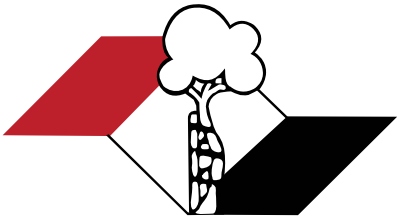
Indexed
PubMed and
PubMed Central
included
ISI and JCR (Journal Citation Reports®)



ISSN 1413-7852

Acta Ortopédica Brasileira

Volume 26 – Number 1 – Year 2018

ISSN 1413-7852

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 Cientificas 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, Medellin, Colombia • Jack Zigler – Texas Back Institute, Texas, Estados Unidos • Jesse B. Júpiter – 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 da 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 Schwartsmann – Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, Brasil;
- Celso Herminio Ferraz Picado – Universidade de São Paulo, Riberão 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 Frota, 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;
- Kodi 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 Luíz 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

Editorial coordination, creation, desktop publishing and graphic production Atha Comunicação e Editora - e-mail: 1atha@uol.com.br

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 being 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:
a) The article category (original article, review article or update article);
b) The full title in Portuguese and English with up to 80 characters. The title should be concise, but informative;
c) 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.[1]).
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 ([1,5,7]). Where there are 3 or more sequential citations, use a numeric range ([4-9]). 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. 2nd ed. New York: Spriger-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. 4th 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, 4° floor. Vila Mariana, 04044-000. São Paulo, SP, Brazil. 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[a]

(This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK. For more information, please visit www.cebm.net.)

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

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

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

[c] Studies provided consistent results.

[d] Study was started before the first patient enrolled.

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

[f] The study was started after the first patient enrolled.

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

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

SUMMARY

VOLUME 26–Nº 1–2018

Original Articles

DOI: http://dx.doi.org/10.1590/1413-785220182601174970

ORIGINAL ARTICLE

IS FUNCTIONAL OUTCOME BETTER AFTER ARTHROPLASTY FOR TROCHANTERIC FRACTURES IN OLDER ADULTS?

O RESULTADO FUNCIONAL É MELHOR DEPOIS DA ARTROPLASTIA PARA FRATURAS TROCANTÉRICAS EM IDOSOS?

Alper Öztürk[1], Serkan İltar[2], Kadir Bahadir Alemdaroğlu[2], Veysel Ercan Dinçel[2], Ahmet Özmeriç[2], Burak Gökgöz[2]

1. Department of Orthopaedics, Baskent University, Konya Research Center.
2. Department of Orthopaedics, Ankara Training and Research Hospital, University of Health Sciences.

ABSTRACT

Objectives: This article evaluated functional recovery and mortality after surgery to repair trochanteric fracture with regard to treatment technique through one year of follow-up. Method: Eighty consecutive patients with trochanteric fractures were divided into two groups according to treatment technique (osteosynthesis and arthroplasty). We evaluated patient data including age, sex, time to surgery, total hospital stay, transfusion volume, and functional status according to FIM (Functional Independence Measure) scores. Scores for FIM were assessed three times: prior to fracture, six months after surgery, and one year after surgery. Results: Patients who received osteosynthesis had shorter hospital stays than arthroplasty patients. The arthroplasty group had significantly higher functional independence six months after surgery, while no difference was detected one year after surgery. Patient age, transfusion volume, and FIM scores were detected as significant predictors of mortality. Conclusion: Trochanteric fractures lead to unavoidable functional loss, although this can be reduced in the short term by treating with arthroplasty instead of osteosynthesis. Age, transfusion and functional situation predict one-year mortality for patients with trochanteric fractures. The patient's functional situation must be considered when choosing treatment for trochanteric fractures in order to reduce patient morbidity. ***Level of Evidence II; Therapeutic prospective study.***

Keywords: Hip fractures. Arthroplasty. Fracture fixation, internal. Rehabilitation.

RESUMO

Objetivo: Este artigo avaliou a recuperação funcional e a mortalidade após cirurgia de fratura do quadril com relação à técnica de tratamento durante um ano de acompanhamento. Método: Oitenta pacientes consecutivos com fraturas trocantéricas foram divididos em dois grupos, de acordo com a técnica de tratamento (osteossíntese e artroplastia). Avaliamos os dados dos pacientes quanto a idade, sexo, tempo até a cirurgia, estadia hospitalar total, volume de transfusão e estado funcional de acordo com a pontuação da MIF (Medida de Independência Funcional). A MIF foi avaliada três vezes: antes da fratura, seis meses e um ano após a cirurgia. Resultados: Os pacientes submetidos à osteossíntese tiveram menor tempo de hospitalização do que os pacientes de artroplastia. O grupo artroplastia teve independência funcional significativamente maior seis meses depois da cirurgia, enquanto nenhuma diferença foi detectada um ano após a cirurgia. Idade, volume da transfusão e a pontuação MIF dos pacientes foram detectadas como preditores importantes da mortalidade. Conclusão: As fraturas trocantéricas levam à perda funcional inevitável, embora ela possa ser reduzida a curto prazo com a artroplastia ao invés da osteossíntese. A idade, a transfusão e a situação funcional são preditores significativos de mortalidade em um ano em pacientes com fraturas trocantéricas. A situação funcional dos pacientes deve ser considerada ao escolher o tratamento de fraturas trocantéricas para reduzir a morbidade dos pacientes. ***Nível de Evidência II; Estudo prospectivo terapêutico.***

Descritores: *Fratura do quadril. Artroplastia. Fixação interna de fraturas. Reabilitação.*

Citation: Öztürk A, İltar S, Alemdaroğlu KB, Dinçel VE, Özmeriç A, Gökgöz B. Is functional outcome better after arthroplasty for trochanteric fractures in older adults? Acta Ortop Bras. [online]. 2018;26(1):8-10. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

As life expectancy grows, the number of hip fractures has been increasing. Since hip fractures are associated with high morbidity and mortality,[1,2] the social and economic burden of hip fractures is also on the rise.[3,4] Conservative treatment is generally not preferred and is reserved for debilitated patients because of critical complications.[5]

Although advances in anesthesia, surgical techniques, and implant designs have designated surgery as the standard treatment, no exact consensus has been reached as to which treatment is best. Even though the type of surgical treatment may vary, postoperative treatment goals are the same, namely to restore the patient to his or her pre-injured functional state.[6,7]

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

Work conducted at the Ankara Training and Research Hospital, Ankara, Turkey.
Correspondence: Başkent University, Konya Research Center, Department of Orthopaedics and Traumatology, Selçuklu, Konya Turkey. dr_alperozturk@yahoo.com

Article received in 01/27/2017, approved in 08/29/2017.

CC BY NC

The main objectives of this study were 1) to explore functional recovery after trochanteric fracture surgery with regard to treatment technique, and 2) to evaluate predictive factors for early mortality.

METHODS

This prospective observational study included 80 patients 60 years of age or older who were admitted to the hospital for intertrochanteric fractures and underwent surgery between September 2012 and May 2014. The study was performed with the consent of the local ethics committee (2014:4688) and after all patients signed the informed consent form.

Patients with intertrochanteric fractures were divided into two groups: group I (osteosynthesis) was treated with a proximal femoral nail, and group II (arthroplasty) was treated with arthroplasty. Each group included 40 consecutive patients.

Arthroplasty surgeries were performed thorough a postero-lateral incision in lateral decubitus position and cemented femoral stems (Bi-Metric Primary Calcar Replacement, Biomet, South Wales, UK) were implanted. Nailing surgeries were performed on a fracture table in supine position. The same proximal femoral nail (Proximal Femoral Nail Antirotation, Synthes GmbH, Oberdorf, Switzerland)) was used in all patients.

All patients only received surgery after coexisting medical conditions were stabilized and a pre-operative anesthesia consultation was performed. All patients received thromboprophylaxis with low molecular weight heparin and antibiotic prophylaxis with first-generation cephalosporin 30 minutes prior to surgery.

Patients who were treated with a femoral nail were allowed to bear weight after surgery as tolerated, and full weight-bearing was permitted in arthroplasty patients after drain removal. All patients were evaluated 15 days, 1 month, 6 months, and 1 year after surgery.

The following data were recorded for each patient during the hospital stay: age, sex, time to operation, total hospital stay, total blood transfusion during hospital stay, and hemoglobin levels at admittance to the emergency department. Functional outcomes were assessed using the Functional Independence Measure (FIM) for three different times: prior to fracture, six months after surgery, and one year after surgery. This evaluation was performed via a face-to-face interview with the patient; the FIM prior to fracture was determined during the hospital stay. All patients were asked to return to the hospital for the functional evaluation six months and one year after surgery.

Statistics analysis

The statistical analysis was performed using SPSS version 20.0 for Windows (IBM SPSS Inc., NY USA). The baseline characteristics of the patients and clinical outcomes such as age, length of stay, and FIM scores were summarized as means and standard deviations. Categorical variables such as sex were summarized as frequencies and percentages. Each variable was analyzed for normal distribution using the Kolmogrov-Smirnov test and groups were compared using Students t-test and the chi-square test. The correlation between mortality and independent variables was analyzed using Spearman's correlation analysis. P-values less than 0.05 were considered significant.

RESULTS

Of the 80 patients admitted, 42 were females and 38 were males, with a mean age of 80.2 years (60–94). The mean follow-up period was 18 months. No difference was observed between groups with regard to age or sex. (Table 1)

The mean total hospital stay was 12.3 days for group I and 14.65 days for group II (p=0.04). The mean period from fracture to surgery was 5.3 days for group I and 6.1 days for group II (p=0.249). (Table 1) Mean hemoglobin on admittance to hospital was 11.9 mg/dl in group I and 11.6 mg/dl in group II (p=0.314). (Table 1) The mean blood transfusion volume required during the hospital stay was 0.95 units for group I and 1.25 units for group II. (Table 2) Although the patients who were treated with arthroplasty required a slightly greater transfusion volume, the difference was not significant (p=0.325).

At the one-year follow-up, 30 patients had died (37.5%): 14 patients in group I (35%) and 16 in group II (40%). There was no significant difference in one-year mortality between groups (p=0.644). Furthermore, age, blood transfusion during the hospital stay, and FIM had a significant correlation with mortality; patient FIM score had the strongest correlation with mortality. (Table 2)

The mean FIM value prior to fracture was 105.5±20.5 in group I and 104.9±17.3 in group II (p=0.381). Six months after surgery, mean FIM values were 84.7±27.1 and 92.9±20.2 in groups I and II, respectively. Group II had significantly higher FIM at six months (p=0.04). One year after surgery, the mean FIM values were 97.7±28.7 for group I and 93.1±22.8 for group II, and there was no significant difference one year after surgery (p=0.476). (Table 3)

Table 1. Demographic data and laboratory findings.

	Osteosynthesis Group			Arthroplasty Group			p*
Parameter	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	
Sex							
Female	17			25			0.07
Male	23			15			
Age (years)	79	10.1	60-94	81.4	7.2	62-93	0.213
Time to Surgery (days)	5.3	2.5	1-13	6.1	3.3	1-16	0.249
Total Hospital Stay (days)	12.3	4	4-23	14.6	5.9	4-32	0.04
Hemoglobin on Admittance (mg/dl)	11.9	1.3	9.9-15.9	11.6	1.5	7.7-15.6	0.314
Blood Transfusion (units)	0.95	1.4	0-6	1.25	1.2	0-5	0.325

**: t-test.*

Table 2. Patient mortality.

Mortality	**Osteosynthesis**	**Arthroplasty**	**p**	**Total**
6 Months	13 (32.5%)	14 (35%)	0.813*	27 (33.8%)
1 Year	14 (35%)	16 (40%)	0.644*	30 (37.5%)
Mortality Correlation	**Correlation Coefficient****	**p**		
Patient Age	0.226	0.001		
Sex	0.102	0.266		
Time to Surgery	0.023	0.804		
Total Hospital Stay	-0.019	0.835		
Hemoglobin on Admittance	-0.145	0.114		
Transfusion	0.223	0.04		
FIM before fracture	-0.472	0.0001		

**: Chi-square test **: Spearman's Rho.*

Table 3. Functional Independence Measure scores over 1 year.

	Osteosynthesis			Arthroplasty			
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**p***
FIM prior to fracture	105.5	20.5	58-126	104.9	17.3	72-126	0.381
FIM 6 months after surgery	84.7	27.1	44-126	92.9	20.2	60-126	0.04
FIM 1 year after surgery	97.7	28.7	44-126	93.1	22.8	45-126	0.476

**: t-test.*

DISCUSSION

This is the first study to report functional progress in patients with trochanteric fracture with regard to treatment method. The results of this study clearly indicate that serious functional regression is unavoidable in treating patients with trochanteric fractures during the first year.

We used FIM scores to evaluate patient function in this study; the FIM evaluates patients with regard to disability and care burden, and predicts how much assistance is required for patients to carry out daily living activities. The validity of the FIM was evaluated by Young et al.; it was described as a valid indicator for the functional status of patients recovering from hip fracture surgery and is also reported to be feasible for longitudinal studies.[8]

This study demonstrated that arthroplasty provides higher functional independence in early results when compared to osteosynthesis. This finding suggests that osteosynthesis cannot restore serious functional loss in early stages, while arthroplasty can provide a certain level of functional independence over even a short time. As Bonnevialle et al.[9] reported, arthroplasty provides better functional results in six months. Fracture treatment involving osteosynthesis could cause weight-bearing problems that result as functional loss in elderly patients with hip fracture. This functional loss was recovered within one year of surgery, and no functional differences were seen between patients treated with arthroplasty or osteosynthesis. Many reports indicate that the functional outcomes for arthroplasty and osteosynthesis are similar after 1 to 2 years of follow-up, as we concluded in this present study.[10,11] Because this study demonstrated a powerful relation between mortality and the patient's functional status, we believe that arthroplasty could be a good treatment choice for patients with trochanteric fractures and low functional status who would not tolerate serious functional loss in a short time period. However, osteosynthesis treatment is preferable for patients with adequate daily functional status because of its advantages such as preserving the patient's own bone, less invasive surgery, a shorter hospital stay, and lower treatment costs.

Although surgery within the first 24 hours has been reported to reduce rates of non-union, length of hospital stay, mortality, and complications,[12-14] early surgery is not always feasible due to medical comorbidities.[15] In our study, nearly 6 days were needed between fracture and surgery in order to resolve pre-operative challenges related to comorbidities.

In contrast with the study by Shokoohi et al.,[16] we found a relationship between transfusion and mortality in this study. One-year mortality for hip fractures has been reported to be around 12% and 37%.[17,18] In this study, the one-year mortality rate was 37%, and no difference was observed regarding surgical technique. Although all the arthroplasties involved the cemented technique, no significant difference in mortality was detected between arthroplasty and osteosynthesis. The predictors for one-year mortality in this study were patient age, transfusion, and functional score. Therefore, the patient's functional situation prior to hip fracture may guide the surgeon when selecting the treatment for trochanteric fractures in older adults.

CONCLUSION

This current study demonstrated that the strongest predictor of mortality in patients with trochanteric fracture are age, transfusion volume, and functional score. Functional loss is unavoidable in patients regardless of treatment choice, but arthroplasty provides better functional results than osteosynthesis in early outcomes. This should be considered particularly in elderly patients with trochanteric fractures and low function who would not tolerate serious functional loss.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AÖ (0000-0003-2986-4083)*: drafting the article and revision. Sİ (0000-0002-1027-7885)* and ED (0000-0001-5605-7514)* performed the surgeries; KBA (0000-0002-5922-9921)*: data analysis, drafting the articles and also the entire intellectual concept of the article; AhÖ (0000-0001-5398-446X)*: statistical analysis, surgeries, and review of the article; BG (0000-0003-0758-5382)* data collection and analysis and surgeries. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Wolinsky FD, Fitzgerald JF, Stump TE. The effect of hip fracture on mortality, hospitalization, and functional status: a prospective study. Am J Public Health. 1997;87(3):398-403.
2. Bentler SE, Liu L, Obrizan M, Cook EA, Wright KB, Geweke JF, et al. The aftermath of hip fracture: discharge placement, functional status change, and mortality. Am J Epidemiol. 2009;170(10):1290-9.
3. LaVelle DG, Canale ST. Fractures of hip. In: Canale ST. Campbell's operative orthopaedics. 10th. Philadelphia; Mosby Press; 2003. p. 2873.
4. Huddleston JM, Whitford KJ. Medical care of elderly patients with hip fractures. Mayo Clin Proc. 2001;76(3):295-8.
5. Handoll HH, Parker MJ. Conservative versus operative treatment for hip fractures in adults. Cochrane Database Syst Rev. 2008;(3):CD000337.
6. Huusko TM, Karppi P, Avikainen V, Kautiainen H, Sulkava R. Randomised, clinically controlled trial of intensive geriatric rehabilitation in patients with hip fracture: subgroup analysis of patients with dementia. BMJ. 2000;321(7269):1107-11.
7. Aguiar FJ, Nemer DS, Leme LEG. Estado nutricional e evolução de cirurgias ortopédicas de urgência em idosos. Acta Ortop Bras. 2011;19(5):293–8.
8. Young Y, Fan MY, Hebel JR, Boult C. Concurrent validity of administering the functional independence measure (FIM) instrument by interview. Am J Phys Med Rehabil. 2009;88(9):766-70.
9. Bonnevialle P, Saragaglia D, Ehlinger M, Tonetti J, Maisse N, Adam P, et al. Trochanteric locking nail versus arthroplasty in unstable intertrochanteric fracture in patients aged over 75 years. Orthop Traumatol Surg Res. 2011;97(Suppl 6):S95-100.
10. Stappaerts KH, Deldycke J, Broos PL, Staes FF, Rommens PM, Claes P. Treatment of unstable peritrochanteric fractures in elderly patients with a compression hip screw or with the Vandeputte (VDP) endoprosthesis: a prospective randomized study. J Orthop Trauma. 1995;9(4):292-7.
11. Lu XD, Wang B, Xu W, Zhang Q, Han D, Zhao YT. Comparison of calcarreplacement arthro plasty and Intertan nail in treatment of intertrochanteric fracture in the aged]. Zhonghua Yi Xue Za Zhi. 2016;96(31):2466-71.
12. Koval KJ, Skovron ML, Aharonoff GB, Zuckerman JD. Predictors of functional recovery after hip fracture in the elderly. Clin Orthop Relat Res. 1998;(348):22-8.
13. Bottle A, Aylin P. Mortality associated with delay in operation after hip fracture: observational study. BMJ. 2006;332(7547):947-51.
14. Ryan DJ, Yoshihara H, Yoneoka D, Egol KA, Zuckerman JD. Delay in hip fracture surgery: an analysis of patient-specific and hospital-specific risk factors. J Orthop Trauma. 2015;29(8):343-8.
15. Makridis KG, Karachalios T, Kontogeorgakos VA, Badras LS, Malizos KN. The effect of osteoporotic treatment on the functional outcome, re-fracture rate, quality of life and mortality in patients with hip fractures: a prospective functional and clinical outcome study on 520 patients. Injury. 2015;46(2):378-83.
16. Shokoohi A, Stanworth S, Mistry D, Lamb S, Staves J, Murphy MF. The risks of red cell transfusion for hip fracture surgery in the elderly. Vox Sang. 2012;103(3):223-30.
17. Panula J, Pihlajamäki H, Mattila VM, Jaatinen P, Vahlberg T, Aarnio P, et al. Mortality and cause of death in hip fracture patients aged 65 or older: a population-based study. BMC Musculoskelet Disord. 2011;12:105.
18. Richmond J, Aharonoff GB, Zuckerman JD, Koval KJ. Mortality risk after hip fracture. J Orthop Trauma. 2003;17(1):53-6.

DOI: http://dx.doi.org/10.1590/1413-785220182601175203

TWO CLASSIFICATIONS FOR SURGICAL WOUND HEMATOMA AFTER TOTAL HIP REPLACEMENT

DUAS CLASSIFICAÇÕES PARA HEMATOMA DE FERIDA OPERATÓRIA APÓS ARTROPLASTIA TOTAL DO QUADRIL

Lorenzo Fagotti[1], Leandro Ejnisman[1], Henrique de Melo Campos Gurgel[1], Helder de Souza Miyahara[1], Alberto Tesconi Croci[1], Jose Ricardo Negreiros Vicente[1]

1. Hip Group, Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: To determine the reliability of two classification methods for wound hematoma after total hip replacement. Methods: This prospective cohort study was conducted on patients who underwent total hip replacement for hip osteoarthritis between May 2014 and April 2015. Epidemiological, surgical, and functional data were assessed. Two experienced hip surgeons evaluated 75 pictures of wounds taken 24 hours after surgery. Both evaluators performed the analysis twice, with a 6-week interval between the two analyses. The subjective classification was divided into four different categories describing the hematoma: absent, mild, moderate, and severe. The objective classification was derived from mathematical calculation of the area of the hematoma using a grid superimposed on a picture of the wound. Results: The subjective classification demonstrated an intra-rater agreement of more than 70%, while kappa values showed poor to moderate inter-rater reliability. The objective classification based on mathematical measurements of the hematoma area was more reliable, with good to excellent intra- and inter-rater reliability. Conclusion: The objective classification demonstrated higher intra- and inter-rater reliability. The classification methods used in this study could serve as a useful instrument for orthopedic surgeons, researchers, and health care providers when assessing wound hematomas after total hip replacement. ***Level of Evidence II; Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard).***

Keywords: Hip injuries. Arthroplasty, replacement, hip. Arthroplasty, replacement, hip. Hematoma. Postoperative complications. Wound infection. Reliability of results.

RESUMO

Objetivo: Determinar a confiabilidade de dois métodos de classificação dos hematomas de ferida cirúrgica após artroplastia total do quadril. Métodos: Este estudo prospectivo de coorte foi conduzido em pacientes com osteoartrose do quadril submetidos à artroplastia total do quadril entre maio de 2014 e abril de 2015. Foram analisados dados epidemiológicos, cirúrgicos e funcionais. Dois experientes cirurgiões de quadril avaliaram 75 fotografias de feridas obtidas 24 horas após a cirurgia. Ambos os avaliadores analisaram as fotografias duas vezes, em intervalo de seis semanas. A classificação subjetiva consistiu em quatro categorias descrevendo o hematoma: ausente, leve, moderado e grave. A classificação objetiva foi obtida pelo cálculo matemático da área do hematoma, sobrepondo-se uma retícula a cada fotografia de ferida. Resultados: A classificação subjetiva mostrou concordância intra-avaliador de mais de 70%, enquanto que os valores de kappa mostraram concordância inter-avaliador baixa a moderada. A classificação objetiva baseada em cálculo matemático da área do hematoma foi mais confiável, com excelente concordância intra e inter- avaliador. Conclusão: A classificação objetiva demonstrou melhor concordância intra e inter-avaliador. Os métodos de classificação usados neste estudo podem ser um instrumento útil para cirurgiões ortopedistas, pesquisadores e profissionais de saúde para avaliar hematomas de feridas cirúrgicas após artroplastia total de quadril. ***Nível de Evidência II; Desenvolvimento de critérios diagnósticos em pacientes consecutivos (com padrão de referência "ouro" aplicado).***

Descritores: *Lesões do quadril. Artroplastia de quadril. Hematoma. Complicações pós-operatórias. Infecção dos ferimentos. Confiabilidade dos Resultados.*

Citation: Fagotti L, Ejnisman L, Gurgel HMC, Miyahara HS, Croci AT, Vicente JRN. Two classifications for surgical wound hematoma after total hip replacement. Acta Ortop Bras. [online]. 2018;26(1):11-5. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Several factors are associated with hematoma formation after total hip replacement (THR). The administration of fresh-frozen plasma, vitamin K, perioperative anticoagulation, or hormonal therapy are independent predictors for hematoma formation.[1] The length of the incision and the skin blood flow are surgical parameters that could possibly influence the severity of soft tissue damage.[2,3] Most hematomas are small and do not cause additional complications. However, this postoperative complication increases the risk of surgical site infection,[4,5] which may require intravenous treatment with antibiotics and a prolonged hospital stay. Mortazavi et al.[1] found that 0.41% of the hematomas after THR required reoperation.

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

Work conducted at the Hip Group, Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, SP, Brazil.
Correspondence: Rua Dr. Ovídio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05403-010. lorenzo_fagotti@hotmail.com

Article received in 02/01/2017, approved in 06/30/2017.

CC BY NC

A clinically evident hematoma can be described as a condition presenting edema, ecchymosis, and serosanguinous wound drainage.[6] The causes of the hematoma should be investigated. Possible etiologies include the following: postoperative trauma, anticoagulation drug complications, or irritation of the iliopsoas tendon.[7-9] In more severe cases, hematomas can lead to vascular and neurological injuries.[10,11] Readmissions for hematoma surgical treatment negatively impact referral hospitals, increasing health care costs and patient morbidity.[12-14]

Given that hematomas can lead to serious postoperative complications and considering its important role in patient recovery, it is crucial to have a classification system to define the severity and extent of postoperative hematomas following THR. The correct identification of a hematoma could provide an outline for proper therapeutic measures and serve as an instrument for optimizing communication between surgeons and health care providers. The goal of the current study was to compare two methods of hematoma classification (subjective and objective) after THR.

METHODS

This study was approved by the local Institutional Review Board under the protocol number CEP 1055. Between May 2014 and April 2015, 81 patients who had THR were included in this prospective cohort study. Informed consent was obtained from all patients. Patients were included if they presented primary or secondary hip osteoarthritis and had failed conservative treatment. Patients with anticoagulant disorders, previous orthopedic surgeries in the ipsilateral limb, and patients in whom a surgical incision greater than 20 cm was performed were excluded from this study. Epidemiological data collected included the following: body mass index (BMI), comorbidities such cardiovascular diseases (CVD) and diabetes mellitus (DM), preoperative etiology of hip osteoarthritis, and smoking. (Table 1)

Surgery was performed through a direct lateral Hardinge approach.[15] A non-cemented porous titanium alloy coated with hydroxyapatite THR (MBA Targos, Groupe Lépine, Genay, France) was used. The same protocol for wound closure and dressing was followed in all cases. Closed suction drainage was used based on a subjective evaluation of bleeding at the end of the procedure. Additionally, the length of the surgical incision was recorded. Chemical prophylaxis for deep vein thrombosis consisted of Enoxaparin (40 mg) administered 12 hours after the procedure and continued for four weeks. The intraoperative bleeding control was achieved with biterminal electrocoagulation or manual compression. No additional drugs for bleeding control (epinephrine or tranexamic acid) were used. One day after the surgery, all patients were encouraged to perform assisted passive mobilization of the lower limb as a mechanical anti-thrombotic prophylaxis. The dressings were not changed before the hematoma evaluation.

Table 1. Baseline characteristics.

Parameter	Participants (n = 75)
Mean age (SD)	56.2 years (13.28 years)
Gender	31 Males; 44 Females
Mean BMI (SD)	27.54 Kg/m^2 (4.87 Kg/m^2)
Primary diagnosis	5 RA; 22 ON; 48 OA
Incision length (SD)	16.3 cm (2.02 cm)
Comorbidities	17 AH; 8 DM
Smoking	18
Alcohol abuse	10

RA, rheumatoid arthritis; ON, osteonecrosis of the femoral head; OA, osteoarthritis; AH, arterial hypertension; DM, diabetes mellitus; SD, standard deviation.

One of the authors (LF), assisted by a nurse, inspected and took standardized pictures of 81 surgical wounds at 24 hours postoperatively in the Intensive Care Unit or infirmary beds. After dressing removal, the patients were positioned in lateral decubitus to allow full visualization of the thigh. Pictures were taken with the same digital camera (iPhone 4S™, 8-megapixel, Apple Inc., Cupertino, USA) one meter away from the patient, centered on the surgical incision, and with similar settings (zoom, brightness and luminosity). All pictures were rated according to an objective and a subjective classification by an evaluator. To obtain an objective classification, the Adobe Photoshop CC 2015 software (Adobe Systems Inc., San Jose, USA) was used to draw a grid of 1 cm^2 squares superimposed on the pictures. The grid was green in color to differentiate from the color of the skin or the hematoma (Figure 1A-B). This grid was then used to estimate the total area of the hematoma post-surgery. According to the rater, a 1 cm^2 square was included in the calculation of total hematoma area when the hematoma filled 50% or more of the grid square. Squares that met inclusion criteria were then summed together to obtain total estimated area of the hematoma. To obtain the real area of the hematoma (HA Real), the real length of the surgical incision was used as a proportional factor to relate the area of the pictured hematoma to the area of the real hematoma. Calculations of HA Real and HA Printed were as follows:

$$HA\ Real = HA\ Picture \times (IL\ Real \div IL\ Picture)^2$$

- *HA Real* = Hematoma area in cm^2
- *HA Printed* = Hematoma area in the picture, which is the sum of all of the inclusion squares of 1 cm^2.
- *IL Real* = real surgical incision length
- *IL Printed* = surgical incision length measured in the printed picture from the workbook

The following example shows how the formula was used for the calculation of the real hematoma area. Data were collected

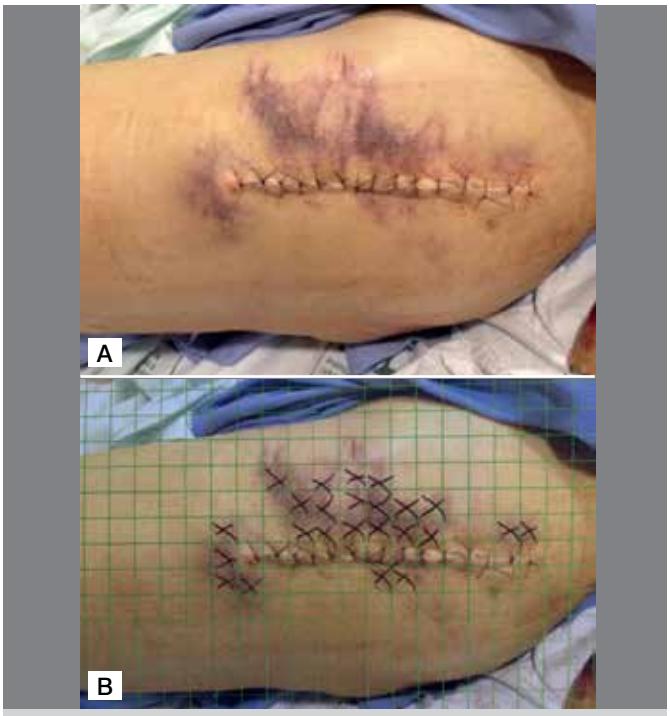


Figure 1. A) Wound hematoma 24 hours after THR. B) A 1 cm^2 grid was superimposed on each picture for the objective classification of the hematoma.

from a patient who presented a moderate hematoma 24 hours after the procedure. (Figure 1A) The real surgical incision length (IL Real) was 17 cm. In the printed version, under a 1 cm^2 grid, the incision length was 8 cm. In this case, Rater 2 marked 24 inclusion squares. (Figure 1B)

$$HA\ Real = HA\ Picture \times (IL\ Real \div IL\ Picture)^2$$
$$HA\ Real = 24 \times (17 \div 8)^2$$
$$HA\ Real = 108.38 cm^2$$

The subjective classification was based on an analysis of the pictures considering the intensity and extent of the hematoma. A PowerPoint presentation (Microsoft® PowerPoint 2011, Redmond, USA) was created, where all of the wound pictures were placed in sequential order. Raters were asked to estimate the hematoma in each picture according to the following descriptions: absent, mild, moderate, and severe.

Two authors (LE and HG), experienced hip surgeons, rated all pictures according to both classification methods. Evaluation of both classifications was performed separately. The order of the pictures was randomized between the PowerPoint presentation used for the subjective evaluation and the printed workbook used for the objective evaluation. After six weeks, raters again evaluated all pictures according to both methods. The raters were told to avoid returning to previous pictures once they started with measurements, and they were recommended to avoid interruptions. The mean period of time each rater took to complete each classification was also recorded.

Finally, all values obtained from the first hematoma evaluation performed by the first rater were used to correlate both the objective and subjective classifications.

Statistical analysis

SPSS software version 20.0 (SPSS, Chicago, USA) was used for the analyses. Categorical data were expressed as absolute numbers, continuous variables with normal distributions were expressed as the mean ± standard deviation (SD). A Chi-squared test or Fisher's exact test were used to compare distributions. We considered $P<0.05$ to be statistically significant. A regression model was developed using the STATA version 14.2 (StataCorp, College Station, USA) software for correlating both the objective and subjective classifications. The minimal and maximal values are reported as range, and the confidence interval (CI) value used was 95%.

RESULTS

Out of the 81 pictures analyzed, 6 were excluded due to inadequate picture quality. A total of 75 patients were then evaluated, comprising 31 males (41.3%) and 44 females (58.7%) with a mean age of 56.2 years. The baseline characteristics of these patients are shown in Table 1.

In the objective classification, for the first measurement, Rater 1 found an area of hematoma ranging from 0 to 729 cm^2 (mean = 177.8, median = 130.4), and Rater 2, an area ranging from 0 to 892 cm^2 (mean = 152, median = 107). After six weeks, the values ranged from 0 to 833 cm^2 (mean = 245.3, median = 130.4) and 0 to 879 cm^2 (mean = 171.3, median = 102.8) for Rater 1 and Rater 2, respectively, as shown in Table 2. Rater 1 took 70 and 75 minutes for the first and second measurement phases, respectively, and Rater 2 took 65 and 50 minutes, respectively ($P>0.05$). The interclass correlation coefficient (ICC) revealed high intra-rater consistency. For Rater 1, the value of ICC was 0.89. The value of ICC for Rater 2 was 0.87. The inter-rater reliability ranged between 0.79 for the first measurement and 0.78 for the second measurement.

The intra-rater reliability in the subjective classification (Table 3) showed moderate agreement for both the first and second raters (kappa value of 0.69, $P<0.001$, and 0.56, $P<0.001$, respectively). Additionally, 80% and 72% of the grades were consistent between Rater 1 and 2, respectively. In the first measurement, the inter-rater reliability was low (kappa = 0.44, $P<0.001$). Here, the raters agreed on 65% of the cases. In the second evaluation, the raters agreed on 73% of their grades, and the inter-rater reliability was higher (kappa = 0.60, $P<0.001$). With respect to the first and the second measurement, the first rater took 13 and 25 minutes, respectively, and the second rater took 20 and 30 minutes, respectively ($P>0.05$). All values obtained from the first measurement of Rater 1 for both the objective and the subjective classifications were compared and are shown in Table 4 and Figure 2. A mild, moderate and severe hematoma were associated with a hematoma area of 107.6 cm^2 ($P=0.032$), 256.8 cm^2 ($P<0.001$) and 558.5 cm^2 ($P<0.001$), respectively.

Table 2. The Intra- and Inter-Rater Reliability for the objective classification.

First Evaluation	Rater 1 (cm^2)	Rater 2 (cm^2)	Inter-rater reliability ICC [95% CI]
Mean	177.8 ± 185.8	152 ± 169	0.79 [0.69 – 0.86]
95% CI	135.1 – 220.5	113.2 – 190.9	
Median	130.4	107.7	
Second Evaluation	**Rater 1 (cm^2)***	**Rater 2 (cm^2)***	**Inter-rater reliability ICC [95% CI]**
Mean	245.3 ± 212.86	171.3 ± 191.1	0.78 [0.67 – 0.85]
CI 95%	196.4 – 294.3	127.3 – 215.3	
Median	203.2	102.8	
Intra-rater reliability ICC [95% CI]	0.89 [0.83 – 0.93]	0.87 [0.8 – 0.92]	

* Time between the first and second measurements was six weeks.

Table 3. The Intra- and Inter-Rater Reliability for the subjective classification.

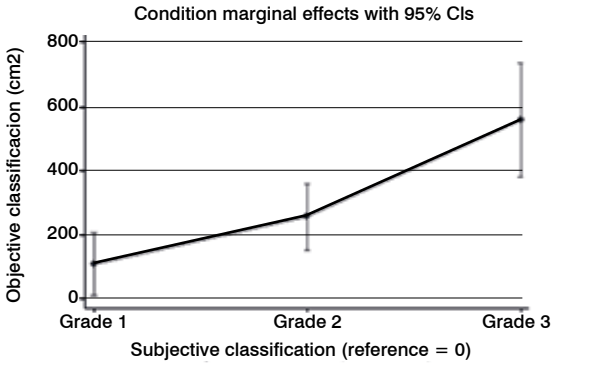
	Intra-Rater Reliability Rater 1 N (highest % of agreement)	Intra-Rater Reliability Rater 2 N (highest % of agreement)	Inter-Rater Reliability N, first measurement (highest % of agreement)	Inter-Rater Reliability N, second measurement (highest % of agreement)
Absent	9 (100)	2 (50)	3 (75)*	4 (57.1)*
Mild	28 (90.3)	27 (75; 75)	25 (69.4)	25 (80.6)
Moderate	20 (80)	20 (83.3)	18 (72)	21 (87.5)
Severe	3 (100)	5 (100)	3 (100)	5 (100)
Kappa	0.69 (P<0.001)	0.56 (P<0.001)	0.44 (P<0.001)	0.6 (P<0.001)
Total % of agreement	80	72	65	73

* Time between the first and second measurements was six weeks.

Table 4. Correlation between objective and subjective classifications.

Subjective	Objective (cm^2)	P value	95% Confidence Interval
Mild Hematoma	107.6	0.032	9.61 - 205.54
Moderate Hematoma	256.8 cm^2	< 0.001	154.07 - 359.52
Severe Hematoma	558.5	< 0.001	382.29 - 734.64

Data obtained from Rater 1, first hematoma measurement.



Grade 1 = Mild Hematoma; Grade 2 = Moderate Hematoma; Grade 3 = Severe Hematoma

Figure 2. Correlation between the subjective and the objective classifications.

DISCUSSION

The current study evaluated the reliability of two different classification methods for wound hematoma measurement in patients undergoing THR. The most important finding of this study was that good to excelent intra- and inter-rater agreement was found for the objective classification. To our knowledge, after a thorough review of the literature, this is the first study to propose a classification system on this topic. These classifications were designed to help orthopedic surgeons and health care providers standardize the evaluation of the intensity and extent of hematomas, especially with regards to scientific research.

Hematomas after THR can reach a substantial size, possibly due to injuries of the musculature during surgery. Damage to the gluteus medius tendon is a known complication of the lateral transgluteal approach. Additional muscle and ligament injuries can also occur depending on type of approach and technique, even those that are minimally invasive.[16]

Hematomas following joint replacement can be a predictive risk factor for wound infection.[4,17] Wound complications may increase patients' length of hospital stay and morbidity.[4,18] A high rate of hospital readmission following primary THR initially led to the creation of institutional programs based on preventive and educational measures,[19]. Hematomas account for 10% of the causes for readmission after THR.[12] Therefore, hematoma formation following THR can potentially lead to a significant economic burden.[19,20]

A classification system for post-THR hematomas is needed and It could be used as a tool for other studies on hip surgery. We expect to facilitate the measurement and interpretation of hematomas in clinical practice and bring awareness to this topic, helping orthopedic surgeons and health care providers to better handle postoperative complications.

In the current study, a high rate of hematomas was found, which was possibly because the study site was a university hospital where residents perform surgeries under supervision. This might lead to longer surgeries, thereby increasing hematoma formation. The same approach, direct lateral, was performed in all cases. This approach may be related to greater damage to the soft tissue, and therefore, a higher rate of hematoma formation might occur.

The objective classification presented better intra- and inter-rater reliability and could be used as a tool for postoperative hematoma measurement. Previous studies described hematoma formation as a complication after THR; however, none of these studies described a method for the accurate clinical evaluation of the hematoma's extent.[1,3,5-9] In our opinion, the method described in the current study is a reliable and easy method to measure the size of a hematoma, which can be particularly useful in research. Future studies should investigate if the proposed classification presents a correlation with complication rates or clinical parameters such as post-operative pain.

The subjective classification presents some advantages. It is faster, easier for the evaluator, and does not require the use of a computer program to add a grid to the picture. However, as it presented a lower kappa value, we believe the objective evaluation is more suitable for research. Nevertheless, the subjective evaluation can be used in day-to-day clinical settings because of its simplicity. When this classification was correlated with the objective one, a statistically significant relation was found. These findings might facilitate communication between surgeons and other healthcare providers, as well as draw attention to the need for a better understanding of the role of hematoma after joint replacement.

A professional camera could be used to obtain clearer pictures. However, a cellular phone camera was chosen because of its availability and easier reproducibility of the methods. Both of the reviewers were experienced hip surgeons, which could have led to higher inter-rater reliability. Future research can investigate if less experienced surgeons or other health professionals present the same scores. The pictures for the wound evaluation were taken 24 hours after the surgery. Since hematomas present a quick evolution, this early assessment could have underestimated its true size. The ideal moment for this evaluation remains to be determined.

CONCLUSIONS

This study proposes two classifications (subjective and objective) for the measurement of postoperative hematomas after THR. The objective classification demonstrated higher intra- and inter-rater reliability.

ACKNOWLEDGMENTS

We thank Fernando Rosas Brito for technical support, Marcos Antonio Almeida Santos for assistance with statistical analysis and Zachary Aman for editing contributions.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. LF (0000-0001-9008-9480)*: project design and drafting the article; LE (0000-0002-9866-1960)*: surgeries and drafting the article; HSM(0000-0002-2532-2685)*: surgeries and review of the article; HMCG (0000-0002-2005-0553)*: writing and review of the article and intellectual concept of the article; ATC (0000-0003-3047-2757)*: contributed to the intellectual concept of the study; JRNV (0000-0003-3528-9249)*: review and approval of the final version of the article, surgeries, and follow-up with operated patients. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Mortazavi SM, Hansen P, Zmistowski B, Kane PW, Restrepo C, Parvizi J. Hematoma following primary total hip arthroplasty: a grave complication. J Arthroplasty. 2013;28(3):498-503.
2. Woolson ST, Mow CS, Syquia JF, Lannin JV, Schurman DJ. Comparison of primary total hip replacements performed with a standard incision or a mini incision. J Bone Joint Surg Am. 2004;86(7):1353-8.
3. Kiyama T, Naito M, Shitama H, Shinoda T, Maeyama A. Comparison of skin blood flow between mini- and standard-incision approaches during total hip arthroplasty. J Arthroplasty. 2008;23(7):1045-9.
4. Saleh K, Olson M, Resig S, Bershadsky B, Kuskowski M, Gioe T, et al. Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program. J Orthop Res. 2002;20(3):506-15.
5. Cordero-Ampuero J, de Dios M. What are the risk factors for infection in hemiarthroplasties and total hip arthroplasties? Clin Orthop Relat Res. 2010;468(12):3268-77.
6. Neviaser AS, Chang C, Lyman S, Della Valle AG, Haas SB. High incidence of complications from enoxaparin treatment after arthroplasty. Clin Orthop Relat Res. 2010;468(1):115-9.
7. Pouliot MA, Lee KB, Goodman SB. Retroperitoneal hematoma: an unusual cause of pain after total hip arthroplasty. J Arthroplasty. 2009;24(7):1144.e9-12.
8. Bartelt RB, Sierra RJ. Recurrent hematomas within the iliopsoas muscle caused by impingement after total hip arthroplasty. J Arthroplasty. 2011;26(4):665.e1-5.
9. Hannon MG, Lamont JG. Compartment syndrome due to massive leg hematoma after primary total hip arthroplasty: a previously unreported complication of fondaparinux. J Arthroplasty. 2012;27(7):1414.e9-1414.e11.
10. Butt AJ, McCarthy T, Kelly IP, Glynn T, McCoy G. Sciatic nerve palsy secondary to postoperative haematoma in primary total hip replacement. J Bone Joint Surg Br. 2005;87(11):1465-7.
11. Khattar NK, Parry PV, Agarwal N, George HK, Kretz ES, Larkin TM, et al. Total hip arthroplasty complicated by a gluteal hematoma resulting in acute foot drop. Orthopedics. 2016;39(2):e374-6.
12. Schairer WW, Sing DC, Vail TP, Bozic KJ. Causes and frequency of unplanned hospital readmission after total hip arthroplasty. Clin Orthop Relat Res. 2014;472(2):464-70.
13. Clement RC, Derman PB, Graham DS, Speck RM, Flynn DN, Levin LS, et al. Risk factors, causes, and the economic implications of unplanned readmissions following total hip arthroplasty. J Arthroplasty. 2013;28(8 Suppl):7-10.
14. Cullen C, Johnson DS, Cook G. Re-admission rates within 28 days of total hip replacement. Ann R Coll Surg Engl. 2006;88(5):475-8.
15. Hardinge K. The direct lateral approach to the hip. J Bone Joint Surg Br.1982;64(1):17-9.
16. van Oldenrijk J, Hoogland PV, Tuijthof GJ, Corveleijn R, Noordenbos TW, Schafroth MU. Soft tissue damage after minimally invasive THA. Acta Orthop. 2010;81(6):696-702.
17. Cheung EV, Sperling JW, Cofield RH. Infection associated with hematoma formation after shoulder arthroplasty. Clin Orthop Relat Res. 2008;466(6):1363-7.
18. Patel VP, Walsh M, Sehgal B, Preston C, DeWal H, Di Cesare PE. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. J Bone Joint Surg Am. 2007;89(1):33-8.
19. Jordan CJ, Goldstein RY, Michels RF, Hutzler L, Slover JD, Bosco JA 3rd. Comprehensive program reduces hospital readmission rates after total joint arthroplasty. Am J Orthop (Belle Mead NJ). 2012;41(11):E147-51.
20. Merollini KM, Crawford RW, Whitehouse SL, Graves N. Surgical site infection prevention following total hip arthroplasty in Australia: a cost-effectiveness analysis. Am J Infect Control. 2013;41(9):803-9.

DOI: http://dx.doi.org/10.1590/1413-785220182601182145

ORIGINAL ARTICLE

AGREEMENT IN DIAGNOSIS OF KNEE INJURIES BY ORTHOPEDISTS WITH CLINICAL EXPERIENCE IN KNEE TREATMENT

CONCORDÂNCIA EM DIAGNÓSTICO DE LESÃO DE JOELHO POR MÉDICOS ORTOPEDISTAS ESPECIALISTAS EM JOELHO

Thiago Rocha Protta[1], Lara Guercio dos Santos[1], Alexandre Kusabara[1], Diego Philip[2], Jonas Grispun[1], Marcelo Schimitd Navarro[1]

1. Department of Orthopedics and Traumatology, Faculdade de Medicina do ABC, Santo André, SP, Brazil.
2. Hospital Estadual Mario Covas, Santo André, SP, Brazil.

ABSTRACT

Objective: To analyze the level of agreement in diagnosing knee injury among orthopedists with clinical experience in knee treatment. Method: An online questionnaire was used to analyze the ability of orthopedic knee surgeons to diagnose intra-articular knee injuries using MRI, the importance given to this test in their clinical practice, and the agreement between these diagnoses and the radiology report. Results: The study participants considered MRI an important tool for clarifying inconclusive diagnoses and surgical planning. The level of agreement between the surgeons and the radiologist was considered to be very slight for posterior cruciate ligament injuries, collateral ligament injuries, and chondral injuries, and was considered slight for anterior cruciate ligament and meniscus injuries. Conclusion: A diagnosis of intra-articular knee injury must be based on the patient history, physical examination, and radiological imaging (MRI) in order to provide a complete approach to the patient. ***Level of Evidence III; Clinical study.***

Keywords: Orthopedics. Magnetic resonance spectroscopy. Knee..

