the surgeons. Finally, we did not record any patient-derived outcome scores such as the Knee Society's new scoring system, KSS 2011.[20]

CONCLUSION

In cases of TKA with EAD, better postoperative KSFS was achieved in the navigation group compared to the manual group, while no significant differences in other clinical outcomes were found. No significant differences in radiological outcomes were found between the groups, though fewer radiological outliers were found in the navigation group than the manual group. Further advanced, large-scale studies with longer follow-up are necessary to verify our results.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. IT (0000-0002-9711-7322)*: wrote and reviewed the article; TM (0000-0003-4587-0029)* and NN (0000-0003-4067-9233)*: performed the surgeries, analyzed the data, and wrote the article; KI (0000-0001-7211-7011)* and KT (0000-0001-9449-0474)*: drafted and reviewed the article and contributed to the intellectual concept of the study; RK (0000-0001-5097-7264)* :and all authors contributed to the intellectual concept of the study and approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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REPLACEMENT VERSUS NON-REPLACEMENT OF THE PATELLAR JOINT SURFACE IN TOTAL KNEE ARTHROPLASTY

SUBSTITUIÇÃO *VERSUS* NÃO SUBSTITUIÇÃO DA SUPERFÍCIE ARTICULAR DA PATELA NA ARTROPLASTIA TOTAL DE JOELHO

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ABSTRACT

Objective. This study addresses functional data, pain, and the reoperation rate in patients undergoing primary total knee arthroplasty (TKA) during which the patella was or was not replaced. Methods: Fifty-three knees were included, 18 with the patella replaced and 35 with the patella not replaced. WOMAC and SF-12 scores and knee pain were analyzed preoperatively and 3, 6, and 12 months after TKA. The reoperation rate was also evaluated. Results: Both groups presented significant improvement in WOMAC score and pain at all postoperative follow-up appointments. There was no significant difference between the groups in all evaluated variables. Two subjects in the group did not undergo patellar replacement due to complaints of anterior knee pain after arthroplasty. There was no difference between the groups in relation to the reoperation rate. Conclusion: Patients receiving patellar replacement during TKA did exhibit significant differences in the rate of reoperation, function, or pain when compared to patients in which the patella was replaced. ***Level of Evidence III; Cohort study.***

Keywords: Arthroplasty. Knee. Patella.

RESUMO

Objetivo: Este estudo confronta dados funcionais, dor e taxa de re-operação de pacientes submetidos à ATJ primária, que substituíram e que não substituíram a patela. Métodos: 53 joelhos, sendo 18 com a patela substituída e 35 com a patela não substituída. Womac, SF-12 e dor no joelho foram analisados no pré-operatório e após 3, 6 e 12 meses da ATJ. A taxa de re-operação também foi avaliada. Resultados: Ambos os grupos apresentam melhora significativa no questionário Womac e dor em todos os seguimentos pós-operatórios. Não houve diferença significativa entre os grupos em todas as variáveis avaliadas. Dois sujeitos no grupo NÃO foram submetidos a substituição da patela devido a queixas de dor anterior no joelho após a artroplastia. Não houve diferença entre os grupos em relação a taxa de re-operação. Conclusão: Pacientes submetidos a substituição da patela na ATJ não obtiveram diferença significativa quanto a taxa de reoperação, função e dor quando comparados aqueles que não substituíram. ***Nível de evidência III; Estudo Coorte.***

Descritores: *Artroplastia. Joelho. Patela.*

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INTRODUCTION

Disagreements on whether to replace or retain the patella during total knee arthroplasty (TKA) have been present throughout the history of knee surgery and continue, with no consensus in the current literature. Surgeons who prefer to replace the patella justify their decision by stating that this reduces the incidence of anterior knee pain, prevents future secondary revisions of the patella, provides greater patient satisfaction, improves overall function, and has a low rate of complications. Surgeons who opt not to substitute the patella indicate more physiological patellofemoral kinematics, the possibility of greater patellofemoral load support, conservation of the patellar bone, reduction of osteonecrosis of the patella, and prevention of complications associated with patellar replacement such as patella fractures, patellar ligament injury, wear or loosening of the implant, and instability.[1,2] Still others maintain that replacement should be selective and based on criteria such as age, quality of the patellar cartilage, the presence of crystal deposit disease, the positioning of the patella, and femoral component type.[3]

Consequently, current studies comparing patients undergoing TKA with or without replacement of the patellar surface do not present a consensus regarding possible differences in the functional questionnaires, pain, or reoperation rate.

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

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The main objective of this study is to evaluate the functional results and reoperation rate in patients undergoing primary TKA with or without replacement of the patellar joint surface over a period of one year post-procedure.

MATERIALS AND METHODS

We retrospectively evaluated 53 subjects with osteoarthritis of the knee (OAK) who underwent TKA at our institution between January 2013 and December 2014. Inclusion criteria were subjects with primary or secondary OAK, with outpatient follow-up of at least 12 months who attended postoperative follow-up visits at three, six, and 12 months post-procedure. Exclusion criteria were previous osteoarticular infection, previous bilateral TKA, incomplete medical record data, and postoperative complications not related to the patella. The study was approved in advance by the institutional review board (CAEE 53544516.1.0000.5440).

The cases selected were subdivided into two groups: "YES" when the patella was replaced and "NO" when the surgeon did not replace it, performing patelloplasty via debridement and excision of the marginal osteophytes. The implant used for total arthroplasty was the same in all patients (PFC Sigma, Depuy-Johnson) and the surgeries were performed by senior staff in the service. The option to not replace the patella was made when the cartilage of the patellar surface did not demonstrate deep lesions, the patella was less than 20 mm thick, and when patellar tracking was good. The data were obtained by analyzing electronic patient records which contained the operative report, patient history and assessment of function; consequently a free and informed consent form was not required. Demographic data were collected on the subjects (age, sex, and BMI) whether the patella was replaced or not, along with the occurrence of reoperation up to the date of data collection (December, 2016). Function prior to and 3, 6, and 12 months after surgery was analyzed using the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) questionnaire,[4] with 0 representing no impairment of function and 100 very compromised function, the physical and mental components of the Short Form 12 (SF12),[5] and pain was measured using the visual analog scale (VAS).

Statistical analysis

The data obtained were processed using SAS Statistical Software (version 9.3; SAS Institute Inc., Cary, NC) with 5% significance (p value $\leq$ 0.05). Mixed-effect linear regression was used to analyze the evolution of the variables WOMAC, SF12, and VAS over time in the YES and NO groups, and to establish the differences between the groups.

RESULTS

The demographic data, pre- and postoperative function, and reoperation rate for each group are presented in Table 1. No statistical difference was found in relation to BMI, age, function, or pain in the preoperative evaluation, showing homogeneity between the groups. Comparison of postoperative function between the two groups showed no significant difference in the rate of improvement in WOMAC, SF12, or VAS scores between groups at any of the postoperative follow-up visits. Two members of the group which did not receive patellar replacement were reoperated to perform patellar arthroplasty due to complaints of patellofemoral pain. One subject in the group that did receive patellar replacement and another in the group that did not receive patellar replacement underwent manipulation under anesthesia to gain flexion movement in the operated knee.

Analysis of the change in variables over time revealed that both groups had significant improvement in WOMAC scores at three, six, and 12 months postoperatively (p<0.001). Pain according to the VAS was significantly reduced in both groups at three, six and 12 months postoperatively (p<0.001). The group which received patellar replacement showed improved scores on the physical domain of the SF12 at the follow-up assessments at three (p=0.019), six (p=0.005), and 12 months (p=0.003) postoperatively. No significant difference was seen between pre- and postoperative assessments in the physical domain of the SF12 in the group which did not receive patellar replacement (p>0.05). The mental component of the SF12 also showed no significant changes in either group (p>0.05). None of the variables showed significant differences between the assessments at three versus six months, three versus 12 months, or six versus 12 months. (Figure 1)

Tabela 1. Demographic and clinical data in the pre- and post-operative periods, and reoperation rate, expressed as mean and standard deviation.

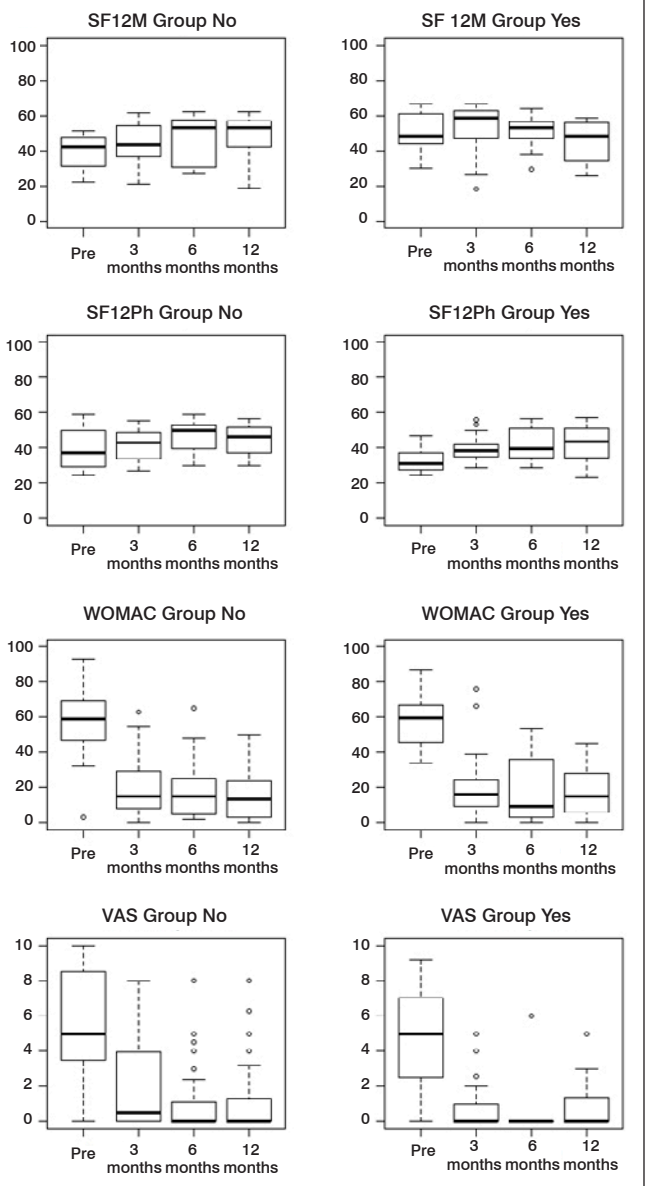
	Patella Replacement				
	No (N=35)		Yes (N=18)		P
Age	68.5	-5.8	68.9	6.9	-0.4
BMI	32.2	-4.8	33.5	4.6	-0.34
Preoperative function					
WOMAC	60	-16.1	58.7	13.9	-0.78
Physical SF12	39.4	-14.5	32.3	6.9	-0.09
Mental SF12	39.5	-12.5	49.5	12.7	-0.49
VAS	5.6	-3.1	4.8	3.1	-0.23
Function 3 months post-op					
WOMAC	19.4†	-16.5	21.2†	21.1	-0.74
Physical SF12	41.9	-9.1	40.3†	8	-0.6
Mental SF12	44.5	-12.4	51.7	15.1	-0.28
VAS	1.8†	-2.4	0.87†	1.5	-0.15
Function 6 months post-op					
WOMAC	16.9†	-14.3	18.4†	18.9	-0.75
Physical SF12	46.6	-8.8	41.4†	9.4	-0.14
Mental SF12	46	-13.7	51	9.3	-0.38
VAS	1.1†	-2	0.3†	1.4	-0.27
Function 12 months post-op					
WOMAC	14.9†	13.5	18.1†	13.5	-0.49
Physical SF12	44.8	9.2	41.8†	10.3	-0.33
Mental SF12	49.6	10.8	45.1	11.8	-0.27
VAS	1.2†	2.1	0.75†	1.4	-0.52
Reoperation rate	2 (5.7%)		1 (5.6%)		

BMI: body mass index; VAS: visual analogue scale; post-op: post-operative. † statistical difference compared to preoperative evaluation.

DISCUSSION

The patellofemoral joint and replacement of the patella are currently among the most widely discussed aspects related to TKA. Our study found no statistical difference in functional characteristics or knee pain between groups that received or did not receive patellar replacement.

The function reported by the total score of the WOMAC questionnaire was significantly better in both groups starting from three months postoperative, as was pain measured by the VAS. A meta-analysis conducted by Pilling et al.[6] showed that previous pain and degree of satisfaction in patients who received patellar replacement were the same as in patients who did not receive patellar replacement.



SF12M, SF12 mental component; SF12F, SF12 physical component; VAS, visual analog scale.

Figure 1. Changes in WOMAC, SF12m, and VAS score over time.

However, Chen et al.[2] suggested that over the long term (five years or more), patellar replacement could yield better functional results as indicated by the Knee Society Score. A recent study by Aunan et al.[7] showed that after three years, scores on the KOOS questionnaire were significantly better in patients who received patellar replacement. Beaupre et al.[8] assessed the function of patients who received or did not receive patellar replacement using the WOMAC questionnaire, and found no difference between groups 1, 5, and 10 years after the procedure. The WOMAC questionnaire includes questions related to pain, stiffness, and function, and has been validated for Brazilian Portuguese; like the SF12 quality of life questionnaire, it is responsive to changes in patients with knee osteoarthritis.[4,8-10] However, our study only evaluated function and pain one year post-procedure, which may not be sufficient time to analyze the benefits of replacing or not replacing the patella.

Anterior knee pain is a frequent complaint in patients who undergo TKA, with an incidence exceeding 30% according to some authors;[11] the hypothesis is that replacing the patella could decrease this incidence. On the other hand, replacement of the patella can cause complications such as poor patellar alignment, sprains, avascular necrosis, failure of the extensor mechanism, fracture, etc.[1,2] Studies show that the surgical reoperation rate due to patella complications is higher when the patella is not replaced.[6,12] The study by Chen et al.[2] showed that patella replacement can reduce the risk of reoperation by 4%. Meanwhile, Breeman et al.[13] found that until five years after arthroplasty, the rate of reoperation, healthcare costs, and functional outcomes are similar whether the patella is replaced or not. In the present study, the time patients were followed to assess reoperation rate ranged from three to four years and no difference was found in the reoperation rate between the groups. The two patients in the group which did not receive patellar replacement who were reoperated to replace the patellar joint surface had different outcomes: one showed improvement after the surgery, while the other still had the same pain as before the revision surgery.

Rodriguez-Merchan et al.[3] recommended replacing the patella when injuries classified as Outerbridge IV are present, and retaining the patella for injuries graded I, II and III. Roberts et al.[14] analyzed the influence of replacing or not replacing the patella in patients who did not have exposed bone on the patellar joint surface, and the results indicated slightly greater patient satisfaction in the group where the patella was replaced, but the functional questionnaire, complication rate, and number of revisions were similar between the groups.

Patelloplasty is routinely performed in our service during TKA. Liu et al.[15] studied the influence of patelloplasty and patellar replacement on the rate of reoperation, function, and pain. The results showed no difference between the groups seven years after the procedure. The authors reported a preference for patelloplasty, suggesting that this procedure preserves sufficient bone stock and can easily converted to a patellar replacement if the patient complains of anterior knee pain. Zha et al.[16] found favorable results for the lateral release of the patella compared to non-release during TKA. We conduct lateral release only in cases when we observe that the tracking of the patella is not appropriate.

This study has some limiting factors. The analysis was retrospective, which did not permit standardized exploration of the degree of degeneration in the patellar articular surface. Furthermore, the sample size of this study was small, which reduces the power of the results presented. Functional assessment was only measured through self-perceived questionnaires completed by the patient about their own function. We believe that prospective randomized studies using instruments to assess physical performance may be more appropriate to determine whether replacement of the patellar surface should be routinely performed in TKA.

CONCLUSION

Total knee arthroplasty with or without patellar replacement has similar results in the first year post-procedure. Prospective studies with larger samples should be conducted.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. RS (0000-0003-3978-4888)*: conducted surgeries, drafted the text, conducted the statistical analysis, contributed to the intellectual concept and composition of the entire research project. FF (0000-0002-6495-3383)* and MKJ (000-0002-4111-1896)*: drafted and revised the text and contributed to the intellectual concept of the study. AMF (0000-0002-1919-893X)*: conducted the statistical analysis and drafted the text. RAFHF (0000-0002-2273-6225)* and LBM (0000-0002-2483-8356)*: obtained the data and drafted the text. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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MEDIAL FEMORAL CONDYLE CORTICOPERIOSTEAL FLAP: ANATOMIC STUDY

RETALHO CORTICOPERIOSTEAL DO CÔNDILO FEMORAL MEDIAL: ESTUDO ANATÔMICO

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ABSTRACT

Objective: The medial femoral condyle corticoperiosteal flap is irrigated by the descending genicular artery, and when this is absent, by the superior medial genicular artery. The descending genicular artery divides into the muscular, saphenous, and osteoarticular branches. The objective of this study was to describe the variables involved in the dissection of the medial femoral condyle flap. Methods: Thirty thighs from 20 cadavers were dissected and the following variables were recorded: age, height, weight, thigh length, presence of the descending genicular artery, whether the saphenous branch originated from the descending genicular artery, the length of the branches originating from the descending genicular artery, and the diameter of the descending genicular artery and the vena comitans. Results: The descending genicular artery was present in 93.3% of the specimens (28/30). The saphenous branch originated from this artery in 76.7% of the dissections (23/70). The mean distance between the origin of the descending genicular artery and the knee joint was 13.4 cm (±1.4), the mean length of the descending genicular artery was 7.5 cm (±1.5), the mean diameter of the descending genicular artery was 1.9 mm (±0.3), and the mean diameter of the vena comitans was 1.7 mm (±0.3). Conclusion: The vascularized medial femoral condyle is a versatile option for reconstruction of musculoskeletal injuries. It allows transference of bone associated with muscle and skin, which are each nourished by independent branches. ***Level of Evidence IV; Case series.***

Keywords: Surgical flaps. Microsurgery. Reconstruction. Arteries/ anatomy and histology. Thigh/ anatomy and histology.

RESUMO

Objetivo: O retalho ósseo vascularizado do côndilo femoral medial deve sua irrigação à artéria genicular descendente e, na ausência desta, à artéria genicular superior medial. A artéria genicular descendente comumente ramifica-se em: ramo muscular, safeno e osteoarticular. O estudo teve por objetivo analisar as variáveis relativas à dissecção do retalho ósseo do côndilo femoral medial. Métodos: Foram dissecados 30 joelhos (20 cadáveres), registrando-se: idade; estatura; peso; comprimento da coxa; presença da artéria genicular descendente; se o ramo safeno tem origem na artéria genicular descendente; comprimento dos ramos da artéria genicular descendente e os diâmetros da artéria genicular descendente e veia comitante. Resultados: A artéria genicular descendente esteve presente em 93,3% dos espécimes (28/30). O ramo safeno originou-se da artéria genicular descendente em 76,7% das dissecções (23/70). Distância entre origem da artéria genicular descendente e interlinha articular = 13,4 (±1,4) cm, comprimento da artéria genicular descendente = 7,5 (±1,5) cm, diâmetro da artéria genicular descendente = 1,9 (±0,3) mm, diâmetro da veia comitante = 1,7 (±0,3) mm. Conclusão: O retalho ósseo vascularizado do côndilo femoral medial mostrou-se a opção versátil para reconstrução de lesões do sistema músculo-esquelético. Permite a elevação de retalho ósseo associado à pele e tecido muscular, cada qual nutrido por ramos independentes. ***Nível de Evidência IV; Série de casos.***

Descritores: *Retalhos cirúrgicos. Microcirurgia. Reconstrução. Artérias/anatomia e histologia. Coxas/anatomia e histologia.*

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INTRODUCTION

Vascularized bone flaps in skeletal reconstructions represent an important tool in managing traumatic, cancer-related, or congenital injuries that challenge surgeons who perform reconstructive surgery.[1]

In 1974, Ostrüp and Fredrickson[2] reported the first free transfer of vascularized bone tissue. However, at this time there are comparatively less options for microsurgical transfer of bone tissue compared with the wide variety of skin flaps which have been described:[3] vascularized transplant of the scapula, humerus, rib, radius, iliac crest, and fibula are some examples.

Cortico-periosteal grafting of the medial femoral condyle was described in English by Sakai et al.,[4] and has received increasing

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attention because of the ease of dissection, long pedicle, minimal morbidity, and possibility to transfer vascularized cortical bone with the periosteum,[5-8] skin, muscle, and joint cartilage.[9]

The medial femoral condyle vascularized bone flap is irrigated by the descending genicular artery (DGA); when this artery is not present, it is irrigated by the superior medial genicular artery (SMGA),[4] both of which stem from the superficial femoral artery (SFA). The classic description of the DGA system cites three main branches: the muscular branch (MB) for the vastus medialis muscle, the saphenous branch (SB) that irrigates vast area of leg skin, and the osteoarticular branch (OAB), which nourishes the periosteum, bone, and subchondral region.[5,10] The common theoretical origin of these branches provides great versatility in reconstruction of multiple tissues (periosteum, bone, subchondral region, muscle, and skin, for example) supplied by a single potential pedicle.[11]

Over the last 25 years, various clinical applications of this flap have been described, including treatment of pseudoarthrosis of the arm,[4,5] bone loss in the femur,[12] tibia,[8,13] foot,[5] and skull.[14,15]

However, questions remain about variability in the origin of the DGA, its ramifications in the MB, SB, and OAB,[15] the length of these vessels, and the diameter of the main artery and veins at their origins. These questions led to the realization of this anatomic study.

