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

ISSN 1413-7852

Acta Ortopédica Brasileira

Volume 28 – Number 4 – Year 2020

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 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.

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.

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 28–Nº 4 – 2020

Original Articles

FOOT AND ANKLE

HAND

KNEE

ORTHOPEDIC TRAUMA

DOI: http://dx.doi.org/10.1590/1413-785220202804233522
ORIGINAL ARTICLE

RANDOMIZED CONTROLLED TRIAL OF LIMITED FASCIECTOMY WITH INJECTION OF ADIPOSE GRAFT FOR DUPUYTREN'S DISEASE

ESTUDO COMPARATIVO RANDOMIZADO DE ENXERTO DE GORDURA PARA A DOENÇA DE DUPUYTREN

Marina Tommasini C. Sambuy[1], *Hugo A. Nakamoto*[1], *Raul Bolliger Neto*[1], *Rames Mattar Jr.*[1], *Marcelo R. Rezende*[1], *Teng Hsiang Wei*[1]

1. Universidade de São Paulo, Medical School, Hospital das Clínicas, Institute of Orthopedics and Traumatology, São Paulo, SP, Brazil.

ABSTRACT

Objective: Dupuytren's disease is a genetic disorder related to the proliferation of myofibroblasts. The pluripotent property of stem cells present in adipose tissue inhibits myofibroblast proliferation. Our study sought to evaluate the effect of stem cell-rich fat grafts in patients that underwent limited fasciectomy. Methods: We studied 45 patients, in a single-blind, prospective, randomized clinical trial. All patients underwent limited fasciectomy. In one group, fat graft was injected. Results: The total passive extension deficit results did not exhibit a significant difference. Fat group exhibited worse functional score at 6 months and 1 year postoperatively, such as higher complication rates (43%), when compared with control group (8%), and more pain at 6 weeks follow-up. Conclusion: Fat grafting associated with limited fasciectomy promotes worse functional results compared to conventional limited fasciectomy in the short term. However, long-term results and recurrence rates should be further assessed. ***Level of Evidence II, Prospective comparative study.***

Keywords: Dupuytren Contracture. Adipose Tissue. Fasciectomy. Stem Cells. Randomized Controlled Trial. Clinical Trial.

RESUMO

Objetivo: A moléstia de Dupuytren (MD) está associada a um distúrbio genético relacionado à proliferação de miofibroblastos. Acredita-se que a propriedade totipotente das células-tronco, presentes no tecido adiposo, seria capaz de inibir a formação dos miofibroblastos. O objetivo deste estudo foi avaliar o efeito do enxerto de gordura, rico em células-tronco, nos pacientes com MD, submetidos à fasciectomia parcial. Métodos: Estudamos 45 pacientes, em um ensaio clínico prospectivo, randomizado e cego. No grupo-controle, era realizada apenas a fasciectomia parcial. No grupo com gordura, era realizada a fasciectomia parcial e injetado o enxerto de gordura. Os desfechos foram avaliados pelo Déficit de Extensão Passiva Total (DEPT) e escore funcional Brief Michigan Hand Questionnaire (BMHQ). Resultados: Os resultados do déficit de extensão passiva total não apresentaram diferença significativa. O grupo com gordura apresentou pior escore funcional após 6 meses e 1 ano, como maiores taxas de complicações (43%) em comparação ao grupo controle (8%) e mais dor com 6 semanas de seguimento. Conclusão: O uso de enxerto de gordura associado à fasciectomia parcial promove piores resultados funcionais em comparação com a fasciectomia parcial convencional, a curto prazo. No entanto, a recidiva e os resultados a longo prazo devem ser avaliados. ***Nível de Evidência II, Estudo prospectivo comparativo.***

Descritores: *Contratura de Dupuytren. Tecido Adiposo. Fasciotomia. Células-Tronco. Ensaio Clínico Controlado Aleatório. Ensaio Clínico.*

Citation: Sambuy MTC, Nakamoto HA, Bolliger Neto R, Mattar R Jr., Rezende MR, Wei TH. Randomized controlled trial of limited fasciectomy with injection of adipose graft for Dupuytren's Disease. Acta Ortop Bras. [online]. 2020;28(4):159-64. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Dupuytren's disease (DD) is a progressive chronic fibroproliferative disease characterized by contractures in flexion of the fingers.[1] Various techniques such as percutaneous fasciotomy, open limited fasciectomy, dermofasciectomy, and collagenase clostridium histolyticum applications have been described for treating DD.[2-5]

Growing evidence suggests that fat-mediated autologous grafting can treat fibrosis and scarring contractures throughout the body.[6] This action is related to the ability of stem cells to inhibit the proliferation of contractile myofibroblasts, and these effects are mediated by soluble factors influenced by cellular.[6-8]

Hovius et al.[9] were among the first to associate fat grafting with percutaneous fasciotomy in their Extensive Percutaneous

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

The study was conducted at Universidade de São Paulo, Medical School, Hospital das Clínicas, Institute of Orthopedics and Traumatology.
Correspondence: Marina Tommasini Carrara de Sambuy. Rua Dona Adma Jafet, 74, cj 144, São Paulo, SP, Brazil, 01308050. marinacarrara@hotmail.com

Article received on 01/31/2020, approved on 02/10/2020.

Aponeurotomy and Lipografting (PALF) technique. They presented certain cases, in which they performed aponeurotomy in every cord path and then injected the fat graft into the space created between the skin and the sectioned cord, obtaining good results.[7,8]
Considering this scenario, the question arises if fat grafting from autologous lipoaspirate can be beneficial when associated with open limited fasciectomy.
Our study sought to evaluate the functional and goniometry outcomes of patients with DD that underwent open limited fasciectomy using stem cell-rich fat graft and compare these results with those that underwent open limited fasciectomy without the addition of fat graft.

MATERIALS AND METHODS

Between February 2014 and November 2017, 45 DD patients were studied in a simple, prospective, randomized clinical trial. Patients over 40 years of age, both males and females, with Total Passive Extension Deficit (TPED) greater than 30 degrees in the metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints were included. Patients with previous treatment or those with medical conditions that precluded general anesthesia were excluded. All patients were informed about the study and signed an informed consent form. The Ethics Committee for Analysis of Hospital Research Projects duly approved the study.

Flow of participants

In total, 100 patients were evaluated for the treatment of DD at the outpatient clinic between February 2014 and November 2017. However, 45 patients were excluded. Of these, 40 had previous surgery and therefore were considered to have a recurrence, and 5 had no clinical conditions to undergo surgery. Before randomization, 5 patients were excluded – two did not return for evaluation, and 3 refused surgery.
A total of 45 patients were included in the study: 24 were randomly assigned to control group and 26 to fat group. During the study, five patients in fat group were excluded – two abandoned follow-up, and 3 did not undergo the minimum follow-up time of 1 year. Thus, 21 patients were included in fat group.

Randomization

The patients were stratified into four subgroups (I to IV) based on the severity of the disease according to the Tubiana Classification of 1986 (Table 1).[1] Each of the four subgroups were randomized separately to obtain homogeneous groups according to the disease severity. The randomization into two groups was performed by electronic software (Excel for Windows) (Figure 1). In one group (control group), only open limited fasciectomy was performed. In the other group (fat group), limited fasciectomy was performed, and the fat graft was injected at the resected cord site (Figure 1).

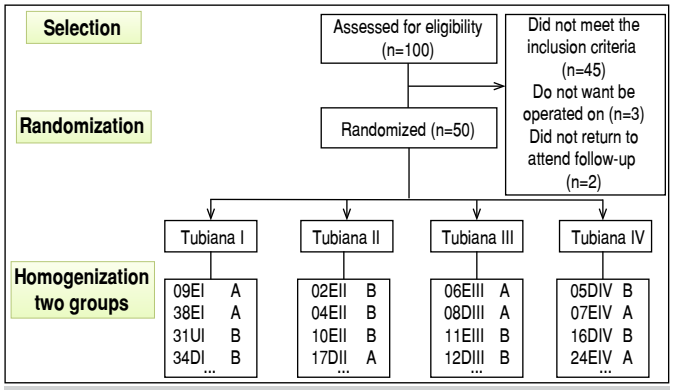

Figure 1. Flow diagram detailing group allocation.

Table 1. Preoperative TPED evaluation of Tubiana classification.

	Groups			
	Control group		Fat group	
Tubiana Stage	N	%	N	%
I (0°-45°)	5	21%	4	19%
II (45°-90°)	10	42%	11	52%
III (90°-135°)	8	33%	4	19%
IV (≥ 135°)	1	4%	2	10%
Total	24	100%	21	100%

TPED (Total Passive Extension Deficit) = Passive Extension Deficit of MF + IFP + IFD

Surgical technique

Patients were subjected to general anesthesia or regional block and sedation, and a pneumatic tourniquet was placed in the arm. All patients underwent open limited fasciectomy after their inclusion on the same protocol of postoperative rehabilitation by the hand therapy team. The protocol involved early mobilization and splinting in extension during the night for 6 weeks.

Open limited fasciectomy

A Brunner-type incision was performed, followed by dissection of the subcutaneous tissue and the cord in the palmar region and finger if necessary. The neurovascular bundle was identified and protected, ensuring its preservation throughout the procedure. The cord was sectioned in its palmar origin followed by its resection in the distal direction until the complete extension of the finger (Figure 2). The tourniquet was released, and hemostasis was carefully performed. The skin was then closed with single stitches (Figure 2). At this time, the surgeon was informed of the group to which the patient was allocated (randomization). If the patient belonged to the control group, a bandage dressing was applied, and the procedure was complete (Figure 2). If the patient belonged to the fat group, harvesting and grafting were performed. Thus, the patients in both groups underwent exactly the same operative technique.

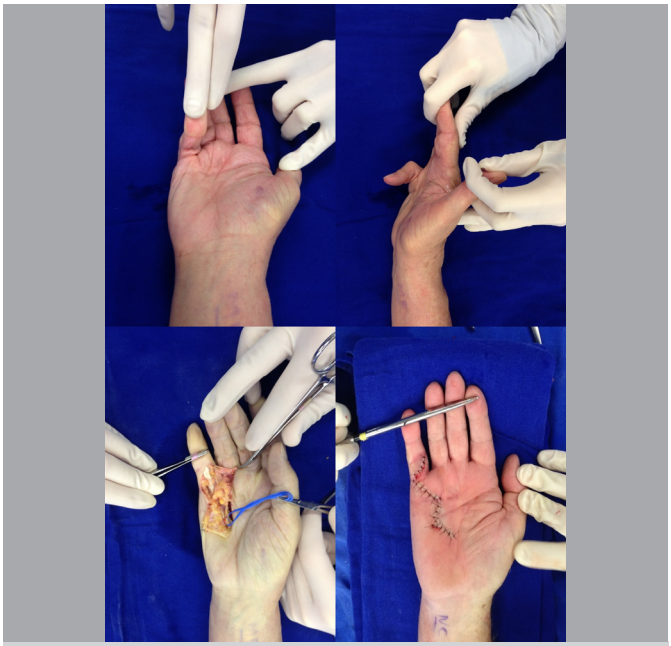

Figure 2. Open limited fasciectomy. (Upper pictures), preoperative clinical aspect demonstrating contracture of the 5th finger, anterior view and profile view; (lower left), intraoperative clinical aspect; (lower right), clinical aspect after skin closure demonstrating complete extension of the finger.

All patients were night splinted for 6 weeks and ultimately participated in approximately 10 sessions of hand therapy. However, patients that experienced CRPS as complication required a different approach by the hand therapy team.

Harvesting and infiltration of autologous lipoaspirate

A small 5-mm incision was made in the periumbilical abdominal region according to the classic technique of liposuction with 1.5 mm thick fine microcannula (Coleman™ Microcannula). The microcannula aspirator coupled to a 20 ml syringe was introduced into the adipose layer via back-and-forth movements, and the fat was released and aspirated.[10,11] Lipoaspiration resulted in 10 ml of autologous fat graft. The contents were placed in properly capped syringes and then transported to a specific centrifuge to be processed. The lipoaspirate was processed in the centrifuge for 3 minutes at 3,000 rpm and 756 of G force. The supernatant was discarded, leaving the viable adipocytes among other components. Five milliliters of purified lipoaspirate were introduced into a sterile syringe and injected through a microcannula between the skin and the deep planes. Lipoaspirate was slowly injected with no pressure as a longitudinal single track of the resected cord, forming a "micro-ribbon" of 1.5 mm, which is consistent with the ideal circumstances for adipocyte survival.[12] The final dressing was performed with the same type of packing as the control group (Figure 3).

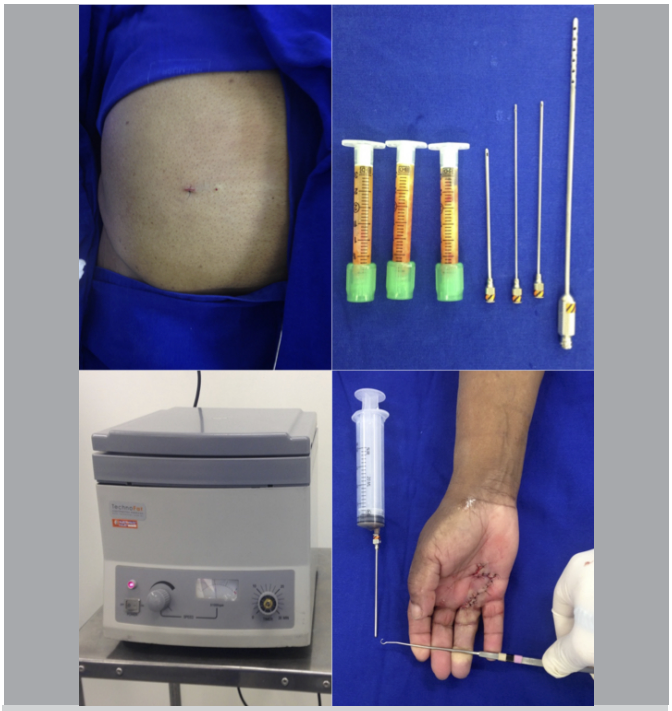

Figure 3. Process of liposuction of fat with thin cannulas. (Upper left), abdomen incision where the liposuction was performed; (upper right), aspirating microcannulas with fat; (bottom left), fat centrifuging; (lower right), fat already injected into the space previously occupied by the cord.

Outcomes and measures

The outcomes were assessed by TPED, the visual analogue scale (VAS) values (from 0, no pain up to 10, worst pain), and the Brief Michigan Hand Questionnaire (BMHQ) functional score, that addresses specifically hand function.[13]
We guaranteed the "blind" evaluation of the results performed by hand therapists in the rehabilitation Department of Hand Therapy, separate from the outpatient clinic. The evaluators assigned to the functional questionnaire and the goniometric measurement were not aware of the group to which the patient belonged. Only the surgeon was aware of this detail. We used the online data storage tool REDCap®, which was developed for scientific research and allows the safe storage of information and online filling by different researchers.[14] Each researcher had a personal login and password, and every change was recorded.
We used only the worst ray measurements of each hand to avoid confounding the data.

Complications

The collected data regarding possible complications were infection, nerve damage, tendon injury, operative wound dehiscence, hematoma, and CRPS. The medical team performed weekly or biweekly returns in the postoperative period until the skin healed.