RESUMO

Objetivo: Analisar o nível de concordância em diagnóstico de lesão de joelho entre médicos ortopedistas com experiência clínica em tratamento do joelho. Método: Um questionário on-line foi usado para analisar a capacidade de o ortopedista cirurgião de joelho diagnosticar lesões intra-articulares de joelho por meio da RM, assim como a importância dada a esse exame em sua prática clínica e a concordância entre os diagnósticos e o laudo do radiologista. Resultados: Os participantes do estudo consideraram a RM um instrumento importante para esclarecer diagnósticos inconclusivos e para planejamento cirúrgico. O nível de concordância entre os cirurgiões de joelho e o radiologista foi considerado muito leve para ligamento cruzado posterior, ligamentos colaterais e lesões condrais e foi considerado leve para as lesões do ligamento cruzado anterior e do menisco. Conclusão: O diagnóstico de lesão intra-articular de joelho deve ser baseado na anamnese, no exame físico e nos exames radiológicos (RM), objetivando a abordagem completa do paciente. ***Nível de Evidência III; Estudo clínico.***

Descritores: *Ortopedia. Espectroscopia de ressonância magnética. Joelho.*

Citation: Protta TR, Santos LG, Kusabara A, Philip D, Grispun J, Navarro MS. Agreement in diagnosis of knee injuries by orthopedists with clinical experience in knee treatment. Acta Ortop Bras. [online]. 2018;26(1):16-8. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Magnetic resonance imaging (MRI) is considered the best test for imaging-based investigation of the knee joint. This is because this technique represents a noninvasive yet accurate option for the evaluation of knee joint pathologies. The diagnosis of knee injuries is directly linked to the clinical history of the patient and careful physical examination.[1,2] MRI is usually a type of complementary accurate examination in the assessment of the knee; however, it is costly.[3,4] MRI is the physical property displayed by the nuclei of certain elements which, when subjected to a strong magnetic field and excited by radio waves at a given frequency, transmit a radio signal that can be captured by an antenna and transformed into an image.[5,6] MRI has greater applicability in the knee than in other joints and provides an excellent diagnosis. It is able to assess lesions of various types, such as ligaments, menisci, tendineae, bone, and chondral lesions. However, there has been no evidence demonstrating that MRI can reduce the number of negative arthroscopies.[7]

In orthopedics, MRI is one of the main imaging examinations of choice for evaluation of meniscal and knee ligament lesions.[6,8] The improvement of the imaging technique has assisted orthopedists in closing the diagnosis and taking action in their cases. MRI must be used in accordance with the physical examination and clinical history of the patient.[9-11]

In the orthopedic residence, each service offers a varied range of emphases and guidance regarding the evaluation and importance of magnetic resonance imaging in daily clinical practice.[12-14] Magnetic resonance imaging is the gold standard for the diagnosis of knee lesions. The objective of this study is to analyze the level of agreement in knee lesion diagnoses by orthopedic doctors with clinical experience on knee treatment.

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

Work conducted at the Hospital Estadual Mario Covas. Rua Dr. Henrique Calderazzo, 321, Paraíso, Santo André, SP, Brazil.
Correspondence: Lara Guercio dos Santos. Rua Guaimbé 207, Mooca, São Paulo, SP, Brazil. laragdossantos@hotmail.com

Article received in 07/02/2017, approved in 09/05/2017.

CC BY NC

METHOD

This is a methodological study.

Twenty orthopedic surgeons will fill out an online questionnaire comprised of multiple choice questions related to the influences of magnetic resonance imaging (MRI) in clinical practice. Ten cases of the most prevalent diseases among the knee pathologies will be shown so that these expert knee surgeons can make their own interpretation of the MRI. The images will be selected by one of the authors, a member of the Brazilian Society of Radiology specializing in the musculoskeletal area, who will report the MRI scans and along with the authors draw up multiple choice questions regarding the diagnosis of these images. The answers will examine the ability of the knee orthopedic surgeons in diagnosing the diseases by means of MRI of the knee. They will also evaluate the importance given to the exam in their practice clinic and the agreement of these results with the radiologist reports.

Patients who are willing to give their images for this work will be informed on the goals and methods and sign an informed consent form, granting researchers the use of their examination results.

The names of the orthopedic doctors who responded to the questionnaires were not disclosed, nor were the answers to these questionnaires, which were not exposed to anyone. With the objective of reducing institutional bias, we counted on the participation of orthopedic doctors with specializations from at least five different institutions.

This study was approved by the medical ethics committee of the institution of the Department of Health of Santo André Municipality number 1.744.861.

To describe the responses of doctors and radiologists as well as the profile of the individuals studied, we used absolute and relative frequency. To analyze the agreement in the diagnosis of knee lesions among orthopedists and radiologists, we used the κ agreement coefficient (Table 1). The significance level was set at 5%. We used the software Stata 11.0.

RESULTS

The sample consisted of 20 orthopedists, all with medical residency in the specialty of knee surgery. From these, 18 (90%) received the title of specialist from the Brazilian Society for Knee Surgery, whereas 8 (40%) became affiliated over a period of 0 to 5 years.

Among the orthopedists interviewed, 16 (80%) judged their level of understanding on the analysis of MR images as good/very good, whereas for 55%, the radiologist's report was considered as important/very important.

The majority (60%) of the sample considered the MRI to be an important test to complement inconclusive clinical diagnoses, and 65% believed this to be an important test for surgical planning.

In the sample, 10 doctors (50%) think of the MRI as an examination of average importance in clinical treatment of patients, and 11 (55%) would change their diagnoses because of MRI results.

Of the orthopedic doctors, 14 (70%) would disagree with the report of the radiologist on the MRI.

In the sample, 11 doctors (55%) consider the physical examination more important than the MRI, while 9 (45%) would submit their patient to the surgical procedure without the MRI examination.

Table 1. Kappa agreement coefficient.

Kappa coefficient	
k< 0.00	inadequate agreement
0.00 < k ≤ 0.20	very slight agreement
0.21 < k ≤ 0.40	slight agreement
0.41 < k ≤ 0.60	moderate agreement
0.61 < k ≤ 0.80	substantial agreement
0.81 < k ≤ 1.00	almost perfect agreement

We performed the analysis of agreement on the diagnosis of knee lesions among participating orthopedists and radiologists, observing the κ index (Table 1). We evaluated lesions in the following structures: anterior cruciate ligament, posterior cruciate ligament, meniscus, collateral ligaments, chondral lesions on the medial femoral condyle, chondral lesions on the lateral femoral condyle, and chondral lesions on the trochlea and patella. (Table 2)

The levels of agreement were statistically relevant items for the anterior cruciate ligament, posterior cruciate ligament, meniscus, collateral ligaments and chondral lesion in the medial femoral condyle ($P < .05$).

Levels of very slight agreement (κ: 0.00 – 0.20) were found for the following evaluated structures: posterior cruciate ligament; collateral ligaments; and chondral lesions in the medial and lateral condyle, trochlea, and patella.

Levels of slight concordance (κ: 0.21 – 0.40) were found for the following evaluated structures: anterior cruciate ligament and meniscus.

Table 2. Agreement between orthopedists and radiologists.

Lesion	Agreement	Expected Agreement	Kappa	p*
Anterior Cruciate Ligament	55%	30.86%	0.3491	0
Posterior Cruciate Ligament	45%	31.12%	0.2015	0
Meniscus	59%	37.85%	0.3403	0
Collateral Ligaments	46%	39.20%	0.1118	0.0491
Chondral Lesion (medial condyle)	36%	25.80%	0.1375	0.0004
Chondral Lesion (lateral condyle)	33%	33%	0	0.5
Chondral Lesion (Troclea/Patella)	27%	23%	0.0529	0.0631

DISCUSSION

Currently, MRI plays an important role in the assessment of trauma in the knee by its ability to obtain thin and multiplanar sections with different imaging weights, and being able to identify meniscal, ligament, tendon, and bone lesions.[9,13]

The protocol type used for the study of the knee in MRI is still variable at each institution as the objective is to obtain images with better spatial resolution. An evaluation of the knee is considered suitable by an exam that contains sectional cuts in axial, coronal, and sagittal planes, with weight imaging in T1, T2, DP, and STIR[13].

The accurate diagnosis of knee lesions is directly connected to the clinical history of the patient and a physical examination. The meniscal and ligamentous lesions of this articulation can be evaluated by means of MRI with great applicability when compared with other joints.[9] However, no evidence has been found that MRI can reduce the number of negative arthroscopies.[7,9] This explains the results found in our study in which 55% of the orthopedic doctors consider the physical examination to be the most important thing to diagnose knee's injuries.

A skilled orthopedic surgeon can certainly diagnose ligament and meniscus lesions through physical examination while the MRI is saved for the most complex and uncertain cases.[5,6,9] In our study, 60% of knee surgeons would agree with the above, and that the MRI is a complementary diagnostic examination for inconclusive cases.

The agreement in classifying the lesions evaluated by the κ coefficient in different studies is considered good for anterior cruciate ligament and lateral meniscus lesions, reasonable for the medial meniscus, and low for chondral lesions.[5,6] The results are in agreement with the literature in which we observed higher concordance in the κ coefficient for lesions of the anterior cruciate ligament and meniscus and poor agreement for the chondral lesions.

In the literature, the chondral lesions present low sensitivity and a negative likelihood value greater than 0.5, thereby reflecting that the

absence of findings in the MRI do not preclude their existence.[4,5,9] This explains the low values of the κ coefficient found for chondral lesions in this study with statistical significance relevant to the analysis of the chondral lesions in the medial femoral condyle.
We did not find in literature other studies comparing the results of MRI interpretations by more than three doctors. That's may explain why our results had lower agreement between observers. We also used a 1.5 T MRI, but others have used a 3.0 T version.
In Brazil, when doctors indicate a surgery, it's needed to ask authorization for the procedure and implants to the patient's insurance. The insurance uses the MRI report to analyze and authorize it. That may result in some difficulties, for example: if the orthopedic surgeon concludes that patient has an ACL rupture and meniscus tear, he is supposed to be paid for both procedures but if the report from the radiologist doesn't agree with the meniscus tear, the insurance will only pay for ACL reconstruction.

CONCLUSION

Orthopedic surgeons considered a physical exam to be the main tool to diagnosis knee injuries, followed by clinical history and MRI. The imaging had a greater importance for those cases that were inconclusive after clinical evaluation.
We also conclude that interobserver agreement was slight for ACL and meniscus tears and very slight for PCL, collateral ligaments, and chondral lesions.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. TRP (0000-0003-3610-7152)*: substantial contributions to the concept of the work and analysis and interpretation of the data. MSN (0000-0002-0466-4993)*: work design and final approval of the manuscript version; LGS (0000-0002-1321-7394)*: data collection and analysis and writing; JG (0000-0002-3197-3679)*: AK (0000-0002-9420-8974)*: data collection and analysis and writing; DP (0000-0002-6089-3459)*: statistical analysis. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Magee T, Shapiro M, Williams D. MR accuracy and arthroscopic incidence of meniscal radial tears. Skeletal Radiol. 2002;31(12):686-9.
2. Scholten RJ, Devillé WL, Opstelten W, Bijl D, van der Plas CG, Bouter LM. The accuracy of physical diagnostic tests for assessing meniscal lesions of the knee:a meta-analysis. J Fam Pract. 2001;50(11):938-44.
3. Feller JA, Webster KE. Clinical value of magnetic resonance imaging of the knee. ANZ J Surg. 2001;71(9):534-7.
4. Barry BP. General principles of arthroscopy. In: Terry SC, editor. Campbell operative orthopaedics. 9ª. ed. Philadelphia: Mosby Inc; 1999. p. 364-73.
5. Karam FC. A ressonância magnética para o diagnóstico das lesões condrais, meniscais e dos ligamentos cruzados do joelho. Radiol Bras. 2007;40(3):179-82.
6. Brooks S, Morgan M. Accuracy of clinical diagnosis in knee arthroscopy. Ann R Coll Surg Engl. 2002;84(4):265-8.
7. Sanders TG, Miller MD. A systematic approach to magnetic resonance imaging interpretation of sports medicine injuries of the knee. Am J Sports Med. 2005;33(1):131-48.
8. Phelan N, Rowland P, Galvin R, O'Byrne JM. A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. Knee Surg Sports Traumatol Arthrosc. 2016;24(5):1525-39.
9. Orlando Júnior N, de Souza Leão MG, de Oliveira NH. Diagnosis of knee injuries: comparison of the physical examination and magnetic resonance imaging with the findings from arthroscopy. Rev Bras Ortop. 2015;50(6):712-9.
10. Cunha DL, Ribeiro EJS, Domingues RC. Ressonância magnética da osteonecrose do joelho: estudo de 19 casos. Radiol Bras. 2010;43(2):77-80.
11. Dzoleva-Tolevska R, Poposka A, Temelkovski Z, Samardziski M, Georgieva D. The role of clinical diagnosis in meniscal lesions of the knee. Prilozi. 2011;32(1):189-97.
12. Kocabey Y, Tetik O, Isbell WM, Atay OA, Johnson DL. The value of clinical examination versus magnetic resonance imaging in the diagnosis of meniscal tears and anterior cruciate ligament rupture. Arthroscopy. 2004;20(7):696-700.
13. De Grossi CM, Marchiori E, Santos AASMD. Comprometimento ósseo do joelho pós-trauma: avaliação pela ressonância magnética. Radiol Bras. 2001;34(3):155-60.
14. Shepard MF, Hunter DM, Davies MR, Shapiro MS, Seeger LL. The clinical significance of anterior horn meniscal tears diagnosed on magnetic resonance images. Am J Sports Med. 2002;30(2):189-92.

DOI: http://dx.doi.org/10.1590/1413-785220182601174568

INFLUENCE OF JOINT HIPERMOBILITY ON POSTOPERATIVE RESULTS OF KNEE SURGERY

INFLUÊNCIA DE HIPERMOBILIDADE ARTICULAR NO RESULTADO PÓS-OPERATÓRIO DE CIRURGIA DO JOELHO

Diego Costa Astur[1], Paulo Henrique Schmidt Lara[1], Marcelo Abdulklech Santos[1], Gabriel Taniguti de Oliveira[1], Gustavo Gonçalves Arliani[1], Moisés Cohen[1]

1. Center for Sports Traumatology, Department of Orthopedics and Traumatology, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: To evaluate the prevalence of joint hypermobility in patients undergoing knee surgery to treat traumatic injury to the meniscus and anterior cruciate ligament, and the influence of this hypermobility on postoperative results. Methods: This prospective study assessed joint hypermobility in patients who underwent surgical reconstruction of the anterior cruciate ligament (ACL), partial meniscectomy, or a procedure combining ACL reconstruction and partial meniscectomy during the period 2011–2015. The Beighton score was used to evaluate joint hypermobility and Tegner activity scale for postoperative assessment. Results: A total of 242 patients underwent surgery during the study period: 107 to treat ACL injuries, 75 to treat ACL injuries associated with meniscus injuries, and 60 to treat meniscus injuries. Of the total, 45 patients had joint hypermobility. We found no association between joint hypermobility and sex or type of injury. Postoperative Tegner scale results were not influenced by the presence of joint hypermobility. Conclusion: No association was found between joint hypermobility and the evaluated variables (gender and type of specific injury), and hypermobility did not have a negative impact on postoperative outcomes. ***Level of Evidence IV; Case series.***

Keywords: Knee. Anterior cruciate ligament. Joint instability. Athletic injuries. Sports medicine.

RESUMO

Objetivo: Avaliar a prevalência de hipermobilidade articular em pacientes submetidos à cirurgia do joelho, devido lesão traumática no menisco e ligamento cruzado anterior e a implicação dessa condição física no resultado pós-operatório. Métodos: Estudo prospectivo, no qual pacientes submetidos a cirurgias para reconstrução isolada do ligamento cruzado anterior, reconstrução do ligamento cruzado anterior associada à meniscectomia parcial e meniscectomia parcial isolada de origem traumática durante o período de 2011 a 2015, foram avaliados quanto à presença de hipermobilidade articular. Foram utilizados o Escore de Beighton para avaliar a hipermobilidade articular e a Escala de atividade de Tegner para avaliação pós-operatória. Resultados: Um total de 242 pacientes foram submetidos à cirurgia nesse período (107 devido a lesões do ligamento cruzado anterior, 75 devido a lesões do ligamento cruzado anterior associadas a lesões meniscais e 60 devido a lesões meniscais), sendo que 45 pacientes tinham hipermobilidade articular. Não encontramos associação entre a presença de hipermobilidade articular e um gênero ou tipo específico de lesão. O resultado da Escala de Tegner no pós-operatório não foi influenciado pela presença de hipermobilidade articular nos grupos avaliados. Conclusão: Não encontramos associação entre hipermobilidade articular e um gênero ou tipo de lesão específico nem correlação entre a hipermobilidade articular e resultado pós-operatório pior. ***Nível de evidência IV; Série de casos.***

Descritores: *Joelho. Ligamento cruzado anterior. Instabilidade articular. Traumatismos em atletas. Medicina esportiva.*

Citation: Astur DC, Lara PHS, Santos MA, Oliveira GT, Arliani GG, Cohen M. Influence of joint hipermobility on postoperative results of knee surgery. Acta Ortop Bras. [online]. 2018;26(1):19-21. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The anterior cruciate ligament (ACL) and the meniscus are the most commonly injured structures in the knee.[1] The ACL is an important primary stabilizer; its main function is to restrict anterior translation and internal rotation of the tibia in relation to the femur.[2] The most important functions of the meniscus are to transmit the load, increase joint cohesion, and distribute the synovial fluid.[3] Injuries to these structures can consequently cause significant functional deficits.

Several predisposing factors for injury to these structures are known.[4] Alteration to the mechanical axis of the lower limbs can lead to meniscus injury, and a narrower intercondylar fossa can lead to ACL injuries.[5,6] The association between ACL rupture and joint hypermobility still remains controversial;[7,8] some studies have found higher rates of joint hypermobility in patients with ACL rupture,[9-10] while others have not.[11-12] Sueyoshi et al.[13] demonstrated that patients with joint hypermobility have a higher risk of knee sprain. There are

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

Work conducted at the Center for Sports Traumatology, Department of Orthopedics and Traumatology, Universidade Federal de São Paulo, São Paulo, SP, Brazil.
Correspondence: Paulo Henrique Schmidt Lara. Rua Estado de Israel, 636, Vila Clementino, São Paulo, SP, Brazil. 04022-001. phslara@gmail.com

Article received in 01/17/2017, approved in 06/30/2017.

CC BY NC

several methods to evaluate joint hypermobility; the most common is the Beighton score.[14]

The association between joint hypermobility and isolated meniscus injuries or meniscus injuries associated with ACL injuries has not yet been evaluated. Furthermore, it is not known whether joint hypermobility is associated with any particular type of knee injury or patient sex.

The objective of this study was to assess the prevalence of joint hypermobility in patients who underwent knee surgery to treat meniscus and ligament injuries, and the impact of this physical condition on postoperative results.

METHODS

This research project was approved by the institutional review board at the Escola Paulista de Medicina - UNIFESP (number 01609812.9.0000.5505). This is a prospective study, in which amateur athlete patients who received surgical treatment for the aforementioned knee injuries from 2011 to 2015 were assessed by an orthopedic specialist to determine the presence of joint hypermobility. Inclusion criteria were amateur athletes who received surgical treatment for isolated ACL injuries, isolated meniscus injuries, and ACL injuries associated with traumatic meniscus injuries. Exclusion criteria were the presence of other associated knee injuries and meniscus injuries treated with sutures. All patients signed an informed consent form before participating in the study.

The patients were divided into three groups: isolated ACL injuries, isolated meniscus injuries, and ACL injuries associated with meniscus injuries. The surgical procedures and evaluation of the presence of joint hypermobility were performed by the same surgical team. The Beighton score was used; the maximum value is nine points, and a score greater than or equal to four was considered joint hypermobility. One point is awarded for each positive result in the following tests on each side of the body: passive hyperextension of the fifth metacarpophalangeal joint (greater than 90 degrees), passive apposition of the thumb to the flexor aspect of the forearm, active hyperextension of the forearm (greater than 10 degrees), active hyperextension of the knee (greater than 10 degrees), and active forward flexion of the trunk with the knees fully extended so that the palms of the hands rest flat on the floor. For postoperative evaluation, the Tegner activity scale was used;[15] this assessment is composed of eight questions and scores are assigned from 0 to 10, ranging from the patient's inability to perform activities to lack of limitation, respectively. In the patients evaluated in this study, the Tegner scale was applied after treatment of the injury was complete and patients began sports activities, which took an average of 3 months after surgery for meniscus injuries and 6 months after treatment of ACL injuries (whether associated with meniscus injuries or not).

The surgical technique for ACL injuries utilized knee flexor tendons (semitendinosus and gracilis) and absorbable interference screws in the tibia and femur buttons as fixation methods in the anatomical reconstruction technique, in which femoral and tibial bone tunnels are created in the center of the anterior cruciate ligament insertion in these bones.[16] For cases of meniscus injury, a partial meniscectomy was performed.

Rehabilitation for the cases of ACL reconstruction took place in accordance with the Multicenter Orthopedic Outcomes Network (MOON) ACL Rehabilitation Guidelines[17] and for cases of meniscus injury, patients underwent physical therapy rehabilitation for an average of three months.

Statistical analysis

Because the data were quantitative and continuous, we utilized statistical parametric tests. To evaluate the qualitative variables, the equality of two proportions test was used. Analysis of variance (ANOVA) was used for comparisons between the groups and sexes in relation to the Beighton score. The Pearson correlation was used to correlate the Beighton score and Tegner scale. A 0.05 (5%) significant level was adopted. SPSS V17 software (SPSS Inc, Chicago, IL) was used to conduct the analysis.

RESULTS

During the study period, 242 patients underwent surgery; 107 to treat isolated ACL injuries, 75 for ACL injuries associated with meniscus injuries, and 60 to treat isolated meniscus injuries. Of these patients, 199 were male and 43 were female. The mean patient age was 32.9 years, ranging from 10 to 72, with a standard deviation (SD) of 11.88 (CI=1.5). The Beighton score ranged from 0 to 9, with 2 the most prevalent and SD of 2.18 (CI=0.27). The Tegner scale varied from 0 to 10, with 3 the most prevalent, and SD of 1.88 (CI=0.24). There were 45 patients with joint hypermobility according to the study criterion (Beighton score greater than or equal to 4). The sex distribution and presence of joint hypermobility according to injury are shown in Table 1. The ethnic makeup of the study group was 151 white, 63 mixed race of African descent, 25 Black, and 3 Asian. Comparison of the presence or absence of joint hypermobility according to Beighton score in the evaluated groups (isolated ACL injury, isolated meniscus injury, and associated ACL and meniscus injuries) showed no statistically significant difference, with the majority of patients not presenting joint hypermobility ($p<0.001$). (Table 2) Comparison of the presence or absence of joint hypermobility according to Beighton score in male and female patients also demonstrated no statistically significant difference, with joint hypermobility absent in patients of both sexes ($p<0.001$). (Table 3 and 4) No significant difference between sexes was seen in the different groups with regard to the presence of joint hypermobility ($p>0.577$). (Table 5)

The results for the Tegner scale upon returning to sports was not influenced by the presence or absence of joint hypermobility for the assessed groups ($p>0.07$). (Table 6)

Table 1. Sex distribution according to injury and presence of joint hypermobility.

	Men		Women	
	Without hypermobility	With hypermobility	Without hypermobility	With hypermobility
ACL	68 (82.9%)	14 (17.1%)	18 (85.7%)	3 (14.3%)
Meniscus	43 (79.6%)	11 (20.4%)	6 (100%)	0 (0%)
ACL + MENISCUS	47 (78.3%)	13 (21.7%)	12 (75%)	4 (25%)

Table 2. Comparison between groups by presence of absence of joint hypermobility.

	Without hypermobility		With hypermobility		P-value
	N	%	N	%	
ACL	86	83.5%	17	16.5%	<0.001
ACL + MENISCUS	59	77.6%	17	22.4%	<0.001
Meniscus	54	83.1%	11	16.9%	<0.001

Table 3. Comparison between groups, females only, by presence or absence of hypermobility.

Female	With hypermobility		Without hypermobility		P-value
	N	%	N	%	
ACL	3	14.3%	18	85.7%	<0.001
ACL + MENISCUS	4	25.0%	12	75.0%	<0.001
Meniscus	0	0.0%	6	100%	<0.001

Table 6. Correlation between Beighton score and Tegner scale, by group.

	Beighton vs. Tegner	
	Correlation (r)	P-value
ACL	-17.6%	0.070
ACL + Meniscus	-1.6%	0.895
Meniscus	-6.6%	0.615
All	-9.1%	0.160

Table 5. Comparison of Beighton scores between sexes for different groups.

Beighton		Mean	Median	Standard Deviation	CV	Min	Max	N	CI	P-value
ACL	Female	1.81	2	1.63	90%	0	7	21	0.70	0.577
	Male	1.53	1	2.10	137%	0	10	86	0.44	
ACL + Meniscus	Female	2.00	2	1.97	98%	0	7	16	0.96	0.784
	Male	2.19	2	2.51	115%	0	8	59	0.64	
Meniscus	Female	1.67	2	0.52	31%	1	2	6	0.41	0.785
	Male	1.93	1.5	2.29	119%	0	9	54	0.61	

Table 4. Comparison between groups, males only, by presence or absence of hypermobility.

Male	With hypermobility		Without hypermobility		P-value
	N	%	N	%	
ACL	14	16.3%	72	83.7%	<0.001
ACL + MENISCUS	13	22.0%	46	78.0%	<0.001
Meniscus	11	20.4%	43	79.6%	<0.001

DISCUSSION

Among patients with ACL injuries, we found a prevalence of 17.1% for joint hypermobility in men and 14.3% in women, results lower than those found in the literature, which range from 40 to 60%.[19,20] Previous studies[19,20] encountered a higher prevalence of joint hypermobility in women, especially adolescents, compared to men. We also found similar results for the prevalence of joint hypermobility among patients with meniscus injuries and associated ACL/meniscus injuries, but since no studies have performed these assessments, no comparisons could be drawn.

The association between joint hypermobility and ACL injury remains controversial, and may be partly due to inconsistency in evaluating joint hypermobility.[8] For example, studies consider different cutoff points for the Beighton score which range from 4 to 6 points. Due to differences in the definition and identification of cases, the prevalence of joint hypermobility in adults varies in studies from 5 to 43%.[18] In a systematic review performed by Pacey et al.,[18] 5 studies described knee injuries and a statistically significant relationship was found between joint hypermobility and greater risk of knee injury. We should note that this study included all knee injuries, not only ACL injuries. In all patient ethnic groups except Asians, more than 80% of patients did not have joint hypermobility. In the Asian patients in our study, 66.6% had joint hypermobility, but we should note that there were only 3 patients in this group.

We compared to the presence or absence of joint hypermobility between the sexes for each group, but found no significant difference. Finally, we performed a correlation between the postoperatory Beighton score and Tegner scale in the three study groups (ACL, meniscus, and ACL/meniscus) to determine whether the presence of joint hypermobility was associated with poorer postoperative results. Although there was no statistical difference (i.e., the variables were independent), the group of patients with isolated ACL injuries presented poorer postoperative results ($p=0.07$) than the groups with isolated meniscus injury ($p=0.615$) and ACL injury associated with meniscus injury ($p=0.895$).

All lesions included in this study were traumatic, but patients aged 10 to 72 years were included; this age difference may have had an influence on the results, and older patients may have had degenerative meniscus injuries prior to the traumatic injury. Furthermore, we do not know if there were changes in joint hypermobility with aging. Risk factors for ligament and meniscus injuries are probably multifactorial, but joint hypermobility may be an important contributor to the stability of the knee and may consequently be a predisposing factor for these injuries.

CONCLUSION

We did not find any association between joint hypermobility and sex or type of injury evaluated, and did not find a correlation between joint hypermobility and poorer postoperative outcomes.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. DCA (0000-0001-9163-7979)*: performed the surgeries, wrote and reviewed the article; PHSL (0000-0002-1623-2071)*: performed data analysis and statistical analysis and wrote the article; MAS (0000-0003-3899-2175)*: and GTO (0000-0001-6288-6896)*: wrote the article; GTO (0000-0001-6288-6896)* and GGA (0000-0003-4371-5041)*: performed the surgeries and reviewed the article; MC (0000-0001-7671-8113)*: performed the surgeries and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Amis AA, Dawkins GP. 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. Astur DC, Batista RF, Arliani GG, Cohen M. Tendências de tratamento das lesões do ligamento cruzado anterior do joelho nos sistemas de saúde pública e privada do Brasil. São Paulo Med J. 2013;131(4):257-63.
3. Renström P, Johnson RJ. Anatomy and biomechanics of the menisci. Clin Sports Med. 1990;9(3):523-38.
4. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. Am J Sports Med. 1995;23(6):694-701.
5. Habata T, Ishimura M, Ohgushi H, Tamai S, Fujisawa Y. Axial alignment of the lower limb in patients with isolated meniscal tear. J Orthop Sci. 1998;3(2):85-9.
6. Görmeli CA, Görmeli G, Öztürk BY, Özdemir Z, Kahraman AS, Yıldırım O, et al. The effect of the intercondylar notch width index on anterior cruciate ligament injuries: a study on groups with unilateral and bilateral ACL injury. Acta Orthop Belg. 2015;81(2):240-4.
7. Griffin LY, Agel J, Albohm MJ, Arendt EA, Dick RW, Garrett WE, et al. Noncontact anterior cruciate ligament injuries: risk factors and prevention strategies. J Am Acad Orthop Surg. 2000;8(3):141-50.
8. Ramesh R, Von Arx O, Azzopardi T, Schranz PJ. The risk of anterior cruciate ligament rupture with generalised joint J Bone Joint Surg Br. 2005;87(6):800-3.
9. Uhorchak JM, Scoville CR, Williams GN, Arciero RA, St Pierre P, Taylor DC. Risk factors associated with noncontact injury of the anterior cruciate ligament: a prospective four-year evaluation of 859 West Point cadets. Am J Sports Med. 2003;31(6):831-42.
10. Magnussen RA, Reinke EK, Huston LJ; MOON Group, Hewett TE, Spindler KP. Factors Associated With High-Grade Lachman, Pivot Shift, and Anterior Drawer at the Time of Anterior Cruciate Ligament Reconstruction. Arthroscopy. 2016;32(6):1080-5.
11. Kalenak A, Morehouse CA. Knee stability and knee ligament injuries. JAMA. 1975;234(11):1143-5.
12. Moretz JA, Walters R, Smith L. Flexibility as a predictor of knee injuries in college football players. Phys Sportsmed. 1982;10:93-7.
13. Sueyoshi T, Emoto G, Yuasa T. Generalized Joint Laxity and Ligament Injuries in High School-Aged Female Volleyball Players in Japan. Orthop J Sports Med. 2016;4(10): 2325967116667690.
14. Beighton P, Solomon L, Soskolne CL. Articular mobility in an African population. Ann Rheum Dis. 1973;32(5):413-8.
15. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res. 1985;(198):43-9.
16. Brown CH Jr, Spalding T, Robb C. Medial portal technique for single bundle anatomical anterior cruciate ligament (ACL) reconstruction. Int Orthop. 2013;37(2):253-69.
17. Wright RW, Haas AK, Anderson J, Calabrese G, Cavanaugh J, Hewett TE, et al. MOON Group. Anterior Cruciate Ligament Reconstruction Rehabilitation: MOON Guidelines. Sports Health. 2015;7(3):239-43.
18. Pacey V, Nicholson LL, Adams RD, Munn J, Munns CF. Generalized joint hypermobility and risk of lower limb joint injury during sport: a systematic review with meta-analysis. Am J Sports Med. 2010;38(7):1487-97.
19. Seçkin U, Tur BS, Yilmaz O, Yağci I, Bodur H, Arasil T. The prevalence of joint hypermobility among high school students. Rheumatol Int. 2005;25(4):260-3.
20. Larsson LG, Baum J, Mudholkar GS. Hypermobility: features and differential incidence between the sexes. Arthritis Rheum. 1987;30(12):1426-30.

DOI: http://dx.doi.org/10.1590/1413-785220182601173883

ORIGINAL ARTICLE

FACTORS ASSOCIATED WITH THE DEVELOPMENT OF EARLY INFECTION AFTER SURGICAL TREATMENT OF FRACTURES

FATORES ASSOCIADOS AO DESENVOLVIMENTO DE INFECÇÃO PRECOCE APÓS TRATAMENTO CIRÚRGICO DAS FRATURAS

João Eurípedes de Alcântara Junior[1], Rogger Aguiar de Aguiar[1], Jose Gilvan Leite Sampaio Neto[1], Matheus Lemos Azi[1], David Sadigursky[1], Daniel Figueiredo de Alencar[1]

1. Manoel Victorino Hospital, Secretary of Health for the State of Bahia. Praça Conselheiro Almeida Couto S/N, 40050-410, Salvador, Bahia, Brazil.

ABSTRACT

Objective: Infection after the internal fixation of fractures is a major complication. Early infection is particularly challenging, because it occurs when the fracture is not yet united. The objective of this study is to identify possible factors related to the development of early infection in patients treated with internal fixation for fractures. Method: This retrospective observational study analyzed 24 patients with long bone fractures who underwent internal fixation and developed infections in the post-operatory period. The infections were classified as early (diagnosis in the first two weeks after surgery) or late (diagnosis after 2 weeks). Results: Of the 24 patients studied, 11 (46%) developed early infections and 13 (54%) were diagnosed with late infections. The early infection group was significantly younger (37.8 versus 53.1 [p = 0.05]) and underwent more surgeries prior to internal fixation (1.2 versus 0.2 [$p < 0.00$]). Conclusion: Risk factors for the development of early infection in the postoperative period should be considered when treating patients with internal fracture fixation in order to diagnose this condition as early as possible. ***Level of Evidence IV; Case series.***

Keywords: Fracture healing. Osteomyelitis. Surgical wound infection.

RESUMO

Objetivo: A infecção após a fixação interna das fraturas é uma complicação grave, sendo a infecção precoce particularmente desafiadora, pois acontece quando a fratura ainda não está consolidada. O objetivo deste estudo é identificar fatores relacionados com o desenvolvimento de infecção precoce em pacientes submetidos à fixação interna de fraturas. Método: Estudo retrospectivo que envolveu 24 pacientes com fraturas de ossos longos submetidos à fixação interna, que evoluíram com infecção no pós-operatório. A infecção foi classificada como precoce (diagnóstico nas primeiras duas semanas após a fixação interna) e tardia (diagnóstico após 2 semanas da realização da fixação). Resultados: Dos 24 pacientes estudados, 11 (46%) desenvolveram infecção precoce e 13 (54%) tiveram infecção tardia. Os pacientes portadores de infecção precoce eram mais jovens (37,8 anos versus 53,1 anos [p = 0,05]) e foram submetidos a um maior número de cirurgias antes da fixação interna (1,2 versus 0,2 [$p < 0,00$]). Conclusão: É recomendável levar em consideração os fatores de risco de desenvolvimento de infecção no pós-operatório em pacientes submetidos à fixação interna de fraturas visando realizar o diagnóstico o mais breve possível. ***Nível de Evidência IV; Série de casos.***

Descritores: *Consolidação da fratura. Osteomielite. Infecção da ferida cirúrgica.*

Citation: Alcântara Junior JE, Aguiar RA, Sampaio Neto JGL, Azi ML, Sadigursky D, Alencar DF. Factors associated with the development of early infection after surgical treatment of fractures. Acta Ortop Bras. [online]. 2018;26(1):22-6. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Infection of the surgical site is a severe complication related to fracture treatment, and is associated with increases in morbidity, mortality, and costs.[1] The rate of infection associated with internal fracture fixation may be as high as 3.6% to 8.1% for closed fractures and 30% for open fracture.[2,3] This high incidence of post-operative infection in fractures contrasts with a risk of less than 2% in elective joint reconstruction surgeries.[3-5]

Many factors have been considered to predispose the development of post-surgical infection, and are related to the host, trauma, and treatment itself; identification of these factors is crucial in planning prevention strategies.[1,5-8] Surgical treatment of fractures occurs in an area which is already traumatized, where the need for early intervention often overrides the desire to wait the time necessary for complete recovery of the soft tissue and minimize comorbidities.[6] The route of infection can be classified as perioperative (contamination during or immediately after the surgery), contiguous (organisms inoculated into the wound from an adjacent focus, or loss of integrity in the soft tissue), or hematogenic (infectious agent migrates from a distant focus through the bloodstream).[2]

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

Work conducted at the Manoel Victorino Hospital, Secretary of Health for the State of Bahia. Praça Conselheiro Almeida Couto S/N, 40050-410, Salvador, Bahia, Brazil.
Correspondence: Matheus Lemos Azi. Manoel Victorino Hospital, Secretary of Health for the State of Bahia. Praça Conselheiro Almeida Couto S/N, 40050-410, Salvador, Bahia, Brazil. mlazi@hotmail.com

Article received in 12/24/2016, approved in 09/13/2017.

CC BY NC

In terms of time of development, infections can be early or late.[2,9] Early infection tends to be the result of perioperative or contiguous infection, and is particularly challenging because it occurs when the fracture is not yet united.[2,5]

The objective of this study is to identify factors related to the patient, fracture, and treatment, which can lead to the development of early infection in patients who undergo internal fracture fixation of the long bones.

METHODS

This retrospective, observational study evaluated data from patients who developed surgical site infections (SSI) after treatment for fracture between January 2014 and December 2015 at a reference hospital for orthopedic treatment. After approval by the institutional review board (CAAE: 49142815.9.0000.0052), we analyzed the medical records of the patients identified by the commission for hospital infection control as having developed post-surgical infection. The group included patients with fractures of the long bones who were surgically treated with internal fixation and developed post-operative infections. The study excluded patients who developed infection after surgical treatment at other hospitals, treatment with external fixation (EF), treatment with arthroplasty, or patients who underwent internal fracture fixation in the hand, foot, or the flat bones such as the pelvis and acetabulum. We also excluded cases with incomplete medical record data.

Patient medical records were reviewed to identify factors that could be related to an increased risk of developing infection after surgical treatment of fractures. We analyzed demographic characteristics (age and sex), host-related factors (local and systemic comorbidities), and characteristics related to trauma (trauma mechanism, organs and systems affected, and number of fractures). The following were considered systematic comorbidities: high blood pressure, diabetes mellitus, chronic kidney disease, congestive heart failure, obesity (body mass index ≥30kg/m^2), and tobacco and alcohol use. Local comorbidities were abrasions, hyperemia, wounds without signs of infection, and wounds with signs of infection. Additionally, patients were classified according to the American Society of Anesthesiology system as well as the system proposed by Cierny-Mader.[8] The fractures were classified according to the AO/OTA classification for fractures and dislocations[10] and the open fractures were classified according to the Gustilo and Anderson classification.[11]

The infections were classified as superficial incision (involving skin and subcutaneous tissue), deep incision (involving deep tissues), or organ/space (involving the bone); definition of these groups considered the recommendations from the United States Centers for Disease Control and Prevention.[12] Infection was also classified according to the time between internal fixation and early diagnosis (within the first two weeks after internal fixation) and late diagnosis (two weeks after internal fixation was performed).[2,9]

Of a total of 87 patients who developed post-surgical infection during the study period, 24 patients with closed or exposed fractures of the long bones who underwent internal fixation and fulfilled the inclusion criteria were selected. The demographic characteristics of these patients are presented in Table 1. Sixty-three patients were excluded: those with fractures of the short or flat bones, infections after surgeries performed at other hospitals, fractures treated with arthroplasty, and patients with incomplete data.

Traffic accidents were the cause of the trauma in 58% of the patients. The left side was more affected by postoperative infection, in 13 (54%) of cases. All patients had associated fractures, with an average of 1 (1–3, SD: 0.6) fracture per patient, and no patient exhibited injuries to other organs or systems. The most frequently affected bone was the femur, with 16 (67%) fractures that progressed to infection in the post-operative period. Table 2 presents the description of the characteristics of the trauma and the affected segment.

Table 1. Demographic characteristics of study participants.

Parameter	Description	n/ mean	%	Interval (SD)
Number of subjects	n	24	100	--
Mean age (years)	Age	46	--	15 - 85 (19.3)
Sex	Male	15	62.5%	--
	Female	9	37.5%	--
ASA	I	15	62.5%	--
	II	7	29.2%	--
	III	2	8.3%	--
Host classification (Cierny)	A	15	62.5%	--
	B	9	37.3%	--
	C	0	0.0%	--
Comorbidities	Diabetes	3	12.5%	--
	HBP	3	12.5%	--
	Obesity	2	8.4%	--
	CKD	1	4.2%	--
	CHF	1	4.2%	--
	Other	2	8.4%	--
Tobacco use	No	20	83.3%	--
	Yes	4	16.8%	
Alcohol use	No	22	91.7%	--
	Yes	2	8.4%	--

n, number. SD: standard deviation ASA, classification of patient's physical state according to the American Society of Anesthesiology. Cierny, host classification according to Cierny and Mader. HBP, high blood pressure CKD, chronic kidney disease CHF, congestive heart failure.

Table 2. Trauma mechanism and injuries associated with the fracture that progressed to infection.

Parameter	Description	n/ mean	%	Interval (SD)
Side	Left	13	54.1%	--
	Right	11	45.9%	--
Type of trauma	Motorcycle	11	45.8%	--
	Fall	8	33.3%	--
	Car	3	12.5%	--
	Blunt trauma	1	4.2%	--
	Firearm trauma	1	4.2%	--
Fractured Segment (Class. AO)	11	1	4.2%	--
	12	2	8.4%	--
	13	1	4.2%	--
	22	1	4.2%	--
	31	3	12.5%	--
	32	10	41.6%	--
	33	3	12.5%	--
	41	1	4.2%	--
	42	1	4.2%	--
	43	1	4.2%	--
Fracture type (closed)	Closed	20	83.3%	--
Fracture type (closed)	GI	--	--	--
	GII	2	8.4%	--
	GIII-A	1	8.4%	--
	GIII-B	--	--	--
	GIII-C	1	4.2%	--
Soft tissue reconstruction	No	24	100.0%	--
	Yes	0	0.0%	--
Skin injury	No injury	15	62.5%	--
	Abrasion/ hyperemia	4	16.6%	--
	Wound	4	16.6%	--
	Infected wound	1	4.2%	--

G, degree in classification by Gustillo and Anderson.

The patients were admitted to the unit for treatment on average 17 days (0–67, SD: 20.9) after the trauma. The laboratory tests conducted upon admission are described in Table 3. Four (17%) patients received blood transfusions prior to surgery, and 15 (63%) after surgery. Sixteen 16 (67%) patients required transfusion before and after surgery, receiving an average of 2.7 units (0–14, SD: 3.5) of packed red blood cells. An average of 0.7 surgeries (0–2, SD: 0.7) were performed prior to the internal fracture fixation which progressed to infection, and the internal fixation procedure was performed an average of 27 days (0–91, SD: 22.0) after the trauma.

The data were stored in digital format and subsequently analyzed using Stata statistical software, version 13 (Corastar, St George, Utah, USA). Normality of the continuous variables was tested using the Shapiro-Wilk test and then analyzed with the t-test or Kruskal-Wallis test. The categorical variables were analyzed with the chi-square test. A significance level of $\alpha = 5\%$ was adopted. Logistical regression with a confidence interval of 95% and analysis of variance were utilized to create graphs.

Table 3. Laboratory parameters at hospital admission.

Laboratory results at admission	n/ mean	%	Interval (SD)
Hemoglobin (g/dL)	11	--	9.1 - 15.4 (1.9)
Hematocrit (%)	35	--	24.7 - 50.2 (5.9)
Leukogram (%/ml)	9,865	--	4,400 - 15,400 (3,213.4)
Platelets (n/ml)	332,000	--	186,000 - 912,000 (156,813.9)
Blood sugar (mg/dL)	143	--	94 - 263 (53.6)
Urea (mg/dL)	32	--	10 - 89 (14.6)
Creatinine (mg/dL)	1	--	0.4 - 4.4 (0.7)
Erythrocyte sedimentation rate (mm)	35	--	0.6 - 52 (18.8)
PCR (mg/l)	36	--	6 - 96 (31.5)

n, number. PCR, C-reactive protein.

RESULTS

In three cases (12.5%), the infection was classified as superficial, deep in 10 cases (41.6%), and as affecting organs/space in 11 (45.9%). Postoperative infection was diagnosed an average of 53 days (1–293; SD: 76.8) after internal fixation, and in 11 cases (46%) the infection was classified as early, and late in 13 (54%). Cultures taken from 15 (63%) patients after debridement of the infection were positive. After infection was diagnosed, an average of 2.8 surgical procedures (1–8; SD: 1.7) were performed in the affected segment. The patients received intravenous antibiotics on an inpatient basis for an average of 24 days (0–97, SD: 21.7). The characteristics of the infectious process in the cases included in this study are presented in Table 4.

Analysis of prognostic factors for the development of early infection

The patients who developed early infections were significantly younger (early, 37.8 years old [SD: 14.2], versus late, 53.1 years [SD: 20.7], $p = 0.05$) and underwent more surgeries prior to the internal fracture fixation that progressed to infection (early: 1.2 procedures [SD: 0.6] versus late 0.2 [SD: 0.4] surgeries, $p < 0.00$). (Figure 1) The use of temporary external fixation to stabilize the fracture was associated with a significant risk of developing late infection ($p = 0.03$). There was no relationship between delaying internal fracture fixation and the start of the infectious process ($p = 0.28$). (Figure 2) None of the other parameters assessed in the study demonstrated a relationship with the start of the infectious process.

DISCUSSION

Infection associated with internal fracture fixation is typically caused by biofilm-producing bacteria.[4] Shortly after implantation, a layer composed mainly of adhesins forms around the biomaterial, allowing adhesion by planktonic forms of infective organisms. Through cell division, recruitment of new free forms, and secretion of bacterial products, the organisms form a colony attached to the implant and protected

Table 4. Diagnosis and treatment of infection.

Case	Fracture	Diag. (days)	Culture after internal fixation				EF (CHECK)	Implant Used	SSI classification
Early infection									
24	32A2	1	Not collected				No	Long cephalomedullar rod	Osteomyelitis
21	33C3	2	Not collected				No	Internal fixator distal fêmur	Osteomyelitis
10	22A2	6	Not collected				Yes	DCP plate	Deep incision
19	32A3	7	Klebsiella pneumoniae				No	Long cephalomedullar rod	Osteomyelitis
2	32B3	11	Proteus Mirabilis				No	DCP plate	Deep incision
12	32C2	11	MRSA				No	Intramedullary nail	Osteomyelitis
23	43B3	11	MRSA				Yes	DCP plate	Deep incision
6	32C2	12	Negative				No	Intramedullary nail	Osteomyelitis
8	32B2	14	Negative				Yes	DCP plate	Deep incision
20	32A1	14	Pseudomonas aeruginosa				Yes	Intramedullary nail	Osteomyelitis
22	11A2	14	Pseudomonas aeruginosa				No	T plate	Deep incision
Late infection									
16	13C3	15	Enterobacter cloacae				No	Reconstruction plate	Deep incision
14	12C3	17	MRSA				No	DCP plate	Superficial incision
17	31A1	17	Pseudomonas aeruginosa				No	Short cephalomedullar rod	Osteomyelitis
4	33C1	22	Staphylococcus aureus				No	DCS plate	Deep incision
1	32B2	25	Not collected				No	Intramedullary nail	Deep incision
3	32A3	47	Not collected				No	DCP plate	Superficial incision
5	31A2	48	Pseudomonas aeruginosa				No	DHS plate	Osteomyelitis
7	32B2	82	Negative				No	DCP plate	Superficial incision
9	41C1	109	Staphylococcus epidermitis				No	DCP plate	Deep incision
13	31A2	121	Pseudomonas aeruginosa				No	DHS plate	Osteomyelitis
15	42A1	179	Staphylococcus aureus				No	DCP plate	Osteomyelitis
18	12A1	217	Not collected				No	DCP plate	Deep incision
11	33A3	293	Not collected				No	DCS plate	Osteomyelitis

Diag, time to diagnose infection. SSI, surgical site infection MRSA, methicillin-resistant *Staphylococcus aureus*. DCP, dynamic compression plate. DCS, dynamic condylar screw. EF, external fixation before internal fixation.

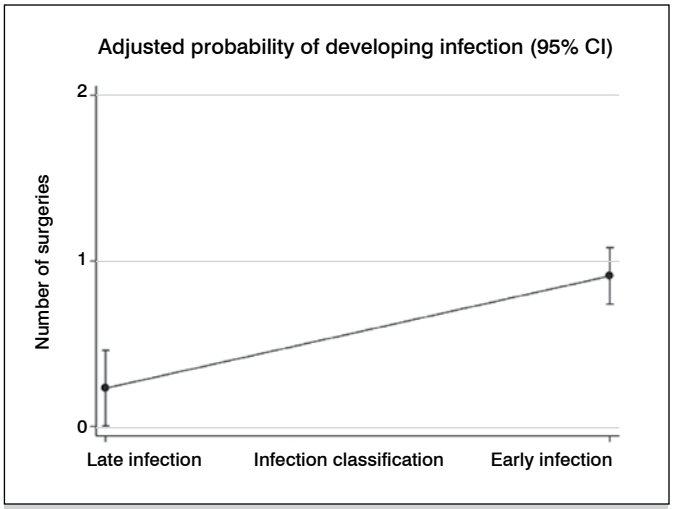


Figure 1. Adjusted probability of developing infection according to the number of surgeries performed before internal fixation of the fracture. Logistic regression.

