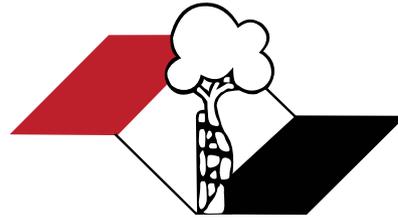


Indexed  
PubMed and  
PubMed Central  
ISI and JCR (Journal Citation Reports®)  
included



ISSN 1413-7852

# Acta Ortopédica Brasileira

26 anos

Volume 26 – Number 4 – Year 2018

# Acta Ortopédica Brasileira



Department of Orthopedics and Traumatology, Faculdade de Medicina da Universidade de São Paulo (DOT/FMUSP), São Paulo, SP, Brazil

Affiliated with Associação Brasileira de Editores Científicos



Indexed in PubMed, PubMed Central, Web of Science, JCR, Scopus Elsevier, SciELO, Redalyc (Red de Revistas Científicas de America Latina y el Caribe, España y Portugal), LILACS (Latin America Health Science Literature) and DOAJ (Directory of open access journals).



## EDITORIAL TEAM

### Editor-in-chief – Olavo Pires de Camargo

Department of Orthopedics and Traumatology, Faculdade de Medicina da Universidade de São Paulo (DOT/FMUSP), São Paulo, SP, Brazil

### Editor Emeritus – Tarcísio Eloy Pessoa Barros Filho

Department of Orthopedics and Traumatology, Faculdade de Medicina da Universidade de São Paulo (DOT/FMUSP), São Paulo, SP, Brazil

### Associate Editors

- Akira Ishida – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo, Unifesp, São Paulo, SP, Brasil • Alberto Cliquet Jr. – Departamento de Ortopedia e Traumatologia Faculdade de Ciências Médicas Universidade Estadual de Campinas – Unicamp, Campinas, SP, Brasil
- Arnaldo José Hernandez – Departamento de Ortopedia e Traumatologia da FMUSP, São Paulo, SP, Brasil • Claudio Santili – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil • Edison Noboru Fujiki – Faculdade de Medicina do ABC, SP, Brasil
- Everth Merida Herrera – Hospital de Ortopedia Magdalena de Las Salinas do Instituto Mexicano de Seguro Social – Cuauhtémoc, Mexico • Flávio Faloppa – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo, Unifesp, São Paulo, SP, Brasil • Gustavo Molina – Departamento de Ortopedia e Traumatologia, Medellín, Colombia • Jack Zigler – Texas Back Institute, Texas, Estados Unidos • Jesse B. Jupiter – Hospital Geral de Massachusetts Harvard – Boston, EUA • José Batista Volpon – Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor (RAL), Faculdade de Medicina de Ribeirão Preto, FMRP-USP, Ribeirão Preto, SP, Brasil • Lawrence Menendez – USC-Keck School of Medicine, Los Angeles, Estados Unidos • Luís Aponte – Hospital Italiano de Buenos Aires, Buenos Aires, Argentina • Luiz Eugenio Garcez Leme – Departamento de Ortopedia e Traumatologia da FMUSP
- Mark Vrahas – Departamento de Ortopedia do Hospital Geral de Massachusetts – Boston, EUA • Moises Cohen – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil • Osmar Avanzi – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil • Philippe Hernigou – Universidade de Paris-Leste – Paris, France • Pierre J. Hoffmeyer – Universidade de Genève – Genebra, Suíça • Rami Mosheiff – Diretor da Unidade de Trauma Ortopédico da Universidade Hadassah Medical Center, Jerusalem, Israel • Ricardo Pietrobon – Departamento de Cirurgia da Duke University Medical Center, Darhan, Estados Unidos • Wade Smith – University of Texas, Denver, Estados Unidos.

### Editorial Board

- Alberto Tesconi Croci – Departamento de Ortopedia e Traumatologia da FMUSP, São Paulo, SP, Brasil;
- André Mathias Baptista – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- André Pedrinelli – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- Antonio Carlos Fernandes – AACD – Associação de Assistência à Crianças Deficientes, São Paulo, SP, Brasil;
- Caio Augusto de Souza Nery – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo, Unifesp, São Paulo, SP, Brasil;
- Carlo Milani – Departamento de Ortopedia e Traumatologia da Faculdade de Medicina do ABC, Santo André, SP, Brasil;
- Carlos Roberto Schwartzmann – Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, Brasil;
- Celso Herminio Ferraz Picado – Universidade de São Paulo, Ribeirão Preto, SP, Brasil;
- Cláudio Henrique Barbieri – Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor – Laboratório Bioengenharia – Faculdade de Medicina de Ribeirão Preto, FMRP-USP, São Paulo, SP, Brasil;
- Edgard dos Santos Pereira – Universidade de Santo Amaro, São Paulo, SP, Brasil;
- Edie Benedito Caetano – Departamento de Ortopedia e Traumatologia Faculdade de Medicina de Sorocaba – PUC, Sorocaba, SP, Brasil;
- Eduardo Barros Puertas – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo, Unifesp, São Paulo, SP, Brasil;
- Fabio Janson Angelini – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- Fernando Antonio Mendes Façanha Filho – Departamento de Ortopedia do Instituto Dr. José Frola, Fortaleza, CE, Brasil;
- Fernando Baldy dos Reis – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil;
- Geraldo Rocha Motta Filho – Instituto Nacional de Traumatologia e Ortopedia – INTO-MS, Rio de Janeiro, RJ, Brasil;
- Gilberto Luis Camanho – Departamento de Ortopedia e Traumatologia da FMUSP, São Paulo, SP, Brasil;
- Gildásio de Cerqueira Daltro – Universidade Federal da Bahia, Salvador, BA, Brasil;
- Glaydson Godinho – Hospital Belo Horizonte, Belo Horizonte, MG, Brasil;
- Hamilton da Rosa Pereira – Universidade Estadual Paulista Júlio de Mesquita Filho, Botucatu, SP, Brasil;
- Helio Jorge Alvachian Fernandes – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil;
- Helton Luiz Aparecido Defino – Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor (RAL), Faculdade de Medicina de Ribeirão Preto, FMRP-USP, Ribeirão Preto, SP, Brasil;
- Isanio Vasconcelos Mesquita – Universidade Estadual do Piauí, Teresina, PI, Brasil;
- João Mauricio Barreto – Departamento de Ortopedia e Traumatologia, Santa Casa de Misericórdia do Rio de Janeiro, Rio de Janeiro, RJ, Brasil;
- Jorge dos Santos Silva – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- José Antonio Pinto – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil;
- José Sérgio Franco – Faculdade de Medicina da Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil;
- Kodí Edson Kojima – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- Luiz Antonio Munhoz da Cunha – Universidade Federal do Paraná, Santa Catarina, PR, Brasil;
- Luiz Aurelio Mestriner – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil;
- Luiz Roberto Gomes Vialle – Universidade Católica do Paraná, Curitiba, Santa Catarina, PR, Brasil;
- Marcelo Tomanik Mercadante – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil;
- Marco Antonio Percope de Andrade – Departamento de Aparelho Locomotor da Faculdade de Medicina, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brasil;
- Marcos Antonio Almeida Matos – Escola Baiana de Medicina e Saúde Pública, Salvador, BA, Brasil;
- Mateus Saito – Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da FMUSP, São Paulo, SP, Brasil;
- Maurício Etchebehere – Departamento de Ortopedia e Traumatologia da Faculdade de Ciências Médicas da Universidade Estadual de Campinas (Unicamp), Campinas, SP, Brasil;
- Miguel Angel Curiel Torres – Instituto Mexicano del Seguro Social, Coyoacán, México;
- Nilton Mazzer – Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor – Hospital das Clínicas – Faculdade de Medicina de Ribeirão Preto – FMRP-USP, São Paulo, SP, Brasil;
- Osmar Pedro Arbix Camargo – Faculdade de Ciências Médicas da Santa de Misericórdia, São Paulo, SP, Brasil;
- Osvandré Luiz Canfield Lech – Instituto de Ortopedia e Traumatologia de Passo Fundo, RS, Brasil;
- Patricia M. de Moraes Barros Fucs – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil;
- Paulo César Schott – Universidade Federal Fluminense, Rio de Janeiro, RJ, Brasil;
- Pedro Péricles Ribeiro Baptista – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil;
- Rames Mattar Junior – Departamento de Ortopedia e Traumatologia da FMUSP, São Paulo, SP, Brasil;
- Renato Graça – Universidade Federal Fluminense, Rio de Janeiro, RJ, Brasil;
- Reynaldo Jesus Garcia Filho – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo, Unifesp – São Paulo, SP, Brasil;
- Roberto Sergio de Tavares Canto – Centro Universitário do Triângulo, Uberlândia, MG, Brasil;
- Rosalvo Zósimo Bispo Júnior – Universidade Federal da Paraíba (UFPB), João Pessoa, PB, Brasil;
- Sérgio Afonso Hennemann – Instituto de Traumatologia e Ortopedia do Hospital Mãe de Deus, Porto Alegre, RS, Brasil;
- Sergio Eduardo Vianna – Instituto Nacional de Traumatologia e Ortopedia, INTO, Rio de Janeiro, RJ, Brasil;
- Sérgio Luiz Checchia – Departamento de Ortopedia e Traumatologia da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brasil;
- Sérgio Zylbersztejn – Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, Brasil;
- Túlio Diniz Fernandes – Departamento de Ortopedia e Traumatologia da FMUSP, São Paulo, SP, Brasil;
- Walter Manna Albertoni – Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo – Unifesp, São Paulo, SP, Brasil;
- William Dias Belangero – Universidade Estadual de Campinas – Unicamp, Campinas, SP, Brasil.

Advisory Editor – Arthur Tadeu de Assis

Executive Editor – Ana Carolina de Assis

Administrative Editor – Atha Comunicação Editora

Logo creation – Caio Augusto de Souza Nery

# ACTA ORTOPÉDICA BRASILEIRA

## INSTRUCTIONS TO AUTHORS

(Reviewed January 2016)

The journal *Acta Ortopédica Brasileira*, official organ of the Department of Orthopedics and Traumatology, Faculdade de Medicina da Universidade de São Paulo (DOT/FMUSP), is published bimonthly in six issues per year (jan/feb, mar/apr, may/jun, jul/aug, sep/oct, and nov/dec) with English version. The titles, abstracts and keywords are published in English and Portuguese. The publication follows entirely the international standard of the International Committee of Medical Journal Editors (ICMJE) - Vancouver Convention - and its uniform requirements [http://www.icmje.org/]. Submitted papers are sent for double-blind peer review evaluation to decide whether they should be published or not, suggesting improvements, asking the authors for clarification and making recommendations to the Editor-in-Chief. The concepts and statements contained in the papers are the sole responsibility of the authors. We ask authors to observe the following instructions for publication.

### ARTICLES FORMAT

**NUMBER OF WORDS RECOMMENDED ACCORDING TO THE PUBLICATION TYPE:** The criteria specified below should be observed for each type of publication. The electronic counting of words should start at the Introduction and end at the Conclusion.

Recommendations for articles submitted to *Acta Ortopédica Brasileira*

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

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

**MANUSCRIPT PREPARATION:** The journal *Acta Ortopédica Brasileira* receives the following types of contributions: Original Article, Update Article and Review Article. The Update and Review articles are only considered by invitation from the Editorial Board.

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

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

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

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

Measurement units (3 ml or 3 mL, but not 3 milliliters) or standard scientific symbols (chemical elements, for example, Na and not sodium) are not considered abbreviations and, therefore, should not be defined. Authors should abbreviate long names of chemical substances and therapeutic combinations terms. Abbreviations in figures and tables can be used for space reasons, but should be defined in the legend, even if they were defined in the article.

**PRESENTATION LETTER:** The cover letter accompanying the submission of the manuscript should be signed by the corresponding author and should include the following information: Title, names of all authors, text authorizing the publication of the article, stating that it has not been submitted simultaneously elsewhere and it has not been previously published (publication in another language is considered as the same article). Authors should make sure that the manuscript is entirely in accordance with the instructions.

**CLINICAL TRIALS:** The journal *Acta Ortopédica Brasileira* supports the Clinical Trials Registry policy of the World Health Organization (WHO) and the ICMJE, recognizing the importance of these initiatives for the registration and international dissemination of clinical studies in open access. Therefore, it will only accept for publication articles involving clinical research that have received an identification number in one of the clinical trials registry platforms validated by WHO and ICMJE. The URLs of these registry platforms are available at the ICMJE page [http://www.icmje.org/about-icmje/faqs/clinical-trials-registration/].

**CONFLICT OF INTERESTS:** As recommended by the ICMJE and resolution of the Brazilian Federal Council of Medicine nº 1595/2000, authors have the responsibility to recognize and declare any potential financial conflicts of interest, as well as conflicts of other nature (commercial, personal, political, etc.) involved in developing the work submitted for publication.

**ACKNOWLEDGEMENTS:** Authors can acknowledge financial support to the work in the form of research grants, scholarships and other, as well as professionals who do not qualify as co-authors of the article, but somehow contributed to its development.

**CORRECTION OF GALLEY PROOFS:** As soon as they are ready, the galley proofs in electronic form will be sent by e-mail to the corresponding author. Authors should return proofs, also by e-mail, with the necessary corrections within 48 hours maximum after its receipt. This aims to expedite the review process and publication of the article.

**COPYRIGHT:** All statements published in the articles are the authors' responsibility. However, all published material becomes the property of the publisher, which shall reserve the copyright. Therefore, no material published in *Acta Ortopédica Brasileira* can be marketed without the written permission of the publisher. All authors of articles submitted to *Acta* must sign a Copyright Transfer Agreement, which will take effect from the date of acceptance of the paper.

**ORGANIZING THE ELECTRONIC FILE:** All parts of the manuscript should be included in a single file. It should be formed by the cover page, then the text, references, figures (with their captions) and finally, tables and charts (with their respective captions).

**COVERPAGE:** The title page should contain:

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

d) The place where the work was performed;

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

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

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

**INTRODUCTION:** The introduction of the article shall present the matter and purpose of the study, including citations without, however, making an extensive review of the matter.

**MATERIALS AND METHODS:** This section should describe the experiments (quantitatively and qualitatively) and procedures in sufficient detail to allow other researchers to reproduce the results or provide continuity to the study.

When reporting experiments on humans or animals, authors should indicate whether the procedures followed the rules of the Ethics Committee on Human Trials of the institution in which the survey was conducted and whether the procedures are in accordance with the 1995 Helsinki Declaration and the Ethics in Experimentation Animals, respectively. Authors should include a statement indicating that the protocol was approved by the Institutional Ethics Committee (affiliate institution of at least one of the authors), with its identification number. It should also include whether a Free and Informed Consent Term was signed by all participants.

Authors should precisely identify all drugs and chemicals used, including generic names, dosages and administration. Patients' names, initials, or hospital records should not be included. References regarding statistical procedures should be included.

**RESULTS:** Results should be present in logical sequence in the text, using tables and illustrations. Do not repeat in the text all the data in the tables and/or illustrations, but emphasize or summarize only the most relevant findings.

**DISCUSSION:** Emphasize new and important aspects of the study and the conclusions that derive from it, in the context of the best evidence available. Do not repeat in detail data or other information mentioned elsewhere in the manuscript, as in the Introduction or Results. For experimental studies it is recommended to start the discussion by briefly summarizing the main findings, then explore possible mechanisms or explanations for these findings, compare and contrast the results with other relevant studies, state the limitations of the study and explore the implications of these results for future research and for clinical practice.

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

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

**ACKNOWLEDGEMENTS**

When applicable, briefly acknowledge the people who have contributed intellectually or technically to the study, but whose contribution does not justify co-authorship. The author must ensure that people agree to have their names and institutions disclosed. Financial support for the research and fellowships should be acknowledged in this section (funding agency and project number).

**AUTHORS IDENTIFICATION:** The ORCID (Open Researcher and Contributor ID, <http://orcid.org/>) of each author should be informed in the authors' statement of contribution, according to the model below.

**STATEMENT OF AUTHORS' CONTRIBUTION:** The declaration of authors' contribution should be included at the end of the article, using minimum criteria for authorship, including:

- Substantial contribution in the work conception or design, or acquisition, analysis or interpretation of data to the study;
- Writing the article or critically reviewing its intellectual content;
- Approval of the final version of the manuscript to be submitted for publication;
- Agree to be responsible for all aspects of the work, to ensure that any matters regarding the completeness or accuracy of any of its parts are properly investigated and resolved;

All articles should include a description of the authors' contribution, as follows:

"Each individual author contributed individually and significantly to the development of this work. MJ (0000-0000-0000-0000)\*: wrote and reviewed the and performed the surgeries; CPV (0000-0002-3904-2836)\*: performed the surgeries, analyzed the data analysis and wrote the articles; JVC (0000-0003-3910-714x (0000-0000-0000-0000)\*: performed statistical analysis, participated at the surgeries and reviewed the article; OMA (0000-0000-0000-0000)\*: analyzed the slides and reviewed the article; MASP (0000-0000-0000-0000)\*: drafted and reviewed the article and contributed to the intellectual concept of the study; ACA (0000-0001-6891-5935)\*: performed the surgeries, wrote the article, performed statistical analysis and contributed to the intellectual concept of the study and the entire research project. \*ORCID (Open Researcher and Contributor ID)."

**REFERENCES:** Original articles may include up to about 20 references, restricted to the essential bibliography to the article's content. Number the references consecutively in the order in which they are first mentioned in the text, using superscript Arabic numerals in the following format: (e.g., Reduction of terminal plate functions.<sup>1</sup>).

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

**a) Article:** Author (s). Article title. Journal title. Year; volume: initial page –final page.

Ex.: Campbell CJ. The healing of cartilage defects. *Clin Orthop Relat Res.* 1969;64:45-63.

**b) Book:** Author(s) or editor (s). Book title. Edition, if it is not the first. Translator (s), if it applies. Publication place: publisher; year.

Ex.: Diener HC, Wilkinson M, editors. Drug-induced headache. 2<sup>nd</sup> ed. New York: Springer-Verlag; 1996.

**c) Book chapter:** Chapter author (s). Chapter title. Book Editor (s) and supplementary data, likewise the previous item.

Ex.: Chapman MW, Olson SA. Open fractures. In: Rockwood CA, Green DP. *Fractures in adults.* 4<sup>th</sup> ed. Philadelphia: Lippincott-Raven; 1996. p.305-52.

**d) Abstract:** Author(s). Title, followed by [abstract]. Journal. Year; volume (supplement and its number, if it applies); page (s).

Ex.: Enzensberger W, Fisher PA. Metronome in Parkinson's disease [abstract]. Lancet. 1996;34:1337.

**e) Personal communications:** should only be mentioned in the text, between parentheses.

**f) Thesis:** Author, title, level (Master, PhD, etc.), city: institution; year.

Ex.: Kaplan SJ. Post-hospital home health care: the elderly's access and utilization [dissertation]. St. Louis: Washington Univ.; 1995.

**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>

**TABLES:** Tables should be numbered in order of appearance in the text with Arabic numerals. Each table should have a title and, when necessary, an explanatory caption. Charts and tables should be sent in editable source files (Word, Excel) and not as images. Tables and charts covering more than one page should be avoided. Do not use image elements, text boxes, or tabs.

**FIGURES (ILLUSTRATIONS AND PHOTOS):** Figures should be submitted on separate pages and numbered sequentially in Arabic numerals, according to the order of appearance in the text. To avoid issues that compromise the journal pattern, all material sent shall comply with the following parameters: all graphics, photographs and illustrations should have adequate graphic quality (300 dpi resolution) and present title and caption. In all cases, the files must have .tif or .jpg extensions. Files with extension .xls, .xlsx (Excel), .eps or .psd to curve illustrations (graphics, drawings and diagrams) shall also be accepted. Figures include all illustrations such as photographs, drawings, maps, graphs, etc. Black and white figures will be freely reproduced, but the editor reserves the right to set a reasonable limit on their number or charge the author the expense resulting from excesses. Color photos will be charged to the author.

Please note that it is the authors' responsibility to obtain permission from the copyright holder to reproduce figures (or tables) that have been previously published elsewhere. Authors must have permission from the copyright owner, if they wish to include images that have been published in other non-open access journals. Permission shall be indicated in the figure legend and the original source must be included in the reference list.

**LEGENDS TO FIGURES:** Type the legends using double space, following the respective figures (graphics, photos and illustrations). Each legend must be numbered in Arabic numerals corresponding to each illustration and in the order they are mentioned in the text. Abbreviations and acronyms should be preceded by the full name when cited for the first time in the text. At the bottom of figures and tables discriminate the meaning of abbreviations, symbols, signs and other informed source. If the illustrations have already been published, they shall be accompanied by written consent of the author or editor, stating the reference source where it was originally published.

**PAPER SUBMISSION:** From January 2008 *Acta Ortopédica Brasileira* adopts the SciELO Publication and Submission System available online at <http://submission.scielo.br/index.php/aob/index>. Authors should follow the registration and article inclusion instructions available at the website.

For further information please contact Atha Comunicação e Editora. Rua Machado Bittencourt 190, 4º floor. Vila Mariana, 04044-000. São Paulo, SP, Brazil. [actaortopedicabrasileira@uol.com.br](mailto:actaortopedicabrasileira@uol.com.br). Tel. +55 11 5087-9502 c/o Ana Carolina de Assis/Arthur T. Assis.

The journal's content, unless otherwise stated, is under Creative Commons Licence CC-BY-NC.

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

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

For more information, please visit [www.cebm.net](http://www.cebm.net).)

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

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

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

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

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

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

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

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

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

## ORIGINAL ARTICLES

## HAND

**INTER- AND INTRA-OBSERVER AGREEMENT IN THE MILCH AND WEISS SYSTEMS .....218**  
**CONCORDÂNCIA INTER E INTRA-OBSERVADOR DOS SISTEMAS MILCH E WEISS**

*Sergio Charles Lozoya, Joaquín Darío Treviño Báez, Jesús María Rangel Flores, Jesús Miguel Brizuela Ventura, Omar Araiza Topete, Andrea Alcázar Juárez*

DOI: <http://dx.doi.org/10.1590/1413-785220182604191367>

**TRANSFER OF NERVE BRANCHES OF THE FLEXOR CARPI RADIALIS TO THE POSTERIOR INTEROSSEOUS NERVE .....222**

**TRANSFERÊNCIA DE RAMOS NERVOSOS DO MÚSCULO FLEXOR RADIAL DO CARPO PARA O NERVO INTERÓSSEO POSTERIOR**

*Edie Benedito Caetano, Luiz Angelo Vieira, Rodrigo Guerra Sabongí, Luca Martinez Correio, Kelson Koiti Ogata, Eduardo Baldy de Sousa Boni*

DOI: <http://dx.doi.org/10.1590/1413-785220182604191853>

## HIP

**NECROSIS OF THE FEMORAL HEAD AND HEALTH-RELATED QUALITY OF LIFE OF CHILDREN AND ADOLESCENTS .....227**

**NECROSE DA CABEÇA DO FÊMUR E QUALIDADE DE VIDA RELACIONADA À SAÚDE DE CRIANÇAS E ADOLESCENTES**

*Marcos Almeida Matos, Luanne Lisle dos Santos Silva, Giordano Bruno Alves, Walter Silva de Alcântara Júnior, Davi Veiga*

DOI: <http://dx.doi.org/10.1590/1413-785220182604174253>

**PRELIMINARY MECHANICAL TEST OF PROXIMAL FEMUR REINFORCEMENT WITH CEMENTED X-SHAPED PMMA .....231**

**ENSAIO MECÂNICO PRELIMINAR DO REFORÇO FEMORAL PROXIMAL COM CIMENTO ÓSSEO EM FORMA DE "X"**

*Anderson Freitas, Welvis Soares Camargo, Ruben Jeri Aquino, Vincenzo Giordano Neto, Aluizio Fernandes Bonavides Junior, Antônio Carlos Shimano*

DOI: <http://dx.doi.org/10.1590/1413-785220182604187691>

## KNEE

**ASSOCIATION OF TOBACCO DEPENDENCE, ALCOHOLISM AND ANABOLIC STEROIDS WITH MENISCOLIGAMENTOUS INJURIES .....236**

**ASSOCIAÇÃO DE TABAGISMO, ALCOOLISMO E ANABOLIZANTES ÀS LESÕES MENISCO-LIGAMENTARES**

*Diego Costa Astur, Igor Neves Sbampato, Gustavo Gonçalves Arliani, Carlos Eduardo da Silveira Franciozi, Pedro Debieux, Moises Cohen*

DOI: <http://dx.doi.org/10.1590/1413-785220182604172699>

**CORRELATION BETWEEN AHLBÄCK CLASSIFICATION AND GONARTHROSIS RISK FACTORS .....240**  
**CORRELAÇÃO ENTRE A CLASSIFICAÇÃO DE AHLBÄCK E FATORES DE RISCO DA GONARTROSE**

*Paulo Alvim Borges, Mauro Henrique José De Almeida, Lucas Moura Araújo, Junji Miller Fukuyama, Fernando Yukio Umada, Miguel Gustavo Luz Arab*

DOI: <http://dx.doi.org/10.1590/1413-785220182604186271>

## ONCOLOGY

**EXTRA-ABDOMINAL DESMOID TUMOR: ANALYSIS OF 23 CONSECUTIVE CASES IN A SINGLE INSTITUTION.....244**

**TUMOR DESMOIDE EXTRA-ABDOMINAL: ANÁLISE DE 23 CASOS CONSECUTIVOS EM UMA ÚNICA INSTITUIÇÃO**

*Juan Pablo Zumárraga, Brian Guilherme Monteiro Marta Coimbra, Felipe Gonçalves dos Santos, André Mathias Baptista, Marcelo Tomio Kohara, Olavo Pires de Camargo*

DOI: <http://dx.doi.org/10.1590/1413-785220182604192681>

## ONCOLOGY

---

### EVALUATION OF QUALITY OF LIFE IN PATIENTS TREATED FOR METASTATIC DISEASE OF THE PROXIMAL FEMUR .....248

#### AVALIAÇÃO DA QUALIDADE DE VIDA EM PACIENTES TRATADOS POR DOENÇA METASTÁTICA DA REGIÃO PROXIMAL DO FÊMUR

Marcos Hajime Tanaka, Marcello Martins de Souza, Daniel Luiz Ceroni Gibson, Monica Paschoal Nogueira

DOI: <http://dx.doi.org/10.1590/1413-785220182604191223>

### TIBIAL ADAMANTINOMA: ANALYSIS OF SEVEN CONSECUTIVE CASES IN A SINGLE INSTITUTION .....252

#### ADAMANTINOMA DA TÍBIA: ANÁLISE DE SETE CASOS CONSECUTIVOS EM UMA ÚNICA INSTITUIÇÃO

Juan Pablo Zumárraga, Ricardo Cartolano, Marcelo Tomio Kohara, André Mathias Baptista, Felipe Gonçalves dos Santos, Olavo Pires De Camargo

DOI: <http://dx.doi.org/10.1590/1413-785220182604192680>

## OSTEOMETABOLIC

---

### EXPLORING CORTICAL BONE DENSITY THROUGH THE ULTRASOUND INTEGRATED REFLECTION COEFFICIENT.....255

#### DENSIDADE ÓSSEA CORTICAL ANALISADA PELO COEFICIENTE DE REFLEXÃO ULTRASSÔNICA

Daniel Patterson Matusin, Aldo José Fontes-Pereira, Paulo Tadeu Cardozo Ribeiro Rosa, Thiago Barboza, Sergio Augusto Lopes de Souza,

Marco Antônio Von Krüger<sup>1</sup>, Wagner Coelho de Albuquerque Pereira

DOI: <http://dx.doi.org/10.1590/1413-785220182604177202>

## SPINE

---

### SACRECTOMY ASSOCIATED WITH VERTEBRECTOMY: A NEW TECHNIQUE USING DOWEL GRAFTS FROM CADAVERS .....260

#### SACRECTOMIA ASSOCIADA À VERTEBRECTOMIA: UMA NOVA TÉCNICA COM USO DE ENXERTO DE CADÁVER

Thiego Pedro Freitas Araújo, Douglas Kenji Narazaki, William Gemio Jacobsen Teixeira, Fábio Busnardo, Alexandre Fogaça Cristante,

Tarcísio Eloy Pessoa de Barros Filho

DOI: <http://dx.doi.org/10.1590/1413-785220182604183451>

## TRAUMA

---

### BIOMECHANICAL COMPARISON OF MEDIAL VERSUS LATERAL SIDED PLATING IN FEMORAL FRACTURES.....265

#### COMPARAÇÃO BIOMECÂNICA DE PLACA ÓSSEA MEDIAL VERSUS LATERAL EM FRATURAS DO FÊMUR

Firat Al, Bilgehan Tosun, Tamer Sinmazcelik, Mustafa Ozmen

DOI: <http://dx.doi.org/10.1590/1413-785220182604191645>

## GENERAL

---

### PHYSICAL ACTIVITY PROGRAM FOR ELDERLY AND ECONOMY FOR THE HEALTH SYSTEM .....271

#### PROGRAMA DE ATIVIDADE FÍSICA PARA IDOSOS E ECONOMIA PARA O SISTEMA DE SAÚDE

Samir Salim Daher, Monica Paschoal Nogueira, Mauro Ferreira, Marcia Regina Martinez Tedeschi, Lilton Rodolfo Castellan Martinez,

Miríam Matsura Shirassu

DOI: <http://dx.doi.org/10.1590/1413-785220182604194374>

### RELATION BETWEEN IMPACT FACTOR IN ORTHOPEDIC JOURNALS AND LEVEL OF EVIDENCE.....275

#### RELAÇÃO ENTRE FATOR DE IMPACTO EM PERIÓDICOS ORTOPÉDICOS E NÍVEL DE EVIDÊNCIA

Maurício Pandini Monteiro de Barros, Fabio Teruo Matsunaga, Marcel Jun Sugawara Tamaoki

DOI: <http://dx.doi.org/10.1590/1413-785220182604168767>

# INTER- AND INTRA-OBSERVER AGREEMENT IN THE MILCH AND WEISS SYSTEMS

## CONCORDÂNCIA INTER E INTRA OBSERVADOR DOS SISTEMAS MILCH E WEISS

SERGIO CHARLES LOZOYA,<sup>1</sup> JOAQUÍN DARÍO TREVIÑO BÁEZ,<sup>2</sup> JESÚS MARÍA RANGEL FLORES,<sup>1</sup> JESÚS MIGUEL BRIZUELA VENTURA,<sup>1</sup> OMAR ARAIZA TOPETE,<sup>1</sup> ANDREA ALCÁZAR JUÁREZ<sup>3</sup>

1. Specialized Orthopedics and Traumatology Unit, Hospital de Traumatología y Ortopedia No. 21 del Instituto Mexicano del Seguro Social, Monterrey, NL, Mexico.

2. High-Speciality, Medical Unit No. 23 del Instituto Mexicano del Seguro Social, Monterrey, NL, Mexico.

3. Health Sciences Division, Universidad de Monterrey, Monterrey, NL, Mexico.

### ABSTRACT

**Objective:** The aim of this study is to estimate the inter- and intra-observer agreement of the Weiss and Milch classification systems in radiological studies of fractures of the lateral humeral condyle in pediatric patients. **Methods:** An agreement study was performed with non-probability sampling of consecutive cases with a sample size of a hundred radiological studies, which were evaluated by three experienced orthopedic surgeons and three resident physicians; following a thorough comparison of both inter- and intra-observer agreements over a six-week period based on the Fleiss' kappa, which was used to determine the inter- and intra-observer agreement rates of both classifications. **Results:** The overall reliability of the entire group of evaluators for the Milch classification in the inter-observer evaluation was  $\kappa = 0.13$ , 95% CI, 0.08–0.18, and the intra-observer evaluation was  $\kappa = 0.08$ , 95% CI, 0.06–0.11. For the Weiss classification, the overall evaluation had an inter-observer agreement of  $\kappa = 0.53$ , 95% CI, 0.50–0.57, and an intra-observer agreement of  $\kappa = 0.22$ , 95% CI, 0.20–0.24. **Conclusion:** In the present study, the Weiss classification system demonstrated greater agreement than the Milch classification; however, the latter may require complementary studies, such as an arthrography to enhance classification accuracy. **Level of Evidence II, Diagnostic Studies – Investigating Diagnostic Examination.**

**Keywords:** Condyle. Children. Fractures, Salter-Harris. Elbow joint. Observer variation.

### RESUMO

**Objetivo:** Este estudo visa estimar a concordância intra e inter-observador da classificação de Weiss e Milch, em estudos radiológicos de pacientes pediátricos com fratura da parte lateral do côndilo do úmero. **Métodos:** Estudo de concordância realizado com amostragem não probabilística de casos consecutivos com amostra de cem estudos radiológicos que foram avaliados por três observadores especialistas e por três médicos residentes; depois de uma comparação completa da concordância inter e intra-observador durante seis semanas, com base no kappa de Fleiss, que foi usado para determinar a concordância inter e intra-observador das duas classificações. **Resultados:** A confiabilidade global de todo o grupo de avaliadores da classificação de Milch na avaliação interobservador foi  $\kappa = 0,13$ , IC 95% 0,08-0,18 e intraobservador foi  $\kappa = 0,08$ , IC 95% 0,06-0,11. A avaliação geral da classificação de Weiss obteve concordância interobservador de  $\kappa = 0,53$ , IC 95% 0,50-0,57 e intraobservador de  $\kappa = 0,22$ , IC 95% 0,20-0,24. **Conclusão:** No presente estudo, o sistema de classificação de Weiss mostrou concordância maior do que a classificação Milch; contudo, esta última pode exigir estudos complementares, como artrografia, para ampliar a acurácia da classificação. **Nível de Evidência II, Estudos Diagnósticos – Investigação de um Exame para Diagnóstico.**

**Descritores:** Côndilo. Criança. Fraturas Salter-Harris. Articulação do cotovelo. Variações dependentes do observador.

**Citation:** Charles-Lozoya S, Treviño-Baéz JD, Rangel-Flores JM, Brizuela-Ventura JM, Topete-Araiza O, Juárez-Alcázar A. Inter- and intra-observer agreement in the milch and weiss systems. *Acta Ortop Bras.* [online]. 2018;26(4):218-21. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

The ideal system for classifying fractures is one that enhances communication between doctors, standardizes research terminology, and guides the decision-making process on the best treatment for each patient.<sup>1,2</sup> An increase in the incidence of pediatric fractures of the lateral humeral condyle has recently been reported. Some

authors report an increase of 9.3%,<sup>3,4</sup> while others report a range between 12 and 13.5%.<sup>5,6</sup> Needless to say, the accurate classification of this type of fracture displacement and joint stability is extremely important to assess the best treatment for these patients, which could be surgical or conservative. In addition, open reduction and internal fixation could be an unnecessary treatment that could

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

Work conducted at the Mexican Social Security Institute, Hospital de Traumatología y Ortopedia No. 21, Department of Pediatrics Orthopedics, Monterrey, NL, Mexico.

Correspondence: Sergio Charles Lozoya. Ave. José Ma. Pino Suárez and Juan Ignacio Ramón, Downtown area, Monterrey, NL, México. 64000. [scharleslozoya@yahoo.com.mx](mailto:scharleslozoya@yahoo.com.mx)

Article received in 02/09/2018, approved in 05/29/2018.



potentially increase the risk of avascular necrosis due to extensive dissection. Nevertheless, conservative treatment, or a percutaneous fixation on an unstable or displaced fracture, could result in consolidation failure and residual deformities.<sup>7</sup> Despite being one of the most widely used classification systems in pediatric orthopedic hospital services, the original Milch classification has not yet demonstrated its usefulness in defining treatment and prognosis,<sup>8</sup> and has been reported to have an inter-observer agreement with a Cohen kappa  $\kappa = 0.12$ .<sup>9</sup> The recently-introduced Weiss classification system, which is also based on joint displacement and congruence, may be able to predict fracture complications, and could indicate the best treatment to follow.<sup>10</sup> The use of an adequate classification could reduce indications for surgery, especially in fractures with minimal displacement, provided the displacement and follow-up can be ensured,<sup>11</sup> hence the importance of using a proper classification system.

There have been no repeatability and reproducibility tests among different observers with different levels of experience and training in the use of these classification systems. Therefore, the main objective of this study was to determine the repeatability and reproducibility of the Weiss and Milch classification systems for pediatric fractures of the lateral humeral condyle in pediatric patients by evaluating the intra- and inter-observer agreements in radiological studies with multiple observers and outcomes.

## MATERIAL AND METHODS

In 2017, an agreement study was performed at the Pediatric Orthopedics Service of the High-specialty Medical Unit of the Trauma and Orthopedics Hospital (*Hospital de Traumatología y Ortopedia No. 21*) of the Mexican Social Security Institute in Monterrey, Mexico. Prior approval from the Research Ethics Committee (R-2017-1903-11) was gained before conducting the study; all the parents signed an informed consent form, and radiological studies from the daily admission sheets of patients between 2015 and 2016 were taken from our hospital's imaging database, for use in the study. Patients aged between 3 and 14 years of age with anteroposterior and lateral radiological studies of the affected elbow were included. Patients with both fracture and elbow luxation, ipsilateral fracture in another area of the elbow, or with repeat fractures, were excluded. In order to measure agreement, the studies were blindly sorted and individually evaluated by three experienced pediatric orthopedists, and by three fourth-year orthopedic surgical residents. The evaluators were summoned on different days and were given the definitions and diagrams of the Milch<sup>8</sup> and Weiss<sup>10</sup> classifications. Figure 1 describes the Milch classification for lateral humeral condyle fractures, Type I having a fracture line that is lateral to the trochlear groove, and Type II having a fracture line into the trochlear groove. Figure 2 describes the Weiss classification system for lateral humeral condyle fractures; Type I fractures have a displacement of less than 2 mm, while Type II fractures have a displacement greater than or equal to 2mm with an intact articular cartilage, and Type III fractures have a displacement greater than or equal to 2 mm with an affected articular surface. The radiographs were shown to the evaluators. Each evaluator was given a test-like form and asked to classify the radiological studies, without receiving any information about the treatment that was previously prescribed to each patient. The amount of time considered adequate for measurement of intra-observer agreement was six weeks, during which time the images from the same cohort of patients were randomly shown to the evaluators. To estimate the sample size, previously reported data of Cohen's kappa from the Pennington et al.<sup>9</sup> study was taken into account. An estimation of the confidence interval in studies seeking agreement among multiple observers was used, as reported by Rotondi et al.<sup>12</sup> and Donner et al.<sup>13</sup> In the present study, which had three

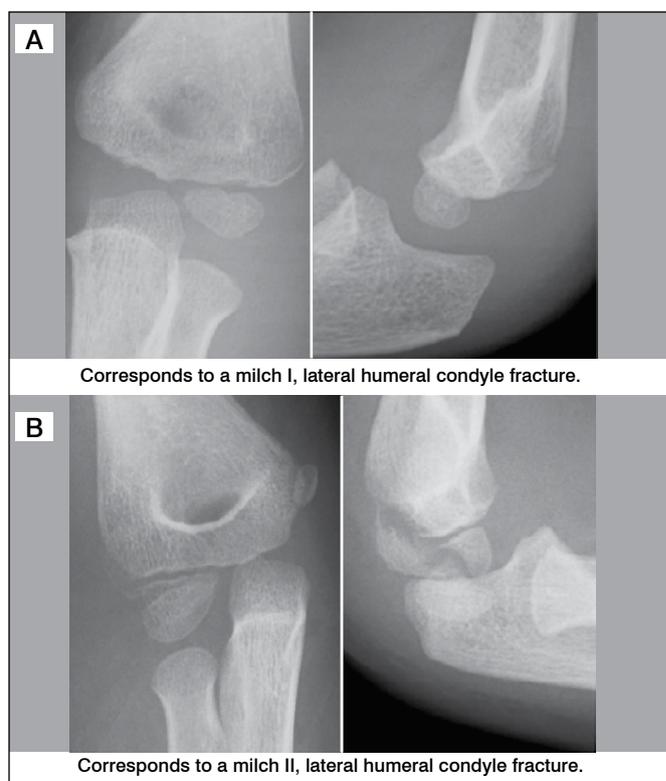


Figure 1. Milch classification for lateral humeral condyle fractures.

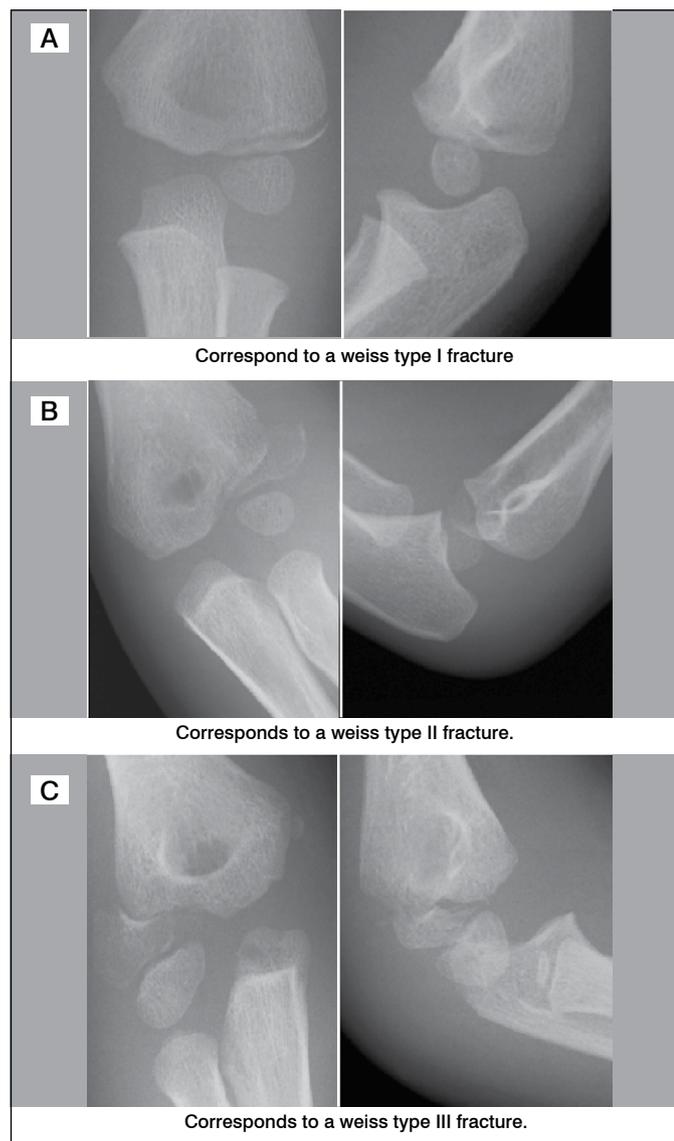
observers in each group and an  $\alpha = 0.05$ , with a lower limit of 0.70 and an upper limit of 0.90, the results for the sample size was 65 patients, but the decision to evaluate 100 radiographs was made in order to increase the variability. The data were both categorically and mutually exclusive for each category. For the analysis, the general kappa index was calculated as described by Fleiss.<sup>14</sup> The agreement levels for the kappa coefficient were in accordance with those proposed by Landis and Koch,<sup>15</sup> who classified them in categories ranging from: < 0.00, poor agreement; to 0.00–0.20 slight agreement; 0.21–0.40 fair agreement; 0.41–0.60 moderate agreement; 0.61–0.80 substantial agreement, and 0.81–1.00 almost perfect agreement.<sup>16</sup> All the statistical analyses were performed with SPSS statistical software version 22 (SPSS, Chicago, IL, USA).

## RESULTS

One hundred radiological tests were analyzed by the evaluators, from which the intra- and inter-observer agreements were determined. Among the three experienced orthopedic surgeons, the overall inter-observer reproducibility for the Milch classification system resulted in moderate agreement ( $\kappa = 0.41$ ; 95% CI, 0.30–0.53). On the other hand, the same group of observers obtained substantial agreement ( $\kappa = 0.61$ ; 95% CI, 0.51–0.69) for the Weiss classification in overall inter-observer reproducibility. For the evaluations performed by the three orthopedic surgical residents, the Milch classification gained very poor, null and negative agreement ( $\kappa = -0.04$ ; 95% CI, -0.07–0.15) in the overall inter-observer reproducibility. In the same group of residents, the results of the overall inter-observer reproducibility for the Weiss classification indicated moderate agreement ( $\kappa = 0.47$ ; 95% CI, 0.39–0.55). The details of each assessment, as well as the types of classification and fracture patterns, are shown in Tables 1 and 2. The estimation of the intra-observer agreement performed by the group of experienced observers, specialists in pediatric orthopedics, using the Milch

classification, showed agreement of  $\kappa = 0.20$ ; 95% CI, 0.15–0.25. In the same group of observers, the results obtained for the Weiss classification were  $\kappa = 0.22$ ; 95% CI, 0.19–0.28, which translated into fair agreement in both evaluations. The intra-observer agreement in the orthopedic residents group showed poor agreement ( $\kappa = -0.01$ ; 95% CI, -0.06–0.04) when using the Milch classification. Finally, the evaluation of intra-observer agreement among the same group of residents using the Weiss classification showed

slight agreement ( $\kappa = 0.17$ ; 95% CI, 0.13–0.20). The details of the intra-observer evaluation are shown in Tables 3 and 4; Table 5 shows the agreement of the entire group of evaluators. Overall, the Weiss classification obtained moderate inter-observer agreement ( $\kappa = 0.53$ ; 95% CI, 0.50–0.57) and fair intra-observer agreement ( $\kappa = 0.22$ ; 95% CI, 0.20–0.24). Using the Milch classification, the inter-observer agreement was  $\kappa = 0.13$ ; 95% CI, 0.08–0.18 and the intra-observer agreement was  $\kappa = 0.08$ ; 95% CI, 0.06–0.11, which translates into slight agreement for both results.