Estimated sample calculation

The primary outcome was TPED of the most contracted finger measured with a goniometer in total passive extension at the 1-year follow-up consult. The considered effect size was a difference of 25 ± 35 degrees of the standard deviation based on the first twenty cases that underwent surgery (10 for each group). We selected a sample of 31 cases for each group based on a 0.05 alpha error and a 0.20 beta error.

Statistical analysis

Baseline data were analyzed to verify if the groups were homogeneous concerning the stratification and randomization process. For analysis of inferential statistics, the Kolmogorov-Smirnov normality test was performed for continuous data to observe the distribution of the sample data. Statistical significance was considered for $p < 0.05$. We used the Wilcoxon-Mann-Whitney test, since the data presented a non-parametric distribution, and the chi-square test, for the analysis of complications. Some missing data were imputed on the final table by calculating the percentage of improvement of the group being analyzed given that they were considered as random losses (Missing at Random) of a group that follows the same pattern. Data analysis was performed using SPSS software version 20.0.

RESULTS

Intrinsic patient variables

The groups were homogeneous regarding the degree of contracture as evaluated by the Tubiana classification (Table 1).
The patients' ages ranged from 49 to 85 years, with an average age of 66 years (Table 2). No significant difference was noted between the two groups regarding the incidence of comorbidities.

Table 2. Intrinsic patient variables and categorical data.

		Groups				
		Control group		Fat group		p
		N	%	N	%	
Gender	Male	20	83%	14	67%	
	Female	4	17%	7	33%	
	Total	24	100%	21	100%	0.176
Dominant side	Yes	13	54%	7	33%	
	No	11	46%	14	67%	
	Total	24	100%	21	100%	0.212
Presence of nodules	Yes	23	96%	19	90%	
	No	1	4%	2	10%	
	Total	24	100%	21	100%	0.592
Presence of cords	Yes	24	100%	19	90%	
	No	0	0%	2	10%	
	Total	24	100%	21	100%	0.212

Analysis of outcomes

Visual analogue pain scale

We used the median to compare the data between the groups, since the results did not follow the normality curve. The median preoperative VAS score was 2 in the control group and 5 in the fat group with no significant difference ($p = 0.616$). At 6 weeks postoperatively, both groups presented pain relief compared to preoperative values; however, VAS score values in the fat group postoperatively were significantly higher than control group ($p = 0.045$). The patients did not refer to pain in the fat donor site. Comparison of the groups at the 6-month and 1-year follow-up showed no statistically significant differences ($p = 0.487$, $p = 0.864$ and $p = 0.290$, respectively) (Table 3).

Table 3. Evaluation of pain level according to VAS during follow-up.

	N	Median	Minimum	Maximum	*p*
Pre-Operative					
Control	24	2	0	9	0.616
With fat	21	5	0	9	
6 weeks					
Control	24	0	0	5	0.045*
With fat	21	2	0	9	
6 months					
Control	24	0	0	5	0.487
With fat	21	0	0	9	
1 year					
Control	24	0	0	5	0.864
With fat	21	0	0	9	

N: number of patients; *p*: level of significance; *: statistical significance ($p < 0.05$).

TPED analysis

TPED analysis results for the two groups showed no significant difference (Table 4, Figure 4). We assume as recurrence criterion a loss greater than or equal to 30 degrees when compared with postoperative measurements.[4]

Table 4. Results of the measurement of TPED during the follow-up.

	N	Median	Minimum	Maximum	*p*
Pre-operative					
Control	24	77.50	35	150	0.784
With Fat	21	75.00	25	155	
6 weeks					
Control	24	15.00	0	55	0.198
With Fat	21	25	0	65	
6 months					
Control	24	10.00	0	45	0.101
With Fat	21	15.00	0	130	
1 year					
Control	24	10.00	0	60	0.151
With Fat	21	25.00	0	135	

N: number of patients; *p*: level of significance.

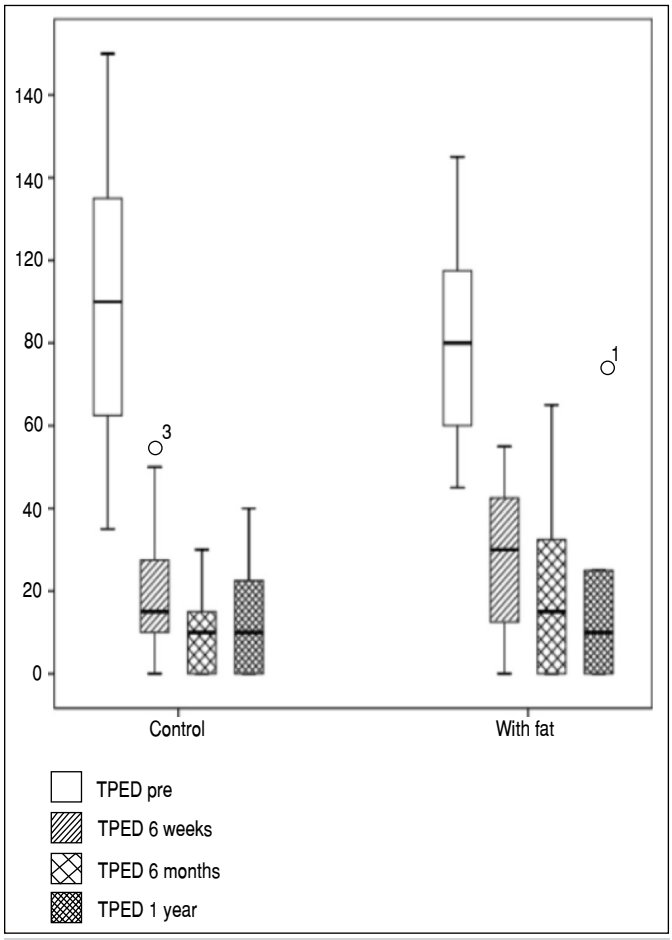

Figure 4. Results of the TPED measurement during the follow-up.

Analysis of the BMHQ score

The median BMHQ score in the preoperative period was 55.20 in the control group and 60.41 in the fat group, and the result was not statistically significant ($p = 0.241$). At the 6-month and 1-year evaluation, significant differences were noted between the groups ($p = 0.040$ and 0.048, respectively). After 6 months postoperatively, the medians were 92.70 in the control group and 83.33 in the fat group. In comparison, the medians observed at 1-year postoperatively were 91.28 in the control group and 87.50 in the fat group. The results are shown in Table 5 and Figure 5.

Table 5. BMHQ score results during follow-up.

	N	Median	Minimum	Maximum	*p*
Pre-operative					
Control	24	55.20	11.13	89.58	0.241
With Fat	21	60.41	27.08	89.58	
6 weeks					
Control	24	79.16	43.75	97.91	0.121
With Fat	21	23.66	22.72	100.00	
6 months					
Control	24	92.70	50.00	100.00	0.040*
With Fat	21	83.33	25.00	100.00	
1 year					
Control	24	91.28	64.58	100.00	0.047*
With Fat	21	87.50	43.75	96.03	

N: number of patients; *p*: level of significance; *: statistical significance ($p < 0.05$).

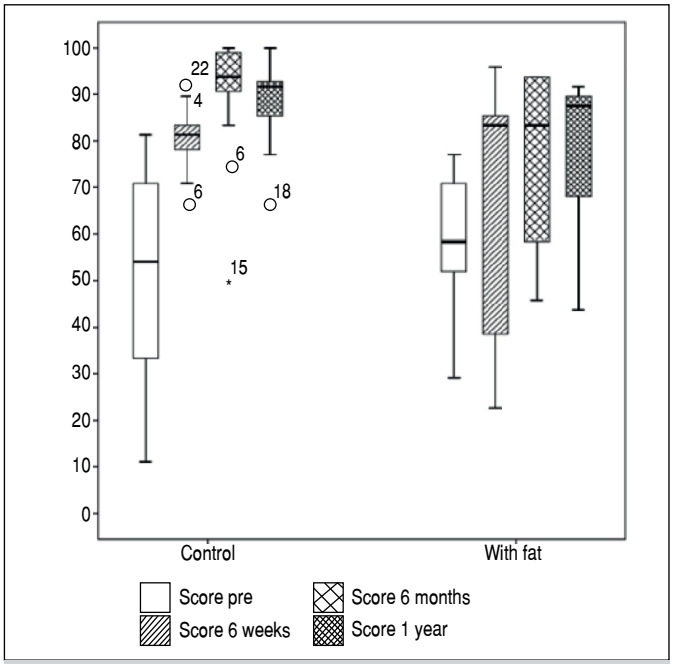

Figure 5. BMHQ score results during follow-up.

Complications

Complications were observed in 11 patients. Two patients had more than one occurrence. One patient presented infection and dehiscence of the surgical wound, and the other had digital nerve injury and CRPS. The following complications were observed: one case of infection, one case of hematoma, one case of hypertrophic scar, three cases of dehiscence, and five cases of CRPS (Table 6, Figure 6).

Table 6. Postoperative complications during follow-up.

	Groups				
	Control group		Fat group		*p*
Intercurrences	N	%	N	%	
Infection	0	0%	1	5%	
Dehiscence	1	4%	2	10%	
Hematoma	0	0%	1	5%	
CRPS	1	4%	4	19%	
Hypertrophic scar	0	0%	1	5%	
Total	2	8%	9	43%	0.019

N: number of patients; *p*: level of significance.

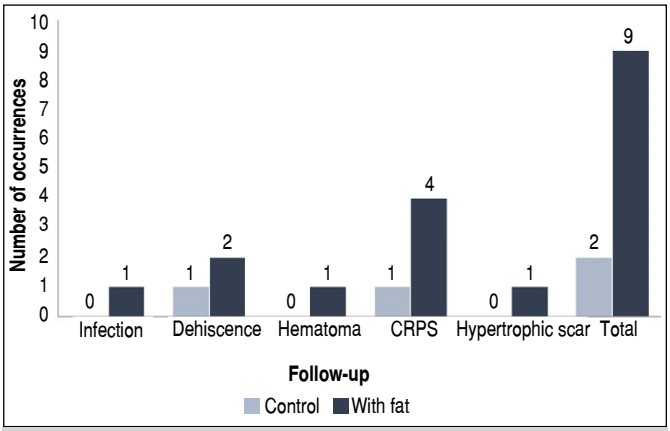

Figure 6. Postoperative complications during follow-up.

Control group had one case of dehiscence and one of CRPS. Fat group had one case of infection, one case of hematoma, one case of hypertrophic scar, two cases of dehiscence, and four cases of CRPS. Of the patients with CRPS, four were type I or "classic" CRPS and one was type II, which involves identifiable peripheral nerve injury (causalgia) due to intraoperative digital nerve injury

DISCUSSION

The benefits of adipose tissue rich in stem cells in the treatment of cicatricial contractures are described in several articles.[6-9,15] These benefits are related to the inhibition of myofibroblasts and the restoration of subcutaneous atrophy by fat graft.[16]

However, there is no evidence of these benefits in the treatment of DD. Studies have assessed fat grafting in the treatment of DD after an extensive percutaneous aponeurotomy and ultimately demonstrated benefits with the association of fat graft.[7-9]

Kan et al.[16] were the first to compare the technique of extensive percutaneous aponeurotomy followed by fat filling with the conventional technique of open limited fasciectomy. The authors obtained similar results among the techniques, but reduced complication and faster return to work were noted in the group in which fat was used.[16] However, no randomized clinical trials that use one surgical technique for all of the patients and associate fat in a group to evaluate its action alone have been performed prior to this study. We consider that the use of fat grafting is essential and should be treated as a single variable; thus, all the patients underwent a standard surgical procedure in our study.

To specifically analyze the effect of fat grafting, we compared two groups (with and without fat) using the conventional technique of open limited fasciectomy.

Our findings showed statistically significant differences between the groups. We observed worse results in the functional BMHQ score at 6 months and 1 year postoperatively in the fat group ($p = 0.040$ and $p = 0.047$, respectively) (Table 5, Figure 5).

The fat group had a significant increase in pain on the VAS scale at 6 weeks postoperatively [median 2 versus 0 in the control group ($p = 0.045$)].

We also observed 9 cases (43%) of complications in the fat group and 2 (8%) in the control group; a statistically significant difference was observed between the groups by the Chi-square test ($p = 0.019$). Among them, five cases were CRPS: four in the fat group (19%) and 1 in the control group (4%). Fat group had one case of nerve injury that may influence the results. We chose not to exclude it due to the importance of showing all negative results.

The incidence of complications following the technique of open limited fasciectomy is typically increased when compared with percutaneous techniques, especially for CRPS, ranging from 1.3% to 13%.[5,17] However, increased rates were noted in the fat group: a total of 43% with complications and 19% of these with CRPS.

Five patients belonging to the fat group were excluded during the study. Three did not return for the final evaluation, one presented CRPS and wanted to leave the study, and the fifth did not return. These cases would possibly contribute to the worsening of the fat group results. The remaining patients did not complete the minimum follow-up time of 1 year.

We believe that the decrease in the BMHQ functional score and the increase in pain at 6 weeks postoperatively in the fat group are due to the high complication rates in this group, in which some individuals shifted the median lower. The worst results found in the fat group differed from the results of previous studies that used fat grafts in the treatment of DD.[7-9,16,18] However, those studies used different surgical techniques between the groups, namely, extensive percutaneous aponeurotomy and fat grafting, and did not used the same technique for the control group. Thus, the reported benefits

could not be exclusively attributed to the action of fat or simply the technique of extensive percutaneous aponeurotomy.

Grafting fat into a larger space (fasciectomy) may compromise neovascularization of part of the fat grafted. However, tissues beneath a resected cord have constant and rich vascularization. Moreover, fat grafting is extensively used in aesthetic and reconstructive plastic surgery, even with larger cannulas (4 mm) without compromising the viability of the fat grafted.

We believe it is important to point out the effects of fat injection based on the adopted surgical technique. Further experimental and clinical studies may demonstrate the physiological mechanisms involved that could explain our results.

Perhaps, surgical aggression associated with fat graft promoted more local inflammatory reaction. However, there are no histological elements in our study to prove this hypothesis.

We found that fat grafting did not confer benefits when compared with the control group when associated with open limited fasciectomy in the short term (1 year postoperatively). However, questions remain regarding the long-term results and if the stem cells exist in the fat graft could interfere with the recurrence of the disease in the future.

One of the limitations of our study is the short follow-up time of 1 year for the evaluation of postoperative recurrence. For a better understanding of the outcomes of this technique, a longer follow-up period would be necessary.

CONCLUSION

The use of the fat graft associated with open limited fasciectomy in the treatment of DD promoted worse results when compared with conventional open limited fasciectomy in a short-term study regarding functional results and complications. Longer follow-up is required to evaluate the fat graft effect on recurrence of the disease.

ACKNOWLEDGEMENTS

The authors acknowledge Mr. Prof. Doctor Marcelo R. Rezende and Mr. Doctor Teng H. Wei, Head of the Hand and Microsurgery Division, respectively, of the Orthopedic and Traumatology Department, University of São Paulo, São Paulo, Brazil, for all support. The authors thanks all the participants involved in this study, including research patients.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. MTCS: substantial contribution in the study conception or design, or acquisition, analysis or interpretation of data to the study and writing the article or critically reviewing its intellectual content; HAN: writing the article or critically reviewing its intellectual content; RBN: substantial contribution in the study conception or design, or acquisition, analysis or interpretation of data to the study; RMJ: approval of the final version of the manuscript to be submitted for publication; MRR: approval of the final version of the manuscript to be submitted for publication; THW: approval of the final version of the manuscript to be submitted for publication.