MATERIALS AND METHODS

This study was approved by the institutional review board (Process 098/15).

Thirty legs from fresh male adult cadavers (aged 18 years and above) obtained from the "Serviço de Verificação de Óbitos" (SVO) were dissected. Individuals exhibiting injury or previous surgery in the legs were excluded.

The dissections were conducted systematically in the following manner:

- The size of the femur (from the greater trochanter to the joint interline of the knee) was recorded, along with the cadaver's height and age.
- The cadaver was positioned in dorsal decubitus with the leg rotated externally and hip abducted.
- A longitudinal incision was made in the medial and distal portions of the thigh along the longest axis of the vastus medialis muscle. (Figure 1)
- The vastus medialis muscle fascia was incised and the muscle moved away in a forward direction. The sartorius muscle was also isolated and moved away in a posterior direction.
- The DGA (or the SMGA if the DGA was not present) was identified and its origin in the superficial femoral artery defined.
- The anatomical parameters of these vessels were noted with regard to origin, length, and branching.
- The diameters of the DGA and the vena comitans were recorded, along with the SMGA when the DGA was absent, and the saphenous artery (SA) when present.

All measurements were taken with a tape measure, a ruler with millimeter increments, and a precision pachymeter. The diameter of the DGA, SMGA, and SA were measured through their cross sections, using the proximal portion of the vessel immediately where it originated from the SFA. A small segment of the sectioned portion was incised longitudinally to measure the circumference of the vessel with a pachymeter.

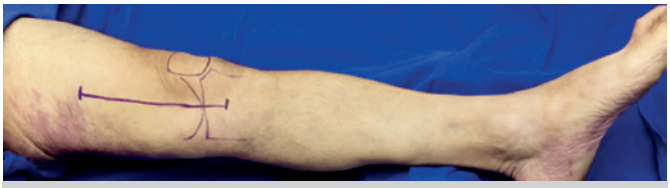

Figure 1. Incision site for dissection of the osseous flap of the medial femoral condyle.

The variables are summarized in Table 1.

Based on previous anatomic studies, 20 to 30 specimens were considered a sufficient number to evaluate the proposed parameters.[11,16,17] Because this was a cross-sectional observational and descriptive study, we used the Pearson coefficient to measure the correlation between the continuous quantitative variables. The normality of data was evaluated using the Shapiro-Wilk test and analysis of the histograms. The data were presented as means, minimum value, maximum value, and standard deviation. A 5% significance level ($p<0.05$) was considered. SPSS version 22.0 software (SPSS Inc, Chicago, IL, USA) was used for the statistical analysis.

Table 1. Variables.

Laterality	Right or left knee
Age	Age in years according to SVO annotation
Height	Height in centimeters according to SVO annotation
Weight	Weight in kilograms according to the SVO annotation
Thigh length	Thigh length: from greater trochanter to joint interline (cm)
DG present?	Is the descending genicular artery present: Yes or No?
MB present?	Is the muscular branch of the descending genicular artery present: Yes or No?
DG-JI	Descending genicular-joint interline: distance between the origin of the descending genicular artery from the femoral artery and the tibial-femoral joint interline - the most distal portion of the medial condyle (cm)
DG-MB	Descending genicular - branch to the vastus medialis muscle: distance between the origin of the DGA from de femoral artery and the branch for the vastus medialis (cm)
Saphenous branch DG?	Does the saphenous branch originate from the descending genicular artery – Yes or no?
DG-Saphenous Branch	Descending genicular – saphenous branch: distance Branch between the origin of the DGA from de femoral artery and the origin of the saphenous branch (cm)
Saphenous Artery-JI	Saphenous Artery-JI: distance between the origin of the saphenous artery from the femoral artery and the tibial-femoral joint interline - the most distal portion of the medial condyle (cm)
MB length	Length of the branch to the vastus medialis muscle: distance between the efferent MB from the DGA and the muscle surface (cm)
DG-periosteum	Descending genicular - periosteum: distance between the origin of the descending genicular artery from the femoral artery and the first branch to the periosteum of the medial condyle (cm)
SMGA length	Length of the superior medial genicular artery: distance from the origin of the superior medial genicular artery to the first branch to the periosteum (cm)
Diam DGA	Diameter of the descending genicular artery (mm)
Diam DGV	Diameter of the descending genicular vein (mm)
Diam SA	Diameter of the saphenous artery originating directly from the superficial femoral artery (mm)
Diam SMG	Diameter of the SMGA at its origin (mm)

RESULTS

We dissected 17 left knees and 13 right knees from 20 male individuals. The mean age of the specimens was 69.1 years (50–93; ±14.0), the mean height was 171.7 cm (162–183; ±5.1) and mean weight was 65.9 kg (35–105; ±15.4). The mean thigh length was 42.8 cm (40.2–45.5; ±1.6).

The descending genicular artery (DGA) was present in 93.3% of the specimens (28/30), originating in the superficial femoral artery (SFA). (Figure 2) The periosteum of the medial femoral condyle was nourished by the superior medial genicular artery (SMGA) in the two remaining cases (2/30; 6.7%). The mean DGA length was 7.5 cm (4.9–11.4; ±1.5).

The mean distance between the origin of the DGA and the tibial-femoral joint interline (JI) was 13.4 cm (10.6–17.0; ±1.4). The SB originated from

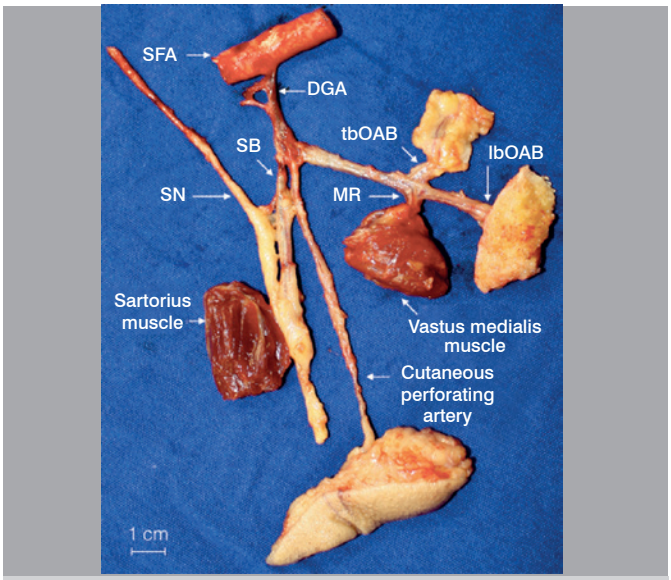

Figure 2. Dissection of the DGA system in its most common conformation. In this dissection, the tbOAB irrigated the periosteum, while the lbOAB nourished the bone of the medial femoral condyle.

the DGA in 73.3% of the dissections (22/30). The mean distance between the origin of the DGA and the SB was 1.2 cm (0–2.6; ±0.7). The mean distance between the origin of the DGA and the MB was 2.6 cm (0–6.6; ±1.6). The mean length of the MB was 0.9 cm (0.3–1.5; ±0.3) and the average length of the OAB was 4.8 cm (2.3–7.6; ±1.4). The mean diameter of the DGA was 1.9 mm (1.3–2.5; ±0.3) and the mean diameter of the vena comitans vein was 1.7 mm (1.2–2.4; ±0.3).

In eight knees, the SB did not originate from the DGA; the SA was seen to branch directly from the SFA in seven cases (7/30; 23.3%) and the SA came from the SMGA in one case (1/30; 3.3%). (Figure 3) In these eight knees, the SA originated an average of 14.5 cm (12.3–15.9; ±1.1) above the JI.

The mean length of the SB (or SA when originated directly from the SFA) exceeded eight centimeters. The mean diameter of the SA, when present, was 1.2 mm (1.1–1.5; ±0.2). The mean length and diameter of the SMGA were 4.1 cm (3.6–4.6; ±0.4) and 1.7 mm (1.6-1.7; ±0.1), respectively.

The DGA derived from the superficial femoral artery and gave rise to the saphenous branch and osteoarticular branch (Figure 4) as classically described, in 73.3% of the dissections (22/30).

All the variables collected showed normal distribution after the Shapiro-Wilk test was applied and the histograms were analyzed. No statistically significant association was found between the variables studied and the laterality, height, femur length, or age. (Figure 4)

DISCUSSION

Since the medial femoral condyle flap technique was conceived,[4] a number of factors have contributed to its growing popularization, namely:[7-9,15,18]

- The relative simplicity of dissection, since the vascular pedicle is located immediately under the vastus medialis muscle, which is located on the surface of the medial face of the thigh;
- The patient is positioned in the usual position, in dorsal decubitus, with the leg externally rotated and abducted;
- The surgical scar is located on the inner surface of the thigh, where it can be easily covered;
- A tourniquet can be used for dissection, providing vessels of a caliber that permit microsurgical anastomosis;

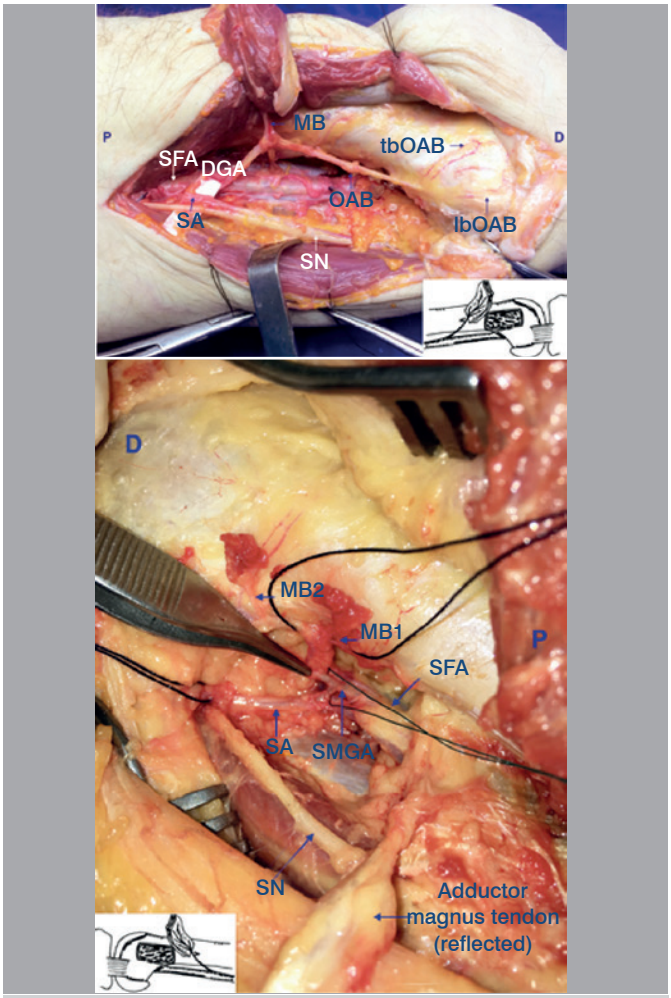

Figure 3. SA originating from the SFA (above) and SMGA (below). P: proximal, D: distal.

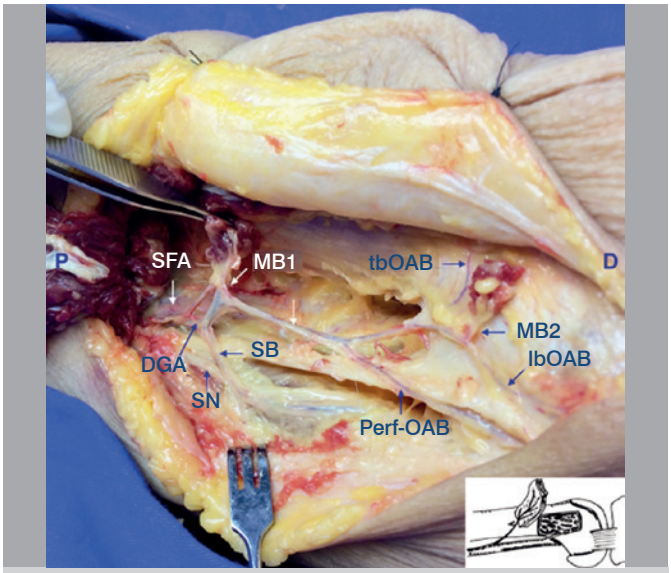

Figure 4. Standard conformation of the DGA system and its branches. Perf-OAB=the artery perforating the skin from the OAB of the DGA; tbOAB: transverse branch of the osteoarticular branch of the DGA; lbOAB: longitudinal branch of the osteoarticular branch of the DGA; MB1=First muscular branch; MB2=Second muscular branch. P: proximal, D: distal.

- Multiple tissues can be transplanted which are potentially supplied by a single vascular pedicle, notably the periosteum, bone and cartilage of the medial femoral condyle, skin of the medial aspect of the knee and leg, vastus medialis muscle, and saphenous nerve.

These advantages are especially interesting compared to existing vascularized bone graft options such as grafts from the fibula, rib, scapula, or iliac crest, for example.[3]

Despite its advantages, the biggest impediments to more frequent use of this type of graft are the limited volume of cortico-periosteal tissue that can be transferred, and the anatomical variability of the vascularization of the different tissues of the region.[8,19]

Sakai et al.[4] reported that preserving the innermost layer of the periosteum (cambium layer) is essential for maintaining osteogenic potential in cortico-periosteal transplants, which is why the isolated transfer of periosteal tissue without a thin layer of cortical bone produces poorer results with regard to osseous consolidation. Martin et al.[14] suggested the use of bone grafts measuring up to 8.0 or 9.0 cm in length to ensure adequate vascularization of the transferred segment and preserve the structural integrity of the femur by not violating the diaphyseal portion of this bone, which reduces the risk of fracture.

Brandtner et al.[15] described the transfer of a bone graft measuring 15 x 4 x 1 cm which resulted in a fracture of the donor femur; these authors suggested bone fragments of up to 3.0 cm with a small island of skin (up to 4.0 cm wide) as ideal, allowing primary closure of the donor area and a lower rate of postoperative complications.

The preference to transfer reduced bone volume, whether associated with cartilage or not and with a small island of skin, explains the preference for the vascularized osseous graft of the medial femoral condyle for reconstructions of the scaphoid and lunate, pseudoarthrosis of the upper limb with little bone loss or defects of the head and neck, which are the most common uses of this flap in the literature.[4,7,9,14,15,18]

The anatomical variability of the irrigation to the periosteum of the medial femoral condyle and neighboring tissues discourages the use of grafts based on vessels from the region, since when the descending genicular artery is absent the pedicle (which is then based on the superior medial genicular artery) becomes shorter and less versatile, because the classical description does not encompass transfer of a skin island based on this vessel.[11]

Hertel and Masquelet,[13] Cavadas and Landin,[8] and other authors[11,15,20] conducted the largest anatomical and clinical series in the literature, studying between 20 and 107 femurs, and reported the presence of the DGA to range from 79 to 100%. The current anatomical study, which analyzed data from 30 knees of fresh human cadavers, demonstrated the presence of the DGA in most of the specimens (28/30; 93.3% of dissections).

It is noteworthy that in all the knees studied in this series, as well as the reports in the literature,[4,5,8,11,13,15,20] microsurgical transfer of vascularized bone tissue alone is always possible, since when the DGA is absent the SMGA is always present, irrigating the periosteum of the medial femoral condyle. Even though it is shorter (mean SMGA length was 4.1 cm, versus 7.5 cm for DGA), the SMGA is sufficient for microsurgical anastomosis, with an average arterial diameter of 1.7 mm.

We believe that the low morbidity and the constant anatomy of the periosteal vascularization of the medial femoral condyle are the two main features that make this technique attractive. At the same time, anatomical variations in the saphenous and muscular branches are important complicating factors to be considered when planning grafts containing multiple tissues. Preoperative imaging studies (angiography, angio-CT) which can define the vascular anatomy of the region are useful in preparing for these reconstructions.

CONCLUSION

The medial femoral condyle vascularized bone flap is a versatile option, with simple dissection and relatively constant anatomy for reconstruction of musculoskeletal injuries.Its irrigation from the descending genicular artery (or the superior medial genicular artery if the descending genicular artery is absent) allows transfer of the corticoperiosteal flap with associated skin and muscle tissue, each of which nourished by independent branches in most cases.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. GBS (0000-0002-8684-4479)*: conducted the dissections, drafted the text, and participated in updating and revision; MTV (0000-0002-4694-6112)* assisted in the dissections; ABC (0000-0002-3099-4750)*: revised the text; RBI (0000-0002-8965-5147)*: conducted the statistical analysis and revised the text; OPC (0000-0002-1128-7292)*: revised the text; RMJ (0000-0003-4202-4652)*: conceived the study and participated in drafting and revising the text. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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BILATERAL LOCALIZED PIGMENTED VILLONODULAR SYNOVITIS OF THE KNEE: CASE REPORT AND REVIEW

SINOVITE VILONODULAR PIGMENTADA LOCALIZADA E BILATERAL DOS JOELHOS. RELATO DE CASO E REVISÃO

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ABSTRACT

Objectives: Several cases of bilateral diffuse pigmented villonodular synovitis (PVNS) or tenosynovial giant cell tumor have been described in the literature. Nevertheless, some presentations are rare and differential diagnoses are necessary. Methods: The purpose of this study was to perform a systematic review of the literature related to PVNS and to report a rare supra-patellar bilateral and focal presentation. We performed a systematic data review in the Pubmed Clinical Queries database using MeSH and keywords related to PVNS and tenosynovial giant cell tumor. Results: Two cases of bilateral and local PVNS had been previously described, but neither was localized in the supra-patellar compartment. To our knowledge, this case report is the first to describe supra-patellar bilateral and localized PVNS of the knee. This case involves a 28 -year-old woman with bilateral localized PVNS of the supra-patellar recess of the knee. MRI showed a low-signal intensity nodule in T1- and T2-weighted images. These were associated with hemosiderin pigmentation. Conclusion: The most important finding of the case reported is related to rarity and location. Histopathology analysis confirmed a rare case of hemosiderin pigmentation in the capsular nodule with internal non-pigmented villous content. Lipoma arborescens in the supra-patellar form must be ruled out as a differential diagnosis since it occurs in the same site. ***Level of Evidence IV; Case series.***

Keywords: Pigmented villonodular synovitis. Review, literature. Knee. Case reports.

RESUMO

Objetivos: Diversos casos de sinovite vilonodular pigmentada difusa bilateral (SVNP) ou tumor de células gigantes tenossinoviais foram descritos na literatura. Entretanto, algumas apresentações são raras e o diagnóstico diferencial é necessário. Métodos: O objetivo do estudo foi realizar uma revisão da literatura relacionada à SVNP e relatar uma apresentação de forma bilateral e localizada rara na região supra-patelar. Foi realizada uma revisão dos bancos de dados do Pubmed Clinical Queries, MeSH e unitermos relacionados com SVNP e tumor de células gigantes tenossinoviais. Resultados: Dois casos de SVNP bilateral e local foram descritos anteriormente. No entanto, nenhum deles foi localizado no compartimento supra-patelar. Até onde sabemos, este relato é o primeiro caso descrito de SVNP bilateral localizada supra-patelar. Apresentamos uma mulher de 28 anos com SVNP bilateral no recesso supra-patelar do joelho. A RM mostrou baixo sinal dos nódulos nas imagens ponderadas em T1 e T2, associados ao pigmento hemossiderina. Conclusão: O achado mais importante está relacionado à raridade e localização. A histopatologia confirmou um caso raro de pigmento de hemossiderina no nódulo da cápsula com conteúdo viloso não pigmentado internamente. O diagnóstico diferencial com lipoma arborescens na forma supra-patelar é necessário devido à localização comum. ***Nível de Evidência IV; Série de casos.***

Descritores: *Sinovite pigmentada vilonodular. Revisão de literatura. Joelho. Relatos de casos.*

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INTRODUCTION

Pigmented villonodular synovitis (PVNS) is a proliferative and inflammatory disease with benign outcome.[1] PVNS presents either in a localized form, with minimal rates of recurrence after surgical resection, or in a diffuse form, with an expansive growth pattern showing formation of osseous erosions and extra-articular manifestation. In the diffuse form, high recurrence rates occur due to total synovectomy.