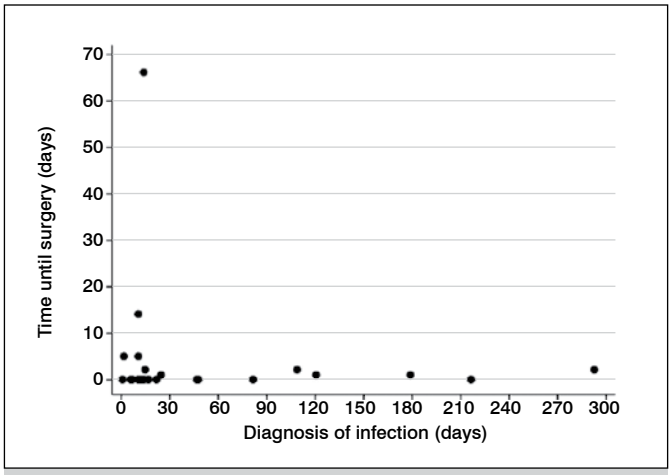


Figure 2. Relationship between trauma/time elapsed until internal fracture fixation and development of early and late infection. Analysis of variance.

by biofilm.[2] These organisms surrounded by biofilm are metabolically less active, facilitating the development of antibiotic resistance.[3,4]

Treatment of infection after internal fracture fixation generally involves a combination of surgery and the use of antibiotics. Surgery includes aggressive debridement of all devitalized tissue and removal of the implants, and sometimes coverage with muscle flaps to provide improved wound vascularization.[8] However, in the presence of early infection the main objective becomes fracture healing.[2] Consequently, early infection represents a therapeutic challenge because it occurs in a non-united fracture, where the stability provided by the implant is essential. At the same time, the presence of the implant in the wound plays an important role in the persistence of the infectious process.[2,5]

Willenneger and Roth[9] presented the results from a series of 40 patients treated for infection after open reduction and internal fixation using a plate. These authors proposed grouping patients according to the time elapsed between surgery and the onset of infection symptoms as early (less than 2 weeks), delayed (between 2 and 10 weeks), and late (more than 10 weeks). However, these intervals were arbitrarily established based on the authors' clinical experience. Schmidt et al.[13] incorporated these parameters as part of a broad classification for osteomyelitis, but stressed that defining the start time and the time elapsed to infection based on only clinical parameters can be faulty. For these authors, histological assessment is much more precise, particularly when seeking to define whether the infection is acute or chronic (defined as those in which the infectious process leads to chronic inflammatory alterations in the tissue, especially bone necrosis).[13-15]

Trampuz and Zimmerli[2] also defined early infection as beginning up to two weeks after the surgical treatment, and believed that this type of infection denotes perioperative contamination and/or the presence of high virulence bacteria. According to McPherson et al.,[7] early postoperative infection should be defined as occurring up to the fourth week after surgery. Infectious processes which begin after this period comprise the late forms, and suggest contamination by low-virulence germs or occasionally hematogenous contamination.[2]

Bowen and Widmaier[6] investigated risk factors for infection after open fractures, and the only predictor for infection they found was tobacco use. Matos et al.[16] also looked for risk factors for acute infection in open fractures and found an association between increased time until treatment and risk of infection. Oliveira et al.[17] analyzed the risk of infection in 1,103 patients with closed fractures who underwent internal fixation compared with 1,887 open fractures, and found a higher incidence of infection in cases of exposed fractures. Dellinger et al.[18] assessed factors associated with the development of infection in open fractures and demonstrated a higher incidence of infection in leg fractures. Srour et al.[19] conducted a prospective study on progress in 315 patients with open fractures after surgical treatment and found that superficial infections accounted for most of the early SSI.

In the present study, the factors related to higher risk for developing early infection were the number of surgeries before the definitive procedure and patient age. One possible explanation is the fact that younger patients are more frequently involved in high-energy traumas which lead to more complex fractures with greater damage to soft tissue; these require more surgeries and consequently this group has a greater risk of infection.

This study has a number of limitations. The retrospective design and the small number of patients are factors that limit the clinical applicability of the findings. The factors related to trauma, patient, infection, and treatment varied, restricting the creation of homogeneous subgroups for statistical analysis. Consequently, infections involving the arms and legs were seen, as well as fixation involving different implants. Furthermore, the ability to establish an accurate diagnosis of infection based on clinical criteria can be considered a limiting factor.

CONCLUSION

Based on the findings of this study, we recommend considering the risk factors for early postoperative infection in patients who undergo internal fracture fixation to increase the chance that early diagnosis can be made and therapeutic measures taken as soon as possible. Multi-center studies involving more patients could validate the findings of this study and identify other possible factors related to the development of early infection after surgery to treat fractures.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. JEAJ (0000-0003-4790-9134)* acquired the data, drafted the article, and approved the final version of the manuscript. RAA (0000-0003-1218-5412)* and JGLSN (0000-0002-5582-7158)* drafted the article and approved the final version of the manuscript. MLA (0000-0002-4456-6423)* conceived and designed the study, analyzed and interpreted the data, drafted the article, and approved the final version of the manuscript. DS (0000-0003-3437-6180)* and DFA (0000-0003-3006-7698)* conceived and designed the study and approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Bosco JA 3rd, Slover JD, Haas JP. Perioperative strategies for decreasing infection: a comprehensive evidence-based approach. Instr Course Lect. 2010;59:619-28.
2. Trampuz A, Zimmerli W. Diagnosis and treatment of infections associated with fracture-fixation devices. Injury. 2006;37(Suppl 2):S59-66.
3. Diefenbeck M, Mückley T, Hofmann GO. Prophylaxis and treatment of implant related infections by local application of antibiotics. Injury. 2006;37(Suppl 2): S95-104.
4. Campoccia D, Montanaro L, Arciola CR. The significance of infection related to orthopedic devices and issues of antibiotic resistance. Biomaterials. 2006;27(11):2331-9.
5. Darouiche RO. Treatment of infections associated with surgical implants. N Engl J Med. 2004;350(14):1422-9.
6. Bowen TR, Widmaier JC. Host classification predicts infection after open fracture. Clin Orthop Relat Res. 2005;(433):205-11.
7. McPherson EJ, Woodson C, Holtom P, Roidis N, Shufelt C, Patzakis M. Periprosthetic total hip infection: outcomes using a staging system. Clin Orthop Relat Res. 2002;(403):8-15.
8. Cierny G 3rd. Surgical treatment of osteomyelitis. Plast Reconstr Surg. 2011;127(Suppl 1):190S-204S.
9. Willenegger H, Roth B. Treatment tactics and late results in early infection following osteosynthesis. Unfallchirurgie. 1986;12(5):241-6.
10. Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. J Orthop Trauma. 1996;10 (Suppl 1):v-ix, 1-154.
11. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am.1976;58(4):453-8.
12. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control. 1999;27(2):97-132.
13. Schmidt HG, Diefenbeck M, Krenn V, Abitzsch D, Militz M, Tiemann AH, et al. Classification of haematogenous and post-traumatic osteomyelitis. Z Orthop Unfall. 2014;152(4):334-42.
14. Waldvogel FA, Medoff G, Swartz MN. Osteomyelitis: a review of clinical features, therapeutic considerations and unusual aspects (second of three parts). N Engl J Med. 1970;282(5):260-6.
15. Gentry LO. Osteomyelitis: options for diagnosis and management. J Antimicrob Chemother. 1988;21 (Suppl C):115-31.
16. Matos MA, Lima LG, de Oliveira LA. Predisposing factors for early infection in patients with open fractures and proposal for a risk score. J Orthop Traumatol. 2015;16(3):195-201.
17. Oliveira PR, Carvalho VC, Felix CS, Paula AP, Silva JS, Lima ALLM. Infecção de sítio cirúrgico após fixação de fraturas fechadas e expostas – Incidência e perfil microbiológico. Rev Bras Ortop. 2016;51(4):396-9.
18. Dellinger EP, Miller SD, Wertz MJ, Grypma M, Droppert B, Anderson PA. Risk of infection after open fracture of the arm or leg. Arch Surg. 1988;123(11):1320-7.
19. Srour M, Inaba K, Okoye O, Chan C, Skiada D, Schnüriger B, et al. Prospective evaluation of treatment of open fractures: effect of time to irrigation and debridement. JAMA Surg. 2015;150(4):332-6.

DOI: http://dx.doi.org/10.1590/1413-785220182601182340

RELATIONSHIP BETWEEN BONE MINERAL DENSITY AND BODY COMPOSITION IN ELDERLY

RELAÇÃO ENTRE A DENSIDADE MINERAL ÓSSEA E A COMPOSIÇÃO CORPORAL EM IDOSOS

Angélica Castilho Alonso[1,2], Tuane Andreatta Gonçalves[1], Jenifer Kristina Alves de Almeida[2], Adriana Machado-Lima[1,2], Rita de Cássia Ernandes[2], Julia Maria D'Andréa Greve[1], Luiz Eugênio Garcez-Leme[1,3]

1. Movement Study Laboratory, Department of Orthopedics and Traumatology, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.
2. Department of Graduate Studies in Aging Sciences, Universidade São Judas Tadeu, São Paulo, SP, Brazil.
3. Orthogeriatrics Group, Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: To evaluate the association between bone mineral density (BMD) and body composition in healthy older adults at different skeletal sites. Methods: We analyzed 87 medical records and BMD along with the body composition of men ranging from 60 to 87 years of age (mean: 68.5, standard deviation: 6.5). Inclusion criteria were normal BMD values (T-score greater than or equal to -1.0) and body mass index within normal or overweight range (18.5 to 29.5 kg/m^2). Body composition was evaluated using bone densitometry with dual-energy X-ray absorptiometry (DEXA) in a LUNAR-DPX apparatus. Results: Greater lean mass, fat mass, and soft tissue was associated with better BMD values in older adults, and higher age was associated with poorer BMD. Conclusion: Body composition (lean and fat masses and soft tissue) in older men is positively associated with BMD at all body sites (arms, legs, and trunk). ***Level of Evidence II; Prognostic studies - Investigating the effect of a patient characteristic on the outcome of disease.***

Keywords: Body composition. Bone density. Densitometry. Osteoporosis. Aged.

RESUMO

Objetivo: Avaliar a associação entre a DMO e a composição corporal em idosos hígidos em diferentes sítios esqueléticos. Métodos: Foram analisados 87 prontuários e exames de DMO com composição corporal de idosos do sexo masculino com média de idade de 68,5 (6,5) variando de 60 a 87 anos. Os critérios de inclusão foram valores de DMO dentro do normal (T-score maior ou igual a -1,0); IMC dentro dos valores normais ou sobrepeso (18,5 a 29,5 kg/m^2). A composição corporal foi avaliada por meio de densitometria óssea por dupla emissão de raios-X (DEXA) em aparelho LUNAR-DPX. Resultados: Quanto maior as massas magra e gorda e os tecidos moles, melhor os valores da DMO dos idosos e quanto maior a idade, pior a qualidade da DMO. Conclusão: A composição corporal (massas magra e gorda e tecidos moles) de homens idosos associa-se positivamente na DMO em todos os locais do corpo (membros superiores, inferiores e tronco). ***Nível do Evidênci II; Estudos prognósticos - Investigação do efeito de caractetísticas de um paciente sobre o desfecho da doença.***

Descritores: *Composição corporal. Densidade mineral óssea. Densitometria. Osteoporose. Idoso.*

Citation: Alonso AC, Gonçalves TA, Almeida JKA, Machado-Lima A, Ernandes RC, Greve JMD, Garcez-Leme LE. Relationship between bone mineral density and body composition in elderly. Acta Ortop Bras. [online]. 2018;26(1):27-9. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

According to Rodrigues-Filho et al.,[1] maintenance of bone mineral density (BMD) is very important to prevent osteoporosis, which is characterized by an imbalance between the activity of the osteoblastic and osteoclastic cells; in other words, the matrix and the bone minerals are lost due to excessive bone resorption in comparison with formation.

In order for adequate bone mineralization to occur, three interrelated factors must be present: the levels of circulating hormones that act in the process of calcification, mechanical load imposed on the skeleton, and adequate intake and production of calcium and vitamin D.[1,2]

The prevalence of osteoporosis in the United States is 10.2 million in people aged 50 years or older. The risk of fracture coincides with a high risk of morbidity and early mortality.[2]

In Brazil, a study involving individuals aged 70 years or above found that the prevalence of osteoporosis in the femoral neck was 33% in women and 16% in men.[3]

Excess body weight may have a preventive effect and the ability to modify the process of bone resorption. The possibility of developing osteoporosis is known to be lower when the BMI is higher,[4] but obesity has adverse pathophysiological consequences for the bones and skeletal muscle. For example, the infiltration of intramuscular fat, which is part of the aging process, is associated with muscle weakness, and consequently increased risk of fracture.[5-8]

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

Work conducted at the Movement Study Laboratory, Department of Orthopedics and Traumatology, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.
Correspondence: Rua Ovídeo Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil, 05403-010. angelicacastilho@msn.com

Article received in 07/05/2017, approved in 08/18/2017.

CC BY NC

Body weight is substantially composed of lean mass and fat mass, and the relative contribution of these masses to BMD continues to be a controversial issue.[1-5,9]

The goal of this study, therefore, was to assess the association between BMD and body composition in healthy older individuals within normal or overweight BMI ranges at different skeletal sites.

METHODS

Sample

We analyzed 87 medical records and BMD evaluations as well as body composition of elderly male group patients in the Geriatrics Group at the Instituto de Ortopedia e Traumatologia (IOT) at the Faculdade de Medicina da Universidade de São Paulo (USP). All the evaluations were performed by a specialized team using the same machine in the IOT Radiology Department and the reports were emitted by the physician in charge from 2001 to 2015.

The inclusion criteria were BMD within normal values (T-score greater than or equal to -1.0) and BMI within normal or overweight range (18.5 to 29.5kg/m^2).

This cross-sectional study was approved by the institutional review board at the Universidade de São Paulo (CAPesq no. 1167/06).

BMD and body composition testing

Body composition was assessed through densitometry with dual-energy X-ray absorptiometry (DEXA) in a LUNAR-DPX device (Madison Corporation, USA).

Statistical analysis

The data were entered and analyzed in SPSS 20.0 software. The Kolmogorov-Smirnov test was used to assess whether the continuous quantitative variables presented normal distribution.

Spearman's correlation coefficient was used to correlate the dependent variable (BMD) with the independent variables (anthropometric characteristics and body composition). An alpha of 5% was used for all statistical tests.

RESULTS

The characteristics of the individuals who participated in the study are described in Table 1.

The data presented in Table 2 show that age had a negative influence on BMD, with the increased age associated with lower BMD. The anthropometric variables all had a positive correlation with BMD, particularly body mass and consequently BMI, with higher values for body weight and BMI corresponding to an increase in BMD.

Table 3 shows the correlation between BMD in different sites with lean mass, fat mass, and soft tissue, and all these variables showed a positive correlation with BMD.

DISCUSSION

The main finding of this study was that body composition (lean and fat mass and soft tissue) is associated with BMD in older men.

Table 1. Characteristics of the study population (anthropometric characteristics and age).

Variable	Older adults		
	Mean (SD)	Minimum	Maximum
Age (years)	68.5(6.5)	60	87
Anthropometric characteristics			
Height (cm)	164.7(5.5)	155	180
Weight (kg)	65.4(7.0)	49	81
BMI (kg/m^2)	24.0(2.2)	19.8	29.8

Table 2. Correlation between bone mineral density (BMD) and anthropometric variables.

Variable	Group of older adults
	N = 87
	BMD (g/cm^2) r(p)
Age	-.263(0.01)*
Anthropometric characteristic	
Height (cm)	.221(0.04)*
Weight (kg)	.630(p≤0.001)*
BMI (kg/m^2)	.576(p≤0.001)*

r - Spearman's correlation coefficient, p≤0.05. BMD= bone mineral density; BMI= body mass index.

Table 3. Correlation between bone mineral density (BMD) and body composition.

		Group of older adults
		N = 87
Region	Variable	BMD (g/cm^2) r (p)
Arm	Fat mass (%)	.264(0.01)*
	Soft tissue (g)	.621(p≤0.001)*
	Fat mass (g)	.432p≤0.001)*
	Lean mass (g)	.579(p≤0.001)*
Leg	Fat mass (%)	.175(0.11)
	Soft tissue (g)	.547(p≤0.001)*
	Fat mass (g)	.352 (0.01)*
	Lean mass (g)	.472(p≤0.001) *
Trunk	Fat mass (%)	.370(.001)*
	Soft tissue (g)	.550(p≤0.001) *
	Fat mass (g)	.422 (p≤0.001)*
	Lean mass (g)	.482(p≤0.001)*
Body -Total	Fat mass (%)	.340(.002)*
	Soft tissue (g)	.600(p≤0.001)*
	Fat mass (g)	.439(p≤0.001)*
	Lean mass (g)	.528(p≤0.001) *

r - Spearman's correlation coefficient, p≤0.05. BMD= bone mineral density.

There was a negative correlation between age and BMD, namely, greater age was correlated with lower BMD, corroborating the work of Biana et al.,[10] who claimed that this mainly occurs at the end of the last decade of life, and may correspond to 5-10% of total bone mass/decade. The reasons for this may include nutritional deficiencies, some chronic diseases, and lack of exercise.

Lean mass, fat mass, and soft tissue mass were positively associated with BMD. This means that body composition promotes mechanical load on the bone, inducing the formation of osteoblasts and the piezoelectric effect; this positive relationship has already been demonstrated in another study.[5,9,10]

It is agreed that lean mass has a positive impact on bone quality;[5,9-12] in this study lean mass had higher correlation values than the other masses. Plujim et al.[10] stated that individuals with greater lean mass generally have a more active lifestyle, with more adequate nutritional habits that may have a direct impact on bone health. Furthermore, the studies by Binder et al.[11] and Vilassa et al.[12] claimed that greater muscle strength leads to better muscle contraction, in turn impacting specific bone sites to produce specific deformations, and stimulating bone cells that are anatomically related to these muscles, which also explains the piezoelectric effect in the increase of bone mass.

Body composition changes significantly in older individuals, including increase and redistribution of adipose tissue; this distribution progressively increases in the abdominal cavity and is less in the

limbs. Although fat mass also had positive relationships in all sites, this is not the most appropriate way of improving bone quality. According to Zhang et al.[13] and Sheu et al.,[14] fat (and especially abdominal fat) elevates the risk for metabolic diseases, sarcopenia, and functional decline. Higher levels of visceral fat reduce muscle mass and increase fragility and risk of fracture through intramuscular fat infiltration.[13-15]

The individuals analyzed in this study were within normal or overweight BMI ranges; we found that both lean and fat masses improve bone quality, but more lean mass in the body composition improves bone biomechanics, stimulating osteoblasts and bone cells and may indicate less modification in BMD during the aging process, as stated by Coin et al.[16]

CONCLUSION

Body composition (lean mass, fat mass, and soft tissue mass) in older men is positively associated with BMD at all sites of the body (arms, legs, and trunk).

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. ACA (0000-0002-9644-5068)* was the lead author, analyzed the data and constructed the article; TAG (0000-0002-3518-6111)* tabulated the data and assisted in constructing the article; AML (0000-0002-5741-3418)* assisted in constructing the article; JKAA (0000-0001-9658-0166)* assisted in constructing the article and was responsible for submission; RCE (0000-0003-2272-5320)* assisted in constructing the article; LEGL (0000-0002-9738-5466)* was the doctor responsible for requesting, collecting, and analyzing the exams and made final corrections to the work. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Rodrigues Filho EA, Santos MA, Silva AT, Farah BQ, Costa MC, Campos FA, et al. Relação entre composição corporal e densidade mineral óssea em jovens universitários com diferentes estados nutricionais. Einstein. 2016;14(1):12-7.
2. Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int. 2006;17(12):1726-33.
3. Camargo MB, Cendoroglo MS, Ramos LR, de Oliveira Latorre MR, Saraiva GL, Lage A, et al. Bone mineral density and osteoporosis among a predominantly Caucasian elderly population in the city of São Paulo, Brazil. Osteoporos Int. 2005;16(11):1451-60.
4. Van Langendonck L, Claessens AL, Lefevre J, Thomis M, Philippaerts R, Delvaux K, et al. Association between bone mineral density(DXA), body structure, and body composition in middle-aged men. Am J Hum Biol. 2002;14(6):735-42.
5. Chaves LM, Gomes L, Oliveira RJ, MB Marques. Relação entre variáveis da composição corporal e densidade mineral óssea em mulheres idosas. Rev Bras Med Esp. 2005;11(6):319-23.
6. Ozeraitiene V, Butenaite V. The evaluation of bone mineral density based on nutritional status, age, and anthropometric parameters in elderly women. Medicina (Kaunas). 2006;42(10):836-42.
7. Wong AK, Beattie KA, Min KK, Gordon C, Pickard L, Papaioannou A, et al. Canadian Multicentre Osteoporosis Study (CaMos) Research Group. Peripheral quantitative computed tomography-derived muscle density and peripheral magnetic resonance imaging-derived muscle adiposity: precision and associations with fragility fractures in women. J Musculoskelet Neuronal Interact. 2014;14(4):401-10.
8. Bian P, Li X, Ying Q, Chen J, Jin X, Yao J, et al. Factors associated with low femoral neck bone mineral density in very elderly Chinese males. Arch Gerontol Geriatr. 2015;61(3):484-8.
9. Ho-Pham LT, Nguyen ND, Lai TQ, Nguyen TV. Contributions of lean mass and fat mass to bone mineral density: a study in postmenopausal women. BMC Musculoskelet Disord. 2010;11:59.
10. Pluijm SM, Visser M, Smit JH, Popp-Snijders C, Roos JC, Lips P. Determinants of bone mineral density in older men and women: body composition as mediator. J Bone Miner Res. 2001;16(11):2142-51.
11. Binder EF, Kohrt WM. Relationships between body composition and bone mineral content and density in older women and men. Clin Exerc Physiol 2000;2:84-91.
12. Vilassa KHC, Ferriolli E, Lima NKC, Paula FJA, Marchini JS, Moriguti JC. Força muscular e densidade mineral óssea em idosos eutróficos e desnutridos. Rev Nutr Campinas. 2011;24(6):845-52.
13. Zhang P, Peterson M, Su GL, Wang SC. Visceral adiposity is negatively associated with bone density and muscle attenuation. Am J Clin Nutr. 2015;101(2):337-43.
14. Sheu Y, Marshall LM, Holton KF, Caserotti P, Boudreau RM, Strotmeyer ES, et al. The Osteoporotic Fractures in Men (MrOS) Research Group. Abdominal body composition measured by quantitative computed tomography and risk of non-spine fractures: the Osteoporotic Fractures in Men (MrOS) study. Osteoporos Int. 2013;24(8):2231–41.
15. Song HJ, Oh S, Quan S, Ryu OH, Jeong JY, Hong KS, et al. Gender differences in adiponectin levels and body composition in older adults: Hallym aging study. BMC Geriatr. 2014;14:8.
16. Coin A, Sergi G, Benincà P, Lupoli L, Cinti G, Ferrara L, et al. Bone mineral density and body composition in underweight and normal elderly subjects. Osteoporos Int. 2000;11(12):1043-50.

DOI: http://dx.doi.org/10.1590/1413-785220182601181195

ORIGINAL ARTICLE

MODIFIED DEGA OSTEOTOMY IN TREATING DEVELOPMENTAL DYSPLASIA OF THE HIP

OSTEOTOMIA DE DEGA MODIFICADA NO TRATAMENTO DA DISPLASIA DO DESENVOLVIMENTO DO QUADRIL

Roberto Guarniero[1], Fernando Barbosa Sanchez[1], Bruno Sergio Ferreira Massa[1], Nei Botter Montenegro[1], Patrícia Moreno Grangeiro[1], Luiz Renato Agrizzi De Angeli[1]

1. Pediatric Orthopedics Group, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: To retrospectively evaluate the preliminary postoperative results of modified Dega-type acetabular osteotomy to treat developmental dysplasia of the hip, confirming the efficacy and reproducibility of this technique. Methods: This retrospective study included patients older than 18 months. A total of 19 hips underwent modified Dega osteotomy. Results: Satisfactory results were obtained, with an average decrease of the acetabular index from 39.2 to 20.6 degrees. The final average center edge angle was 29.6 degrees. Hip joint congruence was reestablished in all cases, and as of this writing, only one case developed necrosis in the femoral head during follow-up. Conclusion: Modified Dega osteotomy demonstrated good initial results, as well as the potential for use in treating developmental dysplasia of the hip. ***Level of Evidence IV; Case series.***

Keywords: Arthroplasty, replacement, hip/methods. Hip dislocation, congenital. Osteotomy. Radiography.

RESUMO

Objetivo: Avaliar, retrospectivamente, os resultados preliminares do pós-operatório de pacientes com displasia do desenvolvimento do quadril, tratados com osteotomia acetabular do tipo Dega modificada e, dessa forma, confirmar a eficácia da técnica. Métodos: Neste estudo retrospectivo foram incluídos pacientes com idades acima de 18 meses. No total, 19 quadris foram submetidos à osteotomia de Dega modificada. Resultados: Os resultados foram satisfatórios, com diminuição média do índice acetabular de 39,2 para 20,6 graus. A média final do ângulo centro-borda foi de 29,6 graus. Em todos os casos houve restabelecimento da congruência articular dos quadris e, até o momento, um caso apresentou necrose da cabeça do fêmur no mesmo período do seguimento. Conclusão: A osteotomia de Dega modificada demonstrou bons resultados iniciais e potencial para ser empregada no tratamento da displasia do desenvolvimento do quadril. ***Nível de Evidência IV; Série de casos.***

Descritores: *Artroplastia de quadril/métodos. Luxação congênita de quadril. Osteotomia. Radiografia.*

Citation: Guarnieiro R, Sanchez FB, Massa BSF, Montenegro NB, Grangeiro PM, De Angeli LRA. Modified dega osteotomy in treating developmental dysplasia of the hip. Acta Ortop Bras. [online]. 2018;26(1):30-2. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Developmental dysplasia of the hip (DDH) describes a broad spectrum of pathological conditions ranging from subtle acetabular dysplasia to irreducible hip dislocation. Salter,[1] and later Wedge,[2] showed that acetabular dysplasia was secondary to malpositioning of the hip. This condition generates marginal erosion from torsion, localized hypoplasia, or overall deficiency of the acetabulum, and reduces the contact area between the acetabular surface with a frequently misshapen femoral head.

The incidence of DDH varies depending on several factors, including even geography. Approximately one in every 1,000 newborn infants is born with hip dislocation and around 10 in 1,000 with hip subluxation.[3] In Brazil, Volpon and Carvalho Filho[4] found an incidence of 2.31 per 1,000. The disease is more prevalent in children born breech and girls; the left side is most affected, firstborn children are twice as likely to be affected than subsequent siblings, and positive family history may be involved in 12% to 33% of cases.[5] The goal of treatment in older children is to delay or prevent the development of osteoarthritis and avoid the need for arthroplasty at a young age.[2]

Several pelvic osteotomies have been described to treat residual acetabular dysplasia secondary to DDH. These osteotomies can be performed as an isolated procedure or in conjunction with open reduction of the hip and proximal femoral osteotomy.

In 1969, Dega[6] reported what he described as a transiliac osteotomy, which consists of an incomplete supra-acetabular osteotomy that preserves the internal plate of the posterior pelvis in relation to the iliopectinial line, preserving the entire cortex of the sciatic notch

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

Work conducted at the Department of Pediatric Orthopedics, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.
Correspondence: Fernando Barbosa Sanchez. Rua Oscar Freire 2040, Apto 153, Pinheiros, São Paulo, SP, Brazil. 05409-011. sanchezfbs@gmail.com

Article received in 06/08/2017, approved in 08/23/2017.

CC BY NC

and leaving a posteromedial hinge intact. A graft of iliac bone is placed in the osteotomy. This surgical technique has been shown to be capable of improving lateral coverage of the hip to near-normal values in patients with DDH. In 1992, Mubarak et al.[7] described the modified Dega technique to treat hip dislocation in patients diagnosed with spastic cerebral palsy.

Although there is significant causality for the Salter osteotomy to correct hip dysplasia in patients with DDH as well as for the use of the Dega osteotomy to treat hip dysplasia in patients with cerebral palsy, there are few publications in Portuguese on the use of the Dega technique in patients diagnosed with DDH.

The objective of this study is to retrospectively assess the preliminary postoperative results in patients with developmental dysplasia of the hip who were treated with modified Dega-type acetabular osteotomy, thus confirming the validity and reproducibility of this technique in treating DDH. The target in the follow-up was new radiographic analysis at five and 10 years after the procedure.

METHODS

This study was approved by the institutional review board at the Instituto de Ortopedia e Traumatologia do Hospital das Clínicas de São Paulo, where the study was conducted (approval number 14117, process number 1,433,929). Since this is a retrospective case series using X-rays, informed consent was not required from patients.

Inclusion criteria

We included patients over age 18 months with a diagnosis of DDH who underwent modified Dega osteotomy between January 2012 and May 2016 at the Institute of Orthopedics and Traumatology, at HCFMUSP. Exclusion criteria were patients with diagnoses of genetic syndromes and/or neuromuscular alterations.

All procedures were conducted by the same group of surgeons specialized in pediatric orthopedics, and followed the technique described by Mubarack et al.[7]

The femur was shortened when necessary to facilitate reduction of the hip, and the principle of relative stability was used along with a 3.5mm DCP plate with four holes. This shortening does not correct rotation and varusing.

We analyzed anteroposterior X-rays of the pelvis taken before the procedure and in the early and late post-procedure periods. The X-rays were analyzed by an experienced pediatric orthopedist from our institute who was familiar with the parameters evaluated, but blinded with regard to the images and the study. The images were randomly distributed before the evaluation. The parameters evaluated in all the X-rays were acetabular index, center-edge angle, Shenton line, and presence of avascular necrosis of the femoral head in accordance with the criteria by Salter.[8-10] (Figures 1 and 2)

Statistical analysis

The values for acetabular index, center edge angle, and measurement of the Shenton line before surgery, immediately after the surgery, and one in the late postoperative period were compared using a paired t-test.

RESULTS

The sample consisted of 17 patients (19 hips) with a minimum age of 2 years and 1 month (2y1m) and a maximum age of 7y2m, mean age of 3y6m; 3 patients (15.79%) were male and 16 were female (84.21%). The right side was affected in 9 hips (47.4%) and the left in 10 hips (52.6%). Two patients were bilaterally affected. Shortening of the femur was associated in 6 cases (31.6%) to facilitate hip reduction. (Table 1) Mean follow-up time was 18.2 months.

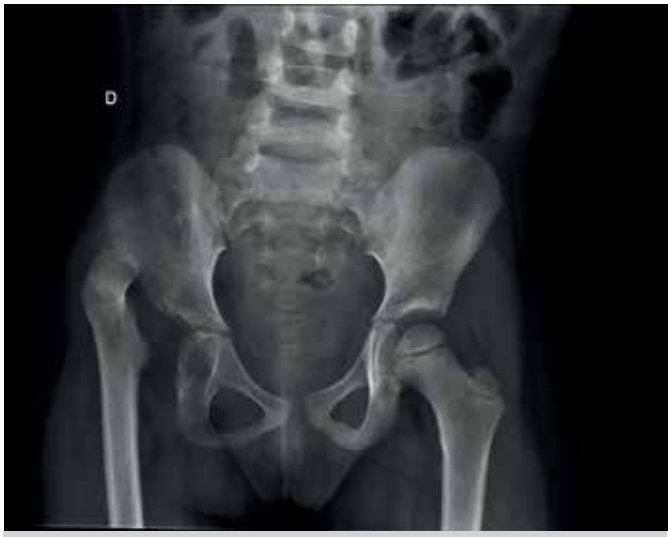


Figure 1. Preoperative antero-posterior X-ray of the pelvis from one of the patients evaluated in the study. Source: Instituto de Ortopedia e Traumatologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo.

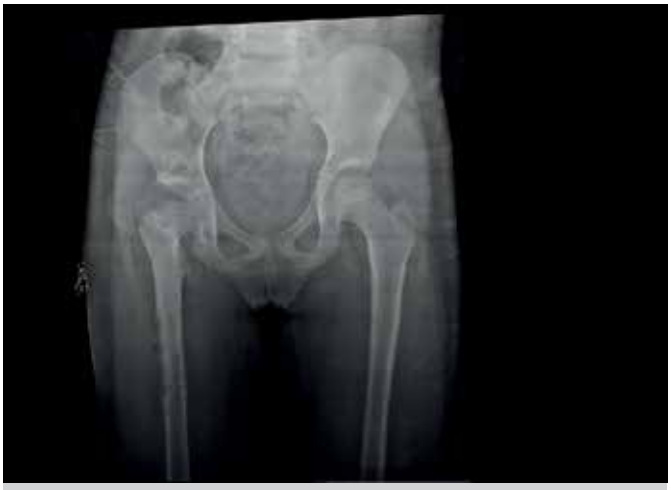


Figure 2. Late postoperative X-ray of the pelvis from the same patient in Figure 1. Source: Instituto de Ortopedia e Traumatologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo.

Table 1. Patient characteristics.

Variable	Description (N=19)
Age (months), mean±SD	42.8±13.9
Sex, n(%)	
Female	16 (84.2%)
Male	3 (15.8%)
Side, n(%)	
Right	9 (47.4%)
Left	10 (52.6%)

One patient developed avascular necrosis during the follow-up period. Postoperative complications such as infection, wound dehiscence, and redislocation were not observed.

The mean preoperative acetabular index was 39.26 degrees, ranging from 21 to 52 degrees, and decreased to a mean value of 24.32 degrees in the immediate postoperative period, ranging from 12 to 32 degrees; at the end of the study period, this mean value

was 20.68 degrees, ranging from 14 to 29 degrees. A significant difference was seen between the mean acetabular index prior to the surgery and in the immediate postoperative period ($p<0.01$), and this was seen in comparing the preoperative and late follow-up values ($p<0.01$). A significant difference was seen between the mean acetabular index and the values immediately after the surgery and at the end of the study ($p<0.01$). (Figure 3)

The center-edge angle in the preoperative period was not included in the analysis, because the hips were dislocated, which impairs its calculation. In the immediate postoperative period the average center-edge angle was 25.95 degrees, ranging from 15 to 35 degrees, and at late follow-up the mean center-edge angle was 29.63, ranging from 17 to 50 degrees ($p<0.085$). This difference, although not statistically significant, suggests some degree of remodeling and improvement of acetabular coverage over time.

With regard to the Shenton line, this was restored in 100% of patients at late follow-up.

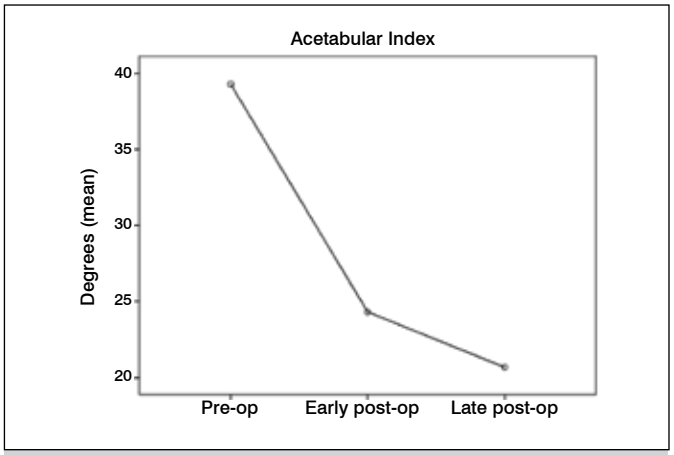


Figure 3. Preoperative, early postoperative, and late postoperative outcomes for the acetabular index.

DISCUSSION

Treatment of late-diagnosed DDH still represents a major challenge for pediatric orthopedic surgeons. Although several pelvic osteotomy techniques have been developed to restore hip joint congruence in these children, there is still debate about which technique is best. The Dega osteotomy, modified by Mubarak et al.[7] in 1992, became the surgical procedure of choice to treat children with neuromuscular dysplasia. Few studies have correlated this type of osteotomy with treatment of DDH.

This surgical technique was seen to successfully restore hip joint congruence from the radiographic parameters studied. The acetabular index decreased by an average of 39.2 to 20.6 degrees, results comparable to those found in previous studies, such as by Ahmed Al-Ghamdi et al.,[11] who found a decrease in the acetabular index from 37 to 19 in a series of 21 cases.

The mean late postoperative center edge angle was 29.63, within the range of 25 and 40 considered normal.[12] According to Wiberg[8] and Cooperman et al.,[13] center edge angle values below 10 are closely linked to the development of osteoarthritis in adults. The difference between the values of the center edge angle in the immediate postoperative and late postoperative periods was not initially statistically significant. In this present study, one of the patients developed necrosis of the femoral head. In all of the patients, hip reduction was obtained and the Shenton line was restored.

Despite the satisfactory results, some limitations of this study should be highlighted. One limitation is the immaturity of the hip in childhood and the fact that changes related to dysplasia make the measurements mentioned above difficult to obtain. Parameters such as the lateral edge of the acetabulum, the core of ossification of the femoral head, and triradiate cartilage, if altered, can complicate measurement of the indices. Another limitation is the lack of correlation between the clinical and radiographic data, for example range of motion, claudication, and leg length discrepancy.

Despite the limitations presented, the radiographic data from our study showed very satisfactory results which closely resembled previous studies.[11,14] The restoration of joint congruence is the final goal in treating children with DDH, and through this case series we show that the modified Dega osteotomy can be used for this purpose. In the present study, there was no increase in the number of early complications. Other techniques should be compared in the near future, but we believe that the selection of techniques should consider not only radiographic and clinical data, but also the experience of each surgeon.

CONCLUSION

Modified Dega osteotomy showed good initial radiological results and the potential for use in treating developmental dysplasia of the hip.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. RG (0000.0002.1798.0653)*, LRAA (0000.0003.3779.6914)*, NBM (0000.0002.0705.1623)* and PMG (0000.0002.1533.659X)* contributed to the intellectual content and analyzed the results. FBS (0000.0003.2211.9347)* drafted the article, performed the statistical analysis, revised the article and submitted the manuscript. BSFM (0000.0002.3335.8661)* contributed to the intellectual content, analyzed the results, revised the manuscript, and performed the surgeries. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Salter RB. Role of innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip in the older child. J Bone Joint Surg Am. 1966;48(7):1413-39.
2. Wedge JH. Hip joint acetabular dysplasia. J Pediatr Orthop. 1997;17(2):141-2.
3. Guarniero R. Displasia do desenvolvimento do quadril: atualização. Rev Bras Ortop. 2010;45(2):116-21.
4. Volpon JB, Carvalho Filho G. Luxação congênita do quadril no recém-nascido. Rev Bras Ortop. 1985;20(7):317-20.
5. Bowen JR, Kotzias-Neto A. Developmental dysplasia of the hip. Brooklandville: Data Trace Publishing Company; 2006.
6. Dega W. Selection of surgical methods in the treatment of congenital dislocation of the hip in children. Chir Narzadow Ruchu Ortop Pol.1969;34(3):357-66.
7. Mubarak SJ, Valencia FG, Wenger DR. One-stage correction of the spastic dislocated hip. Use of pericapsular acetabuloplasty to improve coverage. J Bone Joint Surg Am. 1992;74(9):1347-57.
8. Wiberg G. Studies on dysplastic acetabula and congenital sublux- ation of the hip joint. With special reference to the complication of osteoarthritis. Acta Chir Scand. 1939;58-83(Suppl):5-135.
9. Jones DH. Shenton's line. J Bone Joint Surg Br. 2010;92(9):1312-5.
10. Salter RB, Kostuik J, Dallas S. Avascular necrosis of the femoral head as a complication of treatment for congenital dislocation of the hip in Young children: a clinical and experimental investigation. Can J Surg. 1969;12(1):44-61.
11. Al-Ghamdi A, Rendon JS, Al-Faya F, Saran N, Benaroch T, Hamdy RC. Dega osteotomy for the correction of acetabular dysplasia of the hip: a radiographic review of 21 cases. J Pediatr Orthop. 2012;32(2):113-20.
12. Tönnis D. Normal values of the hip joint for the evaluation of X-rays in children and adults. Clin Orthop Relat Res. 1976;(119):39-47.
13. Cooperman DR, Wallensten R, Stulberg SD. Acetabular dysplasia in the adult. Clin Orthop Relat Res. 1983;(175):79-85.
14. El-Sayed MM, Hegazy M, Abdelatif NM, ElGebeily MA, ElSobky T, Nader S. Dega osteotomy for the management of developmental dysplasia of the hip in children aged 2-8 years: results of 58 consecutive osteotomies after 13 25 years of follow-up. J Child Orthop. 2015;9(3):191-8.

DOI: http://dx.doi.org/10.1590/1413-785220182601178667

ORIGINAL ARTICLE

ANALYSIS OF MEDICAL ASSISTANCE PROVIDED TO SPECTATORS AT THE 2014 FIFA WORLD CUP MATCHES

ANÁLISE DA ASSISTÊNCIA MÉDICA PRESTADA AOS ESPECTADORES NOS JOGOS DA COPA DO MUNDO DA FIFA DE 2014

Gustavo Gonçalves Arliani[1], Paulo Henrique Schmidt Lara[1], André Pedrinelli[2], Benno Ejnisman[1], Luiz Marcelo Bastos Leite[1], Moises Cohen[1]

1. Center of Sports Traumatology, Departament of Orthopedics and Traumatology at the Universidade Federal de São Paulo, SP, Brazil.
2. Institute of Orthopedics and Traumatology at the Hospital das Clinicas, Faculdade de Medicina da Universidade de São Paulo, SP, Brazil.

ABSTRACT

Objective: Several studies have already described the main injuries to soccer players during FIFA World Cup events; however, little is known about the main reasons spectators require medical assistance during these matches. The aim of this study is to assess the number of cases and main reasons spectators required medical assistance during the 2014 World Cup matches in Brazil. Methods: Data were collected from spectators who received medical assistance on all game days, and factors related to the assistance provided were analyzed. Results: Medical assistance was given to spectators in a total of 6,222 cases during the 64 games played in Brazil, an average of 97.2 times per game. The total number of spectators removed from the stadiums by ambulance was 167, a mean of 2.6 removals per game. The main reasons spectators required medical assistance during the World Cup games were headache, gastrointestinal problems, and trauma. Conclusions: Most spectators required medical assistance during the World Cup games for headache, gastrointestinal problems, and trauma; this information is fundamental to develop new prevention strategies and plan medical assistance for large-scale events. ***Level of Evidence IV; Case series.***

Keywords: Soccer. Medical assistance. Sports medicine.

RESUMO

Objetivo: Vários estudos já descreveram as principais lesões dos jogadores de futebol durante os eventos da Copa do Mundo da FIFA; entretanto, pouco se sabe sobre as principais razões para assistência médica aos espectadores durante as partidas. O objetivo deste estudo é avaliar o número de casos e as principais razões pelas quais os espectadores necessitaram de assistência médica durante os jogos da Copa do Mundo de 2014 no Brasil. Métodos: Foram coletados dados dos espectadores que receberam assistência médica durante todos os dias de jogos e os fatores relacionados ao atendimento foram analisados. Resultados: A assistência médica foi prestada aos espectadores em 6.222 casos durante os 64 jogos no Brasil, com média de 97,2 assistências por jogo. O número total de remoções com ambulância foi de 167, com média de 2,6 remoções por jogo. As principais razões para a assistência médica durante os jogos da Copa do Mundo foram cefaleia, problemas gastrintestinais e trauma. Conclusões: A maioria dos espectadores precisou de assistência médica durante os jogos da Copa do Mundo em decorrência de cefaleia, problemas gastrintestinais e trauma; essa informação é fundamental para o desenvolvimento de novas estratégias de prevenção e planejamento de assistência médica em eventos de massa. ***Nível de Evidência IV; Série de casos.***

Descritores: *Futebol. Assistência médica. Medicina esportiva.*

Citation: Arliani GG, Lara PHS, Pedrinelli A, Ejnisman B, Leite LMB, Cohen M. Analysis of medical assistance provided to spectators at the 2014 fifa world cup matches. Acta Ortop Bras. [online]. 2018;26(1):33-5. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The FIFA World Cup, one of the most popular sporting events, is watched on television by millions of people who, in turn, try to mimic the performance of football stars.[1]

Before the World Cup, approximately 10,000 health professionals were trained to act during the tournament. In addition to the plans for providing medical assistance to the spectators, contingency plans were also made for accidents with mass casualties and for scenarios with chemical, biological, radiological and nuclear products.[2]

The past history of accidents and catastrophes related to football matches shows the importance of practical and theoretical planning, preparation, simulation training and analysis of possible patient causes to guarantee the safety and good care of the public during the games in the event.[3,4] A detailed analysis of the causes of medical assistance to spectators during FIFA World Cup is helpful so that possible trends can be better understood and prevention strategies can be developed.[4]

The objective of the present study was to show the numbers and main causes of medical assistance to spectators throughout the matches during the 2014 World Cup games in Brazil.

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

Work conducted at the Center of Sports Traumatology, Departament of Orthopedics and Traumatology at the Federal University of São Paulo, SP, Brazil.
Correspondence: Paulo Henrique Schmidt Lara. Rua Estado de Israel, 636, Vila Clementino, São Paulo, SP, Brasil. 04022-001. phslara@gmail.com

Article received in 04/17/2017, approved in 08/01/2017.

CC BY NC

METHODS

This is a descriptive study with data collected from spectators who received medical assistance at the stadiums' medical rooms during the 64 games of the FIFA World Cup in 2014 in Brazil. Each medical station was trained and prepared to offer emergency medical assistance to spectators, players, and staff from three hours prior to until one hour after the matches. During the games, each of the 12 stadiums had medical stations. A patient record form was used to capture data related to medical assistance. Whenever necessary, the patients were transferred by ambulances to a predetermined referral hospital. This form was developed and approved prior to the tournament. At the end of each game, all the information and data collected were gathered and analyzed by the local medical coordinators.

The patient record forms were filled out by approximately 300 physicians who had received training prior to the World Cup. The data accumulated from all the 64 games played in Brazil included: (1) total number of spectators; (2) total number of assistances; (3) total number of removals; (4) public present in each stadium; (5) disease /injury categories cared for; (6) disease /injury categories transfer to the hospital; (7) relationship between public assistance and tournament phase; (8) relation between number of removals and tournament phase; (9) local accommodation rate. The information about the total number of spectators and public present in each stadium was provided by the local organizing committee (LOC).

The local accommodation rate was defined as the number of spectators per game compared to the maximum capacity for spectators in the stadiums. The patient care rate was defined as the number of patients per 1000 spectators per game. The hospital removal rate was defined as the number of patients transported to hospital by ambulance per 1000 spectators per game. Removal was defined as patients that were transferred to further medical management at a referral hospital.

The following disease and injury categories were used: Neurology/ Cephalea; Gastrointestinal Symptoms; Trauma; Dehydration; Myalgia; Cardiovascular Symptoms; Otorhinolaryngology /Ophthalmology; Dermatology; Respiratory Symptoms; Gynecology/ Obstetrics; Odontology and Urinary Symptoms.

The first phase of the tournament was considered the phase that each of the teams played three group matches and the second phase was considered from the round of 16 stage until the final match.

A mean value and standard deviation for each of the variables were calculated. These statistical analyses were made using the *SPSS for Windows* program, version *16.0*. Statistical methods applied were frequencies, cross-tabulations and x^2 test. Significance was accepted at 5% level. The Ethics and Research Committee of Federal University of São Paulo approved this study (IRB 1319 /10).

RESULTS

During the 2014 FIFA World Cup, 12 cities hosted the matches. The number of matches at each host city is listed in Table 1.

The total number of spectators at the 64 games of the tournament was 3,443,335 and the average attendance per game was 53,802 spectators. The local accommodation rate in the tournament was 91,9 %. The average attendance in the second phase of the tournament was 60,967 spectators, which was significantly greater than the average of 51,414 spectators in the first phase. ($p = 0,0065$)

The total number of medical assistance to spectators during the 64 games in Brazil was 6,222, with an average of 97,2 medical assistances per game. The mean age of patients was 31,7 years old (1–79). The division of medical assistance to spectators by gender during the tournament was 53,7 % male and 46,3 % female. The total number of patients who required removal was 167 (2,7% of the total), with a mean of 2,6 removals per game. The patient care rate during the tournament was 1,82. The removal rate of patients to hospital was 0,05.

The main causes for medical assistance during the World Cup games were neurology/cephalea, gastrointestinal problem and traumas. (Table 2)

The medical categories for removal are shown in Table 3.

The comparison between public, assistance and removals according to the phase of the games is shown in Table 4.

DISCUSSION

The present study, in addition to presenting the indices and main causes of medical assistance to spectators and removal during the 2014 FIFA World Cup, demonstrated differences in these indices in the two phases of the tournament showing the importance of the medical care and spectators assistance in the last games of the championship.

The patient assistance rate during the tournament was 1,824. Slightly lower rates were found by Morimura et al.[5], but it was within the range found in previous studies[4,5]. De Lorenzo et al.[6] reported that the rate of patient assistance in mass events varies from 0,14 to 19 patients per 1000 spectators. Possible factors related to the slightly large patient assistance rate include: larger public, greater local accommodation rate and the importance of the game.[7-9]

Table 1. Number of games at the 12 World Cup host cities.