**Figure 2.** Weiss classification for lateral humeral condyle fractures.

**Table 1.** Inter-observer agreement for the Milch and Weiss classification (Group of expert evaluators).

Classification	Kappa	95% CI
Milch		
I	0.41	0.30 – 0.53
II	0.41	0.30 – 0.53
Overall	0.41	0.30 – 0.53
Weiss		
I	0.72	0.61 – 0.83
II	0.37	0.26 – 0.49
III	0.68	0.57 – 0.80
Overall	0.61	0.51 – 0.69

**Table 2.** Inter-observer agreement for the Milch and Weiss classification (Medical residents group).

Classification	Kappa	95% CI
Milch		
I	0.04	- 0.08 – 0.15
II	0.04	- 0.08 – 0.15
Overall	0.04	- 0.08 – 0.15
Weiss		
I	0.47	0.38 – 0.60
II	0.27	0.15 – 0.38
III	0.62	0.51 – 0.73
Overall	0.47	0.39 – 0.55

**Table 3.** Intra-observer agreement for the Milch and Weiss classification (Group of expert evaluators).

Classification	Kappa	95% CI
Milch		
I	0.20	0.15 – 0.25
II	0.20	0.15 – 0.25
Overall	0.20	0.15 – 0.25
Weiss		
I	0.27	0.21 – 0.32
II	0.12	0.07 – 0.17
III	0.26	0.21 – 0.32
Overall	0.22	0.19 – 0.28

**Table 4.** Intra-observer agreement for the Milch and Weiss classification (Medical residents group).

Classification	Kappa	95% CI
Milch		
I	- 0.01	- 0.06 – 0.04
II	- 0.01	- 0.06 – 0.04
Overall	- 0.01	- 0.06 – 0.04
Weiss		
I	0.17	0.12 – 0.22
II	0.05	0.001 – 0.10
III	0.25	0.20 – 0.30
Overall	0.17	0.13 – 0.20

**Table 5.** Inter-observer and Intra-observer agreement for the Milch and Weiss classification (Entire group).

Classification	Intra-observer agreement			Inter-observer agreement	
	Kappa	95% CI	Kappa	95% CI	
Milch					
I	0.08	0.06 – 0.11	0.13	0.08 – 0.18	
II	0.08	0.06 – 0.11	0.13	0.08 – 0.18	
Overall	0.08	0.06 – 0.11	0.13	0.08 – 0.18	
Weiss					
I	0.25	0.23 – 0.27	0.59	0.54 – 0.64	
II	0.10	0.07 – 0.12	0.30	0.25 – 0.35	
III	0.30	0.27 – 0.32	0.67	0.62 – 0.72	
Overall	0.22	0.20 – 0.24	0.53	0.50 – 0.57	

## DISCUSSION

Multiple attempts have been made to design a classification system for lateral humeral condyle in pediatric patients that is able to answer questions regarding the mechanism of injury, anatomical difference in the displacement, and the best treatment for each fracture.<sup>17</sup> To assess such questions, the concordance of both classification systems was compared. In the present study, the Milch classification, when used by medical residents, obtained intra-observer agreement of  $\kappa = -0.01$  and inter-observer agreement of  $\kappa = 0.04$ , indicating poor and fair agreements, respectively. This corroborates with the previous study performed by Pennington et al.<sup>9</sup> which reported fair inter-observer agreement ( $\kappa = 0.12$ ); however, that same study obtained moderate intra-observer agreement ( $\kappa = 0.45$ ) when comparing the original and modified Milch classifications. The evaluations performed by the expert physicians with the Milch classification showed a higher degree of inter-observer agreement, achieving moderate agreement ( $\kappa = 0.41$ ) along with slight intra-observer agreement ( $\kappa = 0.20$ ), which could possibly reflect repeatability with variable consistency and stability. Moreover, the Weiss classification in the current study demonstrated higher degrees of agreement than those demonstrated with the Milch classification in the group of expert physicians, and the inter-observer estimation was substantial ( $\kappa = 0.61$ ). On the contrary, the intra-observer agreement fell to fair levels ( $\kappa = 0.22$ ), which may be attributed to external reliability in the interpretations of the classification, since the evaluations were performed under similar conditions.

On the other hand, attempts to enhance evaluation of these fractures, as performed by Song et al.<sup>7,18</sup> using the Jakob classification<sup>17</sup> conclude that in order to properly classify the degree of displacement and prescribe the most adequate treatment, an internal oblique radiograph in type I, and an arthrography in types II and III of said classification, must be performed. A report evaluating fractures that showed minimal displacement in a radiograph, therefore being treated conservatively, recommended that the routine use of magnetic resonance imaging in follow-up is consistent with a stable fracture,

thus preventing the need for further imaging or clinical studies.<sup>19</sup> Another recent report concluded that apart from assessing joint stability, fractures with a displacement greater than 2 mm should be assessed for surgery and that the majority of them should be treated with an open reduction and internal fixation.<sup>20</sup>

One of the main limitations of our study is that in the classification developed by Weiss et al.<sup>10</sup> for patients whose fracture caused uncertainty regarding joint congruence and had a displacement greater than 2 mm, arthrography was used to determine the best treatment: closed reduction with nails, or open reduction with internal fixation. Arthrography was not used in the present study, which may have affected the correct classification of the joint congruence of the fracture. This limitation is possibly reflected in the difficulty of classifying fractures as a type II, which obtained fair reliability ( $\kappa = 0.27$ ). However, it was reported in these evaluations that in fractures classified as type III with displacement greater than 4 mm, arthrography was not performed to corroborate the joint congruence. In view of this, arthrography that have been used in fractures with displacement greater than 4 mm that could have an intact articular surface and may be treated with closed reduction and nails. Another limitation of this study is that no internal oblique radiographs were taken; these have proven to be a good method to determine the greatest displacement of the fracture,<sup>18</sup> and this knowledge is useful for classifying and treating fractures.

## CONCLUSION

In hospitals where resources are limited, there is a need for an easy-to-interpret classification system that does not require the costly studies. Based on our results, conservative treatment for lateral humeral condyle pediatric fractures in these environments should only be indicated when follow-up is guaranteed. In the present study, the Weiss classification showed greater agreement than the Milch classification; nonetheless, complementary studies, such as arthrography, may be needed to classify fractures adequately.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. SCHL (0000-0003-3866-0517)\*, JDDB (000-0003-1465-4593)\*, and JMRF (0000-0002-6206-9893)\* were the main contributors to the writing of the manuscript. JMBV (0000-0002-4271-4429)\*, OAT (0000-0001-7760-3879)\* and AAJ (0000-0003-1505-8531)\*, were responsible for collecting the imaging tests for evaluation and the clinical data. SCHL and JDDB, evaluated the data for the statistical analysis and revised the manuscript. JMBV and OAT, contributed to evaluating and classifying the X-ray images, and SCHL conducted the bibliographic research and contributed to the intellectual concept of the study. All authors participated in drafting the article or revising it critically for important intellectual content and final approval of the version to be submitted. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Muller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of fractures of the long bones. Berlin: Springer; 1990.
2. Urrutia J, Zamora T, Besa P, Zamora M, Schweitzer D, Klaber I. Inter and intra-observer agreement evaluation of the AO and the Tronzo classification systems of fractures of the trochanteric area. *Injury*. 2015;46(6):1054-8.
3. Mardani-Kivi M, Zohrevandi B, Saheb-Ekhtiari K, Hashemi-Motlagh K. How much are emergency medicine specialists' decisions reliable in the diagnosis and treatment of pediatric fractures? *Arch Bone Jt Surg*. 2016;4(1):60-4.
4. Behdad A, Behdad S, Hosseinpour M. Pediatric elbow fractures in a major trauma center in Iran. *Arch Trauma Res*. 2013;1(4):172-5.
5. Landin LA, Danielsson LG. Elbow fractures in children. An epidemiological analysis of 589 cases. *Acta Orthop Scand*. 1986;57(4):309-12.
6. Emery KH, Zingula SN, Anton CG, Salisbury SR, Tamai J. Pediatric elbow fractures: a new angle on an old topic. *Pediatr Radiol*. 2016;46(1):61-6.
7. Song KS, Waters PM. Lateral condylar humerus fractures: which ones should we fix? *J Pediatr Orthop*. 2012;32 (Suppl 1):S5-9.
8. Milch H. Fractures and fracture dislocations of the humeral condyles. *J Trauma*. 1964;4:592-607.
9. Pennington RG, Corner JA, Brownlow HC. Milch's classification of paediatric lateral condylar mass fractures: analysis of inter- and intraobserver reliability and comparison with operative findings. *Injury*. 2009;40(3):249-52.
10. Weiss JM, Graves S, Yang S, Mendelsohn E, Kay RM, Skaggs DL. A new classification system predictive of complications in surgically treated pediatric humeral lateral condyle fractures. *J Pediatr Orthop*. 2009;29(6):602-5.
11. Marcheix PS, Vacquerie V, Longis B, Peyrou P, Fourcade L, Moulies D. Distal humerus lateral condyle fracture in children: when is the conservative treatment a valid option? *Orthop Traumatol Surg Res*. 2011;97(3):304-7.
12. Rotondi MA, Donner A. A confidence interval approach to sample size estimation for interobserver agreement studies with multiple raters and outcomes. *J Clin Epidemiol*. 2012;65(7):778-84.
13. Donner A, Eliasziw M. Sample size requirements for reliability studies. *Stat Med*. 1987;6(4):441-8.
14. Fleiss JL. The measurement of interrater agreement. *Statistical methods for rates and proportions*. New York, NY: John Wiley & Sons; 1981.p.212-36
15. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159-74.
16. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med*. 2005;37(5):360-3.
17. Jakob R, Fowles JV, Rang M, Kassab MT. Observations concerning fractures of the lateral humeral condyle in children. *J Bone Joint Surg Br*. 1975;57(4):430-6.
18. Song KS, Kang CH, Min BW, Bae KC, Cho CH. Internal oblique radiographs for diagnosis of nondisplaced or minimally displaced lateral condylar fractures of the humerus in children. *J Bone Joint Surg Am*. 2007;89(1):58-63.
19. Hailotte G, Bachy M, Delpont M, Kabbaj R, Ducou le Pointe H, Vialle R. The Use of Magnetic Resonance Imaging in Management of Minimally Displaced or Nondisplaced Lateral Humeral Condyle Fractures in Children. *Pediatr Emerg Care*. 2017;33(1):21-5.
20. Bakarman KA, Alsiddiky AMM, Alzain KO, Alkawahski HM, Bin Nasser AS, Alsaleh KA, et al. Humeral lateral condyle fractures in children: redefining the criteria for displacement. *J Pediatr Orthop Part B*. 2016;25(5):429-33.

# TRANSFER OF NERVE BRANCHES OF THE FLEXOR CARPI RADIALIS TO THE POSTERIOR INTEROSSEOUS NERVE

## TRANSFERÊNCIA DE RAMOS NERVOSOS DO MÚSCULO FLEXOR RADIAL DO CARPO PARA O NERVO INTERÓSSEO POSTERIOR

EDIE BENEDITO CAETANO<sup>1</sup>, LUIZ ANGELO VIEIRA<sup>1</sup>, RODRIGO GUERRA SABONGI<sup>2</sup>, LUCA MARTINEZ CORREIO<sup>3</sup>, KELSON KOITI OGATA<sup>3</sup>, EDUARDO BALDY DE SOUSA BONI<sup>3</sup>

1. Pontifícia Universidade Católica de São Paulo, Faculdade de Ciências Médicas e da Saúde, Department of Orthopedic Surgery, Sorocaba, SP, Brazil.

2. Universidade Federal do Estado de São Paulo (UNIFESP), São Paulo, SP, Brazil.

3. Pontifícia Universidade Católica de São Paulo, Faculdade de Ciências Médicas e da Saúde, Sorocaba, SP, Brazil.

### ABSTRACT

**Objective:** The objective of this paper was to study the anatomical variations of the flexor carpi radialis muscle (FCR) and determine in cadaver limbs whether the FCR nervous branch can be connected to the posterior interosseous nerve (PIN) without tension and how close to the target muscles the transfer can be performed. **Method:** Thirty cadaveric upper limbs were dissected. **Results:** The FCR received exclusive innervation of the median nerve, distally to the intercondylar line of the humerus. In 5 limbs, an isolated branch was found and in 25, a common trunk with other nervous branches occurred. We investigated whether the branch for the FCR was long enough to be transferred to the PIN. The diameter of the nerve branch for the FCR corresponded on average to 50% of the PIN. **Conclusion:** In 12 limbs, the branch destined to the FCR could be connected to the PIN, distally to the nerve branches to the supinator muscle even during the movements of the forearm and the elbow. In 18 specimens, it was necessary to mobilize the PIN for this innervation. **Level of Evidence IV, Case Series.**

**Keywords:** Peripheral nerve injuries. Nerve transfer. Median nerve.

### RESUMO

**Objetivo:** O objetivo do trabalho foi estudar as variações anatômicas do músculo flexor radial do carpo (FRC) e determinar, em membros de cadáveres, se o ramo nervoso do músculo FRC pode ser conectado ao nervo interósseo posterior (NIP) sem tensão e quão próximo dos músculos alvos a transferência pode ser realizada. **Método:** Trinta membros superiores cadavéricos foram dissecados. **Resultados:** O FRC recebeu inervação exclusiva do nervo mediano, distalmente à linha intercondilar do úmero. Em 5 membros encontrou-se um ramo isolado e em 25 ocorreu um tronco comum com outros ramos nervosos. Investigamos se o ramo para o FRC tinha comprimento suficiente para ser transferido para o NIP. O diâmetro do ramo nervoso para o músculo FRC correspondia, em média, a 50% do NIP. **Conclusão:** Em 12 membros, o ramo destinado ao FRC poderia ser conectado ao NIP, distalmente aos ramos nervosos para o músculo supinador mesmo durante os movimentos do antebraço e do cotovelo. Em 18 peças foi necessária a mobilização do NIP para essa inervação. **Nível de Evidência IV, Série de Casos.**

**Descritores:** Lesões dos nervos periféricos. Transferência de nervo. Nervo mediano.

**Citation:** Caetano EB, Vieira LA, Sabongi RG, Martinez L, Ogata KK, Boni EBS. Transfer of nerve branches of the flexor carpi radialis to the posterior interosseous nerve. *Acta Ortop Bras.* [online]. 2018;26(4):222-6. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

The radial nerve is the most commonly affected in upper limb nerve injuries, causing inability to extend the elbow, wrist, fingers, and thumb. In approximately 12% of causes it occurs in association with humeral fractures, and may be damaged during trauma, fracture reduction, open reduction and internal fixation, or entrapment in the bone callus.<sup>1,2</sup> Radial nerve injuries in the lower third of the arm or forearm can usually be repaired by primary suture or reconstruction using nerve grafts, with good restoration of function. High radial nerve injuries near the axilla and posterior cord brachial plexus injuries

are especially problematic because the distance and time required for reinnervation of the extensor muscles in the forearm usually impede functional recovery.<sup>2-5</sup>

The repair of a nerve injury is based on primary nerve repair, nerve grafts, tendon transfers, and free muscle transfer. However, there are nerve injuries that are not eligible for primary repair and for which grafts do not provide satisfactory results. These injuries include very proximal nerve injury; extensive area of injury, resulting in a long space between nerve stumps, and idiopathic nerve paralysis or neuritis in which there is no healthy proximal nerve segment.<sup>2-4</sup>

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

Work conducted at the Laboratório de Anatomia (Anatomy Laboratory) of the Faculdade de Ciências Médicas e da Saúde da Pontifícia Universidade Católica de São Paulo (Sorocaba Campus). Correspondence: Edie Benedito Caetano. Pontifícia Universidade Católica de São Paulo, Faculdade de Ciências Médicas e da Saúde, Department of Orthopedic Surgery. Rua Joubert Weh, 290, Sorocaba, SP, Brazil. 18030-070. [ediecaetano@uoi.com.br](mailto:ediecaetano@uoi.com.br)



In the case of brachial plexus injuries, with very large gaps between nerve endings, there may not be enough time to regenerate the axons and thus reach the motor endplates of the target muscles, before they become permanently resistant to reinnervation. This prolonged period of denervation leaves target muscles susceptible to irreversible degeneration and fibrosis of the motor endplates.<sup>2-4</sup> Tendon transfers have been performed as first choice to treat radial nerve injuries, but they may be limited as they often prove inconsistent.<sup>5-7</sup>

Plate et al.<sup>6</sup> are of the opinion that nerve transfers have advantages and are preferable to tendon transfers for the following reasons: transfers can use dispensable or redundant nerves, whereas tendon transfers require sacrifice of the donor muscle; tendon transfers require more extensive dissections, and calculating adequate length and tension is difficult; they have frequently been associated with joint stiffness, disorders of natural muscle biomechanics, fibrosis, impaired vascularization and availability of donor muscles.

In FCR transfers or denervation wrist flexion is preserved by the action of the palmaris longus and flexor carpi ulnaris muscles. The disadvantage of nerve transfers is the time required to reinnervate target muscles. Branches of the median nerve leading to the forearm muscles can be transferred to reinnervate the posterior interosseous nerve (PIN).<sup>2-9</sup>

Clinical series using nerve transfer targeting PIN recovery have been reported with good functional response in patients with high radial nerve and brachial plexus injuries.<sup>2-9</sup> Despite these promising clinical results, only a few anatomical studies on the nerves involved in these transfers have been described. The flexor carpi radialis (FCR) muscle receives innervation from the median nerve. In most limbs there is only one branch to the FCR. It arises from the lateral epicondyle of the humerus and adjacent areas. In the wrist its tendon passes through a compartment located next to the carpal tunnel, with its insertion point at the base of the second metacarpal bone.

A number of authors<sup>4,5</sup> have transferred the nerve leading to the FCR to the PIN, given its synergistic relationship with the wrist and finger extensors, including thumb movement. The selection of donor nerves with a synergistic relationship with the recipient nerves facilitates subsequent cortical integration. Flexion of the wrist increases the passive tension of the finger extensors and thus causes their extension, increasing the extension force, while wrist extension has the opposite effect and allows passive finger flexion.<sup>5-10</sup>

The aim of this study was to assess, in 30 cadaveric limbs, whether the median nerve branch leading to the FCR muscle can or cannot be connected to the PIN without tension, and how close to the target muscles the transfer can be performed.

## MATERIALS AND METHODS

This study was based on the dissection of 30 limbs from 15 male cadavers. Each forearm was dissected in the elbow extension and forearm pronation position. None of the cadavers showed evidence of deformities or previous surgical procedures on the forearm. The median nerve was identified in the arm and dissected from proximal to distal. The bicipital aponeurosis was sectioned. The pronator teres muscle (PTM) was disinserted distally. The branches of the median nerve to the PTM, FCR, PL, FDS (flexor digitorum superficialis) muscles and the AIN (anterior interosseous nerve) with its branches leading to the flexor digitorum profundus (FDP), flexor pollicis longus (FPL) and PQ (pronator quadratus) were dissected.

We identified the branches of the radial nerve to the brachialis, brachioradialis, extensor carpi radialis longus (ECRL), and extensor carpi radialis brevis (ECRB) muscles, superficial branch of the radial nerve (SBRN), PIN and their branches to the supinator muscle (SM). Vascular structures were not preserved to facilitate dissection of

the nerves. We measured forearm length from the center of a line between the medial and lateral epicondyles (intercondylar line) to the center of a line between the radial and ulnar styloid processes. The origin of the branch of the MN to the FCR was measured from the intercondylar line. We used a magnifying glass with 2.5x magnification, a ruler and a digital caliper to measure the length and diameter of the donor (MN) and recipient (PIN) nerves at certain stages of the dissection. The measurement of the branches to the FCR was taken in 14 limbs, and PIN was measured in 30 limbs. This study was approved by the Institutional Review Board under opinion number 1.611.295.

In the first anatomical study, the branches of the supinator were transferred to the posterior interosseous nerve. We measured the posterior interosseous nerve and branches to the supinator in 30 limbs. The branches of the median nerve to the muscles: pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, and anterior interosseous nerve were measured in only 14 limbs. The initial idea was to also measure the branches of the median nerve in 30 limbs (there are five branches of the median nerve). It is very tiring and laborious to take these measurements with a digital caliper in 30 limbs. We considered the measurement in 14 branches to be sufficient for the research.

## RESULTS

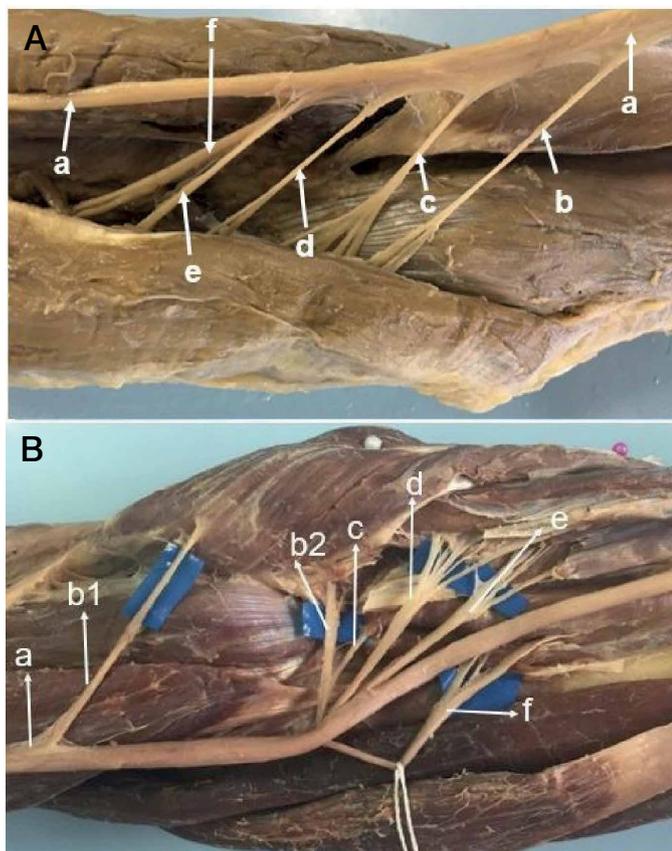
The results of anatomical measurement of donor and recipient nerve length and diameter are shown in Table 1. The mean forearm length was  $26.2 \pm 2.7$  cm. The patterns of branching and distribution of the branches of the MN to the FCR muscle that we recorded in 30 limbs are presented below. The presence of only one branch to the FCR was identified in all limbs, in most cases it was the third muscle of the forearm to be innervated by the median and received exclusive innervation from this nerve in all limbs (Figure 1A). The intercondylar line of the humerus originated distally in all limbs. In 5 limbs it received innervation from an isolated branch (Figures 1A and 1B). In 8 from a common trunk with one of the branches of the PTM, being 2 with the first branch, 5 with the second branch (Figure 2A), and one with the third branch of the PTM (Figure 2B).

In 8 from a common trunk with the branch leading to the PL muscle (Figure 2B). In 4 from a common trunk with branches to the PTM and PL (Figures 3A and 3B). In 3 from a common trunk to the FDS muscle (Figure 4A), and in 2 from a common trunk to the PTM, PL, FDS (Figure 4B) and (Table1).

The results of anatomical measurement of donor and recipient nerve length and diameter are described in Table 2. The length of the PIN was measured from its origin in the radial nerve to the distal margin of the SM. In 14 of the 30 dissected limbs, we assessed the possibility of transferring the branch from the MN leading to the FCR to the PIN without tension, relating to forearm and elbow movements. The mean diameter of the nerve to the FCR corresponds to 50% of the PIN diameter.

**Table 1.** Results of anatomical measurement of the length and diameter of the donor (FCR) and recipient (AIN) nerves.

	Number of branches in 30 limbs	Mean diameter in mm	Mean length of the nerve in mm
Branch of median nerve to flexor carpi radialis	1 in 30 limbs	1.5 ± 0.4 measured in 14 limbs	4.0 (3.0 ± 5.2)
Posterior interosseous nerve	1 in 30 limbs	3.0 ± 0.5 measured in 30 limbs	5.2 (6.5 ± 2.5)



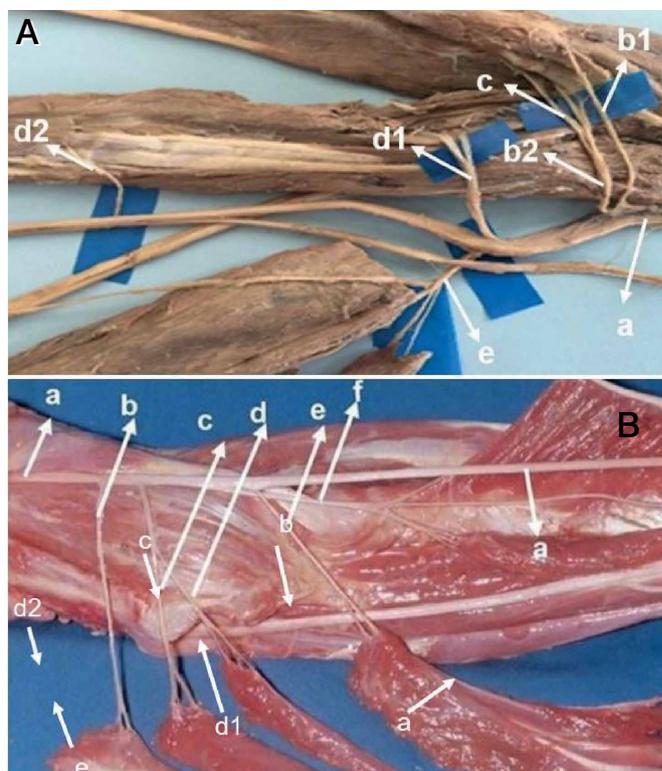
**Figure 1.** A. (a) median nerve; (b) branch from the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e) branch to the flexor digitorum superficialis; (f) anterior interosseous nerve. B. (a) median nerve; (b1) first branch from the pronator teres; (b2) second branch from the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e) branch to the flexor digitorum superficialis; (f) anterior interosseous nerve.

## DISCUSSION

Anatomical treatises describe the classic distribution of the median nerve in the forearm: two branches (upper and lower) to the PTM, a trunk common to the FCR and PL and a branch to the FDS.<sup>10,11</sup> Some studies have revealed considerable variations of this pattern in several anatomical series.<sup>4,12-16</sup>

Sunderland and Ray<sup>12</sup> found a single branch to the FCR in 18 limbs and two branches in two limbs in 19 of the 20 from a common trunk with branches to other forearm muscles. Canovas et al.<sup>13</sup> dissected 10 limbs, finding considerable variability in the branches to the muscles innervated by the median. Chantelot et al.<sup>14</sup> dissected 50 limbs, and found the classic distribution (one common trunk for the FCR and PL in only 20 limbs) (40%). Zawawy et al.,<sup>15</sup> reported that in 20 limbs they identified only one branch to the FCR in 14 limbs (70%), originating as a single branch or in common with branches leading to other muscles. In 6 of the 20 limbs, they observed that the FCR muscle received 2 separate branches of the median nerve. Blair and Joos<sup>16</sup> dissected 20 limbs and reported that the FCR muscle received innervation from the median nerve in all of them. In the majority of limbs the muscle received innervation both from this nerve and from branches of the AIN.

In this study we recorded that only one branch of the median nerve led to the FCR muscle, originating distally to the epicondylar line of the humerus, in five limbs without sharing with branches to other muscles, and in 25 sharing innervation with other muscles of the



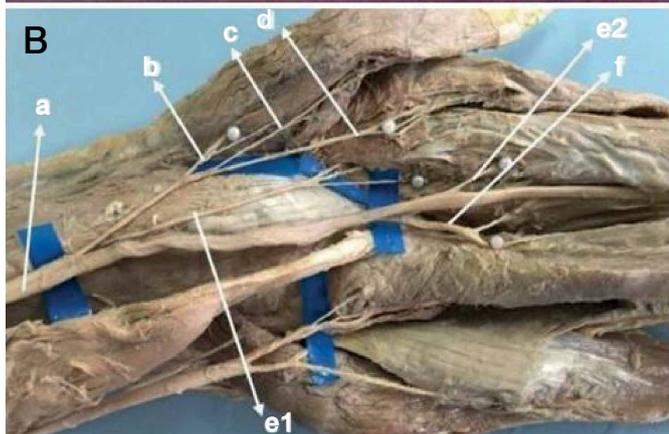
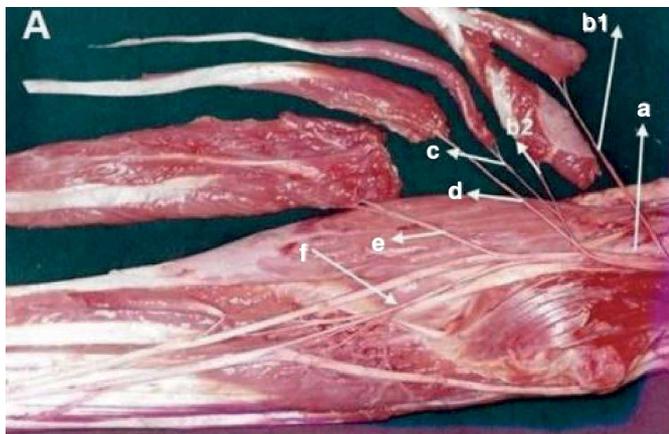
**Figure 2.** A. (a) median nerve; (b1) first branch from the pronator teres; (b2) second branch from the pronator teres; (c) branch to the flexor carpi radialis; (d1 and d2) branches to the flexor digitorum superficialis; (e) anterior interosseous nerve; palmaris longus absent. B. (a) median nerve; (b) branch from the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e) branch to the flexor digitorum superficialis; (f) anterior interosseous nerve.

forearm. We identified the classic pattern of FCR innervation, that is, a common trunk with the PL, in 8 limbs (26.5%). These anatomical details are not an absolute clinical necessity in preparation for a nerve transfer to restore finger extension, but knowledge of these details facilitates the identification of these nerve branches.<sup>17</sup>

Lowe et al.<sup>3</sup> proposed the transfer of branches from the median nerve to the FDS to reinitiate the PIN; since the FDS branch is an antagonist of the digital extensors, the result of this procedure was unsatisfactory. Ray and Mackinnon<sup>4</sup> subsequently transferred the branch of the MN to the FCR to the PIN, and achieved positive clinical results in 18 of the 19 patients, considering synergistic relationships of this transfer. Recovery of motor function tends to be better after radial nerve injury than median or ulnar nerve injury, largely because it is composed mainly of motor fibers and innervates only the extrinsic muscles.<sup>18</sup>

The transfer of the branch of the median nerve leading to the FCR provides several advantages. Firstly, it reduces the distance between the donor and recipient branches, facilitating a faster recovery than nerve suture or graft. Secondly, wrist extension function is maintained by the action of the extensor carpi ulnaris, which receives innervation from the ulnar nerve. Thirdly, the branches of the FCR and PIN are motor nerve branches, although the PIN contains sensory axons, most of them are motor axons.<sup>2,4</sup>

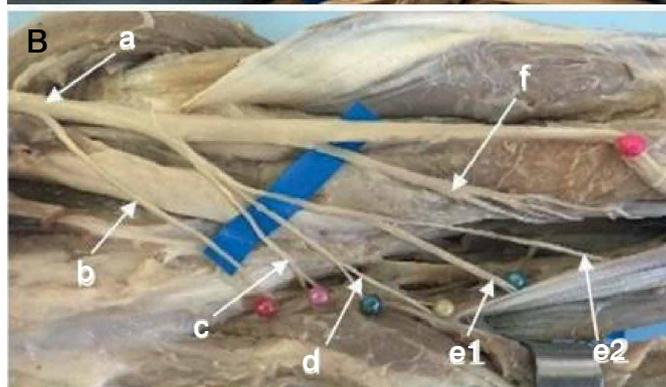
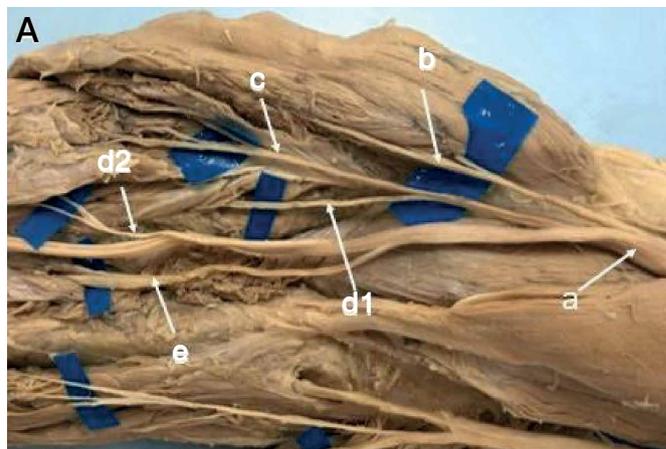
In this anatomical study we adopted the following procedure:<sup>2</sup> the branch for the FCR muscle was sectioned at the neuromuscular junction and directed laterally to be connected to the PIN. The sectioning of the latter depends on each situation, and must be decided during the surgical procedure. In 12 limbs we noticed



**Figure 3.** A. (a) median nerve; (b1) branch to the ulnar head of the pronator teres; (b2) branch to the humeral head of the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e) branch to the flexor digitorum superficialis; (f) anterior interosseous nerve. B. (a) median nerve; (b) branch to the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e1) first branch to the flexor digitorum superficialis; (e2) second branch to the flexor digitorum superficialis (f) anterior interosseous nerve.

that the branch of the FCR was of sufficient length to reach the PIN distally to the point of origin of the branches to the SM, free of tension even with forearm and elbow movements (Figure 5A), and with the advantage that donor nerve axons were not wasted in the unnecessary innervation of the SM, because due to its anatomical characteristics, this muscle is not used in tendon transfers and supination is maintained by the action of the biceps brachii (BB). In 18 limbs the branches to the SM (usually two or more branches) were sectioned to allow the PIN to be moved medially to shorten the distance, in order to make the connection to the branch of the FCR. The SM was sectioned longitudinally, following the course of the PIN, from the Arcade of Frohse to the distal margin of the SM. In this way, the PIN was released and could be mobilized medially towards the branch of the FCR and connected without tension (Figure 5B).

This mobilization is facilitated by the sectioning of the branches leading to the SM, which tend to retain the PIN nerve, restricting its excursion towards the median nerve. The sectioning of the branches leading to the SM also allows all the PIN axons to be directed to muscle groups that provide wrist and finger extension, avoiding the loss of critical axons in redundant functions, since the supination function is preserved by the action of the biceps brachii. The branch to the FCR muscle is sectioned as long as possible and innervated as much as possible without damaging



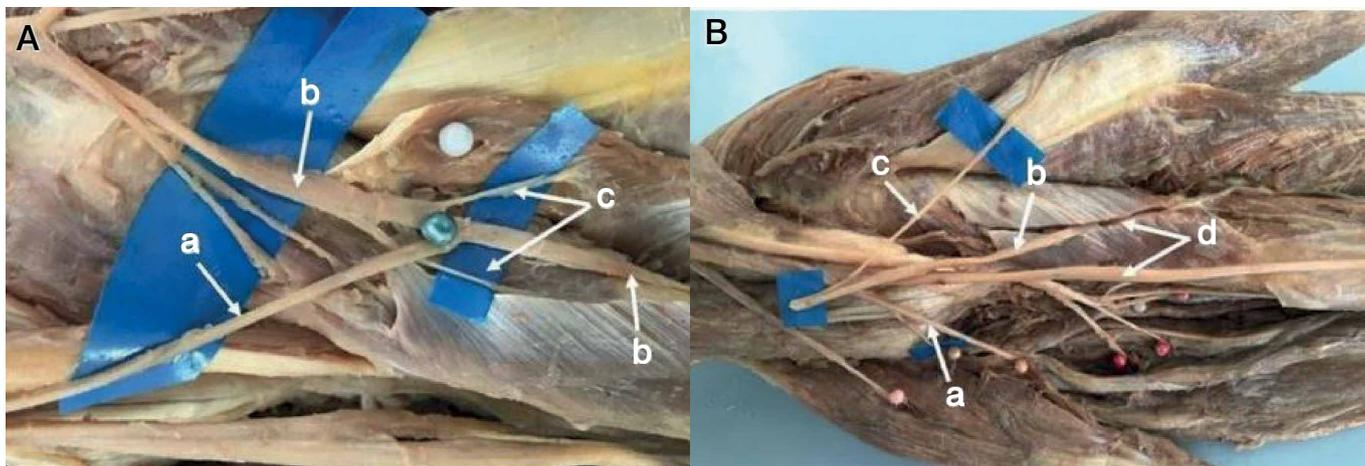
**Figure 4.** A. (a) median nerve; (b) branch to the pronator teres; (c) branch to the flexor carpi radialis; (d) branch to the flexor digitorum superficialis; (e) anterior interosseous nerve; palmaris longus absent. B. (a) median nerve; (b) branch to the pronator teres; (c) branch to the palmaris longus; (d) branch to the flexor carpi radialis; (e1) first branch to the flexor digitorum superficialis; (e2) second branch to the flexor digitorum superficialis (f) anterior interosseous nerve.

**Table 2.** Distribution of branches of the FCR muscle, according to number of branches and sharing of innervation with branches to other muscles.

	Branches			No Sharing						Sharing	Limbs	Absent
	1	2	3		PTM	PL	FCR	FDS	AIN			
FCR	30	-	-	3	8	8	---	3	---	PTM+PL+FDS (3) PTM+PL (3) FDS+AIN (2)	30	0

its axons. To favor axon regeneration, it is desirable to perform nerve cooptation, as close as possible to the target muscle, without tension in the sutures. Sukegawa et al.<sup>2</sup> recommends that once the meeting point between donor and recipient has been identified, the latter should be sectioned 5mm proximal to this point in order to avoid tension in the suture thread. This was done, thus imitating the in vivo procedure in cadaver limbs. It is possible to combine this with the transfer of the nerve to the PL to the FCR, increasing the availability of donor axons. The disadvantage is that an important source of potential subsequent tendon transfer is lost.

We identified that the mean diameter of the branch leading to the FCR muscle recorded in 14 limbs was  $1.5 \pm 0.4$ , which corresponds to 50% of the diameter of the PIN was  $3.0 \pm 0.5$  in 30 limbs. Several studies described in the literature show that nerve transfers of branches with considerable difference in diameter and of nerve



**Figure 5.** A. In 12 limbs we were able to connect the branch leading to the flexor carpi radialis (a) to the interosseous nerve (b), distally to the branches to the supinator muscle (c) without tension, even during forearm pronosupination and elbow flexion/extension movements. B. In 18 limbs it was necessary to mobilize the posterior interosseous nerve (b) for the connection with the branch to the flexor carpi radialis muscle (a); branch to the extensor carpi radialis brevis (c); supinator muscle (d).

fibers provide good results. De Medinaceli<sup>19</sup> believes that the reinnervation of 20-30% of muscle fibers is compatible with normal muscle function. Jiang et al.<sup>20</sup> state that the axons in the proximal stump can multiply up to 3- to 4-fold. Therefore, the donor nerve must have at least 30% of the number of axons of the recipient nerve. Sukegawa et al.<sup>2</sup> describe in their studies that the branch of the MN to the FCR contained approximately 30% of the number of axons in the PIN, which is theoretically sufficient to achieve its good recovery. Other factors support the justification for this nerve transfer, even if the mean diameter of the branch of the MN to the FCR muscle is 50% of the mean diameter of the PIN, for instance,

muscle strength required for finger and thumb extension is minimal, since we need little strength to open our hand, the muscle strength required for gripping is greater than for release.<sup>7</sup>

## CONCLUSIONS

The FCR muscle received exclusive innervation from the median nerve. In 25 limbs (83%), from a common trunk with branches to other muscles of the forearm, we observed that in 12 limbs, the branch leading to the FCR could be connected to the PIN, distally to the branches to the SM, even during the forearm and elbow movements. In 18 limbs it was necessary to mobilize the PIN for this connection.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. LM (0000-0002-6263-2527)\*, KKO (0000-0002-9814-4912)\* and EBSB (0000-0002-6887-2185)\* bibliographical survey and assistance in the anatomical dissections; RGS (0000-0003-0164-3596)\* analysis of results and writing of the article; LAV (0000-0003-4406-2492)\* writing of the article and photographic documentation. EBC (0000-0003-4572-3854)\* was present in all the dissections, writing and revision of the article, analysis of results and intellectual concept of the article and creation of the entire research project. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

- Pet MA, Lipira AB, Ko JH. Nerve transfers for the restoration of wrist, finger, and thumb extension after high radial nerve injury. *Hand Clin.* 2016;32(2):191-207.
- Sukegawa K, Suzuki T, Ogawa Y, Kobayashi T, Matsuura Y, Kuniyoshi K. A cadaver study of median-to-radial nerve transfer for radial nerve injuries. *J Hand Surg Am.* 2016;41(1):20-6.
- Lowe JB III, Sen SK, Mackinnon SE. Current approach to radial nerve paralysis. *Plast Reconstr Surg.* 2002;110(4):1099-113.
- Ray WZ, Mackinnon SE. Clinical outcomes following median to radial nerve transfers. *J Hand Surg Am.* 2011;36(2):201-8.
- Bincz LE, Cherifi H, Alnot JY. [Palliative tendon transfer for reanimation of the wrist and finger extension lag. Report of 14 transfers for radial nerve palsies and 10 transfers for brachial plexus lesions]. *Chir Main.* 2002;21(1):13-22.
- Plate JF, Ely LK, Pulley BR, Smith BP, Li Z. Combined proximal nerve graft and distal nerve transfer for a posterior cord brachial plexus injury. *J Neurosurg.* 2013;118(1):155-9.
- Bertelli JA, Kechele PR, Santos MA, Besen BAMP, Duarte H. Anatomical feasibility of transferring supinator motor branches to the posterior interosseous nerve in C7-T1 brachial plexus palsies. Laboratory investigation. *J Neurosurg.* 2009;111(2):326-31.
- Ustün ME, Ogun TC, Büyükmumcu M. Neurotization as an alternative for restoring finger and wrist extension. *J Neurosurg.* 2001;94(5):795-8.
- Ukrit A, Leechavengvongs S, Malungpaishrope K, Uerpaiojkit C, Chongthammakun S, Witoonchart K. Nerve transfer for wrist extension using nerve to flexor digitorum superficialis in cervical 5, 6, and 7 root avulsions: anatomic study and report of 2 cases. *J Hand Surg Am.* 2009;34(9):1659-66.
- Paturet G. *Traité d'anatomie humaine.* Paris: Masson; 1954.
- Rouviere H, Delmas A. *Anatomie humaine.* Paris: Masson; 1984.
- Sunderland S, Ray LJ. Metrical and non-metrical features of the muscular branches of the median nerve. *J Comp Neurol.* 1946;85:191-203.
- Canovas F, Moulliferon P, Bonnel F. Biometry of the muscular branches of the median nerves to the forearm. *Clin Anat.* 1998;11(4):239-45.
- Chantelot C, Feugas C, Guillem P, Chapnikoff D, Rémy F, Fontaine C. Innervation of the medial epicondylar muscles: an anatomic study in 50 cases. *Surg Radiol Anat.* 1999;21(3):165-8.
- Zawawy EME, Sekily NME, Fouad WA, Emam MH, Hassan MM. Median nerve motor entry points in the forearm: clinical application. *Eur J Anat.* 2016;20(1):1-17.
- Blair W, Joos K. The innervation of the flexor carpi radialis: and interfascicular dissection. *Arch Neurol.* 1982;39(10):647-9.
- Brown JM, Tung TH, Mackinnon SE. Median to radial nerve transfer to restore wrist and finger extension: technical nuances. *Neurosurgery.* 2010;66(3 Suppl Operative):75-83.
- Guerra WK, Baldauf J, Schroeder HW. Long-term results after microsurgical repair of traumatic nerve lesions of the upper extremities. *Zentralbl Neurochir.* 2007;68(4):195-9.
- De Medinaceli L, editor. *Cell surgery to repair divided nerves.* New York: CASIS-CID; 1994
- Jiang BG, Yin XF, Zhang DY, Fu ZG, Zhang HB. Maximum number of collaterals developed by one axon during peripheral nerve regeneration and the influence of that number on reinnervation effects. *Eur Neurol.* 2007;58(1):12-20.

# NECROSIS OF THE FEMORAL HEAD AND HEALTH-RELATED QUALITY OF LIFE OF CHILDREN AND ADOLESCENTS

## NECROSE DA CABEÇA DO FÊMUR E QUALIDADE DE VIDA RELACIONADA À SAÚDE DE CRIANÇAS E ADOLESCENTES

MARCOS ALMEIDA MATOS<sup>1,2</sup>, LUANNE LISLE DOS SANTOS SILVA<sup>2</sup>, GIORDANO BRUNO ALVES<sup>1</sup>, WALTER SILVA DE ALCÂNTARA JÚNIOR<sup>2</sup>, DAVI VEIGA<sup>3</sup>

1. Escola Bahiana de Medicina e Saúde Pública, Salvador, BA, Brazil.

2. Santa Casa de Misericórdia da Bahia, Salvador, BA, Brazil.

3. Hospital das Clínicas da Universidade Federal da Bahia, Salvador, BA, Brazil.

### ABSTRACT

**Objective:** To verify the impact of avascular necrosis of the femoral head on the quality of life of children and adolescents with Perthes disease and sickle cell disease. **Methods:** A comparative study including 24 children between eight and 18 years old with avascular necrosis of the femoral head secondary to Perthes disease and sickle cell disease (Group with Necrosis) and 24 children considered asymptomatic (Group without Necrosis). Clinical and sociodemographic data were collected and the PedsQL 4.0 and the Charnley score for hip dysfunction were applied. **Results:** There was no difference in the overall score and in any domain when comparing the Perthes group (global = 73.1) and the sickle cell disease group (global = 65.9). When comparing the groups with necrosis and without necrosis, the Perthes group had a lower overall score only for the Physical Functioning domain (87.5 versus 68.5); sickle cell disease group had a lower overall score (64.9 versus 79.4) and in the Physical Functioning (68.5 versus 87.5) and School Functioning (62.9 versus 73.7) domains. **Conclusion:** Avascular necrosis of the femoral head produces lower quality of life scores both in the global evaluation and in the domains Physical Functioning and School Functioning. Necrosis, bilateral lesion, and hip function were found to be associated with the loss of quality of life. **Level of Evidence III, Sectional comparative study.**

**Keywords:** Hip. Quality of life. Femur head necrosis.

### RESUMO

**Objetivo:** Verificar o impacto da necrose avascular da cabeça do fêmur sobre a qualidade de vida de crianças e adolescentes com doença de Perthes e anemia falciforme. **Métodos:** Estudo comparativo com 24 crianças entre oito e 18 anos com necrose avascular da cabeça do fêmur secundária à doença de Perthes e à anemia falciforme (grupo com necrose) e 24 crianças consideradas assintomáticas (grupo sem necrose). Foram coletados dados clínicos e sociodemográficos e aplicado o instrumento PedsQL 4.0 e o escore de Charnley para disfunção do quadril. **Resultados:** Não houve diferença no escore global e em nenhum domínio comparando os grupos Perthes (global = 73,1) e anemia falciforme (global = 65,9). Quando comparados os grupos sem necrose e com necrose, nota-se que o grupo Perthes tem escore inferior apenas para o domínio Capacidade Física (87,5 versus 68,5); já o grupo anemia falciforme tem escore global inferior (64,9 versus 79,4) e também nos domínios Capacidade Física (68,5 versus 87,5) e Aspecto Escolar (62,9 versus 73,7). **Conclusão:** A necrose avascular da cabeça do fêmur produz escores de qualidade de vida inferiores tanto na avaliação global, como nos domínios Capacidade Física e Aspecto Escolar. Foram identificadas presença de necrose, lesão bilateral e função do quadril como fatores associados à perda de qualidade de vida. **Nível de evidência III, Estudo seccional comparativo.**

**Descritores:** Quadril. Qualidade de vida. Necrose da cabeça do fêmur.

**Citation:** Matos MA, Silva LLS, Alves GB, Alcântara Jr WS, Veiga D. Necrosis of the femoral head and health-related quality of life of children and adolescents. *Acta Ortop Bras.* [online]. 2018;26(4):227-30. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Avascular necrosis of the femoral head is a chronic, degenerative and progressive disorder that mainly affects young people.<sup>1,2</sup> Its physiopathology is characterized by the reduction or suppression of the blood supply to the femoral head with consequent loss of the trabecular architecture, causing subchondral bone collapse and secondary destructive arthropathy in up to 80% of cases.<sup>1,2</sup> Two clinical entities in particular are recognized as a common cause of

femoral head necrosis in the pediatric population: Perthes (Legg-Calve-Perthes) and sickle cell disease (or anemia).<sup>2,3,4</sup> Perthes disease represents idiopathic childhood avascular necrosis of the femoral head, and is recognized as the only primary form of this condition.<sup>1,2</sup> Sickle cell anemia is a hematologic disease in which normal hemoglobin is genetically replaced by sickle hemoglobin.<sup>4</sup> Vaso-occlusive phenomena are responsible for a high percentage of complications arising from sickle cell disease, including avascular

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

Work conducted at the Escola Bahiana de Medicina e Saúde Pública/Santa Casa de Misericórdia da Bahia and at the Hospital das Clínicas da Universidade Federal da Bahia. Correspondence: Rua da Ilha, 378, Itapua, Salvador-Bahia-Brazil. 41620-620. [marcos.almeida@hotmail.com](mailto:marcos.almeida@hotmail.com)

Article received in 01/09/2017, approved in 04/05/2018.