Typically, only one single joint, the knee in 80% of cases, is involved with diffuse PVNS. Reports of bi- or multiarticular manifestation are rare.[1]

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

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The first description of PVNS is commonly attributed to Chassaignac[2] in 1852. In 1941, Jaffe et al.[3] recognized the common histological appearance of this proliferative disease of the joint's synovial membranes, bursae, and tendon sheaths that is characterized by lipid charged macrophages, multinucleated giant cells, and deposits of hemosiderin within a fibrous stroma.[4]
In 1976, Granowitz et al.[5] distinguished a localized form, with minimal rates of recurrence after removal and a diffuse, highly recurrent form affecting a joint's entire synovial membrane with the capacity of eroding adjacent bone and soft tissue.[4]

METHODS

The purpose of this study was to perform a systematic review of literature related to localized pigmented villonodular synovitis reports about the knee and to present a rare supra-patellar bilateral and focal example.
This is a systematic literature review study conducted according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines.
We performed a systematic review of literature available on PubMed from 1947 to 2015 using "pigmented villonodular synovitis" OR "pigmented villonodular synovitis [MeSH Major Topic] " AND "knee" OR "knee[MeSH Major Topic]".
The selection of articles was performed by two authors (TLF and LDV). The studies maintained were evaluated based on their abstract and were excluded articles that did not refer to "pigmented villonodular synovitis" or were written in a language other than English. Case reports and case series were included.
For each study meeting the inclusion criteria, information about which articular joint, and diffuse or localized form were collected.
Afterwards, we reported a bilateral focal knee involvement in a 28 years old woman and discussed the differential diagnosis with lipoma arborescens, which has a similar presentation.
The patient signed the informed consent form for participation on this Case Report and for publishing, in assigned number protocol IOT-1232, from the Scientific Commission of the Department of Orthopaedic and Traumatology, University of São Paulo, Medical School, São Paulo, Brazil.

RESULTS

Using the defined strategies, we found 563 articles corresponding to primary and sub-primary terms related to "pigmented villonodular synovitis" OR "pigmented villonodular synovitis [MeSH Major Topic]", that were selected by title and abstract.
Two cases of bilateral and local PVNS were described before. However, none of them was localized in supra-patellar compartment. The most important finding of the case reported presented below is related to rarity and location.

Case report

A 28 year-old-woman with a 20 year history of intermittent pain and swelling of both knees presented at Orthopedics and Traumatology Institute, University of São Paulo Medical School. The pain started at her right knee, and four years later appeared on her left knee. There was no history of trauma. The pain worsened with physical activity and knee flexion. Relieve was achieved with stretching.
She attended several physiotherapy sessions, without improvement. Physical examination revealed pain in suprapatellar area of both knees. Magnetic resonance imaging (MRI) (Figures 1, 2 and 3) of both knees showed a synovial hyperplasia of the suprapatellar recess with several areas of fat sign. These findings suggested the following differential diagnosis, chronicle synovitis, metaplasia and lipoma arborescens.

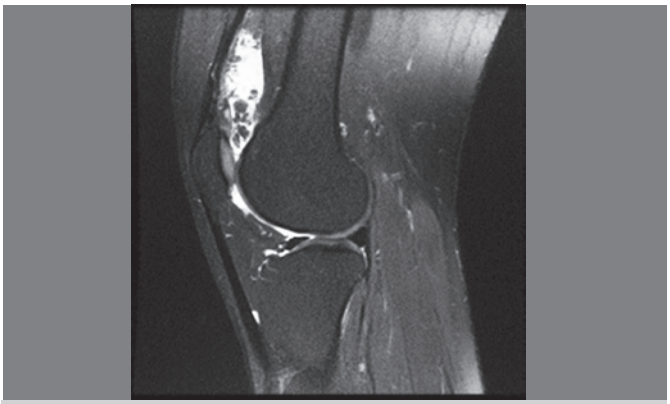

Figure 1. Sagittal imaging of the right knee (Magnetic resonance - T2 weighted signal). Note vilonodullar pattern in the anterior and superior recess.

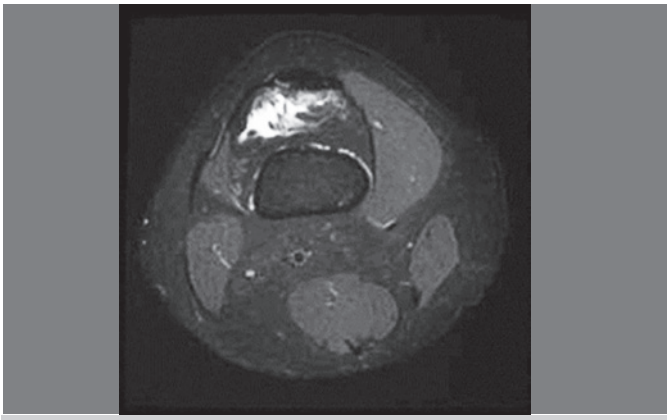

Figure 2. Axial imaging of the left knee (magnetic resonance - T2 weighted signal). Note vilonodullar pattern in the anterior and superior recess.

Figure 3. Sagittal imaging of the left knee (magnetic resonance - T2 weighted signal). Note vilonodullar pattern in the anterior and superior recess.

Focal PVNS was suspected based on these findings and arthroscopic surgery with synovectomy and additional biopsy was performed in left (Figure 4) and right (Figure 5) knees.
The surgery on the right knee was performed first, and 15 days later synovectomy of the left knee was performed. Macroscopic (Figure 6) and histological analysis revealed findings that were consistent with diagnosis of PVNS of both knees. (Figure 7 and 8)
After the procedure, she received multiple physiotherapy sessions, showing a total pain improvement after two months. Moreover, she showed no signs of infection, and made a routine postoperative recovery.

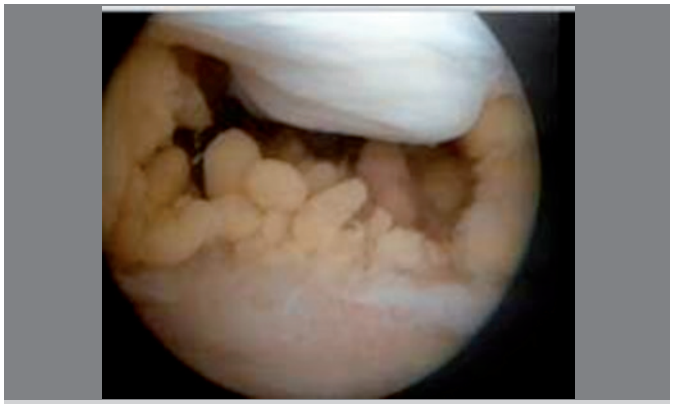

Figure 4. Arthroscopic image of the left knee: nodular image above and vilosities below.

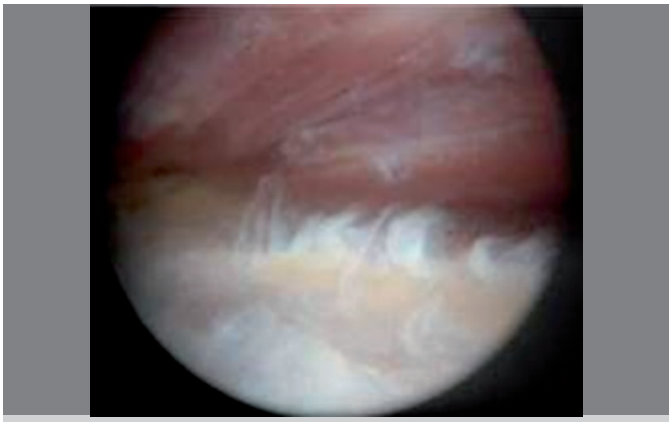

Figure 5. Arthroscopic image of the right knee. Capsule articular surface after synovectomy.

Figure 6. Macroscopic aspect of nodules after arthroscopic resection.

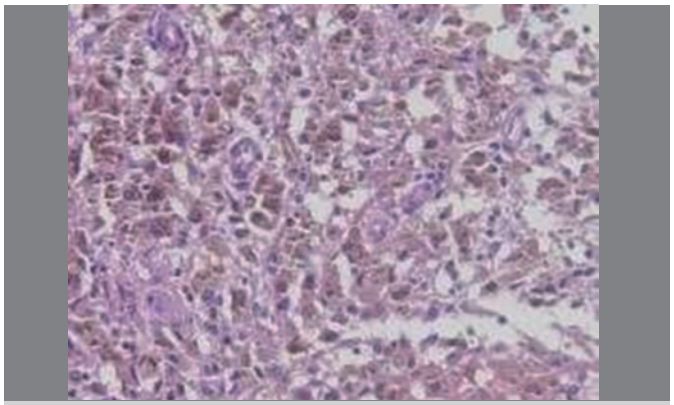

Figure 7. Microscopic H&E 4X. Extensive areas with hemosiderin deposits (brown color).

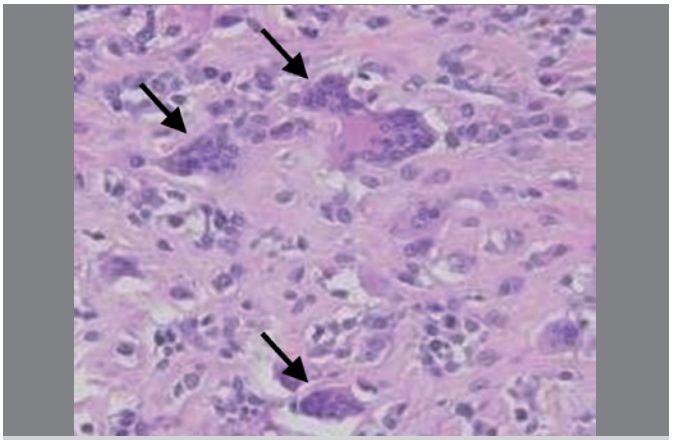

Figure 8. Microscopic H&E 10X. Black arrows: Multinucleated giant cells.

DISCUSSION

Pigmented villonodular synovitis (PVNS) is a rare disease characterized by proliferation of synovial tissue in the joint, tendon sheath, and bursa. The largest study on epidemiological features of PVNS was presented by Myers and Masi in 166 patients with an overall prevalence of 1.8 per million people.[6] The knee was the most affected joint accounting for up to 80% of the cases.[4,6]

Histology of PVNS revealed a hypertrophic synovial process characterized by villous, nodular, and villonodular proliferation and hemosiderin pigmentation. The following forms are described: diffuse (when the entire synovium of joint is affected) or localized (when a single compartment is affected). The diffuse intra-articular form of PVNS most frequently affects the large joints, with knee involvement in 66-80% of the cases. Localized intra- articular involvement represents 6% of all cases.[7]

Some authors agree on the definition given by the World Health Organization (WHO). In this definition no difference is made between PVNS and tenosynovial giant cell tumor (TSGCT).[8] Other authors defend that conventional pigmented villonodular tenosynovitis (PVNS) is a diffuse-type of TSGCT.[9] One of the major problems PVNS is delayed diagnosis due to the insidious course of the disease. The time between onset of complaints and diagnosis may exceed months to years. This allows the focal disease to become gradually more aggressive and result in bone, muscle and tendon invasion.[1]

In most patients with the diffuse form, the diagnosis is easy, because of suggestive clinical findings (recurrent haemarthrosis with pain, stiffness, mirrored bone cysts, cortical erosion, and osteoarthritis). For some diffuse forms, but especially for the localized forms, non-specific symptoms makes this disease a challenging diagnosis.[10] Discomfort is always present but the clinical presentation is variable according to Bouguennec et al.:[10] locking (30–100% of cases), effusion (53–90%), diffuse pain (66–100%), reduced range of motion (45%), palpable mass (11–80%) or pain over the joint line suggest a meniscal injury (10–34%).

The clinical presentation can also suggest the presence of an intra-articular floating foreign body and symptoms related to cartilage injury are also possible. Bouguennec et al.[10] stated that a preoperative diagnosis of meniscal injury was made in 30% of localized PVNS

cases and the PVNS diagnosis was made in only 25% of localized forms. MRI helps with the diagnosis of diffuse forms as it detects areas of inflammation with hemosiderin deposits, and is also the best diagnostic imaging modality for evaluating soft tissue tumors. The localized forms are more challenging. AMRI shows a heterogeneous soft-tissue mass with T1 and T2 hyposignal. The signal is intermediate if only small hemosiderin deposits are present. These hemosiderin deposits are more visible with gradient echo sequences. The image on MRI could be confounded with haemangioma, fibroxanthoma, synovial chondromatosis and amyloid or haemophilic arthropathy.[10] Another important differential diagnosis in this case report is lipoma arborescens. The MRI is the best method to differentiate this pathology.[11]

Differential diagnosis with lipoma arborescens (LA) in supra-patellar form is necessary due to the common localization and benign behavior that does require a surgical treatment. In this case, the presence of tenosynovial giant cells associated with hemosiderin pigmentation confirmed the diagnosis of PVNS.

LA is a rare benign intra-articular lesion of unknown etiology which more frequently involves the suprapatellar pouch of the knee.[12] LA is characterized by replacement of the subsynovial tissue by mature fat cells giving rise to a villous proliferation. The characteristic feature is the macroscopic hypertrophic lipomatous synovial tissue.[13] The main findings of LA in MRI (the most specific method of diagnosis) are: a synovial mass with an arborescent, architecture and a signal intensity similar to that of fat on all pulse sequences, with suppression of the signal on STIR sequencing or pre-saturation of the fat; associated joint effusion potential chemical-shift artifacts at the fat-fluid interface within the joint and absence of magnetic susceptibility effects associated with hemosiderin.[13] In our patient, the presence of tenosynovial giant cells associated with hemosiderin pigment confirmed PVNS diagnosis. MRI revealed presence of hemosiderin in T1 and T2 signal.

Over the past 100 years little progress has been made in treatment strategies. The aim of PVNS treatment, which consists a removal of all abnormal synovial tissue, is to relieve pain, lower the risk of joint destruction, and avoid local recurrence. In cases of residual or recurrent disease, other treatments modalities have been tried. Several options have been proposed for the knee joint – from observation to total knee arthroplasty, including external beam radiation, radioactive synovectomy, or surgical synovectomy. Depending on the synovial extension of PVNS, surgical synovectomy can be performed by open or arthroscopic techniques. Finally, some clinicians have suggested a combined treatment.

Unfortunately, because of the extremely low incidence of PVNS and the long disease free interval, large randomized controlled trials have not been performed and no large studies have clearly shown any superiority of one option over another.[8,14,15]

Acording to Verspoon et al.,[14] a study conducted in 2014 showed recurrence rates of 22% in 27 localized PVNS patients over an average 7.2 years. Recurrence rates of PVNS reduce with time. Long follow-up periods show that diffuse PVNS is a recurring disease becoming more difficult to treat as time passes by. These findings confirm the importance of differentiating PVNS subtypes and also suggest that patients should receive treatment(s) at tertiary centers because of its rarity and destructiveness.[14]

Complications described in literature are infections and stiffness. Than, iatrogenic loss of joint function is a possible complication of PVNS treatment that requires manipulation.[14]

CONCLUSIONS

The bilateral and localized forms are rare presentations of PVNS. This is only the third case reported in literature. Differential diagnosis with lipoma arborescens in the supra-patellar form is needed due to the common site localization and benign behavior that does not requires surgical treatment.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. TLF (0000-0002-6665-3608)*: was responsible for the integrity of the study from inception to completion; TLF and AJH (0000-0001-8645-3956)*: were involved in the conception and design of the study; TLF, LDV (0000-0002-9488-1763)*, SUS (0000-0001-8058-3610)*, AMA (0000-0003-2507-3786)*, and AJH collected and assembled the data; TLF, RJMN (0000-0002-4708-792X)*, LDV (0000-0002-9488-1763)*, SUS, and AJH analyzed and interpreted the data. TLF, RJMN, LDV, AMA, AP (0000-0002-8449-7493)*, SUS, and AJH drafted the manuscript; TLF, RJMN, SUS, AMA, AP, and AJH conducted the critical revision. All authors contributed to the intellectual concept of the study and approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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MEASURING THE DISTANCE BETWEEN STERNOCLAVICULAR JOINT AND HILAR STRUCTURES WITH TOMOGRAPHY

MEDIDA DA DISTÂNCIA DA ARTICULAÇÃO ESTERNOCLAVICULAR AS ESTRUTURAS HILARES POR TOMOGRAFIA

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ABSTRACT

Objectives: To evaluate the tomographic distance between the sternoclavicular joints and the nearest hilar structures. Methods: Computed tomography images (axial and sagittal slices) in 120 healthy individuals (60 men and 60 women) between 18 and 60 years old were prospectively analyzed. The distances from both sternoclavicular joints to the respective brachiocephalic veins, trachea, esophagus, and lung apexes were measured and related to age, sex, and body mass index. Results: Statistically significant differences were found in the distance from the right and left sternoclavicular joint distances and the corresponding brachiocephalic vein, esophagus, and lung apexes. In women, both sides were closer to the noble structures. In patients with body mass index <25, the distances were significantly less than in heavier patients. Conclusion: The left sternoclavicular joint is closer to the hilar structures than the contralateral side. In women, both sternoclavicular joints are closer to the brachiocephalic veins, esophagus, and lung apexes than in men. Patients with body mass index <25 have shorter distances between these joints and the brachiocephalic veins and esophagus. ***Level of Evidence II; Prognostic studies – Investigating the effect of a patient characteristic on the outcome of disease.***

Keywords: Sternoclavicular joint. Anatomy. Tomography.

RESUMO

Objetivos: avaliar a distância tomográfica entre as articulações esternoclaviculares até as estruturas hilares mais próximas. Métodos: foram analisados prospectivamente cortes tomográficos axiais e sagitais em 120 indivíduos hígidos (60 homens e 60 mulheres), entre 18 e 60 anos, sendo mensuradas as distâncias de ambas as articulações esternoclaviculares até as respectivas veias braquiocefálicas, traqueia, esôfago e ápices pulmonares, relacionando-as com idade, gênero e índice de massa corporal. Resultados: houve diferença estatisticamente significativa entre as distâncias da articulação esternoclavicular direita e esquerda até a veia braquiocefálica correspondente, esôfago e ápices pulmonares. Nas mulheres, ambos os lados estavam mais próximos das estruturas nobres. Pacientes com índice de massa corporal <25 as distâncias foram significativamente menores quando comparados a índices superiores. Conclusão: articulação esternoclavicular esquerda está mais próxima às estruturas hilares do que o lado direito. Nas mulheres, as articulações esternoclaviculares bilaterias encontram-se mais próximas das veias braquiocefálicas, esôfago e ápices pulmonares, comparadas aos homens. Pacientes com índice de massa corporal <25 apresentam distâncias menores da articulação até as veias braquiocefálicas e esôfago. ***Nível de Evidência II. Estudos prognósticos – Investigação do efeito de característica de um paciente sobre o desfecho da doença.***

Descritores: *Articulação Esternoclavicular. Anatomia. Tomografia.*

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INTRODUCTION

The proximity of the sternoclavicular joint (SCJ) with noble anatomical structures of the mediastinal thread should be remembered when surgical procedures are proposed in this region. Adequate knowledge of the anatomy and distance between these elements and the SCJ is essential to avoid iatrogenic lesions. Another important factor refers to cases of trauma in the anterior aspect of the thorax. Traumatic SCJ lesions are uncommon but when they occur they may be associated with fatal complications.[1,2] Although serious, fortunately the incidence is less than 3%, generally involving young, economically active young men caused by high energy trauma.[3,4] Traffic accidents and sports injuries account for more than 80% of injuries.[5-7] The increasing number of traffic accidents (especially motorcycles) and the popularization of contact sports such as football, rugby and martial arts , contributed to the increase in incidence in the last decade.[8] Subsequent dislocations correspond to 5% of the dislocations and are more commonly associated with intrathoracic lesions. Early diagnosis and treatment avoid complications and risks to patients. Conventional clinical and radiographic evaluation are important in the initial evaluation,

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

Work conducted at the Orthopedics and Traumatology Department at Hospital XV de Curitiba, in Curitiba, Paraná, Brazil.
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however, due to the lack of experience with the incidences and overlap of the mediastinal and thoracic structures, the correct interpretation is usually difficult. Computed tomography (CT) is the exam of choice for the study of SCJ lesions, because of the speed and ease of obtaining it, as well as the better anatomical definition that favors the more accurate diagnosis.[5,6]

The aim of this study was to measure the distances of the hilar structures: right and left brachiocephalic veins (BCV), trachea, esophagus and pulmonary apex, until the SCJ, demonstrating them as a normal parameter of normality. The hypothesis of variation in measures according to side, age, sex and body mass index (BMI) was also raised.