Host Cities	
Brasília	7 (10.9%)
Rio de Janeiro	7 (10.9%)
Belo Horizonte	6 (9.4%)
Fortaleza	6 (9.4%)
Salvador	6 (9.4%)
São Paulo	6 (9.4%)
Porto Alegre	5 (7.8%)
Recife	5 (7.8%)
Cuiabá	4 (6.3%)
Curitiba	4 (6,3%)
Manaus	4 (6.3%)
Natal	4 (6,3%)
Total	64 (100%)

Table 2. Main causes for medical assistance during the World Cup games.

Causes for medical assistance	n	%
Neurology/Cephalea	1973	31.7
Gastrointestinal Symptoms	941	15.1
Trauma	932	15.0
Dehydration	645	10.4
Myalgia	459	7.4
Cardiovascular Symptoms	328	5.3
Otorhinolaryngology /Ophthalmology	349	5.6
Dermatology	191	3.1
Respiratory Symptoms	196	3.1
Gynecology/Obstetrics	138	2.2
Odontology	54	0.8
Urinary Symptoms	16	0.3
Total	6222	100

Table 3. Main causes of hospital removals during the games.

Causes of hospital removals	n	%
Trauma	62	37.1
Neurology/Cephalea	33	19.7
Cardiovascular Symptoms	21	12.6
Gastrointestinal Symptoms	17	10.2
Myalgia	9	5.4
Dehydration	8	4.8
Urinary Symptoms	6	3.6
Respiratory Symptoms	6	3.6
Gynecology/Obstetrics	2	1.2
Dermatology	2	1.2
Otorhinolaryngology/Ophthalmology	1	0.6
Odontology	0	0
Total	167	100

Table 4. Public, assistance and removals according to the phase of the games in the 2014 World Cup.

	Phase		Combined Average
	First (n=48)	Second (n=16)	(n=64)
Attendance per game			
Average (SD)	51413.9 (12134.7)	60966.6 (10392.8)	53802.1 (12367.4)
Minimum – Maximum	37603 – 74738	41242 – 74738	37603 – 74738
p-value	0.0065		
Medical assistance per game			
Average (SD)	86.8 (40.3)	128.6 (46.9)	97.2 (45.5)
Minimum – Maximum	27 – 198	54 – 222	27 – 222
p-value	0,001		
Patient care rate (‰)			
Average (SD)	1.70 (0.69)	2.17 (0.91)	1.82 (0.77)
Minimum – Maximum	0.69 – 3.25	0.79 – 4.36	0.69 – 4.36
p-value	0,0315		
Removals per game			
Average (SD)	2.4 (1.5)	3.3 (1.4)	2.6 (1.5)
Minimum – Maximum	0 – 7	1 – 5	0 – 7
p-value	0,0289		
Removal rate (‰)			
Average (SD)	0.05 (0.04)	0.06 (0.02)	0.05 (0.03)
Minimum – Maximum	0.00 – 0.17	0.02 – 0.09	0.00 – 0.17
p-value	n.s.		
‰: per thousand à 1‰ = 0,1%			

The present study found differences in the medical assistance rates between the two phases of the World Cup, with the final phase of the tournament having the greatest medical assistance rates. Other studies, however, have not reported a relationship between the number of medical assistances and total number of spectators.[4,10] Other factors may be important in increasing the number of medical assistance to spectators at major sporting events such as: consumption of alcohol, public education and high temperatures/weather during the matches. However, Burton et al.[11] found that alcohol was a contributing factor in only 5% of medical assistances in rugby matches and horse races in the United Kingdom.
The local accommodation rate in the tournament was 91,9%. Morimura et al.[5] reported a lower number (89%) in the 2002 Japan/Korea FIFA World Cup. This rate is an indicator of the public concentration and may have influenced the greater assistance rate found in the present study. Milsten et al.[12] also demonstrated that public density contributed to the number of patients treated at an event.
The patient hospital removal rate was 0,05 in the present study. Morimura et al.[5] reported a similar rate in the Japan/Korea World Cup (0,03 removals). The total number of patients taken to hospital in Brazil was 167 (2,7% of the total). The 2002 FIFA World Cup presented a higher percentage of removals, with 4,4% of the total of patients assisted being removed to referral hospitals.[5]
The main causes of medical assistance and removal during the games were neurology/cephalea, gastrointestinal problems, trauma and cardiovascular problems. Similar findings were reported in another study that the main causes of medical assistance were trauma, headache and abdominal symptoms.[7] Most cases treated during the games did not need removal to hospitals. However, an epidemiological analysis is extremely important in order to plan medical activities, especially in more severe cases that need more care. Nowadays, there is a growing recognition that good historical data for a specific event or type of event can help to forecast medical requirements.[13,14]
In the present study, no difference was found between the two phases of the championship in the patient removal rate. The reason for this phenomenon is unknown, and extra data collection and analyses would be necessary in future studies.
A limitation of the study was that the standard determined for disease and injury classification was not the same as that used in previous studies and severity of illnesses was not measured. The disease and injury classification should be standardized in epidemiological studies of the FIFA World Cups, so that the data can be compared and analyzed in a more precise manner.[3] Another limitation was the difficulty to follow the outcomes of the patients removed to hospital and to identify alcohol as a factor associated to trauma injuries. A final limitation is the variability in documentation among the many physicians.
This study showed medical assistance rate to spectators similar to previous studies but found differences between the two phases of the World Cup, with the final phase of the tournament having the greatest medical assistance rates. This difference hadn't been found in previous studies. This information is fundamental in the development of new prevention strategies and planning medical assistance at mass events.

CONCLUSION

The main causes for medical spectators assistance during the World Cup games were neurology/cephalea, gastrointestinal problem and trauma. There were statistically significant differences between the first and second phases with respect to total attendance per game, number of medical assistance to spectators per game, patient care rate, and number of patients that required removal per game. The results of the present study also offer an opportunity to follow long-term alteration in the frequency and circumstances of medical assistance at future FIFA World Cups.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. GGA (0000-0003-4371-5041)*: collected the data, wrote and reviewed the article, and analyzed the data; PHSL (0000-0002-1623-2071)*: collected the data, wrote and reviewed the article, analyzed the data, and performed the statistical analysis. AP (0000-0002-8449-7493)*: wrote and reviewed the article; BE (0000-0002-3301-1457)*: wrote and reviewed the article and analyzed the data; LMBL (0000-0001-6324-7797)*: wrote and reviewed the article; MC (0000-0001-7671-8113)*: wrote and reviewed the article and contributed to the intellectual concept of the study and the entire research project. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Junge A, Dvo ák J. Football injuries during the 2014 FIFA World Cup. Br J Sports Med. 2015;49(9):599-602.
2. Shoaf K, Osorio de Castro CG, Miranda ES. Hospital preparedness in advance of the 2014 FIFA World Cup in Brazil. Prehosp Disaster Med. 2014;29(4):409-12.
3. Lablanc ML, Henshaw R. Disasters and Tragedies. The world encyclopedia of soccer. 2nd ed. Detroit: Visible Ink Press;1994.
4. Jaslow D, Yancy A 2nd, Milsten A. Mass gathering medical care. National Association of EMS Physicians Standards and Clinical Practice Committee. Prehosp Emerg Care. 2000;4(4):359-60.
5. Morimura N, Katsumi A, Koido Y, Sugimoto K, Fuse A, Asai Y, et al. Analysis of patient load data from the 2002 FIFA World Cup Korea/Japan. Prehosp Disaster Med. 2004;19(3):278-84.
6. De Lorenzo RA. Mass gathering medicine: a review. Prehosp Disaster Med. 1997;12(1):68-72.
7. Franaszek J. Medical care at mass gatherings. Ann Emerg Med. 1986;15(5):600-1.
8. Michael JA, Barbera JA. Mass gathering medical care: a twenty-five year review. Prehosp Disaster Med. 1997;12(4):305-12.
9. Zeitz KM, Schneider DP, Jarrett D, Zeitz CJ. Mass gathering events: retrospective analysis of patient presentations over seven years. Prehosp Disaster Med. 2002;17(3):147-50.
10. Arbon P, Bridgewater FH, Smith C. Mass gathering medicine: a predictive model for patient presentation and transport rates. Prehosp Disaster Med. 2001;16(3):150-8.
11. Burton JO, Corry SJ, Lewis G, Priestman WS. Differences in medical care usage between two mass-gathering sporting events. Prehosp Disaster Med. 2012;27(5):458-62.
12. Milsten AM, Maguire BJ, Bissell RA, Seaman KG. Mass-gathering medical care: a review of the literature. Prehosp Disaster Med. 2002;17(3):151-62.
13. Zeitz KM, Zeitz CJ, Arbon P. Forecasting medical work at mass-gathering events: predictive model versus retrospective review. Prehosp Disaster Med. 2005;20(3):164-8.
14. Hartman N, Williamson A, Sojka B, Alibertis K, Sidebottom M, Berry T, et al. Predicting resource use at mass gatherings using a simplified stratification scoring model. Am J Emerg Med. 2009;27(3):337-43.

DOI: http://dx.doi.org/10.1590/1413-785220182601174278

ORIGINAL ARTICLE

ARCADE OF FLEXOR DIGITORUM SUPERFICIALIS MUSCLE: ANATOMICAL STUDY AND CLINICAL IMPLICATIONS

ARCADA DO MÚSCULO FLEXOR SUPERFICIAL DOS DEDOS: ESTUDO ANATÔMICO E IMPLICAÇÕES CLÍNICAS

Edie Benedito Caetano[1], João José Sabongi Neto[1], Luiz Angelo Vieira[1], Maurício Ferreira Caetano[2], José Eduardo de Bona[1], Thais Mayor Simonatto[1]

1. Faculdade de Ciências Médicas e da Saúde, Pontifícia Universidade Católica de São Paulo, Sorocaba, SP, Brazil.
2. Serviço de Cirurgia de Mão, Conjunto Hospitalar de Sorocaba, Sorocaba, SP, Brazil.

ABSTRACT

Objective: The arcade of the flexor digitorum superficialis muscle (FDS) is an anatomical structure which has not yet been widely studied and is a site of nerve compression. The aim of this study was to analyze the arcade of the FDS muscle and its relations with the median and anterior interosseous nerves through anatomic dissections. Method: Fifty arms from 25 adult cadavers (21 males and 4 females) were dissected; 18 were previously preserved in formalin and glycerin and 7 fresh specimens were dissected in the Laboratory of Anatomy. Results: The arcade of the superficial flexor muscle was identified in all dissected limbs. The radial and humeral heads were present in all specimens, and the ulnar head in 16 (32%). We identified two varieties of the arcade structure: a fibrous arcade in 32 specimens (64%), and a muscular arcade in 11 specimens (22%). In 4 specimens (8%) the arcade was very fine and so transparent that the nerve could be seen within the arcade. In 3 forearms the arcade was considered irregular because of discontinuity between the fibers that comprised this structure. Conclusion: The fibrous arcade of the FDS muscle may be a potential cause of nerve compression of the median and interosseous anterior nerves. ***Level of Evidence IV; Case series.***

Keywords: Muscle, skeletal/abnormalities. Nerve compression syndromes. Cadaver.

RESUMO

Objetivo: A arcada do músculo flexor superficial dos dedos (FSD) é um dos locais de compressão nervosa. Trata-se de uma estrutura anatômica ainda pouco conhecida. O objetivo do estudo foi analisar, através de dissecções anatômicas, a arcada do músculo FSD e suas relações com os nervos mediano e interósseo anterior. Método: Foram dissecados 50 membros superiores de 25 cadáveres adultos, 21 do sexo masculino e quatro do feminino, 18 previamente preservados em formol e glicerina e sete foram dissecados a fresco no Laboratório de Anatomia. Resultados: Identificamos a arcada do músculo flexor superficial em todos os membros dissecados. As cabeças radial e umeral estavam presentes em todos os antebraços e a cabeça ulnar foi encontrada em 16 (32%). Identificamos dois tipos de arcada, arcada fibrosa em 32 (64%) antebraços e arcada muscular em 11 (22%). Em quatro espécimes (8%), a arcada tinha constituição muito fina, sendo possível visualizar o nervo por transparência em seu interior. Em três antebraços, consideramos a arcada irregular, pois havia descontinuidade entre as fibras que a formavam. Conclusão: A arcada do músculo FSD de constituição anatômica fibrosa constitui um dos possíveis locais de compressão dos nervos mediano e interósseo anterior. ***Nível de Evidência IV; Série de casos.***

Descritores: *Músculo esquelético/anormalidades. Síndromes de compressão nervosa. Cadáver.*

Citation: Caetano EB, Sabongi Neto JJ, Vieira LA, Caetano MF, Bona JE, Simonatto TM. Arcade of flexor digitorum superficialis muscle: anatomical study and clinical implications. Acta Ortop Bras. [online]. 2018;26(1):36-40. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The median nerve, which is formed by the junction of the lateral and medial fasciculi of the brachial plexus, originates in nerve fibers within the spinal roots of C5 to T1. In the distal region of the arm, this nerve passes between the brachialis muscle and the intermuscular septum, continues through the cubital fossa, and passes through the bicipital aponeurosis (lacertus fibrosus). It continues its trajectory, passing between the superficial and deep head of the pronator teres muscle, then enters the arcade formed by the humeral, ulnar, and radial insertions of the flexor digitorum superficialis muscle.[1-3] Pronator syndrome is one of three compressive syndromes which affect the median nerve; the other two are anterior interosseous nerve syndrome and the much more common carpal tunnel syndrome. Consequently, whenever a patient presents symptoms of compression of the median nerve, carpal tunnel syndrome should be initially suspected.[1]

The term pronator syndrome was first used by Seyffarth[4] in 1951 to describe compressive neuropathy of the median nerve in the

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

Work conducted at the Faculdade de Ciências Medicas e da Saúde, Pontifícia Universidade Católica de São Paulo, Sorocaba, SP, Brazil.
Correspondence: Faculdade de Ciências Medicas e da Saúde, Pontifícia Universidade Católica de São Paulo. Rua Joubert Wey, 290, Sorocaba, SP. 18030-070. ediecaetano@uol.com.br

Article received in 01/10/2017, approved in 11/09/2017.

CC BY NC

proximal forearm. Classically, pronator syndrome presents as paresthesia in the distribution of the median nerve and pain in the forearm, while proximal weakness may occur in the flexor-pronator muscle group. This may be confused with carpal tunnel syndrome, because the clinical profile may be very similar.[5] The absence of pain at night and decreased sensitivity in the area of innervation of the palmar cutaneous branch of the median nerve may be useful to distinguish the two syndromes.[5,6] There are four possible sites where compression of the median nerve may occur in pronator syndrome (from proximal to distal): 1) the Struthers ligament, 2) the bicipital aponeurosis, 3) the arch formed between the proximal muscle insertions of the superficial flexor muscle, and 4) between the humeral and ulnar heads of the pronator teres muscle. Some provocative tests can be used to differentiate the location of nerve compression, but their reliability in diagnosis is limited.[1,3,7] Tinel's sign can be useful in finding the location of the compression. The results of electrophysiological exams are consistent with nerve compression at the elbow, suggesting but not confirming the exact location of the compression.[8-10]

Only surgical exploration of the nerve in the cubital fossa can identify the structure responsible for the nerve compression.[3,11]

The flexor digitorum superficialis (FDS) is the largest muscle in the forearm. It forms an intermediary muscular layer in the forearm between the superficial and deep groups. The median nerve and ulnar artery enter the forearm through an archway formed by the insertions of this muscle's radial and humero-ulnar heads. However, the relation between the median nerve and the radial and humero-ulnar head of the superficial flexor muscle may be subjected to anatomical variations.[8,9,12,13] The objective of this study was to use anatomical dissections to analyze the relationship between the arcade of the superficial flexor muscle and the median nerve, thus contributing to a better understanding of nerve compression at this site.

METHODS

To conduct this study 50 forearms from 25 adult cadavers (21 men and 4 women) belonging to the FCMS Laboratory at PUCSP were dissected. Ages ranged from 28 to 77 years, 27 cadavers were white and 23 non-white, 18 had been previously preserved in formaldehyde and glycerin, and 7 were fresh. Forearms deformed by trauma, congenital malformations, and scars were excluded. No sign of muscular atrophy was identified in the dissected forearms. With the elbow flexed and the forearm supine, the dissection was performed through a midline incision along the entire forearm and lower third of the upper arm, and two flaps including the skin and subcutaneous tissue were reflected to the radial and ulnar sides, respectively. This same process was repeated for the fascia of the arm and forearm, exposing all the musculature. We analyzed the proximal origins of the superficial flexor muscle, the presence of the radial, humeral, and ulnar heads, the anatomical constitution of the supinator arch, and the distance from the apex of the arch to the medial epicondyle. These dissections were also intended to identify other anatomic sites that could be responsible for compression of the median nerve, such as the Struther's ligament, bicipital aponeurosis, and between the humeral and ulnar heads of the pronator teres muscle. All of the anatomical variations were identified, recorded, and photographed. During certain stages of the dissection, we used a Keeler 2.5x magnifying glass. The study was approved by the institutional review board under process number 1,611,295.

RESULTS

We identified the presence of the arcade in the dissected arms. The radial head of the FDS muscle was identified in 50 forearms (100% of specimens), with extension ranging from 2.5 to 7.5 cm (mean: 5.2 cm). The humeral head was also identified in all the forearms, with insertion in the medial epicondyle, beside the pronator teres muscle. (Figures 1A and 1B) The ulnar head was identified in only 16 forearms (32%), inserting into the area surrounding the coronoid process of the ulna. (Figure 1B) A fibrous arcade was identified in 32 forearms (64%), in 21 with transverse anatomical conformation (Figures 2A and 2B), in 5 with V-shaped conformation (Figure 3A), and oblique in 6. (Figure 3B) A muscular arcade was recorded in 11 specimens (22%), with transverse conformation in 8 (Figure 4A) and oblique in 3. (Figure 4B) The arcade was transparent in 4 forearms (8%), and was so fine that the nerve could be seen within (Figures 5A and 5B). In 3 (6%) forearms the arcade was considered irregular because there was discontinuity between the fibers that formed it. (Figure 6A) Proximity seen in all specimens between the arcade and median nerve. (Figure 6B) In all specimens we observed that the median nerve was in contact with the arcade; no structure or even any space was present between the nerve and the arcade. (Figure 6B) In terms of the relationship between the anterior interosseous nerve and the arcade, we noted that there was often some space between its branches and the arcade, since it was located posterior to the median nerve (since it originates in nerve fibers posterior to the median nerve). (Figures 1B and 2A) The average distance between the point of the arcade that rested on the median nerve and the medial epicondyle was 7.5 cm (6.4–8.2 cm). The width of the arcade ranged from 3 to 6 cm (mean: 4.2 cm). The anterior interosseous nerve originated from the median nerve proximal to the arcade in all forearms. (Figures 3 and 4) The distal arch of the FDS muscle was studied in 30 forearms; this structure was always muscular (Figures 7A and 7B), positioned an average of 3.8 cm proximal to the wrist crease overlying the median nerve in

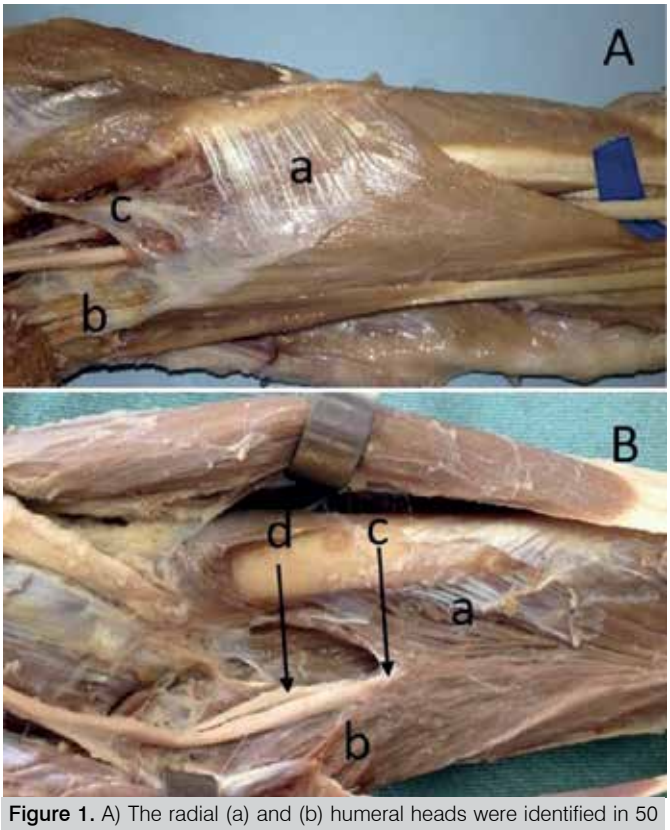


Figure 1. A) The radial (a) and (b) humeral heads were identified in 50 forearms. The ulnar head (c) was identified in only 16 forearms. B) absent ulnar head. Median nerve (c). Anterior interosseous nerve (d).

all the forearms, and overlying the palmar cutaneous branch of the median nerve in 18 of the 30 forearms. (Figure 7B) Although the median and cutaneous palmar nerves were adjacent to each other, they were not seen to be so close that this could be the cause of nerve compression.

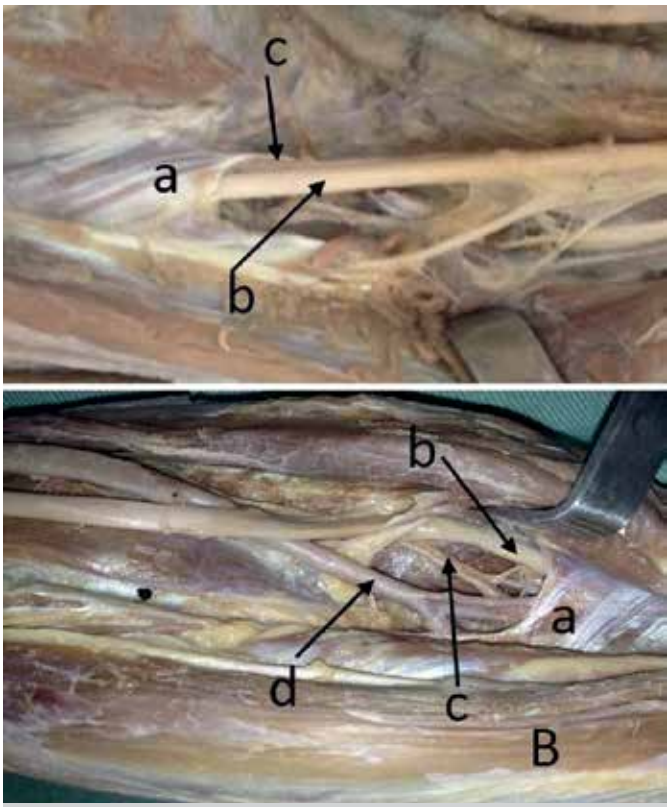


Figure 2. (A e B) Transverse fibrous arcade identified in 19 forearms (a) Median nerve (b). Anterior interosseous nerve (c). Ulnar artery (d).

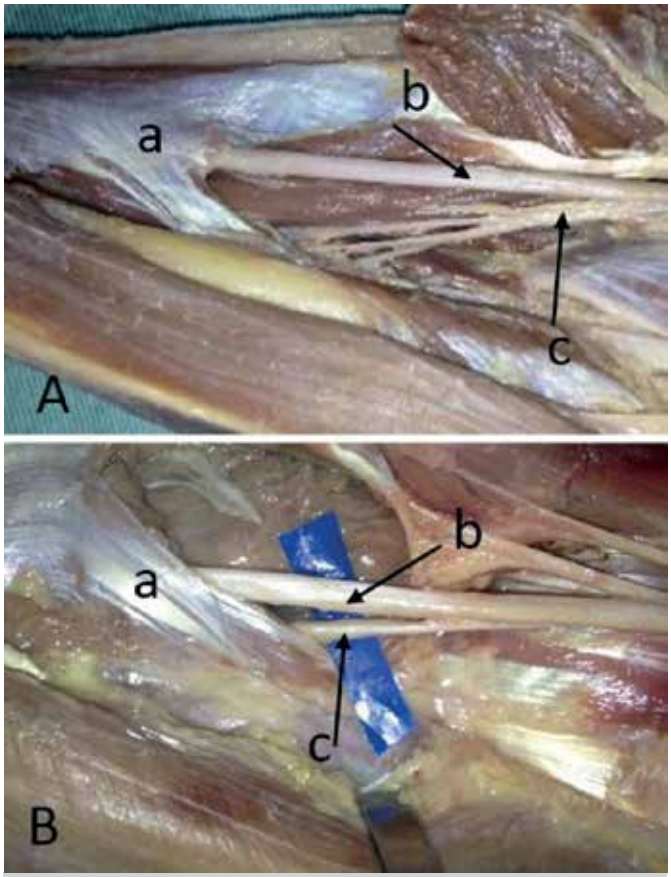


Figure 3. A) A fibrous, V-shaped arcade (a) was identified in 5 limbs. B) A fibrous, oblique arcade was identified in 6 limbs.

DISCUSSION

Some authors disagree that compression in places other than the humeral and ulnar heads of the pronator teres muscle should be called pronator syndrome.[1,7,14] Tubbs et al.[14] consider this denomination incorrect when compression occurs through the arcade of the FDS muscle, the bicipital aponeurosis, or the Struthers ligament, and suggests that the correct name would be proximal compressive neuropathies of the median nerve rather than pronator syndrome. These authors reported that patients with compression caused by the pronator teres muscle complain that the symptoms of pain and paresthesia arise after intense repetitive activities involving pronation and supination, and that in their studies involving 60 dissected forearms they found that the extension of the elbow compressed the nerve more through the arcade of the overlying FDS muscle.

Pronation and supination movements do not alter the relationship between the median nerve and FDS muscle arcade. In the cases we dissected, we recognized the existence of an important limitation. The dissections extended from the arm to the hand, since we analyzed the relation between the median nerve and arcade of Struthers, bicipital aponeurosis, and between the humeral and ulnar heads of the pronator teres muscle and the FDS muscle arcade. In this procedure all fascial structures were sectioned, and consequently the tension created by these structures was eliminated; we noted that even in the fresh cadavers used, the flexion and extension movements and pronation and supination of the forearm do not alter the relationship between the arcade of the FDS muscle and the median nerve. Hartz et al.[9] reported that based on their experience, compression of the median nerve caused by the bicipital aponeurosis resulted in pain that spread diffusely along the volar surface of the forearm, while compression from the arcade of the FDS muscle resulted in very localized pain. Wertsch and Melvin[15] reproduced pain in the proximal forearm in patients with compression of the median nerve under the arcade of the FDS muscle through flexion of the middle finger against resistance. Rengachary[11] states that although several clinical tests have been described to differentiate the location of nerve compression, it is not possible to clinically differentiate the exact location where compression occurs, and that any surgical procedure that does not explore all potential compression sites is incomplete.

Previous studies attempting to establish a link between the arcade of the FDS muscle and nerve compression have been controversial. Olehnik et al.[16] reported operating on 39 forearms with symptoms suggesting compression of the median nerve in the proximal forearm; 19 patients had previously undergone carpal tunnel release, but the symptoms persisted. In 22 of the 39 forearms these authors identified that the compression was caused by the FDS muscle arcade, in 13 by the pronator teres muscle, and in 4 by both. Hartz et al.[9] reported that 36 patients with a clinical diagnosis of pronator teres syndrome were seen over a period of seven years; 36 surgical procedures were performed in 32 forearms, and in 12 the presence of the fibrous arcade of the FDS muscle was identified as compressing the median nerve. In contrast, Johnson and Spinner[2] observed compression in the arcade of the FDS muscle in only 7 of 51 cases operated; in 2 cases the compression was caused by

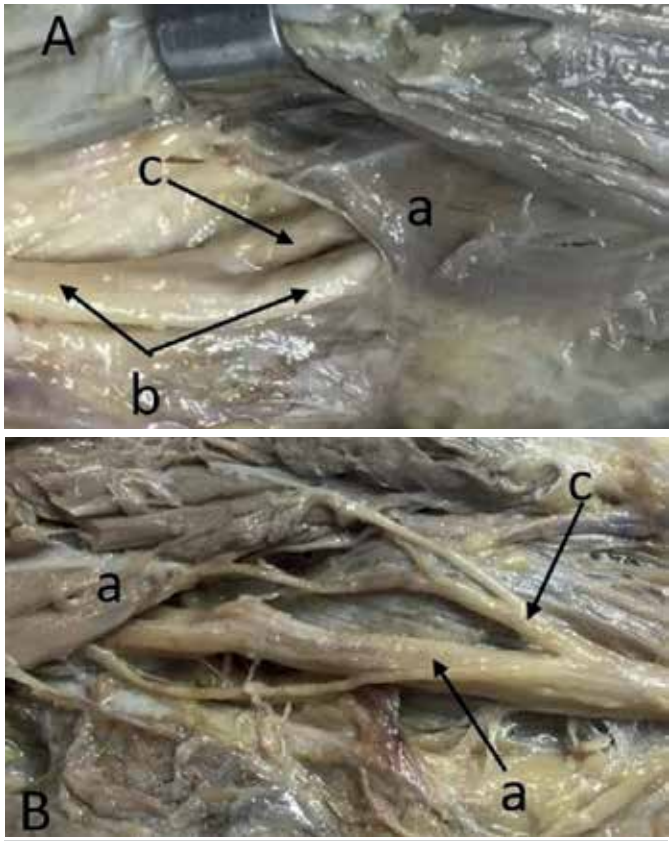


Figure 4. A) A muscular, transverse arcade (a) was identified in 8 limbs. B) A fibrous, oblique arcade was identified in 3 limbs. Median nerve (b). Anterior interosseous nerve (c).

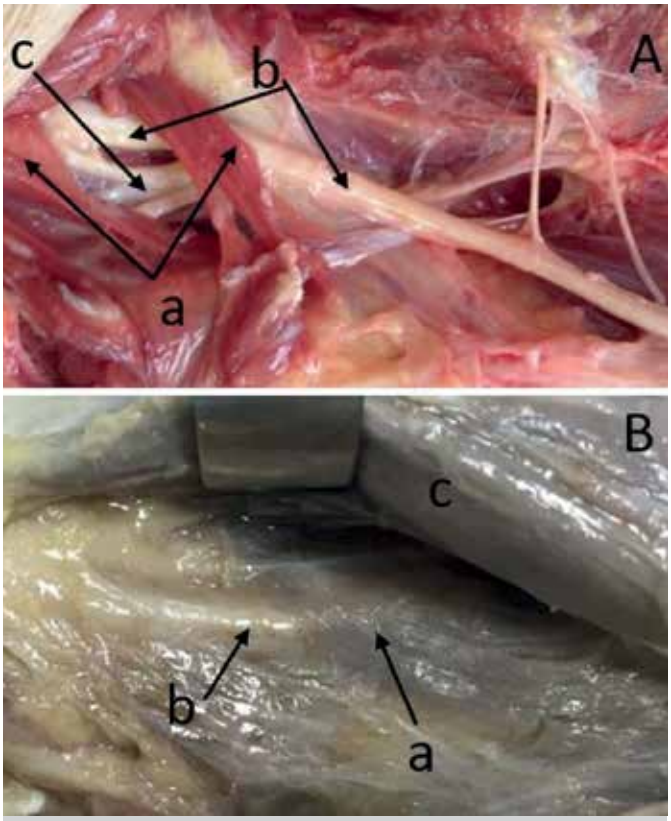


Figure 6. A) Irregular arcade (a) with discontinuity between constituting fibers. B) Proximity between the arcade and median nerve was seen in all specimens. Median nerve (b). Anterior interosseous nerve (c). Pronator teres muscle (d).

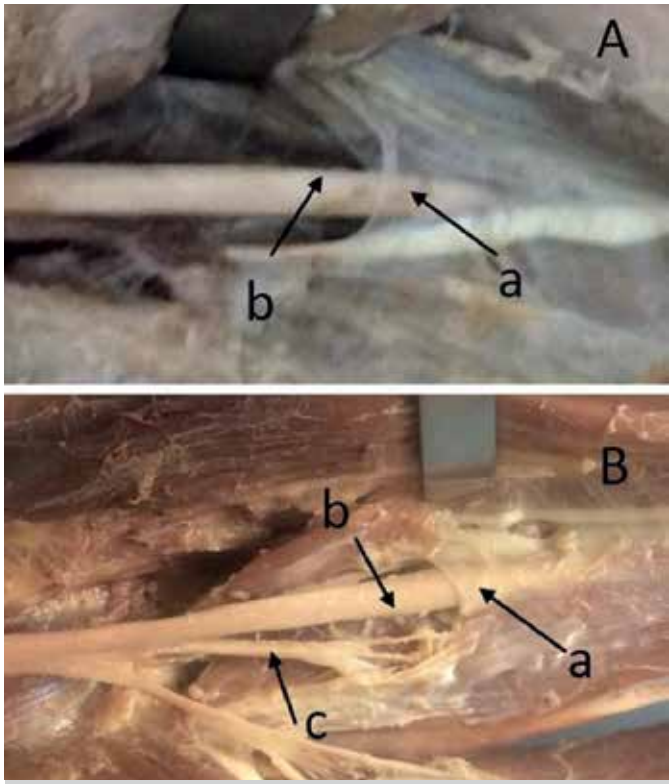


Figure 5. (A e B) A transparent and very fine arcade (a) Note visibility of the median nerve (b) within the arcade. Anterior interosseous nerve (c).

the bicipital aponeurosis, and in 39 by the pronator teres muscle. Park et al.[17] reported that 11 patients with anterior interosseous syndrome were treated with surgical exploration, and that the most common structure responsible for nerve compression was a fibrous band of the FDS muscle.

Few descriptions of the anatomical formation of the FDS muscle arcade can be found in the literature. Bilecenoglu et al.[18] dissected 30 limbs from 15 cadavers fixed in formalin, and in 97.7% of cases found the existence of two heads of the superficial flexor muscle forming an arcade where the median and anterior interosseous nerves passed. In one of these 30 limbs the radial head was not identified, and the arcade was consequently nonexistent. Dellon and Mackinnon[7] identified the FDS muscle in 31 dissected arms. In 4 specimens, these authors found that the muscle originated only in the medial epicondyle of the humerus. In 27 specimens there was also insertion in the coronoid process of the ulna, and in 10 specimens there was a third head originating from the radial diaphysis. In our study we identified the radial head of the FDS muscle in all forearms, with its dimensions varying widely in length from 2.5 to 7.5 cm (mean: 5.2 cm). Similarly, the humeral head was seen in all specimens, with insertion in the medial epicondyle beside the pronator teres muscle. The ulnar head was identified in only 16 forearms (32%), inserting into the area surrounding the coronoid process of the ulna.

Guo and Wang[19] dissected 38 cadaver arms to help clarify which portion of the arcade should be sectioned in each case to decompress the median nerve. These authors identified two types of FDS muscle arcade: one distinct fibrous arcade composed of fibrous tissue in which the entrance was clearly evident, and another indistinct arcade with vertical muscular fibers intermixed with the

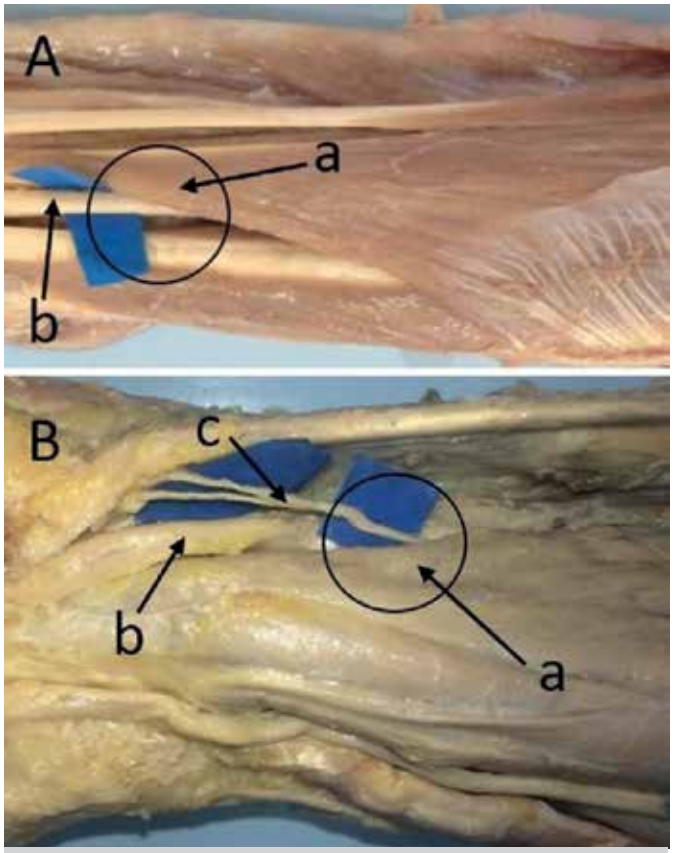


Figure 7. A) Distal arcade of the FDS muscle; (a) always muscular, positioned overlying the median nerve (b) in all the forearms. B) overlying the palmar cutaneous branch of the median nerve (c) in 18 of the 30 forearms.

overlying fascia. A distinct FDS muscle arcade was identified in only 16 forearms (42%). In 22 specimens (58%), the arcade was blurry, and of these the presence of muscular tissue made it difficult to see the arcade in 17 specimens (77%), requiring further dissection to visualize this structure. In contrast, in our dissections the following procedure was followed: after evaluating the relationship between the median nerve and the humeral and ulnar heads of the pronator teres muscle, we detached the insertion of this muscle from the radial diaphysis so that when the muscle was raised there were no difficulties in visualizing the arcade of the FDS muscle. Tubbs et al.[14] dissected 60 forearms from 30 prepared cadavers and found a tendinous arcade in 45 specimens (75%) and a muscular arcade in 15 (25%). Dellon and Mackinnon[7] identified the presence of a fibrous arcade in 11 of 31 dissected limbs (36%). Johnson et al.[2] dissected 40 preserved cadavers, and in 12 (30%) identified a fibrous arcade, in the proximal margin of the FDS muscle in 10 (25%). (Table 1)

Tubbs et al.[14] reported identifying in 60 dissected limbs that the anterior interosseous nerve originated proximal to the arcade of the superficial flexor muscle. Our findings confirm those of Tubbs et al.,[14] since we identified the anterior interosseous nerve as originating proximally to the arcade in all specimens; in many cases it was very close to the arcade but not distal to it, and the branching of the anterior interosseous nerve proximal to the arcade was recorded in only 18 specimens (36%). We identified a fibrous arcade in 32 forearms (64%), a muscular arcade in 11 (22%), and a transparent arcade in 4 (8%); in this latter case, the arcade was very fine and transparent and the nerve could consequently be seen within the arcade. In three (6%) forearms we considered the arcade irregular, since there was discontinuity between the fibers that comprised it.

Table 1. Summary of the literature addressing different rates of occurrence for the fibrous arcade of the FDS muscle.

Year	Authors	Type of study	Forearms	Fibrous arcade	Percentage
1979	Johnson et al.[2]	Anatomical	40	12	30%
1981	Hartz et al.[9]	Clinical (surgical)	32	12	33.5%
1987	Dellon and Mackinnon[7]	Anatomical	31	11	36%
2010	Tubbs et al.[14]	Anatomical	60	45	75%
2014	Guo and Wang[19]	Anatomical	38	16	42%

CONCLUSION

The anatomically fibrous arcade of the FDS muscle is one potential site of compression of the median and anterior interosseous nerves.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. JEB (0000-0002-2416-7281)* and TMS (0000-0002-0654-5373)* conducted the bibliographic survey and anatomical dissections; JJSN (0000-0002-0554-1426)* analyzed the results and conducted the anatomical dissections; LAV (0000-0003-4406-2492)* drafted the article and created the photographic documentation; MFC (0000-0003-0994-2128)* conducted the anatomical dissections and created the photographic documentation; EBC (0000-0003-4572-3854)* participated in all dissections, the drafting and review of the article, analysis of the results, intellectual concept of the article, and preparation of the entire research project. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Spinner M. Injuries to the major branches of the peripheral nerves of the forearm. Philadelphia: Saunders; 1978.
2. Johnson RK, Spinner M, Shrewsbury MM. Median nerve entrapment syndrome in the proximal forearm. J Hand Surg Am. 1979;4(1):48-51.
3. Gainor BJ. The pronator compression test revisited. A forgotten physical sign. Orthop Rev. 1990;19(10):888-92.
4. Seyffarth H. Primary myoses in the M. pronator teres as cause of lesion of the N. medianus (the pronator syndrome). Acta Psychiatr Neurol Scand Suppl. 1951;74:251-4.
5. Dang AC, Rodner CM. Unusual compression neuropathies of the forearm, part II: median nerve. J Hand Surg Am. 2009;34(10):1915-20.
6. Fuss FK, Wurzl GH. Median nerve entrapment. Pronator teres syndrome. Surgical anatomy and correlation with symptom patterns. Surg Radiol Anat. 1990;12(4):267-71.
7. Dellon AL, Mackinnon SE. Musculoaponeurotic variations along the course of the median nerve in the proximal forearm. J Hand Surg Br. 1987;12(3):359-63.
8. Morris HH, Peters BH. Pronator syndrome: clinical and electrophysiological features in seven cases. J Neurol Neurosurg Psychiatry. 1976;39(5):461-4.
9. Hartz CR, Linscheid RL, Gramse RR, Daube JR. The pronator teres syndrome: compressive neuropathy of the median nerve. J Bone Joint Surg Am. 1981;63(6):885-90.
10. Werner CO, Rosén I, Thorngren KG. Clinical and neurophysiologic characteristics of the pronator syndrome. Clin Orthop Relat Res. 1985;(197):231-6.
11. Rengachary SS. Entrapment neuropathies. In: Wilkinds RH, Rengachary SS, editors. Neurosurgery. New York: McGraw-Hill; 1985. p. 1771-95.
12. Kopell HP, Thompson WA. Pronator syndrome: a confirmed case and its diagnosis. N Engl J Med. 1958;259(15):713-5.
13. Sunderland S. Nerves and nerve injuries. 2a. ed. Edinburgh: Churchill Livingstone; 1978.
14. Tubbs RS, Marshall T, Loukas M, Shoja MM, Cohen-Gadol AA. The sublime bridge: anatomy and implications in median nerve entrapment. J Neurosurg. 2010;113(1):110-2.
15. Wertsch JJ, Melvin J. Median nerve anatomy and entrapment syndromes: a review. Arch Phys Med Rehabil. 1982;63(12):623-7.
16. Olehnik WK, Manske PR, Szerzinski J. Median nerve compression in the proximal forearm. J Hand Surg Am. 1994;19(1):121-6.
17. Park IJ, Roh YT, Jeong C, Kim HM. Spontaneous anterior interosseous nerve syndrome: clinical analysis of eleven surgical cases. J Plast Surg Hand Surg. 2013;47(6):519-23.
18. Bilecenoglu B, Uz A, Karalezli N. Possible anatomic structures causing entrapment neuropathies of the median nerve: an anatomic study. Acta Orthop Belg. 2005;71(2):169-76.
19. Guo B, Wang A. Median nerve compression at the fibrous arch of the flexor digitorum superficialis: an anatomic study of the pronator syndrome. Hand (NY). 2014;9(4):466-70.

DOI: http://dx.doi.org/10.1590/1413-785220182601184420

EFFECT OF THE P.A.R.Q.V.E ON RHIZARTHRITIS

EFEITO DO P.A.R.Q.V.E SOBRE A RIZOARTRITE

Fabio Mazetti Reaes[1], Mauricio Menezes Aben Athar Ivo[1], Daniele dos Santos Scarcella[1], Ligia Cortez Almeida[1], Rosana Mayumi Suzuki[1], Marcia Uchoa de Rezende[1]

1. Osteometabolic Diseases Group, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: To evaluate the effect of a clinical management program involving education on hand function in patients with rhizarthritis. Methods: One hundred and eight patients with rhizarthritis and multiple arthritis (191 hands with clinical and radiographic rhizarthritis) followed for two years as part of an educational program on osteoarthritis were administered the SF-36, DASH, and HAQ questionnaires and measured for the strength of their palmar grip, pulp to pulp pinch, key (lateral) pinch, and tripod pinch at the time of inclusion and after 24 months. Age, race, level and frequency of physical activity, sex, body mass index, percentage of body fat, and degree of osteoarthritis were correlated to the test outcomes. Results: Women improved less than men on the HAQ (p=0.037). Each 1% reduction in fat percentage increased the chance of HAQ score improvement by 9.2% (p=0.038). Physical activity did not influence improvement in the parameters evaluated (p>0.05). Palmar grip improvement was affected by age and presence of rhizarthritis (p<0.05); patients with unilateral rhizarthritis improved 5.3 times more than patients without the disease (p=0.015), while improvement in palmar grip strength decreased 6.8% per year (p=0.004). Pulp pinch grip strength improved more in women than in men (p=0.018). Conclusion: Patients with rhizarthritis and multiple arthritis improved quality of life and grip strength through clinical treatment, an educational program, and fat loss. ***Level of Evidence II; Retrospective study.***

Keywords: Hand deformities, acquired. Hand strength. Osteoarthritis. Knee. Health education. Fat body.

RESUMO

Objetivo: Avaliar o efeito de um programa de tratamento clínico com ensino da função das mãos em pacientes com rizoartrite. Métodos: Cento e oito indivíduos com rizoartrite e poliartrose (191 mãos com rizoartrite clínico-radiográfica) acompanhados por dois anos num programa educacional sobre osteoartrite responderam os questionários SF-36, DASH e HAQ e os testes de força de preensão palmar, pinça-polpa, pinça-chave e pinça-trípode no momento da inclusão e 24 meses depois. Idade, raça, nível e frequência de atividade física, sexo, índice de massa corporal, porcentagem de gordura corpórea, grau de osteoartrite foram correlacionados aos testes realizados. Resultados: As mulheres melhoraram em menor grau que homens no HAQ (p = 0,037) e cada redução de 1% no percentual de gordura aumenta 9,2% a chance de melhora no HAQ (p = 0,038). A atividade física não influenciou a melhora dos parâmetros avaliados (p > 0,05). Idade e presença de rizoartrite influenciam a melhora da preensão palmar (p < 0,05), sendo que pacientes com rizoartrite unilateral melhoram 5,3 vezes mais que pacientes sem a doença (p = 0,015) e a melhora da preensão diminui 6,8% por ano (p = 0,004). As mulheres melhoraram em maior grau que homens na pinça-polpa (p = 0,018). Conclusão: Pacientes com rizoartrite e poliartrose têm melhor qualidade de vida e força de preensão com o tratamento clínico, programa educacional e perda de gordura. ***Nível de Evidência II; Estudo retrospectivo.***

Descritores: *Deformidades adquiridas da mão. Força da mão. Osteoartrite. Joelho. Educação em saúde. Corpo adiposo.*

Citation: Reaes FM, Ivo MMAA, Scarcella DS, Almeida LC, Suzuki RM, Rezende MU. Effect of the P.A.R.Q.V.E on rhizarthritis. Acta Ortop Bras. [online]. 2018;26(1):41-7. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Osteoarthritis (OA) is the most frequent cause of musculoskeletal disability worldwide.[1,2] It is considered a final common pathway of several diseases[3-6] characterized by degradation and loss of articular cartilage, sclerotic remodeling of the subchondral bone, formation of cysts and osteophytes at the edges of joints, contraction and loosening of the ligaments, muscular atrophy and contractures, and inflammation of the synovial membrane.[6,7]

OA can develop in any joint, but most frequently affects the knees, hips, hands, the facet joints, and feet.[8] The radiographic prevalence of OA of the hand varies from 27% to over 80%,[1] and symptomatic OA of the hand becomes more prevalent with age, and is more frequent in women and in certain races.[8-10]

We created an educational program for patients with OA of the knee which from the outset included clinical and radiographic evaluation of all patient complaints, including the hands, in addition to classes on joint protection.[11-15] Approximately 70% of our sample was composed of patients with multiple OA and comorbidities, mainly affecting the knees, spine, and hands.[15] The program addressed holistic treatment of OA that extended beyond an educational program

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

Work conducted at the Osteometabolic Diseases Group, Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

Correspondence: Marcia Uchoa de Rezende. Rua Dr. Ovídio Pires de Campos, 333 – Sala 323B, Cerqueira Cesar, São Paulo, SP, Brazil. 05403-010. murezende@uol.com.br

Article received in 08/25/2017, approved in 09/15/2017.

CC BY NC

with or without classes and provided patients with routine diacerein, analgesics, hand orthotics, acupuncture and physiotherapy as required. Patients were always instructed to perform regular physical activity at least three times per week and to lose weight if they were overweight or obese.

The objective of this study is to verify whether the program and/or the personal characteristics for physical behavior and the degree of rhizarthritis in the patients improved arm function and hand grip strength.