Acta Ortop Bras. 2018;26(4):227-30



necrosis of the femoral head itself. The prevalence of the latter in the pediatric population is around 12%.<sup>3</sup> Hip involvement due to osteonecrosis in these two clinical entities involves complex, long-term treatment that often requires surgical procedures, leading to some degree of functional limitation and pain.<sup>1,2,3,4</sup> This set of symptoms, in turn, has all the elements required to produce socioemotional disturbances and human suffering with impacts on the quality of life of individuals.

Avascular necrosis of the femoral head has traditionally had its diagnosis, treatment, and prognosis based solely on clinical orthopedic criteria and on medical imaging.<sup>5</sup> These objective criteria, however, are not able to reflect the true impact that the condition has on the quality of life of the affected subjects. The social, economic and cultural context of patients are essential factors for defining the disease from the subjective perspective of the person who experiences it, also aiding in clinical decision making based on the expectations of the people to be treated. Nevertheless, studies assessing the impact of avascular necrosis of the femoral head on health-related quality of life (HRQoL) are still rare, especially in the pediatric population.<sup>3,4,6</sup>

In view of the above, this study aims at verifying the impact caused by avascular necrosis of the femoral head on health-related quality of life of children and adolescents, evidencing differences between patients with Perthes and sickle cell disease.

## MATERIALS AND METHODS

A comparative cross-sectional study was conducted on the quality of life of children and adolescents with avascular necrosis (AVN) of the femoral head. Pediatric patients with a previous radiographic diagnosis of avascular necrosis of the femoral head monitored in the Pediatric Orthopedic outpatient department of the hospital were labeled the affected group (Group with Necrosis). The Group with Necrosis was further split into two subgroups according to the AVN etiology; therefore, subjects with Perthes disease were separated into one subgroup and those with sickle cell anemia (homozygous) were separated in another, both previously diagnosed in a conventional manner. The unaffected group (Group without Necrosis), composed of subjects who were also in the pediatric age group, were asymptomatic and came from a municipal public school in the same city.

The research study was carried out from September 2012 to October 2015, following approval by the Institutional Review Board of Hospital Santa Izabel according to protocol 89/2012. Parents or guardians of subjects who participated in the study were advised of the research objectives and procedures, and those who agreed to participate signed the Informed Consent Form (ICF).

Children with clinically and radiographically confirmed osteonecrosis of the femoral head, secondary to two exclusive etiologies, Perthes disease and sickle cell disease, were included in the group of cases (Group with Necrosis). Only those aged between eight and 18 years were included in the research project. The selected age belongs to the juvenile age group,<sup>4</sup> with estimated ability to comprehend and answer the quality of life questionnaires used in the study (PedsQL 4.0).<sup>7,8</sup> Subjects who did not have adequate cognition and those with neurological sequelae, other important musculoskeletal diseases, or other conditions with systemic repercussions were excluded.

The radiographic diagnosis in the Group with Necrosis was performed using anteroposterior and lateral (or frog-leg) radiographs, and the avascular necrosis was considered and classified by three specialists in Pediatric Orthopedics according to the Bucholz-Ogden criteria.<sup>3</sup> The Group without Necrosis was formed by children considered healthy and aged between eight and 18 years, selected at a public

school, whose sociodemographic characteristics were similar to those of the Group with Necrosis. All selected individuals underwent clinical orthopedic assessments to ensure absence of signs and symptoms of hip dysfunction, and no radiographic assessments were performed in this group for ethical reasons.

The sample size estimate was 12 subjects per group, calculated to detect a difference of 10 points, considering a standard deviation of 17.1 for quality of life,<sup>4</sup> 5% alpha errors with 90% test power and estimated loss of 10%. The participants were divided into two groups, called Group without Necrosis and Group with Necrosis, and the Group with Necrosis was subdivided into two others, composed of 12 individuals each. These subgroups represented 12 children with Perthes disease (Perthes Group) and 12 children with sickle cell disease (Sickle Cell Group). For this reason, 24 subjects were selected for the Group without Necrosis in order to match the number of participants in both groups (with and without necrosis).

After selection and inclusion, all subjects participating in the study had their clinical and sociodemographic data collected through a standardized collection instrument for the study that contained information regarding age, sex, weight, height, race (self-defined), origin, schooling (in years of study), etc. The following questionnaires were also applied: PedsQL 4.0 to assess Quality of Life in the studied age groups;<sup>7,8,9</sup> and the Charnley-modified hip score to assess hip dysfunction.<sup>10</sup> PedsQL 4.0 was used following authorization from the Research Trust in the Brazilian Portuguese version specifically developed for the juvenile population, with defined and validated intervals.<sup>9</sup>

The Charnley-modified Hip Score was used for quantitative and qualitative assessment of the state of the hip joint.<sup>10</sup> This score assess range of motion, level of pain and gait, totaling 18 points in a clinically normal hip, with lower scores indicating hip dysfunction. Although this score was designed for adults, it has already been tested effectively in the pediatric population.<sup>10,3,4</sup>

The PedsQL 4.0 questionnaire is a widely divulged instrument for assessing the quality of life of children and adolescents, using questionnaires for ages ranging from 8 to 12 and from 13 to 18 years.<sup>7,8,9</sup> All children were assessed and had their quality of life quantified by the PedsQL 4.0 instrument. PedsQL 4.0 can be self-completed by research subjects, but the authors decided to have completion and collection take place in the form of an interview, due to the low socioeconomic and educational level expected for the two groups.<sup>4,7,8,9</sup>

Answers based on the items of the PedsQL 4.0 questionnaire scales are classified as follows: Never, Almost never, Sometimes, Often, and Almost always. However, for the quantitative analysis these answers were reclassified into numerical values (100, 75, 50, 25, 0, respectively). Thus, the value obtained for each scale resulted from the arithmetic mean of the individual questions. The analysis of Health-Related Quality of Life (HRQL) was interpreted based on the values achieved: the higher the value, the better the quality of life and vice versa.<sup>7,8,9</sup>

The descriptive presentation of continuous data in mean and standard deviation was used for statistical analysis, while discrete variables were presented in frequency. To compare the variables between the two main groups (patient with or without AVN of the femoral head) we used the chi-square test for discrete variables and the t-test for continuous variables. For the comparison between the three groups (without necrosis, Perthes and sickle cell disease) we used analysis of variance with Tukey's post-hoc test. When factors associated with quality of life were identified in the univariate analysis, a multivariate analysis was performed by logistic regression in search of confounding factors.

## RESULTS

The study sample showed itself to be homogeneous in all the sociodemographic aspects analyzed, except in the Charnley score and in the classification of necrosis, which, as they are variables related to the presence of necrosis, were different in the intergroup comparison (Table 1).

Two types of comparisons were made with the results obtained for the quality of life assessment. The first was between the three groups, namely Group without Necrosis, Perthes Group and Sickle Cell Group (Table 2). This was followed by a comparison between the Group without Necrosis and the Group with Necrosis, where the latter was composed of the sum of the Perthes and Sickle Cell groups (Table 3). No multivariate evaluation was performed in the first analysis because of the low statistical power, whereas in the second comparison, the sum of the last two groups conferred sufficient power to create the multivariate models.

There was no statistically significant difference in the overall score and in any scale when we compared the Perthes group to the group with sickle cell disease. We when compare the two groups with the control group it can be noted that the Perthes group has a lower score only for the Physical Functioning scale; the sickle cell group has a lower overall score and lower scores also in the Physical Functioning and School Functioning scales. See Table 2. There was a statistically significant difference between the two groups (with and without necrosis) in the overall quality of life score and in the Physical Functioning and School Functioning scales. See Table 3.

The following factors were included in the model in the multivariate analysis of physical functioning: group, sex, age, BMI, race, schooling, hip surgery, laterality, mean Charnley score and radiographic classification of necrosis. Predictors were group (0.012), hip surgery (0.104), laterality (0.010), and mean Charnley score (0.004). Group (0.019; -0.466), laterality (0.021; -0.453), and mean Charnley score (<0.001; 0.703) were independent predictors in the final model.

The following factors were included in the model in the multivariate analysis of School Functioning: group, sex, age, BMI, race,

**Table 1.** Sociodemographic characteristics of the sample, comparing patients with and without avascular necrosis of the femoral head.

Characteristic	Group without necrosis N or mean (standard deviation)	Group with necrosis N or mean (standard deviation)	P
Age	10.6 (2.4)	11.1 (3.5)	0.601
BMI	18.4 (3.9)	18.5 (4.2)	0.970
Sex			0.763
Male	16	15	
Female	8	9	
Race			0.345
Black	10	6	
Mixed-race	11	16	
White	3	2	
Laterality	-		-
Unilateral	-	18	
Bilateral	-	6	
Charnley Score	18	16.2(2.1)	<0.001
Classification of			-
Necrosis	-	6	
Type I	-	8	
Type II	-	7	
Type III	-	3	
Type IV			

**Table 2.** Quality of life scores comparing the group without necrosis to the Perthes and Sickle Cell groups with avascular necrosis of the femoral head.

Quality of life	Group without necrosis mean (standard deviation)	Perthes group mean (standard deviation)	Sickle cell group mean (standard deviation)	P
Total	79.4 (10.9) <sup>1</sup>	73.1 (22.9)	65.9 (12.7) <sup>1</sup>	0.048
Physical Functioning	87.5 (6.9) <sup>2,3</sup>	68.5 (31.8) <sup>2</sup>	65.1 (19.3) <sup>3</sup>	0.002
Emotional Functioning	65.2 (15.1)	75.1 (27.6)	67.5 (13.5)	0.337
Social Functioning	86.9 (15.1)	80.8 (19.4)	77.9 (16.8)	0.279
School Functioning	73.7 (17.2) <sup>4</sup>	72.1 (26.2)	53.7 (17.2) <sup>4</sup>	0.018

1 = 0.039; 2 = 0.019; 3 = 0.005; 4 = 0.017.

**Table 3.** Quality of life scores comparing the group without necrosis to the group with avascular necrosis of the femoral head.

Quality of life	Group without necrosis mean (standard deviation)	Group with necrosis mean (standard deviation)	P
Total	79.4 (10.9)	69.4 (18.5)	0.02
Physical Functioning	87.5 (6.9)	66.8 (25.8)	<0.01
Emotional	65.2 (15.1)	71.2 (21.6)	0.26
Functioning	86.9 (15.1)	79.4 (17.8)	0.12
Social Functioning	73.7 (17.2)	62.9 (23.6)	0.07
School Functioning			

schooling, hip surgery, laterality, mean Charnley score and radiographic classification of necrosis. Predictors were group (0.001) and sex (0.034). Only group (0.008; -0.387) remained as independent associated predictor in the final model.

The following factors were included in the model in the multivariate analysis of Social Functioning: group, sex, Age, BMI, race, schooling, hip surgery, laterality, mean Charnley score and radiographic classification of necrosis. BMI was the predictor (0.026).

## DISCUSSION

The findings of this study demonstrated that the health-related quality of life of children and adolescents affected by avascular necrosis of the femoral head have significantly worse scores, both overall and in the Physical Functioning and School Functioning scales. The isolated analysis of patients with Perthes disease, however, differed in the quality of life scores from those whose necrosis was a result of sickle cell anemia. Perthes disease was only able to significantly decrease the Physical Functioning scale, while sickle cell disease was able to decrease the overall score as well as the Physical Functioning and School Functioning scales.

The multivariate analysis showed that patients with avascular necrosis of the femoral head had the decrease in the Physical Functioning scale directly influenced by the presence of sickle cell disease, presence of bilateral injury, and by greater hip dysfunction (Charnley score). In the case of the School Functioning scale, two factors were associated, sickle cell disease and sex, but only the presence of sickle cell disease was able to lower the score obtained. Quality of life and suffering are two variables that are usually inversely correlated. Avascular necrosis of the femoral head is a chronic condition that severely affects hip function, leading to physical limitation, pain, prolonged treatment and human suffering.<sup>1,2,3,5</sup> These findings are consistent with studies showing that pain and function are directly associated with diminished quality of life of the pediatric population in general.<sup>11</sup> In our results, Physical Functioning was the scale that most strongly affected quality of life, and pain

was the characteristic that contributed most to the drop in the Charnley hip score.

Pediatric patients with chronic diseases usually have a consistently poorer quality of life than that of the healthy juvenile population. Osteonecrosis of the femoral head is also associated with chronic diseases that have already been proven capable of producing loss of quality of life, such as sickle cell anemia.<sup>3</sup> In these diseases, children usually undergo multiple clinical and surgical treatments, which may result in marked functional loss, dissatisfaction, physical, financial and emotional strain.<sup>12,13,14</sup>

Dale et al. 2011<sup>15</sup> assessed quality of life in 127 children and adolescents with sickle cell anemia and found an overall score of 68.6 points using PedsQL 4.0 as a measurement instrument. These authors confirmed significant loss of quality of life in sickle cell disease in all the scales studied compared to healthy subjects. Malheiros et al. 2015<sup>4</sup> studied the quality of life of patients with sickle cell anemia and simultaneously subjects with hip dysfunction; the results indicated an even lower overall score of around 58.57 points, and pain was present in 58.8% of patients with dysfunction. Our patients, however, provided evidence of poorer quality of life than children with sickle cell anemia. This data points to a potentially devastating role that necrosis of the femoral head may play when it appears in the course of this chronic disease, especially as it affects the physical ability of individuals and produces pain that persists for long periods of time.

Our findings also point to the confirmation that necrosis of the femoral head is capable of individually promoting loss of quality of life, even in cases regarded as less severe. Study participants who had osteonecrosis and associated sickle cell disease were among those with the worse HRQL scores, but significantly lower scores were also found in patients with Perthes disease, which is traditionally considered to be "silent" or asymptomatic after the acute phase.

The multivariate analysis also demonstrated that the presence of necrosis, bilateral disease and low hip scores, irrespective of other associated factors, were independent predictors for loss of HRQoL in the population studied.

To the best of our knowledge, there is no similar study with avascular necrosis of the femoral head in pediatric patients that can serve as a comparison. Hailer et al. conducted a health-related quality of life study in patients with Perthes disease in 2014<sup>6</sup>. Although this study was conducted in adults, the authors confirmed lower quality of life scores in this group of subjects versus the general population; this decrease was significantly different particularly in the mobility, usual activities, and pain scales.

Our study represents an original contribution to the subject of avascular necrosis of the femoral head in children, especially from the point of view of the medical assessment based on the perception of the subject. Our data allowed us to confirm the hypothesis that pediatric patients with avascular necrosis of the femoral head have lower quality of life scores than healthy children, both in the overall assessment and in the Physical Functioning and School Functioning scales. Secondly, we also identified predictors associated with the loss of quality of life in these patients, namely presence of necrosis, bilateral injury and hip function (Charnley score).

## CONCLUSIONS

Avascular necrosis of the femoral head is capable of adversely affecting the quality of life of children and adolescents with Perthes and sickle cell disease. When compared to healthy children, patients with Perthes disease have lower quality of life scores only in the Physical Functioning scale, whereas patients with sickle cell disease have a greater impact, with lower scores both overall and in the Physical Functioning and School Functioning scales.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. MAM (0000-0002-3592-986X)\*: Intellectual concept of the article and drafting of the entire research project, collection and analysis of data, writing of the article and revision; LLSS (0000-0002-0745-8992)\* : Intellectual concept of the article and drafting of the entire research project, collection and analysis of data, revision; GBA(0000-0002-9450-1513)\*: Intellectual concept of the article, collection and analysis of data, writing of the article, and revision; WSAJ (0000-0001-9621-6380)\*: Intellectual concept of the article, collection and analysis of data, writing of the article, and revision; DV(0000-0001-7595-9011)\*: Intellectual concept of the article, writing of the article, and revision. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Wiig O, Terjesen T, Sverningsen S. Prognostic factors and outcome of treatment in Perthes' disease. *J Bone Joint Surg.* 2008;90(10):1364-71.
2. Cheng JC, Lam TP, Ng BK. Prognosis and Prognostic Factors of Legg-Calve-Perthes Disease. *J Pediatr Orthop.* 2011;31(2 Suppl):147-51.
3. Matos MA, Silva LLS, Fernandes RB, Malheiros CD, Silva BVP. Avascular necrosis of the femoral head in sickle cell disease patients. *Ortop Traumatol Rehabil.* 2012;14(2):155-60.
4. Malheiros CD, Lisle L, Castelar M, Sá KN, Matos MA. Hip Dysfunction and Quality of Life in Patients With Sickle Cell Disease. *Clin Pediatr (Phila).* 2015;54(14):1354-8.
5. Zhao FC, Li ZR, Zhang NF, Wang BL, Sun W, Cheng LM, et al. Lesion size changes in osteonecrosis of the femoral head: a long-term prospective study using MRI. *Int Orthop.* 2010;34(6):799-804.
6. Hailer YD, Haag AC, Nilsson O. Legg-Calvé-Perthes Disease: Quality of Life, Physical Activity, and Behavior Pattern. *J Pediatr Orthop.* 2014;34(5):514-21.
7. Varni JW, Seid M, Rode CA. The PedsQL: measurement model for the pediatric quality of life inventory. *Med Care.* 1999;37(2):126-39.
8. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory Version 4.0 generic Core Scales in healthy and patient populations. *Med Care.* 2001;39(8):800-12.
9. Klatchoian DA, Len CA, Terreri MT, Silva M, Itamoto C, Ciconelli RM, et al. Quality of life of children and adolescents from São Paulo: Reliability and validity of the Brazilian version of the Pediatric Quality of Life Inventory™ version 4.0 Generic Core Scales. *J Pediatr (Rio J).* 2008;84(4):308-15.
10. Charnley J. The Long-term results of low-friction arthroplasty of the hip performed as a primary intervention. *J Bone Joint Surg Br.* 1972;54(1):61-76.
11. Fisak B, Belkin MH, Von Lehe AC, Bansal MM. The relation between health-related quality of life, treatment adherence and disease severity in a paediatric sickle cell disease sample. *Child Care Health Dev.* 2011;38(2):204-10.
12. Roposch A, Liu LQ, Offiah AC, Wedge JH. Functional outcomes in children with osteonecrosis secondary to treatment of developmental dysplasia of the hip. *J Bone Joint Surg Am.* 2011;93(24):e145.
13. Unal VS, Gulceck M, Soydan Z, Ucaner A, Yazici M. Assessment of quality of life in children after successful treatment of hip dysplasia as compared with normal controls. *Saudi Med J.* 2006;27(8):1212-6.
14. Krebs A, Strobl WM, Grill F. Neurogenic hip dislocation in cerebral palsy: quality of life and results after hip reconstruction. *J Child Orthop.* 2008;2(2):125-131.
15. Dale JC, Cochran CJ, Roy L, Jernigan E, Buchanan GR. Health-related quality of life in children and adolescents with sickle cell disease. *J Pediatr Health Care.* 2011;25(4):208-15.

# PRELIMINARY MECHANICAL TEST OF PROXIMAL FEMUR REINFORCEMENT WITH CEMENTED X-SHAPED PMMA

## ENSAIO MECÂNICO PRELIMINAR DO REFORÇO FEMORAL PROXIMAL COM CIMENTO ÓSSEO EM FORMA DE "X"

ANDERSON FREITAS<sup>1</sup>, WELVIS SOARES CAMARGO<sup>2</sup>, RUBEN JERI AQUINO<sup>2</sup>, VINCENZO GIORDANO NETO<sup>3</sup>, ALUÍZIO FERNANDES BONAVIDES JUNIOR<sup>4</sup>, ANTÔNIO CARLOS SHIMANO<sup>5</sup>

1. Instituto de Pesquisa e Ensino do Hospital Ortopédico e Medicina Especializada (IPE-HOME), Brasília, DF, Brazil.

2. Hospital Regional do Gama (HRG), Brasília, DF, Brazil.

3. Hospital Municipal Miguel Couto (HMMC), Rio de Janeiro, RJ, Brazil.

4. Hospital das Forças Armadas (HFA), Brasília, DF, Brazil.

5. Department of Biomechanics, Medicine and Rehabilitation of the Locomotor Apparatus, Universidade de São Paulo (USP), Ribeirão Preto, SP, Brazil.

### ABSTRACT

**Objective:** To evaluate the mechanical behavior of the proximal end of the femur submitted to the X-shaped polymethylmethacrylate (PMMA) reinforcement technique. **Methods:** Fifteen synthetic femurs, with a Nacional<sup>®</sup> density of 10 PCF, were divided into two groups: the DX group, with 5 units that were submitted to PMMA reinforcement, and the DP group, with 10 units, which were evaluated intact. The volume of PMMA required, the maximum load, and the absorbed energy to fracture were analyzed by means of a static mechanical bending test simulating a fall on the greater trochanter. **Results:** A mean of 6 ml of PMMA was used to model the X-reinforcement; it was observed that the DX group presented significantly higher maximum load (median = 1553 N,  $p = 0.005$ ) and absorbed energy to fracture (median = 9.7 J;  $p = 0.050$ ) than the DP group (median = 905 N and 6.6 J). **Conclusion:** X-reinforcement of the proximal end of synthetic femurs showed a statistically significant increase in the maximum load and absorbed energy to fracture in the mechanical assay when compared to the control group. **Level of Evidence III, Experimental study.**

**Keywords:** Intertrochanteric fractures. Femur. Femoral fractures. Polymethylmethacrylate. Osteoporosis.

### RESUMO

**Objetivo:** Avaliar o comportamento mecânico da extremidade proximal do fêmur submetido à técnica de reforço com polimetilmetacrilato (PMMA) em forma de X. **Métodos:** Foram utilizados 15 fêmures sintéticos, com densidade de 10 PCF da Nacional<sup>®</sup>, divididos nos grupos DX, com 5 unidades submetidas ao reforço com PMMA, e DP com 10 unidades, avaliados com sua integridade intacta. Foram analisados o volume de PMMA necessário, os valores da carga máxima e a energia absorvida até a fratura por meio de ensaio mecânico estático de flexão, simulando queda sobre o trocanter maior. **Resultados:** Foram usados em média 6 ml de PMMA para a modelagem do reforço em X e observou-se que o grupo DX apresentou carga máxima (mediana = 1553 N;  $p = 0,005$ ) e energia absorvida até fratura (mediana = 9,7 J;  $p = 0,050$ ) significativamente maior que o grupo DP (mediana = 905 N e 6,6 J). **Conclusão:** O reforço em X da extremidade proximal de fêmures sintéticos apresentou incremento estatisticamente significativo da carga máxima e energia absorvida até a fratura no ensaio mecânico em comparação com o grupo controle. **Nível de evidência III, Estudo experimental.**

**Descritores:** Fratura intertrocanterica. Fêmur. Fraturas do fêmur. Polimetilmetacrilato. Osteoporose.

**Citation:** Freitas A, Camargo WS, Aquino RJ, Neto VG, Bonavides Jr. AF, Shimano AC. Preliminary mechanical test of proximal femur reinforcement with cemented x-shaped pmma. *Acta Ortop Bras.* [online]. 2018;26(4):231-5. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Osteoporosis is a public health problem worldwide, and is more prevalent among the elderly female population.<sup>1</sup> This disease is characterized by a reduction in bone mineral density, accompanied by a reduction in mechanical resistance of the bone. Its main factor of socioeconomic impact is the occurrence of low energy trauma fractures, and of these, fracture of the proximal femur (PF) is the one with the highest mortality rate.<sup>2</sup>

Mortality arising from fracture of the PF due to osteoporosis is as high as 30% the first post-operative year.<sup>3,4</sup> Patients who present fracture due to osteoporosis in this region have an increased risk of a new fracture in the same region of the contralateral hip in the two-year period following the first fracture, and this percentage can increase five years after the first episode.<sup>5</sup> The various therapeutic resources available are aimed at avoiding or reducing fractures due to osteoporosis of the PF. They can be

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

Work conducted by the orthopedics and traumatology services of Hospital Regional do Gama-DF and by the Instituto de Pesquisa e Ensino do Hospital Ortopédico e Medicina Especializada – IPE-HOME.  
Correspondence: SHCS 613 Conjunto C - Brasília, DF. 70200-730. [andfreitas28@gmail.com](mailto:andfreitas28@gmail.com)

Article received in 00/00/0000, approved in 00/00/0000.

Acta Ortop Bras. 2018;26(4):231-5



divided into nonpharmacological and pharmacological methods.<sup>6,7</sup> The methods have significant results, with a 40% to 60% reduction in the occurrence of fractures of the PF, although there are limiting factors to their use, and complete results. These include: lack of adhesion to treatment, side effects to the medications, adverse events, and difficulty of access by a large portion of the population.<sup>8,9,10</sup> As a result, around 50% of the population treated for osteoporosis is vulnerable to a new fracture of the PF due to interruption of the treatment.<sup>10</sup>

Reinforcing the osteoporotic PF, with the aim of increasing mechanical resistance in this region, using a method that targets the bone tissue, is presented in the literature by experimental studies using cadaver bones. Products used for the reinforcement are: elastomers (silicone), screws, calcium phosphate cement, and polymethylmethacrylate (PMMA), the latter being the most frequently used.<sup>11</sup> The majority of these products present favorable results in relation to properties of maximum load and absorbed energy for the occurrence of fracture of the PF.<sup>12-16</sup> However, questions remain relating to reinforcement PF, such as determining the best positioning to optimize biomechanical performance, and the volume of PMMA to be used.<sup>17</sup>

The aim of this work was to evaluate the mechanical behavior of the proximal femoral head with X-shaped polymethylmethacrylate (PMMA) reinforcement, created by the author and not previously described in the literature.

## MATERIALS AND METHODS

Fifteen synthetic polyurethane femurs were used for the mechanical essays, with density of 10PCF 10PCF (c-1010), obtained from Nacional<sup>®</sup>. The femoral used was 330 mm in diameter with diaphysis length of 45 mm. The femurs were divided into two groups; DP and DX. DP (n=5) is the control group with proximal femoral head intact. DX (n=10) is the group with femurs filled with PMMA in the trochanteric region and femoral neck. Next, two holes (PR) were made, denominated PR I and PR II.

Each PR of the DX group was prepared using a 220 x 2.5 mm steel guidewire, a 180 x 6mm cannulated drill, and a Stryker<sup>®</sup> model 120k electric motor. The holes were positioned as follows:

PR I – A point was marked on a line drawn on the longitudinal axis of the lateral surface of the synthetic model, 25 mm from the apex of the greater trochanter. From this point, another line was drawn, perpendicular to the first, 10 mm in the posterior direction, where the point of entry of the guidewire was established, (Figure 1a). The guidewire was introduced into this hole, using radioscopia, at an angle that enabled a straight line to be drawn through the two principal points – one in the central region of the middle third of the femoral neck and the other in the inferior anterior portion of the femoral head. (Figure 2a, b) Once the guidewire had been positioned, and its correct placement verified in the frontal and axial views, a 6 mm cannulated drill was used to create the PR 1 perforation.

PR II – At the entry point of the PR 1, a line was drawn parallel to the longitudinal axis of the lateral surface of the synthetic model, and as this line passed the apex of the greater trochanter, the point of entry of the PR II was determined. (Figure 1b) in the same plane of PR I, at an angle that enabled a straight line to be drawn between two principal points – the upper transition of the neck of the greater trochanter and PR I, crossing it. (Figure 3a, b) Having determined the correct positioning in the frontal and axial views, using radioscopia, this position was used as a guide to create the hole, using a 6 mm diameter cannulated drill.

After preparing the holes in the DX group, the PR I and II holes were filled in, model by model, with a unit of PMMA from the same

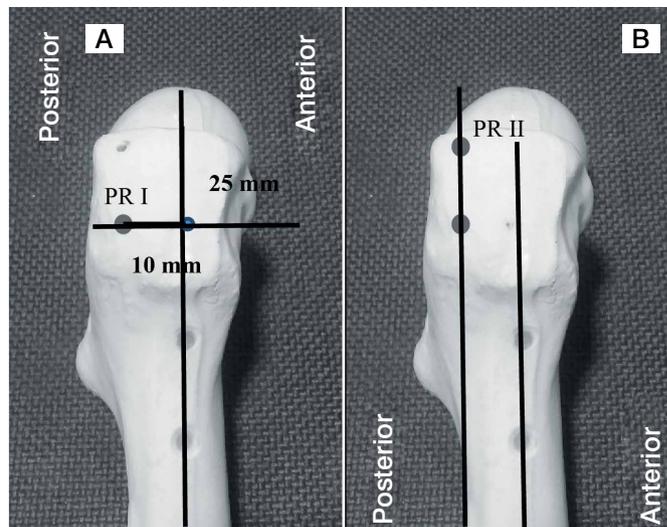


Figure 1. Images illustrating the locations and parameters of the entry points of PR I and PR II.

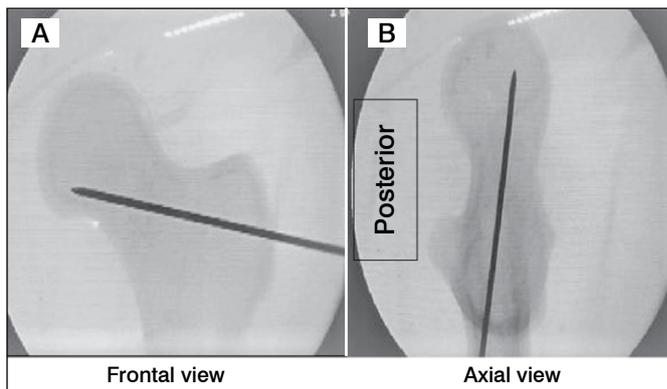


Figure 2. Radioscopic images and positioning of the guidewire, at their points of references for the preparation of PR I.

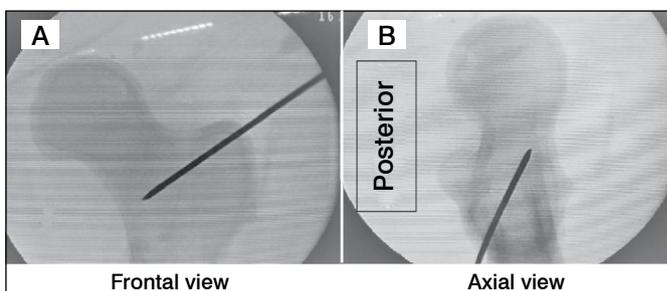


Figure 3. Radioscopic images of the positioning of the guidewire, at its points of reference, for the preparation of PR II.

manufacturer, of the Simplex P<sup>®</sup> brand, with the concentration and volume presented in its commercial kit. These were mixed manually to form a homogenous liquid, and transferred to a 20 ml syringe. Injection of the liquid into holes was anterograde, and complete filling was observed during the procedure using radioscopia. (Figure 4 a,b). The average volume of PMMA used was observed, and calculated by numbering the syringes and recording the amount used. For the mechanical assays, an MTS<sup>®</sup> (“Materials Testing System”) machine, model 810 – FlexTest 40 was used, from the laboratory of mechanical assays – Department of engineering and materials

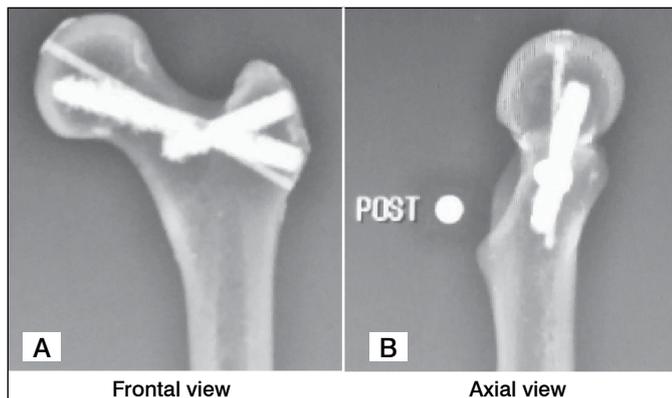
manufacture – UNICAMP- SP. The assayed femur was fixed in an assay device with screws and a metallic support, leaving 150 mm of its length outside the fixation point. The device with the femur was then positioned at the base of the assay machine, tilted 10°, with horizontal and internal rotation of 15°, with the greater trochanter supported on a silicone disk of 30.5 mm in diameter, to simulate a fall onto the trochanter. (Figures 5 a, b) A load cell with 10k/N capacity was used, with a pre-load of 40 N and load application speed of 2 mm/s. the force was applied to the head of the femur until fracture of the assayed region. The mechanical properties evaluated were: maximum load and absorbed energy.

The results of the mechanical properties are presented in the form of tables and graphs. The data in the graphs were expressed as central and dispersion measurements, to illustrate the differences between groups. The Shapiro-Wilk test was conducted to verify the normality of the data. Next, inferential analysis was conducted using the Mann-Whitney test, to compare the properties of maximum load and absorbed energy until fracture between the groups. A level of significance of 5% was adopted. The statistical analysis was processed using the statistical software program SAS® System, version 6.11 (SAS Institute, Inc., Cary, North Carolina).

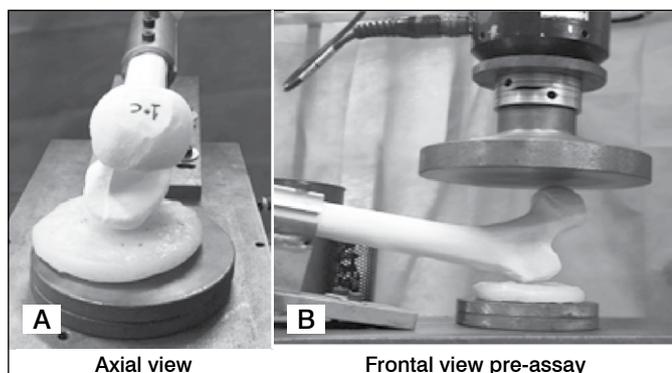
## RESULTS

The mean PMMA used to fill each unit of the DX group was 6 ml. The synthetic models of both groups presented fracture of the femoral neck in the basicervical region. (Figure 6)

The mean maximum load obtained in the DP group was 935 N, with standard deviation of 290 N. In this DX group, this figure was 1500 N, with standard deviation of 180 N.



**Figure 4.** Radiographic images of the synthetic model after completely filling the holes.

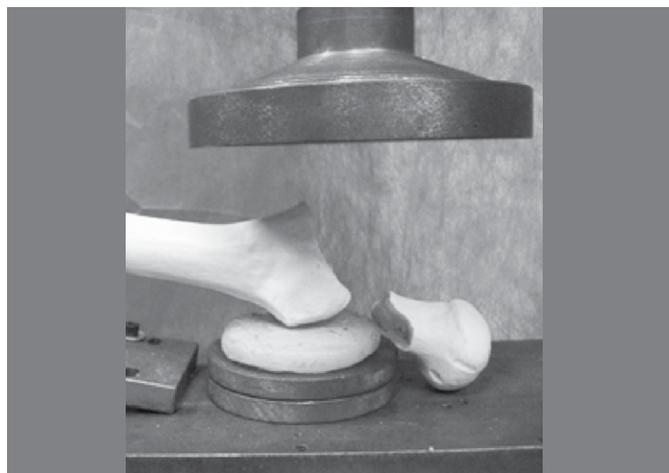


**Figure 5.** Sample of the control group, fixed onto the machine, demonstrating its positioning. At the mechanical pre-assay moment.

The energy absorption values in Joules (J) for the occurrence of fracture in the DP and DX groups were 7.0 J and 9.7 J, respectively. The differences in percentage values obtained in the increases evaluated, in the maximum load and absorbed energy, showed increases of 37.6% and 26.8% between the DP and DX groups, respectively.

The general description of maximum load and energy to fracture, by group (DX, DP), and the corresponding descriptive levels (*p* value) of the Mann-Whitney test, are shown in table 1.

It was observed that the DX group presented significantly greater maximum load (mean = 1500N; *p* = 0.005) and energy to fracture (mean = 9.7J; *p* = 0.050) than the SD group (mean = 935N and 7.1J), as illustrated by Figures 7 and 8, respectively.

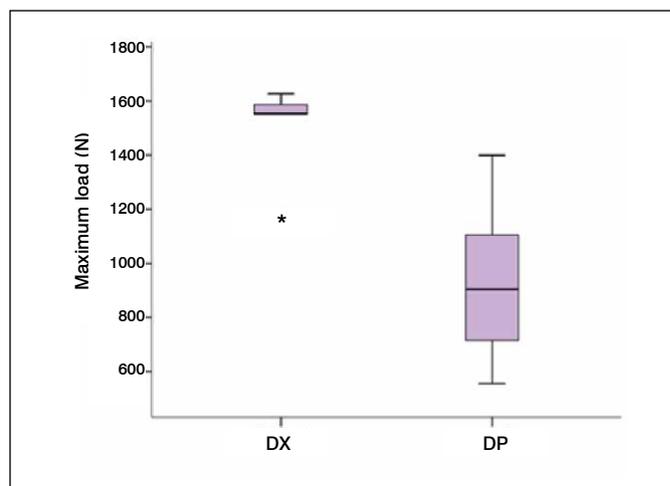


**Figure 6.** Sample of the DX group post-assay, showing the fracture of the femoral neck in the basicervical region.

**Table 1.** Description of maximum load and energy to fracture, by group.

Variable	n	mean	SD	median	IQR	minimum	maximum	p value
<b>Maximum Load (N)</b>								
DX	5	1500	180	1553	1367 - 1607	1182	1627	0.005
DP	10	935	290	905	704 - 1174	555	1399	
<b>Energy to fracture (J)</b>								
DX	5	9.7	1.4	9.7	8.4 - 11.1	8.1	11.5	0.050
DP	10	7.1	2.5	6.6	4.6 - 9.7	4.4	10.4	

SD: Standard deviation; IQR: interquartile range (Q1-Q3). Mann-Whitney test.



**Figure 7.** Maximum load by group (*p* = 0.005).

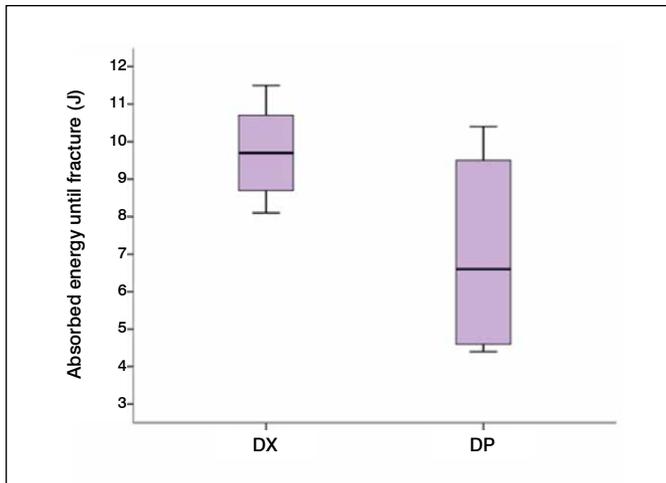


Figure 8. Energy to fracture, by group (p = 0.05).

## DISCUSSION

The fracture mechanism of the PF with fall on the trochanter has its own characteristics, as this positioning of the trauma inverts the mechanical attributions of the structures in this region. The areas that are generally exposed to compression forces are also exposed to traction forces, and vice versa, making this segment, when associated with the bone fragility, susceptible to fractures by minimum trauma fractures, and hindering the search for information on the best positioning of the bone reinforcement with PMMA in this region.<sup>17</sup>

Another difficulty in determining a positioning of excellence in the reinforcement of the PF is the biomechanical complexity of the proximal femur, as well as the inversions of load attributions in this trauma mechanism. No reports were found in the literature describing techniques to study the creation of other holes in different regions of the PF, and in particular, to study the greater trochanter, which carries great mechanical responsibility in the fracture mechanism and dissipation of energy of the trauma.<sup>13,18</sup>

The mean volume of PMMA used to fill each model in the DX group (6.0 ml), which is lower than in cases described in the literature, which range from 9.5 to 40.0 ml of PMMA used.<sup>12-16</sup> This fact is of great importance, as reducing the volume of PMMA will also reduce possible damage to the region by the thermal action caused by the PMMA polymerization process, since the higher the volume of PMMA used, the greater the heat given off at the site.

The choice and use of the synthetic model from same material and batch helps to standardize the mechanical assays, seeking to reduce the variables relating to cadaver models, such as: diameter of the femoral neck, neck angle, variations in thickness of the cortical components, and variations in bone densities, all of which can affect the results.<sup>18,19</sup> However, the composition of the DP group was fundamental, as this enabled a comparative parameter. It should also be emphasized that this group presented a relatively high standard deviation. For this reason, 10 models were assayed to enable it to be reduced, a fact that did not occur in the DX group. The absolute values for maximum load and absorbed energy obtained in this study cannot be compared to the results found in the literature, as the mechanical properties of the model are far beyond those of the cadaver models commonly seen in previous publications. However, the differences obtained in these maximum load and energy tests were 37.6% and 26.8% respectively, between the groups analyzed. The values as percentages, of the assay described in the literature, using the lower mean in volume of PMMA (9.5ml) obtained an increase of 30% in maximum load and 46% in energy value,<sup>13</sup> leading us to believe that we may have equivalent or better results to those previously described, using an even lower volume of PMMA, and using synthetic models that simulate human bones with osteoporosis, and their biomechanical properties.

The challenges related to the technique for reinforcing the PF aimed at reducing the risk of fracture in this region by minimum trauma go beyond the biomechanical structures, and certainly include complex ethical and social evaluations for their application *in vivo*, since implementing a surgical procedure as a prophylactic option for PF fractures can and should be something that is properly explored, as there are literal descriptions of products with this objective, and bibliographic descriptions that describe local femoral reinforcement as extremely acceptable, through the minimally invasive procedure, with little aggression for the patient at imminent risk of fracture in the non-fractured hip during surgery to treat a fractured hip, since the patient is already under anesthetic, and the bone fragility is stabilized.<sup>20</sup> Thus, further research is needed on the subject, to add more information to our knowledge and thereby contribute to optimizing the technique of PF using PMMA, with the lowest risk.

## CONCLUSION

X-shaped reinforcement of the proximal end of synthetic femurs with PMMA increased the maximum load and absorbed energy in the mechanical assays performed.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. AF (0000-0001-6555-8193)\* and WSC (0000-0003-3949-5859)\* were the main contributors to the literature review and writing of the manuscript. RJA (0000-0003-1507-3571),\* VGN (0000-0002-4429-312X),\* AFBJ (0000-0003-1148-8454)\* and AF prepared the methodology and test bodies, accompanied the assays, and gathered data from the mechanical assays. AF and ACS (0000-0002-3119-2362) evaluated the data from the statistical analysis and reviewed the manuscript VGN, AFBJ and ACS also contributed to the intellectual concept of the study. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Szule P, Bouxsein ML. Part I Overview of osteoporosis: epidemiology and clinical management. In: Vertebral fracture initiative. International Osteoporosis Foundation. 2011.
2. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO study group. World Health Organ Tech Rep Ser. 1994;843:1-129.
3. Hernlund E, Svedbom A, Ivergard M, Compston J, Cooper C, Stenmark J, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos. 2013;8:136.
4. Ryg J, Rejnmark L, Overgaard S, Brixen K, Vestergaard P. Hip fracture patients at risk of second hip fracture: a nationwide population-based cohort study of 169, 145 cases during 1977-2001. J Bone Miner Res. 2009;24(7):1299-307.
5. Kanis JA, McCloskey EV, Johansson H, Cooper C, Rizzoli R, Reginster JY. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int. 2013;24(1):23-57.

6. MacLean C, Newberry S, Maglione M, McMahon M, Ranganath V, Suttorp M, et al. Systematic review: comparative effectiveness of treatments to prevent fractures in men and women with low bone density or osteoporosis. *Ann Intern Med.* 2008;148(3):197-213.
7. Kanis JA, Cooper C, Rizzoli R, Abrahamsen B, Al-Daghri NM, Brandi ML, et al. Identification and management of patients at increased risk of osteoporotic fracture: outcomes of an ESCEO expert consensus meeting. *Osteoporos Int.* 2017;28(7):2023-34.
8. Muchmore DB. Raloxifene: a selective estrogen receptor modulator (SERM) with multiple target system effects. *Oncologist.* 2000;5(5):388-92.
9. Paula FJA, Rosen CJ. Developing drugs to treat osteoporosis: lessons learned? *J Clin Endocrinol Metab.* 2009;94(7):2284-9.
10. Canalis E, Giustina A, Bilezikian JP. Mechanisms of anabolic therapies for osteoporosis. *N Engl J Med.* 2007;357(9):905-16.
11. Freitas A, Neri G, de Macedo Neto SL, Borges JLC, de Paula AP. Can be the cement augmentation an improvement method of preventing hip fractures in osteoporotic patients? *Geriatr Gerontol Aging (Impr.).* 2017;11(1):42-7.
12. Basafa E, Armand M. Subject-specific planning of femoroplasty: A combined evolutionary optimization and particle diffusion model approach. *J Biomech.* 2014;47(10):2237-43.
13. Basafa E, Murphy RJ, Otake Y, Kutzer MD, Belkoff SM, Mears SC, et al. Subject-specific planning of femoroplasty: an experimental verification study. *J Biomech.* 2015;48(1):59-64.
14. Beckmann J, Ferquson SJ, Gebauer M, Luering C, Gasser B, Heini P. Femoroplasty-augmentation of the proximal femur with a composite bone cement-feasibility, biomechanical properties and osteosynthesis potential. *Med Eng Phys.* 2007;29(7):755-64.
15. Beckmann J, Springorum R, Vettorazzi E, Bachmeier S, Lüring C, Tingart M, et al. Fracture prevention by femoroplasty-cement augmentation of the proximal femur. *J Orthop Res.* 2011;29(11):1753-8.
16. Fliri L, Sermon A, Wähnert D, Schmoelz W, Blauth M, Windolf M. Limited V-shaped cement augmentation of the proximal femur to prevent secondary hip fractures. *J Biomater Appl.* 2013;28(1):136-43.
17. Varga P, Inzana JA, Schwuedrzik J, Zysset PK, Gueorquiev B, Blauth M, et al. New approaches for cement-based prophylactic augmentation of the osteoporotic proximal femur provide enhanced reinforcement as predicted by non-linear finite element simulations. *Clin Biomech.* 2017;44:7-13.
18. Bakker PM, Manske SL, Ebacher V, Oxland TR, Crompton PA, Guy P. During sideways falls proximal femur fracture initiate in the superolateral cortex: evidence from high-speed video of simulated fracture. *J Biomech.* 2009;42(12):1917-25.
19. Papini M, Zdero R, Schemitsch EH, Zalzal P. The biomechanics of human femurs in axial and torsional loading: comparison of finite element analysis, human cadaveric femurs, and synthetic femurs. *J Biomech Eng.* 2007;129(1):12-9.
20. Cornelis FH, Tselikas L, Carteret T, Lapuyade B, De Baere T, Le Huec JC, et al. Percutaneous internal fixation with Y-STRUT® device to prevent both osteoporotic and pathological hip fractures: a prospective pilot study. *J Orthop Surg Res.* 2017;12:27.