MATERIAL AND METHODS

The study sample was obtained at a private radiology clinic in the city of Curitiba / Pr. (Institute of Advanced Diagnostic Imaging - DAPI). The selection was performed prospectively among patients submitted to CT, with indications of different specialties when investigating other diseases not related to SCJ. Inclusion criteria were: healthy individuals aged between 18 and 60 or investigation of diseases that did not evolve the mediastinum or thorax. Cases with a history of trauma, spontaneous pain or sensitivity in the SCJ, previous radiotherapy, cervical or thoracic surgery, intrathoracic diseases (cancer, chronic bronchitis, emphysema, etc.), rheumatic diseases, peripheral osteoarthritis were excluded. The total selected by the criteria was 120 patients (60 men and 60 women). All volunteers participated in the study and were submitted to informed consent, after approval by the Ethics and Research Committee of Hospital XV, Curitiba / PR (Protocol number: CEXV/002ART/2015). Demographic and anthropometric data were obtained through the corresponding questionnaire. Axial and sagittal images of multi-slice CT were obtained with Siemens Somatom Definition AS tomographs of 64 and 128 channels, with submillimetric cuts of 0.5mm with reconstruction of the images in orthogonal planes with equal quality of the matrix of the image. During the imaging the patients were in apnea after deep inspiration and their arms raised above the head. The body area involved in the tomographic cuts was from the cervical region superiorly to the level of the inferiorly superior renal poles. The mean individual radiation dose was approximately 19 mGy. The images were reconstructed in the transversal plane to measure the distances between the studied structures. (Figure 1). The demarcated references for measurement were the posterior and superior points of the medial extremities of the right and left clavicles, respectively, at the SCJ level, in relation to the corresponding BCV, anterolateral tracheal margin and anterior wall of the esophagus. (Figures 2 and 3) Next, the tomographic data were reconstructed in the sagittal plane, observing the most posterior point of the medial end of the clavicles in relation to the SCJ level and the corresponding pulmonary apex. (Figure 4) The measurements were performed and reviewed separately by two radiologist specialists in the musculoskeletal area. For the analysis

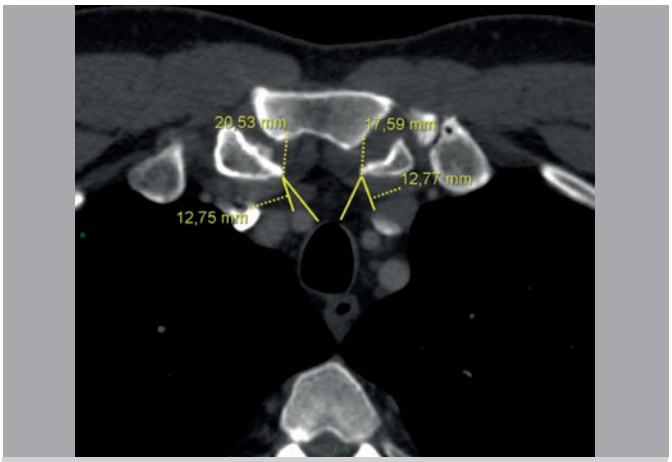

Figure 2. Axial computed tomography image demonstrating measurements of the sternoclavicular joints up to the brachiocephalic veins and trachea.

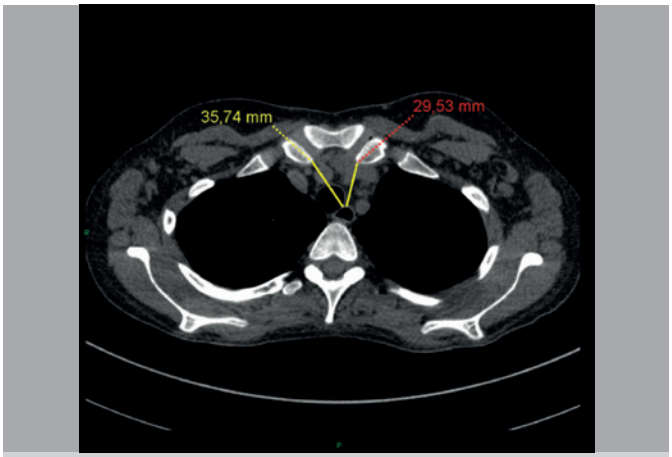

Figure 3. Axial computed tomography image demonstrating measurements of the sternoclavicular joints up to the esophagus.

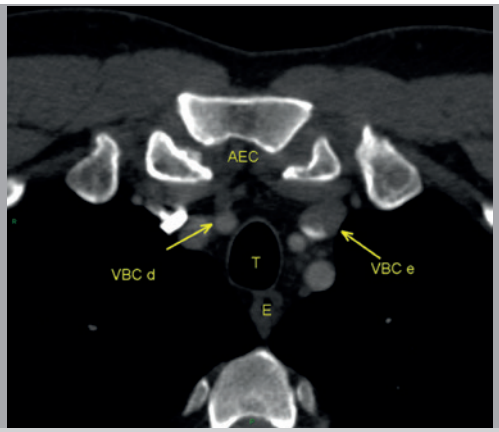

Figure 1. Axial computed tomography image demonstrating the hilar structures (AEC: sternoclavicular joints, VBC d: right brachiocephalic vein, VBC and: left brachiocephalic vein, T: trachea, E: esophagus).

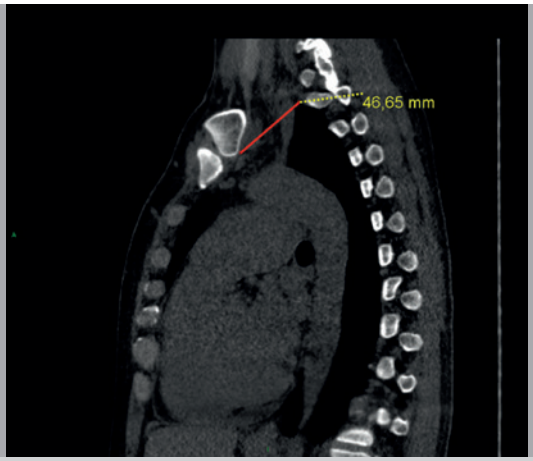

Figure 4. Computed tomography image in sagittal section showing sternoclavicular joint to the pulmonary apex.

of the association between BMI and measures, four groups defined by BMI were considered: ≤ 25; 25.1 to 30; 30.1 to 35 and> 35. The results were submitted to statistical analysis with Statistical software v.8.0, obtaining means, medians, minimum and maximum values and standard deviations. For the comparison between two variables, Student's t-test was used for independent samples. For a group of variables, we used the one-way analysis of variance model and the LSD test for multiple comparisons. Values of p <0.05 indicated statistical significance.

RESULTS

The distances and statistical data are listed in Table 1, showing a significantly higher mean value of the distance between SCJ and right BCV compared to the left side. In relation to the trachea, esophagus and pulmonary apices (Table 2), there was a significantly lower difference between the distance between the left SCJ until esophagus and the right SCJ until the apex. There was no difference in the measurments with respect to age. In the association with gender, mean distance between SCJ and ipsilateral BCV was significantly lower on both sides in women when compared to males. (Table 3) The same has been demonstrated with respect to the esophagus and apex of the lung. (Table 4) There was no difference between genders in the measures between SCJ and trachea. Comparing the different BMIs, individuals with BMI <25 demonstrated significantly lower distances than the others for both SCJ and BCV ratio, especially in relation to left SCJ. Between the trachea and the pulmonary apex there was no difference. The values of distances and statistical comparisons in relation to BMI are shown in Tables 5 and 6, respectively.

Table 1. Measurements of distances (in mm) between sternoclavicular joints to ipsilateral brachiocephalic veins (BCV).

Variable	n	Average	Median	Minimum	Maximum	Standard deviation	p value*
Right BCV	120	10.6	10.4	2.3	24.7	3.5	<0.001**
Left BCV	120	8.1	7.4	2.6	27.1	3.8	<0.001**

* Student's t test for paired samples, p <0.05; ** Statistically significant p value.

Table 2. Measurements of distances (in mm) between the sternoclavicular joints (SCJ) to the trachea, esophagus and ipsilateral apex.

Distances	Right SCJ	Left SCJ	p value*
Trachea	22.2	22.8	0.115
Esophagus	42.8	38.6	<0.001**
Ipsilateral apex	54.9	57.3	<0.001**

* Student's t test for paired samples, p <0.05; ** Statistically significant p value

Table 3. Ratio of distance (in mm) between sternoclavicular joints and ipsilateral brachiocephalic veins (BCV) according to gender.

Variable	Gender	n	Average	Median	Minimum	Maximum	Standard deviation	p value*
Right BCV	Female	60	9.2	9.3	3.8	14.5	2.5	<0.001**
	Male	60	12.2	11.7	2.3	24.7	3.8	<0.001**
Left BCV	Female	60	7.3	6.9	2.6	16	2.8	0.015
	Male	60	9	8	3.5	27.1	4.6	0.015

* Student's t test for paired samples, p <0.05; ** Statistically significant p value.

Table 4. Ratio of distance (in mm) between the sternoclavicular joints (AEC) with the esophagus and ipsilateral apex according to gender.

Variables	Gender	Esophagus		Ipsilateral apex	
		Average	p value*	Average	p value*
Right SCJ	Female	40.6	<0.001**	53.2	0.002**
	Male	45	<0.001**	56.6	0.002**
Left SCJ	Female	37.1	0.003**	54.5	<0.001**
	Male	40.1	0.003**	60.3	<0.001**

* Student's t test for paired samples, p <0.05; ** Statistically significant p value.

Tabela 5. Distância média (em mm) das articulações esternoclaviculares (AEC) em relação às veias braquicefálicas (VBC) e esôfago de acordo com os valores de índice de massa corporal (IMC).

Valores de IMC	AEC e VBC Direita	AEC e VBC Esquerda	AEC e Esôfago Direito	AEC e Esôfago Esquerdo
≤ 25	9.2	6.8	41.1	36.6
25,1 a 30	11.5	9	44.5	39.6
30,1 a 35	11.7	9	43.1	39.6
> 35	12.7	10	43.9	43.2

Table 6. Statistical values comparing the distances between sternoclavicular joints (SCJ) in relation to brachiocephalic veins (BCV) and esophagus according to body mass index (BMI).

BMI values	p value*			
	Right BCV	Left BCV	Right SCJ and Esophagus	Left SCJ and Esophagus
≤ 25 x 25,1 a 30	0.001**	0.006**	0.005**	0.008**
≤ 25 x 30,1 a 35	0.009**	0.040**	0.205	0.040**
≤ 25 x > 35	0.003**	0.015**	0.158	0.001**
25,1 a 30 x 30,1 a 35	0.903	0.959	0.368	0.988
25,1 a 30 x > 35	0.338	0.445	0.747	0.063
30,1 a 35 x > 35	0.442	0.472	0.720	0.098

* Student's t test for paired samples, p <0.05, ** Statistically significant p value.

DISCUSSION

Anatomy in the SCJ region is usually less explored and understood by the orthopedic surgeon, possibly due to the lower number of procedures described and performed in the medial clavicle and SCJ in daily practice, in addition to the proximity to the anatomical retrosternal elements. When necessary, the techniques described require detailed knowledge in this anatomy avoiding the risk of iatrogenic lesions that are often fatal. Some authors recommend including the thoracic surgeon in the surgical team in the SCJ surgeries.[9,10] Another factor related to the possible damages of these structures is related to the posterior dislocation of the SCJ.[15] Fortunately it is infrequent, but by association with high-energy trauma to the chest, it can cause serious injury by its proximity to noble structures. There are few studies in the literature that describe the distance between the SCJ and the hilar elements, which makes it difficult to compare data. CT has been used as the main imaging exam for the diagnosis of SCJ lesions, but there are few studies of anatomical relationships.[5,6] All show BCV as a structure near the SCJ, with a mean distance between 6mm and 7mm, with no difference in relation to the side.[10-12] We found mean values of 8.1mm on the left side and 10.6mm on the right side. In addition to right and left BCV, we include as reference elements the trachea, esophagus and pulmonary apex because they are involved in descriptions of posterior luxation.[1,2,5,6,12,13] Regarding the trachea, the average distance that literature described is 28mm and 31mm, on the right and left side respectively. We had on average 22mm with no difference between the two sides. For the esophagus the mean obtained was 42.8mm on the right and 38.6mm on the left, with significant difference between the sides. We could not compare these values due to lack of data in the literature. The distances found at the apex of the lung were 54.9mm and 57.3mm (right and left side respectively), showing statistical difference in relation to the side. Comparing this data with Ponce et al.[10] Our measurements were much higher (on average they were 7 mm bilaterally) because these authors measured the distance in the axial cut in relation to the pleura and not in the sagittal and apex of the lung. The same authors also had no difference in the measurments regarding sex, age or BMI. There are few articles that compare distances such as age, sex, and BMI. Merriman et al.[14] found differences between

the sexes, with a smaller distance from the medial clavicle to the BCV in females. Regarding these variables, our data demonstrate that the left SCJ is closer to the hilar structures than to the right side; in women both SCJ are closer to the BCV, esophagus and pulmonary apices compared to men; patients with BMI <25 have lower distances up to the BCV and esophagus. Some authors have studied the distance from the SCJ in relation to other structures, such as Lenza et al.[11], recommending a safe distance of 2cm from the superior surface and 1cm from the posterior margin of the joint in relation to the internal jugular vein during surgical access in cadaveric dissection. Variations in relation to our results may have been due to the difference in the methodology used in the other studies. The distances demonstrated by CT suggest greater accuracy because they are obtained in living and healthy individuals, which may vary in cases of cadaveric dissections. On the other hand, during these, data can be modified. Another limitation of this study can be cited by the fact that we did not perform intra- and inter-observer analysis (evaluation of 2 specialists only). The data demonstrated can be followed as anatomical parameters of normality, preventing iatrogenic lesions in the surgical approach of the SCJ. In traumatic cases, especially posterior dislocation of the SCJ, CT is fundamental for the study of possible associated hilar injuries, after clinical evaluation.

CONCLUSION

The anatomical structure closest to the SCJ is the BCV, with a mean distance of 8.1mm on the left side and 10.6mm on the right side. In women, the left ventricle is on average closer to the BCV, esophagus, and pulmonary apexes than in men. Patients with BMI <25 have shorter distances from the SCJ to the BCV and esophagus.

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ORIGINAL ARTICLE

MINIMALLY INVASIVE EXTREME LATERAL APPROACH IN SPINAL LUMBAR METASTASIS

VIA EXTREMO LATERAL MINIMAMENTE INVASIVA EM CASOS DE METASTASES LOMBARES

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ABSTRACT

Introduction: The extreme lateral approach has been widely used for the treatment of degenerative diseases. The objective of this study is to present a minimally invasive extreme lateral approach for the treatment of metastatic lesions in the lumbar spine without the use of the evoked potential exam (MEP). Methods: Two patients with spinal metastases and indication for surgery via the anterior approach were treated in a cancer referral center in Brazil. They were placed in right lateral decubitus, and an oblique incision was made, exposing the psoas muscle. The anterior approach permitted the release of the psoas muscle from vertebral body and disc, without the need for MEP. Conclusions: When cancer cure is no longer possible, a minimally invasive extreme lateral approach to treat tumor metastases in the lumbar spine is a viable option, with short hospitalization time and low morbidity. The dislocation of the psoas muscle avoids the use of the transpsoas approach, which requires MEP equipment and a trained physician. Clinical studies are needed to extend these benefits to oncological patients who have treatment options for their primary disease. ***Level of Evidence IV; Case series.***

Keywords: Minimally invasive surgical procedures. Neoplasms. Neoplasm metastasis. Spine. Spinal fusion. Operative surgical procedures.

RESUMO

Introdução: A técnica extremo-lateral já vem sendo amplamente usada no tratamento de doenças degenerativas fazendo com que o objetivo deste trabalho seja de apresentar a técnica extremo-lateral minimamente invasiva para o tratamento de metástases na coluna lombar, sem a necessidade do potencial evocado motor (MEP). Método: Dois pacientes com metástases em coluna com indicação para cirurgia pelo acesso anterior foram tratados em um centro de referência no Brasil. Eles foram posicionados em decúbito lateral direito e uma incisão oblíqua foi feita, expondo o músculo psoas. Pela via anterior, foi possível descolar as fibras do músculo psoas do corpo vertebral e disco, sem a ajuda do MEP. Conclusão: Quando a cura do câncer não é possível, o acesso extremo lateral por cirurgia minimamente invasiva é uma opção viável no tratamento de metástases tumorais na coluna lombar, com hospitalização curta e baixa morbidade. O descolamento do psoas evita o uso da via transpsoas, que exigiria a assistência com equipamento de MEP e profissional treinado para operá-lo. Estudos clínicos são necessários para que esses benefícios sejam estendidos a pacientes com câncer, para que ainda haja opção de tratamento para a doença primária. ***Nível de Evidência IV; Série de casos.***

Descritores: *Procedimentos cirúrgicos minimamente invasivos. Neoplasias. Metástase neoplásica. Coluna vertebral. Fusão vertebral. Procedimentos cirúrgicos operatórios.*

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INTRODUCTION

Metastatic lesions account for 97% of spine tumors and in these cases, due to the involvement of the vertebral body, intervention by the anterior or posterolateral transpedicular approach is required. For these cases, an extreme lateral approach using a minimally invasive technique (MIS), widely used for degenerative diseases, is a natural option, offering the same advantages with lower patient morbidity.

The extreme lateral approach was described for the treatment of spine pathologies by Ozgur et al.[1] in 2006, with a focus on degenerative pathologies of the spine. The technical advantages noted were: no need for postoperative hospitalization in the intensive care unit (ICU), earlier return to walking, the possibility of the surgery being performed by the team of spine surgeons, without the need for a general surgeon, little need for blood components, and a lower rate of local complications.[1] With the improvement of the method and learning curve, it was possible to expand its application to other diseases, such as degenerative adult lumbar scoliosis and low-grade spondylolisthesis.[2-4]

This technique, previously restricted to the lumbar region, has proved to be feasible for the thoracic region and thoracolumbar transition.[5]

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

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Currently, its safety for elderly patients over than 70 years of age has been confirmed, with a risk that is higher than in younger patients, but still acceptable when compared to other techniques.[6] In this study, we present a minimally invasive extreme lateral approach for the treatment of metastatic lesions in the lumbar spine without the use of the motor evoked potential (MEP).

MATERIALS AND METHODS

Between February 2014 and May 2015, patients at the São Paulo Cancer Institute with metastatic tumors presenting medullary compression and pathological fractures indicated for anterior approach surgery were treated using the extreme lateral approach. The project was approved by the hospital ethics committee (number 1318) and patients signed a consent form to participate.

A total of two patients were treated: patient 1, an East Asian man, 53 years of age with adenocarcinoma of the colon, Tokuhashi score[7] of 9, Tomita score[8] of 7, Spine Instability Neoplastic Score (SINS) score[9] of 10; and patient 2, a Caucasian woman, 42 years of age with a clear cell renal cell carcinoma with Tokuhashi of 10, Tomita of 7 and SINS of 11. Both had lesions in the body of L2, and both had the indication for the procedure due to the presence of lytic lesions affecting the vertebral body and pedicles, resulting in mechanical instability and neurological deficit. Grade 4 motor strength was noted on the left side of levels L2 and L3 in patient 1 and grade 3 strength bilaterally at level L2 in patient 2, with no changes to the other levels noted in either patient.

The patient under general anesthesia, with orotracheal intubation, is positioned in true right lateral decubitus. Flexion of the table or the patient is performed to increase the distance between the costal arches and the iliac crest of the segment to be operated on (Figure 1A). Assisted by radioscope, the true profile is checked and marks are made on the skin. Asepsis and antisepsis are performed with chlorhexidine-alcohol antigerm solution, and sterile drapes are placed over the site.

An oblique approach incision is made (Figure 1B) on the area marked out, noting the primary structures: external oblique, transversus abdominis, and internal oblique muscles. After dilatation of these muscles in the direction of their fibers, the retroperitoneal space is entered. Using digital dissection, the retroperitoneal fat is detached ventrally, creating a space that extends to the anterior edge of the psoas muscle. In both cases presented here, a Syframe (Synthes) retractor was used, and a Pentero (Zeiss) microscope was used in the intercavity approach and lightening.

Because the motor evoked potential (MEP) exam is not always available in the Brazilian public health system, we chose to dislocate the psoas muscle from its anterior edge elevating it. This procedure dismissed the transpsoas approach, which requires MEP evaluation, by avoiding the nerves in the area. The psoas dissection is begun starting at its anterior edge, detaching the muscle from the vertebra and tying off the visible segmental arteries. After adequate retraction, discectomies of the discs above and below the affected vertebra are performed, followed by corpectomy. (Figure 2)

For the reconstruction of the anterior and middle structures, an expandable cage (Synex, Synthes) is used alone in both cases. However, the use of a bone graft from the iliac crest or cement is possible, depending on the expected survival of the patients as estimated by the Tokuhashi, Tomita and SINS classifications[7-9] or by the multidisciplinary oncological clinical impression. Posterior percutaneous pedicular fixation was chosen (Figure 3) because it is a procedure that can be performed during the same surgery after a shift to ventral decubitus. Closure is performed by planes with nylon monofilament threads, 2.0 for the deep structures and 3.0 for the skin.

In both cases, immediate postoperative management occurred in the intensive care unit (ICU) and both patients were discharged from the ICU within the first 24 hours following surgery. Pain, rated according to the VAS (visual analog scale), was initially assessed as 5/10 for patient 1 and 7/10 for patient 2, averaging 6/10. The following analgesics were prescribed for both patients: tramadol (100 mg, three times per day), ketoprofen (100 mg twice a day), and acetaminophen (500 mg four times per day).

Figure 1. (A) Positioning of the patient; (B) Planning the skin incision.

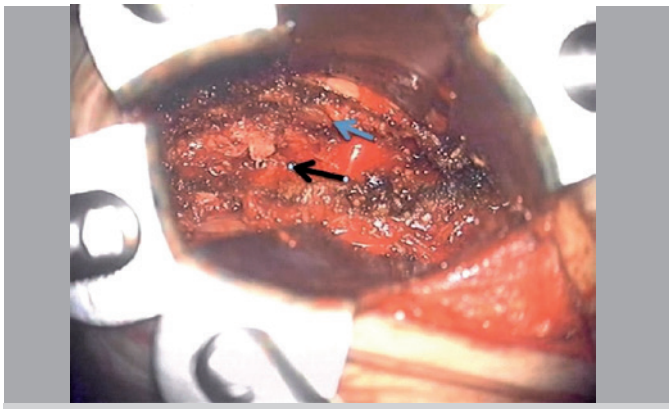

Figure 2. Corpectomy (black arrow) and folded back psoas muscle (blue arrow).