REFERENCES

1. Hurst LH. Dupuytren's contracture. In: Wolf FW, Hotchkiss RN, Pederson WC, Kozin SH, Cohen MS, editors. Green's operative hand surgery. Philadelphia: Elsevier; 2010. p. 141-58.
2. Hurst LC, Badalamente MA, Hentz VR, Hotchkiss RN, Kaplan FT, Meals RA, et al. Injectable collagenase clostridium histolyticum for Dupuytren's contracture. N Engl J Med. 2009;361(10):968-79.
3. Tubiana R. Evaluation of deformities in Dupuytren's disease. Ann Chir Main. 1986;5(1):5-11.
4. van Rijssen AL, Gerbrandy FS, Ter Linden H, Klip H, Werker PM. A comparison of the direct outcomes of percutaneous needle fasciotomy and limited fasciectomy for Dupuytren's disease: a 6-week follow-up study. J Hand Surg Am. 2006;31(5):717-25.
5. van Rijssen AL, Werker PM. Percutaneous needle fasciotomy in Dupuytren's disease. J Hand Surg Br. 2006;31(5):498-501.
6. Pu LL, Yoshimura K, Coleman SR. Future perspectives of fat grafting. Clin Plast Surg. 2015;42(3):389-94.
7. Khouri RK, Smit JM, Cardoso E, Pallua N, Lantieri L, Mathijssen IM, et al. Percutaneous aponeurotomy and lipofilling: a regenerative alternative to flap reconstruction? Plast Reconstr Surg. 2013;132(5):1280-90.
8. Verhoekx JS, Mudera V, Walbeehm ET, Hovius SE. Adipose-derived stem cells inhibit the contractile myofibroblast in Dupuytren's disease. Plast Reconstr Surg. 2013;132(5):1139-48.
9. Hovius SE, Kan HJ, Smit X, Selles RW, Cardoso E, Khouri RK. Extensive percutaneous aponeurotomy and lipografting: a new treatment for Dupuytren disease. Plast Reconstr Surg. 2011;128(1):221-8.
10. Coleman SR. Long-term survival of fat transplants: controlled demonstrations. Aesthetic Plast Surg. 1995;19(5):421-5.
11. Coleman SR. Structural fat grafting: more than a permanent filler. Plast Reconstr Surg. 2006;118(3 Suppl):108S-20S.
12. Khouri RK Jr, Khouri RK. Current clinical applications of fat grafting. Plast Reconstr Surg. 2017;140(3):466e-86e.
13. Fernandes CH, Raduan Neto J, Meirelles LM, Pereira CN, Santos JBG, Faloppa F. Translation and cultural adaptation of the Brief Michigan Hand Questionnaire to Brazilian Portuguese language. Hand (N Y). 2014;9(3):370-4.
14. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81.
15. Hovius SE, Kan HJ, Verhoekx JS, Khouri RK. Percutaneous aponeurotomy and lipofilling (PALF): a regenerative approach to Dupuytren contracture. Clin Plast Surg. 2015;42(3):375-81.
16. Kan HJ, Selles RW, van Nieuwenhoven CA, Zhou C, Khouri RK, Hovius SE. Percutaneous aponeurotomy and lipofilling (PALF) versus limited fasciectomy in patients with primary Dupuytren's contracture: a prospective, randomized, controlled trial. Plast Reconstr Surg. 2016;137(6):1800-12.
17. Cheung K, Walley KC, Rozental TD. Management of complications of Dupuytren contracture. Hand Clin. 2015;31(2):345-54.
18. Harden RN, Bruehl S, Stanton-Hicks M, Wilson PR. Proposed new diagnostic criteria for complex regional pain syndrome. Pain Med. 2007;8(4):326-31.

DOI: http://dx.doi.org/10.1590/1413-785220202804233021
ORIGINAL ARTICLE

GRACILIS MUSCLE TRANSFER TO ELBOW FLEXION IN BRACHIAL PLEXUS INJURIES

TRANSFERÊNCIA DO MÚSCULO GRÁCIL PARA FLEXÃO DO COTOVELO NAS LESÕES DO PLEXO BRAQUIAL

Gustavo Bersani Silva[1], *Maurício Rodrigues Lima Neto*[1], *Alvaro Baik Cho*[1], *Raquel Bernardelli Iamaguchi*[1], *Marcelo Rosa de Resende*[1], *Teng Hsiang Wei*[1]

1. Universidade de São Paulo, Medical School, Hospital das Clínicas, Institute of Orthopedics and Traumatology, São Paulo, SP, Brazil.

ABSTRACT

Objective: Brachial plexus injury can lead to significant functional deficit for the patient. Elbow flexion restoration is a priority in surgical treatment. Free functional muscle transfer is an option for early or late treatment failure. This study evaluated patient characteristics and elbow flexion muscle strength after gracilis functioning muscle transfer. Methods: Medical records of 95 patients operated from 2003 to 2019 were analyzed and the following variables recorded: age, gender, nerve transfer used to motorize the gracilis muscle, time between trauma and surgery, age at surgery and elbow flexion strength after a minimum of 12 months following functioning muscle transfer. Results: 87 patients were included, averaging 30 years of age (17 to 57 years). Fifty-five achieved elbow flexion muscle strength ≥ M3 (55/87, 65%), with a mean follow-up of 37 months. The nerves used for activation of the transferred gracilis were: 45 spinal accessory, 10 intercostal, 8 median n. fascicles, 22 ulnar n. fascicles and 2 phrenic nerves. Conclusion: Functional muscle transfer is a viable surgical procedure for elbow flexion in chronic traumatic brachial plexus injuries in adults. ***Level of Evidence II, Retrospective study.***

Keywords: Surgical flaps. Microsurgery. Brachial Plexus.

RESUMO

Objetivo: A lesão do plexo braquial pode determinar sequelas para o paciente. A restituição da flexão do cotovelo é prioridade no tratamento cirúrgico. A transferência muscular funcional livre é opção na falha do tratamento precoce ou tardio. Este estudo avaliou características dos pacientes e força muscular de flexão do cotovelo após transferência muscular funcional livre. Métodos: Prontuários de 95 pacientes, operados de 2003 a 2019, foram analisados e as seguintes variáveis registradas: idade, sexo, transferência nervosa utilizada para motorizar o músculo grácil, tempo entre o trauma e a cirurgia, idade na cirurgia, força de flexão do cotovelo após prazo mínimo de 12 meses da transferência muscular livre. Resultados: 87 pacientes foram incluídos no estudo, com idade média de 30 anos (17 a 57 anos). Cinquenta e cinco pacientes obtiveram força muscular de flexão de cotovelo ≥ M3 (55/87, 65%), com tempo de seguimento médio pós-operatório de 37 meses. Os nervos utilizados para ativação do músculo grácil foram: 45 espinhais acessórios, 10 intercostais, oito fascículos do n. mediano, 22 fascículos do n. ulnar e dois frênicos. Conclusão: A transferência muscular funcional livre é um procedimento cirúrgico viável para flexão do cotovelo nas lesões traumáticas crônicas do plexo braquial no adulto. ***Nível de Evidência II, Estudo retrospectivo.***

Descritores: *Retalhos Cirúrgicos. Microcirurgia. Plexo Braquial.*

Citation: Silva GB, Lima Neto MR, Cho AB, Iamaguchi RB, Resende MR, Wei TH. Gracilis muscle transfer for elbow flexion in brachial plexus injuries. Acta Ortop Bras. [online]. 2020;28(4):165-7. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Traumatic injury of the brachial plexus has gained special attention from the scientific community in recent decades, not only for being a devastating pathology, but also because its treatment imposes remarkable challenges on the professional involved.[1] Notably, elbow flexion deficit represents a frequent problem for most patients with brachial plexus injury, with its reestablishment being the primary objective of treatment.[2]

Graft reconstructions and nerve transfers for elbow flexion are the preferred approach in early treated brachial plexus injuries.[3] However, patients evaluated late (trauma-surgery interval above 12-18 months) show degeneration of the neuro-muscular junction of the upper limb muscles, an irreversible change that precludes reconstructions and nerve transfers to this musculature.[4] When treatment is delayed or the surgical treatment fails in the acute phase – and there are no muscles strong enough for muscle transfer – the alternative to recover elbow flexion is free functional

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

The study was conducted at Universidade de São Paulo, Medical School, Hospital das Clínicas (HC-FMUSP), Institute of Orthopedics and Traumatology.
Correspondence: Maurício Rodrigues Lima Neto. Rua Dr. Ovídio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil, 05403010. mauriciolimaneto@hotmail.com

Article received on 01/15/2020, approved on 02/10/2020

muscle transplant with intraplexual or extra-plexual nerve transfer, depending on the severity of the brachial plexus injury.[4-5]
Opting for free functional muscle transfer, a donor motor nerve for the transferred muscle must be selected. Total brachial plexus injuries commonly uses the accessory nerve and the intercostal nerves. For high partial injuries, in addition to these nerves, motor fascicles of the median nerve or ulnar nerve can also be transferred.[6] Currently, the free gracilis flap is the most popular choice for elbow flexion reconstruction – a thin muscle with adequate strength and excursion, reliable neurovascular pedicle, easy dissection, resulting in little functional loss of the lower limb.[7]
This study aimed to describe the patients' characteristics and the results of free gracilis muscle transfer to elbow flexion in chronic brachial plexus injuries in adults, after evaluating 87 consecutive cases performed at a university hospital.

MATERIALS AND METHODS

The study began after the formal authorization granted by the institution's and Plataforma Brasil Research Ethics Committee under CAAE 52633015.0.0000.0068 and after all patients have signed the informed consent form.
Between February 2003 and December 2019, 95 patients with traumatic brachial plexus injury underwent free transfer of the gracilis muscle to recover elbow flexion.
The following variables were retrospectively collected by medical records analysis: age, gender, trauma mechanism, injury laterality, injury level, nerve transfer used to motorize the gracilis muscle, interval between trauma and surgical procedure, patient's age during surgery, elbow flexion strength after a minimum of 12 months of free muscle transfer, relevant observations (complications, secondary surgeries, associated trauma, etc.).
The inclusion criteria for the study were: patients older than 18 years of age who received a functioning gracilis muscle flap for elbow flexion reconstruction following post-traumatic brachial plexus injury. Patients with failed free gracilis flap or having less than 12 months of postoperative follow-up at the time of evaluation were excluded. Results after secondary surgery (e.g., Steindler and distal retensioning of the gracilis muscle insertion) were discarded. Patients subjected to secondary surgeries were included considering only the results after free transfer from gracilis muscle, that is, before additional surgeries.
Two patients were excluded due to loss of the transferred free muscle (2/95; 2%), one after venous thrombosis of the flap and one due to infection. Six other patients were excluded due to total postoperative follow-up of less than 12 months, totaling 87 patients included in the study.
Patients were divided into five groups according to the transferred nerve for activating the functional flap of the gracilis muscle: spinal accessory nerve (SAN), intercostal nerves (ICN), median nerve fascicle (MED), ulnar nerve fascicle (ULNAR) and phrenic nerve (PHR).
The final elbow flexion muscle strength was assessed using the British Medical Research Council (BMRC) scale[8] (Table 1). Considering that a patient undergoing a free functional flap has no normal muscle strength, the authors classified the research subjects from M0 to M4, deeming a good result M3 or more.

Table 1. British Medical Research Council (BMRC) Scale.[8]

Degree of muscle strength	
M0	No muscle contraction
M1	Muscle contraction not resulting in joint movement
M2	Muscle contraction with movement excluding gravity
M3	Muscle contraction effective against gravity but does not overcome resistance.
M4	Muscle contraction that overcomes some resistance
M5	Normal muscle strength

RESULTS

Of the 87 cases included in the analysis, 82 patients were male (94.2%) and 5 females (5.8%). The mean age was 30 years (ranging from 17 to 57 years). Of the 87 patients, 48 showed left laterality (55.1%) and 39 right laterality (44.9%). Regarding injury characteristics, 42 patients had partial injury (48.2%), 20 C5-6 injury (47%) and 22 C5-7 (53%), in addition to 45 presenting total injury (51.8%).
Evaluating trauma mechanisms, we found 75 motorcycle accidents (86%), five hit-and-run (5%), two car accidents (3%), two bicycle accidents (3%) and two physical aggressions (3%).
The mean interval between accident and surgery was 79 months (ranging from 8 to 1311 months). The mean follow-up time was 37 months (ranging from 13 to 154 months).
Regarding functional strength, 55 cases had muscle strength ≥ M3 (65%): eight M0 (9%), nine M1 (10%), 15 M2 (17%), 30 M3 (35%) and 25 M4 (29%).
The nerve transfers that activated free functional muscle flaps were: 45 spinal accessory nerve transfers (four using sural nerve graft and 41 cases without grafting), 10 intercostal nerves (three with graft and seven without), eight median nerve fascicles, 22 ulnar nerve fascicles and two phrenic nerves.
Table 2 summarizes the results of the different donor nerve transfers to the functional muscle flap.

Table 2. Results per transferred nerve.

	Overall	SAN	ICN	MED	ULNAR	PHR
Good Result (≥ M3)	**55/87 (65%)**	**33/45 (73.3%)**	**6/10 (60.0%)**	**2/8 (25.0%)**	**13/22 (59.0%)**	**1/2 (50%)**
M0	8/87 (9%)	3/45 (6.5%)	3/10 (30.0%)	0/8 (0.0%)	1/22 (4.5%)	1/2 (50.0%)
M1	9/87 (10%)	4/45 (9.0%)	0/10 (0.0%)	2/8 (25.0%)	3/22 (13.6%)	
M2	15/87 (17%)	5/45 (11.0%)	1/10 (10.0%)	4/8 (50.0%)	5/22 (22.8%)	
M3	30/87 (35%)	22/45 (49.0%)	3/10 (30.0%)	1/8 (12.5%)	3/22 (13.6%)	1/2 (50.0%)
M4	25/87 (29%)	11/45 (24.5%)	3/10 (30.0%)	1/8 (12.5%)	10/22 (45.5%)	

SAN: spinal accessory nerve; ICN: intercostal nerves; MED: median nerve. ULNAR: ulnar nerve; PHR: phrenic nerve.

The complications of the viable flaps were: four re-explorations – three for loss of the skin monitor with the viable flap and one compressed pedicle by hematoma – and four infections (two from the recipient site and one from the donor site), totaling 9.2%.
The secondary surgeries were: eight proximal transfers of the flexo-pronator muscles (Steindler surgery) – five cases going from M2 to M4, two cases from M3 to M4, and one case that from M1 performed triceps to biceps transfer and after Steindler obtained final result of M4 – and one case of distal retensioning of the gracilis muscle insertion in the biceps tendon (without functional gain).
Twelve patients who received free functional muscle transfer had previously undergone unsuccessful exploration and reconstruction of the brachial plexus (four graft reconstructions and eight nerve transfers).