# ASSOCIATION OF TOBACCO DEPENDENCE, ALCOHOLISM AND ANABOLIC STEROIDS WITH MENISCOLIGAMENTOUS INJURIES

## ASSOCIAÇÃO DE TABAGISMO, ALCOOLISMO E ANABOLIZANTES ÀS LESÕES MENISCO-LIGAMENTARES

DIEGO COSTA ASTUR<sup>1</sup>, IGOR NEVES SBAMPATO<sup>1</sup>, GUSTAVO GONÇALVES ARLIANI<sup>1</sup>, CARLOS EDUARDO DA SILVEIRA FRANCOZI<sup>1</sup>, PEDRO DEBIEUX<sup>1</sup>, MOISES COHEN<sup>1</sup>

1. Sports Traumatology Center (CETE), Department of Orthopedics and Traumatology (DOT), Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** To determine a relationship between smoking, alcohol abuse and anabolic steroids and meniscoligamentous injuries. **Methods:** A total of 239 patients underwent surgical treatment of isolated anterior cruciate ligament (ACL) lesion, ACL associated with meniscal injury and isolated meniscal injury, and were inquired by a single team of surgeons about their habits: smoking, alcoholism and use of artificial anabolic agents. In addition, quality of life was assessed using the SF-36 questionnaire. **Results:** It was not possible to establish a direct relationship between habits and meniscal and ligamentous injuries, despite the finding that patients with ACL-associated lesions were more frequently smokers, and that patients with isolated meniscal injuries used more artificial anabolic agents. Regarding quality of life, there were no statistical differences in the habits between the groups; however, except for smokers with isolated meniscal injury, all patients who did not have the habits analyzed presented a better score in the SF-36 questionnaire. **Conclusion:** There were no significant findings correlating smoking, alcohol abuse and artificial anabolic agents with the presence of injuries. In addition, six months after the surgical treatment, there was no difference in the quality of life between the groups evaluated. **Level of Evidence III, Prospective case series.**

**Keywords:** Smoking. Alcoholism. Anabolic agents. Anterior Cruciate Ligament. Meniscus.

### RESUMO

**Objetivo:** Determinar uma relação entre hábito de fumar, abuso de álcool e anabolizantes artificiais com lesões menisco-ligamentares do joelho. **Métodos:** Um total de 239 pacientes foi submetido ao tratamento cirúrgico de lesão isolada do ligamento cruzado anterior (LCA), do LCA associada à lesão meniscal e lesão meniscal isolada e foi indagado, por uma única equipe de cirurgiões, sobre seus hábitos: tabagismo, alcoolismo e uso de anabolizantes artificiais. **Além disso, foi avaliada a qualidade de vida com o questionário SF-36. Resultados:** Não foi possível estabelecer uma relação direta entre os hábitos e as lesões menisco-ligamentares, apesar da constatação de que os pacientes com lesões associadas ao LCA eram, com maior frequência, tabagistas e que os pacientes com lesão meniscal isolada usavam mais anabolizantes artificiais. Com relação à qualidade de vida, não houve diferença estatística quanto aos hábitos entre os grupos, porém, exceto tabagistas com lesão meniscal isolada, todos os pacientes que não tinham os hábitos analisados apresentaram pontuação melhor no questionário SF-36. **Conclusão:** Não houve achados significativos que correlacionassem os hábitos de fumar, abuso de álcool e anabolizantes artificiais com a presença de lesão. Além disso, seis meses após o tratamento cirúrgico, não houve diferença na qualidade de vida entre os grupos avaliados. **Nível de evidência III, Tipo de estudo: série de casos prospectivos.**

**Descritores:** Tabagismo. Alcoolismo. Anabolizantes. Ligamento cruzado anterior. Menisco.

**Citation:** Astur DC, Sbampato IN, Arliani GG, Francozi GES, Debieux P, Cohen M. Association of tobacco dependence, alcoholism and anabolic steroids with meniscoligamentous injuries. *Acta Ortop Bras.* [online]. 2018;26(4):236-9. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

The most commonly injured structures of the knee are the anterior cruciate ligament (ACL) and the menisci, generally affecting active young individuals. The ACL is an important primary stabilizer, whose main function is to restrict the anteriorization and internal rotation of the tibia.<sup>1</sup> The menisci consist of fibrocartilaginous structures composed mainly of type I collagen, whose most important functions

are as follows: load transmission, increase in joint conformity and synovial fluid distribution. Therefore, it is evident that injuries to such structures cause functional deficits or painful conditions.<sup>2</sup> It is known that there are several predisposing factors for injury involving these structures. A number of studies have correlated a higher incidence of ACL tears to patients' intrinsic characteristics, such as intercondylar fossa stenosis<sup>3</sup> and female sex.<sup>4</sup> Some

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

Work conducted at the Sports Traumatology Center – Department of Orthopedics and Traumatology – Sports Traumatology Center – UNIFESP/EPM.  
Correspondence: Diego Costa Astur. Av Pacaembu 1024 CEP 01234-000 São Paulo, SP, Brazil. [mcastur@yahoo.com](mailto:mcastur@yahoo.com)

Article received in 11/28/2016, approved in 05/29/2018.



studies seek to correlate extrinsic factors with meniscocoligamentous injuries. According to Gregory et al.,<sup>5</sup> patients with a history of ACL tears and high body mass index (BMI) present with a higher rate of contralateral injuries or revision of the reconstruction of this previously injured ligament.<sup>6</sup>

Lifestyle habits such as smoking, alcoholism and anabolic steroid use, either in combination or individually, are present in the daily lives of millions of individuals. Because they are changeable factors, unlike the width of the intercondylar notch and the sex of the individual, it is necessary to observe their potential to influence orthopedic knee injuries, especially those involving the menisci and ligaments.

The aim of this study is to observe the relationship between meniscocoligamentous injuries and the presence of the habits of smoking, alcoholic beverage consumption and prior use of artificial steroids. In addition, these habits were correlated with the patients' quality of life, using the SF-36 questionnaire.

## MATERIALS AND METHODS

This is a prospective and observational study of patients operated on for the treatment of meniscocoligamentous injuries between 2010 and 2015. All patients included in the research project signed the informed consent form, agreeing to participate in the study, which was evaluated and approved by the Institutional Review Board (IRB) of the Universidade Federal de São Paulo (UNIFESP).

The inclusion criteria were skeletally mature patient; indication for ACL surgery associated or not associated with the meniscal injury, and isolated meniscal injury. The non inclusion criteria were presence of other associated injuries; involvement of the contralateral limb due to other meniscocoligamentous injuries, and presence of systemic diseases. The patients were assessed by a single team of orthopedic surgeons and, through indication for surgery due to ACL lesions associated or not associated with meniscal injuries, were questioned about their lifestyle habits, including: smoking, alcohol consumption and anabolic steroid use. In addition, a quality of life assessment questionnaire (SF 36) was applied after 6 months of treatment. Statistical correlation was applied to the data obtained and the incidence of injuries, along with the potential deleterious effects of these habits on the injured patient.

Once included, the patients were divided into three groups according to the type of injury: group 1, ACL injury; group 2, associated ACL and meniscal injuries; group 3, isolated meniscal injuries.

### Statistical analysis

Parametric statistical tests were used because the data are quantitative and continuous. In order to verify if two determined variables and/or their levels were statistically significant, we tested for equality of two proportions. We used the Chi-Square test to verify whether two variables and their levels have statistical dependence (association) or not. Differences with  $p < 0.05$  were considered statistically significant. All confidence intervals constructed throughout the study had 95% statistical confidence.

## RESULTS

The study included 239 patients who agreed to participate. Of these, 107 patients had an isolated ACL injury (group 1), 72 an ACL tear associated with the meniscal injury (group 2), and 60 cases had an isolated meniscal injury (group 3). The majority of the patients were male, 196 patients (82%) and 145 patients (60.7%) were white (Caucasian). The mean age was 33 years, ranging from 10 to 72 years with patients in their 30s prevailing. Upon analyzing Body Mass Index (BMI), we found that the majority of patients, 50.2%, were overweight, i.e., with a BMI value between 25 and 29.9 kg/m<sup>2</sup> (Table 1).

Regarding the subjects' lifestyle habits, 51 patients were smokers (21.34%), 189 alcoholic beverage consumers (79.1%), considered regular or social drinkers, and 5.86% (14 cases) of patients reported previous use of anabolic steroids. When assessing the incidence of studied habits by group, the proportion was maintained and no statistical differences were found (Table 2).

There was no statistical difference between the presence of the habits and the group studied, but there was a tendency for patients from group 2 to smoke more frequently ( $p = 0.086$ ). Likewise, the use of anabolic steroids showed a strong tendency for the group of isolated meniscal injuries (group 3) ( $p = 0.055$ ) (Figure 1).

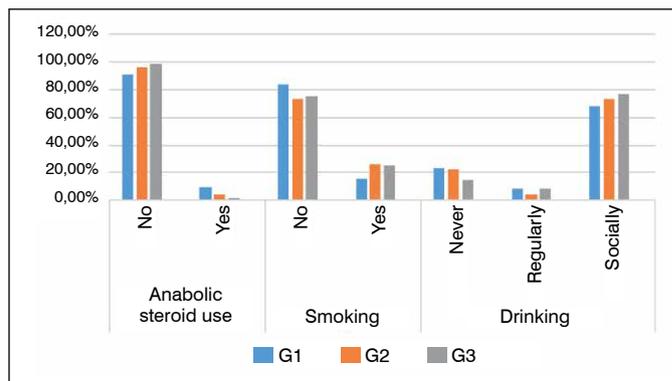
Six months after surgical treatment, the groups did not exhibit any significant differences in their quality of life (according to the SF-36 questionnaire), when compared with the habit evaluated. However, it was noted that with the exception of the score of the smokers in group 3, subjects in all the groups who did not have the habit evaluated had a higher average score (Table 3).

**Table 1.** Distribution of the sample between the groups and their characteristics: sex, age, ethnicity and BMI.

	Variable	G1	G2	G3	Total
Sex	Male	86 (80.4%)	56 (77.8%)	54 (90%)	196 (82%)
	Female	21 (19.6%)	16 (22.2%)	6 (10%)	43 (18%)
Age	mean (min-max)	31 (10-56)	31 (14-58)	39 (14-72)	33 (10-72)
Ethnicity	White	(73) 68.2%	(39) 54.2%	(33) 55%	(145) 60.7%
	Mixed Race	(25) 23.4%	(23) 31.9%	(18) 30%	(66) 27.6%
	Black	(9) 8.4%	(10) 13.9%	(9) 15%	(28) 11.7%
BMI	below	1 (0.93%)	0	0	1 (0.42%)
	normal	38 (35.51%)	24 (33.33%)	23 (38.33%)	85 (35.56%)
	overweight	51 (47.67%)	40 (55.56%)	29 (48.33%)	120 (50.2%)
	obesity	17 (15.89%)	8 (11.11%)	8 (13.34%)	33 (13.82%)

**Table 2.** Characteristics of the groups in terms of the habits assessed.

	Variable	G1	G2	G3	Total
Anabolic Steroid Use	No	90.70%	95.80%	98.30%	$P > 0.05$
	Yes	9.30%	4.20%	1.70%	
Smoking	No	84.1%	73.60%	75.00%	$P > 0.05$
	Yes	15.90%	26.40%	25.00%	
Drinking	Never	23.40%	22.2%	15%	$P > 0.05$
	Regularly	8.40%	4.20%	8.30%	
	Socially	68.20%	73.60%	76.70%	



**Figure 1.** Prevalence of habits between the groups.

**Table 3.** Score obtained in the SF-36 questionnaire to assess patient's quality of life 6 months after surgery, according to the patient's group (there was no statistical difference for all habits assessed,  $p > 0.05$ ).

			Mean	SD	Min	Max	N	CI	p
Group 1	Drinking	Never	110.3	15.6	76.6	139.8	23	6.4	0.299
		Regularly	108.4	16.8	79.5	129.5	9	11	
		Socially	108.4	18.1	11.6	134.2	69	4.3	
	Smoking	No	109.6	17.7	11.6	134.2	84	3.8	0.299
		Yes	104.8	15.2	85.8	139.8	17	7.2	
	Anabolic Steroid Use	No	108.9	17.5	11.6	139.8	93	3.6	0.843
Yes		107.7	16.3	86.5	125.4	8	11.3		
Group 2	Drinking	Never	119.5	12.9	88.6	135.4	13	7	0.211
		Regularly	112.1	21.8	89.6	133.1	3	24.7	
		Socially	110.4	11.6	84.5	130.2	51	3.2	
	Smoking	No	113.4	13.2	84.5	135.4	49	3.7	0.211
		Yes	109	10.8	88.5	132	18	5	
	Anabolic Steroid Use	No	112.3	12.8	84.5	135.4	64	3.1	0.896
Yes		111.3	11.2	104.1	124.2	3	12.7		
Group 3	Drinking	Never	113.9	13.7	97.5	138.2	8	9.5	0.093
		Regularly	106.6	16.3	83.5	121.1	4	15.9	
		Socially	107.8	14.5	76.2	132.1	41	4.4	
	Smoking	No	107.1	15.3	76.2	138.2	41	4.7	0.093
		Yes	114.8	9.8	101.5	129.6	13	5.3	
	Anabolic Steroid Use	No	109.4	14.3	76.2	138.2	53	3.8	0.118
Yes		86.5	x	86.5	86.5	1	x		

## DISCUSSION

Our results showed that there seems to be no influence between the incidence of meniscologamentous injuries and smoking, drinking, or anabolic steroid use, although they are related to greater overall morbidity and mortality,<sup>7</sup> cardiovascular diseases<sup>8</sup> and neoplasia,<sup>9</sup> for example, when compared to the population free of such influences.

The main mechanism of injury of the meniscologamentous lesions is due to direct or indirect knee trauma. This fact could justify the lack of a relationship between lifestyle habits and the injuries mentioned here.

The proportion of drinkers, smokers and anabolic steroid users remained the same between the groups, except for the percentage of tobacco-using patients belonging to group 2 and anabolic steroid users belonging to group 3. However, as the data are not consistent we cannot claim a direct correlation between these variables.

Smoking is known to be associated with worse postoperative functional results in ACL reconstructions, as well as delayed bone healing and wound healing capacity.<sup>10</sup> These deleterious effects are justified by the fact that the products resulting from tobacco combustion cause peripheral tissue hypoxia, cell damage due to the release of free radicals, and vasoconstriction.<sup>11</sup> Thus, although smoking does not seem to be related to the higher incidence of ligament injuries, patients should be provided with guidance on smoking cessation, since there will be a greater potential for unsatisfactory results in the postoperative period.

Artificial steroids have been used for many decades to gain muscle mass and strength and for performance enhancement.<sup>12</sup> Their use was initially restricted to professional athletes, but the use of artificial steroids has gradually become commonplace among individuals who take up different types of sport and for aesthetic purposes.<sup>12</sup> Numerous side effects are known, including cardiovascular disorders,<sup>12</sup> infertility,<sup>13</sup> hepatotoxicity,<sup>14</sup> greater propensity to tendon tears<sup>15</sup> and to develop neoplasms.<sup>16</sup> This study did not show a relationship between exogenous anabolism and ligament injuries, but steroid users displayed a greater tendency to sustain isolated meniscal injuries. However, it is not possible to say whether this tendency is due to the increase in the frequency of physical activities, in anabolic steroid users, or if it is a direct effect of the drug.

Alcohol is one of the most commonly used drugs in the world, either on a regular basis or in a social setting, but has become a serious public health problem, with an estimated 3 million deaths occurring per year due to its use.<sup>17</sup> Although in our study we found no significant relationship between this habit and the presence of meniscologamentous injuries, or an objective deterioration in quality of life, numerous undesirable effects have been demonstrably attributed to the use of this drug. These include psychiatric disorders,<sup>18</sup> hepatotoxicity<sup>19</sup> and a greater propensity to develop certain neoplasms.<sup>20</sup> Therefore its use should be discouraged and dependence should be viewed as a health problem and treated as such.

In our study, we were not able to determine a direct relationship between smoking habits, alcoholic beverage consumption and anabolic steroid use with meniscologamentous injuries, although patients with ACL injuries associated with meniscus rupture smoked more frequently, while subjects with isolated meniscal injuries used anabolic steroids more frequently. In addition, quality of life as assessed by the SF-36 questionnaire did not show any statistical difference, when assessed in relation to the habits of each group; however, note that with the exception of smokers in group 3, all non-smoking patients had higher average scores. Thus, all the habits evaluated should be avoided, since in addition to the numerous side effects already mentioned, quality of life could potentially deteriorate. We should point out some limitations of this study. The patients were assessed 6 months after the surgical treatment, yet we consider it important to make an assessment at different times and to extend the duration of the follow-up for a better assessment of quality of life. We consider this study extremely important, due to the characteristics and size of the sample, as well as the scarcity of studies on the topic in the literature.

## CONCLUSIONS

When assessing patients with ACL injury and/or meniscal injury in terms of smoking and drinking habits and use of artificial steroids, there were no significant results that correlate these variables with the presence of the injury. Moreover, 6 months after the surgical treatment, there was no difference in quality of life between the groups assessed.

## ACKNOWLEDGEMENTS:

Project with support from the Fundação de Apoio à Pesquisa do Estado de São Paulo (FAPESP – Foundation for Support of Research of the State of São Paulo). No. 2012/07721-2

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. DA (0000-0001-9163-7979)\* and GA (0000-0003-4371-5041)\* were the main contributors in writing the manuscript. Diego Astur, GA (0000-0003-4371-5041)\*, PD (0000-0003-3592-6981)\*, CF (0000-0002-0932-6870)\*, MC (0000-0001-7671-8113)\* performed the surgery, monitored the patients and collected clinical data. DA (0000-0001-9163-7979)\* and PD (0000-0003-3592-6981)\* assessed the data from the statistical analysis. DA (0000-0001-9163-7979)\*, GA (0000-0003-4371-5041)\* and CF (0000-0002-0932-6870)\* performed the bibliographic search and revision of the manuscript, and contributed to the intellectual concept of the study. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Amis AA, Dawkins GPC. Functional anatomy of the anterior cruciate ligament. Fibre bundle actions related to ligament replacements and injuries. *J Bone Joint Surg Br.* 1991;73(2):260-7.
2. Renstrom P, Johnson RJ. Anatomy and biomechanics of the menisci. *Clin Sports Med.* 1990;9(3):523-38.
3. Souryal TO, Freeman TR. Intercondylar notch size and anterior cruciate ligament injuries in athletes. A prospective study. *Am J Sports Med.* 1993;21(4):535-9.
4. Schmitz RJ, Ficklin TK, Shimokochi Y, Nguyen AD, Beynon BD, Perrin DH, et al. Varus/Valgus and Internal/External Torsional Knee Joint Stiffness Differs between Sexes. *Am J Sports Med.* 2008;36(7):1380-8.
5. Maletis GB, Inácio MCS, Funahashi TT. Risk factors associated with revision and contralateral anterior cruciate ligament reconstructions in the Kaiser Permanent ACLR registry. *Am J Sports Med.* 2015;43(3):641-7.
6. Bowers AL, Spindler KP, McCarty EC, Arrigain S. Height, weight, and BMI predict intra-articular injuries observed during ACL reconstruction: evaluation of 456 cases from a prospective ACL database. *Clin J Sport Med.* 2005;15(1):9-13.
7. Adhikari B, Kahende J, Malarcher A, Pechacek T. Annual smoking-attributable mortality, years of potential life lost and productivity losses United States 2001-2004. *CDC.* 2008;57(45):1226-8.
8. Hurley SF. Short-term impact of smoking cessation on myocardial infarction and stroke hospitalisations and costs in Australia. *Med J Aust.* 2005;183(1):13-7.
9. Strand TE, Malayeri C, Eskonsipo PK, Grinsrud TK, Norstein J, Grotmol T. [Teenage smoking and lung cancer incidence in early adult age, 1954-1998.] *Tidsskr Nor Laegeforen.* 2005;125(9):1174-6.
10. Wong LS, Martins-Green M. Firsthand cigarette smoke alters fibroblast migration and survival: implications for impaired healing. *Wound Repair Regen.* 2004;12(4):471-84.
11. Misery L. Nicotine effects on skin: are they positive or negative? *Exp Dermatol.* 2004;13(11):665-70.
12. Abidollani F, Joukar S, Najafipour H, Karimi A, Masumi Y, Bindeji F. The risk of life-threatening ventricular arrhythmias in presence of high-intensity endurance exercise along with chronic administration of nandrolone decanoate. *Steroids.* 2016;105:106-12.
13. Nieschlag E, Vorona E. Mechanisms in Endocrinology: Medical consequences of doping with anabolic androgenic steroids: effects on reproductive functions. *Eur J Endocrinol.* 2015;173(2):R47-58.
14. Bond P, Llewellyn W, Van Mol P. Anabolic androgenic steroid-induced hepatotoxicity. *Med Hypotheses.* 2016;(93):150-3.
15. Kanayama G, DeLuca J, Meehan WP 3<sup>rd</sup>, Hudson JI, Isaacs S, Baggish A, et al. Rupture Tendon in Anabolic-Androgenic Steroid Users: a Cross-Sectional Cohort Study. *Am J Sports Med.* 2015;43(11):2638-44.
16. Solbach P, Pothhoff A, Raatschen HJ, Soudbah B, Lehmann U, Schneider A, et al. Testosterone-receptor positive hepatocellular carcinoma in a 29-year old bodybuilder with a history of anabolic androgenic steroid abuse: a case report. *BMC Gastroenterol.* 2015;20:15-60.
17. Stickel F, Moreno C, Hampe J, Morgan MY. The genetics of alcohol dependence and alcohol-related liver disease. *J Hepatol.* 2017;66(1):195-211.
18. Jung J, Galdstein RB, Grant BF. Association of respondent psychiatric comorbidity with family history comorbidity: Results from the National Epidemiologic Survey on Alcohol and Related Conditions-III. *Compr Psychiatr.* 2016;(71):49-56.
19. Mani V, Arivalagan S, Siddique AI, Namasivayam IV. Antioxidant and anti-inflammatory role of zingerone in ethanol-induced hepatotoxicity. *Mol Cell Biochem.* 2016;421(1-2):169-81.
20. Latvala J, Hietala J, Koivisto H, Jarvi K, Anttila P, Niemela O. Immune Responses to Ethanol Metabolites and Cytokine Profiles Differentiate Alcoholics with or without Liver Disease. *Am J Gastroenterol.* 2005;100(6):1303-10.

# CORRELATION BETWEEN AHLBÄCK CLASSIFICATION AND GONARTHROSIS RISK FACTORS

## CORRELAÇÃO ENTRE A CLASSIFICAÇÃO DE AHLBÄCK E FATORES DE RISCO DA GONARTROSE

PAULO ALVIM BORGES<sup>1</sup>, MAURO HENRIQUE JOSÉ DE ALMEIDA<sup>1</sup>, LUCAS MOURA ARAÚJO<sup>1</sup>, JUNJI MILLER FUKUYAMA<sup>1</sup>, FERNANDO YUKIO UMADA<sup>1</sup>, MIGUEL GUSTAVO LUZ ARAB<sup>1</sup>

1. Hospital Geral 'Dr. José Pangella' De Vila Penteado, São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** To demonstrate whether or not there is a correlation between the risk factors for gonarthrosis and the radiographic classification of Ahlbäck. **Methods:** We studied patients with primary gonarthrosis attended at the knee outpatient clinic of the General Hospital of Vila Penteado during their routine visit. We collected data on patient age (years), weight (kg), height (meters), body mass index (BMI = patient weight/height<sup>2</sup>), personal history of hypertension or diabetes mellitus (positive or negative), sedentarism (physical activity less than three times per week, 30 minutes per session), functional demand (how many blocks walked weekly), time of onset of symptoms (in years) and laterality or bilaterality. The data were correlated with the Ahlbäck classification applied to the radiographs performed at the time of the consultation. **Results:** A sample of 108 patients was studied. We did not find an association between the Ahlbäck classification and the patient's age, smoking, sedentary lifestyle, laterality, number of blocks walked per week, diabetes mellitus, and sex; however, a positive association was observed in hypertensive patients as well as a weak correlation with height and weight of the patient and moderate correlation with BMI. **Conclusion:** The Ahlbäck classification is unrelated to most of the risk factors for primary gonarthrosis. **Level of evidence III, Case-control study.**

**Keywords:** Arthropathies. Osteoarthritis. Knee. Radiographic image interpretation, computer-assisted. Radiography.

### RESUMO

**Objetivo:** Demonstrar se existe ou não correlação entre os fatores de risco de gonartrose e a classificação radiográfica de Ahlbäck. **Métodos:** Estudamos pacientes com gonartrose primária, assistidos no ambulatório de joelho do Hospital Geral de Vila Penteado em sua consulta de rotina. Foram coletados dados referentes a idade do paciente (anos), peso do paciente (kg), altura (metros), índice de massa corporal (IMC = peso do paciente/altura<sup>2</sup>), antecedente pessoal de hipertensão ou diabetes mellitus (positivo ou negativo), sedentarismo (se pratica atividade física menos de três vezes por semana, 30 minutos por sessão), demanda funcional (quantas quadras caminha semanalmente), tempo do início dos sintomas (em anos) e lateralidade ou bilateralidade. Os dados foram correlacionados com a classificação de Ahlbäck aplicada às radiografias realizadas no momento da consulta. **Resultados:** Uma amostra de 108 pacientes foi estudada. Não encontramos associação entre a classificação de Ahlbäck e a idade do paciente, tabagismo, sedentarismo, lateralidade, quantidade de quadras percorridas por semana, diabetes mellitus e sexo do paciente, porém verificou-se associação positiva em pacientes hipertensos e correlação fraca com altura e peso do paciente e correlação moderada com IMC. **Conclusão:** A classificação de Ahlbäck não apresenta relação com a maioria dos fatores de risco de gonartrose primária. **Nível de evidência III, Estudo caso-controle.**

**Descritores:** Artropatias. Osteoartrite. Joelho. Interpretação de imagem radiográfica assistida por computador. Radiografia.

**Citation:** Borges PA, Almeida MHJ, Araújo LM, Fukuyama JM, Umada FY, Arab MGL. Correlation between ahlbäck classification and gonarthrosis risk factors. *Acta Ortop Bras.* [online]. 2018;26(4):240-3. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Gonarthrosis is a very common and debilitating disease. It is among the main causes of functional deficiency in the elderly and its incidence is growing along with the aging of the population.<sup>1,2</sup> The most important studied aspects of the disease include risk factors such as age, obesity, smoking, and others. The presence of risk factors contributes to the increased incidence of the disease

in the general population, and correlates with the degree of joint pain experienced by the patient.<sup>1,2,3</sup>

The Ahlbäck<sup>4</sup> classification modified by Keys<sup>5</sup> is among the most frequently used in gonarthrosis. Although its use has been challenged given the low clinical and radiographic correlation of the method,<sup>6</sup> recent studies seek to validate its use to assist in the treatment of gonarthrosis.<sup>7</sup>

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

Work Conducted at the Hospital Geral 'Dr. José Pangella' De Vila Penteado, São Paulo, SP, Brazil.

Correspondence: Paulo Alvim Borges - Rua Sepetiba, 640, Siciliano, São Paulo, SP, Brazil. 05052000. pauloalvimborges@yahoo.com

Article received in 10/06/2017, approved in 06/07/2018.



Since the risk factors produce a higher incidence of disease symptomatology, we question whether the same risk factors are related to more serious radiographic findings. The objective of this study is to demonstrate whether or not there is a correlation between the risk factors for gonarthrosis and the radiographic classification of Ahlbäck.

## MATERIALS AND METHODS

Following approval of the Institutional Review Board (CAAE [Ethics Evaluation Submission Certificate]: 73316517.4.00005452), data were collected from patients being monitored in the orthopedic outpatient clinic of the Hospital Geral de Vila Penteadó over a three-month period, and all the study participants signed the Informed Consent Form. Patients were recruited using convenience sampling as they attended annual routine outpatient appointments. Patients with a diagnosis of primary gonarthrosis of any age or sex, with or without previous clinical treatment, were included in the study. We excluded patients who had undergone any type of surgical treatment for gonarthrosis in the past.

The following data were collected at the consultations: patient age (years), patient weight (kg), height (meters), body mass index (BMI = patient weight/height<sup>2</sup>), personal history of hypertension or diabetes mellitus (positive or negative), sedentary lifestyle (physical activity less than three times a week, 30 minutes per session), functional demand (how many blocks walked weekly), symptom onset time (in years) and laterality or bilaterality.

As per the institution's protocol, all the patients had annual radiographs during the medical consultation to control the progress of their gonarthrosis. The radiographs followed the pattern of the institution in the monopodal-stance frontal view and lateral view with knee at 20 degrees flexion.

The radiographs were processed for assessed using the digital image visualization program PDView (KONICA MINOLTA, INC. V2.20), which allows distances to be measured in scanned images. All radiographs were assessed by a study-blinded investigator who rated all knees according to the Ahlbäck classification. The investigator in question is a specialist surgeon with more than five years of experience in knee surgery.

When a patient presented with bilateral gonarthrosis, the two knees were assessed separately, using the same risk factors present for two knees with different radiographic classification.

All data were submitted to the Kolgomorov normality test and later evaluated with tests compatible with normality. Risk factors were finally assessed along with the results of the Ahlbäck classification to determine whether there was correlation, using the Spearman test. We considered an alpha type error limit of 5%.

## RESULTS

A total of 108 patients were studied. The descriptive statistics of the cases divided by the Ahlbäck classification are summarized in Table 1.

Distribution of Weight, Height, and BMI according to the Ahlbäck classification is shown in Figure 1.

We found no significant difference between the Ahlbäck classification and patient age ( $p = 0.691$ ), smoking ( $p = 0.306$ ), sedentary lifestyle ( $p = 0.091$ ), laterality ( $p = 0.504$ ), number of blocks walked per week ( $p = 0.179$ ) diabetes mellitus ( $p = 0.064$ ) and the patient's sex ( $p = 0.055$ ).

We observed a significant difference between the Ahlbäck classification with hypertension ( $p = 0.008$ ), and noted that the presence of hypertension is associated with a higher grade in the classification. We found a weak correlation between the Ahlbäck classification and patient's weight and height, and a moderate correlation between BMI and the Ahlbäck classification. The results are summarized in Table 2.

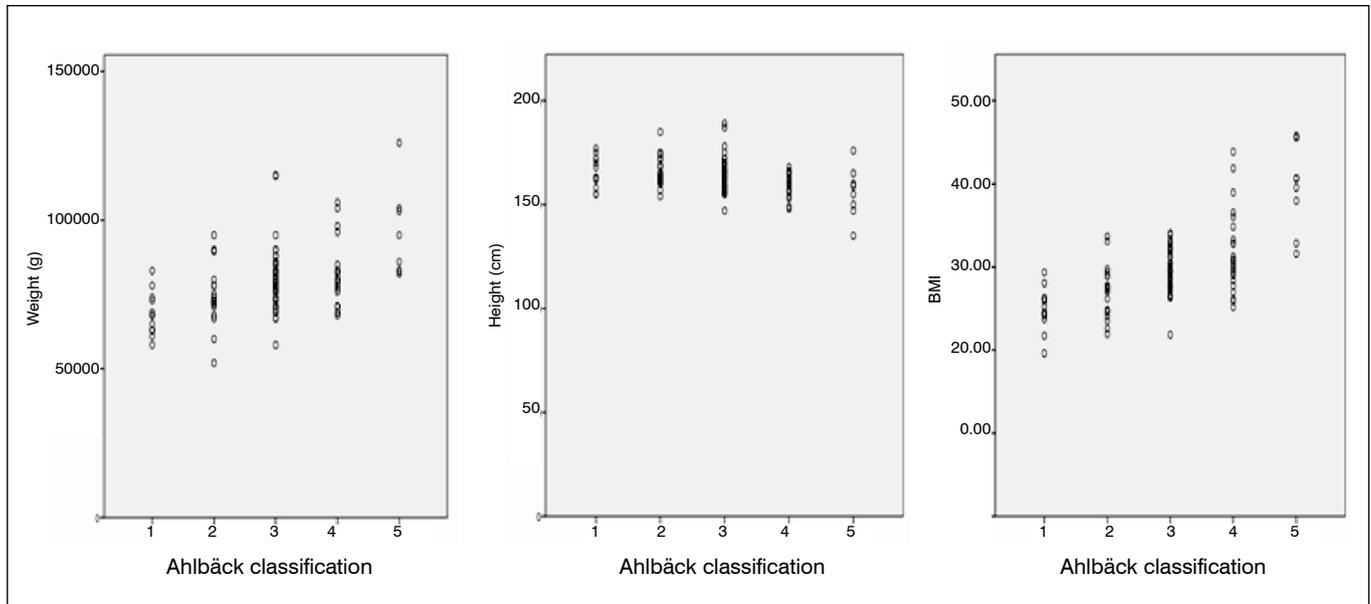
Age at onset of symptoms showed a significant difference in the Kruskal-Wallis test ( $p = 0.015$ ). The Mann-Whitney post hoc analysis showed that the difference lies in the comparison between groups with Ahlbäck classification 1 and 3 (0.006) and between Ahlbäck 1 and 4 (0.008). The comparison between Ahlbäck 3 and 5 presented  $p = 0.058$  while the comparison between Ahlbäck 4 and 5 presented  $p = 0.067$ . The rest of the compared groups presented  $p > 0.1$ .

## DISCUSSION

Although its validity has been questioned,<sup>6</sup> the Ahlbäck classification is still the main topic in discussions about gonarthrosis, with recent studies attempting to validate its use.<sup>7</sup> Even though it is controversial, the Ahlbäck classification is still one of the main criteria of surgical indication and preoperative assessment in gonarthrosis,<sup>8</sup> and it is therefore important for us to build our knowledge about it. Considering that the presence of risk factors for gonarthrosis

**Table 1.** Descriptive statistics of the cases studied.

		Ahlbäck 1	Ahlbäck 2	Ahlbäck 3	Ahlbäck 4	Ahlbäck 5
Sex	Male	N= 8 (61.50%)	N= 8 (40.00%)	N= 16 (36.40%)	N= 4 (17.40%)	N= 1 (12.50%)
	Female	N= 5 (38.50%)	N= 12 (60.00%)	N= 28 (63.60%)	N= 19 (82.60%)	N= 7 (87.50%)
Laterality	Unilateral	N= 6 (46.20%)	N= 8 (40.00%)	N= 11 (25.00%)	N= 9 (39.10%)	N= 2 (25.00%)
	Bilateral	N= 7 (53.80%)	N= 12 (60.00%)	N= 33 (75.00%)	N= 14 (60.90%)	N= 6 (75.00%)
Sah	Yes	N= 5 (38.50%)	N= 16 (80.00%)	N= 27 (61.40%)	N= 19 (82.60%)	N= 8 (100.00%)
	No	N= 8 (61.50%)	N= 4 (20.00%)	N= 17 (38.60%)	N= 4 (17.40%)	N= 0 (0.00%)
DM	Yes	N= 7 (53.80%)	N= 7 (35.00%)	N= 18 (40.90%)	N=14 (60.90%)	N= 7 (87.50%)
	No	N= 6 (46.20%)	N= 13 (65.00%)	N= 26 (59.10%)	N= 9 (39.10%)	N= 1 (12.50%)
Smoker	Yes	N= 4 (30.80%)	N= 5 (25.00%)	N=11 (25.00%)	N= 7 (30.40%)	N= 5 (62.50%)
	No	N= 9 (69.20%)	N= 15 (75.00%)	N= 33 (75.00%)	N= 16 (69.60%)	N= 3 (37.50%)
Sedentary lifestyle	Yes	N= 13 (100.00%)	N= 19 (95.00%)	N= 41 (93.20%)	N= 18 (78.30%)	N= 6 (75.00%)
	No	N= 0 (0.00%)	N= 1 (5.00%)	N= 3 (6.80%)	N= 5 (21.70%)	N= 2 (25.00%)
Age		m= 67.85 (SD= 8.54)	M= 66.10 (SD= 7.15)	M= 65.43 (SD= 6.61)	M= 65.09 (SD= 8.35)	M= 60.38 (SD= 11.85)
Onset of symptoms		M= 52.38 (SD=5,69)	M= 49.65 (SD= 8.49)	M= 48.13 (SD= 6.61)	M= 47.43 (SD= 10.28)	M= 52.00 (SD= 8.84)
Number of blocks		M= 30.53 (SD= 18.20)	M= 24.55 (SD= 17.05)	M= 25.06 (SD= 11.66)	M= 19.17 (SD= 11.07)	M= 30.00 SD= 25.66)
Total		N= 13 (100.00%)	N= 20 (100.00%)	N= 44 (100.00%)	N= 23 (100.00%)	N= 8 (100.00%)



**Figure 1.** A, B and C. Distribution of Weight, Height and BMI (from left to right respectively) according to the Ahlbäck classification.

**Table 2.** Correlation between parameters and the Ahlbäck classification.

Parameter	p-value	Spearman's Rho
Weight	<0.000	0.476
Height	0.001	-0.304
BMI	<0.000	0.637

increases the disease symptomatology,<sup>1,2,3</sup> contributing to the indication of surgery, this study attempts to discover whether the same risk factors influence the radiographic deterioration of the disease, which, at the same time, would also contribute to the indication of surgical treatment.

Our results were very interesting. The patient's age showed no influence on the Ahlbäck classification. This result contradicts the concept that the disease is progressive and demonstrates that the passing of time does not necessarily contribute to radiographic worsening in gonarthrosis. Similarly, smoking, which could contribute to an increase in the injury due to bone perfusion problems, did not appear to be related to the classification. Sedentary lifestyle and the number of blocks walked per week did not prove important either. These factors could have an influence due to the mechanical characteristics of the disease, since not only could sedentary lifestyle provide protection by not increasing the functional demand of the disease, but the number of blocks walked could also produce a more deleterious effect by increasing joint wear. On the other hand, the negative correlation could tell us, for example, that patients with a worse grade on the Ahlbäck scale would tend to be more sedentary or walk fewer blocks per week because they are more symptomatic. Again, we found no positive or negative relationship. Laterality did not appear to be important in influencing the Ahlbäck classification either. We believed that patients with bilateral gonarthrosis could reflect a more serious condition as they manifest the disease more than patients with only one affected knee. Our results showed otherwise.

The presence of diabetes mellitus and the patient's sex had  $p > 0.005$ . However, the p-value was very close to the significance reference ( $p = 0.064$  and  $p = 0.055$ , respectively), and could be influenced by type II error. In terms of sex, in spite of the borderline

p-value, there tended to be a higher number of female patients with higher grades in the Ahlbäck classification. This trend could possibly be explained by differences in the mechanical axis of the knee between men and women. The presence of diabetes mellitus also presented borderline p-value and a tendency to concentrate patients with a higher grading on the Ahlbäck scale. A possible explanation for this result would be the influence of metabolic syndrome on the genesis of gonarthrosis, a finding supported by the positive relationship found in our study between the presence of hypertension and a higher grade in the Ahlbäck classification. Weight, height and BMI showed correlation with the Ahlbäck scale, with a weak positive correlation for Weight, a weak negative correlation for Height, and a moderate positive correlation for BMI. These findings strengthen, contradicting the other aforementioned findings, the contribution of mechanical overload of the joint to the genesis of the disease. It is possible that these factors act in a way that is still poorly understood in the progress of gonarthrosis, and that there is possibly a hidden bias in our analysis. An example would be patients who walk more blocks. On the one hand, they have a greater joint overload, but on the other hand, they are physically fitter, thereby protecting the joint.

Finally, the age of onset of symptoms. Our study presents positive yet controversial results. We expected a logical correlation pattern in which the earlier the onset of disease symptoms, the worse the radiographic findings. However, we did not find a single pattern. The expected outcome was positive between Ahlbäck classifications 1 and 3 and 1 and 4, with the worst grades occurring in patients with earlier onset of symptoms. Paradoxically, patients with Ahlbäck 5 had a higher mean age of onset of symptoms than patients with Ahlbäck 2, 3 and 4. We expected the opposite, since we would expect cases of gonarthrosis progressing with greater joint destruction to have earlier symptoms. Patients who develop Ahlbäck 5 may have a later onset of symptoms but have faster radiographic progression. These patients might experience slow natural progression of the disease, yet suddenly begin to progress rapidly with radiographic alterations after losing a particular knee stabilizing structure, e.g., a cruciate ligament. Another possibility is that the correlation of symptoms with the Ahlbäck classification is not strong in the group classified as Ahlbäck 5. Although we believe more in the latter hypothesis, this conclusion is beyond the scope of this study.

---

The set of results leads us to believe that the correlation between risk factors for gonarthrosis and the Ahlbäck classification is, for the most part, weak or negligible. Our study gives more weight to the criticism against the commonplace use of this classification in the management of gonarthrosis, since in addition to presenting a low clinical and radiographic correlation,<sup>6</sup> it also appears to bear little relationship to the disease-related risk factors.

## CONCLUSIONS

The Ahlbäck classification does not present any association with patient age, smoking, sedentary lifestyle, laterality, number of blocks walked per week, diabetes mellitus, and patient sex. On the other hand, it has a positive association with hypertensive patients, a weak correlation with patient height and weight, and a moderate correlation with BMI.

---

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. PAB (0000-0002-8495-8018)\* conception of the project, data analysis and interpretation, and writing of the manuscript; MHJA (0000-0003-3450-3039)\* conception of the project, data collection, analysis and interpretation; LMA (0000-0001-6730-3805)\* conception of the project, data collection, analysis and interpretation; JMF (0000-0003-4865-4866)\*, FYU (0000-0003-0336-5841)\* and MGLA (0000-0003-1526-444X)\* are responsible for the preparation and participated in the relevant critical review of the intellectual content. \*ORCID (Open Researcher and Contributor ID).

---

## REFERENCES

1. Heidari B. Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I. *Caspian J Intern Med.* 2011;2(2):205-12.
2. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage.* 2015;23(4):507-15.
3. Lee KM, Chung CY, Sung KH, Lee SY, Won SH, Kim TG, et al. Risk factors for osteoarthritis and contributing factors to current arthritic pain in South Korean older adults. *Yonsei Med J.* 2015;56(1):124-31.
4. Ahlbäck S. Osteoarthrosis of the knee. A radiographic investigation. *Acta Radiol Diagn (Stockh).* 1968;Suppl 277:7-72.
5. Keyes GW, Carr AJ, Miller RK, Goodfellow JW. The radiographic classification of medial gonarthrosis. Correlation with operation methods in 200 knees. *Acta Orthop Scand.* 1992;63(5):497-501.
6. Bedson J, Croft PR. The discordance between clinical and radiographic knee osteoarthritis: A systematic search and summary of the literature. *BMC Musculoskelet Disord.* 2008;9:116.
7. Martins GC, Camanho GL, Ayres LM, Oliveiras ES. Correlation between Ahlbäck radiographic classification and anterior cruciate ligament status in primary knee arthrosis. *Rev Bras Ortop.* 2016;52(1):69-74.
8. Hernández-Vaquero D, Fernández-Carreira JM. Relationship between radiological grading and clinical status in knee osteoarthritis. a multicentric study. *BMC Musculoskeletal Disorders.* 2012;13:194.

# EXTRA-ABDOMINAL DESMOID TUMOR: ANALYSIS OF 23 CONSECUTIVE CASES IN A SINGLE INSTITUTION

## TUMOR DESMOIDE EXTRA-ABDOMINAL: ANÁLISE DE 23 CASOS CONSECUTIVOS EM UMA ÚNICA INSTITUIÇÃO

JUAN PABLO ZUMÁRRAGA<sup>1</sup>, BRIAN GUILHERME MONTEIRO MARTA COIMBRA<sup>2</sup>, FELIPE GONÇALVES DOS SANTOS<sup>1</sup>, ANDRÉ MATHIAS BAPTISTA<sup>1</sup>, MARCELO TOMIO KOHARA<sup>1</sup>, OLAVO PIRES DE CAMARGO<sup>1-3</sup>

1. Orthopedic Oncology Group, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.  
2. Instituto de Ortopedia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.  
3. Department of Orthopedics and Traumatology, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** Extra-abdominal desmoid tumor (EDT) is a rare condition, caused by proliferation of fibroblasts. Despite being a benign tumor, it is locally aggressive and has unpredictable clinical behavior. The objective of this study is to present the clinical outcomes of patients with EDT treated surgically between 1995 and 2016. **Methods:** This is a retrospective series of 23 patients with histopathological diagnosis of EDT that underwent surgery at the orthopedic oncology service of our hospital. The information was obtained from the institute's clinical and pathology reports. **Results:** A total of 223 medical records with histopathological reports were evaluated. Only 23 cases of EDT were included in the present study. The mean age was 22.5 years. Twelve (52.2%) patients had the tumor on the lower limbs, seven (30.4%) on the upper limbs and four (17.4%) cases were reported on the back. Five (21.7%) patients had tumors measuring less than 5 cm, while eighteen (78.3%) patients had tumors measuring more than 5 cm. All patients underwent surgery as the definitive treatment in our institute. Twelve (52.2%) cases presented negative margins (NM) and eleven (47.8%) cases had positive margins (PM). Local recurrence (LR) occurred in eleven (47.8%) patients. **Conclusion:** Impairment of the surgical margin was the only prognostic factor found for LR of EDT. **Level of Evidence IV, Case Series.**

**Keywords:** Fibromatosis, aggressive. Surgical oncology. Local neoplasm recurrence. Margins of excision. Prognosis.

### RESUMO

**Objetivo:** O tumor desmoide extra-abdominal (TDE) é raro, formado por proliferação de fibroblastos. Apesar de ser um tumor benigno, é localmente agressivo e tem comportamento clínico imprevisível. O objetivo desta pesquisa é apresentar os resultados clínicos obtidos nos pacientes com TDE, tratados cirurgicamente entre 1995 e 2016. **Métodos:** Trata-se de uma série retrospectiva de 23 pacientes com diagnóstico anatomopatológico de TDE, tratados cirurgicamente no serviço de oncologia ortopédica de nosso hospital. A informação foi obtida dos relatos clínicos e patológicos do instituto. **Resultados:** Um total de 223 prontuários com relato anatomopatológico foi revisado. Apenas 23 casos de TDE foram incluídos no presente estudo. A média de idade foi de 22,5 anos. Doze (52,2%) casos se localizaram nos membros inferiores, sete (30,4%) casos nos membros superiores e quatro (17,4%) casos se localizaram no dorso. Cinco (21,7%) casos tinham tamanho < 5 cm e 18 (78,3%) casos tinham tamanho > 5 cm. Todos os pacientes receberam tratamento cirúrgico como terapia definitiva no instituto. Doze (52,2%) casos apresentaram margens livres (ML) e onze (47,8%) casos tinham margens comprometidas (MC). A recorrência local (RL) ocorreu em onze (47,8%) pacientes. **Conclusão:** O comprometimento da margem cirúrgica foi o único fator de prognóstico encontrado para a RL do TDE. **Nível de Evidência IV, Série de Casos.**

**Descritores:** Fibromatose agressiva. Cirurgia oncológica. Recidiva local de neoplasia. Margens de excisão. Prognóstico.