Walking as early as possible was encouraged during the first postoperative day, with the assistance of a trained physical therapist. The dressings were changed and radiographic exams were performed (Figures 4A, 4B). On the second postoperative day, the patients were encouraged to walk without assistance.

On the third postoperative day, pain was at level 2/10 for patient 1 and level 4/10 for patient 2, with an average VAS of 3/10. They were then discharged from hospital.

The stitches were removed at the first hospital follow-up visit, at 14 days, and subsequent follow-up visits took place on a regular basis at 1, 2, 3, 6, and 12 months following surgery. In both cases, post-surgical radiotherapy was performed as an additional method, for local control of the disease.

Patient #1 was followed-up regularly and suffered from worsening of neurological symptoms (Frankel C) at T10, due to a metastasis at that level. He was operated with decompression, but died in February, 2016, due to lung metastatic complications. Patient #2 maintained neurological stability (Frankel D), and she was followed up 1 year and 2 months without tumor recurrence. She died later due to sepsis (primary focus in the kidney) during chemotherapy treatment.

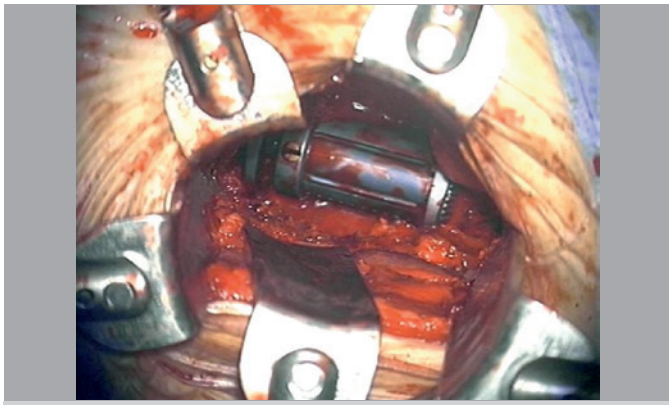

Figure 3. Cage placement.

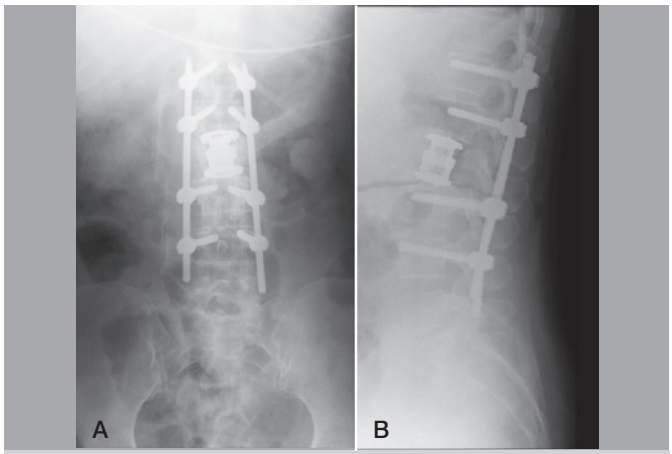

Figure 4. Postsurgical x-ray's.

RESULTS

The surgeries took in average 210 minutes (190-230), including 140 minutes for the extreme-lateral access and 50 minutes for the posterior percutaneous fixation in patient #1 and 165 minutes for extreme--lateral access and 65 minutes for the posterior percutaneous fixation in patient #2. Patients' average blood loss was 625 ml (500 ml for patient #1 and 750 ml for patient #2).

There was no neurological impairment. Both patients stayed one day in the ICU postoperatively. Pain score was 6/10 in the immediate postoperative period and 3/10 in the late postoperative period (average visual analogue scale score). Both patients were able to walk with assistance on the first postoperative day, without assistance on the second day, and both were discharged on the third day.
Our initial analysis show that minimally invasive techniques can be used in oncological patients, with benefits such as short hospitalization period, low morbidity, minimal risk of infection, which have been shown beneficial in the treatment of degenerative diseases.

DISCUSSION

Patients with metastatic lesions, once seen as a sign of reserved prognosis and often as the end of the road for cancer treatments, are now handled with more care, focusing on a better quality of life. From the point of view of spine surgery, the implementation of minimally invasive techniques is advantageous.[10,11] Recent studies have shown shorter hospitalization, similar surgical times, little need for blood components, the non-necessity for a general surgeon, and lower morbidity and mortality.[5,10-12]
When cure is not possible, the use of cytoreduction techniques, like debulking, is still an option. We chose this technique for local disease control and neurological protection. After the surgical procedure, when possible, we still manage the disease with chemotherapy and radiotherapy.
The advantage of this method is that this approach can be used even in the absence of the motor evoked potential exam, which is not available everywhere, and takes additional time and resources. Besides being a minimally invasive technique, by the lateral approach, that is able to promote stabilization with small hospitalization times and bleeding,[5,8,11,12] the technique described here allows treating patients with metastatic diseases using little human and financial resources. By dislocating the psoas, we treated these two patients successfully without the need of MEP equipment or a trained physician in its analysis. Even without using MEP, as expected, there was no degradation of neurological function in neither case in the immediate postoperative period, and an improvement of the motor strength grade was observed in patient 2 in the postoperative period.

CONCLUSION

The extreme lateral approach can be used as an alternative to conventional approaches where curative resection is not expected. The dislocation of the psoas muscle allows a wider use of the technique in centers where MEP is not available.
Further studies are necessary to make more definitive conclusions about the advantages of this technique.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AFC (0000-0002-7797-5274)*, TEPBF (0000-0002-0819-7712)*, and MJT (0000-0002-7974-6045)*: designed the study, interpreted the data, and participated in writing the manuscript; DKN (0000-0001-7895-4830)*, LCCM (0000-0002-7334-8206)*, and WGJT (0000-0001-9036-629X)*: participated in data collection and interpretation and writing the manuscript. All authors revised and approved the final version submitted for publication and are responsible for content of the manuscript. *ORCID (Open Researcher and Contributor ID).

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ORIGINAL ARTICLE

EVALUATION AND COMPARISON OF OPEN AND CLOSED TIBIA SHAFT FRACTURES IN A QUATERNARY REFERENCE CENTER

COMPARAÇÃO DAS FRATURAS DIAFISÁRIAS DE TIBIA EXPOSTAS E FECHADAS EM UM SERVIÇO QUATERNÁRIO

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ABSTRACT

Introduction: Tibia shaft fractures are among the most common in orthopedic practice, but Brazilian literature remains limited on the subject. Objective: To evaluate the characteristics of tibia shaft fractures and conduct a comparison between exposed and closed fractures of the tibia. Methods: This comparative prospective study examined all tibia shaft fractures admitted to our services over a twelve-month period. The cases were evaluated according to age, trauma mechanism, sex, associated fractures, treatment, hospital stay, and readmission rate during the six months after discharge. Results: Fifty-three cases met the inclusion criteria. The average age was 36 years (SD 14.3) and 83% were males ($p<0.001$). Traffic accidents were responsible for 73.6% of fractures ($p<0.001$). Exposed fractures were found in 52.8% of the cases ($p=0.56$). When initial treatment consisted of stabilization with external fixation, these cases were more likely to be rehospitalized ($p=0.009$). Cases of open fracture also had longer hospital stays ($p<0.001$) and a higher readmission rate ($p=0.028$). Conclusion: Open fractures are associated with more severe trauma, expressed in longer hospital stays and high rates of readmission. Cases of fracture which were initially treated with external fixation had a higher readmission rate. ***Level of Evidence II; Prospective comparative study.***

Keywords: Tibial fractures. Fractures, open. Fractures, closed. Prospective study.

RESUMO

Introdução: Fratura diafisária de tíbia é uma das fraturas mais comuns na prática ortopédica, porém a literatura brasileira ainda é limitada na sua avaliação. Objetivo: Avaliar as características das fraturas diafisárias de tíbia e realizar uma comparação entre as expostas e fechadas. Material e Métodos: Foi realizado um estudo, prospectivo comparativo por 12 meses, com todas as fraturas diafisárias de tíbia admitidas. Os pacientes foram avaliados nos seguintes critérios: idade, mecanismo de trauma, sexo, fraturas associadas, tratamento, tempo de internação e índice de reinternação nos seis meses subsequentes à alta. Resultados: Foram avaliados 53 casos que se encaixavam nos critérios de inclusão. A idade média dos pacientes avaliados no nosso estudo era de 36 anos (DP14,3), 83% eram homens ($p<0,001$). Acidente de tráfego foi responsável por 73,6% ($p<0,001$). Lesões expostas foram encontradas em 52,8% ($p=0,56$). O fixador externo, quando utilizado como método de estabilização inicial, apresentou maior índice de reinternação ($p=0,009$). As lesões expostas apresentaram tempo de internação ($p<0,001$) e índice de reinternação superior as fechadas ($p=0,028$). Conclusões: As fraturas expostas estão envolvidas com traumas de maior gravidade, tanto pelo tempo aumentado de internação hospitalar quanto pelo alto índice de reinternação. Fraturas tratadas inicialmente com fixador externo apresentam maior taxa de reinternação. ***Nível de Evidência II; Estudo prospectivo comparativo.***

Descritores: *Fraturas de Tíbia. Fraturas expostas. Fraturas fechadas. Estudos prospectivos.*

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INTRODUCTION

Tibia shaft fractures are very prevalent in emergency orthopedics services and tend to be associated with a specific patient profile: they usually affect men of economically productive age involved in high-energy trauma.[1–3] These patients generally cannot return to their work for an extended period of time, and require many medical visits in the interim, generating high social costs.[4,5]

In the specific case of tibial shaft fractures, most studies are found in the foreign literature and suggest trauma mainly related to sports injuries and traffic accidents.[2] In Brazil, the literature is scarce and the few studies are mostly retrospective, reviewing medical records. It is currently accepted that open fractures have an important relationship with higher-energy trauma, longer treatment time, and higher rates of complications in comparison with closed fractures.[6,7]

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Even though these data are already solidly established in the international literature, no Brazilian studies were found that compared open and closed fractures to determine if our epidemiology is similar to that found in the international literature.
This comparison between exposed and closed fractures permits a better understanding of this type of fracture in the Brazilian scenario and consequently informs cost-effective and efficient ideas for acquisition and availability of equipment to be used in orthopedic urgent care, particularly open fractures. It also can act as a guide for preparing preventive measures for traumas which are related to these fractures.
The rationale for this study is to present the epidemiological data from patients with tibial fracture who were admitted to our service, and to use these data to compare closed and open fractures according to the evaluated criteria.

MATERIALS AND METHODS

This observational, descriptive, prospective study was conducted over a period of twelve months (January-December 2016) involving all patients with tibial shaft fractures who were admitted to our service. The study was conducted with the approval of the institutional review board (process number 47573615.2.0000.5505).
The patients were followed throughout hospitalization and the following data were evaluated: age, sex, trauma mechanism, fracture characteristics, associated fractures, treatment method chosen, skin injury, hospital stay, and hospital readmission during the six months following discharge. All patients enrolled in the study signed an informed consent form (ICF).
The fractures lines were evaluated using radiography and classified as 42-A, 42-B, or 42-C according to the AO classifications,[2,8,9] while the skin injuries were classified according to Gustillo.[7] Both the x-rays and the skin injuries were photographed and classified by at least two researchers in the study. The information about the treatment performed, hospital stay, and readmission during the following six months was obtained from the medical records. Finally, the remaining items were evaluated by questioning the patient directly.
After informed consent form was obtained, all patients over 12 years of age admitted to our service with tibial shaft fractures (AO 42) who did not have a history of previous surgical procedure or tibial fracture were selected.
The statistical analysis was carried out by a professional who did not participate in the study; the confidence interval (CI) was 95% and statistical error was set at a maximum of 5% ($p<0.05$). Parametric tests were used for the analysis, since the data are quantitative and continuous. No tests were used to verify the normal distribution of the study, since the sample was greater than 30. The SD (standard deviation) is presented along with the mean values.

RESULTS

Sixty patients with tibial shaft fractures were admitted, but 7 patients were excluded from the study, yielding a total sample of 53 fractures. One patient was excluded from the study for having previously undergone a tibial procedure, and 6 were under 12 years of age. Of the selected patients, 13.2% ($p<0.001$) did not receive their treatment at our service because they or their families preferred a transfer to private services. Patients who did not receive treatment from our service were excluded from the evaluation of the hospital stay, treatment received, and readmission.

Sex and age

The mean age of the patients with tibial fractures was 36.0 years (SD 14.3 years). The mean ages for female and male patients were 38.7 years (SD 17, $p=0.542$) and 35.4 years (SD 13.9 years; $p=0.542$), respectively. However, this fact showed no statistical significance; 83% of the cases were male and 17% female ($p<0.001$) (Figure 1) (Table 1).

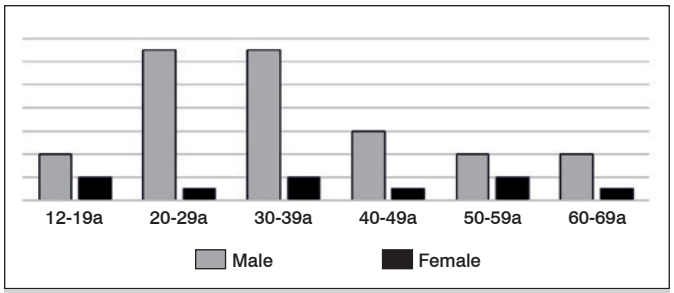

Figure 1. Age and sex ratio.

Table 1. General presentation of the data.

		(% [n])	p-value
Mean age ± SD (years)		**36 ± 14.3**	
Distribution by sex	Male	83.00% (44)	< 0.001
	Female	17.00% (9)	
AO Classification	42 – A	66% (35)	< 0.001
	42 – B	13.2% (7)	
	42 – C	20.8% (11)	
Associated fractures	Yes	83% (44)	< 0.001
	No	17% (9)	
Exposed bone	Yes	52.8% (28)	0.56
	No	47.2% (25)	
Trauma mechanism	Traffic accident	73.6% (39)	< 0.001
	Falls from Height	11.3% (6)	
	Sports Trauma	9.4% (5)	
	Other	5.7% (3)	
Hospitalization ± SD (days)		**14.8 ± 16.2**	
Readmission in 6 months	Yes	13% (9)	< 0.001
	No	87% (44)	

Trauma mechanism and associated injuries

Traffic accidents, falls from height, sports trauma, and other mechanisms were responsible for 74%, 11%, 9%, and 6% of injuries, respectively. ($p<0.001$) (Table 1) Among the victims of traffic accidents, 55% were involved in motorcycle accidents, 36% were hit by a motor vehicle ($p=0.069$), 5% were in a car accident ($p<0.001$), and 3% were in bicycle accidents ($p<0.001$). No statistical correlation was found between traffic accidents or sports trauma and male or female sex ($p=0.25$)
Associated injuries were found in 83% of cases; ($p<0.001$) (Table 1) in this group of patients, fibular fracture was found in 95% of cases ($p<0.001$), ipsilateral femur fracture in 6.8% of cases ($p<0.01$), and forearm fracture also in 6.8% of cases ($p<0.001$).

Fracture characteristics, bone exposure, and associated skin injury

Sixty six percent of patients had a simple fracture classified as AO 42-A, while 13% had a wedge fracture (42-B), and 21% had a segmental fracture. (42-C) ($p<0.001$) (Table1) In terms of skin injury, 53% of fractures involved bone exposure and 47% were closed, but this fact was not statistically significant ($P=0.56$). The fractures were classified as more severe (AO 42-C) were related to open fractures, with statistical significance ($p=0.002$) (Table 2) Of the open fractures, type IIIA accounted for 82%, 11% were IIIB, and 7% were IIIC. ($p<0.001$) (Table 1) No Gustillo classification I or II fractures were documented.

Table 2. Correlation between open fracture, AO classification, and readmission.

Open fracture		No		Yes		Total		P-value Comparison
		N	%	N	%	N	%	
AO Classification	42A	20	80%	15	54%	35	66%	0.002
	42B	5	20%	2	7%	7	13%	
	42C	0	0%	11	39%	11	21%	
Readmission in 6m	No	19	100%	21	78%	40	87%	0.028
	Yes	0	0%	6	22%	6	13%	

Treatment

Upon admission, all cases of open fracture were immediately subjected to an aggressive protocol involving the following components: intravenous antibiotic therapy, surgical debridement and cleaning, fracture stabilization, and early coverage of soft tissue. Initially, 78% of the cases were stabilized with external fixation and 22% with other methods (locked intramedullary nail, amputation, or plaster splint). ($p<0.001$) Of the cases initially stabilized with external fixation, 45% were treated definitively with linear external fixation and 55% were treated with other methods (circular external fixator, locked intramedullary nail or plate). There was also a statistically significant correlation between the use of external fixation to treat tibial fractures, whether temporary ($p=0.009$) or definitive ($p=0.031$), and readmission.

In the closed fractures, 11% of the cases were treated with external fixation and 89% with other methods (locked intramedullary nail, conservative treatment, linear external fixation, or plate) ($p<0.001$).

Hospitalization time and readmission rate

The cases with open fractures remained in the hospital for approximately 21.5 days (SD 17.9, $p<0.001$) and cases with closed fractures remained in the hospital for an average of 5.4 days. (SD 5.6, $p<0.001$)(Table 2)

In the first six months after discharge, 21% of cases which initially had open fractures were readmitted ($p=0.028$). Of the cases that initially had closed fractures, no patients were readmitted. ($p=0.028$) (Table 2)

DISCUSSION

Epidemiological studies portraying the profile of certain fractures are still rare in Brazil, notably because of the absence of a proper recording system with national reach. In the search for a mechanism with the lowest possible losses in data collection, this study was conducted prospectively throughout 2016. The patients were evaluated at admission, accompanied throughout hospitalization, and followed considering a chance of readmission during the six months following discharge.

In general, the majority of patients affected by this injury, in our study as well as other series, are men at economically productive age and involved in traffic accidents.[1–3] The trauma mechanism in our study seems to differ from those found in the literature. In our study, 74% ($p<0.001$%) of patients were victims of traffic accidents, a number that seems to be higher than the findings of other international studies (37.5%)[2] and very similar to another Brazilian study. (77%)[3]

For traffic accidents, the latest recommendations involve a series of public policies that must be carried out on a wide scale with several fronts of intervention. These interventions should be based on measures involving oversight of offenders and implementation of strict penalties, as well as public awareness campaigns.[10,11]

With respect to the fracture characteristics and bone exposure, a statistical significant relationship was seen between open fractures and 42-C type fractures and also between closed fractures and 42-A type fractures. The AO classification involves a scale that increases in severity,[9] with 42-C fractures resulting from greater energy than 42-A fractures. This feature explains the relationship between open fractures (more severe injuries) with 42-C type fractures and closed injuries with the 42-A classification.

As for the most frequent treatment for open fractures, external fixation was most commonly used as the initial treatment, with statistical significance. This preference by Brazilian orthopedic physicians in treating open fractures (whether as damage control or even definitively) had already been demonstrated in a previous Brazilian study.[12] One possible explanation for the extensive use of external fixators as a form of temporary and definitive treatment in Brazil had already been raised by other authors, namely that they are more practical, implant costs are lower, and they are widely available in the public health network.[12,13]

We also found that patients who received external fixation for initial stabilization of open fractures had a statistically significant higher rate of readmission. This higher rate has already been addressed in the literature and is currently accepted as one of the main disadvantages of external fixation, mainly in comparison with the locked intramedullary nail.[6] For this particular finding, it should be noted that the external fixation device is removed in an outpatient setting, and therefore does not count as readmission.

Other relevant findings from this study are the longer hospital stay and higher rate of readmission for open fractures (both with statistical significance), which are probably related to the complexity of treating skin injuries and difficulty of definitive treatment. In the specific case of our institution, the prolonged hospitalization is thought to be principally related to the recent crisis our service is facing and consequent difficulty in acquiring materials. The high rate of readmission can be related to the fact that the procedures are mostly performed by resident physicians and also because of the difficult management of skin injuries involved in open fractures.

Our study presented some limitations: the follow-up period was short, and did not evaluate clinical and radiological outcomes. However, even with these limitations we were able to present the epidemiological characteristics of our service and thus demonstrate the main limitations of a Brazilian public hospital; the findings of this study can be extrapolated to other services with characteristics similar to our hospital.