DISCUSSION

This study reinforces the current understanding that traumatic brachial plexus injury primarily affects young men victimized in motorcycle accidents: 94.2% of the patients were male, with a mean age of 30 years. Flores[9] and Anjos[10] evaluated the victims of motorcycle accidents in different Brazilian states, concluding that they are basically young males. Brachial plexus injury represents a

major impact on these victims' lives[10] due to the long treatment time and permanent functional deficit that it imposes on the injured. We believe that these demographic and natural history characteristics justify all efforts to try to restore the affected limb, even if partially. Based on Dyck et al.,[11] we used the British Medical Research Council (BMRC) scale to assess elbow flexion muscle strength. According to Bengtson et al.,[12] about three quarters of the publications that evaluate brachial plexus use this scale, being a simple and well-established method. An opinion shared by Bhardwaj et al.,[13] who state that this scale is the most popular to assess the return of elbow flexion, but alerting to the variances in inter-observer interpretation of the BMRC grading.

Ikuta et al.[14] were the first to describe free functioning muscle transfer connected to intercostal nerves for elbow flexion reconstruction, with their initial report being followed by numerous publications that selected different nerve donor sources.[10,15] Chung et al.[16] reported free gracilis muscle transfer to elbow flexion using intercostal nerves as the donor, with 78% of patients reaching flexion strength M4 or higher; Krakauer et al.[15] reported M3 or more in three of their four patients (75%) while Chuang et al.,[17] studied 16 cases and 81.2% achieved M3 or more elbow flexion strength. Success rate (≥ M3) of the present study (60%, 6/10) after intercostal nerve transfer to the transplanted gracilis was slightly lower than previously reported. Barrie et al.[18] reviewed 26 patients who underwent free transfer of the gracilis muscle, with intercostal nerves or spinal accessory nerve as the donors, and reported functional elbow flexion in 63% of cases. Kay et al.[19] studied 33 functioning transfers of the gracilis muscle, most of which were attached to intercostal nerves (15 cases) or ulnar nerve fascicles (12 cases) with an overall success rate (≥ M3) of 70%; when only adults were included, this rate reached 53%. Intercostal nerves group yielded better results regarding elbow flexion strength. In the present study the overall good results (≥ M3) reached 65% while ulnar nerve fascicles transfer group achieved a success rate of 59%, similar to the intercostal nerves group (60%).

Sungpet et al.[20] assessed the result of free gracilis transfer to elbow flexion in three patients with high brachial plexus injury (C5/C6), using an ulnar nerve fascicle as donor nerve. After a 33-month follow-up, an average elbow flexion muscle strength of 4.3 kg was observed. The authors reported no loss of hand grip strength or wrist flexion, as well as no change in sensitivity. The advantages of using the ulnar nerve as a donor are highlighted, being easy to perform, avoiding the use of nerve grafts and enabling voluntary control of elbow flexion. The authors of the present study report similar outcomes as ulnar nerve transfer proved to be a reliable procedure, with satisfactory results and no sensory-motor deficit of the donor nerve. Limitations of this study were its retrospective nature and the qualitative assessment of elbow flexion strength (even though the BMRC scale is vastly used in the literature). Likewise, the limited number of patients operated on in some groups (median, intercostal, and phrenic) hinder in-depth group comparison. Data from handwritten medical records was eventually challenging to interpret. The patients' individual effort during assessment and rehabilitation may impact the results.

Limitations of this study were its retrospective nature and the qualitative assessment of elbow flexion strength (even though the BMRC scale is vastly used in the literature). Likewise, the limited number of patients operated on in some groups (median, intercostal, and phrenic) hinder in-depth group comparison. Data from handwritten medical records was eventually challenging to interpret. The patients' individual effort during assessment and rehabilitation may impact the results.

CONCLUSION

The free functioning transfer of the gracilis muscle for traumatic brachial plexus injuries is a reliable surgical technique for gaining elbow flexion in adults. Further studies are needed to elucidate the role of accessory, intercostal, median, ulnar, and phrenic nerves in activating functional muscle flaps for upper limb reconstruction.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. GBS: writing of the article; MRLN: data collection; ABC: study design; RBI: data analysis; MRR: project review; THW: intellectual concept and article review.

REFERENCES

1. Narakas AO. The treatment of brachial plexus injuries. Int Orthop. 1985;9(1):29-36.
2. Coulet B, Boch C, Boretto J, Lazerges C, Chammas M. Free Gracilis muscle transfer to restore elbow flexion in brachial plexus injuries. Orthop Traumatol Surg Res. 2011;97(8):785-92.
3. Teboul F, Kakkar R, Ameur N, Beaulieu JY, Oberlin C. Transfer of fascicles from the ulnar nerve to the nerve to the biceps in the treatment of upper brachial plexus palsy. J Bone Joint Surg Am. 2004;86(7):1485-90.
4. Bishop AT. Functioning free-muscle transfer for brachial plexus injury. Hand Clin. 2005;21(1):91-102.
5. Kimura LK, Nascimento AT, Capócio R, Mattar R Jr, Rezende MR, Wei TH, et al. Microsurgical transfer of the gracilis muscle for elbow flexion in brachial plexus injury in adults: retrospective study of eight cases. Rev Bras Ortop. 2011;46(5):534-9.
6. Chin K, Vasdeki D, Hart A. Inverted free functional gracilis muscle transfer for the restoration of elbow flexion. J Plast Reconstr Aesthet Surg. 2013;66(1):144-6.
7. Manktelow RT, Zuker RM. The principles of functioning muscle transplantation: applications to the upper arm. Ann Plast Surg. 1989;22(4):275-82.
8. Medical Research Council. Aids to the examination of the peripheral nervous system, Memorandum No. 45. London: Her Majesty's Stationery Office; 1981.
9. Flores LP. Epidemiological study of the traumatic brachial plexus injuries in adults. Arq Neuropsiquiatr. 2006;64(1):88-94.
10. Anjos KC. Implicações sociais e econômicas nos pacientes vítimas de acidentes com motocicleta internados no IOT-HCFMUSP [master's thesis]. São Paulo: Universidade de São Paulo; 2012.
11. Dyck PJ, Boes CJ, Mulder D, Millikan C, Windebank AJ, Dyck PJ, et al. History of standard scoring, notation, and summation of neuromuscular signs: a current survey and recommendation. J Peripher Nerv Syst. 2005;10(2):158-73.
12. Bengtson KA, Spinner RJ, Bishop AT, Kaufman KR, Coleman-Wood K, Kircher MF, et al. Measuring outcomes in adult brachial plexus reconstruction. Hand Clin. 2008;24(4):401-15.
13. Bhardwaj P, Bhardwaj N. Motor grading of elbow flexion – is Medical Research Council grading good enough? J Brachial Plex Peripher Nerve Inj. 2009;4:3.
14. Ikuta Y, Yoshioka K, Tsuge K. Free muscle graft as applied to brachial plexus injury-case report and experimental study. Ann Acad Med Singapore. 1979;8(4):454-8.
15. Krakauer JD, Wood MB. Intercostal nerve transfer for brachial plexopathy. J Hand Surg Am. 1994;19(5):829-35.
16. Chung DC, Carver N, Wei FC. Results of functioning free muscle transplantation for elbow flexion. J Hand Surg Am. 1996;21(6):1071-7.
17. Chuang DC, Epstein MD, Yeh MC, Wei FC. Functional restoration of elbow flexion in brachial plexus injuries: results in 167 patients (excluding obstetric brachial plexus injury). J Hand Surg Am. 1993;18(2):285-91.
18. Barrie KA, Steinmann SP, Shin AY, Spinner RJ, Bishop AT. Gracilis free muscle transfer for restoration of function after complete brachial plexus avulsion. Neurosurg Focus. 2004;16(5):E8.
19. Kay S, Pinder R, Wiper J, Hart A, Jones F, Yates A. Microvascular free functioning gracilis transfer with nerve transfer to establish elbow flexion. J Plast Reconstr Aesthet Surg. 2010;63(7):1142-9.
20. Sungpet A, Suphachatwong C, Kawinwonggowit V. Transfer of one fascicle of ulnar nerve to functioning free gracilis muscle transplantation for elbow flexion. ANZ J Surg. 2003;73(3):133-5.

DOI: http://dx.doi.org/10.1590/1413-785220202804233186

ORIGINAL ARTICLE

HYPOALBUMINEMIA IN MICROSURGICAL FLAPS OF THE MUSCULOSKELETAL APPARATUS

A HIPOALBUMINEMIA EM RETALHOS MICROCIRÚRGICOS DO APARELHO MUSCULOESQUELÉTICO

Ana Carolina Oliveira da Silva[1], *Gustavo Bersani Silva*[1], *Alvaro Baik Cho*[1], *Teng Hsiang Wei*[1], *Rames Mattar Junior*[1], *Raquel Bernardelli Iamaguchi*[1]

1. Universidade de São Paulo, Hospital das Clínicas, Medical School, Institute of Orthopedics and Traumatology, Hand and Microsurgery Group, São Paulo, SP, Brazil.

ABSTRACT

Objective: To evaluate if the levels of serum total protein and serum albumin are risk factors for surgical complications of free flap limb reconstruction. Methods: Consecutive inclusion of all patients undergoing microsurgical flaps for limb reconstruction of complex injuries. We recorded epidemiological and laboratory data, including total proteins and fractions, for descriptive and analytical statistics. Results: Our study analyzed one microsurgical flap from 35 patients that underwent complex injuries of the limbs. In total, 23 patients were men, and mean age of all patients was 35 years. After statistical analysis, no influence of pre or postoperative hypoalbuminemia was observed on the incidence of complications. Patients with hypoalbuminemia had a higher length of stay than those with normal albumin levels ($p = 0.008$). Conclusion: We observed that 71% of patients had hypoalbuminemia in early postoperative period and we suggest a nutritional support for patients requiring complex traumatic limb reconstruction. Hypoalbuminemia in patients subjected to microsurgical flaps for the treatment of complex traumatic limb injuries did not influence the complications that required surgical reintervention; However, it was associated with prolonged hospital stay. ***Level of Evidence II, Retrospective study***.

Keywords: Free Tissue Flaps. Risk Factors. Hypoalbuminemia. Postoperative Complications.

RESUMO

Objetivo: Avaliar a influência dos níveis totais de proteína sérica e albumina como fator de risco para complicações de retalhos microcirúrgicos para reconstrução de membros. Métodos: Inclusão consecutiva de todos os pacientes submetidos a retalhos microcirúrgicos para reconstrução de membros de lesões complexas. Foram registrados dados epidemiológicos e laboratoriais, incluindo proteínas e frações totais, para fins estatísticos descritivos e analíticos. Resultados: 35 retalhos microcirúrgicos foram estudados em 35 pacientes com lesões complexas dos membros. A idade média dos pacientes foi de 35 anos, e 23 pacientes eram do sexo masculino. Após análise estatística, não foi observada influência da hipoalbuminemia pré ou pós-operatória na incidência de complicações. Pacientes com hipoalbuminemia permaneceram mais tempo hospitalizados do que aqueles com níveis normais de albumina ($p = 0,008$). Conclusão: Observamos 71% dos pacientes com hipoalbuminemia no início do período pós-operatório e sugerimos fornecer suporte nutricional para pacientes que necessitam de reconstrução traumática complexa dos membros. A presença de hipoalbuminemia em pacientes submetidos a retalhos microcirúrgicos para o tratamento de lesões traumáticas complexas nos membros não influenciou a presença de complicações que exigiam reintervenção cirúrgica, mas foi associada ao tempo de hospitalização prolongado. ***Nível de Evidência II, Estudo retrospectivo.***

Descritores: *Retalhos de Tecido Biológico. Fatores de Risco. Hipoalbuminemia. Complicações Pós-Operatórias.*

Citation: Silva ACO, Silva GB, Cho AB, Wei TH, Mattar R Jr, Iamaguchi RB. Hypoalbuminemia in microsurgical flaps of the musculoskeletal apparatus. Acta Ortop Bras. [online]. 2020;28(4):168-71. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Acute inflammation is the main indicator of tissue infections and lesions, with leukocytosis and extravasation of plasma proteins from extravascular tissue to the site of infection or injury. Pathophysiological responses such as pyrexia, hormone secretion inhibition, and muscle protein depletion are other reactions of the immune system.[1]

Leukocytes and plasma proteins are recruited to the sites of infection and injury, in which they provide immune defense and onset tissue repair. Whereas the concentration of the negative acute phase reactants and albumin reduces, the concentration of plasma proteins entering the inflammatory sites increases, including complement proteins and antibodies.[2] The posttraumatic hypoalbuminemia is

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

The study was conducted at Universidade de São Paulo, Medical School, Hospital das Clínicas (HCF-MUSP), Institute of Orthopedics and Traumatology, Hand and Microsurgery Group.
Correspondence: Raquel Bernardelli Iamaguchi. Rua Doutor Ovídio Pires de Campos, 333, São Paulo, SP, Brazil, 05403-010. rbiamaguchi@gmail.com

Article received on 01/20/2020, approved on 02/10/2020.

questioned not to be an indication of malnutrition but as a biomarker for inflammatory status,[3] although it is commonly associated with complications and malnutrition in studies for orthopedic surgeries.[4] Microvascular flap reconstruction technique has evolved, reaching excellent outcomes with a reduced incidence of complications.[5] However, the treatment of these injuries in traumatic limb reconstruction still presents higher incidences of complications when compared with the treatment for head, neck, and breast.[6] General risk factors for flap failure are multiple or extensive trauma, smoking, age, and peripheral vascular disease.[7] Among the perioperative risk factors studied, hypoalbuminemia is a factor that could negatively influence the results of free flap reconstruction. Common causes of free flap failure include arterial and venous thrombosis, infection, anatomic variations, and flap dissection.[8]
In the medical literature, preoperative hypoalbuminemia is identified in poor nutritional conditions and could influence the increase in total flap loss.[6,9] Studies into the influence of hypoalbuminemia on free flap outcomes have included patients that underwent oncologic reconstruction of the head and neck and breast, in which the patient can have nutritional deficit due to chronic illness, ignoring those subjected to limb reconstruction with microsurgical flaps. Our study sought to evaluate the influence of lower levels of serum total protein and serum albumin in preoperative and postoperative periods in the outcomes of free flap reconstruction of the limbs.