**Citation:** Zumárraga JP, Coimbra BGMM, Santos FG, Baptista AM, Kohara MT, Camargo OP. Extra-abdominal desmoid tumor: analysis of 23 consecutive cases in a single institution. *Acta Ortop Bras.* [online]. 2018;26(4):244-7. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

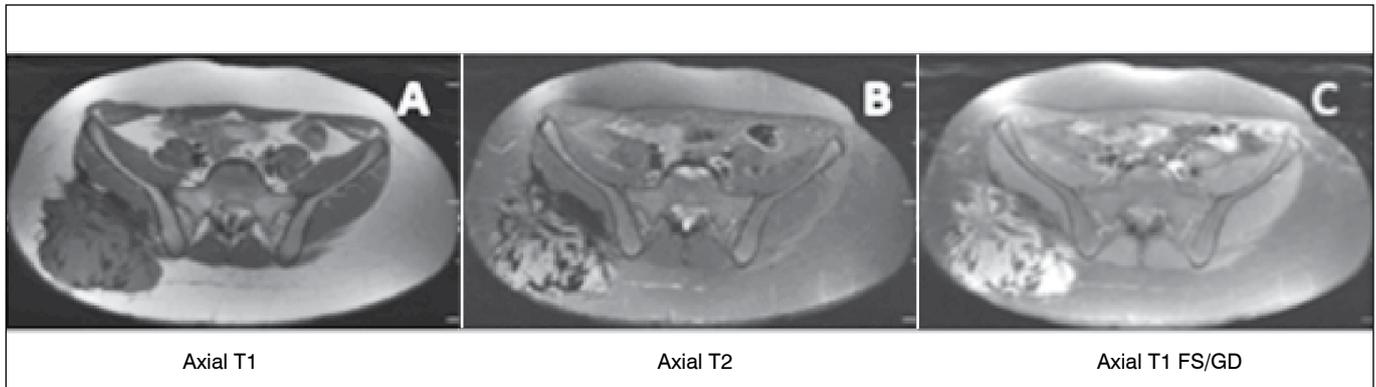
Extra-abdominal desmoid tumors (EDT) are a rare condition caused by the proliferation of fibroblasts. Although the tumor is benign, it is locally aggressive, and its unpredictable clinical behavior leads to disagreement regarding its treatment.<sup>1,2</sup> According to the World Health Organization (WHO), EDT is

defined as a monoclonal proliferation of fibroblasts that affects deep soft tissues. It is characterized by infiltrative growth and a tendency toward local recurrence (LR). It does not present distant metastasis (DM).<sup>3</sup> EDT can affect any part of the body, but appears more frequently on the limbs and trunk (Figure 1). These tumors are rare, with an incidence of 2-4 cases/1,000,000

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

Work conducted at the Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.  
Correspondence: Juan Pablo Zumárraga. Rua Ovídio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05403-010. [juanpzumarraga@hotmail.com](mailto:juanpzumarraga@hotmail.com)





**Figure 1.** MRI: Desmoid tumor in the right gluteal area.

individuals in global statistics. Onset ranges from subjects in their 20s to their 70s, with a higher incidence in subjects in their 40s or thereabouts.<sup>4-6</sup> The treatment of choice is based on resection surgery with negative margins (NM). Clinical surveillance may be used in duly selected cases where constant outpatient follow-up is maintained.<sup>7</sup> In view of the local characteristics of EDT, resection with NM represents a challenge to the surgeon. The pattern of growth with projections and the impossibility of distinguishing the capsule during the surgical procedure increase the risk of involvement of the surgical margins, which are frequently mentioned in pathology reports.<sup>8-11</sup> Therefore adjuvant radiotherapy is a method of choice to avoid LR. When this occurs, it can be isolated or multiple, can acquire a more aggressive biological activity and spread locally.<sup>12-14</sup> If resection is not possible, pharmacological treatment may be indicated. Pharmacological options include anti-hormonal agents (e.g. tamoxifen), nonsteroidal anti-inflammatory drugs (e.g. celecoxib), and conventional chemotherapy (CT).<sup>15,16</sup> Ultimately, treatment of the disease should be multidisciplinary, focusing on the quality of life and function of the affected patient.<sup>17</sup> The purpose of this research is to present the clinical results obtained in patients with EDT treated at our institution.

## MATERIALS AND METHODS

The study was approved by the Institutional Review Board of HCFMUSP under number 1174. It is a cross-sectional retrospective study in which 23 medical records of patients diagnosed with EDT by the IOT-HC-FMUSP Orthopedic Oncology Group covering the period from 1995 to 2016 were used. We reviewed 223 medical records, 200 of which were excluded due to lack of data. All patients included in this study received surgical treatment. Age, sex, laterality, date of diagnosis, tumor size, type of surgery and postoperative outpatient follow-up were acquired from the medical records (Table 1). The histological diagnosis was made by the pathologists of the institute. The patients' characteristics were described using absolute and relative frequencies, and their age was also described using mean and standard deviation.<sup>18</sup> The mean disease-free survival with the respective intervals was estimated with 95% confidence according to characteristics of interest. The mean times were estimated when it was not possible to estimate the median time using the Kaplan-Meier estimator,<sup>19</sup> and times were compared between the categories of characteristics using log-rank tests.<sup>19</sup> The hazard ratios (HR) of LR-free time were estimated between the categories with the respective 95% confidence intervals using bivariate Cox regression models.<sup>19</sup> The tests were conducted with a significance level of 5%.

**Table 1.** Description of patient demographics.

Variable	Frequency	%
<b>Sex</b>		
Female	12	52.2
Male	11	47.8
<b>Age*</b>		
≤20 years	10	45.5
>20 years	12	54.5
Mean (SD)	22.5 (11.9)	
<b>Tumor Site</b>		
Lower Limb	12	52.2
Upper Limb	7	30.4
Back	4	17.4
<b>Laterality*</b>		
Right	10	47.6
Left	11	52.4
<b>Margin</b>		
Negative	12	52.2
Positive	11	47.8
<b>Tumor Size</b>		
<5 cm	5	21.7
≥5 cm	18	78.3
<b>Recurrence</b>		
No	12	52.2
Yes	11	47.8
<b>Total</b>	<b>23</b>	<b>100</b>

## RESULTS

A total of 223 medical records with pathology reports were reviewed for this study. Only 23 cases of EDT were included in the present study. The mean age was 22.5 years. Twelve patients were female (52.2%) and eleven male (47.8%). The left side was affected most often with 11 (52.4%) cases, while there were 10 right-sided cases (47.6%) and two cases involving the midline back. Twelve (52.2%) cases were located in the lower limbs, seven (30.4%) cases in the upper limbs, and four (17.4%) cases were located on the back. Regarding tumor size, five (21.7%) cases measured <5cm and 18 (78.3%) cases measured size >5cm. All patients received surgical treatment as definitive therapy at the institute. The surgery of choice for all patients was surgical resection with NM. The histopathology reports listed twelve

(52.2%) cases with NM and eleven (47.8%) cases with PM. LR occurred in eleven (47.8%) patients. Only the surgical margins influenced the disease-free survival of patients with EDT (Figure 2). Patients with PM presented a 90-fold higher risk of LR when compared to patients with NM ( $p < 0.001$ ) (Table 2).

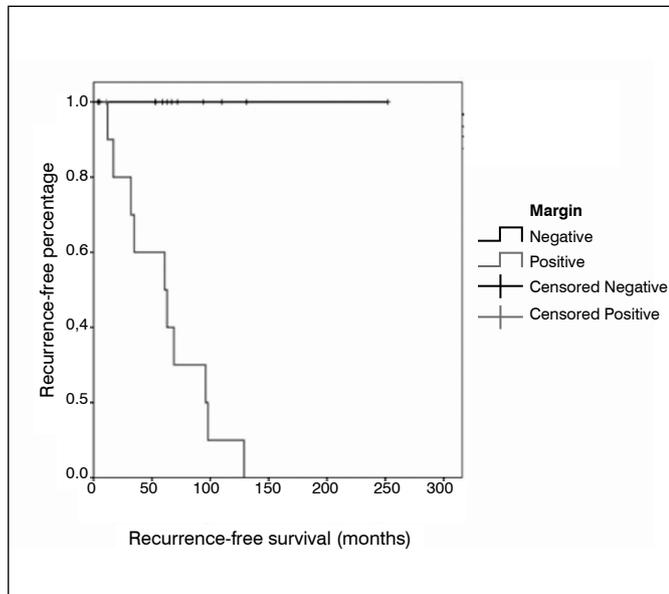


Figure 2. Kaplan-Meier plot of local recurrence according to margin.

## DISCUSSION

The literature presents an extensive list of publications on EDT. Most of the published studies are retrospective series and case reports.<sup>2,6</sup> This study was no exception: we analyzed 23 consecutive cases over 16 years. We did not find many studies addressing EDT in our field. The mean age in our study was 22.5 years, which coincides with that described in the literature.<sup>7,9</sup> In bibliographical terms, EDT predominates slightly in female subjects.<sup>1</sup> In this study we also observed female predominance (52.2%). Published studies indicate that EDT occurs mainly in the abdomen.<sup>14,15,20</sup> This data cannot be compared as the study was conducted at an orthopedic institute. Therefore, we found widespread wide predominance of limb involvement, with a rate of 82.6%. As defined in the literature, the mean preoperative size ranges between 8 and 12 cm.<sup>21</sup> In our study the size varied a great deal, yet most cases involved tumors  $> 5$  cm, a fact similar to the published data. We also reported a PM rate of 47.8%. This data is not commonly reported in numerical values in the literature. One of the few studies with this data reported a rate of 42.5%.<sup>22</sup> Again, this finding is similar to that of our research. The main complication of EDT is LR, with rates ranging between 40 and 60%.<sup>17,21,23</sup> Our study found a LR rate of 47.8%, again coinciding with the literature. The mean patient follow-up time was 98 months. Finally, we report that surgical margin impairment is directly related to the decrease in disease-free survival of the patient presenting with this tumor.

## CONCLUSIONS

Surgical margin impairment was the only prognostic factor found for EDT LR.

Table 2. Mean disease-free survival according to the information resulting from comparative tests.

Variable	Median Time (months)	CI (95%)		Recurrence	Total	%	HR	CI (95%)		p
		Lower	Upper					Lower	Upper	
<b>Sex</b>										<b>0.24</b>
Female	96	34.3	157.7	7	12	58.3	1			
Male*	170.7	98.1	243.3	3	11	27.3	0.43	0.11	1.69	
<b>Age</b>										<b>0.7</b>
$\leq 20$ years	98	20.9	175.1	5	10	50	1			
$> 20$ years	96	35.7	156.3	5	12	41.7	0.78	0.22	2.75	
<b>Tumor Site</b>										<b>0.058</b>
Lower Limb	63	31.7	94.3	7	12	58.3	1			
Upper Limb *	183.3	107.8	258.7	2	7	28.6	0.11	0.01	0.91	
Back	69	#	#	1	4	25	0.86	0.1	7.25	
<b>Laterality</b>										<b>0.344</b>
Right	96	#	#	3	10	30	1			
Left	98	24.4	171.6	6	11	54.5	1.94	0.48	7.84	
<b>Margin</b>										<b>&lt;0.001</b>
Negative	252	#	#	0	12	0	1			
Positive	61	17.6	104.4	10	11	90.9	88.34	0.5	15498.91	
<b>Tumor Size</b>										<b>0.789</b>
$< 5$ cm	98	52.8	143.2	3	5	60	1			
$\geq 5$ cm	96	39.4	152.6	7	18	38.9	1.21	0.31	4.72	
<b>Total</b>	<b>98</b>	<b>58</b>	<b>138</b>	<b>10</b>	<b>23</b>	<b>43.5</b>				

\*Mean recurrence-free survival. #Cannot be estimated.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. JPZ (0000-0001-5941-7714)\*, BGMMC (0000-0001-5461-3644)\*, FGS (0000-0002-6854-6072)\*, AMB (0000-0002-0830-4602)\*, MTK (000-0003-3384-7905)\*, OPC (0000-0002-1128-7292)\*, were the main contributors in writing this work. JPZ participated in: concept, research, design, writing, and analysis; BGMMC participated in research, design and data collection; FGS participated in: concept, research, writing and data collection; AMB participated in concept, research, writing and analysis; MTK participated in research, design and data collection; OPC participated in concept, writing and analysis. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. van Broekhoven DL, Deroose JP, Bonvalot S, Gronchi A, Grünhagen DJ, Eggermont AM, et al. Isolated limb perfusion using tumour necrosis factor and melphalan in patients with advanced aggressive fibromatosis. *Br J Surg*. 2014;101(13):1674-80.
2. Houdek MT, Rose PS, Kakar S. Desmoid tumors of the upper extremity. *J Hand Surg Am*. 2014;39(9):1761-5.
3. Eastley N, Aujla R, Silk R, Richards CJ, McCulloch TA, Esler CP, et al. Extra-abdominal desmoid fibromatosis--a sarcoma unit review of practice, long term recurrence rates and survival. *Eur J Surg Oncol*. 2014;40(9):1125-30.
4. Hori A, Murata S, Kono M, Maeda M, Sueyoshi S, Seki A, et al. [Effect of transarterial chemoembolization for recurrent desmoid tumor - a case report.] *Gan To Kagaku Ryoho*. 2013;40(9):1259-62.
5. Prodinge PM, Rechl H, Keller M, Pilge H, Salzmann M, von Eisenhart-Rothe R, et al. Surgical resection and radiation therapy of desmoid tumours of the extremities: results of a supra-regional tumour centre. *Int Orthop*. 2013;37(10):1987-93.
6. Maher J, Smith DA, Parker WL. Desmoid tumor of the hand: a case report. *Ann Plast Surg*. 2014;73(4):390-2.
7. Oweis Y, Lucas DR, Brandon CJ, Girish G, Jacobson JA, Fessell DP. Extra-abdominal desmoid tumor with osseous involvement. *Skeletal Radiol*. 2012;41(4):483-7.
8. Stollwerck PL, Namdar T, Bartscher T, Lange T, Stang FH, Kujath P, et al. A rare desmoid tumor of the shoulder--excision, implantation of brachytherapy applicators and wound closure by pedicle musculus latissimus dorsi flap. *Ger Med Sci*. 2011;9:Doc04.
9. Sciallis GF, Sciallis AP. Becker nevus with an underlying desmoid tumor: a case report and review including Mayo Clinic's experience. *Arch Dermatol*. 2010;146(12):1408-12.
10. Solanki NS, Macfarlane PL, Marshall NJ. Images for surgeons. An extra-abdominal desmoid tumour in a young woman. *ANZ J Surg*. 2010;80(10):743-4.
11. Jakowski JD, Mayerson J, Wakely PE Jr. Fine-needle aspiration biopsy of the distal extremities: a study of 141 cases. *Am J Clin Pathol*. 2010;133(2):224-31.
12. Couto-Gonzalez I, Brea-Garcia B, Taboada-Suárez A, González-Álvarez E. Aggressive Dupuytren's diathesis in a young woman. *BMJ Case Rep*. 2010;2010.
13. Gallucci GL, Boretto JG, De Carli P. Desmoid tumor of the forearm. Reconstructive surgery and functional result. *Chir Main*. 2009;28(5):326-9.
14. Shido Y, Nishida Y, Nakashima H, Katagiri H, Sugiura H, Yamada Y, et al. Surgical treatment for local control of extremity and trunk desmoid tumors. *Arch Orthop Trauma Surg*. 2009;129(7):929-33.
15. Altmann S, Lenz-Scharf O, Schneider W. [Therapeutic options for aggressive fibromatosis]. *Handchir Mikrochir Plast Chir*. 2008;40(2):88-93.
16. Engelhardt TO, Jeschke J, Piza-Katzer H. [About the self-reported quality of life after amputation of the hand in patients with upper extremity tumors]. *Handchir Mikrochir Plast Chir*. 2008;40(1):23-30.
17. Ozger H, Eralp L, Tokar B, Ağaoğlu F, Dizdar Y. [Evaluation of prognostic factors affecting recurrences and disease-free survival in extra-abdominal desmoid tumors]. *Acta Orthop Traumatol Turc*. 2007;41(4):291-4.
18. Kirkwood BR, Sterne JA. *Essential medical statistics*. 2nd ed. Massachusetts: Blackwell Science; 2006.
19. Kleinbaum DG. *Survival analysis: a self-learning text*. New York: Springer; 1996.
20. Sakamaki Y, Kido T, Yasukawa M, Fujiwara T, Kuwae K, Maeda M. Wide resection of the upper right hemithorax combined with amputation of the right arm for a recurrent desmoid tumor. *Jpn J Thorac Cardiovasc Surg*. 2006;54(8):338-41.
21. Ballo MT, Zagars GK, Pollack A, Pisters PW, Pollack RA. Desmoid tumor: prognostic factors and outcome after surgery, radiation therapy, or combined surgery and radiation therapy. *J Clin Oncol*. 1999;17(1):158-67.
22. Duggal A, Dickinson IC, Sommerville S, Gallie P. The management of extra-abdominal desmoid tumours. *Int Orthop*. 2004;28(4):252-6.
23. Wang YF, Guo W, Sun KK, Yang RL, Tang XD, Ji T, et al. Postoperative recurrence of desmoid tumors: clinical and pathological perspectives. *World J Surg Oncol*. 2015;13:26.

# EVALUATION OF QUALITY OF LIFE IN PATIENTS TREATED FOR METASTATIC DISEASE OF THE PROXIMAL FEMUR

## AVALIAÇÃO DA QUALIDADE DE VIDA EM PACIENTES TRATADOS POR DOENÇA METASTÁTICA DA REGIÃO PROXIMAL DO FÊMUR

MARCOS HAJIME TANAKA<sup>1</sup>, MARCELLO MARTINS DE SOUZA<sup>1</sup>, DANIEL LUIZ CERONI GIBSON<sup>1</sup>, MONICA PASCHOAL NOGUEIRA<sup>1</sup>

1. Hospital do Servidor Público Estadual, São Paulo, Brazil.

### ABSTRACT

**Objective:** Patients with metastatic bone lesions have a limited life expectancy. These metastatic lesions compromise the proximal femur, and fractures are quite common. The survival of these patients depends on the behavior of the primary tumor. The aim of this study was to evaluate the quality of life of patients with extensive metastatic lesion of the proximal femur with pathological or imminent fracture, treated with non-conventional endoprosthesis. **Methods:** From May 2008 to August 2012, twenty-five (25) patients with bone metastases of the proximal femur, with pathological or imminent fracture were recruited into this study. These patients had survived for at least six weeks after surgery and the TESS questionnaire (Toronto Extremity Salvage Score) was administered. **Results:** The final score of the TESS was an average of 57 points (SD 23.78 points). There was no significant difference in TESS values considering: sex, presence of fracture, or site of the bone lesion. **Conclusion:** The TESS questionnaire provides information about the function and quality of life of patients with malignant tumors of the lower limbs, from the patient's perspective. The results can be considered positive, when compared to the limited life expectancy and complexity of this group of patients.

**Level of evidence III, Therapeutic studies, retrospective comparative study.**

**Keywords:** Femoral Neoplasms/surgery. Prostheses and Implants. Quality of Life. Surveys and Questionnaires. Neoplasm Metastasis.

### RESUMO

**Objetivo:** Pacientes com lesões ósseas metastáticas têm expectativa de vida limitada. Essas lesões metastáticas comprometem a parte proximal do fêmur, e as fraturas são bastante comuns. A sobrevivência desses pacientes depende do comportamento do tumor primário. O objetivo deste estudo é avaliar a qualidade de vida de pacientes com lesões metastáticas extensas na parte proximal do fêmur com fratura patológica ou iminente, tratados com endopróteses não convencionais. **Métodos:** De maio de 2008 a agosto de 2012, vinte e cinco (25) pacientes com metástases ósseas da parte proximal do fêmur com fratura patológica ou iminente foram recrutados para este estudo. Esses pacientes tinham sobrevivido de pelo menos seis semanas após a cirurgia e o questionário TESS (Toronto Extremity Salvage Score) foi aplicado. **Resultados:** O escore final do TESS teve média de 57 pontos (DP de 23,78 pontos). Não houve diferença significativa entre os valores do TESS ao se considerar sexo, presença de fratura ou localização da lesão óssea. **Conclusão:** O questionário TESS fornece informações sobre a função e a qualidade de vida dos pacientes com tumores malignos dos membros inferiores, do ponto de vista do paciente. Os resultados obtidos podem ser considerados positivos, diante da expectativa de vida limitada e a complexidade desse grupo de pacientes. **Nível de evidência III, Estudos terapêuticos, Estudo retrospectivo comparativo.**

**Descritores:** Neoplasias femorais/cirurgia. Próteses e implantes. Qualidade de vida. Inquéritos e questionários. Metástase neoplásica.

**Citation:** Tanaka MH, Souza MM, Gibson DLC, Nogueira MP. Evaluation of quality of life in patients treated for metastatic disease of the proximal femur. *Acta Ortop Bras.* [online]. 2018;26(4):248-51. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

The incidence of bone metastatic disease is on the increase as cancer patients now live longer.<sup>1</sup> The most common site of metastases is the bone, followed by the lungs and liver.<sup>2,3</sup> Breast and prostate cancers are the two largest sources of bone metastasis (80%).<sup>4</sup> In cancer patients, bone metastasis is a common cause of decreased quality of life.<sup>5</sup> One third of skeletal lesions occur in the proximal femur.<sup>6</sup> Approximately 10% of patients suffering from metastatic disease have pathological fractures and 65% of

these fractures (requiring surgical treatment) occur in the femur.<sup>7</sup> Pathological fractures or imminent proximal femur fractures can have a disastrous effect on quality of life, resulting in pain and incapacitation, with great impact on the lives of these patients. In recent years, the survival time after diagnosing bone metastasis has increased with advances in oncology, especially in patients with breast and prostate cancers. Surgical considerations include tumor location, type and size of the lesion and conditions inherent to the clinical and emotional state of the patient.

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

Work conducted at the Hospital do Servidor Público Estadual, São Paulo, SP, Brazil.

Correspondence: Hospital do Servidor Público Estadual, São Paulo, Brazil. Rua Borges Lagoa 981, Ibirapuera, São Paulo, SP, Brazil. 04029-000. [tanakamarcos1@gmail.com](mailto:tanakamarcos1@gmail.com)

Article received in 02/06/2018, approved in 05/10/2018.



Most metastatic bone lesions are effectively treated by non-surgical methods such as radiotherapy, chemotherapy, immunotherapy, hormone therapy and administration of bisphosphonates.<sup>8,9</sup> In the presence of pathological or imminent fracture of the proximal femur, surgical treatment is usually the best option. Bone infiltration by metastatic cancer causes weakness and requires prostheses or implants, to last the remaining life of the patients.<sup>10</sup> Reconstruction with endoprosthesis is indicated in patients with major bone destruction. It has low rates of complications and failures and besides that provides relief of pain and restoration of limb function. The most commonly used functional evaluations for patients with bone cancer are: the Musculoskeletal Tumor Society Rating Scale (MSTS)<sup>11,12</sup> the Toronto Extremity Salvage Score (TESS)<sup>13</sup> and Short Form 36 (SF-36).<sup>14</sup> Each of these evaluations covers a different definition of the functional aspect. The TESS is a self-administered questionnaire which is easy to understand and can be sent to the patient by mail. Also, it is one of the questionnaires most commonly used in studies involving functional evaluation in patients with malignant bone tumors and soft tissue sarcomas of the extremities.<sup>15</sup> The TESS (Toronto Extremity Salvage Score)<sup>13</sup> was the chosen instrument used in this study. Information was obtained about the impression and perception of patients who had undergone treatment; the function and quality of life were also evaluated without interference from the doctor.

## MATERIALS AND METHODS

After obtaining approval from the ethics committee under CAAE number: 01390.0388.000-10, 36 consecutive patients who underwent surgical treatment with endoprosthesis between May 2008 and August 2012 were selected retrospectively (with bone metastases or multiple myeloma of the proximal femur with pathological or imminent fracture).

All the patients completed and signed the questionnaire under the researcher's supervision, and those who could not or experienced difficulties coming to the hospital answered the questionnaire and sent them by mailing. From the total of 36 patients, only 25 participated in the study. Five had died at the time of this study, four were not found and two refused to participate. The surgical indication of endoprosthesis of the proximal femur was indicated in treating lesions with extensive destruction.

The Mirels index score evaluates the risk of pathologic fracture of long bones. This index is based on the anatomical location, pain intensity, radiographic features of the lesion and percentage of bone affected. Based on their criteria, above nine points, there is an indication of surgery, even in the absence of fracture.<sup>16</sup> In this study, Mirels criteria were used to indicate surgery in patients without fracture.

The patients answered the questionnaire after surgery (minimum 6 weeks), as well as in restrictions of body movements, mobility, self-care and performance on tasks and daily routines.

The following five questions emphasize the patient's current situation regarding occupation (employed or unemployed, student, etc), brief description of leisure and recreation activities, use of pain medications and their frequency of use, help to move or walk (stroller, crutch, sticks or wheelchair) and what factors can limit the activities of daily life (pain, stiffness, fatigue, weakness, decreased movement).

With the data collected after completing the questionnaire, analysis of the scores obtained by functional assessment (TESS) was conducted. Each question has an alternative that makes it possible to achieve between 0 to 5 points, totaling 150 points. Data collected were analyzed, and items whose answer was "this item does not apply to me", were excluded and divided by a possible score multiplied by 100%. Hence, the higher scores mean better function.

A comparison of TESS scores between qualitative variables was performed using the Student t-test. Correlations between TESS scores, age and postoperative time were assessed by Pearson correlation analysis. With the evaluation of variables that together influence the TESS score, multiple regression analysis was performed.

Data analysis was performed with the statistical package SPSS 12.0 (Statistical Package for Social Sciences), (Chicago, EUA).

## RESULTS

Between May 2008 to August 2012, twenty-five (25) patients answered the questionnaire. Breast tumor (48%) was the primary tumor with the highest incidence, followed by Myeloma (24%) and kidney tumor (12%) (Figure 1).

The 25 patients had an average age of 60.8 years (SD 9.82), as shown in Tables 1 and 2. Six patients showed no imminent fracture and the Mirels score was 10 for 3 patients and 11 for the remaining 3 patients. In total, there were sixteen female patients (64%) and 9 male patients (36%) (Table 1).

From the total of 25 patients, only 17 (68%) had fracture/injury in the femoral neck while 8 (32%), had it in the peritrochanteric region. Nineteen (19) patients (76%) presented with a pathologic fracture (Table 2).

The questionnaire was applied between 2 months to 3 years post-operatively ( $11.96 \pm 10.64$ ). Function was measured by TESS score ranging from 7.5 to 91.7 ( $57.83 \pm 23.78$ ). By assessing different patient characteristics and associating them with the TESS score, there was no statistically significant difference between the groups in relation to any qualitative variable (Table 2).

The correlation between quantitative variables is low. Although they were weak and negative, with increasing age there was a tendency for smaller TESS value, and more time after surgery, reduced the TESS (Table 3). Multiple regression analysis was performed to evaluate the presence of interference from the joint variables with respect to the TESS. The final model was well adjusted ( $p < 0.001$ ) and  $R^2 = 0.868$ ; however, only the variable gender entered the final model. The other variables were not significant for the model.

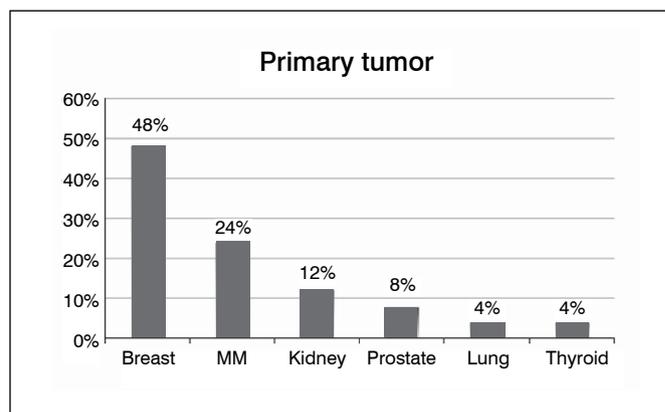


Figure 1. Percentage of the primary tumor in 25 patients.

## DISCUSSION

Pathological fractures occur frequently in the proximal femur. Surgical treatment should be performed as soon as possible, because these fractures present morbidity and high risk to life.<sup>15,17</sup> In their study, they evaluated patients with extensive lesions of the proximal femur (neck and peritrochanteric region) fracture or imminent risk of fracture, where the indication of treatment was the resection of the affected bone and its replacement by unconventional

**Table 1.** Data of patients and TESS results.

Patient	Gender	Age	Race	side	Primary tumor	local	PO Time	Fracture	TESS
1	M	76	Caucasian	R	Prostate	Neck	3y	Y	7.5
2	M	65	Caucasian	R	Lung	Neck	6m	Y	8.3
3	F	60	Caucasian	L	MM <sup>a</sup>	Trochanter	3m	Y	10.8
4	M	62	Caucasian	L	MM <sup>a</sup>	Trochanter	6m	Y	66.6
5	F	72	Caucasian	R	MM <sup>a</sup>	Neck	6m	N	71.6
6	F	63	Black	R	MM <sup>a</sup>	Neck	2m	Y	72.0
7	M	72	Caucasian	R	MM <sup>a</sup>	Neck	6m	Y	67.8
8	M	65	Caucasian	L	Prostate	Trochanter	2y	Y	24.0
9	F	67	Caucasian	R	Breast	Neck	1y	Y	44.4
10	F	75	Caucasian	L	Breast	Neck	3y	N	82.4
11	M	73	Caucasian	R	MM <sup>a</sup>	Trochanter	1y	N	45.1
12	F	50	Caucasian	R	Breast	Neck	1y	Y	90.3
13	F	46	Black	R	Breast	Neck	1y	Y	75.0
14	F	62	Caucasian	R	Breast	Neck	6m	Y	62.5
15	M	63	Caucasian	L	Kidney	Neck	6m	Y	66.6
16	F	60	Caucasian	R	Thyroid	Neck	1y	Y	91.6
17	F	56	Black	L	Breast	Trochanter	2y	Y	73.9
18	F	62	Caucasian	R	Breast	Trochanter	3y	Y	44.3
19	F	41	Caucasian	R	Breast	Neck	1y	N	60.2
20	M	62	Caucasian	L	Kidney	Neck	6m	N	76.1
21	F	51	Black	L	Breast	Trochanter	3m	Y	69.4
22	M	68	Caucasian	R	Kidney	Neck	3m	Y	47.9
23	F	50	Asian	R	Breast	Trochanter	6m	Y	61.1
24	F	56	Caucasian	L	Breast	Neck	6m	Y	57.6
25	F	42	Caucasian	L	Breast	Neck	6m	N	67.8

<sup>a</sup>MM: Multiple Myeloma.

**Table 2.** Qualitative variables correlated with the TESS.

		TESS								
		N	Average	SD	Min	Max	Q25	Median	Q75	P value
Gender	Male	9	45.59	26.52	7.5	76.14	24.07	47.92	66.67	0.051
	Female	16	64.72	19.73	10.83	91.67	58.96	68.65	74.47	
Age group	≤ 60	10	65.81	22.56	10.83	91.67	60.23	68.65	75.00	0.176
	> 60	15	52.51	23.80	7.5	82.41	44.32	62.50	71.67	
Side	Right	15	56.67	24.80	7.5	91.67	44.44	61.11	72.00	0.773
	Left	10	59.57	23.35	10.83	82.41	57.69	67.27	73.91	
Place of injury	Neck	17	61.78	23.89	7.5	91.67	57.69	67.86	75.00	0.234
	Trochanter	8	49.44	22.71	10.83	73.91	34.20	53.15	68.06	
Fracture	No	6	67.25	13.15	45.19	82.41	60.23	69.77	76.14	0.275
	Yes	19	54.86	25.83	7.5	91.67	44.32	62.50	72.00	

**Table 3.** Regression coefficient correlation. Variables X TESS.

	Age	PO (months)	TESS
Age	1	0.30	- 0.32
PO (Months)	0.30	1	- 0.17
TESS	- 0.32	- 0.17	1

endoprosthesis with a stem cementation in the distal femur without replacement of the acetabulum <sup>18</sup>.

The advantage of endoprosthesis is that it can efficiently stabilize the affected segment, with the improvement of pain and possibility of early ambulation. However, it is a procedure with greater likelihood of bleeding and other complications; it is considered a method with low morbidity.<sup>19</sup>

Normally, if there are no clinical complications, the patients start gait training by supporting the operated limb by weight bearing and with the aid of crutches or walker, about the second or third day after surgery. Hospital discharge usually occurs between the fifth and seventh day after surgery. It continues with home rehabilitation and after the removal of stitches the patient is referred to an oncologist, in order to continue treatment of the primary tumor and physical therapy.

Patient survival rate depends on the primary tumor. The average survival time of a patient undergoing surgical treatment for bone metastases is approximately 8.6 months.<sup>5</sup> However, patients with more aggressive tumors as in the case of lung cancer, or other clinical problems that deteriorate the clinical condition, may have a shorter survival. Indeed the minimum period for interviewing a patient in this study was six weeks. Some patients had already died before invitations were sent. The average TESS score in this study was 57.83.

Clayer et al.<sup>13</sup> found statistically significant differences in the TESS values between the different age groups, with the lowest scores being in the elderly. This study, however, examined the appearance of clinical and non-surgical patients. Tunn et al.<sup>18</sup> also demonstrated lower scores in older patients, who underwent surgery with stents. Age seems to be one of the factors that aggravate and worsen the

quality of life of patients with bone metastasis of the proximal femur. The worst TESS score (7.5) was obtained from the older patient (76 years) with a history of prostate cancer and longer survival at the time of the interview (3 years). The highest TESS score (91.67) occurred in a 60 years old patient with thyroid cancer, with 1-year survival at the time of the interview. However, in this study TESS had no correlation with age TESS. When surgery was indicated, the final decision was taken in conjunction with the oncologist and especially with the family, leaving them to make the final decision about the surgical treatment. Cases with poor prognosis and life-threatening surgery, underwent clinical treatment with palliative clinical pain care. TESS scores reflect the patient's opinion about the activities of their daily life, which differs from the performance evaluation regarding the clinical criteria and function of the operated member from the medical professional's point of view. TESS is one of the most widely used questionnaires worldwide, in studies involving the functional assessment of patients with bone and soft tissue tumors of the extremities. There are few study treatments with endoprosthesis and TESS. The results obtained in studies involving endoprosthesis femur and TESS, show the best results in patients with primary tumors.

The results were compared with other studies by Asford et al.<sup>19</sup> and Chandrasekar et al.<sup>20</sup>, who also found TESS scores with values of 68.4 and 64, very similar to that found in the present study (TESS = 57.85), with a larger number of patients in the proximal femur. On the other hand, Tunn et al.<sup>18</sup>(2008) found the same value of TESS, but in another localization (distal femur, proximal femur and proximal tibia) while considering primary tumors.

## CONCLUSION

Studying the results of surgical treatment for bone metastasis is difficult because bone cancer is often an advanced sign of the disease and poor prognosis. Also, metastatic tumors are all different in terms of life span, response to treatment and risk of fractures. Advanced cancer is a condition that can bring multiple complications and deterioration in general health conditions. Information about the quality of life of patients under this point of view, in the final phase of their lives, should not be neglected. In the specific case of metastatic lesions with extensive lesions of the proximal femur, TESS was able to indicate that surgery with unconventional endoprosthesis can be considered a good alternative.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. MHT (0000-0001-7824-584X)\*: concept and design of the study, acquisition, analysis and interpretation of the data for the work and writing the article; MMS (0000-0003-2131-3404)\*: acquisition, analysis and interpretation of the data for the work and writing the article; DLGC (0000-0001-9053-090X)\*: acquisition, analysis and interpretation of the data for the work and writing the article; MPN (0000-0001-5892-2532)\*: Critical review of the content of the work, final approval of the version of the manuscript to be published. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Weber KL, Lewis VO, Randall RL, Lee AK, Springfield D. An approach to the management of the patient with metastatic bone disease. *Instr Course Lect*. 2004;53:663-76.
2. Dorfman HD. Metastatic tumors in bone. In: Dorfman HD, Czerniak B (eds) *Bone Tumors*. St Louis: Mosby; 1998. p.1009-40.
3. Manoso MW, Healey JH. Metastatic cancer to the bone. IN : DeVita Jr. VT, Hellman S, Rosenberg SA (eds) *Cancer: principles and practice of oncology, 7ed* Philadelphia: Lippincott Williams and Wilkins; 2005.p.2368-80
4. Bickels J, Dadia S, Lidar Z. Surgical management of metastatic bone disease. *J Bone Joint Surg Am*. 2009;91(6):1503-16.
5. Hage WD, Aboulaflia AJ, Aboulaflia DM. Incidence, location, and diagnostic evaluation of metastatic bone disease. *Orthop Clin North Am*. 2000;31(4):515-28.
6. Harrington KD. New trends in the management of lower extremity metastases. *Clin Orthop Relat Res*. 1982;(169):53-61.
7. Houston SJ, Rubens RD. The systemic treatment of bone metastases. *Clin Orthop Relat Res*. 1995;(312):95-104.
8. Janjan NA. Radiation for bone metastases: conventional techniques and the role of systemic radiopharmaceuticals. *Cancer*. 1997;80(8 Suppl):1628-45.
9. Thurman SA, Ramakrishna NR, DeWeese TL. Radiation therapy for the treatment of locally advanced and metastatic prostate cancer. *Hematol Oncol Clin North Am*. 2001;15(3):423-43.
10. Weber KL, Randall RL, Grossman S, Parvizi J. Management of lower-extremity bone metastasis. *J Bone Joint Surg Am*. 2006;88:11-9.
11. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. *Clin Orthop Relat Res*. 1993;(286):241-6.
12. Davis AM, Wright JG, Williams JI, Bombardier C, Griffin A, Bell RS. Development of a measure of physical function for patients with bone and soft tissue sarcoma. *Qual Life Res*. 1996;5(5):508-16.
13. Clayer M, Doyle S, Sangha N, Grimer R. The Toronto Extremity Salvage Score in unoperated controls: an age, gender, and country comparison. *Sarcoma*. 2012;7:17213.
14. Brazier JE, Harper R, Jones NM, O'Cathain A, Thomas KJ, Usherwood T, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *BMJ*. 1992;305:160-4.
15. Ward WG, Holsenbeck S, Dorey FJ, Spang J, Howe D. Metastatic disease of the femur: surgical treatment. *Clin Orthop Relat Res*. 2003;(415 Suppl):S230-44.
16. Mirels H. Metastatic disease in long bones. A proposed scoring system for diagnosing impending pathologic fractures. *Clin Orthop Relat Res*. 1989;(249):256-64.
17. Camargo OP, Baptista AM. Conduta atual nas lesões ósseas metastáticas. *Rev Bras Ortop*. 2004;39(6):273-82.
18. Tunn PU, Pomraenke D, Goerling U, Hohenberger P. Functional outcome after endoprosthetic limb-salvage therapy of primary bone tumours--a comparative analysis using the MSTS score, the TESS and the RNL index. *Int Orthop*. 2008;32(5):619-25.
19. Ashford RU, Hanna SA, Park DH, Pollock RC, Skinner JA, Briggs TW, et al. Proximal femoral replacements for metastatic bone disease: financial implications for sarcoma units. *Int Orthop*. 2010;34(5):709-13.
20. Chandrasekar CR, Grimer RJ, Carter SR, Tillman RM, Abudu A, Buckley L. Modular endoprosthetic replacement for tumours of the proximal femur. *J Bone Joint Surg Br*. 2009;91(1):108-12.

# TIBIAL ADAMANTINOMA: ANALYSIS OF SEVEN CONSECUTIVE CASES IN A SINGLE INSTITUTION

## ADAMANTINOMA DA TÍBIA: ANÁLISE DE SETE CASOS CONSECUTIVOS EM UMA ÚNICA INSTITUIÇÃO

JUAN PABLO ZUMÁRRAGA<sup>1</sup>, RICARDO CARTOLANO<sup>2</sup>, MARCELO TOMIO KOHARA<sup>1</sup>, ANDRÉ MATHIAS BAPTISTA<sup>1</sup>, FELIPE GONÇALVES DOS SANTOS<sup>1</sup>, OLAVO PIRES DE CAMARGO<sup>1-3</sup>

1. Orthopedic Oncology Group, Instituto de Ortopedia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

2. Instituto de Ortopedia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

3. Department of Orthopedics and Traumatology, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** Adamantinoma accounts for less than 1% of the primary bone neoplasms. The tibia is the most affected bone and it is predominant in male patients between the second and third decades of life. The objective of this study is to obtain epidemiological and clinical information on patients with adamantinoma of the tibia treated surgically between 1989 and 2016. **Methods:** Retrospective series of seven patients diagnosed with adamantinoma of the tibia that underwent surgery at the orthopedic oncology service of our hospital. The information was obtained from the medical records and histopathological reports of our institution. **Results:** A total of 2870 medical records with histological reports were evaluated. Seven cases of adamantinoma of the tibia were included. The mean age was 28.5 (17-49) years. We found a predominance of females (71.4%) and the most affected side was the left one, with four cases (57.1%). The biopsy revealed bone adamantinoma in four (57.1%) patients, while the diagnosis of the other patients was confirmed after the histological examination of the surgical specimen. All the patients underwent surgery as definitive treatment. No positive margins were reported. No local recurrence (LR) was reported and two patients had distant metastasis (DM). **Conclusion:** The prognosis of survival in cases of adamantinoma of the tibia is high. The rates of LR and DM were low. Surgical treatment with extensive tumor resection is the treatment of choice. **Level of Evidence IV, Case Series.**

**Keywords:** Adamantinoma. Tibia. Bone neoplasms. Biopsy. Surgical oncology.

### RESUMO

**Objetivo:** O adamantinoma representa menos de 1% das neoplasias ósseas primárias. Afeta predominantemente a tíbia, em pacientes do sexo masculino entre a segunda e terceira décadas da vida. O objetivo deste trabalho é obter informação epidemiológica e clínica dos pacientes com adamantinoma da tíbia, tratados mediante cirurgia entre 1989 e 2016. **Métodos:** Série retrospectiva de sete pacientes com diagnóstico de adamantinoma da tíbia, tratados cirurgicamente no serviço de oncologia ortopédica do nosso hospital. A informação foi obtida dos relatos clínicos e patológicos do instituto. **Resultados:** Um total de 2870 prontuários com relatos anatopatológicos foram revisados. Sete casos de pacientes com adamantinoma na tíbia foram encontrados. A média de idade foi de 28,5 anos (17-49). Encontramos predominância do sexo feminino (71,4%). O lado mais afetado foi o esquerdo, com quatro (57,1%) casos. A biópsia diagnosticou adamantinoma em 57,1% dos casos e o diagnóstico dos outros casos foi definido após exame da peça cirúrgica. Todos os pacientes receberam tratamento cirúrgico como terapia definitiva. Não foram reportadas margens comprometidas. Nenhum paciente apresentou recorrência local (RL). Dois pacientes apresentaram metástase à distância (MD). **Conclusão:** O prognóstico de sobrevida do adamantinoma da tíbia é alto. Apresenta taxas baixas de RL e MD. A cirurgia com ampla ressecção do tumor é o tratamento de escolha. **Nível de Evidência IV, Série de Casos.**

**Descritores:** Adamantinoma. Tibia. Neoplasias ósseas. Biópsia. Oncologia cirúrgica.

**Citation:** Zumárraga JP, Cartolano R, Kohara MT, Baptista AM, Santos FG, Camargo OP. Tibial adamantinoma: analysis of seven consecutive cases in a single institution. *Acta Ortop Bras.* [online]. 2018;26(4):252-4. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Adamantinoma is a rare cancerous tumor, accounting for less than 1% of all primary bone tumors.<sup>1</sup> The World Health Organization (WHO) defines it as a biphasic tumor, characterized by a variety of morphological patterns. The most common histological pattern

appears as a cluster of epithelial cells, surrounded by an osteofibrous cell component.<sup>2</sup> It primarily affects patients in their 20s and 30s, who are predominantly male.<sup>3</sup> The tibia is the most commonly affected site (85% of reports).<sup>4,5</sup> Pain is the main patient-reported symptom.<sup>6</sup> Histologically, it is a neoplasm originating from aberrant

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

Work conducted at the Instituto de Ortopedia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

Correspondence: Juan Pablo Zumárraga. Rua Ovídio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05403-010. [juanzumarraga@hotmail.com](mailto:juanzumarraga@hotmail.com)

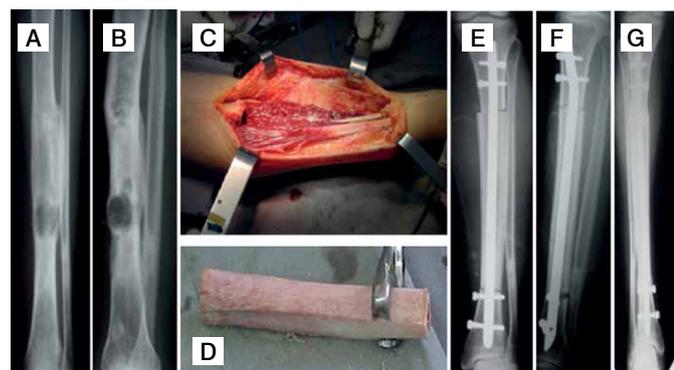
Article received in 03/09/2018, approved in 07/10/2018.



epithelial cells, with spindle-cell osteofibrous component. It can appear in four different patterns: basaloid, tubular, fusiform, and squamous. The basaloid and tubular types are the most common, and usually have a low mitotic index.<sup>2,7,8</sup> Radiography generally has an aggressive pattern, with radiolucent areas interspersed with poorly delimited sclerotic areas, which is known as the soap bubble pattern.<sup>8</sup> The most important differential diagnosis is osteofibrous dysplasia (OD).<sup>1,9-12</sup> There are some publications in the literature which advocate the possibility that OD is a precursor lesion to adamantinoma.<sup>1</sup> The post-biopsy pathological result often defines the lesion as OD. However, the final study of the surgical specimen determines the diagnosis of adamantinoma. This divergence of initial diagnosis supports the hypothesis formulated above.<sup>13,14</sup> Treatment of adamantinoma is based on extensive resection of the lesion with reconstruction of the bone defect (Figure 1). Several procedures described in the literature can be used: autograft, endoprosthesis, allograft and bone transport.<sup>6,13-16</sup> Because it is a lesion of low histologic grade, radical surgery with amputation should be ruled out whenever possible. Neoadjuvant or adjuvant chemotherapy (CT) and radiotherapy (RT) are not recommended in the literature.<sup>17</sup> LR (local recurrence) and DM (distant metastasis) are rare. When present, DM primarily affects the lung. We also find reports of DM in the lymph nodes and bone, of extremely rare occurrence and late presentation.<sup>16,18</sup> This study reports on a series of seven consecutive cases of patients diagnosed with adamantinoma in the tibia and treated surgically at a single institution. Thus, the purpose of this study was to describe the follow-up and outcome of these cases in view of the fact that it is a rare diagnosis with limited literature.