CONCLUSION

Open fractures are associated with more severe trauma, because of the significant relationship between these fractures and 42-C type fractures as well as the increased time of hospitalization and high rate of readmission. Fractures treated initially with external fixation have a higher rate of readmission when compared to other initial stabilization techniques.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. ALS (0000-0002-4063-672X)*: contributed to the substance, concept, and development of the study, collected data, conducted the statistical analysis, and drafted the text; CTN (0000-0003-3043-8727)*: participated in the discussion of the results and drafting the text; GB (0000-0002-4846-9188)* contributed to the substance, concept, and development of the study, as well as the statistical analysis and drafting of the text; GTS (0000-0001-9732-8763)*: participated in the discussion of results, statistical analysis and drafting of the text; MJST (0000-0002-9539-4545)*: participated in the drafting, revision, and final approval of the text; BR (0000-0003-2431-2634)*: contributed to the substance, concept, and development of the study, as well as the revision and final approval of the text. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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ORIGINAL ARTICLE

DIAGNOSIS AND TREATMENT OF RETAINED WOODEN FOREIGN BODIES IN THE EXTREMITIES USING ULTRASOUND

DIAGNÓSTICO E TRATAMENTO COM ULTRA-SOM DE CORPOS ESTRANHOS DE MADEIRA RETIDOS NAS EXTREMIDADES

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ABSTRACT

Objective: This study investigates ultrasonography as an effective tool for localizing and measuring the depth and size of wooden foreign bodies to perform less invasive and easier surgery without the need for any additional radiological techniques. Methods: Fifteen patients were operated to remove foreign bodies in the extremities in 2016. The side of the affected extremity, the material, size, and location of the foreign body and time of admission after injury were noted, along with CRP, WBC, and erythrocyte sedimentation rate; length of incision, surgery duration, and complications were evaluated. Results: The mean patient age was 39.66 (range: 6 to 68). Of the total, 8 of the foreign bodies were in the plantar surfaces of the feet, 3 were in the cruris, 2 were in the palm of the hand, and 2 were in the fingers. All patients underwent ultrasound evaluation before surgery. The surgeries lasted less than 10 min in 13 (87%) of the cases and from 10 to 20 min in 2 cases. No complications were observed in any of the patients. Conclusion: Delayed extraction of foreign bodies can lead to local infections. Ultrasonography can be a reliable option for diagnosing and localizing radiolucent foreign bodies such as wooden objects. ***Level of Evidence IV; Case series.***

Keywords: Foreign bodies. Soft tissues. Ultrasonography.

RESUMO

Objetivo: Neste estudo, procuramos mostrar que a ultra-sonografia é uma ferramenta eficaz para localizar e medir a profundidade e o tamanho dos corpos estranhos em madeira, a fim de realizar uma cirurgia menos invasiva e mais fácil, sem a necessidade de técnicas radiológicas adicionais. Métodos: 15 pacientes foram submetidos à cirurgia para penetração de corpo estranho nas extremidades em 2016. O lado da extremidade afetada, o material, tamanho e localização do corpo estranho e o tempo de admissão após lesão foram observados. CRP, WBC e taxa de sedimentação de eritrócitos também foram observados. O comprimento da incisão, duração da operação e complicações foram avaliados. Resultados: A idade média do paciente foi de 39,66 (intervalo: 6 a 68). No total, oito de todos os corpos estranhos estavam no lado plantar dos pés, três estavam no crúis, dois estavam na palma da mão e dois estavam nos dedos. Todos os pacientes foram submetidos a avaliação ultra-sonográfica antes da cirurgia. A duração da operação foi inferior a 10 minutos em 13 (87%) dos casos e entre 10 a 20 minutos em dois casos. As complicações não foram observadas em todos os pacientes. Conclusão: A extração retardada de corpos estranhos pode levar a infeções locais. A ultra-sonografia pode ser uma opção confiável para diagnosticar e localizar corpos estranhos radiolúcidos, como objetos de madeira. ***Nível de evidência IV; Série de casos.***

Descritores: *Corpos estranhos. Tecidos moles. Ultrassonografia.*

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INTRODUCTION

Residual foreign bodies in extremities after penetrating, lacerating, or crush injuries are commonly encountered. The history of the injury and physical examination of the extremity can provide information, but is usually insufficient. If a residual foreign body is suspected, radiographic visualization is necessary; conventional X-rays, ultrasonography (US), computerized tomography (CT), and magnetic resonance imaging (MRI) can be used to obtain visual images of the foreign bodies. Radiopaque objects can be easily diagnosed with X-rays. One study found that diagnosis was missed by the initial treating physician in 38% of patients. Metal was visible in all of the radiographic images, glass in 96%, and wood in just 15%.[1] Delayed diagnosis can lead to pain, soft tissue infection, delayed and damaged wound healing, and abscess formation. Additionally, delayed surgery can lead to increased neurovascular injury, blood loss, wider surgical incision, and iatrogenic complications.

Ultrasound evaluation does not expose patients to ionized radiation and is highly sensitive to detecting foreign bodies with different densities. It is also more cost effective compared to CT and MRI.[2,3]

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This study included patients who sought treatment at our clinic for complaints of residual wooden foreign bodies. We aimed to show that ultrasonography is an effective tool for localizing and measuring the depth and size of wooden foreign bodies in order to perform less invasive and easier surgery.

MATERIALS AND METHODS

A total of 15 patients (6 male and 9 female) who presented with foreign body penetration in 2016 were evaluated retrospectively. The study was approved in advance by the institutional review board (2016-KAEK-51) and all patients signed an informed consent form. The injured side, material and location of the foreign body, presentation time after injury, length, width and depth of the foreign body, WBC, CRP and erythrocyte sedimentation rate at the time of admission, size of the incision, duration of surgery and complications were all evaluated. (Table 1)

When the penetrating object was wooden and non-palpable or could not be observed superficially, patients underwent US imaging instead of X-ray, MRI, or CT. Wooden particles are visualized brightly in US, and the adjacent reactive inflammatory tissue is visualized as a hypoechoic region. (Figure 1B) A radiologist measured the length, width, depth, and longitudinal axis of the particles and marked the most superficial point of this axis on the skin. (Figure 1C) The radiologist also informed the surgeon about possible adjacent neurovascular structures. Patients were vaccinated against tetanus if more than 5 years had passed since previous vaccination. A first-generation cephalosporin was administered to all patients and all operations were performed under spinal or local anesthesia. Fluoroscopy was not used in any of the cases. An incision was made over the marked skin and foreign bodies were easily accessed. (Figure 1A) In cases where infection was seen, soft tissue debridement was also performed and irrigated with 0.9% saline solution. Only one dose of cephalosporin was administered postoperatively when the case was not infected; in the other cases, antibiotic therapy was stopped after the clinical and laboratory findings returned to normal.

RESULTS

Mean patient age was 39.66 (range: 6 to 68). In total, 8 of the foreign bodies were in the plantar surfaces of the foot, 3 were in the cruris, 2 were in the palm of the hand, and 2 were in the fingers. The duration between injury and admission to the clinic was 1 day for 3 patients, 2–10 days in 4 patients, 11–30 days in 6 patients, and 31–45 days in 2 patients. All patients admitted to the clinic complained of pain; additionally, 4 patients reported drainage, and 3 patients reported redness and swelling. The mean WBC on admission was 7.70 (range: 6.18 to 9.45), mean sedimentation rate was 20.4 (range: 6 to 85), and mean CRP was 3.26 (range 1 to 9).

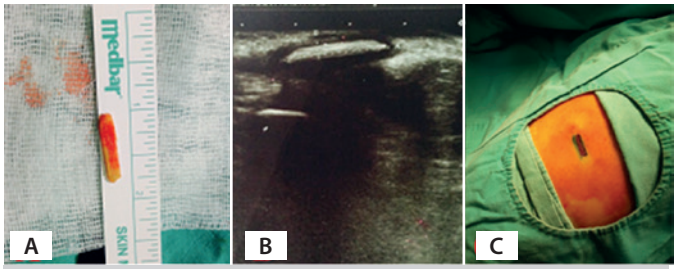

Figure 1. A. Extracted foreign body B. Ultrasound image of wooden foreign body C. Longitudinal axis of foreign body marked on the skin by the radiologist.

The mean length of the foreign bodies was 16.13 mm (range: 4 to 51), the mean width was 4.53 mm (range: 1 to 20 mm), and the mean depth was 10.2 mm (range: 4 to 30 mm). Surgical incisions were shorter than 1 cm in 8 cases, 1–2 cm in 5 cases, and 2–3 cm in 2 cases. The procedure lasted less than 10 mins in 13 (87%) of cases and 10–20 mins in 2 cases. Complications were not observed in any of the patients. In 4 infected cases, 11 (range: 10 to 14) days of antibiotic therapy was required.

DISCUSSION

Penetrating foreign body injuries to the extremities can be caused by various materials such as metals, glass, wood, or plastic objects. Radiologic visualization is required unless the residual material is palpable or can be seen from the outside. Conventional X-rays are useful for detecting metal and radiopaque materials, but are not sufficient to visualize radiolucent objects such as wood particles. One study including 200 patients found that X-ray could only detect 15% of wood particles.[1] Ultrasound should therefore be the first option in penetrant injuries caused by wooden materials.[4-7] A recent meta-analysis found that US has 72% sensitivity and 92% specificity for identifying foreign bodies in soft tissues.[8] Wooden materials are visualized as hyperechoic regions in US, and the adjacent soft tissue appears as hypoechoic due to reactive inflammation.[5,9] (Figure 1B) US can effectively measure the length, width, thickness and depth of wood objects.[9] In our study, we were able to localize and measure the size of the particles in all cases. A cadaver study indicated that 3cc saline injection around foreign bodies can increase the sensitivity and specificity of US, although the authors were not able to detect a statistically significant increase.[10]

Leaving residual foreign bodies or partially extracting them can lead to persistent pain, cellulitis, abscess formation, septic arthritis, osteomyelitis, necrotizing fasciitis, pseudotumor, and swelling.[11-16] In order to extract foreign bodies, extended incisions over the entry point are possible, but are prone to serious risks and complications such

Table 1. Sample data.

	Age	Sex	Location	Depth of object	Length of object	Width of object	Time of admission	Symptoms	WBC	ESR	CRP
1	58	M	R sole of the foot	16 mm	10 mm	2 mm	18th day	Pain	8.47	25	2
2	6	F	R sole of the foot	5 mm	6 mm	1 mm	5th day	Pain	6.75	12	3
3	27	M	R sole of the foot	10 mm	14 mm	2 mm	30th day	Pain, drainage	7.53	14	9
4	68	F	L leg	30 mm	50 mm	20 mm	42nd day	Pain, drainage	7.82	85	6
5	37	M	L sole of the foot	14 mm	8 mm	3 mm	24th day	Pain, swelling, redness	9.45	16	2
6	65 y	M	R hand	5 mm	10 mm	2 mm	28th day	Pain, drainage	8.34	26	2
7	52	F	R leg	23 mm	51 mm	19 mm	16th day	Pain, drainage	7.55	18	8
8	55	M	R leg	7 mm	12 mm	3 mm	7th day	Pain	6.62	6	1
9	34	F	R hand	5 mm	5mm	2 mm	1st day	Pain	7.83	8	1
10	21	F	L sole of the foot	4 mm	6 mm	2 mm	2nd day	Pain	8.2	10	1
11	58	F	R hand	5 mm	4 mm	2 mm	10th day	Pain	6.79	20	3
12	21	F	L sole of the foot	8 mm	6 mm	2 mm	35th day	Pain, swelling	9.17	28	6
13	45	M	R hand	4 mm	10 mm	3 mm	12th day	Pain, swelling	6.94	12	1
14	32	F	R sole of the foot	5 mm	22 mm	3 mm	1st day	Pain	7.88	10	1
15	16	F	R sole of the foot	12 mm	28 mm	2 mm	1st day	Pain	6.18	16	3

CRP: C-Reactive Protein; ESR: Erythrocyte Sedimentation Rate; M: Male F: Female R: Right L: Left MM: Millimeter

as migration of the foreign bodies and residual fragmentation.[17-19] Furthermore, extended dissection can cause further damage to adjacent soft tissue. A retrospective study in which all patients underwent surgery according to local physical examination found failure to completely extract radiolucent foreign bodies and persistent local infection in 2 patients.[17] Consequently, preoperative evaluation of the length, width, depth, and number of objects with US and marking the skin along the long axis of the foreign bodies is essential in order to reduce incision length, procedure duration and most importantly, avoid leaving foreign bodies in the soft tissues.

Authors performing surgeries due to local inflammatory findings state that US depends on the individual radiologist.[4,17] However, detection of wooden objects using US is a simple method that does not require further specialization. In one study, 10 nurses who received 2 hours of US training were able to detect wooden foreign bodies with 95% sensitivity.[20]

Some authors suggest extracting foreign bodies with US in the operating room.[4,21] However, we believe that if preoperative evaluation is effectively performed, intra-operative US is not necessary; we did not require US assistance in any of our cases.

In our case series, the feet (53.33%) and hands (26.6%) were the most affected parts of the body, since they are open to external penetrant injuries. This finding is similar to other case series in the literature.[17] The rough and organic structure of wooden particles provides a favorable environment for germs to reproduce.[22] Metal objects can remain in tissues without causing any complications, but wooden particles can cause infections and consequently should be extracted. One study in the literature described a wooden particle becoming symptomatic after 8 years.[11] In our case, the latest admission was 42 days after injury. Pain was observed in all our patients as an indicator of inflammation. Only 4 of the patients had elevated CRP levels which may have indicated infection. The mean time of admission after injury was 15.46 days, while in these 4 cases with elevated CRP levels, the mean time was 30.75 days. At the time of surgery, infected tissues such as abscesses were seen around the foreign particles in these 4 cases, demonstrating that each day which passes after trauma increases the likelihood of infection. All of these 4 cases were successfully treated by debridement of the adjacent soft tissues and oral antibiotic therapy.

This study has some weak points, namely the limited number of cases and retrospective nature. A prospective study could compare preoperative and postoperative findings, such as the diameters of foreign bodies measured by the US and the diameters of the extracted materials. Further prospective randomized controlled cadaver and animal studies can be performed to investigate the detection of different-sized wooden objects at different depths by US.

Retained foreign bodies are usually referred to orthopedic surgeons because of the workload in emergency and radiology departments; consequently, this topic must be dealt with by orthopedic surgeons from a legal perspective. The number of medical lawsuits is constantly increasing, and neglected foreign bodies can represent legal risk since these cases can present with delayed pain, swelling, drainage and loss of function in the extremity.[23,24] One study in the United States revealed that 32 (59%) of 54 lawsuits against physicians related to wounds in a hospital emergency department in Massachusetts involved neglected foreign bodies in the extremities.[24]

Consequently, we recommend that patients should be informed of possible risk including the retention of foreign bodies despite surgery, and informed consent should be obtained before surgery. We also recommend meticulous preoperative planning and marking of the location of radiolucent foreign bodies with US to increase the success of the surgery.

CONCLUSION

Retained foreign bodies can lead to local infections; ultrasound evaluation and marking can be used preoperatively to diagnose, identify, and localize foreign bodies in the extremities.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. BP (0000-0001-8229-6412)* and YA (0000-0002-9661-4618)*: made substantial contributions to the concept and design of the study and acquired, analyzed, and interpreted the data; AEP (0000-0001-9592-5193)*, TG (0000-0002-8194-6492)*, DK (0000-0003-2360-3907)*, and İTB (0000-0002-1878-0653)*: actively participated in discussion of the results; YA and İTB drafted the article and also participated in the critical review of its intellectual content. All authors contributed to the revision and final approval of the manuscript. *ORCID (Open Researcher and Contributor ID).

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EPIDEMIOLOGICAL STUDY OF OSTEOARTICULAR INFECTIONS IN CHILDREN

ESTUDO EPIDEMIOLÓGICO DAS INFECÇÕES OSTEOARTICULARES EM CRIANÇAS

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ABSTRACT

Objective: To analyze the characteristics of patients diagnosed with pediatric osteoarticular infections treated in a level III trauma center in São Paulo, Brazil. Methods: We retrospectively analyzed patients admitted between September 2012 and August 2014. The outcomes analyzed were: age, sex, diagnosis, etiologic agent, anatomic location, time to diagnosis, history of previous trauma and infection, laboratory tests, treatment, and complications. Results: Twenty patients were included, 50% with septic arthritis, 35% with osteomyelitis, and 15% with both. Boys were predominant (80%), and the mean age was 6.6 years. The most common etiologic agent was *Staphylococcus aureus*. C-reactive protein value and erythrocyte sedimentation rate were elevated. The infections were treated with antibiotic therapy (intravenous and oral) and oxacillin was most frequently used. Most patients underwent at least one surgical procedure, and 35% of patients had complications. Conclusion: This epidemiological mapping identified clinical and demographic characteristics which are useful for improving preparation for care. Future prospective studies with longer patient follow-up and the development of treatment protocols are needed to improve therapeutic decision-making and the prognosis of children with suspected osteoarticular infections. ***Evidence Level II; Prognostic studies - Investigation of the effect of patient characteristics on the outcome of the disease.***

Keywords: Arthritis, infectious. Osteomyelitis. Pediatrics/epidemiology.

RESUMO

Objetivo: analisar as características dos pacientes com diagnóstico de infecção osteoarticular pediátrica, tratados em um hospital de nível terciário em São Paulo. Métodos: Analisamos, retrospectivamente, os pacientes internados no período entre setembro de 2012 e agosto de 2014. As variáveis analisadas foram: idade, gênero, diagnóstico, agente etiológico, localização anatômica, tempo de diagnóstico, histórico de infecção e trauma prévio, exames laboratoriais, tratamento e complicações. Resultados: 20 pacientes foram incluídos, 50% com artrite séptica, 35% osteomielite e 15% ambos. Houve predomínio do gênero masculino (80%), média de idade de 6,6 anos. O agente etiológico mais comum foi o Staphiloccocus aureus. Ambos os exames laboratoriais PCR e VHS aumentaram. O tratamento foi a antibioticoterapia (via endovenosa e oral) e a oxacilina foi o medicamento mais utilizado. A maioria dos pacientes foram submetidos ao menos a um procedimento cirúrgico e 35% dos pacientes apresentaram complicações. Conclusão: Este mapeamento epidemiológico identificou características clínicas e demográficas úteis para melhorar o preparo da equipe para o atendimento. Pesquisas futuras de caráter prospectivo, com maior tempo de acompanhamento dos pacientes e a elaboração de protocolos de atendimento são necessárias para melhorar a tomada de decisão terapêutica e o prognóstico de crianças com suspeita de infecção osteoarticular. ***Nível de Evidência II; Estudos prognósticos - Investigação do efeito de característica de um paciente sobre o desfecho da doença.***

Descritores: *Artrite Infecciosa. Osteomielite. Pediatria/epidemiologia.*

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INTRODUCTION

Osteoarticular infections in children, such as osteomyelitis and septic arthritis, are a growing problem with potential for systemic aftereffects, since they can progress to irreversible joint damage and motor injury or sepsis. Diagnosis of joint or bone infection in children is frequently difficult, since this disease may initially be asymptomatic.[1,2] Early pharmaceutical and surgical treatment are necessary to reduce permanent damage. Evaluation and treatment of these patients require communication and coordination between various hospital departments including the emergency unit, pediatrics, orthopedics, infectious diseases, laboratory services, radiology, nursing, and social services.[3-5]

Clinical manifestations of osteoarticular infections in children vary according to age and the microorganism and bone structure involved.

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

Work conducted at the Mandaqui Hospital Complex, São Paulo, SP, Brazil.
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According to Blyth et al.,[6] the incidence of acute and sub-acute hematogenic osteomyelitis is 2.9 per 100,000 in children under 13 years of age, and principally affects the distal metaphysis of the femur and the proximal metaphysis of the tibia. Septic arthritis is the predominant infection in infants and children, with nearly half of cases occurring before 20 years of age. Its incidence varies from 5.5 to 12 cases per 100,000 children, and boys are three times more affected than girls. The knees, hips, elbows, and shoulders are most affected, but nearly 20% of patients are affected in more than one joint. The main symptoms include localized pain, fever, irritability, and functional limitation.[4,5] The clinical characteristics, X-ray findings, and laboratory results should be considered in conjunction for the diagnosis. In general, bone cultures, subperiosteal exudate, and joint fluid provide the microbiological diagnosis in 30% to 80% of cases.[1]
In Brazil, few epidemiological studies have been published on bone and joint infections in children. These studies provide important information that helps identify clinical and demographic differences between patients which is useful in standardizing assistance procedures and establishing guidelines for starting or continuing organized care in a pediatric hospital. Therefore, the objective of this study was to retrospectively analyze the characteristics of patients with a diagnosis of pediatric osteoarticular infection who were treated at a tertiary hospital in São Paulo, Brazil, from September 2012 to August 2014.

MATERIALS AND METHODS

This transversal retrospective study was conducted at the Mandaqui Hospital Complex in São Paulo, and was approved by the institutional review board (process 902.454). Patients aged 0 to 17 years who were admitted between September 2012 and August 2014 with a clinical and laboratory diagnosis of osteoarticular infection were included. Patients whose charts were incomplete were excluded from the study.
Data for each patient were collected using the HospGestor program (https://www.hgresidencia.com.br/ortopmandaqui), which stores the charts for patients who are hospitalized in this service. The charts are completed daily and in a standardized manner by the orthopedic physicians in the service. Patients who were able to read and write or their parents/guardians were contacted and signed an informed consent term before data were obtained from the database and used.