METHODS

This retrospective study was conducted using data collected during the PARQVE Project (Project Arthritis Recovering Quality of Life through Education, Projeto Artrose Recuperando Qualidade de Vida pela Educação),[11-13,15] which was conducted in the Osteometabolic Diseases Group at the Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HC/FMUSP) from January 2012 to January 2014. The study was approved by the institutional review board for research ethics (CAPPesq, number 622/11).

To comprise the sample of this study, we selected patients who participated in the education program for knee OA (outpatients) who also presented arthritis of the trapezium-first metacarpal joint according to the classification by Eaton et al.[16] Other patient inclusion criteria were age 45 years or above, clinical and/or radiographic diagnosis of knee arthritis with knee pain requiring analgesics, no neurological pathologies, and the ability to understand and provide informed consent.[11-13,15]

The exclusion criteria were: patients undergoing surgery during the study which would stop them from performing physical exercise, participation in another clinical trial or another nutritional support group, and patients without initial and final evaluations (complete clinical and radiological assessments) for carpal-metacarpal arthritis in the thumb.

Intervention

All patients received a book[17] and a DVD containing information about OA and lifestyle change, and were advised to read the material at least three times at home. The patients also received periodic reinforcement from the medical team (in the ambulatory follow-up visits every six months) related to daily practice of physical exercise and diet, as well as prescriptions for diacerein and analgesics, hand orthotics, acupuncture, and physiotherapy.[11-15] After two years in the project (after the last evaluation), some patients received viscosupplementation in the trapezium-first metacarpal joint, and all participated in one more day of class with the multiprofessional team, where occupational therapists taught the participants specific exercises for the hands.[17]

Data Collection

At inclusion and at the end of two years, participants completed the SF-36 questionnaire (Medical Outcomes Study 36-Item Short-Form Health Survey),[18] the DASH assessment (Disabilities of the Arm, Shoulder and Hand),[19] and the HAQ (Health Assessment Questionnaire),[20] and underwent hand dynamometry, which quantified palmar grip strength, key (lateral) pinch strength, pulp to pulp pinch strength, and tripod pinch strength. Data were also collected on the type, frequency, and intensity of physical activity patients habitually practiced each week, as well data such as age, sex, race, educational level, weight, height, body mass index (BMI), and body fat percentage (BFP) were also collected. X-rays were taken of the hands of all patients.

The X-rays were analyzed by a group of three orthopedists and stratified according to the classification by Eaton et al.[17] When there was disagreement between the two observers, the third observer broke the tie.

The diagnosis of rhizarthritis was established if the patient had positive typical symptoms and/or radiographic signs of carpal-metacarpal arthritis of the thumb.

Statistical analysis

Improvement was considered to be a reduction of at least three points on the DASH, an increase of five points for quality of life scores (HAQ and SF-36), and for the other assessments, improvement of 5% between the initial and two-year evaluations. For the strength measurements, if one side improved by at least 5%, the patient was considered to have improved in the analyses in which the patient was evaluated as a whole, not the hands separately. Intense physical activity was defined as swimming, cycling, or weight lifting and/or frequency of more than 180 minutes of physical activity per week. The degrees of rhizarthritis were defined according to the classification by Eaton et al.[17]

The quantitative characteristics were described according to the improvement in each criterion using summary measurements (mean, standard deviation, median, minimum, and maximum) and were compared using Student's t-test or the Mann-Whitney tests. The improvements in each criterion were described according to the qualitative characteristics and association with likelihood ratio or chi-squared tests.

The odds ratios were estimated for each variable of interest with improvement in each criterion, along with their respective 95% confidence intervals using simple logistic regression.

Multiple logistic regression models were estimated, selecting the variables in the non-adjusted analysis which demonstrated a descriptive level below 0.2 ($p<0.2$), and in all models the rhizarthritis variable was maintained to verify the combined influence for reach of the improvement criteria.

To assess the degree to which rhizarthritis influenced improvement in strength measurements, the second degree forces were described using absolute and relative frequencies, and the relationship between the degree and the improvement in strength was assessed using generalized estimation equations with binomial distribution and the logit link function with an interchangeable correlation matrix. To perform the analyses, IBM SPSS for Windows software version 20.0 was used, and Microsoft Excel 2003 was used to tabulate the data. The tests were performed at a 5% significance level.

RESULTS

Of the 195 patients with knee OA (isolated or multiple OA, with and without comorbidities) who completed the two-year program, 49 did not have complete clinical and radiological assessment of the hands and were excluded. Among the 146 patients with complete clinical and radiological assessments, 108 patients had clinical and/or radiographic rhizarthritis. (Figure 1)

The 146-patient sample consisted of 112 women (76%) and 34 men, with an average age of 69.2±9.2 years (minimum 48, maximum 89 years) and 8±3 years of schooling; 93 declared their race as White, 17 Black, 31 mixed-race of African descent, 4 Asian, and 1 did not declare race. The initial mean BMI was 31.1±5.5 (minimum 20.06, maximum 49.0) and the mean final BMI was 31.14±5.7. The initial BFP was 36.10±8.5% (minimum 11.32%, maximum 52%) and the mean final BFP was 37.94±8.7%. Only 16 of the patients performed intense physical activity, while 43 did not perform any physical activity.

With regard to the diagnosis of carpal-metacarpal arthritis of the thumb 108 patients were diagnosed with rhizarthritis (38 without rhizarthritis); 83 had bilateral arthritis and 25 had unilateral rhizarthritis. A total of 191 hands with rhizarthritis were observed: 19 stage 1 on

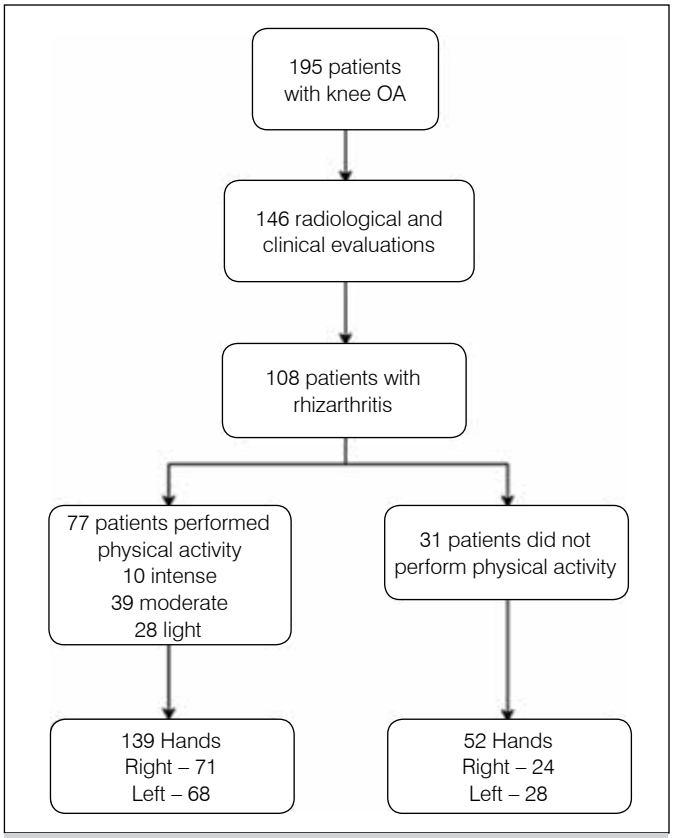


Figure 1. Flow of study participants.

the Eaton scale (9.94%), 103 stage 2 (53.92%), 43 stage 3 (22.51%), and 26 stage 4 (13.61%). Of these, 77 patients practiced physical activity and 31 patients did not practice any physical activity.

The DASH score decreased from 34.0±19.5 to 27.9±18.5 over the 2-year study period, and the HAQ score dropped from 0.80±0.5 to 0.68±0.4.

Average palmar grip strength decreased from 22.6±9.6 to 21.3±7.4 (22.4±9.5 to 21.5±7.4 in the right arm (RA) and 22.8±9.6 to 21.1±7.4 in the left arm (LA); the average pulp to pulp pinch strength rose from 4.0±1.7 to 4.4±1.4 (4.1±1.8 to 4.6±1.4 in the RA and 3.9±1.6 to 4.2±1.3 in the LA); the average key (lateral) pinch strength rose from 6.2±2.3 to 6.7±2.1 (6.4±2.5 to 7.0±2.1 in the RA and 6.0±2.1 to 6.4±2.1 in the LA); and the average tripod pinch strength increased from 5.0±2.0 to 5.4±1.8 (5.2±2.1 to 5.6±1.8 in the RA and 4.9±1.8 to 5.3±1.7 in the LA).

In the statistical analysis of the questionnaires, only race influenced improvement in physical quality of life (SF-36-PCS, $p<0.05$); after adjustment, the chance of improvement in Black patients was 4.76 times the chance of improvement in white patients ($p=0.015$). The presence of rhizarthritis also did not influence improvement in PCS ($p>0.05$). (Table 1) With regard to improvement in psychological quality of life (SF-36-MCS), only the time of study in isolation had an influence on improvement ($p=0.042$), but after adjusting for the other selected characteristics, no assessed variable influenced the score ($p>0.05$). (Table 2) None of the evaluated characteristics influenced improvement in the DASH ($p>0.05$). (Table 3) We found that women had 79% less chance of improvement in HAQ score than men ($p=0.037$) and each 1% decrease in body fat percentage increased the chance of improvement in the HAQ by 9.2% ($p=0.038$), although in most patients the body fat percentage worsened (mean and median values were negative). (Table 4)

Table 1. Improvement in the physical component of the SF-36 (PCS) according to qualitative characteristics and the results of the statistical tests.

Variable	Improvement in Physical Component of the SF-36 (PCS)		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.408				
None	29 (70.7)	12 (29.3)	41	1.00							
Class text/Stretching	20 (62.5)	12 (37.5)	32	1.45	0.54	3.87					
Walking/Gymnastics/Water aerobics	36 (70.6)	15 (29.4)	51	1.01	0.41	2.48					
Swimming/Cycling/Lifting Weights	8 (50)	8 (50)	16	2.42	0.74	7.93					
Intensity of physical activity, n (%)							0.484#				
None	31 (72.1)	12 (27.9)	43	1.00							
Light Activity	39 (63.9)	22 (36.1)	61	1.46	0.63	3.40					
Moderate Activity	19 (67.9)	9 (32.1)	28	1.22	0.43	3.45					
Intense activity	3 (42.9)	4 (57.1)	7	3.44	0.67	17.73					
Sex, n (%)							0.111				
Male	25 (78.1)	7 (21.9)	32	1.00				1.00			
Female	68 (63)	40 (37)	108	2.10	0.83	5.30		2.10	0.51	8.55	0.303
Race, n (%)							0.036#				
White	60 (68.2)	28 (31.8)	88	1.00				1.00			
Mixed race of African descent	22 (73.3)	8 (26.7)	30	0.78	0.31	1.97		0.98	0.37	2.62	0.966
Black	7 (41.2)	10 (58.8)	17	3.06	1.06	8.88		4.76	1.35	16.76	0.015
Asian	4 (100)	0 (0)	4	&				&			
Rhiz, n (%)							0.336				
No arthritis	26 (72.2)	10 (27.8)	36	1.00				1.00			
Unilateral arthritis	10 (52.6)	9 (47.4)	19	2.34	0.73	7.46		3.11	0.80	12.16	0.103
Bilateral arthritis	57 (67.1)	28 (32.9)	85	1.28	0.54	3.01		1.79	0.65	4.94	0.260
Minutes per week				1.002	1.000	1.005	0.160*	1.003	1.000	1.006	0.058
Mean (SD)	104.7 (113.6)	144.8 (163.8)	118.2 (133.3)								
Median (min; max)	90 (0; 480)	120 (0; 840)	90 (0; 840)								
Age (years)				1.019	0.980	1.059	0.353				
Mean (SD)	68.6 (9.3)	70.1 (8.6)	69.1 (9.1)								
Median (min; max)	69 (48; 89)	71 (50; 86)	69 (48; 89)								
Study Time (years)				0.950	0.841	1.072	0.260*				
Mean (SD)	8.2 (2.7)	7.8 (3.4)	8.1 (3)								
Median (min; max)	8 (1; 15)	8 (1; 15)	8 (1; 15)								
BMI (kg/m^2)				1.037	0.974	1.104	0.261				
Mean (SD)	30.7 (5.6)	31.8 (5.7)	31.1 (5.6)								
Median (min; max)	29.8 (20.8; 48)	31 (19.8; 49.9)	30.5 (19.8; 49.9)								
% Body Fat (PBF)				1.030	0.986	1.076	0.185	1.004	0.940	1.073	0.897
Mean (SD)	37.2 (8.5)	39.3 (9.1)	37.9 (8.7)								
Median (min; max)	39.7 (14.1; 48.7)	41.3 (10.1; 49.1)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				1.027	0.838	1.259	0.799				
Mean (SD)	-0.08 (1.8)	0.01 (1.68)	-0.05 (1.76)								
Median (min; max)	-0.01 (-7.82; 4.42)	-0.02 (-3.21; 4.44)	-0.01 (-7.82; 4.44)								
Variation % Body Fat				0.977	0.917	1.041	0.479				
Mean (SD)	-1.43 (5)	-2.19 (7.38)	-1.7 (5.93)								
Median (min; max)	-1.54 (-16.72; 14.62)	-2.14 (-17.88; 35.72)	-1.79 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

Table 2. Improvement in the mental component of the SF-36 (MCS) according to qualitative characteristics and the results of the statistical tests.

Variable	Improvement in Mental Component of the SF-36 (MCS)		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.303				
None	29 (70.7)	12 (29.3)	41	1.00							
Class text/Stretching	23 (71.9)	9 (28.1)	32	0.95	0.34	2.63					
Walking/Gymnastics/Water aerobics	28 (54.9)	23 (45.1)	51	1.99	0.83	4.74					
Swimming/Cycling/Lifting Weights	11 (68.8)	5 (31.2)	16	1.10	0.31	3.85					
Intensity of physical activity, n (%)							0.522#				
None	29 (67.4)	14 (32.6)	43	1.00							
Light Activity	38 (62.3)	23 (37.7)	61	1.25	0.55	2.85					
Moderate Activity	20 (71.4)	8 (28.6)	28	0.83	0.29	2.34					
Intense activity	3 (42.9)	4 (57.1)	7	2.76	0.54	14.06					
Sex, n (%)							0.353				
Male	23 (71.9)	9 (28.1)	32	1.00							
Female	68 (63)	40 (37)	108	1.50	0.63	3.57					
Race, n (%)							0.195#				
White	55 (62.5)	33 (37.5)	88	1.00				1.00			
Mixed race of African descent	24 (80)	6 (20)	30	0.42	0.15	1.13		0.50	0.17	1.46	0.202
Black	9 (52.9)	8 (47.1)	17	1.48	0.52	4.22		1.56	0.47	5.24	0.468
Asian	3 (75)	1 (25)	4	0.56	0.06	5.56		0.99	0.08	12.70	0.993
Rhiz, n (%)							0.808				
No arthritis	22 (61.1)	14 (38.9)	36	1.00				1.00			
Unilateral arthritis	12 (63.2)	7 (36.8)	19	0.92	0.29	2.89		1.02	0.27	3.90	0.978
Bilateral arthritis	57 (67.1)	28 (32.9)	85	0.77	0.34	1.73		1.07	0.41	2.80	0.893
Minutes per week				1.000	0.997	1.002	0.754*				
Mean (SD)	119.5 (141.9)	115.7 (117.1)	118.2 (133.3)								
Median (min; max)	90 (0; 840)	120 (0; 600)	90 (0; 840)								
Age (years)				0.966	0.929	1.005	0.086**	0.973	0.931	1.017	0.222
Mean (SD)	70 (8.4)	67.3 (10)	69.1 (9.1)								
Median (min; max)	70 (50; 86)	67 (48; 89)	69 (48; 89)								
Study Time (years)				1.152	1.018	1.303	0.042*	1.117	0.973	1.282	0.115
Mean (SD)	7.6 (2.9)	8.8 (3)	8.1 (3)								
Median (min; max)	8 (1; 15)	8 (2; 15)	8 (1; 15)								
BMI (kg/m^2)				1.031	0.969	1.098	0.336**	1.010	0.943	1.082	0.773
Mean (SD)	30.7 (6)	31.7 (4.7)	31.1 (5.6)								
Median (min; max)	29.8 (19.8; 49.9)	31.2 (24; 45.8)	30.5 (19.8; 49.9)								
% Body Fat (PBF)				1.022	0.979	1.067	0.313**				
Mean (SD)	37.4 (9.1)	39 (7.9)	37.9 (8.7)								
Median (min; max)	40.3 (12; 49.1)	40.4 (10.1; 48.5)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				1.225	0.985	1.525	0.065**				
Mean (SD)	-0.25 (1.6)	0.34 (1.96)	-0.05 (1.76)								
Median (min; max)	-0.15 (-7.82; 4.42)	0.22 (-4.35; 4.44)	-0.01 (-7.82; 4.44)								
Variation % Body Fat				1.031	0.970	1.095	0.323**				
Mean (SD)	-2.06 (5.2)	-0.99 (7.14)	-1.7 (5.93)								
Median (min; max)	-1.79 (-17.88; 14.62)	-2 (-16.29; 35.72)	-1.79 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

Table 3. Improvement in the DASH according to qualitative characteristics and the results of the statistical tests.

Variable	DASH improvement		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.896				
None	19 (54.3)	16 (45.7)	35	1.00							
Class text/Stretching	14 (45.2)	17 (54.8)	31	1.44	0.55	3.81					
Walking/Gymnastics/Water aerobics	23 (47.9)	25 (52.1)	48	1.29	0.54	3.09					
Swimming/Cycling/Lifting Weights	8 (50)	8 (50)	16	1.19	0.36	3.88					
Intensity of physical activity, n (%)							0.656#				
None	21 (56.8)	16 (43.2)	37	1.00							
Light Activity	25 (43.9)	32 (56.1)	57	1.68	0.73	3.87					
Moderate Activity	14 (50)	14 (50)	28	1.31	0.49	3.52					
Intense activity	3 (42.9)	4 (57.1)	7	1.75	0.34	8.95					
Sex, n (%)							0.251				
Male	17 (58.6)	12 (41.4)	29	1.00							
Female	47 (46.5)	54 (53.5)	101	1.63	0.71	3.76					
Race, n (%)							0.568#				
White	37 (45.7)	44 (54.3)	81	1.00							
Mixed race of African descent	16 (55.2)	13 (44.8)	29	0.68	0.29	1.60					
Black	8 (53.3)	7 (46.7)	15	0.74	0.24	2.22					
Asian	3 (75)	1 (25)	4	0.28	0.03	2.81					
Rhiz, n (%)							0.202				
No arthritis	21 (61.8)	13 (38.2)	34	1.00				1.00			
Unilateral arthritis	7 (38.9)	11 (61.1)	18	2.54	0.79	8.21		2.61	0.79	8.58	0.114
Bilateral arthritis	36 (46.2)	42 (53.8)	78	1.89	0.83	4.29		2.03	0.87	4.73	0.100
Minutes per week				1.000	0.997	1.002	0.841*				
Mean (SD)	127 (153.6)	118.6 (113.6)	122.7 (134.3)								
Median (min; max)	95 (0; 840)	102.5 (0; 480)	100 (0; 840)								
Age (years)				0.980	0.943	1.019	0.307**				
Mean (SD)	70.2 (8.3)	68.6 (9.6)	69.4 (9)								
Median (min; max)	69 (54; 89)	69 (48; 89)	69 (48; 89)								
Study Time (years)				0.956	0.849	1.076	0.306*				
Mean (SD)	8.1 (3.1)	7.7 (2.7)	7.9 (2.9)								
Median (min; max)	8 (1; 15)	8 (2; 15)	8 (1; 15)								
BMI (kg/m^2)				1.008	0.948	1.072	0.802**				
Mean (SD)	31 (5.2)	31.2 (6.1)	31.1 (5.6)								
Median (min; max)	30.5 (22.4; 46.8)	30.6 (19.8; 49.9)	30.6 (19.8; 49.9)								
% Body Fat (PBF)				1.027	0.986	1.070	0.200**	1.027	0.984	1.071	0.220
Mean (SD)	37.1 (9.2)	39.1 (8)	38.1 (8.7)								
Median (min; max)	40.4 (10.1; 48.7)	40.8 (12; 49.1)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				1.110	0.904	1.364	0.318**				
Mean (SD)	-0.19 (1.8)	0.12 (1.63)	-0.04 (1.74)								
Median (min; max)	-0.11 (-7.82; 4.44)	0.29 (-4.35; 4.02)	0.05 (-7.82; 4.44)								
Variation % Body Fat				0.972	0.915	1.033	0.358**				
Mean (SD)	-1.28 (7.1)	-2.26 (4.7)	-1.77 (6.01)								
Median (min; max)	-1.07 (-17.88; 35.72)	-2.46 (-16.29; 9.09)	-1.86 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

In the analysis of the data for strength, age and the presence of rhizarthritis both separately and jointly influenced improved grip strength ($p<0.05$). After adjustment, the chance of improved grip in patients with unilateral rhizarthritis was 5.30 times the chance of improvement than in patients without rhizarthritis ($p=0.015$), and for each additional year of patient age the chance of improved grip decreased 6.8% ($p=0.004$). (Table 5) For pulp to pulp pinch strength, the only factor which influenced improvement was sex ($p<0.05$), and after adjustment, female patients had a 2.95 greater chance of improvement than male patients ($p=0.018$). (Table 6) With regard to the evaluation of key (lateral) pinch or tripod pinch strength, none of the evaluated characteristics influenced improvement, alone or after adjustment ($p>0.05$).

No relationship was found (using the chi-square test) between the presence of rhizarthritis and improved quality of life or arm functionality by scores on the SF-36 ($p>0.05$), DASH ($p=0.089$), or HAQ ($p=0.864$).

There was also no relation between the presence of rhizarthritis and improved palmar grip strength ($p=0.819$), pulp to pulp pinch strength ($p=0.222$), or key (lateral) pinch strength ($p=0.411$) measured by dynamometry. Improvements in tripod pinch strength were more likely in patients with rhizarthritis than in patients without the disease ($p=0.036$).

Stratification according to the Eaton classification[16] showed no relationship between the degree of rhizarthritis and improvements in palmar grip strength ($p=0.055$), pulp to pulp pinch strength ($p=0.470$), key (lateral) pinch strength ($p=0.815$), or tripod pinch strength ($p=0.463$), measured by dynamometry.

DISCUSSION

Although this study is retrospective, it is part of a thematic project called PARQVE.[11,13,15] The main objective of this project was to offer multiple-modality treatment for patients with OA of the knee. Seven teams (orthopedic doctors, physiotherapists, a dietitian, physical educators, occupational therapists, social workers, and psychologists) joined forces to develop a two-day educational program explaining the disease and its treatment. Each team developed subprojects evaluating objective and subjective parameters within its area.

At inclusion, the prevalence of OA was similar to that described in the literature (23.7%),[1,8,12] but after one year prevalence of symptomatic OA of the hands was 47.4%, alerting us to the need to evaluate how effective the program was for OA of the hands.

Since at least one fourth of our patients obtained examinations outside of our institution, we were unable to recover the electronic file images from 49 of these patients, who were excluded. (Figure 1) Consequently, of the 146 patients with clinical and radiological assessments of the hands, 108 had rhizarthritis in at least one of their hands (74%). The prevalence of OA of the hand is known to be higher in women, and increases with age and obesity.[1,8] Our sample contains 76% obese women (obesity I, on average) with a mean age of 69 years, extending to 89. Of the 108 patients with rhizarthritis, 83 had bilateral involvement.

Intense physical activity, weight lifting, and frequent physical activity exceeding 180 minutes per week were factors that positively impacted the function of patients with knee OA,[13,14] but this was not the case with OA of the hand. One explanation could be that rhizarthritis exercises aim to relax the thenar region and strengthen the thumb

Table 4. Improvement in the HAQ according to qualitative characteristics and the results of the statistical tests.

Variable	HAQ improvement		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.168				
None	21 (58.3)	15 (41.7)	36	1.00				1.00			
Class text/Stretching	11 (35.5)	20 (64.5)	31	2.55	0.95	6.85		0.77	0.04	14.00	0.857
Walking/Gymnastics/Water aerobics	23 (47.9)	25 (52.1)	48	1.52	0.64	3.64		0.44	0.02	9.04	0.597
Swimming/Cycling/Lifting Weights	5 (31.2)	11 (68.8)	16	3.08	0.89	10.73		0.61	0.02	17.66	0.776
Intensity of physical activity, n (%)							0.134#				
None	23 (60.5)	15 (39.5)	38	1.00				1.00			
Light Activity	25 (43.9)	32 (56.1)	57	1.96	0.85	4.52		3.75	0.21	68.54	0.373
Moderate Activity	9 (32.1)	19 (67.9)	28	3.24	1.16	9.03		7.38	0.36	151.88	0.195
Intense activity	3 (42.9)	4 (57.1)	7	2.04	0.40	10.46		2.96	0.09	99.47	0.545
Sex, n (%)							0.070				
Male	9 (31)	20 (69)	29	1.00				1.00			
Female	51 (50)	51 (50)	102	0.45	0.19	1.08		0.21	0.05	0.91	0.037
Race, n (%)							0.648#				
White	38 (46.3)	44 (53.7)	82	1.00							
Mixed race of African descent	12 (41.4)	17 (58.6)	29	1.22	0.52	2.88					
Black	7 (46.7)	8 (53.3)	15	0.99	0.33	2.98					
Asian	3 (75)	1 (25)	4	0.29	0.03	2.88					
Rhiz, n (%)							0.518#				
No arthritis	16 (47.1)	18 (52.9)	34	1.00				1.00			
Unilateral arthritis	6 (33.3)	12 (66.7)	18	1.78	0.54	5.84		3.75	0.95	14.72	0.058
Bilateral arthritis	38 (48.1)	41 (51.9)	79	0.96	0.43	2.15		1.15	0.44	3.03	0.773
Minutes per week				1.00	0.999	1.005	0.318*				
Mean (SD)	103 (103.7)	137.7 (154.4)	121.8 (134.2)								
Median (min; max)	95 (0; 350)	100 (0; 840)	100 (0; 840)								
Age (years)				0.973	0.935	1.012	0.166**	0.967	0.922	1.015	0.177
Mean (SD)	70.6 (7.6)	68.4 (9.9)	69.4 (8.9)								
Median (min; max)	70 (55; 86)	69 (48; 89)	69 (48; 89)								
Study Time (years)				0.924	0.819	1.042	0.198*	0.903	0.784	1.040	0.158
Mean (SD)	8.3 (2.8)	7.6 (3)	7.9 (2.9)								
Median (min; max)	8 (1; 15)	8 (1; 15)	8 (1; 15)								
BMI (kg/m^2)				0.986	0.927	1.049	0.653**				
Mean (SD)	31.3 (6)	30.9 (5.3)	31.1 (5.6)								
Median (min; max)	30.4 (19.8; 48)	30.7 (20.8; 49.9)	30.6 (19.8; 49.9)								
% Body Fat (PBF)				0.970	0.931	1.012	0.159**	1.046	0.971	1.127	0.234
Mean (SD)	39.3 (8.1)	37.1 (9)	38.1 (8.6)								
Median (min; max)	41.2 (12; 48.7)	39.9 (10.1; 49.1)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				1.105	0.905	1.349	0.329**				
Mean (SD)	-0.17 (1.9)	0.14 (1.62)	0 (1.78)								
Median (min; max)	0.03 (-7.82; 4.42)	0.2 (-4.35; 4.44)	0.08 (-7.82; 4.44)								
Variation % Body Fat				1.058	0.990	1.130	0.090**	1.092	1.005	1.186	0.038
Mean (SD)	-2.67 (5.4)	-0.87 (6.45)	-1.71 (6.03)								
Median (min; max)	-1.86 (-17.88; 8.04)	-1.79 (-12.45; 35.72)	-1.79 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

Table 5. Improvement in palmar strength according to qualitative characteristics and the results of the statistical tests.

Variable	Improvement in Palmar Grip		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.676				
None	23 (65.7)	12 (34.3)	35	1.00							
Class text/Stretching	19 (61.3)	12 (38.7)	31	1.21	0.44	3.31					
Walking/Gymnastics/Water aerobics	28 (60.9)	18 (39.1)	46	1.23	0.49	3.08					
Swimming/Cycling/Lifting Weights	6 (46.2)	7 (53.8)	13	2.24	0.61	8.16					
Intensity of physical activity, n (%)							0.890#				
None	24 (64.9)	13 (35.1)	37	1.00							
Light Activity	33 (58.9)	23 (41.1)	56	1.29	0.55	3.04					
Moderate Activity	15 (60)	10 (40)	25	1.23	0.43	3.51					
Intense activity	3 (50)	3 (50)	6	1.85	0.33	10.49					
Sex, n (%)							0.111				
Male	20 (74.1)	7 (25.9)	27	1.00				1.00			
Female	56 (57.1)	42 (42.9)	98	2.14	0.83	5.54		1.79	0.44	7.21	0.414
Race, n (%)							0.412#				
White	52 (65.8)	27 (34.2)	79	1.00							
Mixed race of African descent	13 (48.1)	14 (51.9)	27	2.07	0.86	5.03					
Black	9 (64.3)	5 (35.7)	14	1.07	0.33	3.51					
Asian	2 (50)	2 (50)	4	1.93	0.26	14.44					
Rhiz, n (%)							0.033				
No arthritis	20 (62.5)	12 (37.5)	32	1.00				1.00			
Unilateral arthritis	6 (33.3)	12 (66.7)	18	3.33	0.99	11.22		5.30	1.38	20.28	0.015
Bilateral arthritis	50 (66.7)	25 (33.3)	75	0.83	0.35	1.97		1.51	0.58	3.97	0.403
Minutes per week				1.000	0.997	1.003	0.567*				
Mean (SD)	119.4 (145.3)	120 (117)	119.6 (134.4)								
Median (min; max)	95 (0; 840)	90 (0; 480)	90 (0; 840)								
Age (years)				0.939	0.899	0.980	0.003**	0.932	0.888	0.977	0.004
Mean (SD)	71.4 (9.2)	66.6 (8)	69.5 (9)								
Median (min; max)	71.5 (48; 89)	64 (54; 89)	69 (48; 89)								
Study Time (years)				1.086	0.960	1.229	0.553*				
Mean (SD)	7.7 (2.6)	8.4 (3.5)	8 (3)								
Median (min; max)	8 (1; 15)	8 (1; 15)	8 (1; 15)								
BMI (kg/m^2)				1.032	0.967	1.101	0.344**				
Mean (SD)	30.6 (5.6)	31.6 (5.5)	31 (5.6)								
Median (min; max)	30.4 (19.8; 49.9)	30.6 (23; 46.8)	30.5 (19.8; 49.9)								
% Body Fat (PBF)				1.031	0.986	1.078	0.182**	1.007	0.945	1.073	0.833
Mean (SD)	37.2 (9.4)	39.4 (7.2)	38.1 (8.6)								
Median (min; max)	40.4 (10.1; 49.1)	40.6 (17.6; 49)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				0.985	0.804	1.207	0.885**				
Mean (SD)	-0.03 (1.7)	-0.08 (1.99)	-0.05 (1.79)								
Median (min; max)	-0.01 (-4.35; 4.44)	0.13 (-7.82; 4.02)	0.01 (-7.82; 4.44)								
Variation % Body Fat				0.999	0.942	1.061	0.982**				
Mean (SD)	-1.65 (6.5)	-1.68 (5.53)	-1.66 (6.12)								
Median (min; max)	-1.79 (-17.88; 35.72)	-1.98 (-16.72; 14.62)	-1.79 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

Table 6. Improvement in pulp pinch strength according to qualitative characteristics and the results of the statistical tests.

Variable	Pulp Pinch Grip Improvement		Total	OR not adjusted	95% CI		p	OR adjusted	95% CI		p
	No	Yes			Below	Above			Below	Above	
Type of physical activity, n (%)							0.788#				
None	10 (29.4)	24 (70.6)	34	1.00							
Class text/Stretching	8 (25.8)	23 (74.2)	31	1.20	0.40	3.57					
Walking/Gymnastics/Water aerobics	17 (36.2)	30 (63.8)	47	0.74	0.29	1.90					
Swimming/Cycling/Lifting Weights	4 (28.6)	10 (71.4)	14	1.04	0.26	4.12					
Intensity of physical activity, n (%)							0.435#				
None	12 (33.3)	24 (66.7)	36	1.00							
Light Activity	14 (24.6)	43 (75.4)	57	1.54	0.61	3.85					
Moderate Activity	11 (42.3)	15 (57.7)	26	0.68	0.24	1.93					
Intense activity	2 (33.3)	4 (66.7)	6	1.00	0.16	6.26					
Sex, n (%)							0.013				
Male	14 (50)	14 (50)	28	1.00				1.00			
Female	25 (25.5)	73 (74.5)	98	2.92	1.23	6.96		2.95	1.21	7.19	0.018
Race, n (%)							0.211#				
White	24 (30.4)	55 (69.6)	79	1.00							
Mixed race of African descent	6 (21.4)	22 (78.6)	28	1.60	0.58	4.45					
Black	8 (53.3)	7 (46.7)	15	0.38	0.12	1.17					
Asian	1 (33.3)	2 (66.7)	3	0.87	0.08	10.09					
Rhiz, n (%)							0.400				
No arthritis	13 (39.4)	20 (60.6)	33	1.00				1.00			
Unilateral arthritis	4 (22.2)	14 (77.8)	18	2.28	0.61	8.45		1.93	0.51	7.33	0.335
Bilateral arthritis	22 (29.3)	53 (70.7)	75	1.57	0.67	3.69		1.71	0.71	4.15	0.234
Minutes per week				0.999	0.996	1.002	0.632*				
Mean (SD)	133.2 (135.5)	116.7 (133.6)	121.8 (133.9)								
Median (min; max)	120 (0; 480)	90 (0; 840)	95 (0; 840)								
Age (years)				1.008	0.967	1.051	0.714**				
Mean (SD)	69.1 (8.6)	69.8 (9.3)	69.6 (9.1)								
Median (min; max)	69 (50; 89)	70 (48; 89)	69.5 (48; 89)								
Study Time (years)				0.956	0.841	1.085	0.287*				
Mean (SD)	8.2 (2.8)	7.8 (3.1)	7.9 (3)								
Median (min; max)	8 (1; 15)	8 (1; 15)	8 (1; 15)								
BMI (kg/m^2)				0.982	0.918	1.050	0.599**				
Mean (SD)	31.5 (6.8)	30.9 (5)	31.1 (5.6)								
Median (min; max)	30.7 (19.8; 49.9)	30.4 (22.4; 48)	30.6 (19.8; 49.9)								
% Body Fat (PBF)				1.008	0.965	1.053	0.715**				
Mean (SD)	37.7 (9.8)	38.3 (8.1)	38.1 (8.6)								
Median (min; max)	40.4 (12; 49.1)	40.4 (10.1; 49)	40.4 (10.1; 49.1)								
BMI Variation (kg/m^2)				1.055	0.852	1.306	0.625**				
Mean (SD)	-0.14 (1.6)	0.04 (1.86)	-0.02 (1.79)								
Median (min; max)	0.13 (-3.75; 3.36)	0.01 (-7.82; 4.44)	0.05 (-7.82; 4.44)								
Variation % Body Fat				0.987	0.928	1.050	0.683**				
Mean (SD)	-1.29 (4.7)	-1.78 (6.68)	-1.62 (6.1)								
Median (min; max)	-0.46 (-17.88; 8.04)	-2.14 (-16.72; 35.72)	-1.79 (-17.88; 35.72)								

Chi-squared test; # Likelihood ratio test; * Mann-Whitney test; ** Student's t-test; OR: Odds Ratio; CI: Confidence interval; Logistic regression results

extensor and abductor muscles to stabilize the trapeziometacarpal joint, while gym exercises develop palmar grip on equipment.[17]
Black participants were 4.8 times more likely to improve their physical quality of life than white participants, and the presence of rhizarthritis did not affect improvement in the physical component of the SF-36. (Table 1) Time seemed to affect improvement in the mental component of the SF-36, but no variable influenced this improvement. (Table 2) We questioned the accuracy of the findings from the SF-36 because patients may have had difficulty understanding the questionnaire, considering that they had an average of 8 years of schooling. Similarly, none of the variables influenced improvement according to the DASH questionnaire. (Table 3) Women showed 79% less chance of improvement than men in the HAQ (p=0.037), and each decrease of 1% in body fat percentage increased the chance of improvement in the HAQ by 9.2% (p=0.038). (Table 4) We already knew that patients who lose weight improve their overall muscular strength (as assessed by the HAQ),[12] but even though few participants lost weight, this result was constant at each annual evaluation.
As expected, age and the presence of rhizarthritis influenced grip strength.[1,8] (Table 5). Patients with unilateral rhizarthritis are 5.3 times more likely to improve than patients without rhizarthritis, because these patients were expected to be worse and after treatment their grip may have improved. Here we should recall that all patients received diacerein for knee OA, and that patients who had hand symptoms were fitted for orthotics by the occupational therapists. Patients with unilateral rhizarthritis could (data not analyzed) have milder degrees of OA than patients with bilateral rhizarthritis. As expected, and like the functional results for the knees, age had a negative impact on grip strength,[14,15] probably because of sarcopenia.[8] Sex influenced pulp to pulp pinch strength, with females 2.95 times more likely to improve their pulp to pulp pinch strength than men (p=0.018). The simple explanation may be that they were more affected than men in this area and that treatment offered more significant improvement in women than in men. Tripod pinch strength improved more in patients with rhizarthritis than in patients without this disease. The degree of rhizarthritis did not influence strength improvement to the same extent as other joints with OA.[8,14,15]

CONCLUSION

Patients with multiple arthritis and rhizarthritis improved their quality of life and grip strength through clinical treatment, an educational program, and fat loss.

ACKNOWLEDGMENTS

This study is part of a project that would not have been possible without the help of Heloísa Ungaro, Paulo Dallari, Miriam Damaris Di Maio, TRB Pharma, Alípio Jose Gusmão dos Santos, Pérola Grinberg Plapler, and Professor Olavo Pires de Camargo. The work of the secretaries (especially Suellen Lima, Natalia Borges, Abel Narciso Telecesqui, Rosilane Z. Castro Dutra, Mercedes Alves Coutinho, and Marlene Dezablanco) was essential in completing the project and acquiring the data. We are grateful to all the teams: nutrition (Nadia Lucila Rocha Brito), the social assistants, physical therapists, psychologists, and physical educators, as well as the security personnel at the Hospital das Clínicas, Department of Orthopedics, São Paulo Medical School, who made this multidisciplinary care and education project possible.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. FMR (0000-0003-2447-9469)* and MMAAI (0000-0001-6807-7555)* collected and analyzed the data and drafted the manuscript; DSS (0000-0002-0346-6506)*, LCA (0000-0002-3926-5669), and RMS (000-0003-2016-0661)* elaborated the project, collected the data, and edited the manuscript; MUR (0000-0002-2020-9501)* prepared the study, collected and analyzed the data, and drafted and edited the manuscript. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, Deyo RA, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. Arthritis Rheum. 2008;58(1):26–35.
2. Mathers C, World Health Organization. The Global Burden of Disease: 2004 Update. World Health Organization; 2008.
3. Arden N, Nevitt MC. Osteoarthritis: epidemiology. Best Pract Res Clin Rheumatol. 2006;20(1):3–25.
4. Brandt KD, Radin EL, Dieppe PA, van de Putte L. Yet more evidence that osteoarthritis is not a cartilage disease. Ann Rheum Dis. 2006;65(10):1261–4.
5. Brandt KD, Dieppe P, Radin EL. Etiopathogenesis of osteoarthritis. Rheum Dis Clin North Am. 2008;34(3):531–59.
6. Lane NE, Brandt K, Hawker G, Peeva E, Schreyer E, Tsuji W, et al. OARSI-FDA initiative: defining the disease state of osteoarthritis. Osteoarthritis Cartilage. 2011;19(5):478–82.
7. Martel-Pelletier J, Boileau C, Pelletier J-P, Roughley PJ. Cartilage in normal and osteoarthritis conditions. Best Pract Res Clin Rheumatol. 2008;22(2):351–84.
8. Litwic A, Edwards MH, Dennison EM, Cooper C. Epidemiology and burden of osteoarthritis. Br Med Bull. 2013;105:185–99.
9. Jamshidi AR, et al. Clinical Hand Osteoarthritis in Tehran: Prevalence, Signs, Symptoms, and Pattern - COPCORD Stage I, Iran Study. J Rheumatol. 2008; 35(7):1467–8.
10. Zeng QY, Chen R, Darmawan J, Xiao ZY, Chen SB, Wigley R, et al. Rheumatic diseases in China. Arthritis Res Ther. 2008;10(1):R17.
11. Rezende MU, Campos GC, Pailo AF, Frucchi R, Pasqualin T, Camargo OP. PARQVE – Project Arthritis Recovering Quality of Life by means of Education short-term outcome in a randomized clinical trial. J Arthritis. 2013; 2:2.
12. Kuhn VC, Scarcella DS, Suzuki RM, Almeida LC, Brito NL, Rezende MU. Prevalence and incidence of hand osteoarthritis and upper limb complaints in patients with knee osteoarthritis. Correlations among functionality grip strength, changes in body mass index and symptoms among patients in an educational osteoarthritis program. Open J Orthop. 2016;6:1-9.
13. Rezende MU, Hissadomi MI, Campos GC, Frucchi R, Pailo AF, Pasqualin T, et al. One-year results of on educational program on osteoarthritis: a prospective randomized controlled trial in Brazil. Geriatr Orthop Surg Rehabil. 2016;7(2):86-94.
14. Kirihara RA, Catelan FB, Farias FE, Silva CA, Cernigoy CH, Rezende MU. Intensidade, duração e tipo de atividade física para melhora da função na gonartrite. Acta Ortop Bras. 2017;25(1):25-9.
15. Rezende MU, Frucchi R, Pailo AF, Campos GC, Pasqualin T, Hissadomi MI. PARQVE: projeto artrose recuperando qualidade de vida pela educação: resultados em dois anos. Acta Ortop Bras. 2017;25(1):18-24.
16. Eaton RG, Lane LB, Littler JW, Keyser JJ. Ligament reconstruction for the painful thumb carpometacarpal joint: A long-term assessment. J Hand Surg Am 1984;9:692-99.
17. Rezende MU, Pailo AF, Strutz CG, Cernigoy CHA, Silva CAC, Scarcella DS, et al. Tratamento multiprofissional da artrose. Rio de Janeiro: Revinter; 2015.
18. Ciconelli RM, Ferraz MB, Santos W, Meinão I, Quaresma MR. Tradução para a língua portuguesa e validação do questionário genérico de ava- liação de qualidade de vida SF-36 (Brasil SF-36). Rev Bras Reumatol. 1999;39(3):143-50.
19. Orfale AG, Araújo PM, Ferraz MB, Natour J. Translation into Brazilian Portuguese, cultural adaptation and evaluation of the reliability of the Disabilities of the Arm, Shoulder and Hand Questionnaire. Braz J Med Biol Res. 2005;38(2):293-302.
20. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). Am J Ind Med. 1996;29(6):602-8.

DOI: http://dx.doi.org/10.1590/1413-785220182601181880

ORIGINAL ARTICLE

HOW DO BOARD-CERTIFIED HAND SURGEONS MANAGE CARPAL TUNNEL SYNDROME? A NATIONAL SURVEY

COMO O CIRURGIÃO ESPECIALISTA EM MÃO ABORDA A SÍNDROME DO TÚNEL DO CARPO? UM LEVANTAMENTO NACIONAL

Aldo Okamura[1,2], Bruna Calvi Guidetti[1], Raphael Caselli[1], Jonas Aparecido Borracini[1], Vinicius Ynoe de Moraes[2], João Carlos Belloti[2]

1. Hospital Dr. Fernando Mauro Pires da Rocha (Hospital Municipal do Campo Limpo), São Paulo, SP, Brazil.
2. Hospital Alvorada, Moema, São Paulo, SP, Brazil.

ABSTRACT

Objective: To evaluate tendencies in the planning, diagnosis, and treatment of carpal tunnel syndrome (CTS) by Brazilian hand surgery specialists. Methods: This cross-sectional study was performed at the 36th Brazilian Hand Surgery Congress. We prepared a questionnaire about preferences in the management of CTS, and board-certified hand surgeons that attended the congress were asked to fill out the questionnaires. A total of 174 questionnaires were analyzed. Results: Electromyography examination is used by most surgeons. Night splinting is the most commonly used conservative treatment option. Half of the surgeons utilized prophylactic antibiotics. Most of the interviewees conduct inpatient surgery in the operating room and prefer intravenous regional anesthesia. Most of surgeons use the standard open technique associated with proximal release of the antebrachial fascia and do not perform neurolysis. Compressive dressings are most commonly used for 7 days. Conclusion: The approach to CTS among Brazilian hand surgeons with regard to pre-, intra-, and post-operatory conduct is consistent with the international literature. However, there is a need to reflect and conduct new studies on non-surgical treatment involving local corticosteroid injection, use of prophylactic antibiotics, hospital admission, and type of anesthesia in order to provide more cost-effective approach to surgical treatment for CTS. ***Level of Evidence V; Expert opinion.***

Keywords: Carpal tunnel syndrome. Epidemiology. Therapy. Questionnaire. Cross-sectional studies.

RESUMO

Objetivo: Avaliar as tendências no planejamento, diagnóstico e tratamento da síndrome do túnel do carpo (STC) dos cirurgiões brasileiros especialistas em mão. Métodos: Este estudo transversal foi realizado no 36º Congresso Brasileiro de Cirurgia da Mão. Preparamos um questionário sobre as preferências no tratamento de STC, e os cirurgiões especialistas em mão que participaram do congresso foram solicitados a responder os questionários. Foram analisados 174 questionários. Resultados: A eletroneuromiografia é usada pela maioria dos cirurgiões. A tala noturna é a modalidade de tratamento conservador mais usada. Metade dos cirurgiões utiliza antibióticos profiláticos de rotina. A maioria dos entrevistados realiza as cirurgias no centro cirúrgico com internação hospitalar e prefere anestesia regional intravenosa. A maior parte dos cirurgiões emprega a técnica aberta padrão associada à abertura da fáscia antebraquial e não realiza neurólise. Curativos compressivos são habitualmente usados por sete dias. Conclusão: A conduta pré, intra e pós-operatória na STC entre os cirurgiões de mão brasileiros é compatível com a literatura internacional. Entretanto, há necessidade de reflexão e de novos estudos sobre a infiltração local de corticoides, o uso de antibióticos profiláticos, internação hospitalar e tipo de anestesia com o objetivo de proporcionar melhor custo-efetividade ao tratamento cirúrgico da STC. ***Nível de Evidência V; Opinião do especialista.***

Descritores: *Síndrome do túnel carpal. Epidemiologia. Terapia. Questionário. Estudos transversais.*

Citation: Okamura A, Guidetti BC, Caselli R, Borracini JA, Moraes VY, Belloti JC. How do board-certified hand surgeons manage carpal tunnel syndrome? A national survey. Acta Ortop Bras. [online]. 2018;26(1):48-53. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Carpal tunnel syndrome (CTS) is a major cause of compressive neuropathy, occurring by the compression of the median nerve in the carpal tunnel. Related literature has a large number of publications, ranging for etiology investigation to less invasive treatment options. As the condition is frequent and impacts in function and quality of life, best evidence efforts should be considered to optimize cost reduction and clinical effectiveness. However, literature is conflicting regarding to CTS management and consensus initiatives have not reached the hand surgeon routine, which incurs in substantial

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

Work conducted at the Hospital Dr. Fernando Mauro Pires da Rocha (Hospital Municipal do Campo Limpo), São Paulo, SP, Brazil e Hospital Alvorada-Moema, São Paulo, SP, Brazil. Correspondence: Aldo Okamura. Estrada de Itapecerica, 1661, Campo Limpo, São Paulo, SP, Brazil. 05835-005. aldookamura@gmail.com

Article received in 06/27/2017, approved in 08/22/2017.

CC BY NC

heterogeneity in practice, fact that is relevant from the health policy perspective. Systematic reviews conclude that there is not enough evidence to enable decision making on the best methods of diagnosis and treatment.[1-3] Motivated by the clinical importance of the disease and the absence of conclusive scientific substrate that allow the elaboration of an definitive algorithm for CTS diagnosis and treatment, we idealized this study with the objective of assessing the opinion of hand surgery specialists in 36th Brazilian Congress of Hand Surgery (BCHS), regarding to CTS management.