MATERIALS AND METHODS

This is a prospective, cross-sectional study with predefined data collection, approved by the Ethics Committee (CAAE 42679515.2.0000.0068). We performed a consecutive inclusion of all patients who underwent microsurgical flap reconstruction of limbs, performed at a public university hospital. Patients signed an informed consent form. A monitoring protocol was used with the patient's epidemiological data, pathology-related data and dates of occurrence, as well as clinical follow-up, complication, and end-result data.
The epidemiological data analyzed were sex, age, body mass index (BMI) – in kilograms per square meter (kg/m^2), in which obesity was defined when patients achieved a BMI greater than 30 kg/m^2 – and the presence of comorbidities. We recorded Pre-operative and postoperative laboratory data for hemoglobin (Hb) in grams per deciliter (g/dL), the number of platelets multiplied by 10^3 per cubic milliliter ($\times$ 10^3/mm^3), and levels of serum total protein and serum albumin (g/dl). The cause of the injury that led to the microsurgical procedure was also recorded.
Perioperative data observed were type of flap in relation to the donor area, type of arterial anastomosis, number of venous anastomoses, and ischemia time of microsurgical flap, defined as the time elapsed between clamping of the vessels at the donor site and releasing of the microvascular clamps of the artery and at least one venous anastomoses, obtaining free flap reperfusion.
We described and included complications following the Clavien-Dindo classification[10,11] grade III, which requires surgical intervention. Complications were dehiscence, partial or total flap loss, thrombosis with indication of revision of anastomoses, and infection.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 20.0 software was used for analysis with descriptive statistics and the univariate analysis was performed using Pearson Chi-squared test. Fisher's exact test was applied when the expected frequency was less than five. A value of p less than 0.05 was considered statistically significant. For the division of values and analysis, we considered both the presence and absence of comorbidities and hemoglobin values greater than, equal to, or less than 11 g/dL, according to the World Health Organization[12] standard anemia definition. Platelets were divided into values greater than, equal to, or less than 450 $\times$ 10^9/L, according to standardized thrombocytosis values.[13] Values less than 3.4 g/dL were defined as hypoalbuminemia and values less than 6.6 g/dL were defined as hypoproteinemia, according to the tests performed in the same clinical laboratory.

RESULTS

We included 35 microsurgical flaps, one flap from each patient, for complex injuries of the limbs in a one year period, (September 2018 through September 2019). The mean age of the patients was 35 years (SD 14.11). In total, 12 patients were women and 23 were men. Traumatic injuries accounted for 90% of cases, being motorcycle accident the most common cause of injury, occurring in 55% of the patients.
The anterolateral thigh (ALT) was the most common type of flap, followed by the latissimus dorsi flap (Figures 1 e 2).

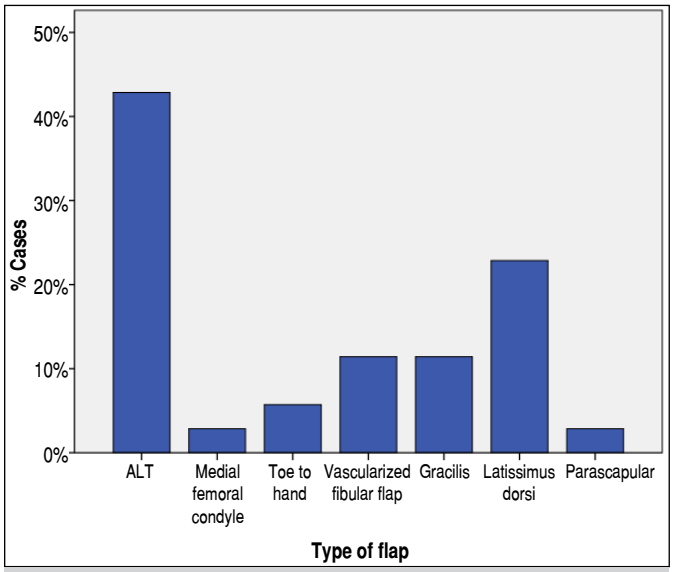

Figure 1. Type of microsurgical flap by donor area.
ALT: anterolateral thigh flap.

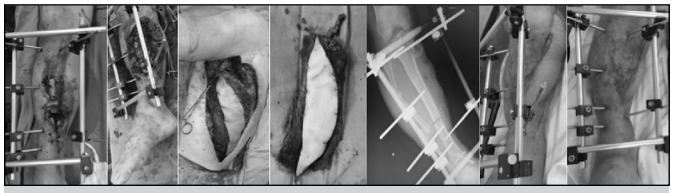

Figure 2. Male, 51 years, motorcycle accident with Gustilo IIIB leg open fracture. Patient referred for orthoplastic treatment after 1 month and subjected to a Latissimus Dorsi free flap for coverage.

Regarding laboratory data, the patients had a mean pre-hemoglobin value of 12.21 (± 2.08) g/dL. In the postoperative period, the mean hemoglobin value for the group was 10.65 (± 1.74) g/dL. Eleven patients presented anemia during the preoperative and 12 in the postoperative period.
Analysis of the platelet counts showed that two patients had pre-operative thrombocytosis, with a mean value of 326.82 $\times$ 10^9/L (± 125.58 $\times$ 10^9).
The level of serum total protein in pre-operative period was 6.16 g/dL on average (± 1.05) and the mean of the level of serum albumin was 3.72 (± 0.89). The mean level of serum total protein in postoperative

period was 5.43 g/dL (± 0.73) and the mean level serum albumin was 3.07 g/dL (± 0.56). Twelve patients had hypoalbuminemia in pre-operative and 25 patients in postoperative period.
Eight patients had complications, five of which required take-back flap due to microvascular thrombosis (total loss of four flaps). There was one case of total flap loss due to infection and one case of dehiscence of the surgical wound. The mean pre - and postoperative hemoglobin values for these eight patients were 12.28 (± 1.58) g/dL and 10.73 (± 2.23) g/dL. Preoperative platelets had a mean value of 338.75 $\times$ 10^3/mm^3 (± 0.92).
The statistical analysis showed no influence of pre- ($p = 0.891$) or postoperative ($p = 0.984$) anemia, thrombocytosis ($p = 0.556$), or hypoalbuminemia ($p = 0.115$) on the incidence of complications of the microsurgical flaps for limb reconstruction.
The mean hospital stay was of 28.60 days for the patients with hypoalbuminemia and 9.80 days for patients without hypoalbuminemia, with a p-value of 0.008 using the Mann-Whitney U test.
The microsurgical flap success rate was 86%.

DISCUSSION

In situations with great physical stress, such as long surgeries for the treatment of complex limb injuries, the serum albumin level decreases, since it is a negative acute phase reactant and the skeletal tissue is the source for restitution of serum albumin level. The intensity of this stress metabolism depends of the extension of trauma, that initiates an acute inflammation in minutes to hours, thus resulting in post-traumatic protein catabolism that can persist for around four months.[14] A sufficient quantity of proteins is essential for wound healing and immune response;[4,15] however, the nutritional status of surgical patients is still disregarded, even for oncologic patients.[16]
The nutritional status of surgical patients is an important factor in postoperative complications, including surgical site infection and mortality rates.[4] Malnutrition is associated with prolonged hospital stay and complications due to surgical stress.[17] However, studies on the influence of hypoalbuminemia on outcomes and complications of microsurgical flaps for traumatic limb injuries is scarce, being only available for microsurgical flaps for oncologic reconstructions.[18]
In the Hospital das Clínicas da Faculdade de Medicina, the Reconstructive Microsurgery and Hand Surgery Group focusses on the treatment of complex injuries in the Orthopedic Department, which is a reference for trauma. Our population is composed of young adults with normal nutritional status. However, the extensive trauma causes protein depletion such as tumors, similar to the occurring in patients with chronic diseases. Therefore, it is important to study and monitor the nutritional status of these patients after hospitalization.
The timing of treatment of complex limb injuries with microsurgical flaps depends on the type of trauma, associated lesions, the referral to the Microsurgery reconstructive Group and the patient's clinical condition. In our study, 34% of the patients had hypoalbuminemia in pre-operative period, demonstrating that, despite being young adults with a mean age of 35 years, both the severity of the trauma and the delay in referral for definitive microsurgical treatment may lead to a high incidence of malnutrition. We suggest referring to a orthoplastic center for a multidisciplinary treatment at the earliest convenience to avoid protein depletion and complications, as recommended in the literature.[19] Although serum albumin level is considered to be a long-term marker for nutrition status,[6] we observed that, after the free flap surgery for limb reconstruction, the percentage of patients with hypoalbuminemia raised to 71% in early postoperative period. Such increase on protein turnover with a negative whole-body protein balance[20] suggests the monitoring of the patients and a nutritional support for those requiring limb reconstruction with microsurgical flaps in orthoplastic centers.
Offodile et al.[18] reported an association between hypoalbuminemia and prolonged hospital stay in patients who underwent free flap treatments. In our study, the patients with hypoalbuminemia had a higher mean length of hospital stay than those with normal albumin levels (28.6 days versus 9.8 days, respectively), with statistical significance ($p = 0.008$). Therefore, hypoalbuminemia is still associated with higher costs due to prolonged Hospital stay caused by healing delay and infection with clinical treatment in patients with traumatic injuries of the limbs, although the serum albumin level is no longer considered a good marker for malnutrition.[2]
Shum et al.[6] studied patients who underwent reconstruction with microsurgical flaps of the head and neck and observed that those either malnourished or with low prealbumin levels had a higher incidence of total flap loss. A study by Wang et al.[21] observed that, in radial free forearm flaps, low postoperative concentration of albumin was a risk factor for complications. In our study, hypoalbuminemia in preoperative or post-operative periods was not associated with higher incidence of complications Clavien-Dindo grade III or total flap loss, being the first study of microsurgical flaps for traumatic limb reconstruction not related with oncologic resection and flap reconstruction.
The limitation of our study is the sample size, making it impossible to lead to definitive conclusions. This is a preliminary study and requires further research with continuity of prospective data capture.

CONCLUSION

Hypoalbuminemia in patients subjected to microsurgical flaps for the treatment of complex traumatic limb injuries did not influence the occurrence of complications that required surgical reintervention; however, it was associated with prolonged hospital stay.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. ACOS: wrote the paper and edited the manuscript; GBS: performed the surgeries and supervision; ABC: performed the surgeries and supervision; THW: performed the surgeries and supervision; RMJ: supervision; RBI: wrote the paper, edited the manuscript, performed the surgeries and supervision.

REFERENCES

1. Johnson RW. Inhibition of growth by pro-inflammatory cytokines: an integrated view. J Anim Sci. 1997;75(5):1244-55.
2. Gillis C, Carli F. Promoting perioperative metabolic and nutritional care. Anesthesiology. 2015;123(6):1455-72.
3. Gabay C, Kushner I. Acute-phase proteins and other systemic responses to inflammation. N Engl J Med. 1999;340(6):448-54.
4. Lizaur-Utrilla A, Gonzalez-Navarro B, Vizcaya-Moreno MF, Lopes-Prats FA. Altered seric levels of albumin, sodium and parathyroid hormone may predict early mortality following hip fracture surgery in elderly. Int Orthop. 2019;43(12):2825-9.
5. Ninkovic M, Voigt S, Dornseifer U, Lorenz S, Ninkovic M. Microsurgical advances in extremity salvage. Clin Plast Surg. 2012;39(4):491-505.
6. Shum J, Markiewicz MR, Park E, Bui T, Lubek J, Bell RB, et al. Low prealbumin level is a risk factor for microvascular free flap failure. J Oral Maxillofac Surg. 2014;72(1):169-77.
7. Namdar T, Bartscher T, Stollwerck PL, Mailänder P, Lange T. Complete free flap loss due to extensive hemodilution. Microsurgery. 2010;30(3):214-7.
8. 8. Wei FC, Demirkan F, Chen HC, Chuang DC, Chen SH, Lin CH, et al. The outcome of failed free flaps in head and neck and extremity reconstruction: what is next in the reconstructive ladder? Plast Reconstr Surg. 2001;108(5):1154-60.

9. Khuri SF, Daley J, Henderson W, Hur K, Gibbs JO, Barbour G, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. J Am Coll Surg. 1997;185(4):315-27.
10. Clavien PA, Barkun J, Oliveira ML, Vauthey N, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250(2):187-96.
11. Moreira LF, Pessôa MC, Mattana DS, Schmitz FF, Volkweiss BS, Antoniazzi JL, et al. Cultural adaptation and the Clavien-Dindo surgical complications classification translated to Brazilian Portuguese. Rev Col Bras Cir. 2016;43(3):141-8.
12. World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity [Internet]. Geneva: World Health Organization; 2011. Available from: http://www.who.int/vmnis/indicators/haemoglobin
13. Harrison CN, Bareford D, Butt N, Campbell P, Conneally E, Drummond M, et al. Guideline for investigation and management of adults and children presenting with a thrombocytosis. Br J Haematol. 2010;149(3):352-75.
14. Rittler P, Jacobs R, Demmelmair H, Kuppinger D, Braun S, Koletzko B, et al. Dynamics of albumin synthesis after major rectal operation. Surgery. 2007;141(5):660-6.
15. Stechmiller JK. Understanding the role of nutrition and wound healing. Nutr Clin Pract. 2010;25(1):61-8.
16. Müller-Richter U, Betz C, Hartmann S, Brands RC. Nutrition management for head and neck cancer patients improves clinical outcome and survival. Nutr Res. 2017;48:1-8.
17. Ho JW, Wu AH, Lee MW, Lau SY, Lam PS, Lau WS, et al. Malnutrition risk predicts surgical outcomes in patients undergoing gastrointestinal operations: results of a prospective study. Clin Nutr. 2015;34(4):679-84.
18. Offodile AC, Aherrera A, Guo L. Risk factors associated with prolonged postoperative stay following free tissue transfer: an analysis of 2425 patients from the american college of surgeons national surgical quality improvement program database. Plast Reconstr Surg. 2014;134(6):1323-32.
19. Olesen UK, Pedersen NJ, Eckardt H, Lykke-Meyer L, Bonde CT, Singh UM, et al. The cost of infection in severe open tibial fractures treated with a free flap. Int Orthop. 2017;41(5):1049-55.
20. Schricker T, Wykes L, Eberhart L, Carli F, Meterissian S. Randomized clinical trial of the anabolic effect of hypocaloric parenteral nutrition after abdominal surgery. Br J Surg. 2005;92(8):947-53.
21. Wang C, Fu G, Liu F, Liu L, Cao M. Perioperative risk factors that predict complications of radial forearm free flaps in oral and maxillofacial reconstruction. Br J Oral Maxillofac Surg. 2018;56(6):514-9.

DOI: http://dx.doi.org/10.1590/1413-785220202804230335

ORIGINAL ARTICLE

OUTCOME OF NON-SURGICAL TREATMENT OF MALLET FINGER

RESULTADO DO TRATAMENTO NÃO CIRÚRGICO DO DEDO EM MARTELO

Stephan Alejandro Dávalos Barrios[1], *Arturo Felipe de Jesús Sosa Serrano*[2], *Jorge Alberto Gama Herrera*[2], *Maria Fernanda Ramírez Berumen*[1], *Jose Manuel Pérez Atanasio*[1]

1. Instituto Mexicano del Seguro Social, Hospital General Regional No. 2 El Marqués, Querétaro, Mexico.
2. Instituto Mexicano del Seguro Social, Hospital de Traumatología Dr. Victorio de la Fuente Narváez, Ciudad de México, Mexico.

ABSTRACT

Objective: To establish the association between initial and residual angulation of the distal interphalangeal joint (DIJ) in mallet finger treated conservatively. Methods: An observational, prospective, descriptive and analytical research developed with uncomplicated closed mallet finger patients between January and December 2017. A total of two measurements of the DIJ were done, at the initial trauma and 6 weeks after conservative treatment. All measurements were ranked according to the Crawford Classification and Relative Risk was measured. Results: In total, 43 patients were studied, in which 53.48% of outcomes obtained were excellent. The sample was divided in two groups; one with less than 30º of DIJ initial angulation, which had 28% of residual angulation. The second group with more than 30º presented 72.22% of residual angulation. The Relative Risk to present a residual angulation in patients that had 30º of DIJ initial angulation was 2.99 (CI 95%) with $p = 0.0059$. Conclusion: It is suggested that patients with an initial DIJ angulation more than 30º are more likely to present residual angulation with conservative treatment. ***Level of Evidence IV, Case series.***

Keywords: Tendons. Finger joint. Follow-up studies. Outcome study. Acquired Hand Deformities.