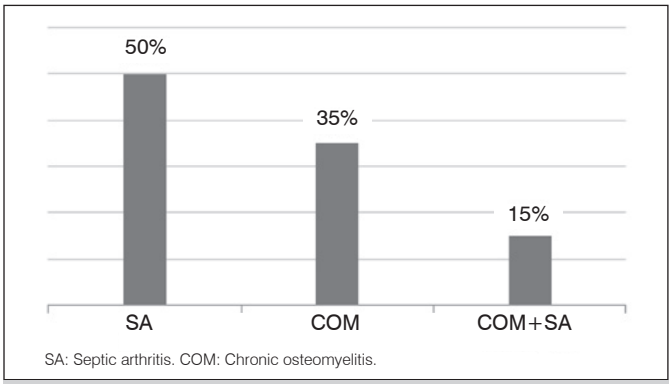
- The variables analyzed were:
- Demographic characteristics: age (< 1 year, 1–5 years, 6–10 years, > 10 years) and sex
- Type of infection (criteria for diagnosis):[7]
  - Septic arthritis: acute joint infection, blood culture, and signs of acute arthritis and joint effusion.
  - Osteomyelitis: chronic bone infection, blood culture, and X-ray imaging.

  Osteomyelitis + septic arthritis: concomitant bone and joint infections, blood culture, joint effusion, and X-ray imaging.
- Anatomical location of the infection
- Time to diagnosis (in days)
- Identification of etiologic agents (culture)
- History of previous infection, comorbidities, or trauma
- Laboratory exams:
  - C-reactive protein (CRP, normal value < 1 mg/dl)[8]
  - Erythrocyte sedimentation rate (ESR, normal value < 20 mm/h)[8]
- Treatment (pharmaceutical and surgical)
- Complications

The statistical analysis was calculated using the mean and standard deviation of the quantitative variables (95% confidence interval), as well as frequency analysis (percentage) for the categorical variables (95% confidence interval).

RESULTS

The initial sample was composed of 22 patients who fit the selection criteria. Of these, two were excluded because of missing data in their charts. Of the 20 patients included, half had a diagnosis of septic arthritis (50%), followed by osteomyelitis (35%) and associated osteomyelitis and septic arthritis (15%). (Figure 1)
Boys were more predominantly affected (80%) and the mean age was 6.6 years (DP ± 5.4; 0-17); the boys tended to be older than the girls (8.8 ± 4.7 years versus 4.3 ± 4.5 years, respectively). Patients older than 10 years were more severely affected (35%). (Figure 2)
As for anatomical location of the infection, three patients presented septic arthritis in the hip, two in the elbow, and five in the knee. The cases of osteomyelitis occurred in the following locations: one in the femur shaft, one at the distal end of the femur, one at the distal end of the tibia, one in the ankle, one in a phalange, another in the clavicle, and one in the humerus. Finally, three patients were diagnosed with septic arthritis associated with osteomyelitis: two cases in the hip and one case of septic arthritis of the elbow and ankle associated with osteomyelitis of the ulna and fibula. The right side was most affected (60%).
Twelve patients (60%) reported a history of infection or previous trauma; pulmonary diseases were most frequent (40%), including bronchiolitis, bronchial pneumonia, pneumonia, and tuberculosis, followed by fractures (5%), epiphysiolysis of the femoral head (5%), snakebite injury (5%), and bacterial conjunctivitis (5%).
As for the etiologic agents, blood culture detected the growth of isolated pathogens in 11 patients: six cases of *Staphylococcus* spp. (5 *aureus*, 1 *haemolyticus*), one of *Acinetobacter baumannii*, one of *Streptococcus pyogenes*, one of *Enterobacter cloacae*, and one of *Serratia marcelis*, and one patient with associated pathogens



SA: Septic arthritis. COM: Chronic osteomyelitis.

Figure 1. Sample distribution by diagnosis.

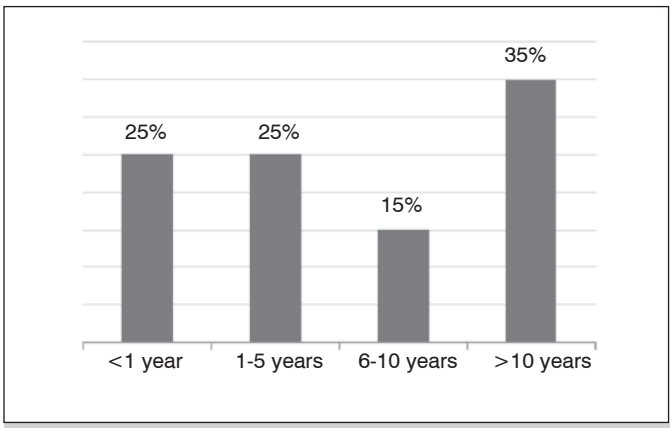


Figure 2. Sample distribution by age range.

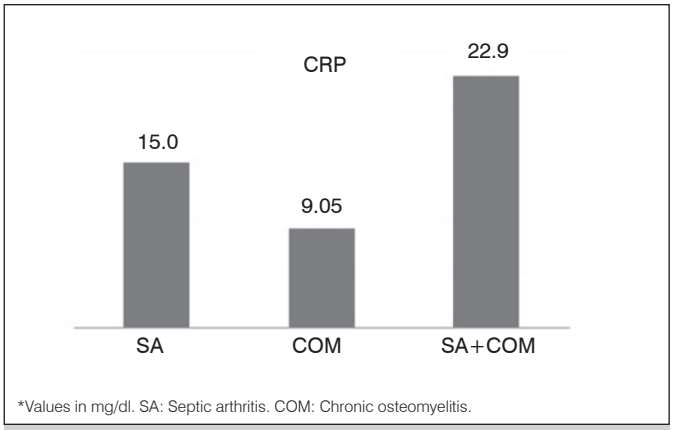
(*Pseudomonas aeruginosa* and *Acinetobacter baumannii*). In the other patients no growth of biological agents was found.

CRP level and ESR were assessed in all patients at the time of hospital admission. Among the patients with septic arthritis, the mean serum concentration of CRP was 15 mg/dl; for patients with osteomyelitis, this value was 10.55 mg/dl, and in cases of osteomyelitis associated with septic arthritis, the average value was 22.9mg/dl. (Figure 3) The average ESR was 63 mm/h, 45.1 mm/h and 70.7 mm/h, respectively. (Figure 4)

The mean hospital stay was 26.9 days (4-106). The treatment involved intravenous antibiotic therapy during hospitalization and oral antibiotics after discharge in all patients. Mean therapy duration (intravenous and oral) was 3.7 weeks. Oxacillin was the most frequent antibiotic, and was used in 70% of the patients, followed by amikacin (15%) and vancomycin (10%). Of the 20 patients included, 16 (80%) underwent at least one surgical procedure, which was most frequently surgical cleaning. In six patients the infection recurred, and additional surgery was performed when necessary. One patient presented joint stiffness due to immobilization. Table 1 shows the clinical characteristics and treatment of each patient included in the study.

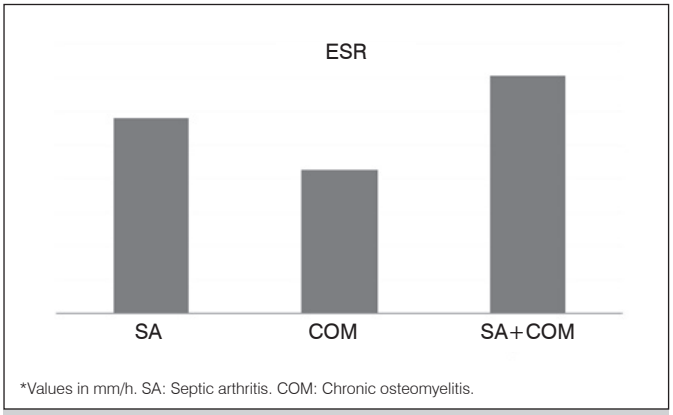
DISCUSSION

This study analyzed the clinical and epidemiological characteristics and treatment of osteoarticular infections in children, based on data collected from patients treated at a tertiary hospital. The results showed predominantly male patients with a mean age of 6.6 years.



*Values in mg/dl. SA: Septic arthritis. COM: Chronic osteomyelitis.

Figure 3. Sample distribution by diagnosis and C-reactive protein level (CRP).



*Values in mm/h. SA: Septic arthritis. COM: Chronic osteomyelitis.

Figure 4. Sample distribution by diagnosis and erythrocyte sedimentation rate (ESR).

Half of the patients were diagnosed with septic arthritis (50%), followed by osteomyelitis (35%), and septic arthritis associated with osteomyelitis (15%), and the majority of the cases affected the hip and knee joints. Grammatico-Guillon et al.[9] analyzed 2911 patients with osteoarticular infections using the French National Hospital Database, and reported similar data in relation to the greater prevalence in boys than in girls (24 versus 19 per 100,000 inhabitants, respectively), with 52% of the cases of septic arthritis and 44% of osteomyelitis. In a prospective epidemiological study, Mitha et al.[10] found 52% of cases involved septic arthritis and 41% osteomyelitis, with 80% of cases involving the legs.

Most of the studies show that confirmation of the diagnosis of septic arthritis, osteomyelitis, or both should be based on signs and symptoms found in imaging examinations and laboratory tests.[10-13] However, bone alterations only become apparent in X-rays after seven to 10 days of infection, and initial laboratory data can present within normal limits.[8] Furthermore, approximately 30% to 50% of causative pathogens are not identified through culturing, since some microorganisms require specific culture media or a longer growth period.[12] In the present study, 40% of the cases demonstrated negative culture results.

Chen et al.[8] examined 27 children, 55.6% of whom had a diagnosis of concomitant septic arthritis and osteomyelitis. These authors believed that the use of more precise instruments, such as magnetic resonance imaging, computed tomography, and bone scintigraphy, may have led to a better definition of the pathologies in the bones and joints, thus improving the accuracy of the diagnosis. These authors also observed high CRP and ESR levels in all patients.

According to Dodwell et al.,[12] approximately 85% of children with osteomyelitis and 100% of children with osteomyelitis associated with septic arthritis presented elevated CRP and ESR levels. Pääkkönen et al.[7] analyzed 265 children with positive culture results and observed that, due to the rapid normalization of serum CRP results in the first week, this examination is slightly more sensitive for diagnosis than ESR, but the best sensitivity for diagnosis (98%) was obtained from a combination of the results of both tests. In the present study, 100% of patients with septic arthritis, 57% of patients with osteomyelitis, and 100% with concomitant osteomyelitis and septic arthritis had elevated CRP values. ESR values were higher in 90% of cases of septic arthritis, 57% of cases of osteomyelitis, and 100% of cases with concomitant septic arthritis and osteomyelitis.

According to Ceroni et al.,[11] direct inoculation of the microorganism into the bone or joint after trauma, internal fracture fixation, or soft tissue infections occurs less frequently in children. Most pediatric bone and joint infections are hematogenous in origin, and the respiratory tract is considered the main route of entry for the pathogen. Bacteria such as *Streptococcus pneumoniae* and *Staphylococcus aureus* may reside in the surface of the respiratory mucosa and are able to penetrate into the bloodstream, spread, and invade distant organs.

In this study, 40% of the patients reported a history of pulmonary diseases, and 25% of these were contaminated by *Staphylococcus aureus*. This finding is similar to other studies. Gafur et al.[14] studied 554 children in an American medical center in Dallas and reported that *Staphylococcus aureus* was the main causative agent of musculoskeletal infections. Chen et al.[8] found *Staphylococcus aureus* in 83.3% of cases, and a study by Grammatico-Guillon et al.[9] found it in 63% of the cases. According to Dodwell et al.,[12] although *Staphylococcus aureus* is typically described as the most common cause of pediatric infections, gram-negative bacteria may affect approximately 60% of children below 4 years of age, and *Kingella kingae* has been the cause of approximately 82% of the infections in this age range. However, detection of this microorganism is

Table 1. Patient characteristics.

Age/ Sex	Diagnosis/ Location (side)	Etiology	History of infection and/or trauma	Lab tests		Hospital stay (days)	Treatment	Complications
				CRP mg/dL	ESR mm/h			
1y M	SA R hip	Acinetobacter baumannii	Bronchiolitis	6.2	45	16	SC + oxacillin 6 days and gentamicin 7 days (after culture) Discharge: cephalexin 3 weeks	Reoperated 2 days after the first surgery following recurrence
4y M	SA L hip	No growth	-	19.1	70	16	SC + oxacillin 15 days Discharge: cephalexin 3 weeks	-
5m F	SA L hip	S aureus	BCP	27.1	110	23	SC + oxacillin and gentamicin 3 weeks Discharge: ciprofloxacin 3 weeks	Reoperated 4 days after primary surgery. Sepsis during hospitalization – in ICU 7 days
15y M	SA R elbow	No growth	Bacterial conjunctivitis	8.6	50	12	SC + ciprofloxacin, azithromycin, metronidazole 7 days Discharge: cephalexin 3 weeks	-
11y M	SA R elbow	No growth	-	7.2	65	16	SC + oxacillin 14 days Discharge: cephalexin 2 weeks	-
2y F	SA L knee	No growth	BCP	16.6	125	17	Oxacillin 15 days, amikacin 11 days Discharge: cephalexin 3 weeks	-
15y M	SA L knee	No growth	-	24.8	10	25	Oxacillin 25 days, amikacin 11 days Discharge: cephalexin 3 weeks	-
1y F	SA L knee	No growth	-	1.0	95	16	SC + oxacillin 14 days Discharge: cephalexin 2 weeks	-
4m M	SA R knee	S haemolyticus	BCP	2.9	20	17	SC + clindamycin 14 days Discharge: cephalexin 2 weeks	-
10y M	SA R knee	S aureus	-	36.5	40	26	SC + oxacillin 25 days, amikacin 11 days Discharge: cephalexin 3 weeks	-
7y M	COM R humerus	Streptococcus pyogenes	Elbow fracture - Surgical treatment (10 months prior)	3.0	59	22	Oxacillin 21 days Discharge: cephalexin 2 weeks	Elbow joint stiffness
5y M	COM R scapula	No growth	Tuberculosis	9.0	18	16	Oxacillin and ceftriaxone 14 days Discharge: cephalexin 2 weeks	-
12y M	COM phalanges L foot	Acinetobacter haemolyticus	Snakebite in L leg + COM L hallux (1 year previous)	7.6	9	26	SC + oxacillin 25 days, amikacin 11 days Discharge: cephalexin 3 weeks	Reoperated to amputate distal phalange of the L hallux
12y M	COM of the L femur	Enterobacter cloacae	Femur shaft fracture - Surgical treatment (1 year prior)	0.6	18	19	SC + IMR cephazolin, oxacillin + amikacin 10 days Discharge: ciprofloxacin 2 weeks	-
2m M	COM R distal femur	Oxacillin- resistant S aureus	Bronchiolitis	17.1	70	33	SC + amikacin and vancomycin 21 days Discharge: cephalexin 6 weeks	Reoperated 3 days after the first surgery following recurrence
6y M	COM R distal tibia	Serratia marcelis	BCP	33.1	85	33	SC + amikacin and meropenem 21 days Discharge: ciprofloxacin 8 weeks	-
3y M	COM R elbow	No growth	-	0.5	57	4	Oxacillin 21 days Discharge: cephalexin 3 weeks	-
3y F	SA elbow and ankle + COM R ulna and fibula	S aureus	Pneumonia	41.5	52	73	SC forearm and R leg + vancomycin and Imipenem 9 weeks	-
11y F	SA + COM L hip)	Pseudomonas aeruginosa Acinetobacter baumannii complex	Epiphysiolysis of the femur head - Surgical treatment (30 days previous)	3.3	50	106	SC + IMR vancomycin 50 days, tigecycline, imipenem 56 days Discharge: ciprofloxacin and clindamycin 16 weeks	Resection of the proximal femur (limb shortening 10 cm)
14y M	SA + COM R hip	S aureus	-	23.9	110	22	SC + oxacillin 21 days Discharge: clindamycin 6 weeks	Reoperated 9 days after the first surgery following recurrence

y: years; m: months; M: male; F: female; SA: Septic arthritis. COM: Chronic osteomyelitis; R: right; L: left; S Aureus: Staphylococcus Aureus, BCP: Bronchial pneumonia; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; SC: Surgical cleaning; w: weeks; IMR: implant material removed.

complex, and there is no way to specify its exact frequency due to the difficulty of isolating it in routine exams.

Kocher et al.[15] developed guidelines to treat pediatric orthopedic infections and emphasized the inclusion of antibiotic therapy and surgery according to need. The patients are usually admitted to the hospital, and until exams to identify the pathogen are completed, treatment is begun with empirical antibiotics. Empirical treatment is used to address the most likely pathogens, and the medication is chosen according to the age of the child, the local prevalence of infectious agents, and early laboratory results. When the results of culture are available, antimicrobial therapy may be modified depending on the microorganism and the pattern of susceptibility.[11,12] According to Kaplan et al.,[16] oxacillin is recommended as the first option along with vancomycin in cases of critically ill children. Clindamycin is an option for less serious cases in which there is no suspicion of bacteremia. These data corroborate the findings of the present study.

The duration and administration route for antibiotic therapy depend on the virulence of the pathogen, the location of the infection, and the clinical and laboratory response to treatment.[11,12] According to Kaplan et al.,[16] transitioning from intravenous to oral administration is important to complete treatment and avoid complications. It is recommended that treatment last a total of at least three weeks, depending on the patient's clinical response. In the sample analyzed in this study, all patients received intravenous antibiotic therapy during hospitalization and oral antibiotics after discharge, with an average total duration

of six weeks. The average hospital stay was 26 days, while in the study by Grammatico-Guillon et al.[7] it was 8.6 days. However, our sample included two serious cases of septic arthritis and concomitant osteomyelitis, which required several surgical procedures.

For Kaplan et al.,[16] multiple surgical procedures are often needed in the most serious cases of osteoarticular infection. In the study by Chen et al.,[8] 74.1% of the patients needed surgical intervention. In this present study, 80% of patients underwent at least one surgical procedure, most frequently surgical cleaning.

The main limitations of this study include retrospective analysis of the data, small sample size, and lack of long-term patient follow-up. The importance of prospective studies with longer patient follow-up is evident, as well as complete care protocols for children with suspected osteoarticular infection which include physical examination, laboratory exams and imaging, empirical antibiotic therapy, and definitive surgical treatment. Standardization of procedures for care and treatment may improve therapeutic decision-making and lead to a better prognosis for these patients.

CONCLUSION

Epidemiological mapping of pediatric patients with osteoarticular infections identified clinical and demographic characteristics which can help the team prepare to attend future cases. Additional prospective studies with longer patient follow-up and the creation of care protocols are necessary to improve therapeutic decision-making and the prognosis for children with suspected osteoarticular infection.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. CSO (0000-0001-9151-8101)*, EOG (0000-0001-9518-0574)*, and FCJN (0000-0001-6374-4398)*: each helped draft the manuscript; CSO and EOG collected the data; FCJN evaluated the data from the statistical analysis; CSO, EOG, and FCJN conducted the bibliographic research, revised the manuscript, and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

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ORIGINAL ARTICLE

PERIPHERALLY INSERTED CENTRAL CATHETERS IN ORTHOPEDIC PATIENTS: EXPERIENCE FROM 1023 PROCEDURES

CATETER CENTRAL DE INSERÇÃO PERIFÉRICA EM PACIENTES ORTOPÉDICOS. EXPERIÊNCIA EM 1023 PROCEDIMENTOS

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ABSTRACT

Objectives: The advantages of using a peripherally inserted central catheter (PICC) in hospitalized patients make this device very important for intravenous therapy. This study describes the use of PICCs at the Institute of Orthopedics and Traumatology at the Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo over the last 10 years. Methods: This retrospective study analyzed 1,057 medical records and included 1,023 medical files with complete information on the punctured vein, diagnosis, duration of catheterization, complications, and catheter tip positioning. Results: Seven hundred and twenty PICCs (70.4%) were considered successfully positioned, and mean duration of catheterization was 34.3 days. The basilic vein was used in 528 (51.6%) patients, while 157 (15.4%) catheters were removed due to complications. No cases of catheter-related thrombosis or infection were found. Eight hundred and sixty-six (84.6%) patients completed their treatment with PICC in place. Conclusion: PICC is a safe intravenous device that can be successfully utilized for medium- and long-course intravenous therapy in hospitalized and discharged orthopedic patients. ***Level of Evidence IV; Case series.***

Keywords: Catheterization, central venous. Catheterization, peripheral. Infusions, intravenous. Nursing care.