METHOD

A total of 350 questionnaires were distributed during the 36th BCHS, with 18 objective questions about the main aspects of diagnosis and treatment for CTS. (Annex 1) As inclusion criterion, only the questionnaires answered in full were considered and from board-certified members. Participants were invited to participate, in a random form. Participation was voluntary and responses were kept confidential. From 350 randomly distributed questionnaires, 101 were excluded because they were incomplete, 44 filled out by non-specialists from Brazilian Society of Hand Surgery (BSHS) and 31 filled out by resident physicians, resulting in the final inclusion of 174 questionnaires.

Statistical analysis

Results were computed and submitted to statistical analysis. To estimate the sample size, we considered an expected proportion of 10% from the total number of members of the society, considering a 95% confidence interval and a alpha as 5%, sample size resulted in the need to consider 158 questionnaires. The variables were analyzed descriptively through the observation of the values and percentage calculation.

RESULTS

There were 694 participants on 36th BCHS, being 387 members of the BSHS. Most of the participants practice were in the southeast region (Figure 1) and have less than 10 years of experience as a hand surgery specialist. (Figure 2)

Regarding conservative treatment, 82% of surgeons answered that they had had conservative treatment before surgery in at least half of the patients. (Table 1) Regarding conservative treatment time, 55% considered treatment for 5-8 weeks and 25% for 9-12 weeks. (Table 1)

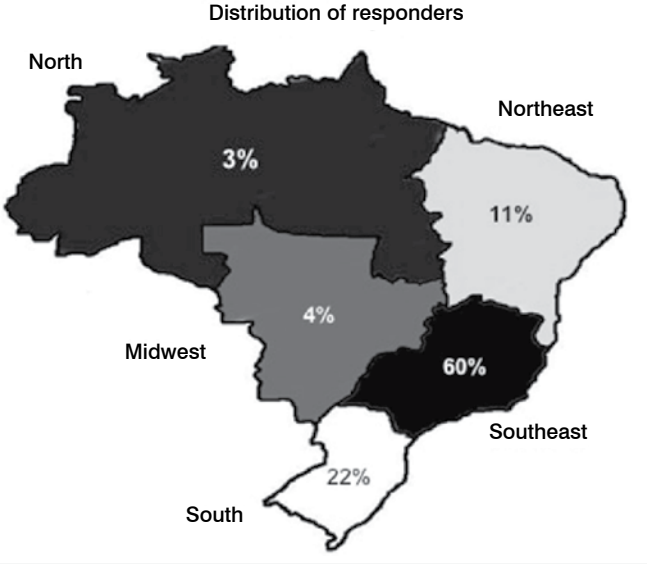


Figure 1. Distribution of responders.

Most applied non-surgical treatment was night splinting (90%) associated or not with non-steroidal anti-inflammatory drugs (56%) and/or intramuscular corticosteroid (55%) and/or corticosteroid local injection in the carpal tunnel (33%). (Table 1)

Most of the participants (58%) always performed electrodiagnostic test in addition to clinical diagnosis. (Figure 3)

The vast majority of the interviewees (93%) performed surgeries in the main operating room with hospitalized patients and half of those used a prophylactic antibiotic. (Table 2)

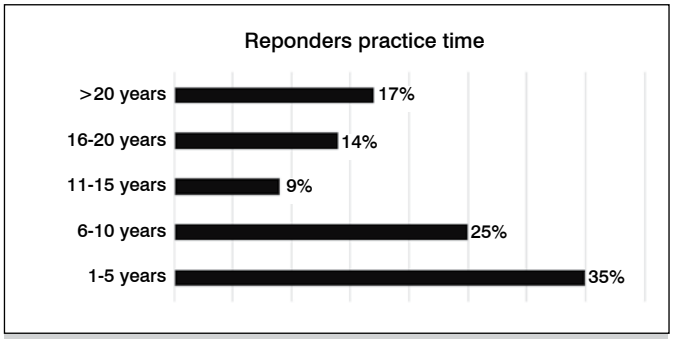


Figure 2. Responders practice time in hand surgery speciality.

Table 1. Patient selection and non-surgical treatment.

Percentage of patients with conservative treatment before surgery.	
Alternatives	**Answers**
a) 0%	1%
b) 25%	17%
c) 50%	40%
d) 100%	42%
Modalities for non-surgical treatment of CTS (more than one alternative is possible).	
Alternatives	**Answers**
a) Intramuscular corticosteroid	55%
b) Diuretics	1%
c) *NSAIDs*	56%
d) Local corticosteroid injection	33%
e) Night splint	90%
Conservative treatment time.	
Alternatives	**Answers**
a) <1 week	0
b) 1-4 weeks	13%
c) 5-8 weeks	55%
d) 9-12 weeks	25%
e) >12 weeks	14%

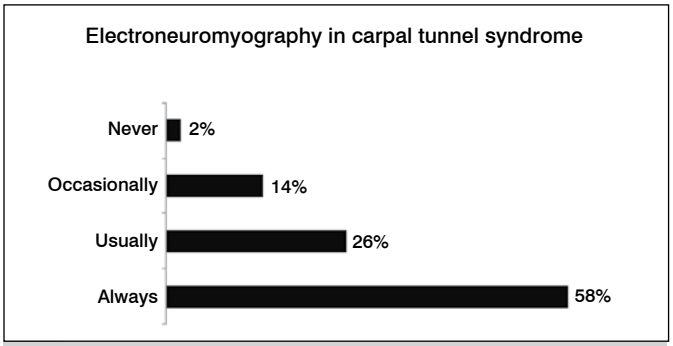


Figure 3. Use of electrodiagnostic test in CTS.

Table 2. Surgical technique.

Surgeries performed outside main operating room (hospital setting)	
Alternatives	Answers
a) never	93%
b) 1-25%	4%
c) 26-50%	3%
d) 51-75%	0%
e) 76-99%	0%
f) 100%	0%
Prophylactic antibiotic utilization	
Alternatives	Answers
a) yes	50%
b) no	50%
Hemostasis review prior to wound closure (after deflate the tourniquet)	
Alternatives	Answers
a) yes	28%
b) no	72%
Surgeries performed by classical open surgery in the last year	
Alternatives	Answers
a) never	14%
b) 1-25%	14%
c) 26-50%	5%
d) 51-75%	8%
e) 76-99%	13%
f) 100%	52%
Surgeries performed by retinaculotome	
Alternatives	Answers
a) never	68%
b) 1-25%	11%
c) 26-50%	6%
d) 51-75%	6%
e) 76-99%	5%
f) 100%	4%
Surgeries performed by endoscopic technique	
Alternatives	Answers
a) never	58%
b) 1-25%	18%
c) 26-50%	5%
d) 51-75%	4%
e) 76-99%	8%
f) 100%	4%
Single portal (Agee)	90%
Double portal (Chow)	10%
Canal flexor tenolysis	
Alternatives	Answers
a) never	40%
b) sometimes	39%
c) frequently	6%
d) always (if necessary)	13%
Antebrachial fascia openning	
Alternatives	Answers
a) yes	65%
b) no	35%

Regional anesthesia is the most used (45%), followed by local (33%) and general anesthesia (22%). Among the participants who opted for regional anesthesia, the majority (79%) preferred to use the technique described by Bier (intravenous regional anesthesia), followed by peripheral nerve block (21%). Of those who chose local anesthesia, the largest proportion chose to use lidocaine (46%), without vasoconstrictor (72%), associated with sedation (86%) and with tourniquet use (90%). (Figure 4)

As for the surgical technique, considering the participants who answered that they perform a certain surgical technique in more than half of cases, we found that open surgery was the most used (73%), followed by the endoscopic surgery (16%) and mini-open with the aid of a retinaculotome (15%). Surgeons who perform the endoscopic technique have wide preference for the Agee single portal technique. (Table 2)

In open surgery, in addition to the opening of the transverse carpal ligament, most of the participants (65%) performed opening of the proximal antebrachial fascia and only 13% perform routine flexor tenolysis. (Table 2) Only 17% of hand surgeons perform routine median nerve neurolysis, while 41% said they never perform. (Figure 5) Removal of the tourniquet for hemostasis review was not performed routinely by most of participants (72%), regardless of the anesthetic technique. (Table 2). The majority of participants (98%) did not use corticosteroid in the carpal tunnel before wound closure and did not use drains. (Table 3)

Regarding postoperative care, the majority (67%) of the participants use compressive dressing (table 3) most of the time for 7 days. (Figure 6) Among the adjuvant treatment modality, the most used (73%) in the postoperative period were analgesics between 5 and 7 days, followed by non-steroidal anti-inflammatory drugs (NSAIDs) (62%) between 5 and 7 days and splinting (38%) between 5 - 15 days. (Figure 6)

DISCUSSION

Our results were representative of the demographical distribution of the participants members of BSHS. The majority are young specialists practicing in the southeast region. Non-surgical approach of CTS is performed by the vast majority of participants. The treatment time between 5-8 weeks is consistent with other studies with a similar methodological design.[1,4]

For non-surgical treatment, the vast majority of the interviewees use night splint (90%) and NSAIDs (56%), supported by good evidence from the literature.[5,6] Studies with good methodological quality have shown that corticosteroid local injection in the carpal tunnel is also a safe and effective procedure for regression of symptoms for up to 12 months, besides being a good parameter to infer the prognosis of the surgical treatment.[1,7] Despite this benefit only 1/3 of Brazilian hand surgeons report using it routinely.

Regarding diagnostic methods, although clinical examination and CTS6[8] score prove to be good diagnostic tools, most (58%) of the interviewees use electromyography as a routine in the diagnosis of carpal tunnel syndrome, which is consistent with other authors suggesting that this is the most accurate non clinical diagnostic tool.[9]

In Brazil, the surgical treatment of CTS is performed most often in a main operating room sterility (hospital setting) with intravenous regional anesthesia (Bier). The research with US hand surgeons has described that they perform CTS surgery also in a hospital setting, but they frequently use local anesthesia, sedation and tourniquet.[4] However, in the last decade some studies have described the procedure in an minor procedure rooms (ambulatory setting) with field sterility under pure local anesthesia, mostly without tourniquet and with lidocaine with epinephrine. They found substantial cost reduction and wait times for surgery, increased patient and

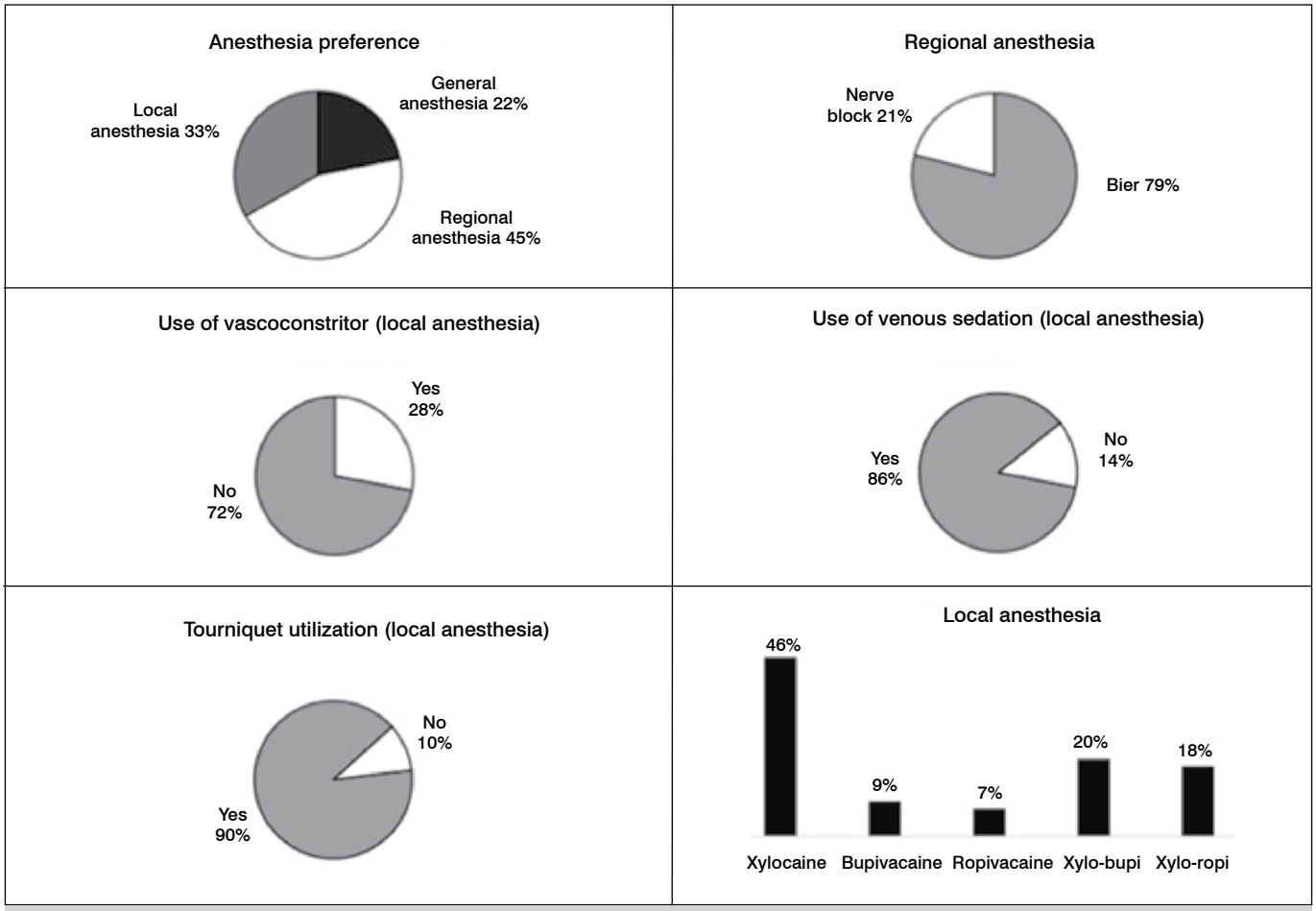


Figure 4. Anesthesia preference for CTS surgery.

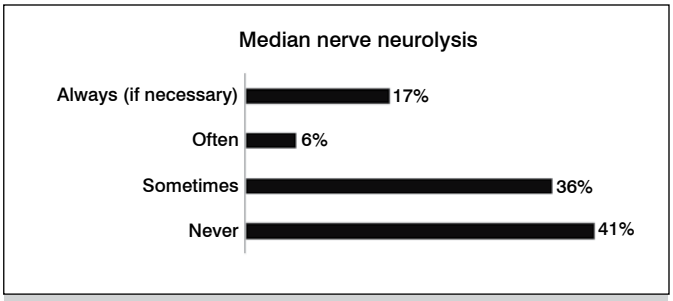


Figure 5. Preference regarding to median nerve neurolysis.

Tabela 3. Postoperative.

Corticosteroid intracanal before wound closure	
Alternatives	Answers
a) yes	2%
b) no	98%
Postoperative drain utilization	
Alternatives	Answers
a) yes	2%
b) no	98%
Postoperative compressive dressing	
Alternatives	Answers
a) yes	67%
b) no	33%

surgeon convenience, but has not increased wound infection rates, which leads us to reflect on the need for comparative studies in our environment about safety and cost-effectiveness of these methods.[10,11,12] There is currently the need to optimize the use of the resources available in our Health System, both in the public and private sectors. We believe this is an important subject of research. Although there is conclusive evidence on the inefficacy of prophylactic antibiotic use in CTS surgeries, even in patients with diabetes, we found in our results that half of Brazilian hand surgeons use prophylactic antibiotics.[13] Similar study described that 35% of US surgeons use routine preoperative antibiotics for CTS surgery.[4]

Most Brazilian and American surgeons do not release the tourniquet before wound closure.[4] However, we have to consider that this surgical step is generally not possible in cases of anesthesia with the Bier technique nor when the surgical technique chosen is retinaculotome or endoscopic. The tenolysis also cannot be performed with the endoscopic and mini open techniques with the aid of retinaculotome.

The endoscopic surgical technique was chosen as preferred by 16% of respondents, lower index when compared to the American study with a similar methodological design[4]. The retinaculotome technique was the one that had greatest rejection, 68% of the participants report that they never use it. However, there are studies that show that patients operated by the retinaculotome technique were satisfied with the surgical outcome.[14] The AAOS American Academy conducted a review of the literature and concluded that there was strong evidence recommending surgical treatment of

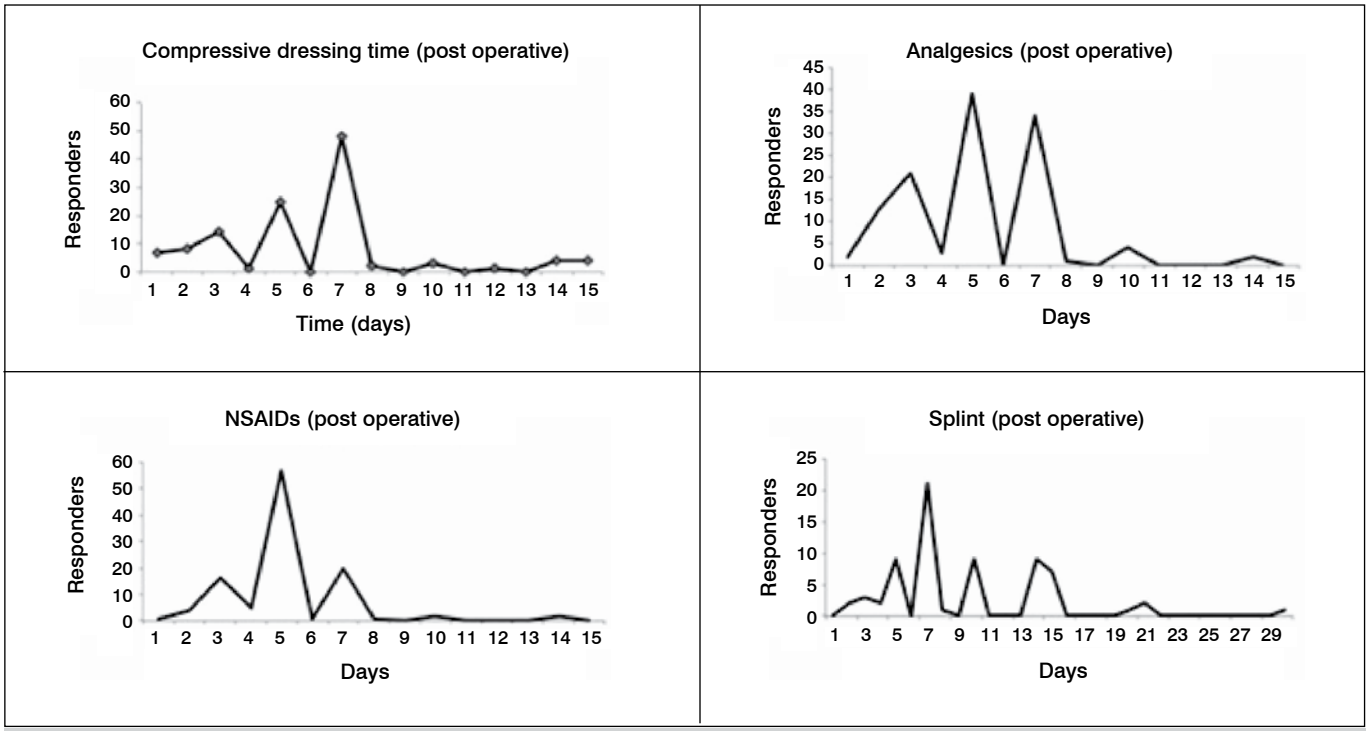


Figure 6. CTS postoperative care preferences.

carpal tunnel syndrome by fully opening the flexor retinaculum regardless of the surgical technique chosen.[1,15]

Following the precepts of Phalen we found that 65% of participants open the antebrachial fascia. The author in his description of the surgical technique emphasized the importance of the complete incision of all distal extension of the roof of the carpal tunnel and also of the proximal fascia to the transverse carpus ligament. His studies suggest that the proximal and distal aspects of the fascia are important sources of carpal tunnel syndrome.[16] Further studies show that the transition area between the forearm fascia and the transverse carpal ligament is the most likely site of flexion-induced deformation of the median nerve and may be responsible for the challenge of the Phalen signal.[17] However no statistically significant difference was found in carpal tunnel pressure after release of the proximal portion of the flexor retinaculum in the resting position or with palmar grip strength.[18]

According to the international literature 41% of the respondents answered that they never perform the neurolysis of the median nerve. Studies concluded that internal neurolysis does not add significant improvement in the sensory or motor outcome of patients with carpal tunnel syndrome.[19]

In our setting, concomitant procedures following surgical release such as corticosteroid intracanal before wound closure and drainage placement are rarely performed (2%), while tenolysis and neurolysis are occasionally performed. Our results are in agreement with other studies with similar methodological design.[1,4]

As an hemostatic measure we found that 67% of the interviewees used compressive dressing in the postoperative period for approximately 7 days. A recent study concluded that the use of a bulky dressing after open surgery (mini-incision) for carpal tunnel syndrome and replacement with a tape in 48 to 72 hours does not cause wound complications and the clinical outcome is the same compared to wearing a dressing bulky for 2 weeks.[20]

We found the least used postoperative treatment modality was immobilization (38%) which is in line with that proposed by the American guideline.[1]

Some limitations of this study are the possibility that the response of the participants was conditioned to the economic power of the region where it operates, generating discrepancy in the diagnosis and treatment of patients with carpal tunnel syndrome in some centers in relation to others. The fact that the research was carried out in a scientific congress may have generated a potential selection bias in relation to the interest / academic training of the interviewees present to the detriment of those who did not participate. In the questionnaire, ultrasound was not evaluated as a diagnostic tool.

CONCLUSION

Most of the hand surgeons use routine electroneuromyography for diagnosis. Conservative treatment is considered between 5-12 weeks and there is predilection for prescription of night splint and NSAIDs.

Most commonly performed is open surgery, with intravenous regional anesthesia (Bier) associated with antebrachial fascia opening and compressive dressing for one week.

Surgeons and health care policy makers should be aware about a local corticosteroid injection non-surgical treatment, the ineffectiveness on the use of prophylactic antibiotics, high costs of ward hospitalization and the need standardization of anesthesia methods in order improve cost-effectiveness in the CTS treatment scenario.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AO (0000-0003-00115-2236)* and JCB (0000-0003-3396-479X)*: were the main contributors in preparing the manuscript, performing the literature reviews, evaluating the data from the statistical analysis, and revising the manuscript; BCG (0000-0001-8068-8287)* and RC (0000-0002-3103-396X)*: application of questionnaires; JAB (0000-0003-1531-5235)*: technical support; VYM (0000-0002-4933-4007): statistical analysis and intellectual support. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Keith MW, Masear V, Chung KC, Maupin K, Andary M, Amadio PC, et al. American Academy of Orthopaedic Surgeons Clinical Practice Guideline on diagnosis of carpal tunnel syndrome. J Bone Joint Surg Am. 2009;91(10):2478-9.
2. Verdugo RJ, Salinas RA, Castillo JL, Cea JG. Surgical versus non surgical treatment for carpal tunnel syndrome. Cochrane Database Syst Rev. 2008;8;(4):CD001552.
3. Zuo D, Zhou Z, Wang H, Liao Y, Zheng L, Hua Y, Cai Z. Endoscopic versus open carpal tunnel release for idiopathic carpal tunnel syndrome: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2015;10:12.
4. Leinberry CF, Rivlin M, Maltenfort M, Beredjiklian P, Matzon JL, Ilyas AM, et al. Treatment of carpal tunnel syndrome by members of the American Society for Surgery of the Hand: a 25-year perspective. J Hand Surg Am. 2012;37(10):1997-2003.e3.
5. O'Connor D, Marshall S, Massy-Westropp N. Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome. Cochrane Database Syst Rev. 2003;(1):CD003219.
6. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Exercise and mobilization interventions for carpal tunnel syndrome. Cochrane Database Syst Rev. 2012;13;(6):CD009899.
7. Blazar PE, Floyd WE 4th, Han CH, Rozental TD, Earp BE. Prognostic indicators for recurrent symptoms after a single corticosteroid injection for carpal tunnel syndrome. J Bone Joint Surg Am. 2015;7;97(19):1563-70.
8. Atroshi I, Lyrén PE, Ornstein E, Gummesson C. The six-item CTS symptoms scale and palmar pain scale in carpal tunnel syndrome. J Hand Surg Am. 2011;36(5):788-94.
9. Sears ED, Swiatek PR, Hou H, Chung KC. Utilization of preoperative electrodiagnostic studies for carpal tunnel syndrome: an analysis of national practice patterns. J Hand Surg Am. 2016;41(6):665-672.e1.
10. Lalonde D, Bell M, Benoit P, Sparkes G, Denkler K, Chang P. A multicenter prospective study of 3,110 consecutive cases of elective epinephrine use in the fingers and hand: the Dalhousie Project clinical phase. J Hand Surg Am. 2005;30(5):1061-7.
11. Leblanc MR, Lalonde DH, Thoma A, Bell M, Wells N, Allen M, et al. Is main operating room sterility really necessary in carpal tunnel surgery? A multicenter prospective study of minor procedure room field sterility surgery. Hand (N Y). 2011;6(1):60-3.
12. Robles DS, Esteves S, Liça M, Lopes D, Lima S, Sousa C. Tratamento da síndrome do túnel cárpico: anestesia geral versus local. Rev Port Ortop Traum. 2015;23(3):217-24.
13. Harness NG, Inacio MC, Pfeil FF, Paxton LW. Rate of infection after carpal tunnel release surgery and effect of antibiotic prophylaxis. J Hand Surg Am. 2010;35(2):189-96.
14. Meireles LM, Santos JBG, Santos LL, Branco MA, Faloppa F, Leite VM, et al. Avaliação do questionário de Boston aplicado no pós-operatório tardio da Síndrome do Túnel do Carpo operados pela técnica de retinaculótomo de Paine por via palmar. Acta Ortop Bras. 2006;14(3):126-32.
15. Paryavi E, Zimmerman RM, Means KR Jr. Endoscopic compared with open operative treatment of carpal tunnel syndrome. JBJS Rev. 2016;4(6): pii:01874474-201606000-00005.
16. Phalen GS. The carpal-tunnel syndrome. Seventeen years' experience in diagnosis and treatment of six hundred fifty-four hands. J Bone Joint Surg Am.1966;48(2):211-28.
17. Cobb TK, Dalley BK, Posteraro RH, Lewis RC. Anatomy of the flexor retinaculum. J Hand Surg Am. 1993;18(1):91-9.
18. Okutsu I, Hamanaka I, Tanabe T, Takatori Y, Ninomiya S. Complete endoscopic carpal tunnel release in long-term haemodialysis patients. J Hand Surg Br. 1996;21(5):668-71.
19. Mackinnon SE, McCabe S, Murray JF, Szalai JP, Kelly L, Novak C, et al. Internal neurolysis fails to improve the results of primary carpal tunnel decompression. J Hand Surg Am. 1991;16(2):211-8.
20. Ritting AW, Leger R, O'Malley MP, Mogielnicki H, Tucker R, Rodner CM. Duration of postoperative dressing after mini-open carpal tunnel release: a prospective, randomized trial. J Hand Surg Am. 2012;37(1):3-8.

Annex 1.

How do board-certified hand surgeons manage carpal tunnel syndrome? A national survey.
( ) Hand surgery specialist ( ) Resident ( ) Other

Please indicate your region and performance time (hand surgery)
( ) Southeast ( ) South ( ) Midwest ( ) Northeast ( ) North
( ) 1-5 years ( ) 6-10 years ( ) 11-15 years ( ) 16-20 years ( ) >20 years

Selection of patients and non-surgical treatment

1. What percentage of patients had conservative treatment, by you or another specialist before surgery?
a) 0% b) 25% c) 50% d) 100%

2. What types of non-surgical treatment do you use for CTS? More than one alternative is possible.
a) Intramuscular corticosteroid
b) Diuretics
c) *NSAIDs*
d) Corticosteroid local injection
e) Night splint

3. Conservative treatment in weeks?
a) < 1 b) 1-4 c) 5-8 d) 9-12 e) >12

4. When do you use electromyography?
a) Always b) Usually c) Ocasionally d) Never

Surgical Technique

5. How many surgeries are performed outside sterility main operating room (hospital setting)?
a) 0% b) 1-25% c) 26-50% d) 51-75% e) 76-99% f) 100%

6. Do you use routine prophylactic antibiotics?
a) Yes b) No

7. What type of anesthesia do you prefer?
a) General anesthesia
I. tourniquet use II. without tourniquet

b) Regional anesthesia
I. BIER II. nerve block

Local anesthesia
Anesthetic?_____
I. vasoconstrictor II. without vasoconstritor
I. sedation II. without sedation
I. tourniquet II. without tourniquet

8. Do you deflate the tourniquet for hemostasis review prior to wound closure?
a) Yes b) No

9. How many surgeries have been performed by classical (open) surgery in the last year?
a) 0% b) 1-25% c) 26-50% d) 51-75% e) 76-99% f) 100%

10. How many surgeries have been performed using retinaculotome?
a) 0% b) 1-25% c) 26-50% d) 51-75% e) 76-99% f) 100%

11. How many surgeries have been performed by endoscopic technique?
a) 0% b) 1-25% c) 26-50% d) 51-75% e) 76-99% f) 100%

I. single portal (Agee) II. double portal (Chow)

12. Do you perform canal flexor tenolysis?
a) Never b) sometimes c) frequently d) always (if necessary)

13. Do you do neurolysis of the median nerve?
a) Never b) sometimes c) frequently d) always (if necessary)

14. Do you open the antebrachial fascia?
a) Yes b) No

15. Do you instill corticosteroid intracanal before wound closure?
a) Yes b) No

16. Do you use a drain?
a) Continuous suction drain
b) Penrose
c) Never

Postoperative care

17. Do you apply postoperative compressive dressing?
a) Yes. How long? _____ days b) No

18. Which treatment is applied in the postoperative period and how long? More than 1 alternative is possible.
a) Analgesics – ___ days.
b) NSAIDs – ___ days.
c) Night splint – ___ days.

DOI: http://dx.doi.org/10.1590/1413-785220182601179613

ORIGINAL ARTICLE

PROPOSAL TOMOGRAPHIC CLASSIFICATION FOR INTRA-ARTICULAR DISTAL RADIUS FRACTURES

PROPOSTA DE CLASSIFICAÇÃO TOMOGRÁFICA PARA AS FRATURAS INTRA-ARTICULARES DA EXTREMIDADE DISTAL DO RÁDIO

Valdênia das Graças Nascimento[1], Antonio Carlos da Costa[2], Leandro Rodrigues da Silva[1], Diego Figueira Falcocchio[2], Ivan Chakkour[2], Sergio Luiz Checchia[2]

1. Universidade Federal do Triângulo Mineiro, Uberaba, MG, Brazil.
2. Department of Orthopedics, Hand Surgery Group, Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: The objective of this study was to present a proposal tomographic classification for intra-articular distal radius fractures. Methods: This descriptive study was based on observing tomographic images from 74 patients with distal radius fractures. The cases were grouped by similarity according to the presence of several parameters which determine fracture complexity; the results of the descriptive analysis were transcribed as tomographic classification. Results: The proposal tomographic classification for intra-articular distal radius fractures comprised three major groups and nine sub-groups, which are organized by increasing severity according to the presence of spacing between articular fragments, angulation, loss of radial height, cortical depression, and associated dislocation. Conclusion: This proposal tomographic classification for intra-articular distal radius fractures can help professionals indicate therapeutic options. ***Level of Evidence IV; Case series.***

Keywords: Classification. Radius fractures. Tomography.

RESUMO

Objetivo: O objetivo deste estudo foi apresentar a proposta de uma classificação tomográfica das fraturas intra-articulares da extremidade distal do rádio. Métodos: Este estudo descritivo baseou-se na observação de imagens tomográficas de 74 pacientes com fratura da extremidade distal do rádio. Os casos foram agrupados por semelhança de acordo com a presença de alguns parâmetros determinantes da complexidade da fratura. Os resultados da análise descritiva foram transcritos na forma de uma classificação tomográfica. Resultados: A classificação tomográfica proposta para as fraturas intra-articulares da extremidade distal do rádio compreendeu três grupos maiores e nove subgrupos, organizados em ordem crescente de gravidade, de acordo com a presença de espaçamento entre os fragmentos articulares, desvio angular, perda da altura radial, afundamento cortical e luxação associada. Conclusão: Esta classificação tomográfica proposta para as fraturas intra-articulares da extremidade distal do rádio pode auxiliar os profissionais na indicação da conduta terapêutica. ***Nível de Evidência IV; Série de casos.***

Descritores: *Classificação. Fraturas do rádio. Tomografia.*

Citation: Nascimento VG, Costa AC, Silva LR, Falcocchio DF, Chakkour I, Checchia SL. Proposal tomographic classification for intra-articular distal radius fractures. Acta Ortop Bras. [online]. 2018;26(1):54-8. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Distal radius fractures are the most common lesions of the upper limb, accounting for 10-12% of all human skeletal fractures.[1] Organizing fractures into widely recognized classifications is important for determining and planning treatment options.[2] A number of authors have attempted to simplify the current classification systems available, despite the challenges of obtaining excellent reliability, guaranteeing ideal treatment and predicting prognoses.[3]

Technological evolution of new imaging exams and research on improved radiographic views has furthered understanding of fracture patterns, articular involvement and allowed detailed observation of fragments hitherto not well visualized on traditional radiographic views. This advance has led to questioning of the current classifications in use, the criteria for instability, recommended treatments and prediction of prognoses.

Pruit et al.[4] showed that computed tomography (CT) can disclose the involvement of the distal radio-ulnar joint in fractures better than radiographic imaging. In addition, the authors hold that CT is a highly useful exam for enhanced diagnostic elucidation, enabling easier and more reliable classification.

Given that the majority of classification systems used worldwide are based on observation of plain radiographs in two views, and drawing on previous studies by the Hand Surgery and Microsurgery Group investigating the influence of computed tomography

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

Work conducted at the Department of Orthopedics, Hand Surgery Group, Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.
Correspondence: Centro de Reabilitação, Hospital de Clínicas da UFTM. Rua da Constituição, 1009, Bairro Abadia, Uberaba, MG, Brazil. 38025-110. vallfmtm@yahoo.com.br

Article received in 05/06/2017, approved in 09/12/2017.

CC BY NC

on classifications and on treatment options for distal radius fractures,[5] it was decided to propose a classification based on intra-articular fragments observed in tomographic images on sagittal, coronal and axial planes.

MATERIAL AND METHODS

A descriptive study of a tomographic classification for distal radius fractures was performed by observing radiographic and tomographic images from patients seen at a Hand Surgery Service in Santa Casa de São Paulo between June 2012 and October 2015. The study was approved by our Institution Review Board (IRB) and Research Ethics Committee with protocol number 571.246. This study exempts the Term of Free and Informed Consent.

Images were included from patients aged over 18 years, irrespective of gender, ethnicity or laterality, and who had radiographs for the four projections taken on admission (posteroanterior – PA; profile – P; 45º semi-pronated oblique– PO; 45º semi-supinated oblique – SO) as well as sagittal, axial and coronal tomographs. Patients who were skeletally immature or had inappropriate or insufficient images were excluded.

Related literature data on the main classifications in use and the key parameters determining the severity, instability and irreducibility of distal radius fractures were reviewed. Most of these are reported based on the observation of radiographic images. For the proposal classification, these were assessed in depth and correlated with tomographic images in coronal, sagittal and axial cross-sections. After tomographic interpretation of the traits of each fracture, the cases were grouped by similarity according to the presence of spacing and misalignment of the radiocarpal articulation and/or distal radio-ulnar articulation, to angulations and loss of radial height, fragmentation and articular depression, existence of radiocarpal and perilunate dislocations, and according to the treatment method recommended in the literature. Lastly, descriptive statistical analysis was carried out and the results obtained were transcribed in the form of a tomographic classification, and schematic drawings of the possible groups and subgroups were devised.

After assessment of the tomographic images on coronal, sagittal and axial planes of 74 cases of patients with distal radius fractures, a tomographic classification was devised for the intra-articular distal radius fractures comprising 3 major groups and organized in increasing order of severity of fracture pattern, treatment complexity, and determination of prognosis. Fractures in the first group exhibited no articular displacement or if present, this had spacing between articular fragments < 2mm; the second group included fractures with articular displacement ≥ 2mm; while the third group contained any intra-articular radiocarpal fracture associated with dislocation. Below, each group and subgroup are outlined in detail along with their respective particularities.

Group I Fractures – Without articular displacement

Encompass all intra-articular distal radius fractures whose spacing between articular fragments is < 2mm. These are divided into three sub-groups:

IA – Intra-articular fractures with involvement of the distal radio-ulnar or radiocarpal joint. These have single or multiple fracture lines in the distal radio-ulnar or radiocarpal articulation with spacing between fragments < 2mm, without dorsal angulation ≥ 20º. These fractures do not exhibit radial shortening ≥ 9mm. (Figure 1A-C)

IB – Intra-articular fractures with involvement of both the distal radio-ulnar and radiocarpal joint. These have single or multiple fracture lines in both articulations, with spacing between fragments < 2mm, without dorsal angulation ≥ 20º. These fractures do not exhibit radial shortening ≥ 9mm. (Figure 2A-C)

IC – Intra-articular fractures with involvement of both the distal radio-ulnar and radiocarpal joints. These have single or multiple fracture lines in both articulations, with spacing between fragments < 2mm. They have single or multiple metaphyseal fragments, with dorsal angulation ≥ 20º and/or radial shortening ≥ 9mm. (Figure 3A-C)

Group II Fractures – With articular displacement

Encompass all intra-articular distal radius fractures whose spacing between intra-articular fragments is ≥ 2mm. These are divided into three sub-groups:

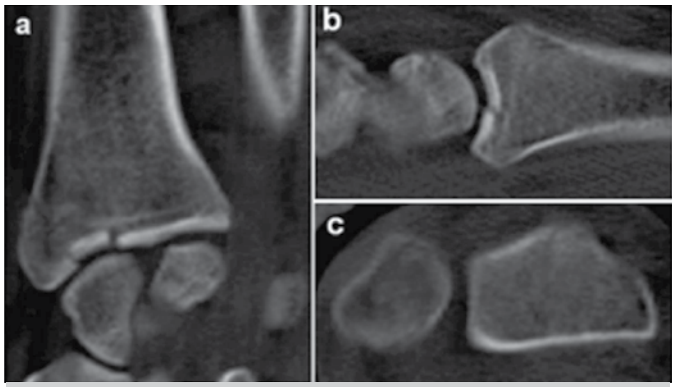


Figure 1. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal fracture of the distal end of the radius, without displacement, from subgroup IA.

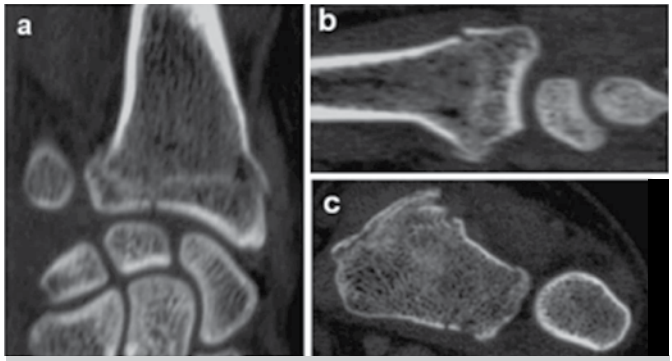


Figure 2. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius, without displacement, from subgroup IB.

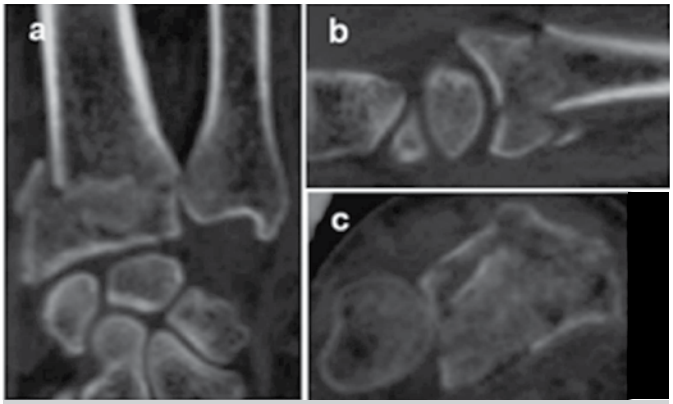


Figure 3. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius, associated with metaphyseal fragment, fragmented, with angulation and radial shortening, from subgroup IC.

IIA – Intra-articular distal radio-ulnar and/or radiocarpal fractures with spacing between articular fragments ≥ 2mm, without dorsal angulation ≥ 20º. These fractures do not exhibit radial shortening ≥ 9mm. (Figure 4A-C)
IIB – Intra-articular distal radio-ulnar and/or radiocarpal fractures with spacing between articular fragments ≥ 2mm, associated with single or multiple metaphyseal fragments, and dorsal angulation ≥ 20º. May be associated with radial shortening ≥ 9mm. (Figure 5A-C)
IIC – Intra-articular distal radio-ulnar and/or radiocarpal fractures with depression of the scaphoid and lunate fossae and/or sigmoid notch, irrespective of the presence of dorsal angulation and/or radial shortening. (Figure 6A-C)

Group III Fractures – Fractures-dislocations

Encompass all intra-articular fractures of the distal end of the radius associated with dislocation of the radiocarpal or perilunate articulation of the carpus. May or may not have spacing between fragments, angulations, radial shortening or cortical depression. These are divided into three sub-groups:
IIIA – Intra-articular radiocarpal fractures with dorsal subluxation. May be associated with intra-articular distal radio-ulnar fracture. (Figure 7A-C)
IIIB – Intra-articular radiocarpal fractures with volar subluxation. May be associated with intra-articular distal radio-ulnar fracture. (Figure 8A-C)
IIIC – Intra-articular radiocarpal and/or distal radio-ulnar fracture associated with perilunate dislocation of the carpus. (Figure 9A-C)

RESULTS

The tomographic classification proposal has the advantage of encompassing the known intra-articular patterns into only three groups, comprising nine logical easy-to-memorize possibilities in increasing order of severity of articular involvement. (Figure 10) A total of 74 cases of patients with distal radius fractures were classified. All of the fractures had involvement of the radiocarpal

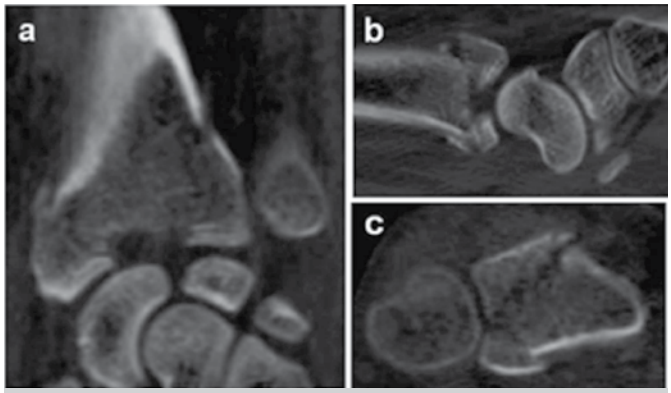


Figure 6. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius, with spacing between articular fragments > 2 mm, associated with depression of the scaphoid fossa, from subgroup IIC.

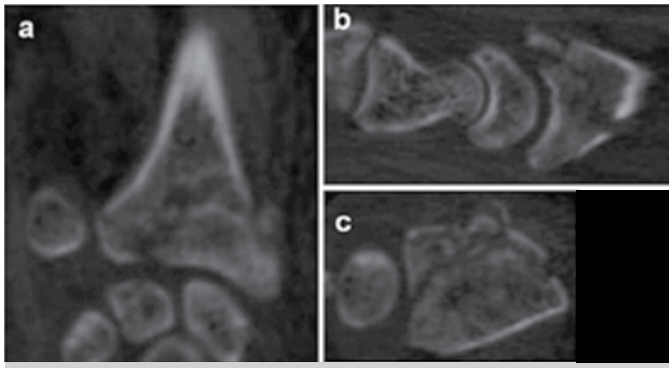


Figure 4. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius, with spacing between articular fragments ≥ 2 mm, without angulation and without loss of radial height ≥ 9mm, from subgroup IIA.

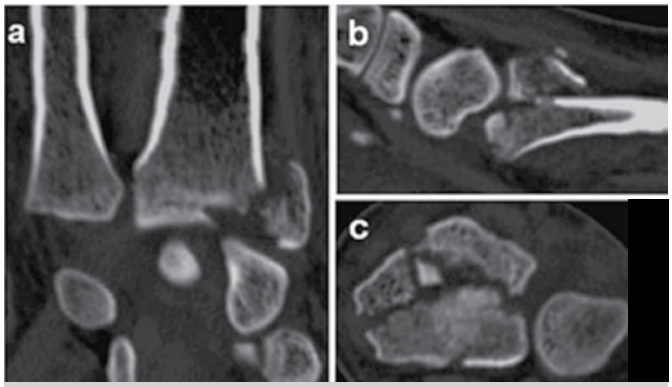


Figure 7. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius associated with radiocarpal dorsal dislocation, from subgroup IIIA.

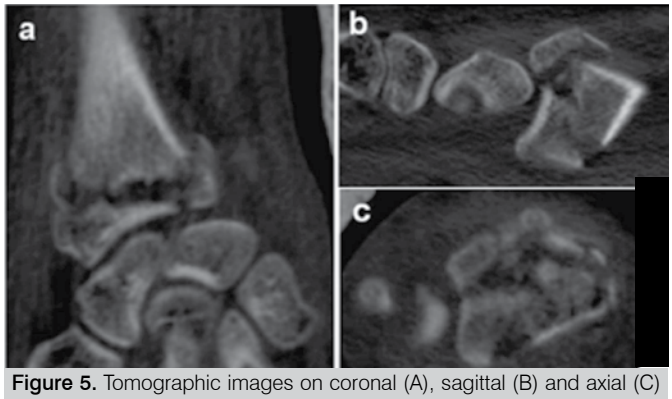


Figure 5. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius, with spacing between articular fragments ≥ 2 mm, associated with metaphyseal fragment with angulation > 20º and radial shortening > 9mm, from subgroup IIB.

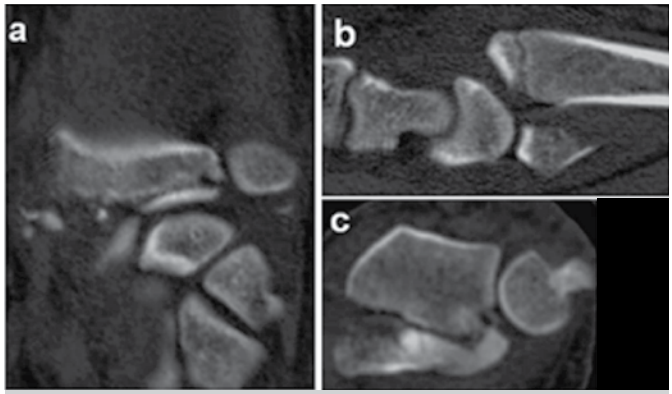


Figure 8. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal and distal radio-ulnar fracture of the distal end of the radius associated with radiocarpal volar dislocation, from subgroup IIIB.

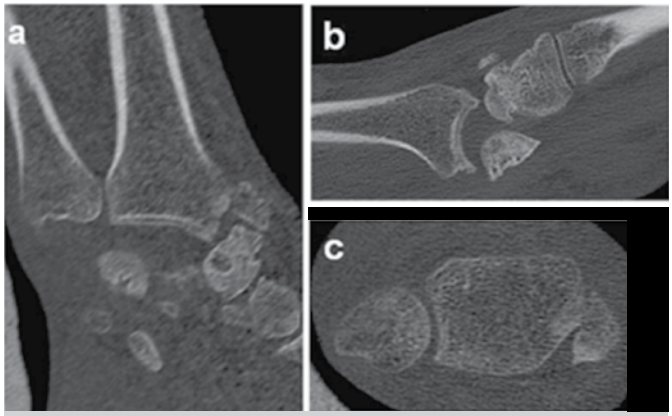


Figure 9. Tomographic images on coronal (A), sagittal (B) and axial (C) planes depicting intra-articular radiocarpal fracture associated with trans-scaphoid perilunate dislocation of the carpus, from subgroup IIIC.