## MATERIALS AND METHODS

The study was approved by the Institutional Review Board of HCF-MUSP under number 14148. It is a retrospective study in which seven medical records of patients diagnosed with adamantinoma of the tibia by the Orthopedic Oncology Group of IOT-HC-FMUSP between 1989 and 2016 were used. All patients included in this



**Figure 1.** Case 3. Adamantinoma of the Tibia. Treatment with Allograft. A-B: Initial AP + Lat. X-ray. C: Surgical resection. D: Allograft. E-F: Reconstruction of the bone defect with allograft. G: 15 years after surgery, consolidation of the allograft.

study received surgical treatment. Age, sex, initial symptomatology, date of diagnosis, clinical stage, radiological characteristics, type of surgery and postoperative outpatient follow-up were acquired from the medical records. The histological diagnosis was made by the pathologists of the institute. Clinical and demographic characteristics were described using the following measures: mean, median, minimum and maximum for quantitative variables, and absolute and relative values for qualitative variables.<sup>19</sup> Clinical symptoms, histological presentation, treatment and results were described.

## RESULTS

A total of 2870 medical records with pathology reports were reviewed for this study. Only seven cases of adamantinoma of the tibia were found (Table 1). The mean age was 28.5 years (17-49). Five patients were female (71.4%) and two male (28.5%). The mean time from onset of symptoms to surgical treatment was 33.6 months. The left side was affected the most. Pain was the clinical characteristic present in all patients. We observed deformity of the tibia in six (85.7%) cases. Antecurvatum deformity was standard for these cases. Radiographic examination, with frontal and lateral views of the leg, respected the characteristic findings of the lesion, with a mean of 9.16 cm (4.1-12.8). The biopsy defined the diagnosis of adamantinoma in four (57.1%) cases. OD was reported in two (28.5%) cases and one (14.2%) case was reported as non-specific fibrosis. After the study of the surgical specimen, all cases were reported as adamantinoma. All patients received surgical treatment as definitive therapy at the institute. The surgery of choice for all patients was extensive resection of the bone lesion. Allograft reconstruction was performed in five (71.4%) cases and nonconventional diaphyseal endoprosthesis of the tibia in two (28.5%) cases. Two (28.5%) cases progressed to amputation. We had complication of skin and deep soft tissues (infection) in one (14.2%) case involving reconstruction with non-conventional diaphyseal endoprosthesis of the tibia. The infection, uncontrolled after extensive treatment with antibiotic therapy, progressed to disarticulation of the knee. Two (28.5%) cases had DM: one (14.2%) case in the inguinal lymph nodes in which the lesion was resected, and one (14.2%) case in the ipsilateral proximal femur. The case with bone metastasis progressed to disarticulation of the hip. No patient in this series had compromised surgical margins or LR. Furthermore, none of the patients in this study died. The mean follow-up time was 180 months (36-324).

## DISCUSSION

The medical literature does not contain an extensive volume of publications on adamantinoma, mainly because of the rarity of this disease. Most published studies are retrospective series and case reports. This was no exception: we analyzed seven consecutive cases over 29 years. We did not find studies on this topic in our field. The mean age of our study was 28.5 years, which coincides with that described in the literature.<sup>1,3</sup> Although accordingly to bibliographical references the disease is more predominant in male

**Table 1.** Distribution of cases in chronological order.

Case	Age*	Size**	Year of Surgery	Surgical Margins	Reconstruction	Complications	Local Recurrence	Metastasis
1	58	9.3x5.8x4.2	1989	negative	allograft	no	no	no
2	48	10.2x5.3x4.8	1994	negative	endoprosthesis	no	no	yes
3	57	11.4x6.1x5.2	2000	negative	allograft	no	no	no
4	53	9.6x5.8x4.1	2001	negative	endoprosthesis	infection	no	no
5	41	13.5x5.9x5.1	2003	negative	allograft	no	no	no
6	21	7.3x4.9x4.2	2012	negative	allograft	no	no	no
7	17	11.8x5.6x4.9	2014	negative	allograft	metastasis	no	yes

Current age of the patient,\* size in cm of the surgical specimen\*\*.

patients,<sup>3</sup> in this we observed predominance of female patients (71.4%). Published studies indicate that 85% of adamantinoma cases occur in the tibia.<sup>4,5</sup> This data cannot be compared since this study analyzed cases located only in the tibia. We found pain to be the main symptom of the disease, coinciding with the description presented in the publications.<sup>4,5,6</sup> In the literature, there are reports of different histopathological diagnoses in the biopsy, when compared with that of the surgical specimen. An initial diagnosis of OD is a common occurrence.<sup>13</sup> In this study, we also obtained this divergence, two (28.5%) cases obtained an initial diagnosis of OD. The common histogenetic origin between OD, osteofibrous dysplasia-like adamantinoma- and adamantinoma hinders the post-biopsy histopathological diagnostic definition.<sup>20</sup> Clinical, histopathological and imaging correlations should be compared for an adequate definition of the treatment. As defined in the literature, the treatment of choice for all cases was extensive resection with reconstruction. Complications of surgical treatment of adamantinoma can affect

66.6% of cases. The most common complications are infection, allograft consolidation failure, and fracture.<sup>21,22</sup> In this case series, we obtained a lower rate of complications than that found in the literature. We reported one (14.2%) case of infection. Moreover, we did not report any cases that presented with LR. In the literature, we can see that the LR rate is as high as 30%.<sup>21</sup> For DM we presented a rate of 14.2%, which is similar to the rate published, since reports describe a 15% rate of metastasis.<sup>21</sup> Adamantinoma has a high survival rate, with reports ranging between 85 and 95% at 5 years.<sup>23</sup> This is another difference of our study, in which we obtained a 100% survival rate. Finally, multicenter studies are needed to optimize the diagnosis and to define treatment protocols for adamantinoma.

## CONCLUSIONS

The prognosis of survival of adamantinoma in the tibia is high. It has low LR and DM rates. Surgical treatment with extensive resection of the tumor continues to be the standard therapeutic choice.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. JPZ (0000-0001-5941-7714)\*, RC (0000-0002-7853-1325)\*, MTK (000-0003-3384-7905)\*, AMB (0000-0002-0830-4602)\*, FGS (0000-0002-6854-6072)\*, and OPC (0000-0002-1128-7292)\*, were the main contributors in writing this work. JPZ participated in: research, design, writing and data collection; RC participated in: concept, research, writing and data collection; MTK participated in: concept, research, writing and data collection; AMB participated in: concept, design, and analysis; FGS participated in: research, design and data collection; OPC participated in: concept, writing and analysis. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

- Mavrogenis AF, Sakellariou VI, Tsididakis H, Papagelopoulos PJ. Adamantinoma of the tibia treated with a new intramedullary diaphyseal segmental defect implant. *J Int Med Res.* 2009;37(4):1238-45.
- Hogendoorn PCW, Kanamori M. Adamantinoma. In: Fletcher CDM, Bridge JA, Hogendoorn PCW, Mertens F. WHO classification of tumors of soft tissue and bone. 4th. Lyon: International Agency for Research on Cancer; 2013. p. 343-45.
- Moon NF, Mori H. Adamantinoma of the appendicular skeleton updated. *Clin Orthop Relat Res.* 1986;(204):215-37.
- Czerniak B, Rojas-Corona RR, Dorfman HD. Morphologic diversity of long bone adamantinoma. The concept of differentiated (regressing) adamantinoma and its relationship to osteofibrous dysplasia. *Cancer.* 1989;64(11):2319-34.
- Keeney GL, Unni KK, Beabout JW, Pritchard DJ. Adamantinoma of long bones. A clinicopathologic study of 85 cases. *Cancer.* 1989;64(3):730-7.
- Jain D, Jain VK, Vasishta RK, Ranjan P, Kumar Y. Adamantinoma: a clinicopathological review and update. *Diagn. Pathol.* 2008;15(3):8.
- Fisher B. Primary adamantinoma of the tibia. *Z Pathol.* 1913;12:422-41.
- Ryrie BJ. Adamantinoma of the tibia: aetiology and pathogenesis. *Br Med J.* 1932;2(3752):1000-20.
- Imran MB, Othman SA. Bilateral tibial adamantinomas simulating stress fractures on scintigraphy. *Clin Nucl Med.* 2011;36(9):788-90.
- Kahn LB. Adamantinoma, osteofibrous dysplasia and differentiated adamantinoma. *Skeletal Radiol.* 2003;32(5):245-58.
- Ulmar B, Dellling G, Werner M, Huch K, Reichel H. Classical and atypical location of adamantinomas—presentation of two cases. *Onkologie.* 2006;29(6):276-8.
- Bethapudi S, Ritchie DA, Macduff E, Straiton J. Imaging in osteofibrous dysplasia, osteofibrous dysplasia-like adamantinoma, and classic adamantinoma. *Clin Radiol.* 2014;69(2):200-8.
- Khanna M, Delaney D, Tirabosco R, Saifuddin A. Osteofibrous dysplasia, osteofibrous dysplasia-like adamantinoma and adamantinoma: correlation of radiological imaging features with surgical histology and assessment of the use of radiology in contributing to needle biopsy diagnosis. *Skeletal Radiol.* 2008;37(12):1077-84.
- Scholfield DW, Sadozai Z, Ghali C, Sumathi V, Douis H, Gaston L, et al. Does osteofibrous dysplasia progress to adamantinoma and how should they be treated? *Bone Joint J.* 2017;99-B(3):409-16.
- Kiral A, Pehlivan O, Cilli F, Akmaz I, Rodop O, Solakoglu C. Reconstruction of intercalary gap after wide surgical resection of adamantinoma of the tibia. *Orthopedics.* 2008;31(11):1143.
- Szendroi M, Antal I, Arató G. Adamantinoma of long bones: a long-term follow-up study of 11 cases. *Pathol Oncol Res.* 2009;15(2):209-16.
- Sakellariou VI, Mavrogenis AF, Papagelopoulos PJ. Limb salvage surgery using the intramedullary diaphyseal segmental defect fixation system. *J Long Term Eff Med Implants.* 2008;18(1):59-67.
- Frey SP, Harges J, Ahrens H, Winkelmann W, Gosheger G. Total tibia replacement using an allograft (in a patient with adamantinoma). Case report and review of literature. *J Cancer Res Clin Oncol.* 2008;134(4):427-31.
- Kirkwood BR, Sterne JA. Essential medical statistics. 2nd ed. Massachusetts: Blackwell Science; 2006.
- Ramanoudjame M, Guinebretière JM, Mascard E, Seringe R, Dimeglio A, Wicard P. Is there a link between osteofibrous dysplasia and adamantinoma?. *Orthop Traumatol Surg Res.* 2011;97(8):877-80.
- Filippou DK, Papadopoulos V, Kiparidou E, Demertzis NT. Adamantinoma of tibia: a case of late local recurrence along with lung metastases. *J Postgrad Med.* 2003;49(1):75-7.
- Giannoulis DK, Gantsos A, Giotis D, Paschos NK, Vagionas A, Arnaoutoglou CM, et al. Multiple recurrences and late metastasis of adamantinoma in the tibia: a case report. *J Orthop Surg (Hong Kong).* 2014;22(3):420-2.
- Qureshi AA, Shott S, Mallin BA, Gitelis S. Current trends in the management of adamantinoma of long bones. An international study. *J Bone Joint Surg Am.* 2000;82-A(8):1122-31.

# EXPLORING CORTICAL BONE DENSITY THROUGH THE ULTRASOUND INTEGRATED REFLECTION COEFFICIENT

## DENSIDADE ÓSSEA CORTICAL ANALISADA PELO COEFICIENTE DE REFLEXÃO ULTRASSÔNICA

DANIEL PATTERSON MATUSIN<sup>1</sup>, ALDO JOSÉ FONTES-PEREIRA<sup>1</sup>, PAULO TADEU CARDOZO RIBEIRO ROSA<sup>1</sup>, THIAGO BARBOZA<sup>2,3</sup>, SERGIO AUGUSTO LOPES DE SOUZA<sup>2,3</sup>, MARCO ANTÔNIO VON KRÜGER<sup>1</sup>, WAGNER COELHO DE ALBUQUERQUE PEREIRA<sup>1</sup>

1. Biomedical Engineering Program, Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia (COPPE), Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil.

2. Laboratório de Marcação de Células e Moléculas (LMCM), Department of Radiology, School of Medicine, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil.

3. Laboratório microPET/SPECT/CT, Centro Nacional de Biologia Estrutural e Bioimagem (CENABIO), Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil.

### ABSTRACT

**Objective:** This work evaluates the relationship between ultrasonic reflection and bone density from fourteen cylindrical bovine cortical bone samples (3.0-cm thick). **Methods:** Twenty US reflection signals per sample were acquired along the bone surface (2.0-mm step). The Integrated Reflection Coefficient (IRC) from each signal was compared to Quantitative Computed Tomography (QCT). **Results:** Seven IRC and QCT curves presented Pearson's Correlation R-values above 0.5. For weak correlation curves, QCT and IRC showed similar trends in several segments. **Conclusion:** IRC was sensitive to bone density variation. **Level of Evidence: Experimental Study, Investigating a Diagnostic Test.**

**Keywords:** Ultrasonics. Cortical bone. Bone and Bones. Tomography. Bone density.

### RESUMO

**Objetivo:** Este estudo avalia a relação entre a reflexão ultrassônica e a densidade óssea de 14 amostras cilíndricas de osso cortical bovino (3,0 cm de espessura). **Métodos:** Foi realizada a aquisição de 20 sinais de reflexão ultrassônica por amostra (passo de 2,0 mm), ao longo da superfície óssea. O Coeficiente de Reflexão Integrado (IRC) de cada sinal foi comparado por Tomografia Computadorizada Quantitativa (QCT). **Resultados:** Sete curvas de IRC e QCT apresentaram valor de Correlação R de Pearson acima de 0,5. Para curvas de correlação fraca, QCT e IRC apresentaram tendências semelhantes em vários segmentos. **Conclusão:** O IRC foi sensível à variação da densidade óssea. **Nível de evidência: Estudo Experimental, Investigação de Exame Diagnóstico.**

**Descritores:** Ultrassom. Osso Cortical. Osso e ossos. Tomografia. Densidade Óssea.

**Citation:** Matusin DP, Fontes-Pereira AJ, Rosa PTCR, Barboza T, Souza SAL, von Krüger MA, Pereira WCA. Exploring cortical bone density through the ultrasound integrated reflection coefficient. *Acta Ortop Bras.* [online]. 2018;26(4):255-9. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Aging, trauma and other biological conditions like osteogenesis imperfecta, osteomalacia, bone metastasis and osteoporosis can affect bone physical properties. Among them, osteoporosis is the more common disease and is characterized by bone mass loss, affecting the microarchitecture of cortical and trabecular bone leading to increased susceptibility to fracture caused by low-impact trauma. Such injury may lead to disability, morbidity and mortality of individuals. From the health system point of view, it represents a financial cost as for instance, in USA, more than 2 million fractures were associated with osteoporosis in 2005 and it is estimated that the number of cases will increase up to 3 million in 2025.<sup>1</sup> Densitometry is the gold standard for diagnosis of osteopenia, osteoporosis and bone tissue evaluation. Its advantages are the

relative low cost and low radiation exposure. The quantitative computed tomography (QCT), despite offering results that are more accurate, is more expensive and demands higher X-ray exposure. The criterion for human osteoporosis diagnosis is a bone loss of 25% or more than 2.5 standard deviations below the average of bone loss regarding age and sex.

Quantitative ultrasound (QUS) methods can be an option for the diagnosis of diseases affecting bone tissue, as ultrasound propagation through tissue is dependent of the composition and architecture of the material. Indeed current literature describes several QUS techniques applied to trabecular bone.<sup>2</sup> However, QUS is not yet able to diagnose osteoporosis with the same accuracy of bone densitometry<sup>3</sup> or QCT. The potential advantage of QUS compared to bone densitometry for characterization of bone fragility and fracture risk is its stronger

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

Work conducted at the Laboratório de Ultrassom/Programa de Engenharia Biomédica [Ultrasound Laboratory/Biomedical Engineering Program]/Universidade Federal do Rio de Janeiro. Correspondence: Universidade Federal do Rio de Janeiro – UFRJ/Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia - COPPE/Programa de Engenharia Biomédica. Av. Horácio Macedo, 2030, Rio de Janeiro, RJ, Brazil; PO Box 68.510. 21941-914. [patter.daniel@gmail.com](mailto:patter.daniel@gmail.com)

Article received in 05/15/2017, approved in 05/21/2018.



relation to bone mechanical properties.<sup>4</sup> Densitometry uses density to indirectly estimate bone fragility. Moreover, QUS can estimate different tissue parameters from its interaction with ultrasound,<sup>5</sup> while bone densitometry estimates only a parameter related to X-ray attenuation. The cortical bone constitutes 80% of the skeleton, which is affected by osteoporosis<sup>6</sup> and injuries, but its assessment by US is poorly explored. Transmission-reception techniques, pulse-echo and B-mode images are valuable techniques for cortical bone assessment. Kotha *et al.*<sup>7</sup> after analyzing ultrasound reflection signal, estimated the acoustic impedance of bovine cortical bone and correlated it with indicators of bone mechanical properties. Fontes-Pereira *et al.*<sup>8</sup> presented the possibility to characterize femur diaphysis of rats in vivo by the ultrasonic pulse-echo method associated with wave reflection and backscattering.

The high density of cortical bone makes its US exploration notable by high reflections signals at interface bone/soft tissues. Exploring reflection properties can be useful in assessing the composition and characteristics of cortical bone, offering additional data for bone characterization.

The aim of this work was to evaluate the relation between ultrasonic reflection and the density of bovine cortical bone. The reflection was characterized by Integrated Reflection Coefficient (IRC) and compared to QCT values.

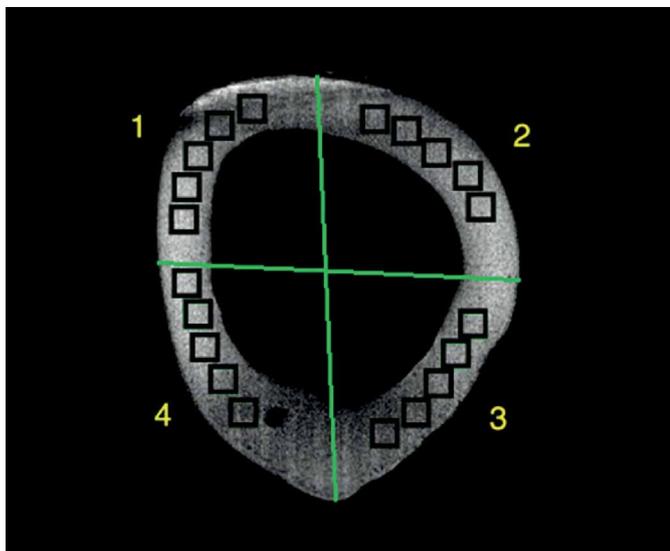
## MATERIALS AND METHODS

### Bovine Samples

Three samples from *ex vivo* bovine cortical femoral bone extracted from five animals aging ranging from 2 to 3 years old. Each sample is a cross-sectional segment 3-cm thick kept at -16.5 °C before the experiment. The sliced surface was divided in four quadrants to promote a signal acquisition distributed in all regions. QUS and QCT parameters were estimated for five points at each quadrant and compared each other (Figure 1).

### Quantitative Computed Tomography acquisition

The QCT images obtained with 75 kVp and 145 mA, through a Triumph II microPET/SPECT/CT equipment (Trifoil imaging, Northridge, Chatsworth, CA, USA) were processed with Osirix software. Bone density (Hounsfield Units - HU) was estimated for



**Figure 1.** QCT image with the four quadrants division. Square windows are the regions of US signal acquisition. QCT mean values (HU) were estimated for the same regions.

five non-overlapping 3 x 3 mm squared areas of each quadrant along the most superficial image layer of bone. The pulse-echo ultrasound signals were acquired in these same areas.

### Experimental setup and US signal acquisition

A SR9000 pulse generator (Matec® Inc., Hopkinton, MA, USA) excited a US transducer (model V326, Olympus® NDT Inc., Waltham, MA, EUA) with 5 MHz nominal frequency, 9.5-mm diameter and 2.1-mm focus diameter. The transducer was immersed in 24.5°C degassed water tank pointing to the sample cross-section surface positioned at focal length of 70 mm.

The acquisition of five signals was made for each of the four marked areas using 2.0 mm step displacement of ultrasonic beam along the sample surface performing 20 signals per sample. A reference signal was collected from a polished steel reflector, positioned at the same focal distance.

The echo signals were acquired on an oscilloscope (model TDS 2024B, Tektronix® Inc., Beaverton, OR, USA) and further, transferred to a microcomputer to be processed by a program developed in Matlab® (MathWorks Inc., Natick, MA, USA) (Figure 2).

### Measurement of ultrasound parameter

A Hamming window selected the steel echo from reference signal. The limits of the selected signal were defined by choosing the most distant points with 10% of peak value for each side. A window with the same dimension selected the reflection echo from the water/bone interface for each sample.

The US parameter IRC – Integrated Reflection Coefficient were estimated from the RTF - Reflection Transfer Function (Equation 1).

$$RTF = 10 \log_{10} P_{specimen}(f) - 10 \log_{10} P_{reference}(f),$$

where  $P_{specimen}$  e  $P_{reference}$  are power spectra of sample and reference signal, respectively.

Equation 2 estimates the IRC value for each signal:

$$IRC = \frac{\int_{f_{low}}^{f_{high}} (RTF) df}{f_{high} - f_{low}}$$

where  $f_{low}$  and  $f_{high}$  are the inferior and superior frequency limits of bandwidth transducer at -6 dB of peak value. The IRC indicates the quantity of energy reflected from bone surface.

### Statistical analysis

The Kolmogorov-Smirnov and equal variance tests were used to check normality. The statistic tests were implemented in SigmaStat 3.5 (Systat Software, Inc., San Jose, CA, USA). Pearson's correlation coefficient was used to quantify the correlation between the parameter and density (HU) from QCT.

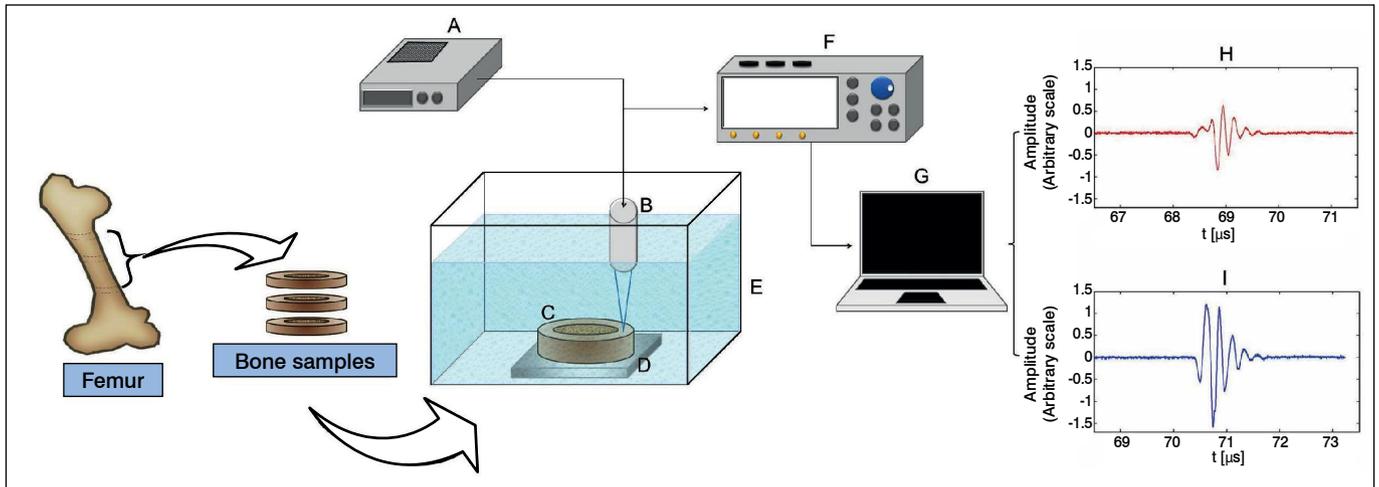
## RESULTS

The Pearson's Correlation (R) and p-values between IRC and QCT for each point are presented in Table 1. Figures 3 to 7 display examples of normalized curves with different correlation of IRC and QCT to show the behavior of values.

High R-values indicate high correlation between US parameters with QCT values. It has high correlation for IRC parameter at seven of 14 bones.

## DISCUSSION

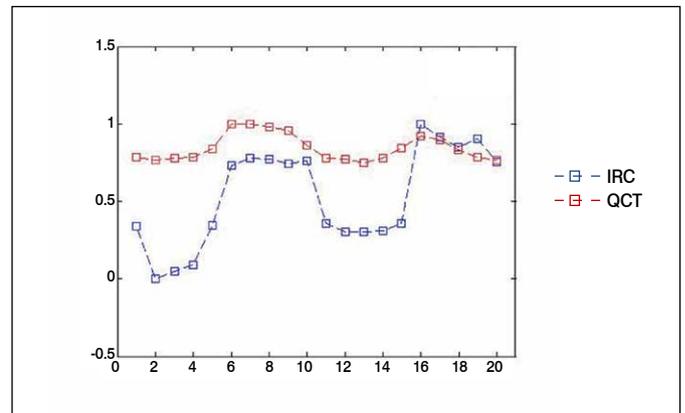
The use of commercial bovine bones has the advantage of low cost and easy acquisition from animals with rigorous food and health administration, regular age and gender. Bovine bones allow the investigation of US parameters in bones with dimensions, shape



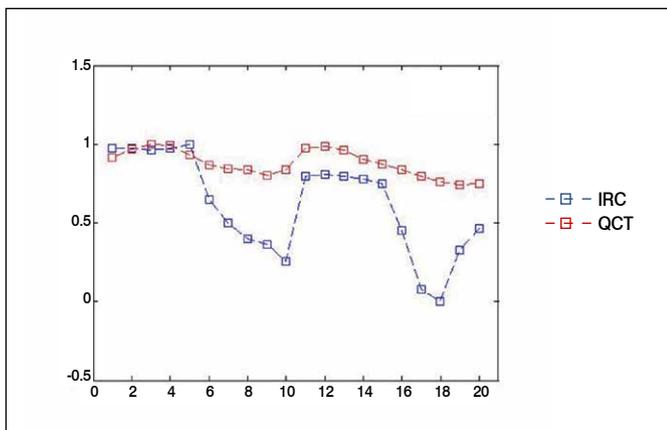
**Figure 2.** Experimental setup for US signal acquisition. A - Pulse generator; B - US transducer; C - cylindrical disc sample of bovine bone; D - Polished steel reflector; E - Acoustic tank; F - Oscilloscope; G - Microcomputer; H - cortical bone ultrasound signal; I - reference steel plate signal.

**Table 1.** R and p-values of Pearson correlation values between IRC and bone density from QCT, point to point for each bone samples of each animal.

Animal	Sample	Pearson	
		R	p
1	A	0.86	0.000001
	B	0.14	0.561
	C	0.51	0.02
2	A	0.33	0.153
	B	0.63	0.003
	C	0.02	0.929
3	A	0.76	0.0001
	B	0.74	0.0001
	C	0.38	0.097
4	A	0.60	0.005
	B	0.01	0.974
	C	0.63	0.002
5	A	0.19	0.415
	C	0.48	0.031



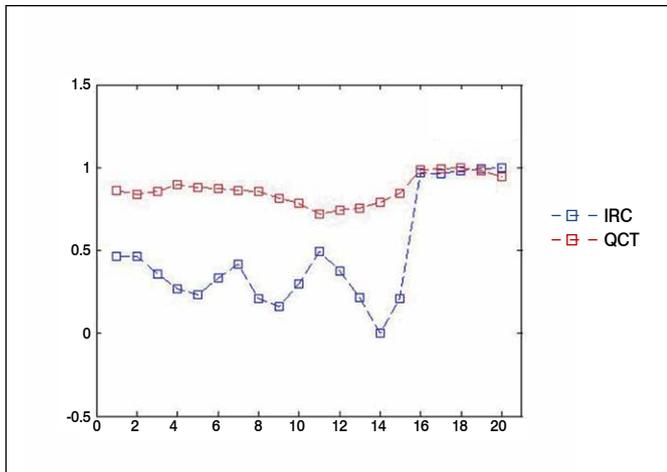
**Figure 4.** Twenty values of IRC and QCT from sample 2B (normalized scale). Figure show the similarity of plateaus formation on samples every five points according to signal acquisition characteristics. R-value of 0.63.



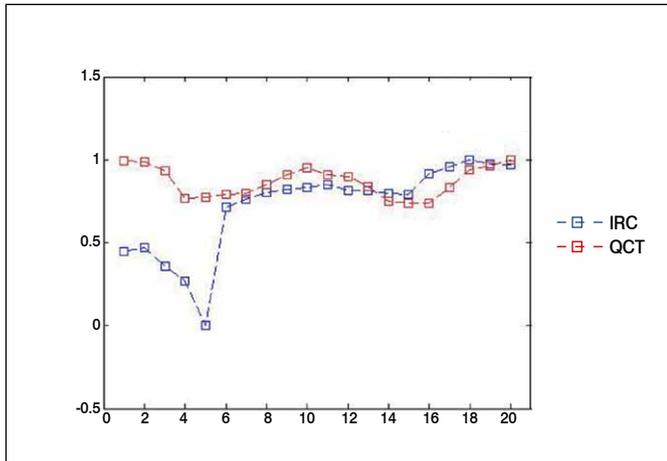
**Figure 3.** Twenty values of IRC and QCT from sample 1A (normalized scale). This sample presented the higher R-value: 0.86.

and composition similar to humans. A thicker tissue sample ensures transducer alignment with the region of interest of the sample, which is difficult with other smaller animals like rats or rabbits.

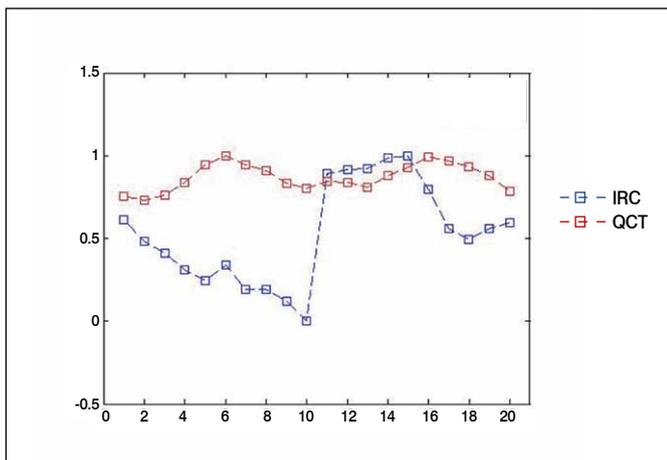
QUS parameters often characterize properties such as the speed of sound propagation, attenuation and backscatter. The high-density characteristic of cortical bone causes a high reflectivity and very few scattering, compared to trabecular bone.<sup>9</sup> The setup for the parameters estimation is very similar to those used on backscattering.<sup>10</sup> Many QUS studies in bone tissue characterization made parameters estimation by the average value of many signals for a tissue area or volume, but bone is a heterogeneous material with a great difference between nearby areas. Its variation depends on anatomy and modifications caused by nutrition and mechanical forces exerted on tissue, like compressive stresses and pulls tendon insertions that promote the osteons density and organization. The density variation produces a large range of values for both parameters. For QCT, the mean value was  $3098.6 \pm 356$  HU and for IRC was  $-5.43 \pm 3.31$  dB. All R-values were positive values what indicates a trend of increasing IRC value as bone density increases, which is consistent with theory,<sup>11</sup> since the higher the bone density is, the higher should be the reflection. Pearson correlation coefficients between IRC and QCT values (Table 1) were positive for all samples, and seven of fourteen samples have  $R > 0.5$ , designating strong correlation ( $p < 0.05$ ).



**Figure 5.** Twenty values of IRC and QCT from sample 3A (normalized scale). IRC values have a fluctuation for the first 15 points and grow when the density is higher on last five points. R-value of 0.76.



**Figure 6.** Twenty values of IRC and QCT from sample 1B (normalized scale). The curves present a weak correlation (R-value 0.14). It is possible observe a shift on IRC values that happen in between the sequences of five points obtained at each quadrant.



**Figure 7.** Twenty values of IRC and QCT from sample 4B (normalized scale). Even with weak correlation ( $R = 0.01$ ), values present similar curves between five points sequences, from 6 to 10 and 11 to 15, when the signal acquisition is closer.

Figures 3, 4, and 5 display high correlated curves.<sup>12</sup> While QCT curves show a smooth fluctuation of values, IRC presents stronger variations, but always reasonably following the tendency of QCT. In Figures 3 and 4, plateau formations are notable after an abrupt change occurring every five points. This change occurs probably because signal acquisition jumps to another quadrant of bone. IRC seems to distinguish these jumps as well as the flat areas caused by signals from close sites.

It is visually recognizable, even at samples with weak correlation, the few oscillations at QCT values reproduced by IRC values, principally between signals acquired in sites close to each other. When considering the quadrants individually, the same tendency on values of QCT and IRC is seen at many segments as shown in Figures 6 and 7. Probably the low R-values in both figures are caused by the great shift of values between quadrants. The cause of this shift is still not clear.

For the first fifteen values in Figure 5, there is a stronger oscillation of IRC as compared to QCT values. For the last five points (denser region), both curves have a similar behavior. The study of other material properties aspects may help elucidate this higher floatability of IRC values. For instance, an interesting investigation could be the relation of porosity and decalcification (by the use of EDTA) associated with transducer frequency and beam shape variations.

The density and diameter of Haversian system (called osteons) in bovine bones are similar to humans. A particularity of bovine cortical bone is the great quantity of plexiform bone found in large mammals, but rare in humans.<sup>13</sup> The plexiform bone presents a plate aspect, similar lamellar structure, denser blood plexus and an array of osteons in longitudinal, radial and circumferential directions.<sup>14</sup> The signals acquisition made centrally on the cross-section surface of bone minimized the influence of plexiform bone, mostly localized in the periosteum. The Haversian canals in the bone samples have axial orientation. The osteons orientation is important for bone anisotropy, especially for in vivo applications.

Sasso et al.<sup>6</sup> found anisotropy evidence for the values of Broadband Ultrasound Attenuation in bovine bones when the signals were collected axial, transverse and tangentially to the bone structure. Trebacz and Gadwa<sup>15</sup> have also detected anisotropic properties in cortical and trabecular bone, this time with the parameters propagation speed and attenuation.

In our study the US propagation was chosen to be along and not across the bone axis.

The advantage of this approach adopted to validate the reflection parameters is to avoid the external surface of the bone. The surface shape is usually convex and the effect of convexity is determined by the relationship between the radius of curvature of the bone region of interest and the diameter of the ultrasonic beam at the distance between sample and transducer. Reflection is proportional to the radius of curvature and, in the case of bone, varies according to the examined site. The signal acquisition taken from a plain cut surface in the present study was design to avoid the effect of bone surface curvature.

Moreover, techniques can be developed to compensate the curvature effects, as Lakshmanan et al.<sup>16</sup> used a rotational stage to study the reflection of a cylindrical shaped bone.

Our study intends to contribute to the development of non-invasive and low-cost methods to evaluate local bone density. We have specially investigated the relationship between bone density and ultrasound reflection of flat surface cortical bone.

Our results indicate that the reflection parameter IRC was sensible to healthy bone density variation and presented strong to moderate values correlated to QCT for the majority of the samples. So, it is worth to continue to explore its potential applicability to evaluate and monitor conditions that affect bone surface mineral density.

## CONCLUSION

The proposed protocol and Integrated Reflection Coefficient (IRC) calculated demonstrated the IRC was sensible to bone density variation.

## ACKNOWLEDGMENTS

This work was supported by the CNPq under Grant [number 308.627/2013-0]; CAPES/PROEX under Grant [number 3485/2014]; and FAPERJ under Grant [number E-26/203.041/2015].

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. DPM (0000-0002-2534-2555)\* provided the concept/research design and carried out the data collection, wrote the article, and reviewed and analyzed the data analysis; AJFP (0000-0003-3584-3342)\* provided the concept/research design, wrote the article, and reviewed, and analyzed the data analysis; PTCRR (0000-0000-0000-0000)\* provided the data collection and reviewed the article; TB (0000-0003-0970-1236)\* provided the data collection, wrote the article, and reviewed the article; SALS (0000-0002-7901-4805)\* provided the data collection, wrote the article, reviewed the article and contributed to the intellectual concept of the study; MAVK (0000-0003-4574-695X)\* wrote the article, and contributed to the intellectual concept of the study and the entire research project; WCAP (0000-0001-5880-3242)\* wrote the article, performed the statistical analysis, and contributed to the intellectual concept of the study and the entire research project. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. *J Bone Miner Res.* 2007;22(3):465–75.
2. Guglielmi G, Scalzo G, de Terlizzi F, Peh WCG. Quantitative ultrasound in osteoporosis and bone metabolism pathologies. *Radiol Clin North Am.* 2010;48(3):577–88.
3. Laugier P. Instrumentation for in vivo ultrasonic characterization of bone strength. *IEEE Trans Ultrason Ferroelectr Freq Control.* 2008;55(6):1179–96.
4. Hakulinen MA, Töyräs J, Saarakkala S, Hirvonen J, Kröger H, Jurvelin JS. Ability of ultrasound backscattering to predict mechanical properties of bovine trabecular bone. *Ultrasound Med Biol.* 2004;30(7):919–27.
5. Flöter M, Bittar CK, Zabeu JL, Carneiro AC. Review of comparative studies between bone densitometry and quantitative ultrasound of the calcaneus in osteoporosis. *Acta Reumatol Port.* 2011;36(4):327–35.
6. Sasso M, Haïat G, Yamato Y, Naili S, Matsukawa M. Dependence of ultrasonic attenuation on bone mass and microstructure in bovine cortical bone. *J Biomech.* 2008;41(2):347–55.
7. Kotha SP, DePaula CA, Mann AB, Guzelsu N. High Frequency Ultrasound Prediction of Mechanical Properties of Cortical Bone with Varying Amount of Mineral Content. *Ultrasound Med Biol.* 2008;34(4):630–7.
8. Fontes-Pereira A, Matusin DP, Rosa P, Schanaider A, von Krüger MA, Pereira WC. Ultrasound method applied to characterize healthy femoral diaphysis of Wistar rats in vivo. *Braz J Med Biol Res.* 2014;47(5):403–10.
9. Pinton G, Aubry JF, Bossy E, Muller M, Pernot M, Tanter M. Attenuation, scattering, and absorption of ultrasound in the skull bone. *Med Phys.* 2012;39(1):299–307.
10. Hoffmeister BK, Johnson DP, Janeski JA, Keedy DA, Steinert BW, Viano AM, et al. Ultrasonic characterization of human cancellous bone in vitro using three different apparent backscatter parameters in the frequency range 0.6–15.0 mhz. *IEEE Trans Ultrason Ferroelectr Freq Control.* 2008;55(7):1442–52.
11. Abu-Zidan FM, Hefny AF, Corr P. Clinical ultrasound physics. *J Emerg Trauma Shock.* 2011;4(4):501–3.
12. Rodgers JL, Nicewander WA. Thirteen Ways to Look at the Correlation Coefficient. *Am Stat.* 1988;42(1):59–66.
13. Locke M. Structure of long bones in mammals. *J Morphol.* 2004;262(2):546–65.
14. Hillier ML, Bell LS. Differentiating Human Bone from Animal Bone: A Review of Histological Methods. *J Forensic Sci.* 2007;52(2):249–63.
15. Trębacz H, Gawda H. The estimation of structural anisotropy of trabecular and cortical bone tissues based on ultrasonic velocity and attenuation. *Acta Bioeng Biomech.* 2001;3(2):41–8.
16. Lakshmanan S, Bodi A, Raum K. Assessment of anisotropic tissue elasticity of cortical bone from high-resolution, angular acoustic measurements. *IEEE Trans Ultrason Ferroelectr Freq Control.* 2007;54(8):1560–70.

# SACRECTOMY ASSOCIATED WITH VERTEBRECTOMY: A NEW TECHNIQUE USING DOWEL GRAFTS FROM CADAVERS

## SACRECTOMIA ASSOCIADA À VERTEBRECTOMIA: UMA NOVA TÉCNICA COM USO DE ENXERTO DE CADÁVER

THIEGO PEDRO FREITAS ARAÚJO<sup>1</sup>, DOUGLAS KENJI NARAZAKI<sup>2</sup>, WILLIAM GEMIO JACOBSEN TEIXEIRA<sup>2</sup>, FÁBIO BUSNARDO<sup>3</sup>, ALEXANDRE FOGAÇA CRISTANTE<sup>4</sup>, TARCÍSIO ELOY PESSOA DE BARROS FILHO<sup>4</sup>

1. Institute of Orthopedics and Traumatology, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP), São Paulo, SP, Brazil.

2. Spine Surgery Division, Tumors of the Vertebral Spine, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP), São Paulo, SP, Brazil.

3. Surgery Division, Faculdade de Medicina da Universidade de São Paulo, São Paulo, SP, Brazil.

4. Medical Investigations Laboratory, Spine Surgery Division, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP), São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** The purpose of this study was to demonstrate, in a case series, a new sacrectomy technique using an iliac crest dowel graft from a cadaver. **Study design:** Report of a case series with description of a new surgical technique. **Methods:** The technique uses four bars to support the posterior spine and a dowel graft in the iliac wings, with compression of the spine and pelvis above it, to support the anterior spine. Three cases were operated on, and in all of them, a vertebrectomy was used. **Results:** In the first two cases, the technique was performed as a two-stage surgery. The first stage was performed via the anterior and peritoneal access routes, and the second stage via the posterior access route. In the third case, retroperitoneal access via the anterior route meant that the technique could be performed in one stage, resulting in an overall reduction in surgical time (1250 vs. 1750 vs. 990 minutes, respectively). **Conclusion:** The new technique enables fixation with biomechanical stability, which is essential to support the stress in the lumbosacral transition and promote earlier rehabilitation. **Level of evidence IV, case series.**

**Keywords:** Spine. Cadaver. Lumbosacral Region. Bone neoplasms.

### RESUMO

**Objetivo:** O propósito do estudo foi demonstrar, por meio de uma série de casos, uma nova técnica de sacrectomia com uso de enxerto encavilhado da crista ilíaca de cadáver. **Desenho do estudo:** Relato de série de casos com descrição de uma nova técnica cirúrgica. **Métodos:** A técnica usa quatro barras para sustentação da parte posterior da coluna e um enxerto encavilhado nas asas do íliaco, com compressão da coluna e pelve sobre ele, para suporte da parte anterior da coluna. Foram operados três casos e em todos eles, realizou-se vertebrectomia. **Resultados:** Nos dois primeiros casos, a técnica foi utilizada em duas etapas. A primeira etapa foi realizada por via anterior e acesso peritoneal, e a segunda etapa, por via posterior. No terceiro caso, o acesso retroperitoneal por via anterior significou que a técnica pôde ser realizada em apenas uma etapa, resultando em redução do tempo cirúrgico total (1250 x 1750 x 990 minutos, respectivamente). **Conclusão:** A nova técnica permite a fixação com estabilidade biomecânica, que é essencial para suportar a tensão na transição lombossacral e para a reabilitação precoce. **Nível de evidência IV, série de casos.**

**Descritores:** Coluna vertebral. Cadáver. Região lombossacral. Neoplasias ósseas.

**Citation:** Araújo TPF, Narazaki DK, Teixeira WGJ, Busnardo F, Cristante AF, Barros Filho TEP. Sacrectomy associated with vertebrectomy: a new technique using dowel grafts from cadavers. *Acta Ortop Bras.* [online]. 2018;26(4):260-4. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

Primary tumors of the sacrum are uncommon, representing approximately 1% of all spinal tumors.<sup>1</sup> They are located in an anatomical region that is unfavorable for resection, particularly in cases of total sacrectomy, due to their position in relation to the adjacent tissues and viscera. Sacrectomy usually involves a motor deficit, as well as sexual, seminal vesicle and rectal dysfunctions.<sup>2</sup> *En bloc* resection with wide margins is the treatment of choice for primary tumors that do not respond to radiotherapy or chemotherapy, such as chordomas and chondrosarcomas. It is also indicated

for aggressive benign tumors, such as giant cell tumors.<sup>3</sup> When they affect the spine, these tumors most commonly occur in the sacrum in the third or fourth decade of life.<sup>4</sup>

There is currently no consensus as to the best reconstruction technique following sacrectomy due to the low frequency of cases and the variety of techniques that have been described.<sup>3,5-8</sup> In addition, there are reports in the literature of cases where reconstructions were not performed but that still showed good long-term results. The problem is not the reconstruction itself but instead the rehabilitation as the patient must be restricted to the bed for a long period.

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

Work conducted at Department of Orthopaedics and Traumatology, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP), São Paulo, Brazil.

Correspondence: Alexandre Fogaça Cristante. Rua Dr. Ovídio Pires de Matos, 333, São Paulo, SP, Brazil. 04018-001. [aacristante@uol.com.br](mailto:aacristante@uol.com.br)

Article received in 08/01/2017, approved in 06/05/2018.



In the study by Guo and Yadav, the patient restarted rehabilitation 45 days after sacrectomy and only experienced significant pain relief while getting up or sitting down when using a lumbar-sacral corset.<sup>9</sup> The defect created after the resection causes the pelvic ring to become detached from the spine, and several techniques have been described to address this issue: screw fixation of the sacroiliac joint, fixation with transiliac rods, Galveston rods, and even custom-made prostheses.<sup>6,7,10</sup> Biomechanical studies using cadavers and computer models have attempted to determine which reconstructions are more stable and better avoid breakage of the material in the lumbar-pelvic junction or the loosening of the synthesis material.<sup>11-13</sup> Regardless of the chosen technique, the purpose of the surgery is to reestablish the connections and the support that the sacrum lends to the pelvis and spine.

We operated on three patients with primary tumors using *en bloc* resections of vertebrae L4 and L5 and the sacrum. The cases included a giant cell tumor, a chordoma, and a sarcoma of the peripheral nerve sheath. The first two cases involved two-stage surgeries. In the third case, it was possible to perform a one-stage procedure. Based on these three case reports, this study describes a new surgical technique for spinal-pelvic reconstruction with bone grafting after complex resections of the sacrum along with lumbar vertebrae.

## MATERIALS AND METHODS

The study was conducted with new surgical technique performed in three consecutive cases of sacrectomy associated with vertebrectomy in diseases that required this kind of treatment. This study was approved by Ethics Committee of the Department of Orthopaedics and Traumatology, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP), number 1252, with written informed consent obtained from all patients.