RESUMO

Objetivo: Estabelecer a associação entre a angulação inicial e residual da articulação interfalângica distal em casos de dedo em martelo tratados de forma conservadora. Métodos: Estudo observacional, prospectivo, descritivo e analítico desenvolvido com pacientes que apresentavam dedo em martelo fechado, sem complicações, no período de janeiro a dezembro de 2017. Foram realizadas duas medidas na articulação interfalângica distal, no trauma inicial e seis semanas após o tratamento conservador. Todos foram classificados de acordo com a Classificação Crawford e o Risco Relativo (RR) foi calculado. Resultados: Foram estudados 43 pacientes, dos quais 53,48% apresentaram resultados excelentes. A amostra foi dividida em dois grupos: um com < 30º de angulação interfalângica distal inicial, com 28% de angulação residual, e outro com > 30º, apresentando 72,22% de angulação residual. O risco relativo de apresentar angulação residual em pacientes com 30º de angulação inicial da articulação interfalângica distal foi de 2,99 (IC 95%) com um valor de p = 0,0059. Conclusão: Sugere-se que os pacientes com angulação inicial da articulação interfalângica distal superior a 30º têm maior probabilidade de apresentar angulação residual com tratamento conservador. ***Nível de Evidência IV, Série de casos.***

Descritores: *Tendões. Articulações dos Dedos. Seguimentos. Avaliação de Resultados em Cuidados de Saúde. Deformidades Adquiridas da Mão.*

Citation: Dávalos Barrios SA, Sosa Serrano AFJ, Gama Herrera JA, Ramírez Berumen MF, Pérez Atanasio JM. Outcome of non-surgical treatment of mallet finger. Acta Ortop Bras. [online]. 2020;28(4):172-6. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The extensor mechanisms of fingers, hand and wrist are extremely intricated.[1-3] The terminal tendon injury of the extensor mechanism is referred as mallet finger (MF) deformity.[3-6]

Epidemiologically, this is a common injury with an international prevalence of 9.3% among all tendinous injuries in the body, and incidence of 5.6% among all hand and wrist tendinous injuries.[7,8]

There are many studies that have concluded that the recommendation is to immobilize the affected region from six to eight weeks. Nevertheless, there is no evidence of superiority if the splint is placed in a volar or dorsal position.[1,5,6,9,10,11-14]

Surgical treatment is controversial in closed MF, but it is indicated in open and fracture associated injuries.[15-17]

In 1984, Crawford described a widely used therapeutic assessment method in four stages: excellent, good, average and poor results.[15-18]

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

The study was conducted at Instituto Mexicano del Seguro Social, Hospital de Traumatología Dr. Victorio de la Fuente Narváez, Unidad Médica de Alta Especialidad.
Correspondence: Stephan A. Dávalos. Cto. Universidades II, Ejido La purisima, El Marqués, Querétaro, México, 76090. dr.stephan.davalos@gmail.com

Article received on 10/24/2019, approved on 02/27/2020

Another classification was described by Albertoni who divides the injury according to results from a lateral X-ray of the DIJ, and categorizes it into four types: A, B, C and D. Each type is subdivided into 1 and 2.[19] Type A is a pure tendinous injury and Type B is an injury with bone avulsion.[19] In types A and B, subtype 1 is described as an injury with less than 30° and subtype 2 by a flexion deformity greater or equal to 30°.[19] Deformities greater than this point of angulation can occur possibly due to damage to the retinacular ligaments and capsular structures in types A2 and B2.[19] Type C is subdivided into C1, congruent joint (stable), and C2, sub-dislocated or dislocated joint (unstable). Type D is subdivided into D1, epiphyseal detachment (Salter and Harris lesion type 1) and D2, fracture-detachment (Salter and Harris type 3).[20]

In order to support Albertoni's description and to reproduce his findings we tried to determine which degree of DIJ is necessary to achieve excellent result with a splint for closed MF. If such value is determined, we will be able to reduce prolonged incapacity and obtain optimal results for patients with this injury.

Our aim was to determine the initial DIJ angulation, in which the Relative Risk (RR) increased in a statistically significant manner to present residual angulation after conservative treatment. Second, we aimed to identify the most affected hand, finger, gender and age group in our population.

MATERIALS AND METHODS

Study design

Clinical, Observational, Descriptive, Analytical, Prospective and Unicentric research.

Location

Highly Specialized Medical Unit, Traumatology Hospital "Dr. Victorio de la Fuente Narváez" (Mexican Social Security Institute). Mexico City.

Ethics approval and consent to participate

Our study does not endanger the patient's integrity in any way (biological, functional or ethical). This research fulfills International and National ethics codes. The study was approved by the Research Ethics Committee (Mexican Social Security Institute). Every patient signed an Informed Consent Form, granting their approval to join the research.

Universe

Patients with closed MF that arrived to the Emergency Department between January 2017 and December 2017.

Inclusion Criteria
- Age between 18 – 45 years old
- Both genders
- Injury in one finger
- Injury in one hand
- Less than 24 hours of injury evolution

Exclusion Criteria
- Associated injuries (bone, nerve, vessel and/or flexor tendon)
- Comorbidities

Elimination Criteria
- Patients who did not complete follow-up time
- Patients who did not complete treatment
- Patients who modified the treatment
- Patients who have not completed radiological studies

Design and sample

The sampling was non-probabilistic type with consecutive cases. The annual prevalence of closed MF in 2016 in our Hospital (Reference Center of MF in Mexico City) was 153 cases. Therefore, we used the formula based on the prevalence to estimate a statistically significant sample with a 95% confidence interval (CI), and the result was 42.94 patients. Then, 43 patients were recruited for the study.

Data collection

We identified patients diagnosed with closed MF that met the criteria previously mentioned. First, we obtained a posteroanterior and lateral X-Ray of the affected hand, in which there was no support for the affected hand or finger. Secondly, we determined the DIJ angulation in the lateral X-ray. Then a line was drawn in the middle point of both middle and distal phalanx, in its transverse axis to measure the angulation. After that, we estimated the exact angulation with the digital X-ray software.

Thus, we placed a volar cast splint to immobilize the DIJ in a hyperextension position for six weeks. Finally, we removed the splint and estimated again the DIJ angulation, comparing initial and final results.

Data analysis

We classified the patients with the final result after six weeks according to Crawford Criteria (CC). This maneuver supported the estimation of patients' frequency in every stage of the CC. All study variables measured were organized in Table 1. We used the SPSS version 22 to statistically analyze the sample. The variable analysis was carried out with Chi square test to associate them. A calibration point was estimated using a 2 × 2 contingency table (Table 2). Therefore, we estimated the RR in which the result is statistically significant. After that, a homogeneity test was measured with chi square comparing age and gender. Finally, the sample was classified in two groups; the first with patients that had an initial DIJ angulation less than thirty degrees; and the second group with more than thirty degrees (Table 2). Relative Risk (RR) was used to determine the probability to develop residual angulation.

Table 1. Study variables.

	Name	Gender	Age	Affected hand	Affected finger	Initial angulation	Final angulation	Crawford classification
1	RMM	Male	43	Left	V	12.56	0	Excellent
2	BJM	Female	40	Left	IV	12.94	0	Excellent
3	MSJ	Male	44	Right	IV	13.08	0	Excellent
4	RMJ	Male	25	Right	III	13.16	0	Excellent
5	GMO	Male	18	Right	IV	14.55	0	Excellent
6	LTJ	Male	42	Left	III	14.57	12.83	Average
7	HCM	Male	23	Right	V	14.76	11.57	Average
8	RGA	Female	42	Left	IV	15.23	19.84	Average
9	PMC	Male	25	Right	IV	18.13	0	Excellent
10	LPM	Male	43	Right	IV	18.62	0	Excellent
11	SRL	Male	44	Right	III	18.63	0	Excellent
12	SSD	Male	24	Left	IV	20.74	0	Excellent
13	CGL	Male	22	Left	II	21.19	0	Excellent
14	IBL	Female	40	Right	II	21.26	4	Good
15	ROR	Male	35	Right	III	21.46	0	Excellent
16	LGM	Male	37	Right	III	21.93	0	Excellent
17	AGJ	Female	34	Left	V	22.8	0	Excellent
18	MOR	Male	26	Left	V	23.28	0	Excellent
19	GRA	Female	40	Right	III	23.49	7.21	Good
20	TAJ	Female	43	Right	III	24.37	16.49	Average
21	BBD	Male	44	Right	V	24.84	16.13	Average
22	SRS	Male	20	Right	V	24.87	0	Excellent

Table 1. Study variables.

	Name	Gender	Age	Affected hand	Affected finger	Initial angulation	Final angulation	Crawford classification
23	IBF	Male	38	Right	V	25.12	0	Excellent
24	LHL	Female	44	Right	IV	26.79	0	Excellent
25	VTG	Male	42	Left	III	27.26	0	Excellent
26	VAL	Male	44	Left	V	31.08	9.88	Good
27	RLR	Male	36	Right	V	32.75	0	Excellent
28	MAS	Male	39	Right	III	32.99	5.72	Good
29	MRA	Male	38	Right	III	34.08	2.11	Good
30	BLD	Male	44	Right	III	35.38	7.56	Good
31	BHA	Male	45	Left	IV	35.53	17.08	Average
32	ESG	Male	44	Left	III	36.14	6.46	Good
33	VTO	Female	44	Left	III	36.29	14.09	Average
34	AMM	Male	28	Left	V	37.15	0	Excellent
35	ZMJ	Male	36	Left	III	37.27	0	Excellent
36	HMA	Female	44	Left	V	37.97	12.47	Average
37	MRC	Male	39	Left	III	40.28	7.28	Good
38	GGM	Female	44	Right	V	42.13	0	Excellent
39	TJI	Male	43	Right	V	45.15	20.12	Poor
40	CEA	Male	32	Right	V	45.71	9.23	Good
41	ORE	Female	44	Right	III	46.41	17.53	Average
42	TRL	Male	44	Left	IV	46.5	0	Excellent
43	GLH	Male	44	Right	V	56.07	25.77	Poor

Table 2. 2 × 2 Contingency Table.

	> 30 degrees	< 30 degrees	Total
Residual angulation	13	7	20
Non-residual angulation	5	18	23
Total	18	25	43

RESULTS

Frequency

A total of 43 patients were studied, in which 32 were men and 11 women (Figure 1). 55.8% were middle-aged patients (between 40 and 45 years). (Figure 2). Of the total, 58.1% of the sample were injured in the right hand (Figure 3). The most affected finger was the middle one, with 37.2% (Figure 4). By comparing results between fingers, we observed that the middle finger showed the worst result for treatment (37.5% excellent result), and ring finger showed the best result (80% excellent result) (Figure 5).

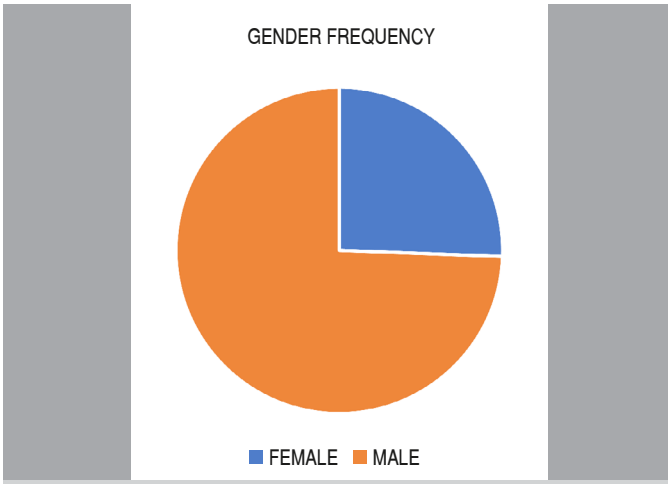

Figure 1. Male were the most affected gender.

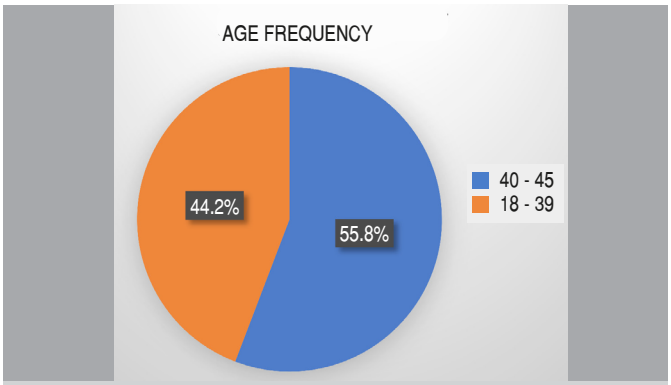

Figure 2. Middle-aged people were the most affected population in our study.

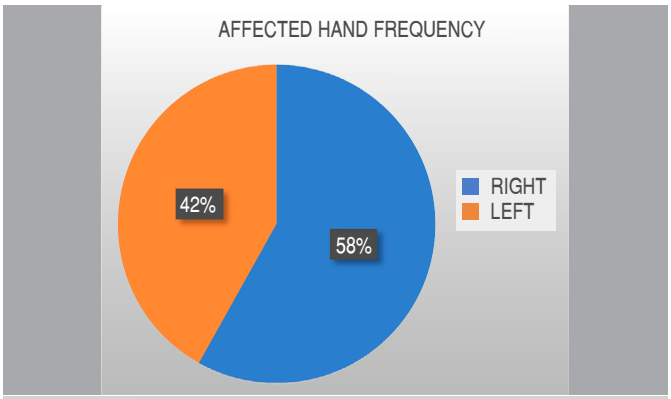

Figure 3. Mallet Finger affects more frequently the right hand.

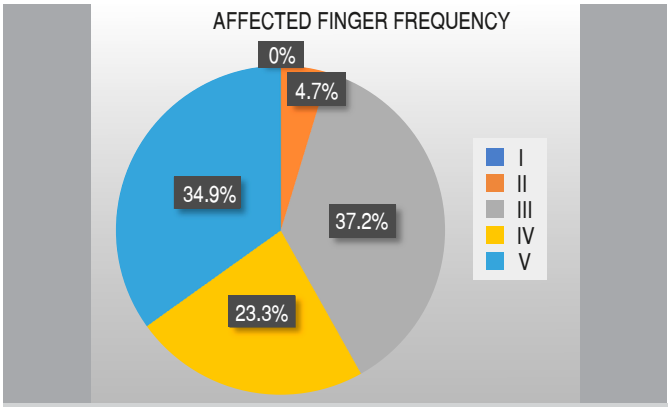

Figure 4. Middle finger was the most frequently affected.

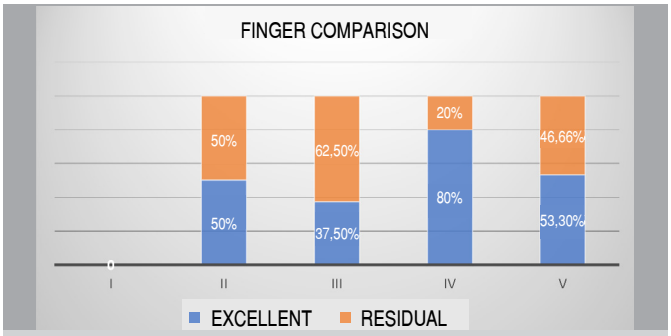

Figure 5. The worst outcome was reported for middle finger. The ring finger had the best results.