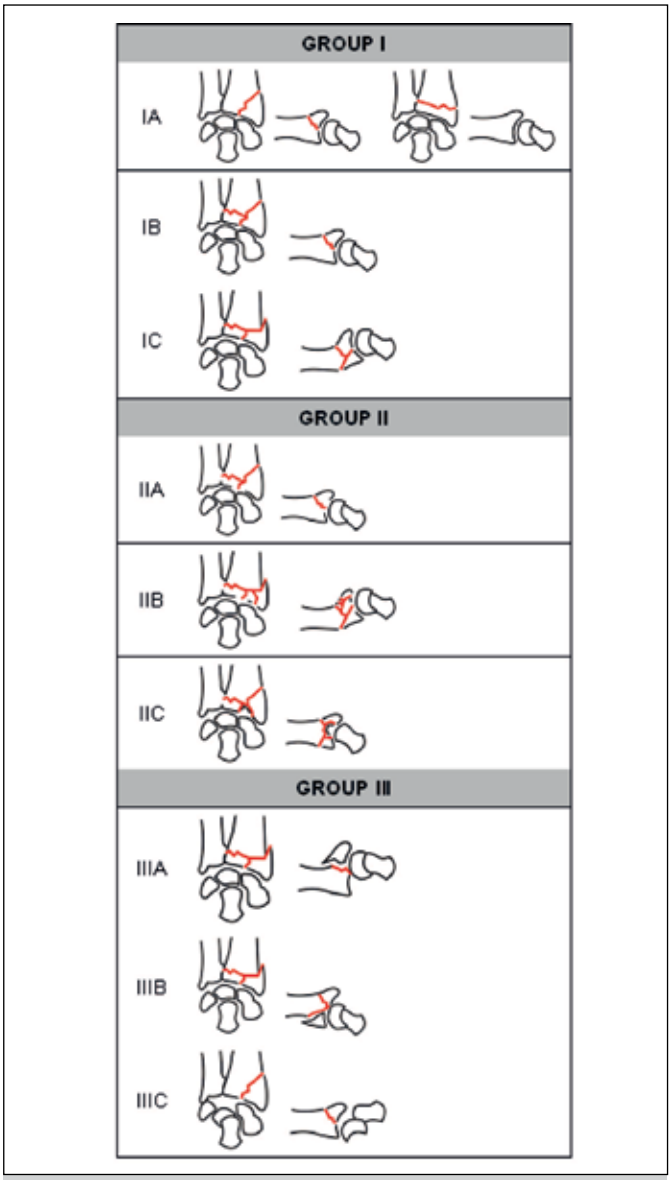


Figure 10. Schematic Drawing of the Tomographic Classification of the Hand Surgery Group of the hospital where the research was conducted.

joint, distal ulnar-radial joint or both. The most prevalent fracture pattern was subgroup IIB (33 cases), i.e. fractures with spacing between articular fragments ≥ 2mm associated with metaphyseal fragments and angulation ≥ 20º and/or radial shortening ≥ 9mm, followed by subgroups IC (15 cases) and IIC (11 cases). The least prevalent patterns were subgroups IA, IB, IIIA and IIIC, all of which had only two cases each.

With regard to the groups, Group II fractures proved the most frequent (46 cases), followed by Group I (19 cases) and Group III (9 cases). Concerning patient age, mean age was 47.91 years overall (minimum 21 years and maximum 90 years), 54.63 years for Group I, 47.58 years for Group II and 34.55 years for Group III.

DISCUSSION

The emphasis placed on fracture classification systems in Orthopedics is explained by the fact that these can help dictate treatment and prognosis. Consequently, it is paramount that such systems are both reliable and reproducable.[5]

Computed tomography (CT) provides useful information for operative planning and can sometimes lead the surgeon to change a conservative approach in favor of surgical treatment due to the technique´s greater reliability in quantifying intra-articular fragments compared with plain radiographs.[6] CT also yields additional information on articular misalignment, involvement of scaphoid and semi-lunate fossae and metaphyseal defects.[4]

Cole et al.[7] stated that CT can be considered an adjuvant method, facilitating classification and treatment indication in fractures of the distal end of the radius. These authors reported that the complementary use of CT in more complex cases helps determine articular involvement, misalignment and fragmentation. This previous study was pivotal in the adoption of a new conception regarding classification based on tomography.

Our tomographic classification system is comprised by essentially articular distal radius fractures and does not cover extra-articular fractures, based on the premise that radiographic images on postero-anterior, profile, semi-pronated oblique and semi-supinated oblique views are invariably sufficient for diagnosing these lesions. Rozental et al.[8] hold that CT has the advantage of more accurately revealing fractures of the sigmoid notch in 65% of cases. Our proposal classification includes the presence of articular involvement and spacing of both the radiocarpal and distal radio-ulnar joints. Moreover, under the new system proposal, the presence of depression of the sigmoid notch and semi-lunate and scaphoid fossae are regarded as a specific subgroup, since our in-depth analysis revealed that tomographic images allow clearer elucidation and quantification of irreducible impacted fragments.

Nowadays, it is clear that the paradigm of population aging is undergoing major changes, owing to the greater dissemination of the deleterious effects of sedentarism and smoking, and also through the incentive to change habits and life style to include a healthier diet and practice physical activities. These recommendations play a key role in preserving bone quality, and therefore we do not regard chronological age as an instability factor.

After observation of the tomographic images of the 74 cases of the present sample, some parameters were considered irreducible, including: a) Depression of the scaphoid and semi-lunate fossae and of the sigmoid notch: considered irreducible owing to the impossibility of returning the fracture fragments to their previous anatomic positions using closed reduction maneuvers and ligamentotaxis alone. We broadened this concept to include similar depression of the scaphoid fossa and sigmoid notch (Group II, subgroup IIC). Failure to recognize articular depressions can lead to collapse of the radiocarpal joint, with greater prevalence of osteoarthrosis, chronic pain and limitation in range of motion.

b) Fracture-dislocation (dorsal radiocarpal, volar radiocarpal and perilunate): in Orthopedics, acute dislocations after trauma are known to be serious lesions with reserved prognosis that require immediate reduction of the joint. In the present classification, fractures-dislocations are pooled together in Group III, and are therefore deemed more serious than the other groups.

Under our tomographic classification, all fractures with articular spacing ≥ 2mm are included in Group II, based on the view that this criteria is a factor associated with greater severity and instability compared to Group I. Dorsal angulation ≥ 20º was also included in our classification as an instability factor in Group I, subgroup IC, and in Group II, subgroup IIB, but only where this deviation corresponded to a metaphyseal fragment associated with intra-articular fracture. Loss of radial height ≥ 9mm was also included as another instability factor in Groups I and II, subgroups IC and IIB, respectively.

We elected to include fractures with single or multiple intra-articular fragments and spacing ≥ 2mm in Group II (subgroup IIA), associated with metaphyseal fragment, comminuted or otherwise, with dorsal angulation ≥ 20º and/or radial shortening ≥ 9mm (subgroup IIB), and not to include metaphyseal dorsal fragmentation as a separate instability factor.

The inclusion of the distal ulna fracture as an isolated instability factor is debatable. We believe that stability should be tested pre-operatively, after stabilization of the fracture of the radius. Some authors indicate that surgical management is unnecessary unless the distal radio-ulnar joint is unstable after fixation of the fracture of the radius[9].

Burstein[10] suggests that all classification systems be submitted to previous tests of reliability and reproducibility prior to their use. For the tomographic classification presented, reliability and reproducibility studies are planned to test the applicability of the system in routine practice.

Intra-articular distal radius fractures were organized into three larger groups in increasing order of severity (fractures without displacement, fractures with displacement and fractures-dislocations). Likewise, the subgroups were also organized into three divisions (A, B and C) again in increasing order of severity, starting with the fracture line of < 2mm of spacing between fragments in the distal radio-ulnar or radiocarpal articulation (IA), in both distal and radio-ulnar and radiocarpal joints (IB) or either of the two joints associated with metaphyseal fragment with dorsal angulation ≥ 20º and/or loss of radial height ≥ 9mm (IC). These fractures generally have a good prognosis.

Group II fractures differ in severity from Group I fractures in that they have spacing between articular fragments ≥ 2mm. When there is only this intra-articular space, the fractures are considered to belong to subgroup IIA. If, besides the spacing ≥ 2mm, there is also the presence of metaphyseal fragment with angulation ≥ 20º and/or radial shortening ≥ 9mm, these cases are classified into subgroup IIB. On the other hand, if the fracture has any depression of the scaphoid and semilunate fossae and/or of the sigmoid notch, irrespective of the presence of angulation and/or loss of radial height, they are deemed to have greater severity and complexity and are classified into the IIC subgroup. The prognosis is more disfavorable compared to the previous classification, given that failure to achieve harmonic reestablishment of the articular congruence can lead to collapse of the fragments, early osteoarthrosis, chronic pain in the hand and limitation in movements.

Lastly, Group III comprises all intra-articular fractures of the distal extremity of the radius associated with dislocation, irrespective of the presence or otherwise of spacing and articular depression, fragmentation, angulations and loss of radial height. These cases may present as radiocarpal dorsal dislocation (IIIA), radiocarpal volar dislocation (IIIB) or as intra-articular fracture of the distal end of the radius associated with perilunate dislocation of the carpus. These are extremely serious and complex lesions, associated with an unfavorable prognosis, particularly when not recognized and treated rapidly and effectively, potentially evolving to collapse of the fragments, early osteoarthrosis, articular block and chronic pain.

In terms of limitations, although all 74 cases were included in our classification, a larger number of images could increase the confidence that many patterns of fracture are covered in the classification. Future studies including new images and investigations on reliability and reproducibility should be implemented so that this tomographic classification can be adapted if necessary and applied in clinical practice to help medical residents and surgeons by providing a more straightforward and reliable classification, establishing accurate treatment approaches and predicting the prognosis of lesions.

CONCLUSION

The tomographic classification proposal for distal radius fractures is applicable only to intra-articular fractures.

The tomographic classification proposal has the advantage of encompassing the known intra-articular patterns into only three groups, comprising nine logical easy-to-memorize possibilities in increasing order of severity of articular involvement.

AUTHORS' CONTRIBUTIONS: Each author made significant individual to the development of the study. VGN (0000-0003-0214-7746)*: was the main contributor in drafting the manuscript, collected clinical data, bibliographic research and statistical analysis; ACC (0000-0003-4499-5233)* and SLC (0000-0002-9086-734X)*: contributed to the intellectual concept and coordination of the study. ACC was responsible for guiding the others participants; LRS (0000-0002-0003-1144)*: and DFF (0000-0002-3833-5397)*: collected clinical data; VGN, ACC and IC (0000-0003-3870-0523)*: reviewed the manuscript. All authors reviewed the manuscript and contributed to the intellectual concept. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Alffram PA, Bauer GC. Epidemiology of fractures of the forearm. A biomechanical investigation of bone strength. J Bone Joint Surg Am. 1962;44:105-14.
2. Evans S, David M, Quraishi MK, Hanif UK, Sadique H, Machani B. The use of plain radiographs in the classification of distal radius fractures. J Orthop. 2014;11(3):142-4.
3. Harness NG, Ring D, Zurakowski D, Harris GJ, Jupiter JB. The influence of three-dimensional computed tomography reconstructions on the characterization and treatment of distal radial fractures. J Bone Joint Surg Am. 2006;88(6):1315-23.
4. Pruitt DL, Gilula LA, Manske PR, Vannier MW. Computed tomography scanning with image reconstruction in evaluation of distal radius fractures. J Hand Surg Am. 1994;19(5):720-7.
5. Nascimento VG, da Costa AC, Falcochio DF, Lanzarin LD, Checchia SL, Chakkour I. Computed tomography's influence on the classifications and treatment of the distal radius fractures. Hand (N Y). 2015;10(4):663-9.
6. Arealis G, Galanopoulos I, Nikolaou VS, Lacon A, Ashwood N, Kitsis C. Does the CT improve inter- and intra-observer agreement for the AO, Fernandez and Universal classification systems for distal radius fractures? Injury. 2014;45(10):1579-84.
7. Cole RJ, Bindra RR, Evanoff BA, Gilula LA, Yamaguchi K, Gelberman RH. Radiographic evaluation of osseous displacement following intra-articular fractures of the distal radius: reliability of plain radiography versus computed tomography. J Hand Surg Am. 1997;22(5):792-800.
8. Rozental TD, Bozentka DJ, Katz MA, Steinberg DR, Beredjiklian PK. Evaluation of the sigmoid notch with computed tomography following intra-articular distal radius fracture. J Hand Surg Am. 2001;26(2):244-51.
9. Palmer AK. Fractures of the distal radius. In: Green DP. Operative Hand Surgery. New York, NY: Churchill Livingstone; 1993. p.929-967.
10. Burstein AH. Fracture classification systems: do they work and are they useful? J Bone Joint Surg Am. 1993;75(12):1743-4.

DOI: http://dx.doi.org/10.1590/1413-785220182601181560

ORIGINAL ARTICLE

EVALUATION OF A BONE REINFORCEMENT TECHNIQUE USING FINITE ELEMENT ANALYSIS

AVALIAÇÃO DE UMA TÉCNICA DE REFORÇO ÓSSEO COM O MÉTODO DE ELEMENTOS FINITOS

Anderson Freitas[1,2], Lucas Carreiro da Silva[2], Nathan Drumond Vasconcelos Godinho[2], Amirhossein Farvardin[3], Mehran Armand[3], Ana Patrícia de Paula[4]

1. Hospital Ortopédico e Medicina Especializada, Brasília, DF, Brazil.
2. Hospital Regional do Gama, Brasília, DF, Brazil.
3. Department of Mechanical Engineering, Johns Hopkins University, Baltimore, Maryland, USA.
4. Postgraduate program, Fundação de Ensino e Pesquisa em Ciências da Saúde (FEPECS), Brasília, DF, Brazil.

ABSTRACT

Objectives: To compare the results of a simulated fall on the greater trochanter in the proximal portion of a synthetic femur before and after femoral reinforcement with tricalcium phosphate bone cement (TP) and polymethyl methacrylate (PMMA), using finite element analysis (FEA). Methods: Using two synthetic proximal femurs, a FEA simulating a fall on the greater trochanter was performed, using the Bi-directional Evolutionary Structural Optimization (BESO) program. For this analysis, the femurs were filled with TP and PMMA after perforations were created in the trochanteric region and neck. The results were compared with the strength values obtained from testing the control specimen, a synthetic bone without reinforcement. Results: FEA showed a value of 600 N prior to reinforcement. After cementing with PMMA, the load increased by 57.5% (945 N), and by 53% (920 N) after cementing with TP. Conclusion: Synthetic femurs gained resistance to fracture-causing forces in a simulated fall on the trochanter after bone reinforcement with PMMA and TP. ***Level of Evidence III; Experimental study.***

Keywords: Osteoporosis. Femoral fractures. Hip.

RESUMO

Objetivos: Avaliar, com o método de elementos finitos (EF), os resultados obtidos com a simulação de queda sobre o trocanter maior, usando a porção proximal de um fêmur sintético, com a finalidade de comparar os valores obtidos antes e após técnica de reforço femoral com cimento de fosfato tricálcico (FT) e polimetilmetacrilato (PMMA). Métodos: Utilizando dois fêmures proximais sintéticos, foi realizada a análise de elementos finitos, simulando queda sobre o trocanter maior com o programa Bi-directional Evolutionary Structural Optimization (BESO). Para essa análise, os fêmures foram preenchidos, após a realização de pertuitos na região trocantérica e no colo, com FT e PMMA e os resultados foram comparados com a força obtida na análise do corpo de prova controle, osso sintético sem preenchimento. Resultados: Comparando a análise de elementos finitos antes do reforço femoral, obteve-se o valor de 600 N. Depois da cimentação com PMMA, foi observado um aumento na carga máxima da ordem de 57,5% (945 N) e de 53% (920 N) com o FT. Conclusão: Os fêmures sintéticos ganharam resistência aos fatores causadores de fratura em queda simulada sobre o trocanter depois do reforço ósseo com PMMA e cimento de FT. ***Nível de Evidência III; Estudo experimental.***

Descritores: *Osteoporose. Fraturas do fêmur. Quadril.*

Citation: Freitas A, Silva LC, Godinho NDV, Farvardin A, Armand M, Paula AP. Evaluation of a bone reinforcement technique using finite element analysis. Acta Ortop Bras. [online]. 2018;26(1):59-62. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The World Health Organization (WHO) predicts that the incidence of osteoporotic fractures of the proximal femur will triple by 2050. In the population below 65 years of age, the incidence of femoral neck fractures is 2–4 cases per 10,000 people. However, this value increases in the population above 70 years of age to 28/10,000 in men and 64/10,000 in women. It is estimated that 6.3 million osteoporotic fractures will occur by 2050, three times the current number; half of these fractures will occur in Asia.[1] In the United States, the annual cost related to treatment of osteoporotic fractures is 20 billion dollars, and hip fractures account for 60% of this cost.[2] Between 1 and 1.5% of all hospital beds in Europe are occupied by patients with osteoporotic fractures.[3] Twenty-two million women and 5.5 million men in the European Union (EU) received a diagnosis of osteoporosis in 2010, and 3.5 million insufficiency fractures occurred that year, 610,000 in the hip.[3] The cost of treating these fractures was 37 billion euros, and is expected to increase by 25% by 2025.[3] The measures of care for patients with osteoporosis in the EU have demonstrated significant results, with multidisciplinary application techniques that can reduce the occurrence of new fractures by 80%. However, this

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

Work conducted at the Hip Surgery Department of the Hospital Ortopédico e Medicina Especializada (HOME), Brasília, Distrito Federal, DF, Brazil.
Correspondence: Hospital Ortopédico e Medicina Especializada. SGAS Quadra 613, Conjunto C, Brasília, DF, Brazil. 70200-730. andfreitas28@gmail.com

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

percentage falls to 40% in preventing hip fractures.[3] The mortality of patients who experience a fracture of the proximal femur after surgical treatment is 30% in the first year; patients with these fractures have up to 30% greater risk of fracturing the contralateral femur over a 2-year period, and this value rises further over a 5-year period.[4] In the case of non-simultaneous fracture of the contralateral hip, mortality reaches 64% in men and 58% in women.[5] Several methods have been proposed to reduce the risk of proximal femur fracture in osteoporosis, such as adjustments to the home environment, use of hip protectors, multidisciplinary treatment, and use of medications. Many drugs of different classes have been suggested for this purpose, but even though many have shown satisfactory results in preventing fractures (approximately 50% reduction in new osteoporotic fractures and 40% reduction in hip fractures), they have undesirable characteristics such as adverse effects with long-term use, high cost, and contraindications.[6] The reduction rates are influenced by sex, and according to published studies, this rate is always observed in women but not always in men.[7]

Bone strengthening using polymethyl methacrylate (PMMA) and tricalcium phosphate (TP) bone cement has already been described in the literature, generally in cadaver models and mechanical tests simulating falls on the greater trochanter.

This study consequently describes the behavior of synthetic bone subjected to a femoroplasty technique, and presents the results simulating falls on the greater trochanter in synthetic bone using PMMA and TP bone cement.

METHODS

Since this study does not involve humans, ethics committee approval was not required. We used two synthetic proximal femurs (Sawbone 3rd generation, Pacific Research Laboratories, Vashon, WA, USA) with a cortical segment manufactured in 30 pcf solid polyurethane foam and the following properties provided by the manufacturer: Poisson ratio ~ 0.3, tensile modulus ~450 MPa, and yield strain of 0.7%. The spongy segment consisted of 5MPa open cell polyurethane foam with the following mechanical properties: Poisson ratio ~ 0.3, elasticity module ~5 MPa, and yield strain of 3%. The images of this model were obtained before (control model) and after cementing, using helical computed tomography (Toshiba Activion 16/BF, Toshiba Medical Systems, Tochigi, Japan) with the following acquisition parameters: X-ray voltage = 120 kVp; X-ray power = 250 BUT; collimation (slice thickness) = 1.0 mm; space between slices = 0.5 mm. Multiplanar reconstructions were performed after image acquisition, as well as volumetric reconstructions. A steel guide wire, cannulated drill bit, and electric drill were used to create three filling holes in the following positions:

Hole I - 25–50 mm from the apex of the greater trochanter using the 2.5 mm guide wire in the centrolateral aspect of the synthetic model. With the aid of fluoroscopy, the hole crossed two main points in a straight line: one in the upper anterior region of the middle third of the femoral neck, and another in the central portion of the femoral head. Once the correct positioning of the wire on the frontal and axial planes as described above was confirmed, a 5.00 mm cannulated drill bit was used to perforate the first tunnel. Next, the guide wire was removed and the wire was redirected (using fluoroscopy) through Hole I to create Hole II.

Hole II - positioned at an angle connecting two other main points: one in the posterior-inferior region of the medial third of the femoral neck, and another in the posterior inferior portion of the femoral head. Once the appropriate position was determined in the axial and front views using fluoroscopy, a 5.0 mm cannulated drill bit was used to create the second tunnel.

Hole III - The references for the third hole are the lateral hole, which was already created for the first and second tunnels, and the apex of the lesser trochanter (medial calcar femorale). After fluoroscopy was used to orient and confirm the position of the guide wire to reach these two points, a 5.0 mm cannulated drill bit was used to create the third hole. (Figures 1A and 1B)

Approximately 24ml of TP and PMMA were used separately to fill in the structures in the synthetic model. The cement was injected with a syringe through previously made holes.

To conduct the finite element analysis (FEA), images were obtained before and after femoral reinforcement using Bi-Directional Evolutionary Structural Optimization software (BESO), which has the ability to highlight points with lesser load resistance and add elements in areas of higher mechanical stress, using resistance to traction as a criterion and thus optimizing the areas where cement is applied. This in turn allows the determination of mechanical resistance in Newtons (N) before (Figure 2) and after (Figure 3) reinforcement. The conditions used in the simulations are similar to a fall on the greater trochanter. Increasing force was applied and evenly distributed across the surface nodes of the femoral head.

RESULTS

Analysis of the synthetic model prior to cementing showed that in the simulated fall, two areas had significant concentrations of stress: one in the upper anterior basicervical region and another in the posterior inferior area of the same region. (Figure 3)

The synthetic model endured a load of 600 N before cement (control model) after TP was applied this load rose to 920 N, an increase of 53%. When PMMA was used, the load reached 945N before collapse, an increase of 57.5% (Figure 4).

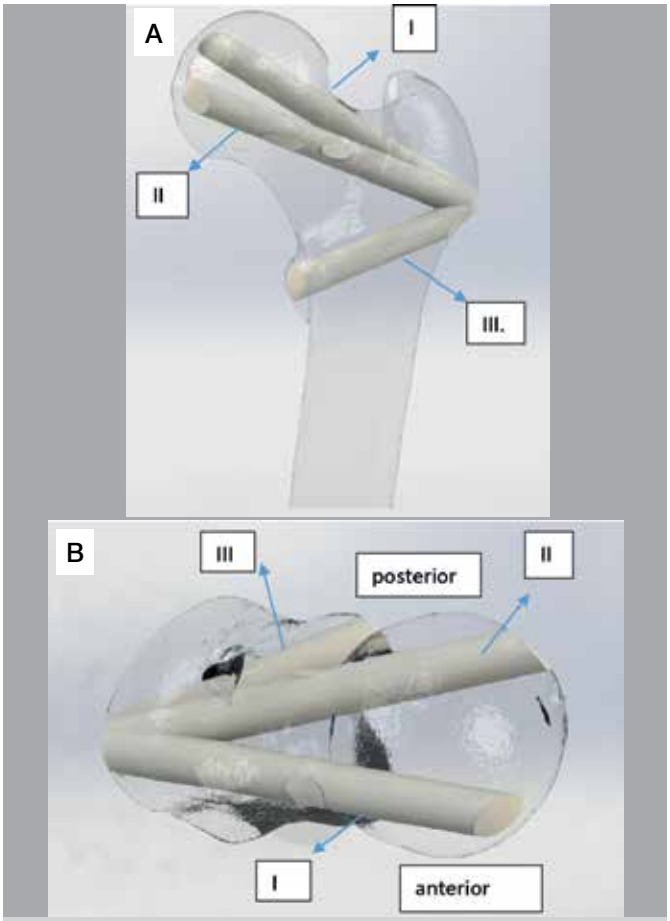


Figure 1. A) anterior view B) axial view, representation and positioning of tunnels I, II and III.

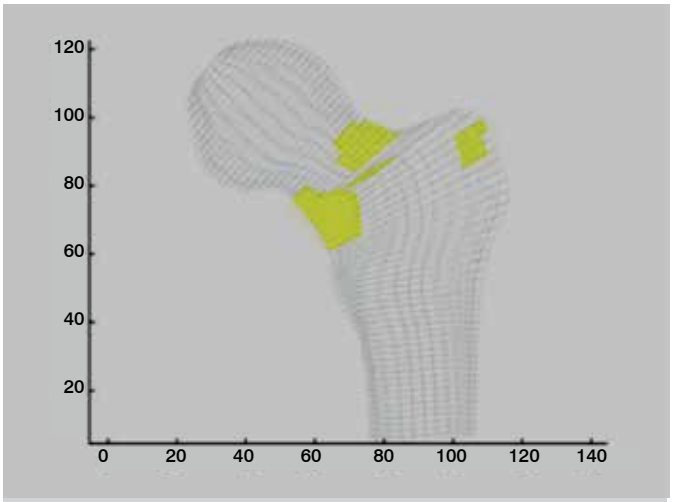


Figure 2. The areas in yellow represent the highest points of tension during FE analysis, in the position of falling on the large trochanter.

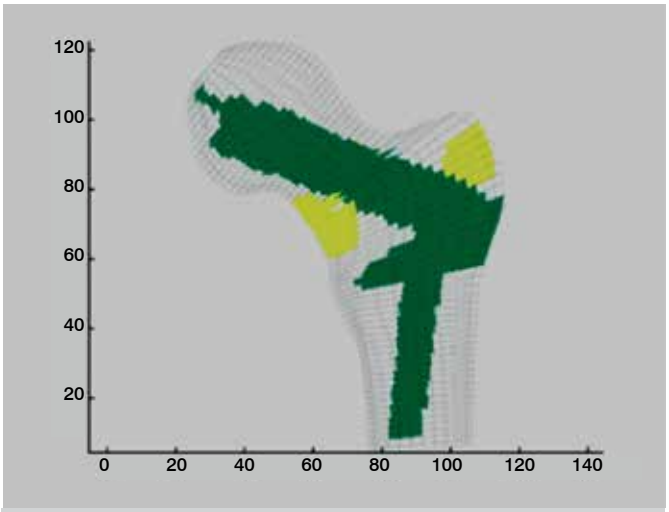


Figure 3. Synthetic model after filling the tunnels with PMMA, represented by green areas, during FE analysis.

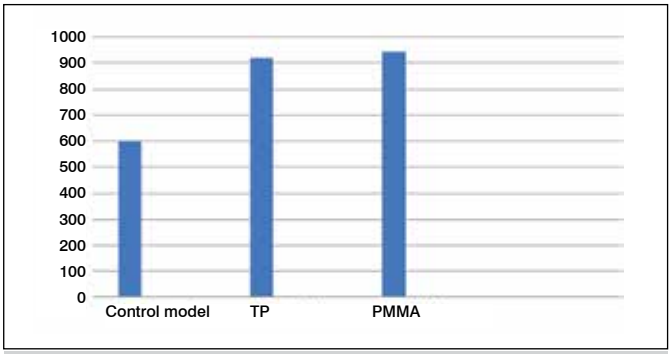


Figure 4. Strength (N) in FE analysis of synthetic models reinforced with PMMA, TP and control model (standard synthetic model, without perforations and without filling).

DISCUSSION

Reinforcement of the hip bone has already been described in the literature to prevent fractures in focal neoplasia, but its use in preventing osteoporotic fractures requires trials with good levels of evidence to validate results; this is because even though significant improvement has been seen in mechanical resistance, most articles which have been published are experimental studies.[8]

Other studies using PMMA for femoral reinforcement have shown up to 33% greater bone resistance to fracture, using volumes of cement ranging from 6 to 40 mL.[9-13] For TP the additional resistance values varied from 21 to 43%, but the volumes of cement used were not described.[14,15]

It should be noted that the results obtained in this study for increases in bone resistance correspond with previous works in the literature describing both synthetic bone models and cadaverous specimens. The absolute values are lower in cadaver bones, but the relative values are similar.[9]

Some considerations are important when comparing these results with other studies. First, this present study differs in its methodology by using synthetic bones for FEA, a new technique in this field of study.

Secondly, FEA was conducted before and after femoral reinforcement, which differs from the methodology in the lines of research used as references, which conducted in vitro stress tests in cadaver bones.

In terms of the evaluation technique, we used a protocol similar to that of Basafa et al.,[16] which was based on FEA to perform optimized and personalized femoroplasty for better results in increased bone strength. However, not all studies followed the same methodology, which complicates comparative analysis and makes it impossible to extrapolate the results.

There is no consensus on the ideal compound for femoroplasty in various studies. Some authors found superior results for PMMA, but did not address the advantages of calcium phosphate, namely its osteointegrative ability and security in terms of not inducing thermal necrosis.[15]

With regard to the cementing technique, the osteoconductive properties of TP immediately restore part of the lost bone mineral content. Furthermore, this compound facilitates the stabilization of fragile cell areas, theoretically increasing the bone matrix, and does not carry the theoretical risk of thermal necrosis caused by the polymerization of PMMA, an undesirable adverse effect in cases with low bone mineral density.[9,14]

Despite the varying methodologies and the lack of multicenter studies, femoroplasty seems to be a viable alternative for preventing fractures of the proximal femur.[17,18] The development of a standardized methodology would facilitate the progression of this technique and the evaluation of results in future studies. The use of substances with biological properties can theoretically provide even greater benefits for individuals with reduced bone mass.

CONCLUSION

We observed an increase in resistance to forces causing fracture in synthetic femur bones during simulated falls on the greater trochanter after the use of both PMMA and TP in a pre-defined cementing technique.

ACKNOWLEDGMENT

Thanks to Prof. Rodrigo Roesler of the Laboratory of Biomechanical Engineering. Hospital Universitário - UFSC- Brazil, for the development of figures 1, B.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AF (0000-0001-6555-8193)*: drafting and revising the article, cementing procedure; LCS (0000-0003-0006-8139)*, NDVG (0000-0002-3987-5635)*, and APP (0000-0003-3809-2230)*: drafting and reviewing the article; AF (0000-0002-6567-7536)* and MA (0000-0002-1947-9846)*: testing with the computer model. All authors approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. World Health Organization: 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.
2. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. Lancet. 2002;359(9319):1761-7.
3. Hernlund E, Svedbom A, Ivergård M, Compston J, Cooper C, Stenmark J, et al. 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. Lawrence TM, Wenn R, Boulton CT, Moran CG. Age-specific incidence of first and second fractures of the hip. J Bone Joint Surg Br. 2010;92(2):258-61.
5. 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.
6. MacLean C, Alexander A, Carter J, Chen S, Desai SB, et al. Comparative effectiveness of treatments to prevent fractures in men and women with low bone density or osteoporosis. Ann Intern Med. 2008;(148):197-213.
7. Chevalley T, Guilley E, Herrmann FR, Hoffmeyer P, Rapin CH, Rizzoli R. Incidence of hip fracture over a 10-year period (1991-2000): reversal of a secular trend. Bone. 2007;40(5):1284-9.
8. Morgan EF, Bayraktar HH, Keaveny TM. Trabecular bone modulus-density relationships depend on anatomic site. J Biomech. 2003;36(7):897-904.
9. Heini PF, Franz T, Fankhauser C, Gasser B, Ganz R. Femoroplasty-augmentation of mechanical properties in the osteoporotic proximal femur: a biomechanical investigation of PMMA reinforcement in cadaver bones. Clin Biomech (Bristol, Avon). 2004;19(5):506-12.
10. Sutter EG, Wall SJ, Mears SC, Belkoff SM. The effect of cement placement on augmentation of the osteoporotic proximal femur. Geriatr Orthop Surg Rehabil. 2010;1(1):22-6.
11. 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.
12. 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.
13. Sutter EG, Mears SC, Belkoff SM. A biomechanical evaluation of femoroplasty under simulated fall conditions. J Orthop Trauma. 2010;24(2):95-9.
14. Strauss EJ, Pahk B, Kummer FJ, Egol K. Calcium phosphate cement augmentation of the femoral neck defect created after dynamic hip screw removal. J Orthop Trauma. 2007;21(5):295-300.
15. Beckmann J, Ferguson 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.
16. 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.
17. van der Steenhoven TJ, Schaasberg W, de Vries AC, Valstar ER, Nelissen RG. Augmentation with silicone stabilizes proximal femur fractures: an in vitro biomechanical study. Clin Biomech (Bristol, Avon). 2009;24(3):286-90.
18. van der Steenhoven TJ, Schaasberg W, de Vries AC, Valstar ER, Nelissen RG. Elastomer femoroplasty prevents hip fracture displacement In vitro biomechanical study comparing two minimal invasive femoroplasty techniques. Clin Biomech (Bristol, Avon). 2011;26(5):464-9.

DOI: http://dx.doi.org/10.1590/1413-785220182601179926

COULD OZONE TREATMENT BE A PROMISING ALTERNATIVE FOR OSTEOMYELITIS? AN EXPERIMENTAL STUDY

O TRATAMENTO COM OZÔNIO PODE SER UMA ALTERNATIVA PROMISSORA PARA A OSTEOMIELITE? UM ESTUDO EXPERIMENTAL

Ali Bilge[1], Ömür Öztürk[2], Yasemen Adali[3], Sefer Üstebay[4]

1. Department of Orthopedics and Traumatology, Kafkas University, Faculty of Medicine, Kars, Turkey.
2. Department of Anesthesia and Reanimation, Kafkas University, Faculty of Medicine, Kars, Turkey.
3. Department of Pathology, Kafkas University, Faculty of Medicine, Kars, Turkey.
4. Department of Pediatrics, Kafkas University, Faculty of Medicine, Kars, Turkey.

ABSTRACT

Objective: The aim of the present study was to investigate the biochemical and histopathological impact of ozone treatment in an experimental model of osteomyelitis in rats. Methods: A total of 24 adult male Sprague-Dawley rats (3 months old, each weighing 300 to 400 g) were randomly allocated into three groups. Group I (n=8) served as a control and received no interventions or medications. In Group II (n=8), osteomyelitis was induced in the femur and no treatment was applied. Group III (n=8) received intraperitoneal ozone treatment for 3 weeks after the formation of osteomyelitis in the femur. Serum samples were taken to assess total antioxidant capacity (TAC), protein carbonyl content (PCO), and lactate dehydrogenase (LDH). Bone specimens obtained from the femur were histopathologically evaluated for inflammation, necrosis, osteomyelitis, and abscess formation. Results: Serum TAC levels were notably higher (p<0.001), while LDH levels were lower (p=0.002) in Group III than Group II. No significant difference was detected between groups with respect to PCO level. Similarly, Group III displayed more favorable histopathological outcomes with respect to osteomyelitis (p=0.008), inflammation (p=0.001), necrosis (p=0.022), and abscess formation (p=0.022). Conclusion: Ozone may be a useful adjunct treatment for osteomyelitis. Further studies in animals and humans are needed to clarify and confirm these preventive effects, understand the underlying pathophysiology, and establish guidelines. ***Level of Evidence II; Prospective comparative study.***

Keywords: Osteomyelitis/therapy. Ozone/adverse effects. Ozone/therapeutic use.

RESUMO

Objetivo: O objetivo do presente estudo foi investigar o impacto bioquímico e histopatológico do tratamento de ozônio em modelo experimental de osteomielite em ratos. Métodos: Vinte e quatro ratos Sprague-Dawley machos adultos (3 meses de idade, pesando de 300 a 400 g) foram alocados randomicamente em três grupos. O grupo I (n = 8) serviu como controle. No Grupo II (n = 8), o modelo de osteomielite experimental foi induzido no fêmur e não foi aplicado nenhum tratamento. O grupo III (n = 8) recebeu tratamento com ozônio intraperitoneal por 3 semanas depois da formação de osteomielite no fêmur. Foram coletadas amostras de sangue para avaliar a capacidade antioxidante total (CAT), a concentração da proteína carbonil (PCO) e da lactato desidrogenase (LDH) no soro. As amostras do fêmur foram avaliadas por histopatologia quanto a inflamação, necrose, osteomielite e formação de abscesso. Resultados: Os níveis séricos de TAC foram notavelmente maiores (p < 0,001), enquanto os níveis de LDH foram menores (p = 0,002) no Grupo III em comparação com o Grupo II. Nenhuma diferença significativa foi detectada entre os grupos com relação ao nível de PCO. Do mesmo modo, o Grupo III apresentou resultados histopatológicos mais favoráveis para osteomielite (p = 0,008), inflamação (p = 0,001), necrose (p = 0,022) e formação de abscesso (p = 0,022). Conclusão: O ozônio pode ser um tratamento adjuvante útil na osteomielite. Mais estudos com animais e com seres humanos são necessários para esclarecer e confirmar esses efeitos preventivos, compreender a fisiopatologia subjacente e estabelecer diretrizes. ***Nível de Evidência II; Estudo prospectivo comparativo.***

Descritores: *Osteomielite/terapia. Ozônio/efeitos adversos. Ozônio/uso terapêutico.*

Citation: Bilge A, Öztürk Ö, Adalı Y, Üstebay S. Could ozone treatment be a promising alternative for osteomyelitis? An experimental study. Acta Ortop Bras. [online]. 2018;26(1):63-7. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Osteomyelitis is an infection which may be accompanied by necrosis of the bone. Even after debridement, persistence of necrotic tissue may prevent blood from circulating and antibiotics from reaching necrotic tissue. This isolation from defensive and remedial mechanism may cause the process to become chronic.[1] Treatment is based on eliminating the infection and maintaining ideal physiological function of the relevant area. High rates of recurrence,

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

Work conducted at the Şehitler Mah. 2. Kombine Binası Kafkas Üniversitesi Kampüsü Sağlık Araştırma ve Uygulama Hastanesi Merkez\Kars.
Correspondence: Department of Orthopedics and Traumatology, Kafkas University, Faculty of Medicine, Kars, Turkey. alibilge498@hotmail.com

Article received in 05/13/2017, approved in 11/07/2017.

CC BY NC

increased medical costs, and long duration of disability are the principal therapeutic challenges. Even though sufficient surgical intervention, appropriate antibiotic regimen, and reconstruction of tissue architecture are the mainstays of treatment, optimal outcomes cannot always be achieved.[2]

Contemporary management of osteomyelitis consists of long-term administration of high-dose antibiotics, along with drainage of the purulent material. However, even this regimen may not always stop acute inflammation from progressing to a chronic, ongoing process. There is still debate on the duration of antibiotic treatment and time for surgical drainage. Enhancement of the host's defense system is important to eradicate infection. Therefore, local and systemic defense mechanisms should be supported to achieve therapeutic goals.[2]

Ozone is an oxidizing gas which can be synthesized by ultraviolet rays and is used as a disinfectant in the food and water industries. Despite its toxic potential, ozone may also serve as a pro-drug at controlled, non-toxic doses; it can help ameliorate ischemic injury in various tissues.[3] Ozone exerts its beneficial effects by decreasing the levels of free oxygen radicals, inducing local migration of polymorphonuclear leukocytes, and promoting oxygen supply to injured tissues.[3] Ozone increases the activity of leukocytes, and these cells may not function effectively when sufficient oxygen is not present in the medium. Furthermore, long-term use of ozone increases oxygen in the blood and may diminish the likelihood of allergic reactions.[3]

Since ozone can eradicate pathogenic factors, it may be useful to manage the high socioeconomic burden associated with chronic infections and diseases. Ozone may stimulate growth factors, control inflammatory processes, and elicit vascularization. The prolonged and challenging treatment of osteomyelitis leads researchers to investigate new therapeutic strategies;[1] the purpose of the present study was to investigate the biochemical and histopathological impacts of ozone treatment in an experimental model of osteomyelitis in rats.

METHODS

Experimental design

This study was carried out in the experimental laboratory of our university after approval by the Kafkas University Animal Experimentation Ethics Committee.

The study adhered to the principles established in the National Institute of Health's Guide for the Care and Use of Laboratory Animals. The animals were fed a standard rat chow diet, and access to water and food was allowed ad libitum. Cages were kept at a temperature of 24 ± 2 °C and humidity of 55 ± 5% in a 12 hour light & dark cycle. A total of 24 adult male Sprague-Dawley rats (3 months old, each weighing 300 to 400 g) were randomly allocated into three groups. Group I (n=8) served as a control and received no interventions or medications. In Group II (n=8), osteomyelitis was induced in the femur and no therapeutics were applied. Group III (n=8) received ozone treatment after osteomyelitis was induced in the femur.

Surgical procedure

The experimental model of osteomyelitis was induced by implanting discs containing pathogeneous *S. aureus* in the femur. These discs were prepared in the microbiology laboratory using a McFarland nephelometer, which permits the use of a solution with a known concentration of microorganisms.[4]

Inhaled anesthetics were administered using specially designed conical canine anesthesia masks. For all groups, sevoflurane was introduced at a rate of 2 L/min together with 100% oxygen. The oxygen flow was set at a rate of 4 L/min using the anesthesia apparatus. The concentration of sevoflurane was adjusted according to respiratory pattern and heart rate. The same sevoflurane vaporizer was utilized for all rats.

Under general anesthesia and a sterile dressing, a 3 cm skin incision was made above the right lower hind limb. After the femoral bone was exposed, a fracture was formed on the distal diaphysis. Reduction of the fracture was accomplished with the retrograde application of thin tip (80.5 mm) Kirschner wire through the medulla after access from the knee joint. Discs containing *S. aureus* were placed onto the fracture zone to create an experimental model of osteomyelitis. (Figures 1 and 2) The operation was finished by suturing the layers in the anatomical plane. Group III received daily intraperitoneal ozone treatment (2 ml, 30 μg) during the follow-up period of 3 weeks. Groups I and II received no therapeutic interventions. At the end of this period, blood samples were collected from tail veins, and histopathological specimen were gathered by resecting bone tissue from fracture areas where the bacteria was inoculated. (Figures 3 and 4).

Histopathological examination

Bone tissue specimens were initially preserved in 10% phosphate buffered formalin before histopathological examination. These tissue samples were embedded in paraffin wax and sliced into 4 mm thick sections. All sections were stained with hematoxylin-eosin and examined under light microscopy (*Olympus BX50; Olympus Optical Co. Ltd., Tokyo, Japan*) by a blinded pathologist.

Bone tissue samples were evaluated for the presence of osteomyelitis, necrosis, and abscess formation. (Figures 5-9) Inflammation

Figure 1. Inoculation of discs containing S. aureus onto femur to induce osteomyelitis.

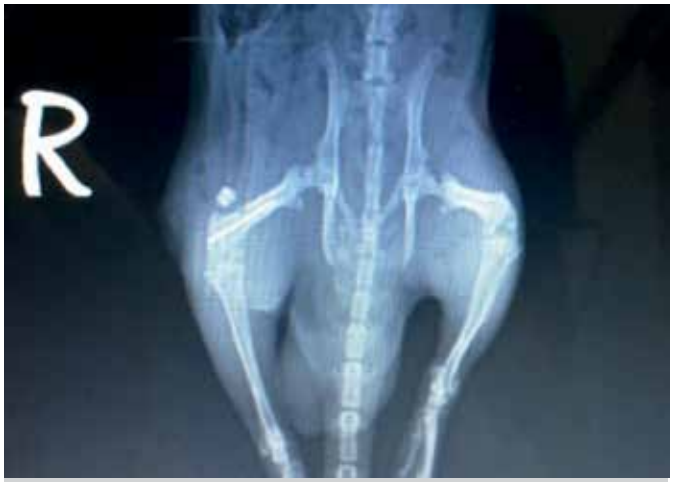


Figure 2. X-ray after inoculation with infective disc.

Figure 3. Dissection of the area with osteomyelitis after the 3-week study period.

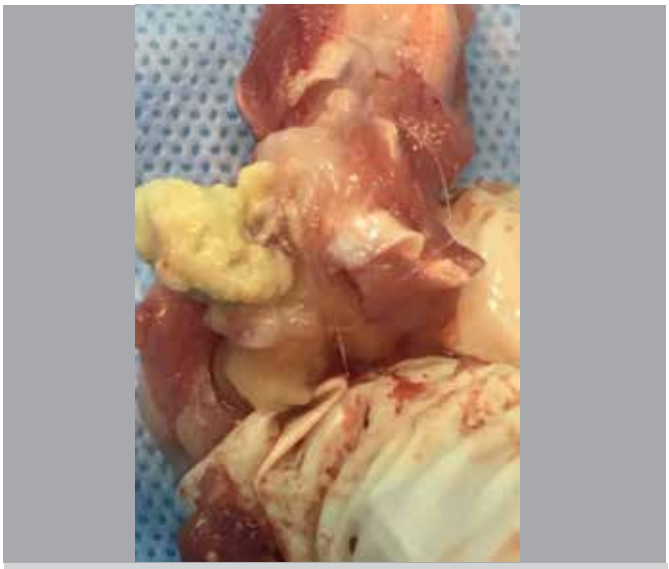


Figure 4. Bone specimen obtained from the site of osteomyelitis.

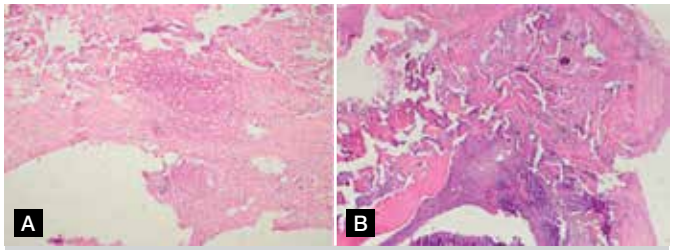


Figure 5. (A and B) Inflammation (left) and abscess cavity formations (right) (H&E X100).

was graded using a scale based on a previously described method as 0 (no changes), 1 (focal, mild changes), 2 (multifocal, intermediate changes), or 3 (extensive, prominent changes).[5,6]

Serum studies

Total antioxidant capacity (TAC)

Total antioxidant capacity was measured using an autoanalyzer machine (*Selectera XL, Holland*) and commercially available kits based on the colorimetric method.[7]

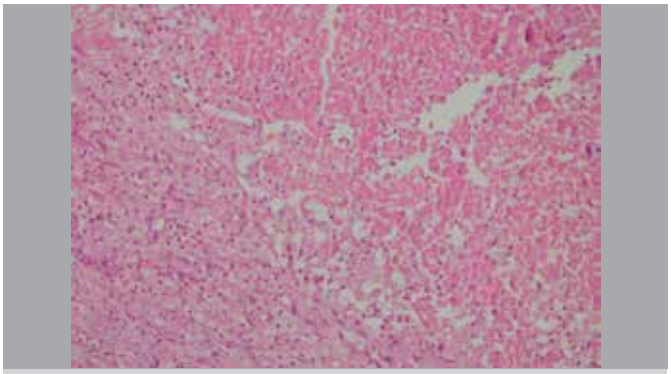


Figure 6. Areas of necrosis can be seen clearly in the specimen (H&E X 200).

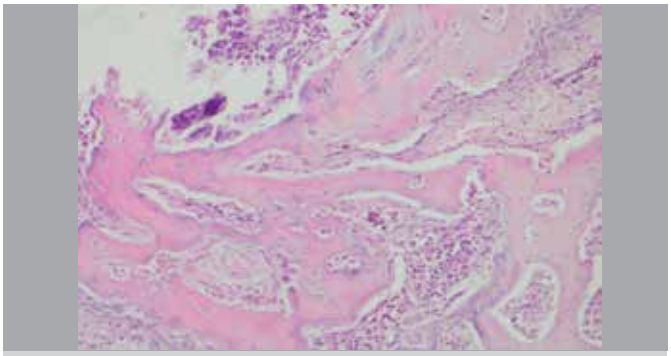


Figure 7. Mild degree of inflammation (H&E X 200).

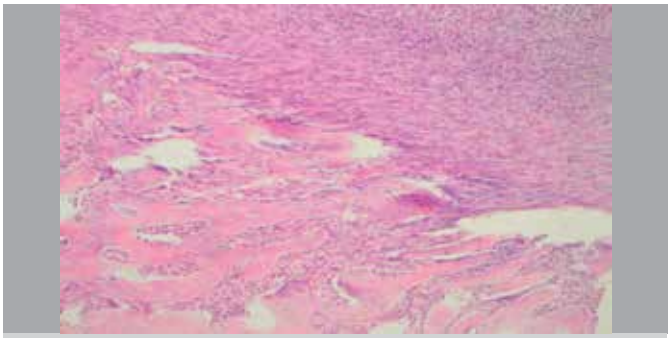


Figure 8. Moderate degree of inflammation (H&E X 100).

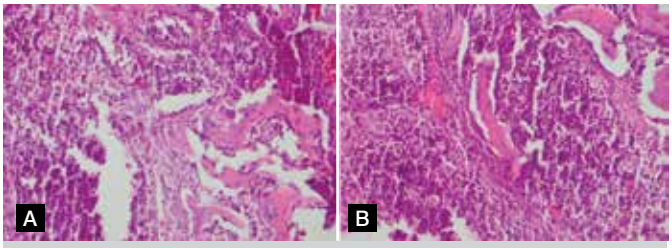


Figure 9. (A and B) Areas demonstrating severe inflammation (H&E X 200).