### Description of the surgical technique

The vascular surgery team obtained anterior access by making an incision from the xiphoid process to the pubic symphysis, opening the peritoneum, retracting the intestinal loops, and accessing the retroperitoneal space. The infrarenal abdominal aorta was dissected, with the ligation of the lumbar arteries of the respective vertebrae (L4 and L5) to be resected *en bloc* together with the sacrum. Next, the internal and external common iliac arteries were dissected and retracted (Figure 1). The left and right hypogastric arteries and the median sacral artery were ligated (Figure 2).

At this point, the spinal surgery team began the first stage of the procedure. A dissection was performed to expose the anterior spine, and discectomy of L3-L4 was performed proximally, releasing the psoas muscle bilaterally along the sides of vertebrae L4 and L5. In the anterior region of the sacrum and the tumor, lysis of the structures was performed, which included the sacral roots, along with the release of the mesorectum with the aid of a 30-degree optic. The tumor was dissected laterally, with a wide margin that extended as far as the iliac crest. Osteotomy of the iliac bones was then carried out, extending laterally to the sacroiliac joints, and leaving the joint together with the piece to be resected as an oncological safety margin (Figure 3). Bovine pericardium was placed between the vascular structures that were released (aorta, inferior vena cava, iliac arteries and iliac veins) and the spine. The wound was closed by planes, and closure was performed according to normal procedures.

In a second surgical procedure, performed via the posterior route, a median incision and dissection of the soft parts were performed via the median route, exposing the laminae and transverse processes of the vertebrae to be fixed. Next, pedicle screws were inserted bilaterally in vertebrae T11 to L3 and S2, using bilateral iliac screws (Figure 4). The tumor mass was identified and dissected, taking care to remove the tumor capsule as a whole. This was followed

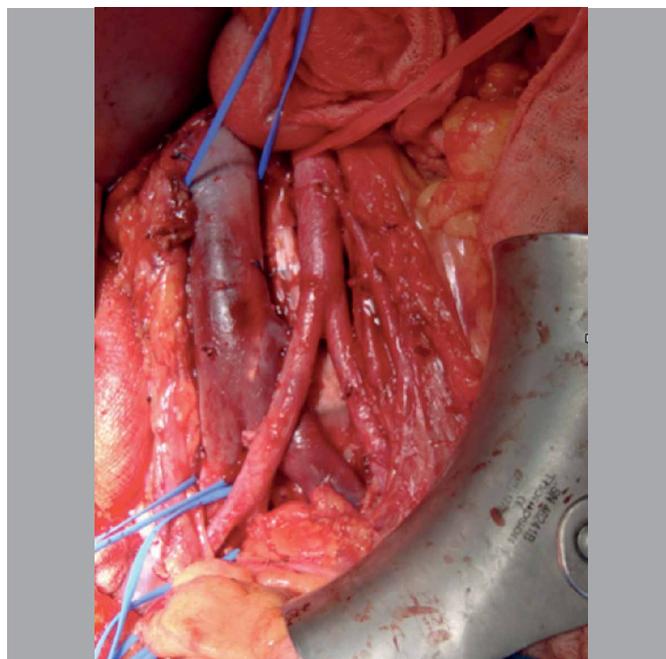


Figure 1. Surgery anterior access showing aorta artery, cava vein and iliac common artery and vein.

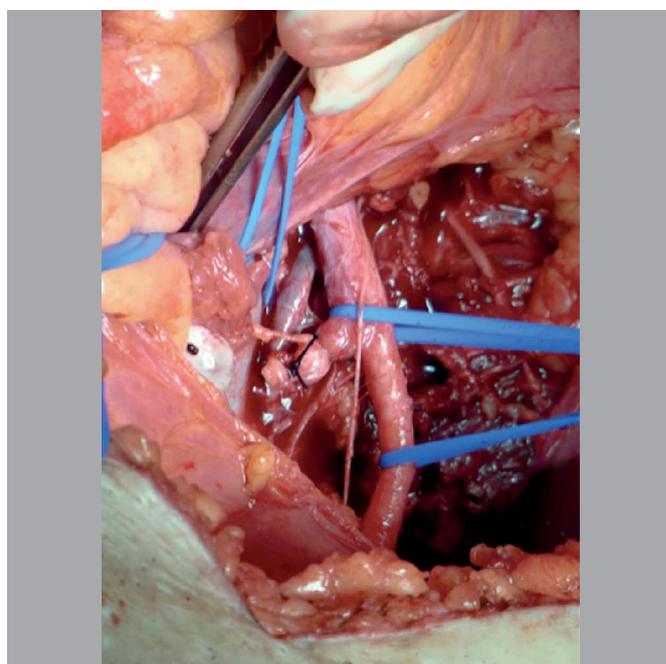


Figure 2. Ligated hypogastric artery.

by the laminectomy of L3 and the bilateral inferior facetectomy of L3. Next, ligation of the dural sac and roots was performed with 2.0 cotton thread, incising the roots of L4, L5, and S1-S5, and the suture at the bottom of the dural sac was reinforced with Prolene 4.0. Posterior L3-L4 discectomy was then performed. The musculature of the transverse processes and pedicles was released laterally. The osteotomy was complemented via the posterior route. Next, the posterior musculature of the sacrum was released, followed by a posterior proximal to distal rotation maneuver of the piece being removed (L4, L5, sacrum) *en bloc*, followed by the lysis of previously mentioned structures under direct vision.

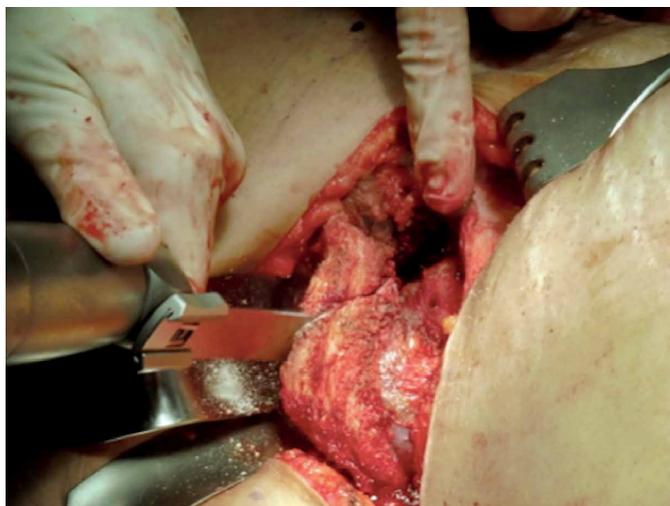


Figure 3. Iliac wing osteotomy in anterior access.

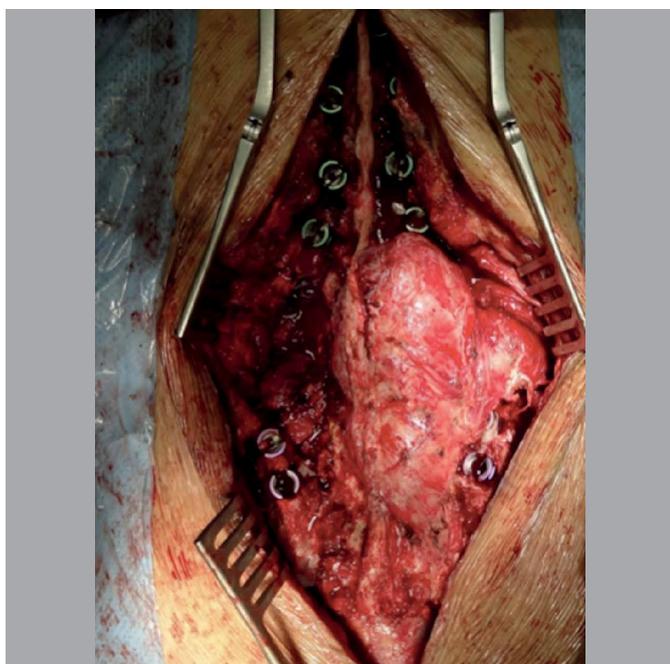


Figure 4. High-grade tumor of the peripheral nerve sheath in posterior view with pedicle and iliac screws.

The vertebrae (L4-L5) and the sacrum were removed *en bloc* with the tumor (Figure 5). A bone bank graft from the femur was inserted, and it was doweled into the two wings of the iliac after making a slit in the wings of the iliac crests, and the graft was positioned under pressure. Four bars were placed between the pedicle screws and the iliac screws. Compression between the spine and the graft was performed through the bars, placing a spongy bone graft in the areas of contact between the bone and the graft (Figure 6). At this stage of the surgery, plastic surgeons helped with replacing the soft tissue covering. The rotation of the rectus abdominal muscles or large dorsal muscles was used to reduce the dead space.

In the third patient operated on, the whole procedure was performed in just one surgical stage. The difference in technique was that it used a double retroperitoneal access to perform the surgical steps carried out via the previous route. This modification led to

a significant reduction in surgery time. A bilateral and oblique incision was made in the hypogastric region, without opening the peritoneum, and the bowel loops were retracted to access the retroperitoneal space. The other steps were similar to the steps of the procedures mentioned above. A summary of the data from the three cases is given in Table 1.

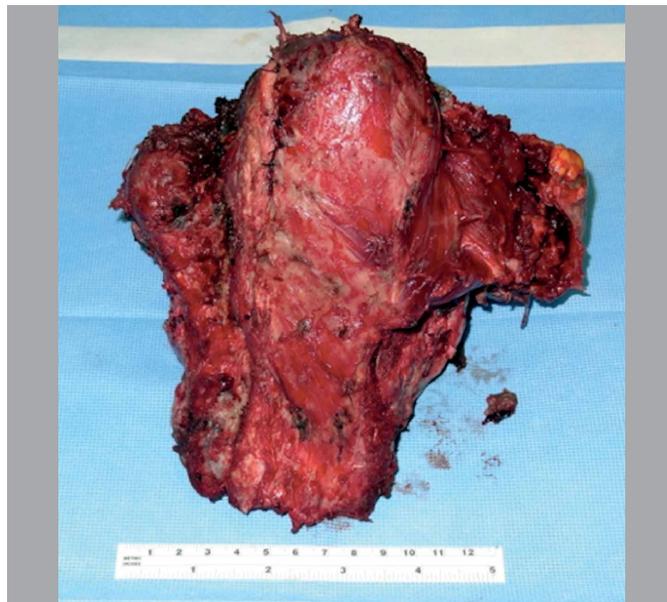


Figure 5. High-grade tumor of the peripheral nerve sheath en bloc resection.

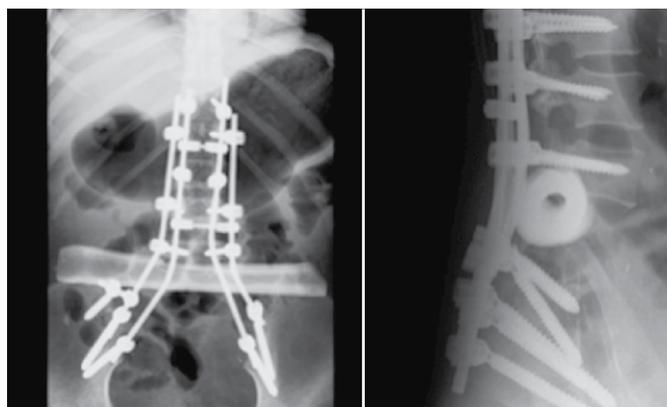


Figure 6. Postoperative radiographs showing compression of the graft with double bars fixation.

Table 1. Summary of surgical data.

	Case 1	Case 2	Case 3
<b>Type of tumor</b>	<b>Chordoma</b>	<b>Giant cell tumor</b>	<b>High-grade tumor of the peripheral nerve sheath</b>
Surgical procedures	Two-stage	Two-stage	One stage
First stage duration	8h10	10h30	16h30
Second stage duration	12h40	18h40	-
Total time (min)	1250	1750	990
Erythrocyte concentrate in the first stage (units)	4	6	9
Erythrocyte concentrate in the second stage (units)	10	12	0

## Case Series

We performed sacrectomy associated with vertebrectomy in three patients, who all presented with the long-term development of cauda equina syndrome.

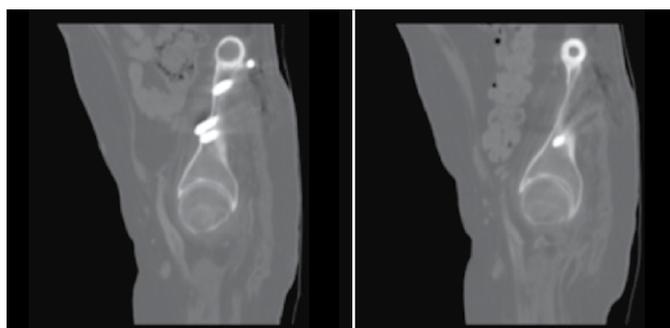
The first two cases had positive margins in the resection, showing tumor recurrence. One of the three cases presented a loosening of the synthesis material. The patient with the chordoma had a recurrence three years and five months later in the allograft and in the quadrilateral laminae and was sent for treatment with radiosurgery. The recurrence of the giant cell tumor was treated with surgical resection *en bloc*. The first case had loosening of the iliac screws on the right side five months after surgery.

The osseointegration of the graft occurred at different points at different times. For example, integration in the second case occurred in one of the iliac bones at 12 months and in the other at 24 months. Computed tomography (CT) scanning was performed postoperatively at one year and five months and showed graft integration in the chordoma case (Figure 7). For more information on the follow-ups, see Table 2.

In rehabilitation, there was no restriction on immediately being in a standing position, but the plastic surgery team restricted it for three weeks on average to prevent the loss of the flap. During this period the patient was in a supine or lateral ventral position. After receiving the authorization of the plastic surgery team, the patient was allowed to walk according to the protocols of the physical therapy and physiatry teams.

## DISCUSSION

Resection of the sacrum has a great impact on spinal-pelvic stability. In a study conducted on cadavers by Gunterberg et al., it was observed that sacrectomy at the level of S1-S2 resulted in a 30% loss of strength in the pelvic ring, whereas the same procedure performed more cephalically, resecting S1 a centimeter below the promontory, increased this deficit to 50%. However, the residual force was sufficient to allow early weight-bearing.<sup>14</sup>



**Figure 7.** Computed tomography showing integration of allograft on both iliacs one year and five months after surgery.

**Table 2.** Follow-up data.

	Case 1	Case 2	Case 3
<b>Free margins</b>	<b>No</b>	<b>No</b>	<b>Yes</b>
Recurrence	41 months	8 months	No
Osseointegration*	17 months (I)	12/24 months (I/I)	7/14 months (I/S)
Complications	Dehiscence	SIRS/ARI/UTI	SSI
Walking?	Yes	No	Yes
Adjuvant therapy?	No	zoledronic acid	radiotherapy
Follow-up	41 months	46 months	20 months

\*3 points of osteointegration evaluated. I = iliac bone; S = spine; SIRS = systemic inflammatory response syndrome; ARI = acute respiratory infection; urinary tract infection; SSI = surgical site infection.

Sacral tumors that are treatable via curative resection usually present with invasion of S1 and even of the lumbar vertebrae, causing the treatment to affect the stability of the spinal-pelvic junction. Subsequent reconstruction is therefore necessary. However, what the best reconstruction procedure has not yet been determined. In studies in cadavers and in computational analyses, it has been observed that constructions with double bars, with two iliac screws on either side of the iliac crest and with anterior support of the reconstruction, showed better biomechanical resistance, likely with greater safety and a faster rehabilitation.<sup>11,12</sup> In the technique described in this case report, the reconstruction that gave anterior support to the spine was a dowel graft from the femur, which was supported both in the iliac wings and in the body of the lumbar vertebra.

In our cases, we started using a triangular reconstruction with a cadaver graft and fixation of the screws in the cadaver bone. In these cases, we found that the screws in the graft became loose. We then opted to alter the construction by not using synthesis material in the graft. This new technique presents biomechanical improvements relative to those previously used. It presents good load distribution on the reconstruction, as demonstrated by the biomechanical simulation of Kawahara et al.,<sup>11</sup> with good anterior and posterior support. In their biomechanical study, instead of a graft from the bone bank, the authors used a bar that connects the iliac wings to L5, resulting in a similar construction to the one used in our cases. No concentration of compressive load stress on the construction was observed, indicating the immediate rigidity and stability of the system, and resulting in earlier and safer rehabilitation. There is another reason for positioning the dowel graft in the iliac crests rather than in the sacral region. Our patients had involvement of the lumbar vertebrae, and *en bloc* resection in conjunction with the sacrum was necessary for treatment. Thus, the position of the graft results in a minimum loss of height, as it is positioned more cephalically than the original position of the sacrum.

Another factor to consider in the evolution of the technique is that it was performed in the third case via an anterior retroperitoneal access route, resulting in a significant reduction in surgery time, allowing a one-stage procedure. The total time was reduced by 21% in relation to the first case and by 43% in relation to the second. In addition to eliminating the need for a second procedure, this also saves hospital resources and makes the surgery more cost-effective. The spinal-pelvic junction experiences high levels of transmitted force, acting as a major lever arm in the lumbosacral junction.<sup>5,15,16</sup> To increase the stability of the construction and avoid screw pull-out or breakage of the implants, other modifications were added to the technique. The use of four bars, as described by Shen et al.,<sup>8</sup> helps increase stability during flexion, extension and lateral flexion compared with the conventional use of two bars connected by a cross-link. In addition, a cross-link was used to increase the rotational resistance of the construction.<sup>17</sup>

Biomechanical studies in cadavers have demonstrated that the use of two iliac screws on either side offers adequate stability for compression and torsion, particularly when placed parallel to each other and angled towards the anterior-inferior iliac.<sup>18,19</sup> This technique therefore involved the fixation of two iliac screws on each side. The use of a bone bank graft poses some risks, such as the high rate of non-integration with the living bone, the increased risk of infection, and the risk of disease transmission. We observed that all of our patients had some episode of infection, although without serious repercussions. In relation to the high rate of non-integration of the graft from the bone bank with the recipient's bone, another advantage of our technique is that when we create slits in the iliac bone and when performing compression of the spine over the iliacs, our technique favors the stability of the construction and the integration of the graft.<sup>20</sup>

Another development that we are currently working on relates to the anterior access route, with less morbidity and with double retroperitoneal access for the dissection of large vessels, discectomies, osteotomies of iliac bones lateral to the sacrum, and the release of the mesorectum anterior to the sacrum. We tend to avoid the ligation of the hypogastric arteries; therefore, we extended the option of coverage with the gluteal flaps, which would otherwise have been impaired as a result of ischemia. In addition, by not opening the peritoneum, it is possible to decrease surgical morbidity and postoperative complications such as paralytic ileus. In the last case of our series, the patient was operated on in just one stage, with less morbidity and a shorter overall surgery time.

## CONCLUSION

We describe a new technique for spinal-pelvic reconstruction in patients who present potentially curable diseases of the sacrum that have extended to the lumbar vertebrae. Our technique has several biomechanical advantages; it avoids the use of synthesis material in the graft from the bone bank, and it places compression on the points of contact between the donor-recipient bone, favoring the integration of the graft. There is increased security in the fixation, and the construction quality is maintained over time. The technique also has the disadvantage that it uses a bone bank graft. Further studies are needed, with longer follow-up times, to improve our understanding of the spinal-pelvic reconstructions used in these patients.

**AUTHORS' CONTRIBUTIONS:** TPFA (0000-0002-8670-1793)\*, AFC (0000-0002-7797-5274) \* and TEPBF (0000-0002-0819-7712)\* designed the study, interpreted the data and participated in writing the manuscript. DKN (0000-0001-7895-4830)\*, WGJT (0000-0001-9036-629X)\* and FB (XXX) participated in data collection and interpretation and writing of the manuscript. All authors revised and approved the final version submitted for publication, and are responsible for the content of the manuscript. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

- Feldenzer JA, McGauley JL, McGillicuddy JE. Sacral and presacral tumors: problems in diagnosis and management. *Neurosurgery*. 1989;25(6):884-91.
- Nakai S, Yoshizawa H, Kobayashi S, Maeda K, Okumura Y. Anorectal and bladder function after sacrifice of the sacral nerves. *Spine (Phila Pa 1976)*. 2000;25(17):2234-9.
- Fourney DR, Rhines LD, Hentschel SJ, Skibber JM, Wolinsky JP, Weber KL, et al. En bloc resection of primary sacral tumors: classification of surgical approaches and outcome. *J Neurosurg Spine*. 2005;3(2):111-22.
- Hsieh P, Gokaslan ZL. Evaluation and management of spinal axis tumors: benign and primary malignant. In: Winn R, editor. *Youmans Neurological Surgery*. Philadelphia: Saunders; 2011. p. 3144-53.
- Doita M, Harada T, Iguchi T, Sumi M, Sha H, Yoshiya S, et al. Total sacrectomy and reconstruction for sacral tumors. *Spine (Phila Pa 1976)*. 2003;28(15):E296-301.
- Gokaslan ZL, Romsdahl MM, Kroll SS, Walsh GL, Gillis TA, Wildrick DM, et al. Total sacrectomy and Galveston L-rod reconstruction for malignant neoplasms. Technical note. *J Neurosurg*. 1997;87(5):781-7.
- Newman CB, Keshavarzi S, Aryan HE. En bloc sacrectomy and reconstruction: technique modification for pelvic fixation. *Surg Neurol*. 2009;72(6):752-6.
- Shen FH, Harper M, Foster WC, Marks I, Arlet V. A novel "four-rod technique" for lumbo-pelvic reconstruction: theory and technical considerations. *Spine (Phila Pa 1976)*. 2006;31(12):1395-401.
- Guo Y, Yadav R. Improving function after total sacrectomy by using a lumbar-sacral corset. *Am J Phys Med Rehabil*. 2002;81(1):72-6.
- Zhang HY, Thongtrangan I, Balabhadra RS, Murovic JA, Kim DH. Surgical techniques for total sacrectomy and spinopelvic reconstruction. *Neurosurg Focus*. 2003;15(2):E5.
- Kawahara N, Murakami H, Yoshida A, Sakamoto J, Oda J, Tomita K. Reconstruction after total sacrectomy using a new instrumentation technique: a biomechanical comparison. *Spine (Phila Pa 1976)*. 2003;28(14):1567-72.
- Mindea SA, Chinthakunta S, Moldavsky M, Gudipally M, Khalil S. Biomechanical comparison of spinopelvic reconstruction techniques in the setting of total sacrectomy. *Spine (Phila Pa 1976)*. 2012;37(26):E1622-7.
- Zhu R, Cheng LM, Yu Y, Zander T, Chen B, Rohlmann A. Comparison of four reconstruction methods after total sacrectomy: a finite element study. *Clin Biomech (Bristol, Avon)*. 2012;27(8):771-6.
- Gunterberg B, Romanus B, Stener B. Pelvic strength after major amputation of the sacrum: An experimental study. *Acta Orthop Scand*. 1976;47(6):635-42.
- Shen FH, Crowl A, Shuler TE, Feldenzer JA, Leivy SW. Delayed recognition of lumbosacral fracture dislocations in the multitrauma patient: the triad of transverse process fractures, unilateral renal contusion and lumbosacral fracture dislocation. *J Trauma*. 2004;56(3):700-5.
- Wuisman P, Lieshout O, Sugihara S, van Dijk M. Total sacrectomy and reconstruction: oncologic and functional outcome. *Clin Orthop Relat Res*. 2000;(381):192-203.
- Kelly BP, Shen FH, Schwab JS, Arlet V, Diangelo DJ. Biomechanical testing of a novel four-rod technique for lumbo-pelvic reconstruction. *Spine (Phila Pa 1976)*. 2008;33(13):E400-6.
- Yu BS, Zhuang XM, Li ZM, Zheng ZM, Zhou ZY, Zou XN, et al. Biomechanical effects of the extent of sacrectomy on the stability of lumbo-iliac reconstruction using iliac screw techniques: what level of sacrectomy requires the bilateral dual iliac screw technique? *Clin Biomech (Bristol, Avon)*. 2010;25(9):867-72.
- Yu BS, Zhuang XM, Zheng ZM, Li ZM, Wang TP, Lu WW. Biomechanical advantages of dual over single iliac screws in lumbo-iliac fixation construct. *Eur Spine J*. 2010;19(7):1121-8.
- Rahn BA, Gallinaro P, Baltensperger A, Perren SM. Primary bone healing. An experimental study in the rabbit. *J Bone Joint Surg Am*. 1971;53(4):783-6.

# BIOMECHANICAL COMPARISON OF MEDIAL VERSUS LATERAL SIDED PLATING IN FEMORAL FRACTURES

## COMPARAÇÃO BIOMECÂNICA DE PLACA ÓSSEA MEDIAL VERSUS LATERAL EM FRATURAS DO FÊMUR

FIRAT AL<sup>1</sup>, BILGEHAN TOSUN<sup>2</sup>, TAMER SINMAZCELİK<sup>3</sup>, MUSTAFA OZMEN<sup>3</sup>

1. Golcuk Necati Celik State Hospital, Kocaeli, Turkey.

2. School of Medicine, Kocaeli University, Kocaeli, Turkey.

3. Mechanical Engineering, Kocaeli University, Kocaeli, Turkey.

### ABSTRACT

**Objective:** The aim of the present study was to determine whether the side of application of the plate itself affects the mechanical stability of the fixation. The specific question addressed is whether or not a lateral or medial plate application is biomechanically better, for the treatment of distal diaphysis fractures of the femur. **Methods:** Stability and stiffness of medial sided plating relative to the conventional lateral sided plating in distal diaphysis of the femur were measured by analyzing axial loading forces leading to implant failure. Sixty synthetic femurs were tested in physiological bending, to calculate the yield and ultimate load to displacement following fixation of distal diaphysis fractures of the femur by either medial or lateral sided plating. Axial loading was applied to samples using a uniaxial testing machine. **Results:** There was more implant deformation in the lateral sided plating group – a difference with statistical significance. **Conclusion:** Medial sided plating was found to be as stiff as lateral plating. Medial plating may be a reasonable treatment option that can be used safely in selected cases. **Level of Evidence I, Therapeutic Studies Investigating the Results of Treatment**

**Keywords:** Femoral fractures. Bone plates. Stress, mechanical.

### RESUMO

**Objetivo:** O objetivo deste estudo foi determinar se o lado de aplicação da placa em si afeta a estabilidade mecânica da fixação. A questão específica abordada é se a aplicação da placa lateral ou medial é melhor ou não em termos biomecânicos para o tratamento das fraturas da diáfise distal do fêmur. **Métodos:** A estabilidade e a rigidez da placa medial com relação à lateral, convencional na diáfise distal do fêmur, foram medidas pela análise das forças de carga axial que levam à falha do implante. Sessenta fêmures sintéticos foram testados em flexão fisiológica, para calcular a tolerância e a carga final para o deslocamento após a fixação das fraturas diafisárias distais do fêmur com placa medial ou lateral. A carga axial foi aplicada às amostras usando máquina de teste uniaxial. **Resultados:** Verificou-se maior deformação do implante no grupo de placa lateral – diferença com significância estatística. **Conclusão:** Constatou-se que a placa medial era tão rígida quanto a lateral. A placa medial pode ser uma opção de tratamento razoável e segura em casos selecionados. **Nível de evidência I, Estudos terapêuticos - Investigação dos resultados do tratamento.**

**Descritores:** Fraturas do fêmur. Placas ósseas. Estresse mecânico.

**Citation:** Al F, Tosun B, Sinmazcelik T, Ozmen M. Biomechanical comparison of medial versus lateral sided plating in femoral fractures. *Acta Ortop Bras.* [online]. 2018;26(4):265-70. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

The standard treatment for femoral shaft fractures is intramedullary nailing.<sup>1</sup> However, a plate osteosynthesis is particularly advantageous in certain situations. Patients with fractures of the proximal or distal shaft,<sup>2,3</sup> an excessively narrow intramedullary canal,<sup>4,5</sup> polytrauma patients,<sup>6</sup> and those with vascular injury associated with femoral fractures<sup>7</sup> constitute the spectrum of the indications for plate osteosynthesis. From previous investigations, it is known that the tension side of the femur, which is the lateral side, transfers to the anterior side at the distal part.<sup>8,9</sup> Also, the compression side of the femur is the medial aspect proximally, whereas it is the dorsal aspect distally. Based on this information we hypothesized that a plate applied to the lateral or medial side of the femur in distal diaphyseal femoral fractures acts as a compression device. Therefore, we expected

similar biomechanical results when the plate was applied either medially or laterally in distal femoral diaphyseal fractures.

To our knowledge, there is no previous study that compares the stability of medial versus lateral femoral plating.

The purpose of this study was to compare the biomechanical behaviors of medial and lateral sided plating in synthetic femurs with fractured distal diaphysis, by analyzing axial loading forces leading to implant failure.

### MATERIALS AND METHODS

Sixty left synthetic composite femurs (Anatomiturk, Kayseri, Turkey) were used to eliminate variations in geometry and mechanical properties such as bone density. The composite femurs were 420 mm in length from the tip of the greater trochanter to the lateral femoral

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

Work conducted at the Kocaeli University, Kocaeli, Turkey.

Correspondence: Bilgehan Tosun, M.D. Kocaeli University School of Medicine, Department of Orthopedics, Uctepeler Mvkii, Umuttepe Kampusu, 41100, İzmit, Kocaeli, Turkey. [bilgehantosun@yahoo.com](mailto:bilgehantosun@yahoo.com)

Article received in 02/16/2018, approved in 05/29/2018.

*Acta Ortop Bras.* 2018;26(4):265-70



condyle, and 30 mm in diameter at the mid-diaphysis. The femur was divided into three parts, the proximal femur, diaphysis and distal femur. These parts were delineated as the proximal femur, ending at the distal part of the lesser trochanter, the middle – from this point to the distal metaphysis - and the distal femur, including the distal metaphysis and epiphysis. The diaphysis was further divided into proximal, mid-diaphysis and distal diaphysis. Fracture was created in 30 samples, at the junctional area between the diaphysis and distal metaphysis, 150 mm (36%) proximal from the distal joint surface. Fractures were also created in a further 30 samples, just inside the distal 1/3 portion of the diaphysis, 180 mm (43%) proximal from the distal joint surface. Thus, the models were categorized into four groups according to their osteotomy levels and fixation methods. Group 1 had an osteotomy 150 mm from the distal joint surface that was stabilized by medial sided plating (M-15, n=15); Group 2, 180 mm osteotomy level - medial sided plating (M-18, n=15); Group 3, 150 mm osteotomy level - lateral sided plating (L-15, n=15) and Group 4, had 180 mm osteotomy level - lateral side plating (L-18, n=15).

4.5 mm low-contoured broad locked dynamic compression plates with 8 holes were bent so that they fit the femoral curve during plate application. The plates were first provisionally applied to the lateral or medial surface of the femur, to dictate the screw position. Screw holes were prepared by drilling centrally through the oval holes of the plate. The plate was then placed either on the medial or lateral side, in neutral mode. After drilling the screw holes, 4.5 mm tapping was done to facilitate insertion of the screws. Eight cortices were screwed by 4.5 mm non-locking cortical screws on each side of the simulated fracture. Each model was then anatomically positioned on the uniaxial testing machine (Shimadzu Autograph AG-X, 2007, Kyoto, Japan) to accept load along their mechanical axes (Figure 1). To secure the distal femur, 8 pointed screws were inserted with a jig, into the femoral condyles. The femoral head was also stabilized by a bolt pin to the spherical connection adaptor (Figure 2). After calibrating the testing machine, which was repeated before each test, static tests were performed in compression mode of 10 kN load capacity (Shimadzu AG-X tensile test machine) according to the ASTM D695<sup>10</sup> testing standard, with a crosshead velocity of 5 mm/min. Fifteen synthetic femur specimens for each case were tested. The femurs were loaded progressively at a speed of 5 mm/min until the occurrence of a subsequent fracture. During the tests, load-displacement (deformation) curves (Figure 3) were recorded online using the Trapexium X software, and analyzed for the following structural bone properties: yield load (the force causing the first bone damage visible in the load displacement curve, the force at which the load displacement curve broke from linearity), ultimate load (the force causing bone fracture), displacement at yield (defined as the amount of bone deformation at the yield point), and displacement at fracture (deformation at the fracture point). According to the producer, the measurement error of the method was  $\pm 1\%$  of the recorded value. Testing after each experimental period was performed on the same day, by the same operator. The level of the subsequent fracture was determined by the distance from the upper end of the greater trochanter to the fracture line on the lateral cortex. The first 60 mm from the upper end of the greater trochanter was defined as the proximal part of the femur. Thus, the following 258 mm femoral diaphysis was divided equally into proximal, mid and distal diaphyseal parts (Figure 4). Some models showed two fracture lines. According to the level and number of subsequent fracture, six groups of subsequent fractures were observed. Implant deformation was also evaluated for plastic deformation of the plate, by inspecting each model.

The configuration of subsequent fracture was separated into four groups, based on the fracture line. A transverse fracture line originating from the

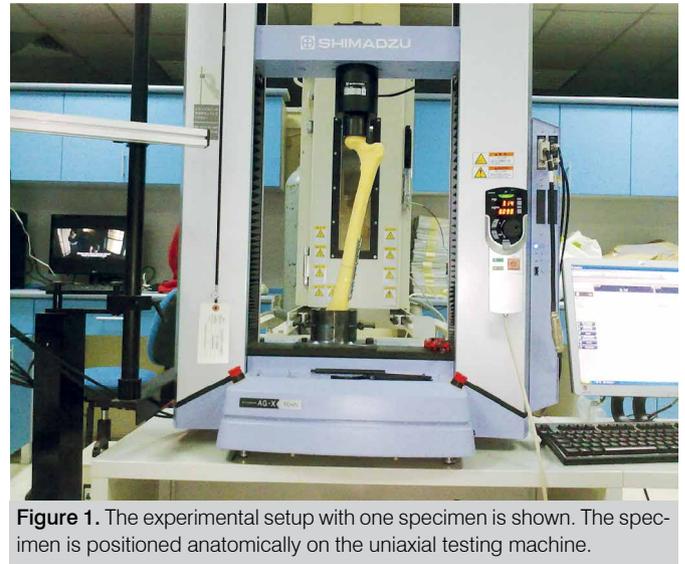


Figure 1. The experimental setup with one specimen is shown. The specimen is positioned anatomically on the uniaxial testing machine.

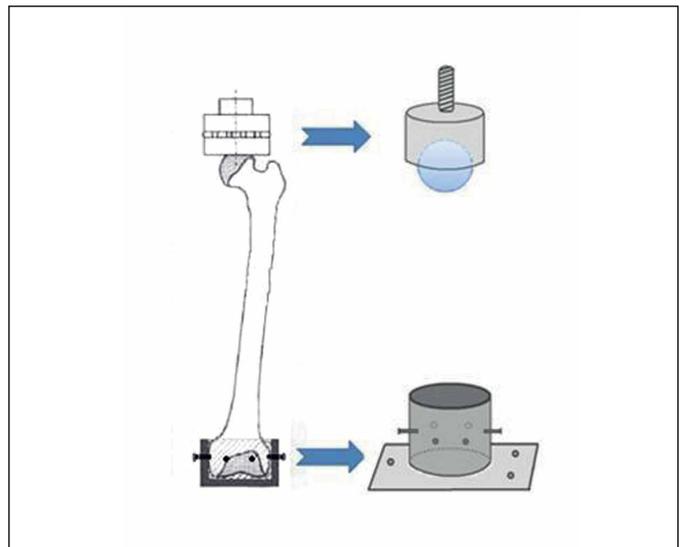


Figure 2. Stabilization of the models by securing the distal femur to the spherical connection adaptor with 8 pointed screws and the femoral head by a bolt pin.

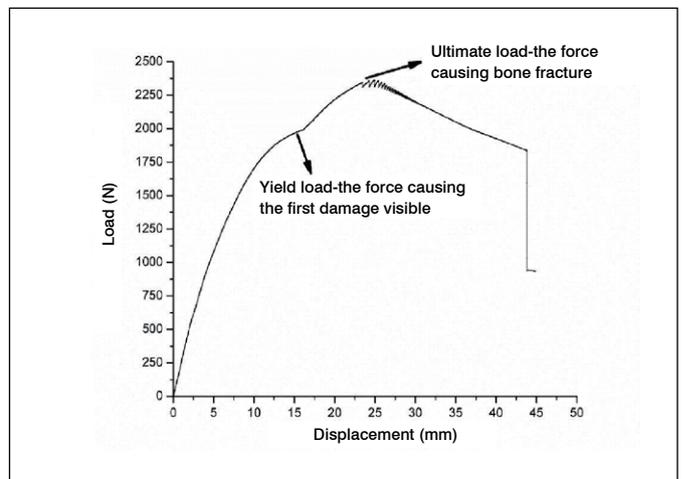
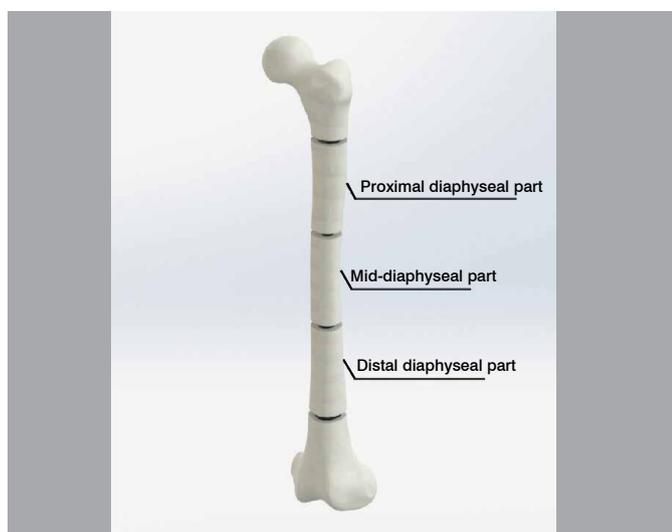


Figure 3. Symbolic load-displacement curve of a synthetic femur specimen.

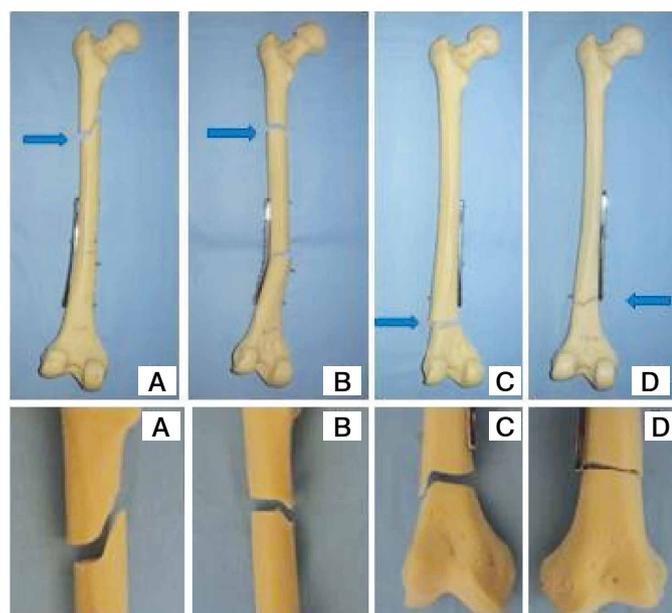
lateral cortex that had a reverse oblique pattern on the medial cortex was placed in Group A. Group B consisted of a transverse fractures originating from the lateral cortex that had an oblique pattern on the medial cortex; Group C consisted of transverse fractures originating from the medial cortex that had a reverse oblique pattern on the lateral cortex. Group D had a fracture line related to a screw entry point (Figure 5).

### Statistical Methods

The normality of distribution of the parametric data was checked using the Kolmogorov-Smirnov test. The distribution was accepted as parametric if the results of the Kolmogorov-Smirnov test were not significant. The results for yield and ultimate load to displacement, and comparisons of the subsequent fracture levels between 15



**Figure 4.** Level of the subsequent fracture. Femoral diaphysis was divided equally into proximal, mid and distal diaphyseal parts.



**Figure 5.** Types of subsequent fractures. A. Transverse fracture line originating from the lateral cortex had a reverse oblique pattern on the medial cortex. B. Transverse fracture originating from the lateral cortex had an oblique pattern on the medial cortex. C. Transverse fracture originating from the medial cortex had a reverse oblique pattern on the lateral cortex. D. Fracture line related to a screw entry point.

and 18 cm osteotomy groups, were subjected to the *t* test. Multiple pairwise comparisons were performed by the Mann-Whitney U test. The number of subsequent fracture and implant deformations was analyzed by the Chi-Square test. Kruskal-Wallis one-way analysis of variance was used to measure statistical differences between modalities, and *P* values < 0.05 were considered significant.

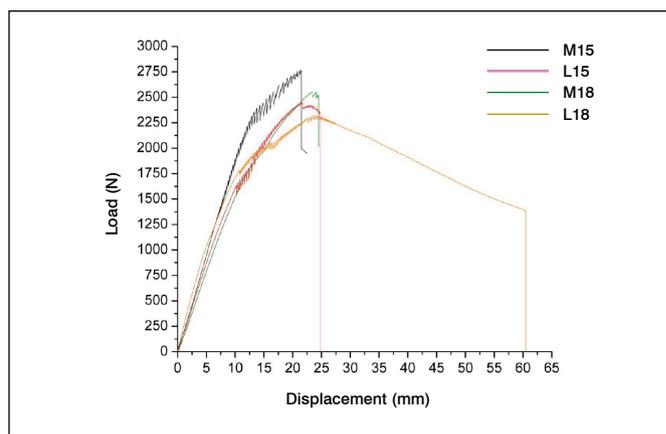
### RESULTS

Fifty-three synthetic composite femurs were available for the current study. Of the sixty models, two models with inexact osteotomy levels and five models with improper data acquisition during testing were excluded from the study.

As the experiment progressed and stiffness increased, the synthetic femurs began to break at different sides in different models.

#### Stability and Stiffness

In all the specimens, it was noted that there was a significant difference in yield displacement values between medial sided plating and the conventional lateral sided plating in the distal diaphysis of the femur specimens (Figure 6). The yield displacement values of M15, M18, L15 and 18 were 13.79 mm, 14.92 mm, 10.75 mm and 10.18 mm, respectively. The ultimate load values of M15, M18, L15 and 18 were 2826.59 N, 2556.61 N, 2456.41 N and 2326.1 N, respectively. The ultimate load values of the medial sided plating specimens at osteotomy levels 15 and 18 were higher than those of the lateral sided plating specimens (Table 1). Yield ( $P^{15}=0.409$ ,  $P^{18}=0.427$ ) and ultimate loads to displacement ( $P^{15}=0.357$ ,  $P^{18}=0.701$ ) values were not statistically significantly different between groups.



**Figure 6.** Load-displacement curves according to four different types of fixation and osteotomy levels.

**Table 1.** Values for mean yield load, ultimate load and displacement at fracture according to the type of fixation and osteotomy levels.

	Group	Number of specimen	Mean values	Standard deviation (+)	Standard deviation (+)
Yield load (N)	M15	15	2333.58	65	60
	L15		1627.32	80	70
	M18		1978.45	45	45
	L18		1778.31	55	70
Ultimate load (N)	M15	15	2826.59	85	90
	L15		2456.41	70	75
	M18		2556.61	80	65
	L18		2326.1	60	55
Displacement at fracture	M15	15	21.40	0.25	0.5
	L15		24.80	0.3	0.6
	M18		24.45	0.4	0.3
	L18		60.2	0.9	0.85

### Features of Subsequent Fracture

The samples demonstrated at least one subsequent fracture. Subsequent fractures mostly occurred at the proximal femoral region. A single subsequent fracture was seen in 41 samples (77.3%), while 12 samples (22.7%) showed two subsequent fractures. The second fracture was always at the first or eighth screw hole (91.7%). In the models with two subsequent fractures, the mean distance from the greater trochanter to the first fracture line was 164.6 mm, while the distance to the second fracture line was 289.5. Subsequent fractures seen in lateral sided plating (L15 and L-18) group demonstrated a predilection for the proximal femur. In the group of medial sided plating (M-15 and M-18), subsequent fractures mostly occurred in the mid-diaphyseal region (Table 2). There were no statistically significant differences in terms of the number and location of subsequent fractures.

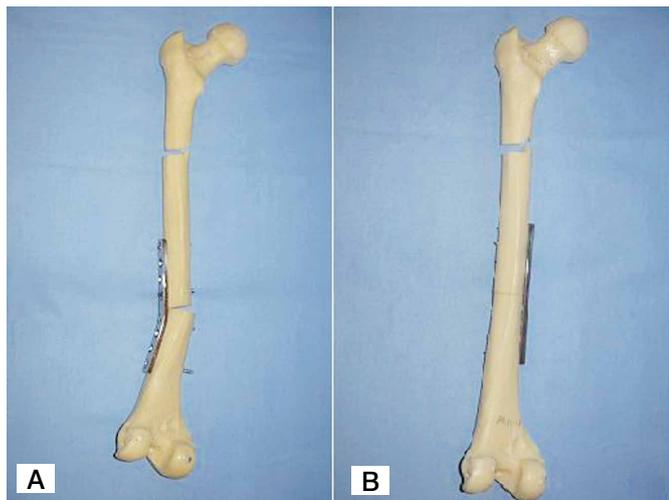
For the subsequent fractures, a transverse fracture line originating from the lateral cortex that had a reverse oblique pattern on the medial cortex was the most frequent fracture configuration (58.5%). This was followed by a transverse fracture originating from lateral cortex with an oblique pattern on the medial cortex (13.2%); a transverse fracture originating from the medial cortex with a reverse oblique pattern on the lateral cortex (1.9%), and a fracture line at a screw hole (26.4%), respectively.

### Implant Deformation

Of the 53 synthetic femurs, plastic deformation of the plate was seen in 21 samples (39.6%) after accomplishing axial loading. Surprisingly, these deformed implants, with the exception of one at the 18 cm osteotomy, all belonged to lateral sided plating group (Figure 7). The implant deformation rate was 71.4% in the L15 group, and 76.9% in the L18 group (Table 3). There was more implant deformation in lateral sided plating group, with statistical significance ( $P < 0.0001$ ).

**Table 2.** Subsequent fracture location. Lateral sided plating group has a predilection for the proximal femur. In the group of medial sided plating, subsequent fractures mostly occurred in the mid-diaphyseal region.

Group	Sample size	Mean (mm)	Standard deviation	Fracture location
M15	13	211.69	111.70	Mid-diaphyseal
L15	14	142.00	70.31	Proximal diaphyseal
M18	13	169.69	70.56	Mid-diaphyseal
L18	13	126.23	26.24	Proximal diaphyseal



**Figure 7.** Implant deformation in the lateral sided plating group. B. Excellent plate contour in the medial sided plating group.

**Table 3.** Implant deformation according to the groups. All deformed implants, except for one belong to lateral sided plating group.

Group	Sample size	Implant deformation		Implant deformation
		-	+	
M15	13	13	0	0%
L15	14	4	10	71.4%
M18	13	12	1	7.7%
L18	13	3	10	76.9%

### DISCUSSION

For fractures of the femoral diaphysis, from the lesser trochanter to 10 cm proximal to the knee joint, locked intramedullary nailing is the standard treatment modality. However, a plate osteosynthesis is particularly advantageous in certain situations. Patients with an excessively narrow intramedullary canal,<sup>4,5</sup> polytrauma patients,<sup>6</sup> and those with vascular injury associated with the femoral fractures<sup>7</sup> constitute good indications for plate osteosynthesis.