Changes in angulation

The initial angulation of the DIJ results obtained a mean 28.01, median 24.87, standard deviation 11.18, minimum 13, and maximum 56. The results of Final Angulation were a mean of 5.66, standard deviation 7.41, minimum of 0, and maximum of 26.
Crawford Classification: After 6 weeks of treatment the patients were classified according to their results in which 53.48% were excellent, 20.93% good, 23.25% average, and 2.32% poor. (Figure 6).

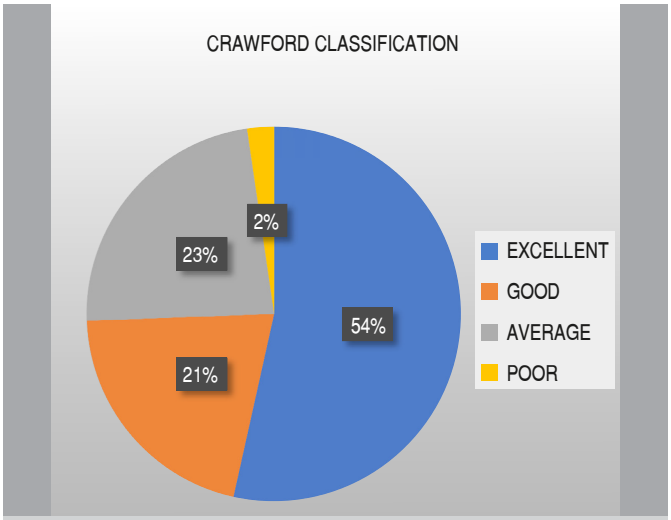

Figure 6. More than half of the sample achieved an excellent result after 6 weeks.

Results by groups

Statistical tests determined the homogeneity of groups with Chi square test based on age (chi square 0.35; p = 0.66); and gender (chi square 0.18, p = 0.55), with no statistical differences.
In the first group, 28% of the patients developed residual angulation after 6 weeks, compared to the second group which had 72.22% of residual angulation (Figure 7 and 8).
Our findings show that patients with 30° of initial angulation, presented RR values as 2.99 (1.73-25.8, IC 95%, p = 0.0059) to develop residual angulation at the end of the conservative treatment. We classified the patient's results based on Albertoni's Classification (Table 3).

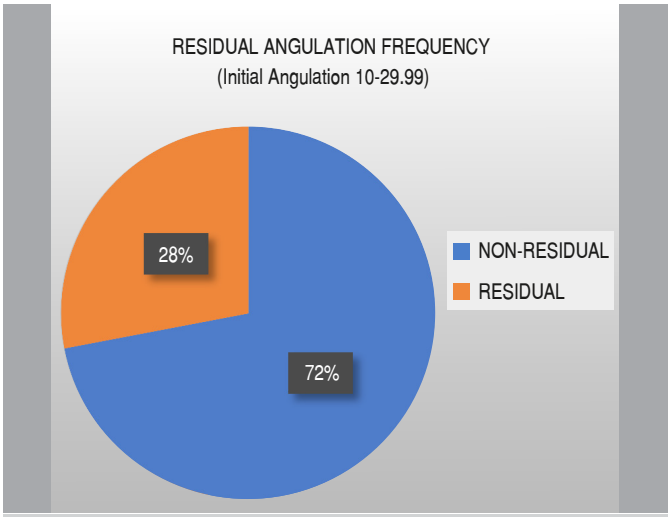

Figure 7. In almost two thirds of the sample, the outcome was no residual angulation in cases with less than 30 of initial angulation of DIJ.

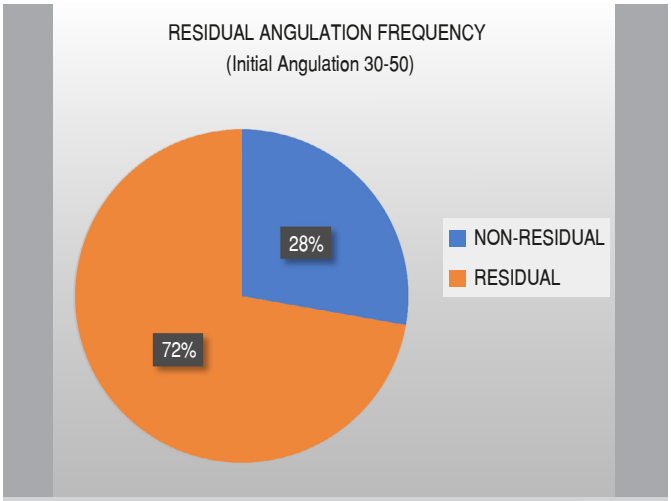

Figure 8. Most residual angulation after 6 weeks occurred in patients with more than 30° initially.

Table 3. Findings grouped according to Albertoni's Classification.

A 1	A 2
Before Treatment	Before Treatment
25	18
After Treatment	After Treatment
43	0

DISCUSSION

In 2008, Clayton et al.[8] assessed the distribution of population in a variety of musculoskeletal disorders. They reported the same frequency in gender, age, and most affected hand as our research. Furthermore, they described a populational peak in young adult, fact that can be attributed in greater frequency to hand workers.
Altan et al.[17] in 2014 reported, in the same way that our study, the middle finger as the most affected one. We reported the middle finger as the one who developed the worst outcome comparing with other fingers, this may occur due to the increased frequency of injury in this finger. Notably, our research had a six-week period to compare, since it is the established time to use the splint. Altan's results showed that 66% of patients achieved an excellent result, in our study this value was 53.48%. This fact probably occur because we did a six-week follow-up and Altan did a follow-up for several months.
In our research, 25% of patients had a poor outcome, requiring secondary procedures due to a greater angulation of the DIJ that caused functional alterations. Altan mentioned that it is not possible to conclude the time limit for orthosis treatment but this is still controversial.
Our data support the findings of Albertoni in 1980s, claiming that 30° is the point where mallet finger decreases its possibilities to obtain an excellent result. The Relative Risk to develop residual angulation in patients with an initial DIJ angulation of 30° was statistically significant.

CONCLUSION

Thirty degrees in the initial DIPJ angulation is the point where the mallet finger decreases its outcome. Therefore, above this value the probabilities of developing residual angulation after six weeks of conservative treatment in closed mallet finger are increased.
The Mexican population has the same epidemiologic frequency in gender, age, most affected hand and finger, as reported worldwide.

ACKNOWLEDGEMENTS

We thank the Instituto Mexicano del Seguro Social for all the facilities that was given to us in order to develop and finish this research, as well as the nurses, physicians and residents that helped us.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. SADB: data research, patient's gathering and treatment, as well as data analysis; AFJSS: reviewed current data about the topic and helped with the data analysis; JAGH: reviewed current data about the topic and helped with the data analysis; MFRB: assisted in the treatment of every patient and also manuscript drafting; JMPA: reviewed the data and made important changes in the manuscript.

REFERENCES

1. Matzon J, Bozentka D. Extensor tendon injuries. J Hand Surg Am. 2010;35(5):854-61.
2. McMurtry J, Isaacs J. Extensor tendon injuries. Clin Sports Med. 2015;34(1):167-80.
3. Bellemère P. Treatment of chronic extensor tendons lesions of the fingers. Chir Main. 2015;34(4):155-81.
4. Posner MA, Green S. Diagnosis and treatment of finger deformities following injuries to the extensor tendon mechanism. Hand Clin. 2013;29(2):269-81.
5. Valdes K, Naughton N, Algar L. Conservative treatment of mallet finger: a systematic review. J Hand Ther. 2015;28(3):237-45.
6. Salazar Botero S, Hidalgo Diaz JJ, Benaïda A, Collon S, Facca S, Livernaux PA. Review of acute traumatic closed mallet finger injuries in adults. Arch Plast Surg 2016;43(2):134-44.
7. de Jong JP, Nguyen JT, Sonnema AJ, Nguyen EC, Amadio PC, Moran SL. The incidence of acute traumatic tendon injuries in the hand and wrist: a 10-year population-based study. Clin Orthop Surg. 2014;6(2):196-202.
8. Clayton RA, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. Injury. 2008;39(12):1338-44.
9. Facca S, Nonnenmacher J, Liverneaux P. [Treatment of mallet finger with dorsal nail glued splint: retrospective of analysis of 270 cases]. Rev Chir Orthop Reparatrice Appar Mot. 2007;93(7):682-9. French.
10. Gruber JS, Bot AG, Ring D. A prospective randomized controlled trial comparing night splinting with no splinting after treatment of mallet finger. Hand (N Y). 2014;9(2):145-50.
11. Pike J, Mulpuri K, Metzger M, Ng G, Wells N, Goetz T. Blinded, prospective, randomized clinical trial comparing volar, dorsal and custom thermoplastic splinting in treatment of acute mallet finger. J Hand Surg Am. 2010;35(4):580-8.
12. Handoll HHG, Vaghela MV. Interventions for treating mallet finger injuries. Cochrane Database Syst Rev. 2004;(3):CD004574.
13. Nellans KW, Chung KC. Pediatric hand fractures. Hand Clin. 2013;29(4):569-78.
14. Smit JM, Beets MR, Zeebregts CJ, Rood A, Welters CFM. Treatment options for mallet finger: a review. Plast Reconstr Surg. 2010;126(5):1624-9.
15. Alla RS, Deal N, Dempsey IJ. Current concepts: mallet finger. Hand (N Y). 2014;9(2):138-44.
16. Lamaris GA, Matthew MK. The diagnosis and management of mallet finger injuries. Hand (N Y). 2017;12(3):223-8.
17. Altan E, Alp NB, Baser R, Yalçin L. Soft-tissue mallet injuries: a comparison of early and delayed treatment. J Hand Surg Am. 2014;39(10):1982-5.
18. Crawford GP. The molded polythene splint for mallet finger deformities. J Hand Surg Am. 1984;9(2):231-7.
19. Almeida VAS, Fernandes CH, Santos JBG, Schwarz-Fernandes FA, Faloppa F, Albertoni WM. Evaluation of interobserver agreement in Albertoni's classification for mallet finger. Rev Bras Ortop. 2017;53(1):2-9.
20. Albertoni WM. Mallet finger: classification. Rev Hosp Sao Paulo Esc Paul Med. 1989;1(3):133-6.

DOI: http://dx.doi.org/10.1590/1413-785220202804230946
ORIGINAL ARTICLE

HIGHER RISK OF COMPLICATIONS AFTER TOTAL KNEE ARTHROPLASTY IN OCTOGENARIANS

OCTOGENÁRIOS APRESENTAM MAIOR RISCO DE COMPLICAÇÕES APÓS ARTROPLASTIA TOTAL DO JOELHO

Gabriel Garcez de Araujo Souza[1], *Raphael Soejima Correia Ramalho*[1], *Rodrigo Sattamini Pires e Albuquerque*[1,2], *João Maurício Barretto*[3], *Rafael Souza Mançano Chaves*[1], *Eduardo Branco de Sousa*[1]

1. Instituto Nacional de Traumatologia e Ortopedia, Knee Surgery Center, Rio de Janeiro, RJ, Brazil.
2. Universidade Federal Fluminense, Niterói, RJ, Brazil.
3. Clínica São Vicente, Rio de Janeiro, RJ, Brazil.

ABSTRACT

Objective: To evaluate the complication rate of total knee arthroplasty (TKA) in octogenarian patients and identify predictive factors. Methods: The study comprised 70 octogenarians and 70 non-octogenarian patients as control group, all submitted to TKA. We analyzed the medical records of these patients, seeking for complications during the first postoperative year. Regarding the risk factors, we evaluated: age, sex, race, American Society of Anesthesiologists score, body mass index, smoking, hypertension and diabetes mellitus. Results: In the control group, the incidence of complications was 7.1%. Whereas in the octogenarian group it was significantly higher, reaching 34.3% (OR 6.8; 95% CI 2.4-19.1). We found no association to sex, skin color, and comorbidities. Age is an independent risk factor for postoperative complications. Our data may help patients to acknowledge the risks of undergoing primary TKA and physicians to assess and adjust perioperative risk. Conclusion: The incidence of postoperative complications is significantly higher in octogenarians. ***Level of Evidence III, Case-control study.***

Keywords: Arthroplasty. Knee. Postoperative Complications. Aged, 80 and over.

RESUMO

Objetivo: O objetivo do estudo foi avaliar a taxa de complicações da artroplastia total do joelho (ATJ) em pacientes octogenários e tentar identificar fatores preditivos. Métodos: Foi realizado um estudo envolvendo 140 pacientes, divididos em dois grupos (70 octogenários e 70 com idade abaixo de 80 anos), submetidos a ATJ no período de janeiro de 2014 a agosto de 2016. Os prontuários desses pacientes foram analisados buscando a presença de complicações ocorridas no prazo de um ano após a cirurgia. Em relação aos fatores de risco foram avaliados idade, sexo, raça, American Society of Anesthesiologists, Indice de Massa Corpórea, tabagismo, hipertensão arterial e diabetes. Resultados: No grupo-controle, a incidência de complicações foi de 7,1%. Já no grupo estudado foi significativamente maior, chegando a 34,3%. A razão de chances para complicações é 6,8, com intervalo de confiança ao nível de 95% igual a (2,4;19,1). A idade maior ou igual a 80 constitui, assim, fator de risco aumentado para a incidência de complicações pós-artroplastia total de joelho. Conclusão: A ocorrência de complicações após ATJ é significativamente maior no grupo dos octogenários. ***Nível de Evidência III, Estudo de caso-controle.***

Descritores: *Artroplastia. Joelho. Complicações Pós-Operatórias. Idoso de 80 Anos ou Mais.*

Citation: Souza GGA, Ramalho RSC, Albuquerque RSP, Barreto JM, Chaves RSM, Sousa EB. Higher risk of complications after total knee arthroplasty in octogenarians. Acta Ortop Bras. 2020;28(4):177-81. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Total knee arthroplasty (TKA) is a high-complexity orthopedic procedure indicated for treating patients with severe knee osteoarthritis to relieve pain, improve joint function and correct deformities to improve patients' quality of life.[1]

The age up from which a person is considered old varies, but there is a consensus around 64 years. In 1963, the World Health Organization recommended the following categorical definition: middle age, 45 to 59 years; active seniors, 60 to 74 years; dependent seniors, 75 to 90 years; and oldest-old, over 90 years.[2]

Because of the increase in life expectancy and medical progress, elderly patients have been progressively submitted to more complex, longer and larger surgical interventions.[2]

Age is a non-modifiable risk factor. Aging alters the natural history of diseases: it is considered a risk factor for various diseases and

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

The study was conducted at Instituto Nacional de Traumatologia e Ortopedia, Knee Surgery Center.
Correspondence: Gabriel Garcez de Araujo Souza. Rua Santa Clara, 50, sala 421, Rio de Janeiro, RJ, Brazil, 22041012. drgabrielgarcez@genutarso.com.br

Article received on 11/11/2019, approved on 02/06/2020.

a determinant for longer hospital stay and higher incidence of adverse drug reactions.[2]

The American Society of Anesthesiology (ASA) score has changed little over the years. It remains one of the most used for its practicality and sensitivity in predicting patients' overall risk of mortality based on age and functional status, regardless of the type of procedure that will be performed.[3]

Despite total knee arthroplasty being successful, 11 to 20.8% of patients develop perioperative complications,[4,5] among which the most common are: surgical wound, thromboembolic disease, infection, neurovascular lesions, periprosthetic fracture, extensor mechanism injury, and joint stiffness.[4] Surgery complications in elderly patients will be focused due to aging; that is, due to their lower adaptability to environmental changes and to their own homeostasis as a result of organic reserve reduction.[2]

This study aimed to evaluate the complications of total knee arthroplasty in octogenarian patients and identify predictive factors.