Protein carbonyl content (PCO)

A spectrophotometric method was utilized to evaluate PCO, as described in the relevant literature.[8] PCO reacts with 2,4-dinitrophenylhydrazine (DNPH) to generate chromophoric dinitrophenylhydrazones. A 0.5 ml (1–2 mg) sample was added to an equal volume of 10 mM DNPH in 2N HCl and incubated for 1 hour. After shaking the mixture intermittently at room temperature, a corresponding blank

was formed by adding only 2 N HCl to the sample. After incubation, the mixture was precipitated with 10% trichloroacetic acid and centrifuged. The precipitate was washed twice with ethanol:ethyl acetate (1:1) and finally dissolved in 1 ml of 6 M guanidine HCl, centrifuged at low speed, and the supernatant was read at 366 nm. The difference in absorbance between the DNPH-treated and HCl-treated samples was determined and expressed as nmoles of carbonyl groups per mg of protein, using the molar extinction coefficient of DNPH, e = 22.000 $mM^{-1}cm^{-1}$.[8]

Lactate dehydrogenase (LDH) level

The level of LDH was assayed spectrophotometrically by standard procedures using an automated analyzer (OpeRA, Bayer, USA).[9]

Outcome parameters

Three experimental groups were compared for three biochemical parameters and four histopathological variables. The biochemical parameters consisted of serum levels of TAC, PCO, and LDH, and the histopathological variables were osteomyelitis, inflammation, necrosis, and abscess formation. The existence and degree of inflammation was scaled as none, mild, moderate or severe. The presence of osteomyelitis, necrosis, and abscess formation was also noted.

Statistical analysis

The data were analyzed using IBM Statistical Package for Social Sciences Statistics 20 software (*SPSS Inc., Chicago, IL, USA*). Normal distribution of biochemical variables was assessed with the Lilliefors corrected Kolmogorov-Smirnov test. Serum levels of TAC and PCO displayed normal distribution, and comparison of their levels between groups was performed using ANOVA (post-hoc Bonferroni test). Kruskal-Wallis variance analysis (post-hoc Mann-Whitney U test, with a revised p-value for statistical significance) was used to evaluate serum LDH levels (Mann-Whitney U test was based on a new p-value of 0.05/3=0.016 for LDH levels). The chi-square test was used to analyze the qualitative data. The level of significance was $p<0.05$ for all variables except for serum LDH levels.

RESULTS

Serum levels of TAC, PCO and LDH are shown in Table 1. TAC was notably different between groups ($p<0.001$), while no remarkable difference was seen in PCO ($p=0.273$). TAC differed between Groups I and II ($p<0.001$) and Groups I and III ($p=0.001$). On the other hand, TAC in Groups II and III did not differ significantly ($p=0.372$). PCO content did not differ between Groups I and II ($p=0.393$), Groups I and III ($p=1.000$), or Groups II and III ($p=0.668$).

Table 1. Levels of total antioxidant capacity (TAC), protein carbonyl content (PCO), and lactate dehydrogenase (LDH) in 3 experimental groups.

Variable	Group			p-value
	I	II	III	
TAC	3.57 0.39	1.47 0.71	2.03 0.91	<0.001*
PCO	68.36 0.47	77.49 18.11	70.19 4.63	0.273
LDH	1067.25 68.34	1732.00 49.83	1553.38 211.62	0.002*

*= statistically significant.

There was a noteworthy difference between serum LDH levels in all three groups ($p=0.002$), between Groups I and II ($p=0.010$), and between Groups I and III ($p<0.001$). On the other hand, Group II and Group III had similar serum LDH levels ($p=0.161$).

The chi-square test was used to analyze the histopathological parameters; the results are shown in Table 2. Statistically significant differences were seen between all three groups ($p<0.05$) for the frequency of osteomyelitis ($p=0.008$), inflammation ($p=0.001$), necrosis ($p=0.022$), and abscess formation ($p=0.022$). Since expected values below 5 were seen in more than 20% of the cells in the tables, interpretations can reliably be made on a descriptive basis. Conclusions can be more accurately drawn for data presented in multicellular tables, such as degree of inflammation.

DISCUSSION

The current trial assessed the biochemical and histopathological impacts of ozone treatment in an experimental model of osteomyelitis in rats. Our results indicated that ozone treatment may enhance and improve TAC against osteomyelitis. It may consequently attenuate the deleterious effects of oxidative stress, and therefore may be a promising alternative for treating osteomyelitis. Further clinical and experimental trials are needed to clarify the role of oxidative stress in developing osteomyelitis, determine the efficacy of ozone treatment, and establish guidelines.

The beneficial effects of ozone treatment for osteomyelitis may involve several mechanisms: direct antibacterial and antiseptic impacts, improved tissue perfusion and oxygenation, and anti-inflammatory effects together with promotion of wound healing.[1]

Administering ozone treatment after osteomyelitis seems to ameliorate unfavorable histopathological alterations such as necrosis, abscess formation, inflammation, and osteomyelitis. The lack of difference in PCO levels between the groups serves as a reminder that oxidative stress injury may occur by a different mechanism in osteomyelitis. The beneficial impacts of ozone in osteomyelitis may be associated with activation of antioxidant mechanisms.[10]

A multidisciplinary approach may provide a more effective option for managing the complex biochemical and histopathological outcomes of osteomyelitis. Ozone treatment may affect different steps of the pathophysiological reactions involved in osteomyelitis. Dose, duration, and timing of ozone treatment may have important clinical implications for its use against osteomyelitis.

Some authors have suggested that oxidative stress can be reduced by enhancing local antioxidant systems and increasing endogenous capacity for reactive oxygen species (ROS) scavenging.[11]

Ozone treatment has distinct features and remarkable potential for treating various conditions in medical practice. Ozone has antimicrobial, immunomodulatory, anti-inflammatory, anti-hypoxic and hemostatic activities. These beneficial effects may be utilized to overcome the chronic refractory course of osteomyelitis and eliminate the resistance of the disease to conventional treatment. In the medical literature, hyperbaric oxygen treatment has been shown to improve the host response by creating a more favorable microenvironment for leukocyte activity, neovascularization, and

Table 2. Histopathological parameters (osteomyelitis, inflammation, necrosis and abscess formation) in 3 experimental groups.

Group	Variables									
	Osteomyelitis		Inflammation				Necrosis		Abscess	
	-	+	None	Mild	Moderate	Severe	-	+	-	+
I	8 (100%)	0	8	0	0	0	8 (100%)	0	8 (100%)	0
II	2 (25%)	6 (75%)	0	0	4 (50%)	4 (50%)	3 (37.5%)	5 (62.5%)	3 (37.5%)	5 (62.5%)
III	5 (62.5%)	3 (37.5%)	3 (37.5%)	0	4 (50%)	1 (12.5%)	6 (75%)	2 (25%)	6 (75%)	2 (25%)
p-value	0.008*		0.001*				0.022*		0.022*	

Legend: *= statistically significant.

resorption of sequestrum.[2] Our preliminary results demonstrated that ozone treatment might provide similar favorable therapeutic outcomes by reducing inflammation, necrosis and abscess formation. Mader et al.[12] have shown that hyperbaric oxygen alone was as effective as antibiotics in treating experimental *Staphylococcus aureus* osteomyelitis. On the other hand, the best results were achieved by combined use of hyperbaric oxygen and antibiotics. To the best of our knowledge, the current study is the first experimental trial to evaluate the biochemical and histopathological impacts of ozone treatment in osteomyelitis. The search for the ideal preventive regimen must focus on investigating the effectiveness, safety, and optimization of combination treatment protocols. Our findings consequently may provide novel insights about preventive and therapeutic alternatives to treat osteomyelitis.

The limitations of the present study involve the experimental design, the complexity of counteracting oxidants and antioxidant substances in biological systems, and the lack of standardization for histopathologic data. On the other hand, simultaneous assessment of biochemical and histopathologic markers constitute an important strength of our study.

CONCLUSION

Our results demonstrated that ozone treatment may alleviate the deleterious biochemical and histopathological effects of osteomyelitis by enhancing antioxidant mechanisms and decreasing oxidative stress. Even though ozone treatment yielded promising results for osteomyelitis, the need for surgical debridement and antibiotic treatment should not be ignored. Ozone treatment must instead be considered a useful and effective adjunct to conventional treatment in selected cases. Further experimental and clinical trials are needed to clarify and confirm these preventive effects, understand the underlying pathophysiology, and establish guidelines.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. AB (0000-0002-8277-8697)* wrote and reviewed the article and performed the surgeries; OO (0000-0003-2270-2778)* performed the surgeries, analyzed the data, and wrote the article; SU (0000-0003-1507-5921)* performed the statistical analysis, participated in the surgeries, and reviewed the article; YA (0000-0002-8004-7364)* analyzed the slides and conducted the pathological data analysis. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Dastan SA, Masoodi H, Salehi A. Use of ozone to treat wounds. Cumhuriyet Sci J. 2015;36(6):1365-73.
2. Chen CE, Ko JY, Fu TH, Wang CJ. Results of chronic osteomyelitis of the femur treated with hyperbaric oxygen: a preliminary report. Chang Gung Med J. 2004;27(2):91-7.
3. Das S. Application of ozone therapy in dentistry. Indian J Dental Adv. 2011;3:538-42.
4. Bollela VR, Sato DN, Fonseca BA. McFarland nephelometer as a simple method to estimate the sensitivity of the polymerase chain reaction using Mycobacterium tuberculosis as a research tool. Braz J Med Biol Res. 1999;32(9):1073-6.
5. Gulmen S, Kiris I, Narin C, Ceylan BG, Mermi B, Sutcu R, et al. Tezosentan reduces the renal injury induced by abdominal aortic ischemia-reperfusion in rats. J Surg Res. 2009;157(1):e7-e13.
6. Tiemann A, Hofmann GO, Krukemeyer MG, Krenn V, Langwald S. Histopathological Osteomyelitis Evaluation Score (HOES) - an innovative approach to histopathological diagnostics and scoring of osteomyelitis. GMS Interdiscip Plast Reconstr Surg DGPW. 2014;3:Doc08. doi: 10.3205/iprs000049.
7. Atashpour S, Kargar Jahromi H, Kargar Jahromi Z, Zarei S. Antioxidant effects of aqueous extract of Salep on Paraquat-induced rat liver injury. World J Hepatol. 2017;9(4):209-216.
8. Reznick AZ, Packer L. Oxidative damage to proteins: spectrophotometric method for carbonyl assay. Methods Enzymol. 1994;233:357-63.
9. Işeri SO, Sener G, Yüksel M, Contuk G, Cetinel S, Gedik N, et al. Ghrelin against alendronate-induced gastric damage in rats. J Endocrinol. 2005;187(3):399-406.
10. Stübinger S, Sader R, Filippi A. The use of ozone in dentistry and maxillofacial surgery: a review. Quintessence Int. 2006;37(5):353-9.
11. Seidler V, Linetskiy I, Hubálková H, Stanková H, Smucler R, Mazánek J. Ozone and its usage in general medicine and dentistry. A review article. Prague Med Rep. 2008;109(1):5-13.
12. Mader JT, Hicks CA, Calhoun J. Bacterial osteomyelitis. Adjunctive hyperbaric oxygen therapy. Orthop Rev. 1989;18(5):581-5.

DOI: http://dx.doi.org/10.1590/1413-785220182601149210

UPDATE ARTICLE

EFFICACY OF TRANEXAMIC ACID IN REDUCING BLOOD LOSS IN TOTAL KNEE ARTHROPLASTY

EFICÁCIA DO ÁCIDO TRANEXÂMICO NA REDUÇÃO DA PERDA SANGUÍNEA EM ARTROPLASTIA TOTAL DO JOELHO

David Sadigursky[1,3], Larissa Martins Araujo[2], Rogério Jamil Carneiro Fernandes[3]

1. Faculdade de Tecnologia e Ciências de Salvador, Salvador, BA, Brazil.
2. Escola Bahiana de Medicina e Saúde Pública, Salvador, BA, Brazil.
3. Center for Studies in Orthopedics and Traumatology at the Clínica Ortopédica Traumatológica (CEOT COT), Salvador, BA, Brazil.

ABSTRACT

Objective: To evaluate the efficacy of tranexamic acid in reducing blood loss in total knee arthroplasty by examining the existing literature. Method: This literature review investigated the use of tranexamic acid in knee arthroplasty. The search was performed in the Pubmed, Science Direct, Google Scholar, and Lilacs databases over a 20-year period using the keywords: "*knee arthroplasty, tranexamic acid, and efficacy*". Only randomized clinical trials published between 2000 and 2016 in English, Spanish, or Portuguese were accepted, and only trials which scored above 3 on the Jadad scale were selected. Results: A total of 7 randomized clinical trials met the inclusion criteria, with a sample of 948 patients. Conclusion: The use of tranexamic acid in total knee arthroplasty (unilateral or bilateral) reduces perioperative and postoperative blood loss more than other available antifibrinolytics. With this reduction in total blood loss and the need for blood transfusions without any increase in side effects, the use of tranexamic acid can be considered safe and effective in controlling bleeding after knee arthroplasties. ***Level of Evidence II; Systematic review.***

Keywords: Tranexamic acid. Arthroplasty, replacement, knee. Efficacy. Bleeding.

RESUMO

Objetivo: Avaliar a eficácia do ácido tranexâmico na redução da perda sanguínea em artroplastia total de joelho com relação à literatura existente. Método: O presente artigo é uma revisão da literatura a respeito da utilização do ácido tranexâmico nas artroplastias de joelho. A busca foi realizada nas bases de dados do Pubmed, Science Direct, Google Scholar e Lilacs com os descritores: "knee arthroplasty", "tranexamic acid", and "efficacy", ao longo de 20 anos. Foram aceitos apenas ensaios clínicos randomizados, publicados entre o período de 2000 e 2016, nos idiomas inglês, espanhol e português. Somente os ensaios graduados acima de três pela escala de Jadad foram selecionados. Resultados: No total, sete ensaios clínicos randomizados satisfizeram os critérios de inclusão, com uma amostra de 948 pacientes. Conclusão: O uso do ácido tranexâmico na artroplastia total do joelho, tanto uni quanto bilateral, reduz a perda de sangue no peri e no pós-operatório em comparação com outros antifibrinolíticos usados. Com a redução da perda total de sangue e da necessidade de transfusões sanguíneas, sem qualquer aumento dos efeitos colaterais, a utilização do uso do ácido tranexâmico pode ser considerada segura e eficaz no controle do sangramento depois de artroplastias do joelho. ***Nível de Evidência II; Revisão sistemática.***

Descritores: *Ácido tranexâmico. Artroplastia do joelho. Eficácia. Sangramento.*

Citation: Sadigursky D, Araujo LM, Fernandes RJC. Efficacy of tranexamic acid in reducing blood loss in total knee arthroplasty. Acta Ortop Bras. [online]. 2018;26(1):68-71. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Total knee arthroplasty (TKA) is a procedure which is subject to a series of postoperative complications; excessive blood loss is one of the main complications in the intraoperative and immediate postoperative period, and is related to prolonged hospital stay, increased hospitalization costs, and possible patient dissatisfaction.[1] Blood loss in TKA may vary from 800 ml to 1800 ml, and 10-38% of patients may require blood transfusions.[2]

Even when tourniquets are used in TKA, there is considerable bleeding and this procedure may even be considered controversial.[3] Zhang et al.[4] demonstrated that when the tourniquet is released, fibronolysis is activated at the site, increasing blood loss.[2]

Alternatives are continuously being assessed to minimize intraoperative and postoperative bleeding as well as complications. These include the use of tranexamic acid (TA), epinephrine, fibrin glue, Floseal hemostatic matrix, and transfusion. TA is gaining wide attention from surgeons because of its low cost, easy access and use, and is a medication which is widely known in the literature.[5] Considering this scenario, studies on the clinical effectiveness of TA in reducing blood loss during TKA are extremely important, since

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

Work conducted at the Center for Studies in Orthopedics and Traumatology at the Clínica Ortopédica Traumatológica (CEOT COT), João das Botas, 28, Canela, Salvador, BA, Brazil. Correspondence: Rua Colmar Americano da Costa, 121, apt. 1404C, Pituba, Salvador, BA, Brazil. CEP: 41830-600. davidsad@gmail.com

Article received in 05/01/2015, approved in 09/12/2017.

there is no consensus regarding the best application protocol or dosage in the current literature.[6]

TA, which is a synthetic antifibrinolytic agent, contains the trans isomer of 4-amino-carboxylic methyl cyclohexane (Transamin), a synthetic derivative of the amino acid lysine,[7,8] which acts through competition to inhibit the activation of plasminogen to plasmin. This formula has a strong attraction to the site where lysine connects to the plasminogen and plasmin, thus inhibiting the activation and competing action of plasmin. Its action is primarily based on slowing down the fibrinolytic process (it is a potent inhibitor of the fibrinolytic action of plasmin) after clot formation, extending the time of dissolution of the fibrin network, thus preserving the clot and not resulting in the activation of the coagulation cascade. These properties increase the efficiency of the hemostatic substance, reducing the intensity and the risks of bleeding in surgical procedures, trauma and diseases where bleeding is likely.[7,9] TA has rapid absorption of approximately 90% of an intravenous dose excreted in the urine in 24 hours, a plasma half-life of approximately 2 hours, and therapeutic levels maintained for 6–8 hours.[5,10]

Many techniques have been proposed to minimize blood loss and the need for blood transfusions in TKA, and this review consequently analyzes the effectiveness of TA in reducing blood loss in TKA and compares it with other methods presented in the literature.

METHODS

This systematic review was performed according to the PRISMA Statement protocol[11] to select scientific articles analyzing the effectiveness of TA in primary knee arthroplasty. The search was performed in the Pubmed, Medline, and Lilacs databases using the keywords "*knee arthroplasty, "tranexamic acid," and "efficacy*" over a 20-year period. Only randomized clinical trials in English, Spanish, or Portuguese were accepted. The pre-selected trials were graded according to the Jadad scale[9] and only trials with scores over three were selected. Since this is a review article, the institutional review board approval for clinical studies was not necessary.

RESULTS

Using the keywords "*knee arthroplasty," "tranexamic acid," and "efficacy*," we obtained 31 articles from Pubmed, 27 articles from Medline, and only 1 article from Lilacs, with a total of 59 articles to be reviewed, as shown in Figure 1. After excluding duplicate articles, we were left with 7 articles from Pubmed and Medline, and none from Lilacs. (Table 1) The other articles were excluded because they did not meet the pre-established inclusion criteria, i.e., a score above three on the Jadad scale. The selected studies were summarized and are shown in Table 2, while the type of intervention as well as the dosage used in the studies are shown in Table 3.

The study by Aguilera et al.[12] described a randomized clinical trial (RCT) with 166 patients, who were separated into four groups by use of fibrin glue, fibrinogen with troponin, and intravenous tranexamic acid (IVTA), and the last group without any hemostatic mechanism (control). These authors concluded at the end of the study that IVTA can reduce blood loss in the postoperative period.

The study by Pachauri et al.[8] used a RCT with 99 patients receiving two doses of IVTA: the first applied one hour before incision and the second applied six hours after wound closure. After reviewing the results, Pachauri et al.[8] concluded that IVTA can be regarded as an effective method to control and minimize blood loss in TKA.

Kim et al.[13] performed a RCT with 326 patients: one group undergoing unilateral hip arthroplasty received more than one dose (10 mg/kg) IVTA before deflation of the tourniquet during surgery and again three hours after surgery, and a second group which underwent bilateral arthroplasty received more than one dose

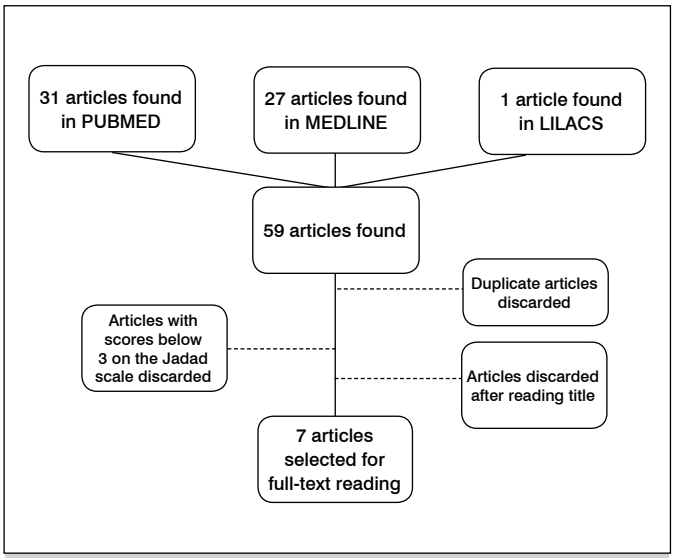


Figure 1. Flowchart of results.

Table 1. Studies included in the review.

Author and Year of Publication	Location	Type of Study	Sample
Pachauri et al.,[8] 2013	Lucknow, India	Randomized clinical trial	99
Aguilera et al.,[12] 2013	Barcelona, Spain	Randomized clinical trial	172
Kim et al.,[13] 2014	Gyeonggido, Korea	Randomized clinical trial	326
Wong et al.,[14] 2010	Toronto, Canada	Randomized clinical trial	124
Roy et al.,[15] 2012	New Delhi, India	Randomized clinical trial	50
Kankar et al.,[16] 2009	New Delhi, India	Randomized clinical trial	50
Camarasa et al.,[17] 2006	Barcelona, Spain	Randomized clinical trial	127

Table 2. Table summarizing the results of the studies included in the review.

Author	Procedure	Type of intervention	Results
Pachauri et al.,[8] 2013	Total knee arthroplasty	Tranexamic acid	Reduction in hemoglobin drop
Aguilera et al.,[12] 2013	Total knee arthroplasty	Fibrin glue, fibrinogen with thrombin, intravenous tranexamic acid	Less blood loss when used tranexamic acid used
Kim et al.,[13] 2014	Total knee arthroplasty, bilateral and unilateral	Tranexamic acid	Reduction in total blood loss when tranexamic acid used, reduction in rate of blood transfusion varies according to procedure performed
Wong et al.,[14] 2010	Total knee arthroplasty	Tranexamic acid	Reduction in postoperative hemorrhage
Roy et al.,[15] 2012	Total knee arthroplasty, unilateral	Tranexamic acid	Reduction in blood transfusion when tranexamic acid used
Kankar et al.,[16] 2009	Total knee arthroplasty, bilateral and unilateral	Tranexamic acid	Reduction in total blood loss and blood transfusion rate when tranexamic acid used
Camarasa et al.,[17] 2006	Total knee arthroplasty, unilateral	Tranexamic acid	Reduction in total blood loss and blood transfusion

Table 3. Tranexamic acid dose and method of application.

Author and Year of Publication	Type of intervention
Pachauri et al.,[8] 2013	2 doses of tranexamic acid, injection, first dose one hour post-procedure and six hours post-procedure
Aguilera et al.,[12] 2013	Fibrin glue, fibrinogen with troponin, intravenous tranexamic acid
Kim et al.,[13] 2014	More than one dose (10 mg.kg^{-1}) of tranexamic acid before deflation of the tourniquet
Wong et al.,[14] 2010	Tranexamic acid 1.5 to 3.0g applied in the joint for five minutes at the end of surgery
Roy et al.,[15] 2012	Tranexamic acid 5ml, applied in the joint after the procedure
Kankar et al.,[16] 2009	Tranexamic acid 10 mg.kg^{-1} applied shortly before inflation of the tourniquet, followed by 1 mg.kg^{-1} until the end of the procedure
Camarasa et al.,[17] 2006	Intravenous tranexamic acid 10 mg.kg^{-1} applied shortly before deflation of the tourniquet and three hours later, or use of epsilon aminocaproic acid 100 mg.kg^{-1}

(10 mg/kg) before deflation of the tourniquet. This study concluded that the use of IVTA significantly reduced blood loss, but the transfusion rate may vary depending on whether the procedure is unilateral or total arthroplasty.

Wong et al.[14] published a study based on a RCT with 124 patients who received 1.5 or 3.0g of TA in 100ml of saline solution or an equivalent volume of placebo applied in the joint at the end of the surgery. They concluded that the use of TA reduces bleeding and increases hemoglobin levels after the procedure compared with the placebo.

Roy et al.[15] conducted a RCT with 50 patients in two groups: the first group received TA topically applied to the joint through infusion via suction drain after skin closure, and the second group (control) received intra-articular application of saline as a placebo. After analysis of the results, the authors concluded that TA reduced postoperative bleeding by almost half in patients undergoing TKA, reducing the need for blood transfusion in these patients.

Kakar et al.[16] conducted a RCT with 50 patients divided into four groups according to procedure, with bilateral and unilateral hip arthroplasty, and their respective control groups. A test dose of 1 ml was used, then a dose of 10 mg.kg^{-1} IV followed by an infusion of 1 mg.kg^{-1}1hr^{-1} of TA after skin closure. The control groups received an equivalent amount of saline. Kakar et al.[16] concluded that the use of TA significantly reduced blood loss when compared with the control groups.

In 2006, Camarasa et al.[17] conducted a RCT with 127 patients divided into two groups, one using IVTA shortly before deflating the tourniquet and three hours after the end of the procedure in the first group, and a control group, which received epsilon aminocaproic acid (EACA). In the conclusion of the article, these authors described a significant reduction in blood loss when antifibrinolytic agents were used in patients undergoing TKA, along with a reduction in the number of blood transfusions.

DISCUSSION

In previous reviews, Kim et al.[13] found 28 RCTs, Zhang et al.[4] reviewed 15 RCTs with a total of 842 patients, and Panteli et al.[18] found 7 articles in their review. The present review, which includes seven articles analyzing a total sample of 948 patients, also demonstrated the positive effects in reducing bleeding in TKA, decreased the need for blood transfusions, and low rates of complications when using tranexamic acid.

Aguilera et al.[12] analyzed 172 adult patients undergoing TKA for the first time. Their study investigated the efficacy of IVTA and fibrin glue (FG), comparing two types of FG with TA. The first group used FG from the Catalonia tissue bank, the second group used Tissucol (fibrinogen, aprotinin, and thrombin; Baxter AG, Vienna, Austria), a third group used TA, and a fourth group was a control. The results of this study showed lower blood loss in the group which used TA as hemostasis than in the groups that used the two types of FG and the control. No complications were reported from the use of hemostatic agents. The numbers of patients in each group were small in this study, which may have influenced the results observed. Pachauri et al.[8] conducted a RCT with a total of 99 patients to evaluate the efficacy of TA in reducing intraoperative and postoperative bleeding in knee arthroplasties, and concluded that there was a significant reduction in hemoglobin drop in these patients.

In 2013, Kim et al.[13] performed another RCT to analyze the efficacy of TA in reducing blood loss and transfusion rates in unilateral TKA (uTKA) and bilateral TKA (bTKA). They included 180 patients who underwent uTKA and 146 patients who underwent bTKA. The results showed that TA use decreased the total blood loss, but its effects on transfusion rate may vary; the transfusion rate decreased when TA was used during bTKA, but there was no effect in uTKA. Like Kim et al.,[13] Kakar et al.[16] conducted a similar study, but with 24 patients who underwent uTKA and 26 patients who underwent bTKA. This study also found reduction in blood loss in both groups, although this reduction was more significant in patients who underwent bTKA. The authors also concluded that the use of TA led to a reduction in postoperative blood transfusions in both groups. This aspect differs from the conclusion by Kim et al.,[13] which only demonstrated this reduction in patients who underwent the bilateral procedure. This divergence may be related to sample size. The protocol for application and dosage of TA also differed significantly between the studies. Other studies included in this review with similar results corroborated the findings of Kakar et al.[16]

The analysis conducted by Roy et al.[15] involving 50 patients who underwent uTKA evaluated the efficacy of topical intra-articular TA in reducing blood loss during the postoperative period when compared with the control group. Roy et al.[15] found a similar reduction in blood transfusion in patients who underwent uTKAu, like Kakar et al.[16] The parameters used in this analysis were drop in hemoglobin and hematocrit. The results showed that the control group received six times more blood transfusions than the group that received TA.

Like Kakar et al.,[16] Kim et al.,[13] and Roy et al.,[15] Camarasa et al.,[17] obtained similar results. Based on a study with 127 patients, Camarasa et al.[17] evaluated the efficacy of fibrinolytics during treatment, in this case TA, to reduce perioperative blood loss during uTKA, and concluded that antifibrinolytics significantly decrease blood loss in patients undergoing TKA, which is reflected in a reduced number of blood transfusions.

In a study of 124 patients undergoing TKA, Wong et al.[14] analyzed topical use of TA directly in the knee joint, and demonstrated that topical application of TA can reduce postoperative hemorrhage by approximately 20-25%.

The limitations of this review include a wide divergence of protocols of use, dose, and time of administration of TA. A small number of studies were used, because of the design (RCT) and the use of this medication in only TKA. The total number of patients analyzed was suitable for a review study. Patient follow-up in the studies evaluated was also short, and new RCTs with longer follow-up are necessary; these should investigate the occult bleeding rate, as well as the occurrence of late complications such as deep venous thrombosis (DVT) and pulmonary embolism (PE).[19]

The studies found did not permit a conclusion as to whether intravenous application is better than topical in terms of effectiveness. The choice between the two methods can be based on the surgeon's preference, considering that the rate of complications did not increase when IVTA was used in comparison with topical application. The main complications such as DVT, pulmonary embolism, stroke, or acute myocardial infarction are not greater with IVTA than with topical use of this medication, and adverse effects also are not more likely. As a result, this review and others found in the literature[2-4,20,21] allow us to conclude that TA is an effective medication for controlling bleeding in knee arthroplasty procedures, regardless of how it is applied.

CONCLUSION

After analysis and comparison of the studies included in this review, we can conclude that the use of tranexamic acid in total knee arthroplasty (whether unilateral or bilateral) significantly reduces blood loss in the perioperative and postoperative periods when compared to other antifibrinolytic agents, and no difference was seen between intravenous or topical application. Because of this reduction in total blood loss and the reduced rate of hemoglobin and hematocrit as well as blood transfusion, and no increase in adverse effects, TA can be considered safe to use. The use of TA as a hemostasis mechanism can reduce costs, decrease hospitalization time, and avoid the need for blood transfusions.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. DS (0000-0003-3437-6180)* and LMA (0000-0001-9008-0689)* drafted the manuscript. DS, LMA, and RJFC (0000-0001-5450-064X)* selected the articles and gathered the clinical data. LMA and DS organized the selected articles. RJFC and DS reviewed the manuscript and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Marra F, Rosso F, Bruzzone M, Bonasia DE, Dettoni F, Rossi R. Use of tranexamic acid in total knee arthroplasty. Joints. 2017;4(4):202-13.
2. Chen T-P, Chen Y-M, Jiao J-B, Wang Y-F, Qian L-G, Guo Z, et al. Comparison of the effectiveness and safety of topical versus intravenous tranexamic acid in primary total knee arthroplasty: a meta-analysis of randomized controlled trials. J Orthop Surg. 2017;12(1):11.
3. Wang Z, Shen X. The efficacy of combined intra-articular and intravenous tranexamic acid for blood loss in primary total knee arthroplasty: A meta-analysis. Medicine (Baltimore). 2017;96(42):e8123.
4. Zhang H, Chen J, Chen F, Que W. The effect of tranexamic acid on blood loss and use of blood products in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2012;20(9):1742–52.
5. Kim TK, Chang CB, Koh IJ. Practical issues for the use of tranexamic acid in total knee arthroplasty: a systematic review. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2014;22(8):1849-58.
6. Fu Y, Shi Z, Han B, Ye Y, You T, Jing J, et al. Comparing efficacy and safety of 2 methods of tranexamic acid administration in reducing blood loss following total knee arthroplasty. Medicine (Baltimore). 2016;95(50):e5583.
7. Dunn CJ, Goa KL. Tranexamic acid: a review of its use in surgery and other indications. Drugs. 1999;57(6):1005–32.
8. Pachauri A, Acharya KK, Tiwari AK. The effect of tranexamic acid on hemoglobin levels during total knee arthroplasty. Am J Ther. 2014;21(5):366-70.
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.
10. Hoylaerts M, Lijnen HR, Collen D. Studies on the mechanism of the antifibrinolytic action of tranexamic acid. Biochim Biophys Acta. 1981;673(1):75-85.
11. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. PLoS Med. 2009 ;6(7):e1000100.
12. Aguilera X, Martinez-Zapata MJ, Bosch A, Urrútia G, González JC, Jordan M, et al. Efficacy and safety of fibrin glue and tranexamic acid to prevent postoperative blood loss in total knee arthroplasty: a randomized controlled clinical trial. J Bone Joint Surg Am. 2013;95(22):2001-7.
13. Kim TK, Chang CB, Kang YG, Seo ES, Lee JH, Yun JH, et al. Clinical value of tranexamic acid in unilateral and simultaneous bilateral TKAs under a contemporary blood-saving protocol: a randomized controlled trial. Knee Surg Sports Traumatol Arthrosc. 2014;22(8):1870-8.
14. Wong J, Abrishami A, El Beheiry H, Mahomed NN, Roderick Davey J, Gandhi R, et al. Topical application of tranexamic acid reduces postoperative blood loss in total knee arthroplasty: a randomized, controlled trial. J Bone Joint Surg Am. 2010;92(15):2503-13.
15. Roy SP, Tanki UF, Dutta A, Jain SK, Nagi ON. Efficacy of intra-articular tranexamic acid in blood loss reduction following primary unilateral total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2012;20(12):2494-501.
16. Kakar PN, Gupta N, Govil P, Shah V. Efficacy and Safety of Tranexamic Acid in Control of Bleeding Following TKR: A randomized clinical trial. Indian J Anaesth. 2009;53(6):667-71.
17. Camarasa MA, Ollé G, Serra-Prat M, Martín A, Sánchez M, Ricós P, et al. Efficacy of aminocaproic, tranexamic acids in the control of bleeding during total knee replacement: a randomized clinical trial. Br J Anaesth. 2006;96(5):576-82.
18. Panteli M, Papakostidis C, Dahabreh Z, Giannoudis PV. Topical tranexamic acid in total knee replacement: a systematic review and meta-analysis. The Knee. 2013 ;20(5):300-9.
19. Sadigursky D, Andion D, Boureau P, Ferreira MC, Carneiro RJF, Colavolpe PO, et al. Effect Of Tranexamic Acid On Bleeding Control In Total Knee Arthroplasty. Acta Ortop Bras. 2016;24(3):131-6.
20. Lin C, Qi Y, Jie L, Li H-B, Zhao X-C, Qin L, et al. Is combined topical with intravenous tranexamic acid superior than topical, intravenous tranexamic acid alone and control groups for blood loss controlling after total knee arthroplasty: A meta-analysis. Medicine (Baltimore). 2016;95(51):e5344.
21. Zhao-Yu C, Yan G, Wei C, Yuejv L, Ying-Ze Z. Reduced blood loss after intra-articular tranexamic acid injection during total knee arthroplasty: a meta-analysis of the literature. Knee Surg Sports Traumatol Arthrosc. 2014;22(12):3181-90.

DOI: http://dx.doi.org/10.1590/1413-785220182601148079

Technical Note

METHOD FOR REMOVING BROKEN PROXIMAL FEMORAL NAILS USING EXISTING SCREW HOLE

MÉTODO DE REMOÇÃO DE HASTE FEMORAL PROXIMAL QUEBRADA USANDO OS ORIFÍCIOS DE PARAFUSOS EXISTENTES

Cho Hong Man[1], *Min Woong Bae*[1]

1. Department of Orthopedic Surgery, Gwangju Veterans Hospital, Gwangju, Korea.

ABSTRACT

The use of intramedullary nailing to treat proximal femoral fractures has increased in recent years. Nail breakage is a rare complication of intramedullary nailing of the femur, and generally occurs at the non-united fracture site. Removal of the distal fragment of a broken nail is a challenging problem. In this article, the authors describe the methods used to remove strongly fixed broken intramedullary nails. ***Level of Evidence IV; Case series.***

Keywords: Femur. Hip fractures. Fracture fixation, intramedullary. Prosthesis failure.

RESUMO

O uso de hastes intramedulares para tratar fraturas proximais do fêmur aumentou nos últimos anos. A quebra da haste é uma complicação rara das hastes intramedulares do fêmur, que em geral ocorre no local de não união da fratura. A remoção do fragmento distal da haste quebrada é um problema desafiador. Neste artigo, os autores descrevem os métodos usados para remover hastes intramedulares quebradas e com forte fixação. ***Nível de Evidência IV; Série de casos.***

Descritores: *Fêmur. Fraturas do quadril. Fixação intramedular de fraturas. Falha de prótese.*

Citation: Cho HM, Min W. Method for removing broken proximal femoral nails using existing screw hole. Acta Ortop Bras. [online]. 2018;26(1):72-4. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

In cases of delayed union or non-union, use of intramedullary (IM) nailing to treat proximal femoral fracture can lead to fatigue fracture of the implant. Distal fragments of the broken nail are difficult to remove, which has prompted many researchers to investigate various extraction and remedial techniques, all of which involve the application of both specially designed extraction tools and supplementary locking screws.[1-8] In this report, the authors present a new technique utilized to extract the broken distal portion of the IM nail in cases of proximal femoral fracture where the distal portion of the broken nail was firmly fixed in the medullary canal, making removal difficult. The simplicity of this technique lies chiefly in the fact that it does not require any specially made extractor.

TECHNIQUE

Patient history

A 69-year-old woman with left subtrochanteric femur fracture resulting from a fall underwent internal fixation using a proximal femoral nail antirotation (PFNA) (diameter: 9 mm, length: 200 mm) at another hospital. (Figure 1A) Three months postoperatively, breakage of the nail passing through the distal locking screw hole was observed, along with signs of injury. (Figure 1B) Because the fragment of the broken nail could not be completely removed, it was left *in situ*, and revision surgery was performed at the same hospital using a locking plate. (Figure 1C) Six weeks after the second surgery, the patient was admitted to our hospital due to pain at the site of the subtrochanteric fracture. Radiography showed non-union of the fracture, breakage of the proximal part of the plate, and the remaining distal nail fragment. (Figure 1D). The patient had had hypertension for 5 years, which was well-controlled with medication. Her other medical history was non-specific; preoperative laboratory results showed no infectious or autoimmune disease. After removal of the locking plate and remaining nail fragment, the femur was reconstructed using a new Synthes Expert Antegrade Femoral Nail (A2FN nail, Synthes, Oberdorf, Switzerland). (Figures 1E and F) The surgery lasted 125 minutes; 250 ml of blood was lost during the procedure, and the patient received transfusion (2 units).

Surgical technique

The patient was placed supine on a fracture table, as for ordinary proximal femoral fracture surgery. Under general anesthesia, the broken plate and locking screws were removed though incisions (using pre-existing incisions whenever possible). In order to extract the remaining distal nail fragment, the second screw hole below the distal end of the broken nail was enlarged by burring its upper edge medially and its lower edge laterally with a reamer, (Figure 2A) and a bulb-tipped guidewire was inserted in a retrograde manner.

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

Work conducted at the Department of Orthopedic Surgery, Gwangju Veterans Hospital. Sanwol-dong 887-1, Gwangsan-gu, Gwangju Korea. 506-705.
Correspondence: Department of Orthopedic Surgery, Gwangju Veterans Hospital. Sanwol-dong 887-1, Gwangsan-gu, Gwangju Korea. 506-705. chm1228@hanmail.net

Article received in 04/03/2015, approved in 09/12/2017.

CC BY NC

Previous surgical testing with PFNA fixation showed that the tip of the guidewire employed was too large to extract when inserted in a retrograde direction. The guidewire was carefully chosen in reference to the medullary canal diameter to avoid adverse effects on the medullary canal. (Figure 2B) The proximal portion of the retrograde-inserted guidewire was held firmly with a pin vise, and several hammer blows were performed to remove the remaining distal nail fragment, but without success. The screw hole was further reamed upwards and downwards. (Figure 2C) The screw was tapped cautiously with a slotted hammer to prevent damage to the cortical bone, and transferred the broken nail fragment slightly toward the proximal end. The fragment was then extracted by pulling back the guidewire. (Figures 2D and E) The cortical bone remained undamaged during the extraction process. After fracture reduction with the bone clamp, (Figure 2F) the A2FN nail was inserted. However, because the fracture reduction was not stable, a circular-shaped wire and crimp system were also employed. (Figure 1E) Because the inserted retrograde bulb tip wire still remained, a bendable Schanz screw was employed as an external fixator. (Figure 3A) By bending the screw, its contours were adjusted to prevent any damage to the reamed cortical bone. It was then inserted through the reamed screw hole and advanced to the distal end of the nail, where its slightly concave end contacted the bulb-tipped guidewire. (Figure 3B)

DISCUSSION

An IM nail can break if the fractured proximal femur does not heal or if the fixation for the fracture is not stable, leading to delayed union or non-union. Removal of the distal fragment of a broken nail can be challenging. Various extraction techniques involving specially designed instruments such as hooks, screws, or guidewires have been introduced.[1-8]

In cases of broken nails that are not tightly fixed, insertion of a long extractor with a distal hook is a common strategy.[1] A hook cannot be used, however, if the inside of the nail is narrow. Alternatively, Brewster et al.[2] and Kim et al.[3] have suggested insertion of one or two straight guidewires in addition to a hook or bulb-tipped guidewire, respectively. It is not easy to insert more than two guidelines into the narrow inside space of the nail; moreover, insertion of multiple guidewires might also pose a problem when the nail canal is narrow. Park et al.[4] reported that a broken nail was easily extracted using a flexible guidewire with a grooved and bent tip. This method can be adopted primarily when no other tools are available which can be employed without concern for possible damage to the medullary canal. While the flexible guidewire has a grooved distal end, unless its distal end is firmly engaged it can slip off the nail. It also is not useful when the broken nail is stuck within the medullary canal.

Magu et al.[5] reported successful removal of a broken nail by inserting a ball-tipped guidewire with a 7 mm washer loaded retrogradely into the medullary canal. However, such an insertion is difficult when the IM nail is short, due to the long distance from the knee joint, as described in their study. An additional concern is that this method entails the removal of more than 7 mm of cortical bone,

Figure 3. A) Schanz screw before and after bending. B) Bent Schanz screw and guide wire used to remove broken proximal femoral nail through screw hole.

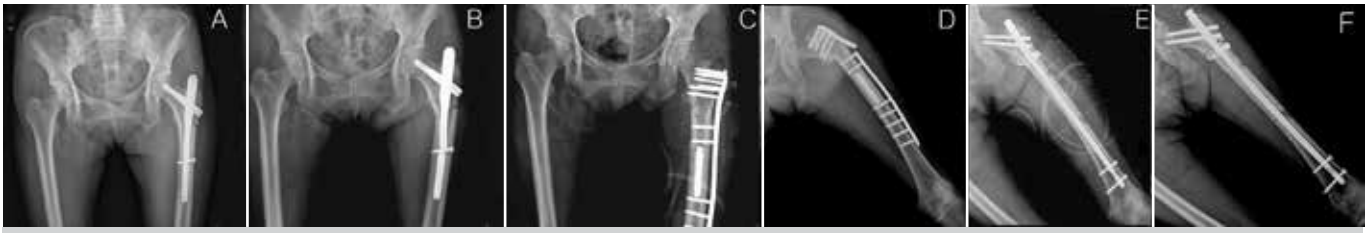


Figure 1. Subtrochanteric fracture in 69-year-old woman. A) Fixation using PFNA. B) Non-union and broken nail developed three months after initial operation. C) Second operation performed with locking plate. The broken distal nail tip remained after removal of the proximal portion of the PFNA. D) Non-union and hardware failure developed six weeks after second operation. E) Anteroposterior view of left femur after nailing. F) Radiograph at 6 months after surgery.

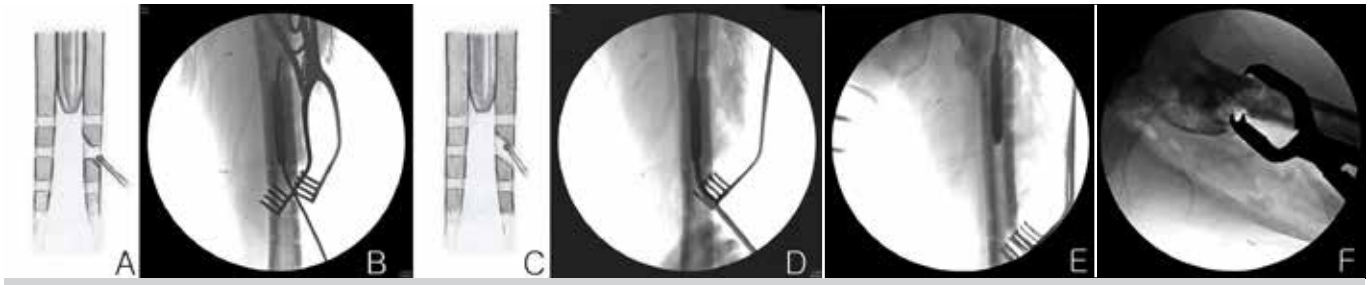


Figure 2. A) Small-sized burr used in reaming. B) Guidewire retrogradely delivered through distal end. C) Large-sized burr used in reaming. D) Schanz screw delivered through widened hole. E) Extraction of broken distal nail tip. F) Fracture reduction with bone clamp.

with concomitant damage to the articular cartilage of the knee joint. Furthermore, a cortical bone defect below the implant increases the possibility of secondary injury resulting from accumulated fatigue in the bone. When the broken IM nail is only loosely fixed, a modified flexible guidewire has been successfully used for simple and easy removal. But this instrument, using the method described in this report, is difficult to use in cases of firmly fixed nails because of the lack of sufficient medullary space. Indeed, a nail firmly jammed at the isthmus of the medullary canal cannot be removed with such a guidewire. Alternatively, as reported of a previous study,[6] a guidewire was inserted to the broken nail, after which a reamer was used to enlarge the space between the nail and the inner side of the cortical bone. Unfortunately, this method requires a special instrument, and is not suitable for small-diameter nails. Additionally, the reaming process can leave behind fragments that act as foreign bodies. Karladani et al.[7] inserted a 3.5 mm screw, and Lee et al.[8] a 10 mm k-wire insert, into the distal locking screw hole, and then pulled out the nail using the bulb-tipped guidewire. But because of the additional procedure, this method lengthens the surgical time and increases the intraoperative radiation load of the image intensifier. Furthermore, positioning the 10 mm wire accurately into the distal screw hole is not a simple procedure, because the wire can easily fall into the medullary canal, and removal is difficult. And even though the wire is fixed at the desired site, its function as an extracting instrument cannot be effective unless it is firmly connected with the ball-tipped guidewire.

CONCLUSION

Revision surgery performed to replace a broken proximal femoral nail usually requires a longer nail than that used in the initial surgery, as well as a distal locking screw hole made farther from the previous locking screw hole. In this present study on revision surgery, the authors instead utilized the pre-existing distal locking screw hole from a firmly fixed nail, reaming it slightly. If no distal screw hole was present, a new hole was formed for the removal. The reaming was performed cautiously, by burring the upper edge of the hole medially and the lower edge laterally, in order to minimize damage to the cortical bone.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. Cho HM (0000-0001-5160-2640)* and Min W (0000-0002-7500-7229)* were the main contributors in drafting the manuscript. Cho HM performed surgery, followed patients, and gathered clinical data. Min W performed the literature search, reviewed the manuscript, and contributed to the intellectual concept of the study. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Poehling GG, Webb LX. Retrieval and replacement of a broken Küntscher rod by a closed technique. Technical note. J Bone Joint Surg Am. 1982;64(9):1389-90.
2. Brewster NT, Ashcroft GP, Scotland TR. Extraction of broken intramedullary nails--an improvement in technique. Injury. 1995;26(4):286.
3. Kim DS, Kwon CS, Ahn JK, Jeong BH, Sung YB, Yum JK, et al. Simple method for the extraction of the broken intramedullary nail of femur -case report. J Korean Orthop Assoc. 1999;34:171-4.
4. Park SY, Yang KH, Yoo JH. Removal of a broken intramedullary nail with a narrow hollow. J Orthop Trauma. 2006;20(7):492-4.
5. Magu NK, Sharma AK, Singh R. Extraction of the broken intramedullary femoral nail-an innovative technique. Injury. 2004;35(12):1322-3.
6. Georgilas I, Mouzopoulos G, Neila C, Morakis E, Tzurbakis M. Removal of broken distal intramedullary nail with a simple method: a case report. Arch Orthop Trauma Surg. 2009;129(2):203-5.
7. Karladani AH. Removal of a broken nail using a guide wire and a screw. Acta Orthop. 2006;77(6):986-8.
8. Lee M, Yang KH. Removal of a broken intramedullary nail with a narrow hollow using a bulb-tipped guide wire and kirschner wire: a case report. J Korean Fract Soc. 2010;23:377-81.