Orthopaedic surgeons tend to attach a lateral plate in almost all cases, due to the simplicity of the procedure, and better preservation of the muscles, nerves and vascularization. Medial sided femoral plating has been reported less frequently for the clinical management of lower limb deformities after correction osteotomies.<sup>11-15</sup> Despite its occasional use, no clinical and mechanical information on this technique in the trauma setting has been reported. From a mechanical standpoint, our results showed no significant difference between lateral and medial sided plating by means of axial loading.

Superficial femoral vessels are injured with greater frequency than common femoral vessels in femoral fractures.<sup>16</sup> In the setting of femoral fractures associated with vessel injury, the vessels should be explored via a posteromedial approach to the femur. A posteromedial approach allows medial plating to the distal femur diaphyseal fracture. Therefore, fractures located in the distal diaphyseal region were used for the study.

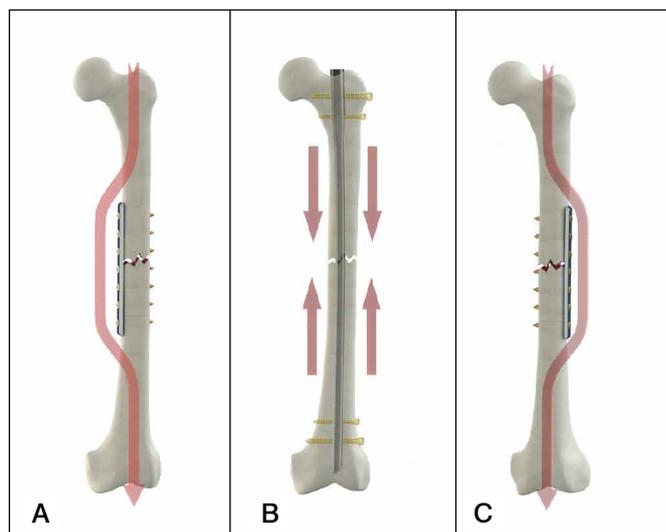
The loading model described by Koch is used to investigate the biomechanical behavior of the femur models.<sup>17</sup> Koch carried out a detailed analysis of a femur without muscles and soft tissues to show that the lateral side of the femur was in tension and the medial side was in compression. An analysis of Koch's model by Fetto et al.<sup>18</sup> revealed that the tensile load on the lateral side changed to a compressive load when the actions of the iliotibial band and vastus lateralis- gluteus complex were included. It was the contribution of Pauwels<sup>19</sup> that introduced the tension band principle, which states that tensile forces on the convex side of a curved tube can be converted to compressive forces by applying an implant to the convex side of the tube. The tension band principle works when there is anatomic apposition of cortices on the opposite side of application of plate. It does not apply when there is comminution on the opposite cortex or in comminuted fractures. Ascenzi et al.<sup>20</sup> had demonstrated the different collagen orientation within the femoral diaphysis as to the aspect of compression and tension. This principle was strongly propagated by AO. They offered the typical application of this principle by fixing a plate to the femur on the lateral side of the diaphysis.<sup>21</sup> However, Cordey et al. speculated that the tension side of the femur, which is at the lateral aspect, particularly at the proximal part, turns around the anterior aspect distally. The compression side of the femur also turns from the medial to the posterior aspect distally.<sup>8,9</sup> This means that when a plate is fixed to the lateral aspect of the distal femur, this plate may not be applied according to the tension

band principle. A plate that is fixed to the lateral or medial side of the distal femur may act as a compression device, due to the rotation of the axis, in order to produce tension at the anterior aspect and compression at the posterior aspect within the distal diaphysis of the femur.

Cordey et al.<sup>9</sup> evaluated the strain within the diaphysis during axial loading. They also measured high bending forces and stresses in the diaphysis, when the tension band effect of the iliotibial tract has been neglected. High bending forces were explained by the higher bending moment in the frontal plane. Because effect of the soft tissues on stability and stiffness was not taken into account, subsequent fractures mostly occurred at the proximal femoral region in the lateral sided plating group. The lack of muscle attachments will probably have a dramatic effect on the secondary fracture pattern.

The plates applied to the lateral side of the femur have more stress, as the bending moment experienced by the plate is directly related to the force of application and the distance of the implant from the force of application. The line of application of the weight-bearing force is approximately 1 to 2 cm distant from the force of application with plate fixation of the femur. Stress applied to the femur passes directly up the femoral shaft and bypasses the femur by means of absorption of stress through the distal screws into the plate, and back into the femur through the proximal screws.<sup>22</sup> The placement of the plate relative to the loading direction will determine the proportion of the load supported by the plate. By medializing the plate fixation, some of the load supported by the plate will be shared by bone fragments (Figure 8). Thus, lateral sided plates were the only ones that experienced plastic deformation. This is because the loading path was more medial, meaning that the lateral plates were subjected to bending that the medial plates were spared.

The variability of cadaveric specimens has always been a problem, requiring enormous sample sizes to obtain satisfactorily significant results. For this reason, synthetic femurs were chosen for this study. Synthetic femurs have a standardized geometry, very small specimen to specimen variability, and material behavior approximating that of bone.<sup>23</sup> Schoenfeld et al. looked at the pullout strength and load to failure properties of self-tapping cortical screws in synthetic and cadaveric environments representing healthy and osteoporotic bone, and found that although the trends may be similar, screw performance in the synthetic models was markedly different from that in cadavers.<sup>24</sup> As distal diaphyseal femoral fractures are mostly seen in young adults, due to high energy related traumas, part of the experiment was to represent bone quality by the synthetic composite femurs. Therefore, we used a thoroughly validated model of human femur to remove these undesirable characteristics seen in cadaveric specimens.



**Figure 8.** Diagrammatic representation of load sparing in femoral diaphyseal fractures. A. Medial femoral plating. By medializing the plate fixation, some of the load supported by the plate is shared by bone fragments. B. Intramedullary nailing. C. Traditional lateral femoral plating.

In a situation of a vascular injury, the first step is to shunt the limb, followed by rapid external fixation, then vascular repair, immediately followed by the definitive fixation, provided the patient is well enough. A midlateral approach is traditionally used for femoral fractures in which plates and screws are used for the fixation. In such cases, especially with a vascular injury, this procedure requires two separate incisions; a medial approach for the vascular repair, and a lateral approach for the fracture treatment. The soft tissue disruption associated either with open reduction and internal fixation, or with external fixation, may be reduced by using a single medial approach that allows bone stabilization under direct visualization of the repaired vessels.

In the current study, medial sided plating constructs were comparable in stiffness to the conventional lateral sided plating constructs. In selective cases, medial plating may be a reasonable treatment option that can be used safely.

In this study, only the primary fixation strength in a composite femur model was tested by axial loading. Torsional testing could also have been tested. It is also unknown how the results of this study translate to actual bone healing rates, loss of correction, and clinical outcome. As a limitation of our study, the failure of fixation rarely occurs with one-time high level loading. It would have been more appropriate to perform the testing in cyclic loading.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. FA (0000-0003-4208-8162)\* and BT (0000-0002-0184-8850)\* were the main contributors in the drafting of the manuscript. FA and Mustafa Ozmen (0000-0001-6795-2856)\* evaluated the data from the statistical analysis. FA, BT and TS (0000-0002-3276-5820)\* performed the literature search and review of the manuscript, and contributed to the intellectual concept of the study. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Winquist RA, Hansen ST Jr, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. *J Bone Joint Surg Am.* 1984;66(4):529-39.
2. Krettek C, Schandelmaier P, Tscherne H. [Distal femoral fractures. Transarticular reconstruction, percutaneous plate osteosynthesis and retrograde nailing]. *Unfallchirurg.* 1996;99(1):2-10.
3. Kinast C, Bolhofner BR, Mast JW, Ganz R. Subtrochanteric fractures of the femur. Results of treatment with the 95 degrees condylar blade-plate. *Clin Orthop Relat Res.* 1989;(238): 122-30.
4. Sink EL, Hedequist D, Morgan SJ, Hresko T. Results and technique of unstable pediatric femoral fractures treated with submuscular bridge plating. *J Pediatr Orthop.* 2006;26(2):177-81.

5. Kanlic EM, Anglen JO, Smith DG, Morgan SJ, Pesántez RF. Advantages of Submuscular Bridge Plating for Complex Pediatric Femur Fractures. *Clin Orthop Relat Res.* 2004;426:44-51.
6. Apivatthakakul T, Chiewcharntanakit S. Minimally invasive plate osteosynthesis (MIPO) in the treatment of the femoral shaft fracture where intramedullary nailing is not indicated. *Int Orthop.* 2009;33(4):1119-26.
7. Sher MH. Principles in the management of arterial injuries associated with fracture/dislocations. *Ann Surg.* 1975;182(5):630-4.
8. Hommel GJ, Lobrano C, Ogden AL, Mukherjee DP, Anissian L, Marymont JV. A quantitative analysis of tension band plating of the femur diaphysis. *Arch Orthop Trauma Surg.* 2011;131(10):1325-30.
9. Cordey J, Borgeaud M, Frankle M, Harder Y, Martinet O. Loading model for the human femur taking the tension band effect of the ilio-tibial tract into account. *Injury.* 1999;30 Suppl 1:26-30.
10. ASTM D695-10. Standard Test Method for Compressive Properties of Rigid Plastics. ASTM. 2008;8:1-8
11. Backstein D, Morag G, Hanna S, Safir O, Gross A. Long-term follow-up of distal femoral varus osteotomy of the knee. *J Arthroplasty.* 2007;22(4 Suppl 1):2-6.
12. Preston CF, Fulkerson EW, Meislin R, Di Cesare PE. Osteotomy about the knee: applications, techniques, and results. *J Knee Surg.* 2005;18(4):258-72.
13. Wang JW, Hsu CC. Distal femoral varus osteotomy for osteoarthritis of the knee. *J Bone Joint Surg Am.* 2005;87(1):127-33.
14. Aglietti P, Menchetti PP. Distal femoral varus osteotomy in the valgus osteoarthritic knee. *Am J Knee Surg.* 2000;13(2):89-95.
15. McDermott AG, Finkle JA, Farine I, Boynton EL, MacIntosh DL, Gross A. Distal femoral varus osteotomy for valgus deformity of the knee. *J Bone Joint Surg Am.* 1988;70(1):110-6.
16. Asensio JA, Kuncir EJ, García-Núñez LM, Petrone P. Femoral vessel injuries: Analysis of factors predictive of outcomes. *J Am Coll Surg.* 2006;203(4):512-20.
17. Koch JC. The laws of bone architecture. *Am J Anat.* 1917;21(2):177.
18. Fetto J, Leali A, Moroz A. Evolution of the Koch model of the biomechanics of the hip: clinical perspective. *J Orthop Sci.* 2002;7(6):724-30.
19. Pauwels F. Die Bedeutung der Bauprinzipien des Stütz und Bewegungsapparates für die Beanspruchung der Röhrenknocken. *Z Anat Entw Gesch.* 1948;114:129-66.
20. Ascenzi A, Improta S, Portigliatti Barbos M, Carando S, Boyde A. Distribution of lamellae in human femoral shafts deformed by bending with inferences on mechanical properties. *Bone.* 1987;8(5):319-25.
21. Müller ME, Allgöwer M, Schneider R, Willenegger H. Manual of internal fixation. 2<sup>nd</sup> ed. Berlin: Springer, 1979.
22. Mooney V, Claudi B. Fractures of the shaft of the femur. In: *Fractures.* Rockwood, CA. Jr.; Green, DP., eds. Philadelphia, JB Lippincott; 1975.p.1093.
23. Papini M, Zdero R, Schemitsch EH, Zalzal P. The biomechanics of human femurs in axial and torsional loading: comparison of finite element analysis, human cadaveric femurs, and synthetic femurs. *J Biomech Eng.* 2007;129(1):12-9.
24. Schoenfeld AJ, Battula S, Sahai V, Vrabec GA, Corman S, Burton L, et al. Pullout strength and load to failure properties of self-tapping cortical screws in synthetic and cadaveric environments representative of healthy and osteoporotic bone. *J Trauma.* 2008;64(5):1302-7.

# PHYSICAL ACTIVITY PROGRAM FOR ELDERLY AND ECONOMY FOR THE HEALTH SYSTEM

## PROGRAMA DE ATIVIDADE FÍSICA PARA IDOSOS E ECONOMIA PARA O SISTEMA DE SAÚDE

SAMIR SALIM DAHER<sup>1</sup>, MONICA PASCHOAL NOGUEIRA<sup>1</sup>, MAURO FERREIRA<sup>2</sup>, MARCIA REGINA MARTINEZ TEDESCHI<sup>2</sup>, LILTON RODOLFO CASTELLAN MARTINEZ<sup>3</sup>, MIRIAN MATSURA SHIRASSU<sup>4</sup>

1. Health Sciences Graduate Studies Program, Instituto de Assistência Médica ao Servidor Público Estadual de São Paulo (IAMSPE), São Paulo, SP, Brazil.

2. Municipal Government of São Paulo, Coordenadoria de Gestão das Políticas e Programas de Esporte e Lazer (CGPE), São Paulo, SP, Brazil.

3. Department of Cardiology, Instituto de Assistência Médica ao Servidor Público Estadual de São Paulo (IAMSPE), São Paulo, SP, Brazil.

4. Centro de Promoção e Proteção à Saúde – Prevenir, Instituto de Assistência Médica ao Servidor Público Estadual de São Paulo (IAMSPE), São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** To evaluate the impact of physical activity on the use of the health system and the quality of life in sedentary elderly. **Methods:** A prospective interventional study was carried out between March 2010 and February 2011 with 100 subjects (60-90 years of age,) divided into active group (AG) and control group (CG). During this period, AG performed physical exercise twice a week in 60-minute sessions and the CG remained sedentary with observation of their activities. Before and after the study, all subjects were clinically evaluated and completed a quality of life questionnaire. **Results:** Eighty-nine subjects (AG = 44; CG = 45) were analyzed. AG had fewer visits to emergency room ( $p = 0.0056$ ), hospitalizations ( $p = 0.0011$ ), length of hospital stay ( $p = 0.0012$ ) and fewer subsidiary tests ( $p = 0.0236$ ) compared to the CG. The quality of life score analyzed before and after physical activity increased in AG compared to CG ( $p < 0.0001$ ) and among subjects in AG ( $p < 0.0001$ ), with no change in the CG. **Conclusion:** The intervention of a physical activity program for sedentary elderly can contribute to reduce the use of the health system and improve the quality of life. **Level of evidence II, Therapeutics Studies. Prospective comparative study.**

**Keywords:** Quality of life. Aged. Motor activity. Health systems. Sedentary lifestyle.

### RESUMO

**Objetivo:** Avaliar o impacto da atividade física sobre o uso do sistema de saúde e a qualidade de vida em idosos sedentários. **Métodos:** Estudo prospectivo intervencionista (março/2010 a fevereiro/2011) com 100 indivíduos (mín. 60 e máx. 90 anos de idade), divididos em grupo ativo (GA) e grupo controle (GC). Nesse período, o GA realizou exercício físico duas vezes por semana, em sessões de 60 minutos e o GC permaneceu sedentário, com observação de suas atividades. Antes e depois do estudo, todos os indivíduos foram avaliados clinicamente e responderam a um questionário de qualidade de vida. **Resultados:** Foram analisados 89 indivíduos (44 no GA, e 45 no GC). O GA teve menor número de visitas ao pronto-socorro ( $p = 0,0056$ ), internações ( $p = 0,0011$ ), tempo de internação ( $p = 0,0012$ ) e de exames subsidiários realizados ( $p = 0,0236$ ) comparado com o GC. O escore de qualidade de vida, analisado pré e pós-atividade física apresentou aumento no GA em comparação com o GC ( $p < 0,0001$ ) e entre os indivíduos do próprio GA ( $p < 0,0001$ ), não havendo alteração no GC. **Conclusão:** A intervenção de um programa de atividade física para idosos sedentários pode contribuir para reduzir a utilização do sistema de saúde e melhorar a qualidade de vida. **Nível de Evidência II, Estudos terapêuticos. Estudo prospectivo comparativo.**

**Descritores:** Qualidade de vida. Idoso. Atividade motora. Sistemas de saúde. Estilo de vida sedentário.

**Citation:** Daher SS, Nogueira MP, Ferreira M, Tedeschi MRM, Martinez LRC, Shirassu MM. Physical activity program for elderly and economy for the health system. *Acta Ortop Bras.* [online]. 2018;26(4):271-4. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

In 2013, life expectancy in Brazil was 75.2 years, growth of more than three years in a decade.<sup>1</sup> As the population is living longer, there is a notable increase in the prevalence of chronic diseases, many influenced by factors such as: inadequate lifestyle, environmental, inherited and genetic factors.<sup>2</sup> As a result of this process, there is

a quantitative increase in the use of the health system, intensifying the challenge of managing this system, in ensuring quality care for the entire population,<sup>3</sup> which already faces a shortage of health professionals and basic infrastructure in some areas, especially in the public service, making it even more difficult to provide adequate care to the population.<sup>4</sup>

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

Work conducted at the Centro de Promoção e Proteção/Prevenir do Instituto de Assistência Médica ao Servidor Público Estadual (IAMSPE), in partnership with the Municipal Department of Sports (SEME) of the city of São Paulo, SP, Brazil.

Correspondence: Samir Salim Daher. Av. Ibirapuera, 981, Vila Clementino, São Paulo, SP, Brazil. 04029-000. [samirdaher@uol.com.br](mailto:samirdaher@uol.com.br)

Article received in 04/12/2018, approved in 05/10/2018.

*Acta Ortop Bras.* 2018;26(4):271-4



Considering the main risk factors that influence the way we age (inadequate eating habits, smoking, stress and sedentary lifestyle),<sup>5</sup> all of which are preventable, a greater development of preventive interventional actions can improve quality of life in the aging population and, consequently, reduce their morbidity and use of the health system.<sup>2</sup>

Since a sedentary lifestyle was considered the fourth major risk factor for mortality among the elderly<sup>5</sup> in 2014, we agree with the standpoint of Haskell et al.<sup>6</sup> and Di Raimondo et al.,<sup>7</sup> that a supervised physical activity program can help prevent or delay the occurrence of new diseases, especially those among the elderly, in addition to maintaining health, at all ages.

Thus, health promotion actions can contribute to reduce the demand for hospital care and dependency, and to improve the quality of life of the population, in addition to their considerable social benefits, especially for the elderly.<sup>6,8-11</sup>

The aim of this study was to evaluate the impact of supervised physical activity on the quality of life of the sedentary elderly population and on the use of the health system.

## MATERIALS AND METHODS

This is a prospective, interventional study in which 100 elderly patients were monitored from March 1, 2010 to February 28, 2011, conducted by the Center for Promotion and Protection of our Institution in partnership with the Municipal Department of Sports (Secretaria Municipal de Esportes - SEME) of the city of São Paulo, SP, Brazil. This study was approved by the Institutional Review Board of the Department of Public Management under No. 0122/09. All patients completed and signed the Informed Consent Form (ICF). The patients were divided into two groups: active group (AG) and control group (CG), with 50 patients in each group.

To be eligible to participate in the study the patients had to be 60 years of age or older, not have been engaged in physical activity for at least one year prior to the start of the program, and had to participate in at least 75% of the activities offered. Exclusion criteria were recent surgery or other medical contraindications to physical activity.

Individuals in both groups underwent a clinical assessment performed by the physician in charge of the study and a nurse, including a full physical examination, blood pressure and capillary blood glucose measurements, and answered the quality of life questionnaire WHOQOL-Bref (World Health Organization Quality of Life Assessment).<sup>12</sup>

The AG received a twice-weekly supervised physical activity program, held on Tuesday and Thursday mornings with a duration of 60 minutes per session, on the premises of the Bicycle Park of SEME, in an outdoor space with an asphalt walking trail, with an area alongside the trail with fitness equipment installed as part of the Longevity Playground of the aforementioned park, also known as the "Senior Citizen Fitness Academy". The physical activity program consisted of aerobic physical exercises - continuous 30-minute walks along the park trail, of mild to moderate intensity, followed by resistance training - specifically designed for the main muscle groups of the various parts of the body in the form of a circuit with the different apparatuses installed in the Senior Citizen Playground, besides the use of free weights (dumbbells) weighing 1 to 2 kg and, finally, muscle stretching exercises - of moderate intensity, initially in the upright position then on the ground using mats.<sup>6,9,13</sup>

The CG remained under closer clinical observation over the same period, but did not engage in any physical activity.

At the end of the period, all patients were clinically reassessed by the same team, with the performance of a full physical examination,

blood pressure and capillary blood glucose measurements. The WHOQOL-Bref quality of life questionnaire was also reapplied.<sup>12</sup> The variables were analyzed using the relevant descriptive measures: mean, standard deviation (SD), median, minimum and maximum values for quantitative variables and absolute (n) and relative (%) frequency for categorical variables. The study groups were compared in terms of distribution of categorical variables using Pearson's Chi-square test (the Likelihood-Ratio Chi-squared test was applied if the assumptions of the classic test were not satisfied). The Student's t-test was applied in the comparison between the groups in terms of mean age and daily quality of life score. The groups were compared in terms of number of children, number of appointments attended, number of visits to the emergency department, length of hospital stay and number of drug products consumed per day using the nonparametric Mann-Whitney test. A paired t-test was used to compare the two applications of the quality of daily life questionnaire in patients in the active group. A significance level of  $p \leq 0.05$  ( $\alpha = 5\%$ ) was adopted, and the SPSS (Statistical Package for the Social Sciences) program, version 15.0 for Windows (University of Chicago, USA) was used in all the tests and statistical analyses.

## RESULTS

In total, 89 patients were assessed, 44 in the AG and 45 in the CG. The withdrawal of six patients from the AG included five for personal reasons, and one for health-related reasons; in the CG 5 patients were withdrawn, 2 due to health problems and 3 for personal reasons. The mean frequency of the AG was 38 patients per class (86%), with a minimum of 36 (82%) and a maximum of 40 (90%) patients.

Similarity was observed in the intergroup demographic data, predominantly in the female patients. The mean age was 76.4 years for the AG and 75 years for the CG. There was no difference in marital status, ethnicity or level of education among the study subjects. Regarding the presence of noncommunicable (chronic) diseases (NCDs), there was no statistical difference between the groups in terms of the ratio of diseases. The presence of the disease and its characteristics were recorded in the various body systems, as described in Table 1.

Regarding how many subjects took drug products daily as well as the amount used, there was no statistically significant difference between the groups. In the AG 40 patients (90.9%) were taking drug products on a daily basis and in the CG, 43 (95.6%), with a mean of 2.6 drugs per day for both groups.

In relation to hospital admissions entered in the medical records during the study period, we observed the following significant differences: number of visits to the emergency department, subsidiary tests/examinations (except clinical analysis), hospital admissions and length of hospital stay per individual. The CG had a higher participation in all related items, when compared to the AG (Table 2).

**Table 1.** Presence of noncommunicable disease in the patients.

Health Data	Active Group	Control Group	p-value
	(n=44)	(n=45)	
Systemic Arterial Hypertension	30 (68.2%)	26 (57.8%)	0.3096
Diabetes Mellitus	11 (25.0%)	10 (22.2%)	0.7576
Neoplastic Diseases	6 (13.6%)	9 (20.0%)	0.4227
Endocrine Diseases	4 (9.1%)	7 (15.6%)	0.3542
Heart Diseases	9 (20.5%)	10 (22.2%)	0.8388
Neurological Diseases	4 (9.1%)	8 (17.8%)	0.2303
Musculoskeletal Diseases	15 (34.1%)	20 (44.4%)	0.3174

Two causes of hospital admission which occurred in the AG were related by digestive problems. In the CG, 14 hospital admissions were recorded: four due to gastrointestinal causes, three cardiovascular, two in respiratory clinics, two orthopedic and in the urology, neurology and vascular surgery sectors. Four of these patients underwent surgery, one of which was elective, to perform total knee arthroplasty due to osteoarthritis. Three surgeries were characterized as urgent for the treatment of lower limb thromboembolism due to deep vein thrombosis, osteosynthesis of wrist fracture caused by a fall, and stent placement due to coronary artery obstruction. Regarding the pre-physical activity quality of life score, the CG had a statistically higher score than the AG. Among the members of the AG, pre and post-physical activity scores showed a significant increase at the end of the program. However, exclusively in relation to the end of the program, there was a difference in scores when comparing both groups, where the AG had higher scores than the CG (Table 3).

## DISCUSSION

The aging of the population is relevant in our social context, since it gives rise to concern over the inability of the health system to absorb the demand of its specific needs, among other factors.<sup>2,14</sup> Scheduled physical activity, as a health promoting factor, can contribute to reduce the use of health services and improve the quality of life of the elderly population.<sup>15</sup>

The fact that the population of our study group was homogeneous in terms of demographics, the presence of NCDs, comparable to that of the global elderly population, the number of drug products taken daily and the number of outpatient visits allowed us to make an adequate comparison of the benefits of physical activity intervention between groups.<sup>16</sup>

The AG patients underwent fewer additional diagnostic tests of greater complexity than the CG. Interventional health promotion actions may have influenced this observation, as individuals with more adequately controlled health tend to use the global health system less often. Similarly, our study also noted that visits to the emergency department may be reduced in a physically active population. Elderly individuals have their own characteristics when seeking an emergency service. This may be associated with increased frailty in this age group, which in turn has a higher prevalence of chronic diseases and are at a greater risk in terms of related complications. Health promotion along with the reduction of risk factors, including falls, may also contribute to a decrease in the incidence of emergency department visits.<sup>4,17</sup>

Not only are hospital admissions more frequent among the elderly, but the length of hospital stays is also greater when compared to other age groups. We also noted that individuals in the CG had a greater frequency and length of hospital stay than the AG. This corroborates the theory that the adoption of preventive measures to reduce risk factors can contribute decisively to the reduction of hospital intervention, offering better health conditions to the patient, while reducing the length of hospital stays.<sup>17,18</sup>

The surgical procedures in our study were performed only in the CG patients and were consistent with situations arising from age-related diseases such as heart disease, peripheral vascular disease, osteoarthritis and falls from standing height. However, results could be avoided or delayed if health promotion programs were implemented. Physical activity may have made a potential contribution to the AG not needing any surgical interventions. Improving clinical conditions and physiological responses to control NCDs, such as better balance, flexibility and muscle strength, contribute to a lower risk of falls and their consequences. Thus, this effectively reduces the risks of surgical intervention.<sup>10,18</sup>

Regarding quality of life, the AG had a significant improvement comparing the beginning and end of the study, and in comparison with the subjects in the CG. The CG results did not show a significant difference from start to finish. We suggest that the fact that patients in the AG had a quality of life score that was initially lower than that of the CG is probably because the previous activities of the AG were not sufficient to provide good quality of life. The CG, on the other hand, seem to be regard their daily activities as an established routine, and do not seek alternative measures to improve their quality of life.

Quality of life appears as a new paradigm of health, especially for the elderly. Healthy aging, from this perspective, arises as a result of the interaction between physical health, mental health, and social integration. Given the complexity of establishing an adequate definition of quality of life, we understand that maintaining the autonomy and independence of the older population is a determining factor. Indeed, the evidence reveals that the ability of

**Table 2.** Use of Hospital – Health data of the patients in the study period.

Use of Hospital	Active Group (n=44)	Control Group (n=45)	p-value
Outpatient consultations	27 (61.4%)	25 (55.6%)	0.5783
Consultations held			
Mean (SD)	5.2 (6.3)	7.0 (9.2)	0.6856
Median	2.5	5.0	
Minimum – Maximum	0 – 24	0 – 42	
Visits to the Emergency Department	10 (22.7%)	23 (51.1%)	0.0056
Number of visits to the Emergency Department			
Mean (SD)	0.4 (0.8)	0.9 (1.9)	0.0125
Median	0	1	
Minimum – Maximum	0 – 3	0 – 12	
Tests performed	8 (18.2%)	18 (40.0%)	0.0236
Hospital admission	2 (4.5%)	14 (31.1%)	0.0011
Length of hospital stay (days)			
Mean (SD)	0.4 (2.4)	2.9 (5.7)	0.0012
Median	0	0	
Minimum – Maximum	0 – 16	0 – 22	
Surgery performed in the study period	0 (0%)	4 (8.9%)	0.1305

Note: 4 (9.1%) patients of the Active Group underwent cataract surgery and were not considered in the analysis of surgery performed during the study period.

**Table 3.** Daily Quality of Life Score of the patients according to Study group.

Daily quality of life score	Active Group (n=44)	Control Group (n=45)	p-value
Pre-assessment			< 0.0001
Median (SD)	4.1 (2.5)	6.4 (1.7)	
Median	4	6	
Minimum – Maximum	0 – 10	2 – 10	
Post-physical activity assessment			
Median (SD)	9.9 (0.5)		< 0.0001
Median	10		
Minimum – Maximum	8 – 10		
Active Group: pre-assessment vs. post-assessment			
Final assessment			< 0.0001
Median (SD)	9.9 (0.5)	6.5 (1.7)	
Median	10	6	
Minimum – Maximum	8 – 10	2 – 10	

the aging population to implement their own desires is essential for healthy aging, far more so than simply aging without disease.<sup>12,19</sup> Physical exercise in primary health care is clearly important as a factor involved in deceleration of the physiological aging process. It is a healthy alternative that can contribute to active aging and maintain an independent lifestyle, consequently reducing use of the health system, such as hospitalization, length of hospital stay, more complex tests, and visits to the emergency department. In addition, it helps individuals to develop self-confidence, self-image, and socialization, significantly improving their quality of life.<sup>9,18,20</sup>

## CONCLUSIONS

Supervised physical exercise, applied to sedentary older individuals, is an effective intervention to promote health and improve quality of life, and reduces use of health care services. In this study we observed a significant reduction in the following indicators: visits to the emergency department, hospital admissions, length of hospital stay and more complex subsidiary tests/exams. Regarding the quality of life of elderly people who have started to engage in physical activity, there was also a significant improvement when results were compared at baseline and to sedentary elderly subjects.

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript: SSD (0000-0002-8113-0178)\* intellectual concept of the article, writing and revision of the article, data analysis, approval of the final version of the work. MF (0000-0001-9991-7297)\* data analysis and interpretation, participated in the revision process. MRMT (0000-0002-8817-9089)\* writing and revision of the article, critical review of the intellectual content. MMS (0000-0001-8059-0044)\* = data analysis and interpretation, participated in the revision process. LRCM (0000-0001-8053-4501)\* writing and revision of the article, critical review of the intellectual content. MNP (0000-0001-5892-2532)\* = critical review of the intellectual content and approval of the final version of the work. \*ORCID (Open Researcher and Contributor ID).

## REFERENCES

1. Instituto Brasileiro de Geografia e Estatística (IBGE). Estimativas populacionais para os municípios e para as Unidades da Federação brasileiros em 01.07.2015 [Internet]. Rio de Janeiro: IBGE; 2015. Available at: [http://www.ibge.gov.br/home/estatistica/populacao/estimativa 2015/](http://www.ibge.gov.br/home/estatistica/populacao/estimativa%202015/). Access 2016/09/23.
2. Campolina AG, Adami F, Santos JFL, Lebrão ML. A transição de saúde e as mudanças na expectativa de vida saudável da população idosa: possíveis impactos da prevenção de doenças crônicas. *Cad Saúde Pública*. 2013;29(6):1217-29.
3. Bulamu NB, Kaambwa B, Ratcliffe J. A systematic review of instruments for measuring outcomes in economic evaluation within aged care. *Health Qual Life Outcomes*. 2015;13:179.
4. Carret MLV, Fassa AG, Paniz VMV, Soares PC. Características da demanda do serviço de saúde de emergência no sul do Brasil. *Ciênc Saúde Coletiva*. 2011; 16(Suppl 1):1069-79.
5. World Health Organization (WHO). World health statistics 2014 [Internet]. Geneva: World Health Organization; 2014. Disponível em: [http://apps.who.int/iris/bitstream/10665/112738/1/9789240692671\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/112738/1/9789240692671_eng.pdf?ua=1). Access 2016/09/27.
6. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423-34.
7. Di Raimondo D, Musiari G, Miceli G, Arnao V, Pinto A. Preventive and therapeutic role of muscle contraction against chronic diseases. *Curr Pharm Des*. 2016;22(30):4686-99.
8. Morris JN, Crawford MD. Coronary heart disease and physical activity of work: evidence of a national necropsy survey. *Br Med J*. 1958;2(5111):1485-96.
9. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1435-45.
10. Valderrabano V, Steiger C. Treatment and prevention of osteoarthritis through exercise and sports. *J Aging Res*. 2010;2011:374653.
11. Gill DL, Hammond CC, Reifsteck EJ, Jehu CM, Williams RA, Adams MM, et al. Physical activity and quality of life. *J Prev Med Public Health*. 2013;46(Suppl 1):S28-34.
12. Fleck MPA. O instrumento de avaliação de qualidade de vida da Organização Mundial da Saúde (WHOQOL-100): características e perspectivas. *Ciênc saúde coletiva*. 2000;5(1):33-8.
13. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc*. 2011;43(7):1334-59.
14. Gulland A. Global life expectancy increases by five years. *BMJ*. 2016;353:i2883.
15. da Silva LS, Cotta RMM, Rosa COB. Estratégias de promoção da saúde e prevenção primária para enfrentamento das doenças crônicas: revisão sistemática. *Rev Panam Salud Publica*. 2013;34(5):343-50.
16. Ferreira DN, Matos DL, Loyola Filho AI. Ausência de consulta médica de rotina entre idosos hipertensos e/ou diabéticos: um estudo epidemiológico baseado na Pesquisa Nacional por Amostra de Domicílios 2008. *Rev Bras Epidemiol*. 2015;18(3):578-94.
17. Siqueira FV, Facchini LA, Piccini RX, Tomasi E, Thumé E, Silveira DS, et al. Prevalência de quedas em idosos e fatores associados. *Rev Saúde Pública*. 2007;41(5):749-56.
18. Boing AF, Vicenzi RB, Magajewski F, Boing AC, Moretti-Pires RO, Peres KG, et al. Redução das internações por condições sensíveis à atenção primária no Brasil entre 1998-2009. *Rev Saúde Pública*. 2012;46(2):359-66.
19. Oliveira AC, Oliveira NMD, Arantes PMM, Alencar MA. Qualidade de vida em idosos que praticam atividade física - uma revisão sistemática. *Rev Bras Geriatr Gerontol*. 2010;13(2):301-12.
20. Vidmar MF, Potulski AP, Sachetti A, Silveira MM, Wibelinger LM. Atividade física e qualidade de vida em idosos. *Saud Pesq*. 2011;4(3):417-24.

# RELATION BETWEEN IMPACT FACTOR IN ORTHOPEDIC JOURNALS AND LEVEL OF EVIDENCE

## RELAÇÃO ENTRE FATOR DE IMPACTO EM PERIÓDICOS ORTOPÉDICOS E NÍVEL DE EVIDÊNCIA

MAURICIO PANDINI MONTEIRO DE BARROS<sup>1</sup>, FABIO TERUO MATSUNAGA<sup>1</sup>, MARCEL JUN SUGAWARA TAMAOKI<sup>1</sup>

1. Universidade Federal de São Paulo, São Paulo, SP, Brazil.

### ABSTRACT

**Objective:** This study aims to assess the quality of articles published in the leading orthopedic surgery journals, by measuring the relation between the impact factor and the number studies with a high level of evidence. **Methods:** A literature review was performed of articles published in four previously selected journals. A score of journal evidence (RER – Relation between Randomized clinical trials and Systematic reviews) was calculated, considering the number of RCTs and SR published and the total number of full-text articles. **Results:** The selected journals were JBJS-Am, ASMJ, BJJ-Br and Arthroscopy, with Impact factors of 5.280, 4.362, 3.309 and 3.206 respectively in 2015. In the study, the RER Scores, in the same order, were 9.408, 6.153, 7.456 and 7.779. **Conclusion:** The journal JBJS-Am is the best available source of information on orthopedic surgery from this point of view. It has the highest Impact Factor and clearly the highest RER Score. On the other hand, we could conclude that the number of published RCT and good quality SR is very low, with less than 10% of all the articles. **Level of evidence III, Analyses based on limited alternatives and costs, and poor estimates.**

**Keywords:** Review Literature as Topic. Impact Factor. Evidence-Based Medicine. Orthopedics. Study Characteristics.

### RESUMO

**Objetivo:** Este estudo tem como objetivo avaliar a qualidade dos artigos publicados nos principais periódicos de cirurgia ortopédica, medindo a relação entre o fator de impacto e o número de estudos com alto nível de evidência. **Métodos:** Realizou-se a revisão de literatura com artigos publicados em quatro periódicos previamente selecionados. Um escore de evidência de periódicos (RER – Relação entre Ensaios Clínicos Randomizados e Revisões Sistemáticas) foi calculado, considerando-se o número de ECR e RS publicados e número total de artigos com textos completos. **Resultados:** Os periódicos selecionados tiveram o fator de impacto de 5.280, 4.362, 3.309 e 3.206 respectivamente para JBJS-Am, ASMJ, BJJ-Br e Arthroscopy no ano de 2015. No estudo, os escores RER foram, na mesma ordem, 9.408, 6.153, 7.456 e 7.779. **Conclusão:** A revista JBJS-Am é a melhor fonte disponível de informações sobre cirurgia ortopédica deste ponto de vista. Tem o maior fator de impacto e claramente o maior escore RER. Por outro lado, podemos concluir que o número de ECR e RS publicados de boa qualidade é muito baixo, com menos de 10% do total de artigos. **Nível de Evidência III, Análises baseadas em alternativas e custos limitados, e estimativas ruins.**

**Descritores:** Literatura de revisão como assunto. Fator de Impacto. Medicina baseada em evidências. Ortopedia. Características dos estudos.

**Citation:** Barros MPM, Matsunaga FT, Tamaoki MJS. Relation between impact factor in orthopedic journals and level of evidence. Acta Ortop Bras. [online]. 2018;26(4):275-7. Available from URL: <http://www.scielo.br/aob>.

### INTRODUCTION

An enormous number of articles are published annually by each orthopedic journal, which leads to a progressive increase of new information, new surgical techniques, updates of diseases and case reports that can be easily accessed.

With too much data available in the literature, effective and judicious analysis of these data should be done in order to guide and complement surgeon's decision-making process, defining therefore, the central point of practicing Evidence-Based Medicine (EBM). It should involve integration of clinical expertise, patients' perceptions and values, and the best available research evidence.

However, most of knowledge of orthopedic surgeons is based only on clinical experience of some experts.<sup>1</sup>

Aiming for the best quality of information, students, researchers, clinical practitioners and surgeons may choose an article based on the journal according to its relevance, which can be measured by Impact Factor (IF). The IF was created as a measurement of the number of citations of scientific articles published in a determined period.<sup>2</sup> The IF shows indirectly the relevance and quality of the publications by a journal, and it is calculated by a relation between published articles and articles that are mentioned, quoted or cited in the biennium prior to the year in which the IF is calculated.

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

Work conducted at the Department of Orthopedics and Traumatology, Escola Paulista de Medicina, Universidade Federal de São Paulo (Unifesp).

Correspondence: Maurício Pandini Monteiro de Barros, R. Professor Tranquilli, 212 apto 144, CEP 04126-010, Vila Mariana, São Paulo, SP, [mpmbarros@gmail.com](mailto:mpmbarros@gmail.com)

Article received in 09/02/2016, approved in 06/12/2016.

Acta Ortop Bras. 2018;26(4):275-7



Another method to assess the quality of the study is the analysis its design, considering the level of evidence, which is categorized in six levels:<sup>3</sup> (Figure 1)

## OBJECTIVE

This study aims to assess the quality of published articles in the most important orthopedic surgery journals, by measuring the relation between the impact factor and the number of high-evidence level studies.

## METHODS

Inclusion criteria used was the four orthopedic surgery journals with the highest impact factor (IF) included in the list of *Journal of Citation Report of Web of Knowledge*.<sup>2</sup>

A systematic assessment of published articles of these four journals was performed. Full articles published from January 1<sup>st</sup> 2013 to December 31<sup>st</sup> 2014 were selected. A score of journal evidence (RRS – Relation of Randomized clinical trials and Systematic Revision) was calculated considering the number of RCTs and SR published and total of full articles (Figure 2).

Editorials, letters and communications were excluded from the calculation. Also, narrative reviews were not considered high-evidence articles and were not included in the sum of RCTs and SRs. From that point, we could estimate the RRS score of each journal selected and compare with IF.

## RESULTS

The selected journals in orthopedic surgery field with higher IF selected were:

- Journal of Bone and Joint Surgery – American Volume (JBJS-Am);
- American Journal of Sports Medicine (AJSM);
- The Bone and Joint Journal – British Volume (BJJ-Br) and

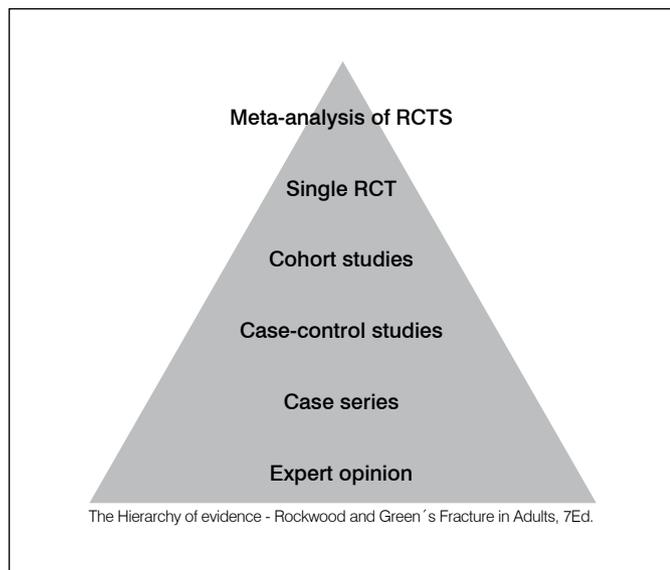


Figure 1.

$$\text{RRS SCORE} = \frac{\text{NUMBER OF RCT AND SR}}{\text{NUMBER OF ALL THE ARTICLES}} \times 100$$

Figure 2. RRS score calculation formula.

- Arthroscopy – The Journal of Arthroscopic and Related Surgery. A total of 210 level 1 and 2 (high-evidence level) articles were identified in the four selected journals. Of these 26 were systematic reviews / meta-analysis and 184 RCTs (Tabela 1).

**Table 1.** Demonstrates relation of total published articles to number to high-evidence articles, RRS Score and Impact factor.

	Total published articles 2013 - 2014	RCTs / SRs	RRS Score	IF
JBJS-Am	659	62	9.408	5.280
AJSM	650	40	6.153	4.362
BJJ-Br	523	39	7.456	3.309
Arthroscopy	887	69	7.779	3.206

RCT: Randomized Controlled Trial; SR: Systematic Review; RRS\*\*\*; IF: Impact Factor (JCR-Web of Knowledge); JBJS-AM: Journal of Bone and Joint Surgery – American Volume; AJSM: American Journal of Sports Medicine; BJJ-Br: The Bone and Joint Journal – British Volume; Arthroscopy – The Journal of Arthroscopic and Related Surgery.

## DISCUSSION

Since 2003, the main orthopedic journal – The Journal of Bone and Joint Surgery – American Volume (JBJS-Am), have been using a scale based on the pyramid of evidence, ranking their published articles according to level of evidence.<sup>4</sup> Actions like this promote readers and authors to practice EBM, improve the quality of studies to be published and demonstrate the increasing influence of this practice in science of orthopedic surgery. Some journals publish a large number of letters, communications and editorials. In order to not compromise results, these publications were excluded from the analysis in this study.

The proposed RRS Score assesses the proportion of high-evidence articles published by a journal each year. However, the highest obtained RRS score in this study of 9.408 of JBJS-Am means that less than 10% of all articles published in the journal of highest impact factor represents high-evidence quality. Other studies also demonstrate even lower rates of quality articles published. Rodrigues have found 0.84% in plastic surgery journals, Moraes found 2.4% in orthopedic literature and Rosales found from zero to 8.3% in hand surgery journals.<sup>5 6 7</sup>

The impact factor of a scientific journal reflects its importance and relevance in the literature.<sup>8</sup> Despite the fact that there are some criticisms about the validity of IF, once many authors self-citation and policies practiced by journal editors to increase its IF rating. Limitation of this study is lack of assessment of quality of published RCTs. Tools like the one described by Jadad demonstrate fails and risks of biases in these studies.<sup>9</sup> This further and deeper evaluation may be postponed and be the next step when a larger amount of high-quality evidence studies is published.

Another limitation is that prospective cohort studies for prognosis and accuracy studies for diagnostics were not included as high quality evidence articles even though they represent the highest evidence for each study design.

## CONCLUSION

The conclusion of this study was that the JBJS-Am is the best available source of information in orthopedic surgery. It has the highest Impact Factor and clearly the highest RRS Score. On the other hand, we could conclude that the number of published RCT and good quality SR is very low, with less than 10% of all the articles.

---

**AUTHORS' CONTRIBUTIONS:** Each author made significant individual contributions to this manuscript. MJS (0000-0002-9539-4545)\* was the supervisor, and was responsible for organizing the idea and the work. FT (0000-0001-7328-1446)\* and MPMB (0000-0002-9995-8723)\* wrote the text, investigated the data and carried out the analysis. \*ORCID (Open Researcher and Contributor ID).

---

## REFERÊNCIAS

1. VY Moraes, JC Belloti, FY Moraes, JA Galbiatti, EP Palácio, JBG Santos. Hierarchy of evidence relating to hand surgery in Brazilian orthopedic journals. *Sao Paulo Med J.* 2011;129(2):94-8.
2. Garfield E. Citation analysis as a tool in journal evaluation. *Science.* 1972;178(4060):471-9.
3. Bucholz RW, Heckman JD, Court-Brown CM, Tornetta P. Outcome Studies in Trauma. In: Rockwood CA, Green DP. *Fracture in Adults.* 7<sup>th</sup> ed. Philadelphia: Lippincott Williams & Wilkins; 2010. p. 410-30.
4. Wright JG, Swiontkowski MF, Heckman JD, James D. Introducing levels of evidence to the journal. *J Bone Joint Surg Am.* 2003;85(1):1-3.
5. Rodrigues MA, Tedesco AC, Nahas FX, Ferreira LM. Journal impact factor versus the evidence level of articles published in plastic surgery journals. *Plast Reconstr Surg.* 2014;133(6):1502-7.
6. Moraes VY, Moreira CD, Tamaoki MJC, Faloppa F, Belloti JC. Randomized clinical trials in orthopedics and traumatology: Systematic assessment of the national evidence. *Rev Bras Ortop.* 2010; 45(6):601-5.
7. Rosales RS, Reboso-Morales L, Martin-Hidalgo Y, Diez de la Lastra-Bosch I. Level of evidence in hand surgery. *BMC Res Notes.* 2012;5:665.
8. Garfield E. The evolution of the Science Citation Index. *Int Microbiology.* 2007;10(1):65-9.
9. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials.* 1996;17(1):1-12.