RESUMO

Objetivos: As vantagens da utilização do Cateter Central de Inserção Periférica (CCIP) no ambiente hospitalar faz com que esse cateter ocupe uma posição de destaque na terapia intravenosa. Este trabalho relata o uso do CCIP nos pacientes do Instituto de Ortopedia e Traumatologia do Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HC-FMUSP) nos últimos 10 anos. Métodos: Trata-se de um estudo retrospectivo, no qual foram analisados 1057 prontuários. Foram incluídos 1023 prontuários de pacientes submetidos à inserção do CCIP, em que foram analisados a veia puncionada, diagnóstico do paciente, tempo em que o paciente permaneceu com o cateter, complicações e posicionamento da ponta do CCIP. Resultados: Setecentos e vinte CCIPs (70,4%) foram considerados adequadamente posicionados. O tempo médio de utilização do cateter foi de 34,3 dias. A veia basílica foi a mais utilizada em 528 (51,6%) pacientes. Cento e cinquenta e sete (15,4%) cateteres foram removidos devido a complicações. Nenhum caso de trombose ou infecção relacionada ao cateter foi observada. Oitocentos e sessenta e seis (84,6%) permaneceram com o CCIP até o final do tratamento. Conclusão: O CCIP é um dispositivo intravenoso seguro e pode ser utilizado para terapia intravenosa de média e longa duração em pacientes ortopédicos hospitalizados ou desospitalizados. ***Nível de Evidencia IV; Série de casos.***

Descritores: *Cateterismo venoso central. Cateterismo periférico. Infusões intravenosas. Cuidados de enfermagem.*

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INTRODUCTION

Peripherally inserted central catheter (PICC) is the gold standard device for prolonged intravenous therapy and its use is constantly growing. Some of the PICCs benefits are: the ability to maintain prolonged therapy with fewer vein punctures, the low incidence of infection, the possibility to insert this device at bedside, the possibility to administer parenteral nutrition with dextrose concentration greater than 10%, vesicant, irritant, vasoactive drug and solutions with extreme osmolarity or non physiological pH.[1-3,4,5-7] PICC began to be used in Brazil in the early 1990s, initially in neonatal patients.[5] Its use quickly expanded to patients of all ages due to its advantages over other central venous catheters, including reduced risk of pneumothorax and sepsis resulting from colonization of the skin around the insertion point, lower insertion costs compared with other central venous

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

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catheters, easy maintenance, and the ability to discharge patients while still continuing antibiotic therapy and chemotherapy.[1,8,9] For the PICC to function properly as a central line, it is critical that the tip be properly positioned in the central circulation. When the puncture is performed in the arms, the basilic and the cephalic veins are recommended for insertion. PICC can be inserted via direct puncture, also known as blind puncture or with the aid of ultrasound (US), using the modified Seldinger technique. The tip is positioned using an anatomical measurement which is made before starting the procedure. Improper positioning of the tip in the vascular system is associated with a significant increase in malfunction of the device, fibrin formation, and venous thrombosis. When the tip of the catheter is located in the lower portion of the right atrium or right ventricle, it may cause arrhythmias, tricuspid valve dysfunction, erosion, or atrial thrombosis. The tip of the catheter may also be inadvertently placed in the subclavian vein, jugular vein, or other thoracic veins. This type of poor positioning is consistently associated with pain during infusion, device malfunction, or venous thrombosis.[10,11] To confirm the position of the catheter tip, a chest x-ray is required at the end of the procedure. (Figures 1 and 2) Variations in image interpretation may occur due to anatomic abnormalities or in obese patients. Other forms of verifying the placement of the catheter tip using fluoroscopy and electrocardiogram (ECG) are being incorporated into the procedure to assure correct positioning.[10,12,13] The objective of this study is to evaluate whether PICC is safe and suitable for medium- and long-term intravenous therapy in orthopedic patients.

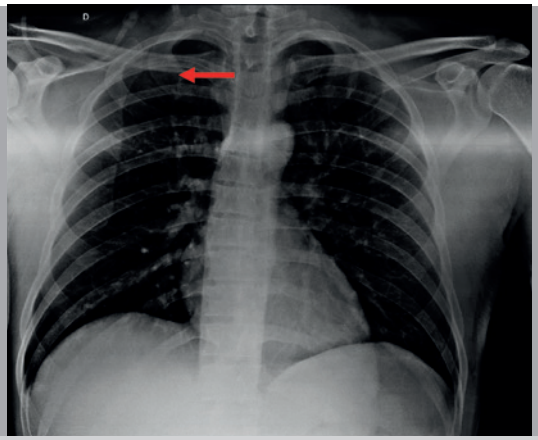

Figure 1. Chest x-ray showing the tip of the PICC positioned in the subclavian vein.

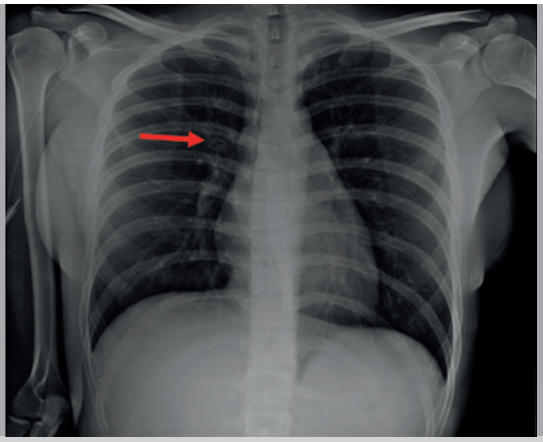

Figure 2. Chest x-ray showing the tip of the PICC positioned in the superior vena cava.

MATERIALS AND METHODS

This retrospective cross-sectional study was conducted at the Institute of Orthopedics and Traumatology of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT HC FMUSP), approved by the institutional review board (process 13542). We examined the medical records of patients who were treated with PICCs between 2007 to 2017. Of the 1057 medical records pertaining to patients whose treatment included PICC, 34 were excluded for not having complete data for subsequent analysis. A total of 1023 patient records were included. All PICCs were inserted by certified nurses trained in insertion of this catheter. All patients agreed to receive intravenous therapy via PICC and signed an informed consent form. The Intravenous Therapy Group at our institute developed an algorithm which uses the time of intravenous therapy and the characteristics of the drugs prescribed as criteria for selecting central devices. (Figure 3) The following data were obtained from the medical records: age, sex, diagnosis, date of PICC insertion, indication for insertion, type of puncture performed, vein punctured, number of punctures performed, positioning of catheter tip, medications administered, complications related to the use of the catheter, reason for removing the catheter, date of PICC removal, and PICC duration. All catheters used were made of silicone, 4 Fr, and had a single lumen and anti reflux valve. PICCs were inserted via direct puncture or guided by US. PICCs were installed at the patient's bedside, using the maximal barrier technique to establish a sterile field. For safety purposes, the procedures were performed by two nurses, which is the normal practice in our institution. Children under 13 years were sedated in the surgical center in order to perform the procedure. The basilic, cephalic or the veins of the antecubital fossa were punctured. The anatomic measurements were made before starting the procedure. In accordance with the manufacturer's instructions, the nurse measured the distance from the puncture site to the anterior axillary fold, from the anterior axillary fold to the head of the right clavicle, and from the head of the right clavicle to the right edge of the sternum in the third intercostal space. Even if the puncture is made in the left arm, the distance to the head of the right clavicle should still be measured. (Figure 4) After the procedure, all patients underwent chest x-rays to confirm the placement of the catheter tip. The catheter was considered properly positioned when the tip of the PICC was located in the superior vena cava, and poorly positioned when the tip of the catheter was in the peripheral veins or the subclavian vein. Catheters positioned in the atrium or in the jugular vein were repositioned, and an additional chest x-ray was taken. Only the final positioning was considered. The quantitative characteristics were described using summary measures (mean, standard deviation, median, minimum and maximum) and the qualitative characteristics were described using absolute and relative frequencies.[14] The data were analyzed with SPSS for Windows version 20.0 software, and Microsoft Excel 2008 was used to tabulate the data.

RESULTS

The study population (n=1023) was 75.5% men (n=772) and 24.5% women (n=251). The median age was 42.4 ± 18.3 years. The most frequent diagnoses of patients who received PICCs were: postoperative infection of the lower limbs (39%), postoperative infection of the upper limbs (14%), open fractures (12%), and multiple trauma (89%). (Table 1) As for veins punctured, 51.6% of the PICCs were inserted in the basilic vein, 38.3% in the cephalic vein, and 10.10% in the veins of the antecubital fossa. In terms of insertion technique, 82.7% of PICCs were inserted via direct puncture and 17.3% were guided by ultrasound. We observed that 70.4% of the catheters were properly positioned, while 29.6% of PICCs were improperly positioned. PICC was properly inserted after the first

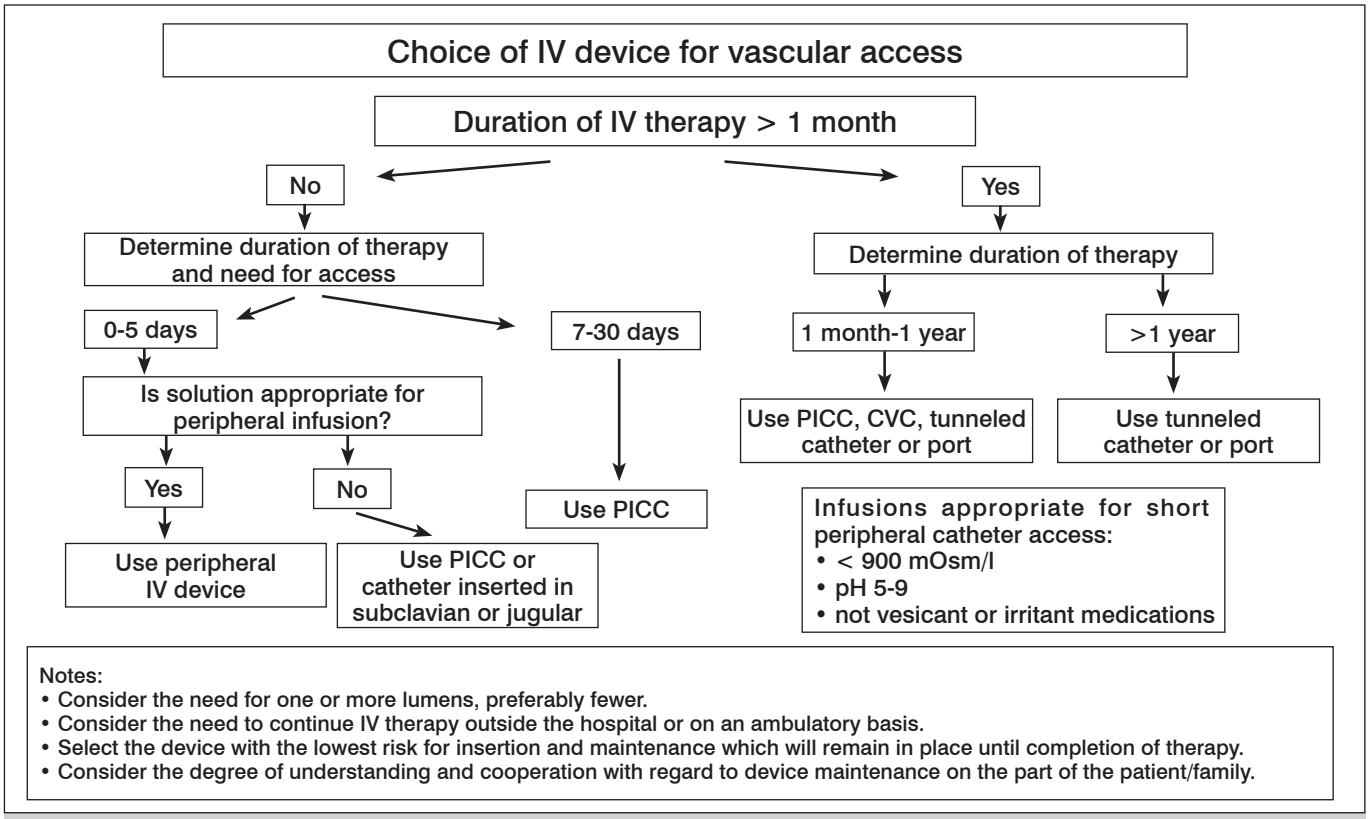

Figure 3. Algorithm for intravenous device selection.

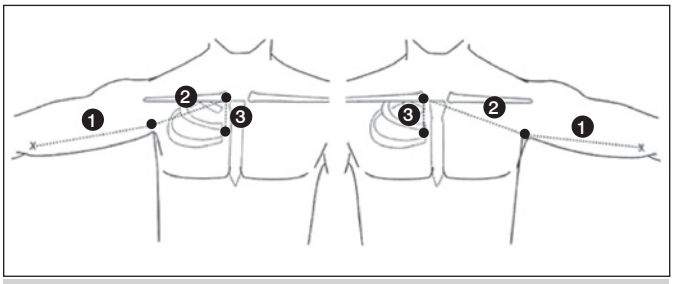

Figure 4. Measurements taken prior to procedure for proper positioning of the PICC

Table 1. Distribution of patients receiving PICC, by diagnosis.

Diagnosis	n	%
Postoperative infection (upper limbs)	403	39
Postoperative infection (lower limbs)	140	14
Open fracture	120	12
Multiple trauma	88	9
Clinical complications	74	7
Chronic osteomyelitis	67	7
Postoperative infection (pelvic ring)	45	4
Pyoarthritis	34	3
Postoperative infection (spine)	21	2
Tumor	14	1
Amputation	11	1
Spondylodiscitis	6	1

puncture in 89.7% of cases, the second puncture in 5.7% of cases, the third in 2.6% of cases, the fourth in 1.3% of cases, the fifth in 0.4% of cases, and the sixth in 0.3% of cases. The main indication was antibiotic therapy. The most commonly used antibiotics in treating patients who used PICC were teicoplanin, prescribed in 47.8% of cases (487 patients), followed by amikacin, prescribed in 26.2% of cases (267 patients), clindamycin in 22.5% of cases (229 patients), and gentamicin in 17.8% of cases (181 patients). (Table 2) As for the number of antibiotics prescribed to the same patient, 671 patients (65.85%) were treated with two antibiotics, 44 patients (4.32%) used three antibiotics, 11 patients (1.08%) used four antibiotics, and one patient (0.1%) used nine different antibiotics. The patients maintained PICCs for a mean time of 34.3 days; the maximum duration was 414 days. The reasons for PICC removal were: completion of treatment (77.3%), catheter malfunction (5.7%), medical indication (4.6%), accidental removal (2.4%), death (1%), phlebitis (0.7%), removed during surgery to approach the limb (0.6%), and allergic reaction (0.4%). Discharge with PICC (7.3%) is not a reason for withdrawal, but is presented to differentiate patients who completed intravenous therapy in our institute from those who completed therapy in other health services. (Table 3)

DISCUSSION

Most of the studies describes the uses of PICCs in pediatric patients, cancer patients, or patients in intensive care units.[15-19] Few studies for exclusively orthopedic patients are found in literature, as this series of 1023 cases does. This fact grants this study importance for addressing the use of PICCs in a different group of patients. Valbousquet Schneider et al.[16] conducted a retrospective study with 136 orthopedic patients in a military hospital in France from 2009 to 2014. A total of 180 PICCs were inserted using ultrasound-guided puncture. The average duration of the catheter was 21 days. The

Table 2. Antibiotics most frequently used and infused via PICC.

ATB, n (%)	n	(%)
Teicoplanina	487	47.8%
Amicacina	267	26.2%
Clindamicina	229	22.5%
Gentamicina	181	17.8%
Ceftriaxona	94	9.2%
Ciprofloxacina	85	8.3%
Ceftazidima	75	7.4%
Oxacilina	69	6.8%
Meropenem	43	4.2%
Vancomicina	42	4.1%
Colistina	39	3.8%
Ertapenem	32	3.1%
Ampicilina	28	2.7%
Tigeciclina	23	2.3%
Cefazolina	19	1.9%
Sulbactam	13	1.3%
Linezolida	12	1.2%
Fluconazol	12	1.2%
Imipenem	12	1.2%
Metronidazol	11	1.1%
Levofloxacina	10	1.0%
Piperacilina	9	0.9%
Cefepime	9	0.9%
Tazobactam	8	0.8%
Penicilina	2	0.2%
Daptomicina	2	0.2%
Sulfametoxazol	1	0.1%
Azitromicina	1	0.1%
Voriconazol	1	0.1%
Claritromicina	1	0.1%
Trimetropim	1	0.1%
Amoxicilina	1	0.1%

* Most of the patients used more than one antibiotic.

Table 3. Distribution of patients receiving PICC according to reason for catheter removal.

Reason for removal, n (%)	n	%
Completion of treatment	791	77.3
Discharged with the catheter	75	7.3
Occlusion	58	5.7
Medical indication	47	4.6
Accidental removal	25	2.4
Death	10	1
Phlebitis	7	0.7
Removed during surgery	6	0.6
Allergic reaction	4	0.4

most frequent diagnosis was osteomyelitis. Sixty-four percent of patients had the catheter removed at the end of the treatment. In 2015, Park et al.[17] analyzed 4,101 PICCs inserted by direct puncture in a tertiary hospital in Korea from 2002 to 2010. These authors reported that 33.6% of the patients were attended by the oncology department, 13.3% by internal medicine, 9.8% by general surgery, and 8% by orthopedic surgeons. As for indication, 5% of the catheters were placed for antibiotic therapy, 3.2% for chemotherapy, 2.9% for parenteral nutrition, and 88% for venous access. The basilic vein was punctured in 65.9% of cases, followed by the cephalic vein in 30.9%, and the median antecubital fossa in 3.2% of cases. The catheter remained in place until the end of the treatment in 61.5% of the patients, and was removed in 23.8% of cases because of complications. In this study, 1023 PICCs were inserted between 2007 and 2017. Seventy-five per cent of patients were male and the mean age was 42.4 years (SD: 18.3). Direct puncture (82.7%) and ultrasound-guided puncture (17.3%) were used to insert the PICCs. The average time patients retained the catheter was 34.3 days. The most frequent diagnosis was postoperative infection of the lower limbs. The most frequently punctured vein was the basilica, in 51.6% of the cases. Seventy-seven per cent of hospitalized patients remained until the end of their treatment with the catheter, and 7.3% of the patients were discharged with the catheter to complete treatment on an outpatient basis. A study by Sainathan et al.[20] showed that of the 700 PICCs inserted, 48.7% were indicated for prolonged antibiotic treatment, 22.3% for difficult peripheral venous access, and the rest divided between patients in the intensive care unit, infusion of irritating medications, and outpatient treatment. In the present study, 92.8% of PICCs were inserted for antibiotic therapy and 7.2% were inserted to treat clinical complications. The most frequent diagnoses were postoperative infection of the lower limbs (39.4%), followed by postoperative infection of the upper limbs (13.7%), open fractures (11.7%), and multiple trauma (8.6%). The most commonly used antibiotics were teicoplanin (47.8%), amikacin (26.2%), clindamycin (22.5%), and gentamicin (17.8%). We also reported that 71.34% of patients received more than one antibiotic. Teicoplanin has a pH similar to blood (7.35–7.45), while the others are more acidic, and when acidic drugs are infused into the peripheral veins they cause histological changes in the vessel walls; consequently, chemical phlebitis may be a complication.[21] For this reason, it is essential to understand the characteristics of the prescribed drugs. In a 2007 study, Trerotola et al.[22] analyzed the positioning of PICC tips placed at the patient bedside. The X-rays were interpreted by radiologists who used the angle of the right cephalic trunk as a reference for the origin of the superior vena cava and the rounded portion of the upper part of the right atrium junction to estimate the cavo-atrial junction. Of the 1,654 catheters inserted, 163 (10%) were poorly positioned. The statistical analysis showed that the vein punctured was related to poor placement, with the cephalic vein (16%) presenting the greatest association. Venkatesan et al.[23] used the carina as a reference to evaluate the placement of the PICC tip. The catheter was considered properly positioned when the tip was 3–5 cm below the carina. In this study, of the 215 PICCs analyzed, only 37% were properly positioned. In this study, the lower portion of the superior vena cava or the cavo-atrial junction were used as references for as ideal positioning, in accordance with the recommendations of the Infusion Nurse Society (INS) and the National Association of Vascular Access Networks (NAVAN).[24] The anatomical reference was the third posterior intercostal space, located via an anteroposterior chest x-ray. Of the 1023 catheters inserted, 70.4% were adequately placed and 29.6% were incorrectly positioned. This study only considered the final positioning of the catheter tip after any repositioning maneuvers (when necessary). As for infection, Liscynesky et al.[25] reported that 5% of PICCs were

removed because of this complication. These authors also reported that 4% of PICCs were unnecessarily removed because of suspected infection, confirmed by negative blood cultures. In 2013, Chopra et al.[26] published a systematic review of 1185 studies to compare the rate of infection of PICC versus central venous catheters (CVC). Of the 1185 studies, 23 met the inclusion criteria. Of the 23 included publications, 20 reported infection as a complication in PICC and CVC. The authors concluded that the rate of infection in patients who used PICC for intravenous therapy was lower than in patients who utilized CVC. In this study, 5.7% of the catheters were removed by medical recommendation because of suspected infection. After samples from all the removed catheter tips and the patient's peripheral blood were cultured, no cases of catheter-related infection were confirmed. The low rate of complications found in this study may be associated with less severe clinical condition of orthopedic patients and the choice of a smaller caliber PICC with a single lumen (4 Fr). Finally, this is the first study in our region that reports the use of PICC exclusively in orthopedic patients, and is also one of the few in literature that evaluates the benefits and complications of this catheter in this group of patients. The low rate of complications reported, especially for thrombosis and infection (which generate great concern related to the use of this catheter and were not observed in this study) differentiate this study from other publications.

CONCLUSION

The peripherally inserted central catheter is an intravenous device which is safe and suitable for medium- and long-term intravenous therapy in hospitalized or discharged orthopedic patients.

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