MATERIALS AND METHODS

A cross-sectional (observational) study was performed involving patients over 60 years old with primary osteoarthritis of the knee and submitted to total arthroplasty with cement between January 2014 and August 2016.

The study included patients who underwent TKA with one-year follow-up: the study group consisted of 70 octogenarian patients, and the control group consisted of 70 patients between 60 and 65 years. All patients had clinical indication for primary TKA and formed a homogeneous group with moderate osteoarthritis of the knee (Ahlback II/III) and no severe deformities (varus/valgus: 15 degrees).

The same surgical protocol was applied to all patients during the procedure, as follows. The surgery was performed with spinal anesthesia associated with combined femoral and sciatic nerve block. Arthroplasty was performed under ischemia with pneumatic tourniquet inflated to 125 mmHg above patient's systolic pressure after limb exsanguination. The procedures were performed with classic medial parapatellar approach and patients in supine position. In all cases, Hemovac® drains were placed and removed within 24 postoperative, with corresponding output. Posterior-stabilized Press-Fit Condylar (PFC sigma/DePuy-Synthes®) Sigma implants with patellar replacement were used. The pneumatic tourniquet was released before wound closure. Surgeons members of our Hospital knee group (all members of the Sociedade Brasileira de Cirurgia do Joelho) performed the surgeries. Antimicrobial surgical prophylaxis protocol (Cefazolin/24 hours) was applied to all patients, as well as for thromboembolic events (low-molecular-weight heparin for 15 days), as effective norms of the institution.

The standard postoperative rehabilitation protocol was applied for both groups, without distinctions. Motion and gait training were stimulated during the first or second postoperative day.

Data were collected by the analysis of patients' medical records. We evaluated the incidence of postoperative complications during the first postoperative year for both groups and also the risk factors for complications following TKA, such as: age, sex, race, American Society of Anesthesiology (ASA) score, body mass index (BMI), history of smoking, and presence of hypertension and Diabetes Mellitus. We considered complications any events that modified normal postoperative evolution, requiring any kind of intervention or acceptance of functional loss by the patient.

The complications or outcomes observed in the medical records were categorized into systemic and local. The frequency of outcomes was analyzed from the intraoperative period until the end of the first postoperative year. Systemic complications were subdivided into: pulmonary – pulmonary embolism; cardiac – acute myocardial infarction, and others. Local complication was subdivided into acute arterial occlusion, deep vein thrombosis, skin necrosis, superficial or deep surgical site infection, amputation, and others.

This study was approved by the Research Ethics Committee of our institution (CAAE: 79996217.9.0000.5273) and followed the National Health Council recommendations for Research Involving Human Beings.

The data were tabulated in Microsoft Excell® for analysis. Descriptive statistics characterized the variable Age of the study population by: frequencies; proportions; minimum, maximum and mean values; standard deviations, median, and coefficient of variation (CV). The variability of distribution of age was classified following the convention: low variability, if $CV < 0.20$; moderate, if $0.20 \leq CV < 0.40$; and high, if ≥ 0.40.

For inferential analysis, the Binomial test compared two complementary proportions. The chi-square was used to investigate the significant association between two qualitative variables; whenever its results were inconclusive and the situation was appropriate (tables 2×2), Fisher's exact test was used. Odds Ratio was used to express risk, which evaluated the chance of an individual in a group presenting a complication outcome in relation to the chance of an individual in the complementary group presenting a complication outcome. The OR significance level was assessed by the OR confidence interval, which cannot contain the value 1, as it would mean individuals from different groups present the same chance for the analyzed outcome. Kolmogorov-Smirnov test (KS) and the Shapiro-Wilk test (SW) verified the hypothesis of normality of distribution of age. Distribution was considered normal if both tests did not reject the null hypothesis of normality. As normality of the distribution of age was rejected for both groups, the Mann-Whitney test compared patients' ages from two independent groups.

Statistical analyses were performed by 20.0 Statistical Package for the Social Sciences® (SPSS), and graphics were built in Microsoft Excel 2007®. Discussions regarding the tests were conducted considering a 5.0% maximum significance level.

RESULTS

Our research sample was composed by 140 patients with primary osteoarthritis of the knee submitted to total arthroplasty with cement: 107 female (76.4%) and 33 male (23.6%), as shown in Figure 1.

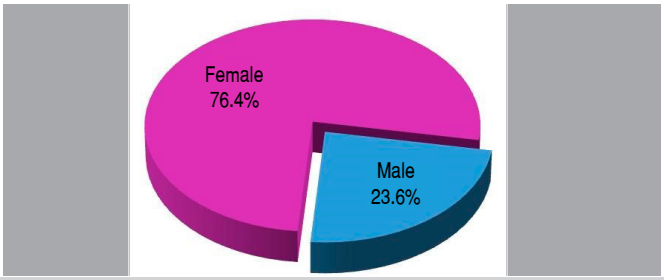

Figure 1. Distribution of patients by sex.

Table 1 describes the main analyses of the age distribution of patients, overall and by sex. Overall, patients were between 60 and 94 years old, mean and median of 73.0 years, and standard deviation of 10.3 years with coefficient of variation of 0.149, denoting low variability between patients' ages. From the *p* values for the normality tests, we concluded that age did not follow normal distribution, neither in the overall sample nor in female and male groups. Thus, the Mann-Whitney test compared distributions of age within female and male patients, resulting in $p = 0.115$. We found no significant difference between the distributions of age in male and female patients.

Table 1. Key statistics of patients' age, overall and by sex.

Statistics	Overall	Female	Male
Minimum	60	60	60
Maximum	94	94	90
Mean	73.0	74.1	69.5
Standard deviation	10.3	10.3	9.8
Median	73	80	64
CV	0.14	0.14	0.14
KS test p value	0.000	0.000	0.000
SW test p value	0.000	0.000	0.000

The group of patients over 80 years old, herein "Octogenarian Group," comprises 50% of the sample. Table 2 shows the frequency distribution of variables that characterize patients in octogenarian and non-octogenarian groups. The proportion of male patients in the octogenarian group (14.3%) is significantly lower than that in the non-octogenarian group (32.9%), chi-square test. $p = 0.010$. White and mixed-race were predominant among patients, and we found no significant difference among the distribution of skin color in both groups ($p = 0.054$). All patients had an ASA score equal to two. Within our study sample, the most prevalent comorbidities were: SAH, affecting 85.0% of patients; Diabetes Mellitus, with 17.1% prevalence; and obesity, with 12.1% prevalence. According to the *p*-values of the association tests, only the prevalence of obesity was significantly different between both groups: the proportion of obese patients in the octogenarian group (4.3%) was significantly lower than in the non-octogenarian group (20.0%), $p = 0.004$. We found no significant difference in the prevalence of other comorbidities between both groups.

Table 2. Patients' characteristics, overall and within interest groups.

Characteristic	Overall		Non-octogenarians		Octogenarians		test *p*-value
	F	%	F	%	F	%	
Gender							
Female	**107**	**76.4%**	**47**	**67.1%**	**60**	**85.7%**	**0.010**
Male	**33**	**23.6%**	**23**	**32.9%**	**10**	**14.3%**	
Skin color							
White	56	40.0%	21	30.0%	35	50.0%	0.054
Mixed race	65	46.4%	38	54.3%	27	38.6%	
Black	19	13.6%	11	15,7%	8	11.4%	
Comorbidities							
SAH	119	85.0%	58	82.9%	61	87.1%	0.478
DM	24	17.1%	11	15,7%	13	18.6%	0.654
Obesity	**17**	**12.1%**	**14**	**20.0%**	**3**	**4.3%**	**0.004**
Hypo/ hyperthyroidism	11	7.9%	3	4.3%	8	11.4%	0.116
Depression	8	5.7 %	4	5.7 %	4	5.7 %	1,000[(b)]
Dyslipidemia	8	5.7 %	2	2.9%	6	8.6%	0.275[(b)]
Smoking	7	5.0%	5	7.1%	2	2.9%	0.441[(b)]
Prostate	5	3.6%	0	0.0%	5	7.1%	0.058[(b)]
Bronchitis/Asthma	4	2.9%	1	1.4%	3	4.3%	0.620
Prior CVA	3	2.1%	0	0.0%	3	4.3%	0.245[(b)]
Anemia	2	1.4%	1	1.4%	1	1.4%	1,000[(b)]
AF	2	1.4%	1	1.4%	1	1.4%	1,000[(b)]
CRF	2	1.4%	1	1.4%	1	1.4%	1,000[(b)]
Epilepsy	1	0.7%	0	0.0%	1	1.4%	1,000[(b)]
Gout	1	0.7%	1	1.4%	0	0.0%	1,000[(b)]
Hepatopathy	1	0.7%	0	0.0%	1	1.4%	1,000[(b)]
Panic Disorder	1	0.7%	0	0.0%	1	1.4%	1,000[(b)]

(b): the chi-square test was inconclusive; therefore, fisher's exact test was performed.

In the overall analysis of the study sample, the incidence of postoperative complications was 20.7% (39 patients). The chi-square test showed a significant difference in the incidences of complications between both groups ($p = 0.000$). Figure 2 shows the difference between these incidences. In the non-octogenarian group, the incidence of complications was 7.1% (five patients), whereas in the octogenarian group the incidence of complications was significantly higher (34.3%; 24 patients). The odds ratio for complications was 6.8, with 95%CI (2.4;19.1). As the confidence interval of the odds ratio does not contain the value 1, being 80 years or older represented an increased risk factor for the incidence of complications following total arthroplasty with cement for the treatment of primary osteoarthritis of the knee.

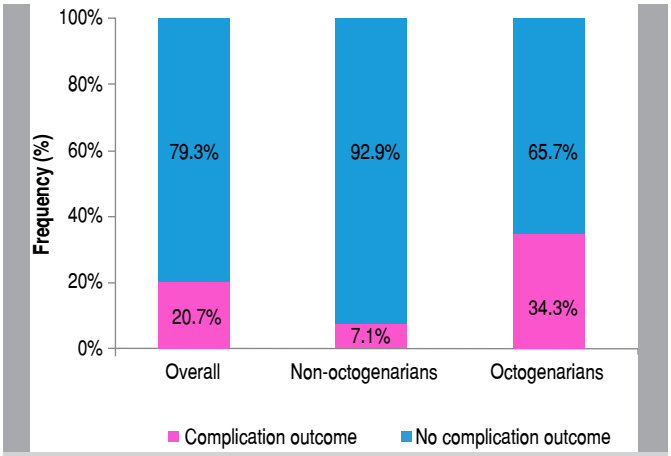

Figure 2. Incidence of complications following total arthroplasty with cement for the treatment of primary osteoarthritis of the knee, overall and within interest groups.

Table 3 shows the description and frequency distribution of postoperative complications of patients submitted to total arthroplasty with cement according to age.

Table 3. Frequency distribution of postoperative complications in patients submitted to total arthroplasty with cement for the treatment of primary osteoarthritis of the knee, overall and within interest groups.

Description of complication	Overall		Non-octogenarians		Octogenarians	
	F	%	F	%	F	%
Loss of range of motion	5	3.5	3	4.2	2	2.8
TKA infection	3	2.1	2	2.9	1	1.4
Anemia	2	1.4	0	0	2	2.8
Cellulitis	2	1.4	0	0	2	2.8
Chronic pain	2	1.4	0	0	2	2.8
Periprosthetic fracture	2	1.4	0	0	2	2.8
Peroneal neuropraxia	2	1.4	0	0	2	2.8
Deep vein thrombosis	2	1.4	0	0	2	2.8
Anasarca/ IPO Hyponatremia	1	0.7	0	0	1	1.4
IPO Decompensated asthma	1	0.7	0	0	1	1.4
IPO Pulmonary congestion	1	0.7	0	0	1	1.4
Delirium/ IPO ARF	1	0.7	0	0	1	1.4
IPO AF	1	0.7	0	0	1	1.4
IPO Hematoma/ Surgical Dressing	1	0.7	0	0	1	1.4
Ligament injury during TKA - Indicated by TC3 Review	1	0.7	0	0	1	1.4
Delaying Wound Healing	1	0.7	0	0	1	1.4
Intestinal sub-occlusion	1	0.7	0	0	1	1.4

The most frequent complication was the loss of the range of motion, affecting 4.2% of the control group and 2.8% of the studied group. Infection was the second most prevalent, twice as common in the control group as in the octogenarian group. The two most common complications in both groups were local. Furthermore, some complications occurred solely within the group of octogenarians. Among local complications, we excel cellulitis, chronic pain, periprosthetic fracture, IPO hematoma, ligament injury indicative of surgical revision, delayed wound healing, and peroneal neuropraxia. Among general complications, those that affected solely octogenarian group were anemia, deep vein thrombosis, anasarca, decompensated asthma, pulmonary congestion, delirium, atrial fibrillation, and intestinal sub-occlusion.

DISCUSSION

TKA is currently the top elective surgery in the United States,[6] and in patients over 85 years old it represents 5% of the total.[7]
Fang et al. suggest that octogenarian population presents a lower BMI.[8] We believe that obesity within this age group represents a factor that increases morbidity or mortality following surgery.
In our culture, the decision for surgery lays with both the patient and his family, regardless of age. Despite the increased risk of complications, patient's careful selection allows a safe surgery with good results.[9]
Van den Belt et al.[10] found that a high ASA score resulted in a longer hospital stay. However, age was not a factor in increasing the length of stay.
The literature reports high mortality rates during the first 30 postoperative days, as well as high complication and morbidity rates in patients with advanced age.[11] Thus, the adequate clinical follow-up is one year. Similar researches applied the same evaluation period.[12]
The literature is controversial regarding the percentage of the complication rates in octogenarians and lacks consistency in defining "complication." Some authors do not consider surgical manipulation as complication. Others consider surgical complications only, excluding clinical complications.[7,12] Our data collection was thorough, including any event that altered the pattern of a TKA postoperative rehabilitation.
To avoid a selection bias, our study was based on the ASA, and clinical and radiographic patterns of the knee. We believed that large knee deformities and marked bone defects could increase surgical time and bewilder our results.
We found a higher complication rate within the octogenarian group, and several other studies in the literature corroborate our results.[13-15] However, Seo et al.[12] observed no differences in complication rates among their study groups.
Kodaira et al.[16] analyzed complications within octogenarians and the control groups, finding no increase in general clinical complications. In assessing the aseptic implant failure, they reported 5 cases in the younger group and no case in octogenarians.[16]
Kreder et al.[15] concluded that octogenarians undergoing TKA have a risk of mortality 3.4 times higher than a control group.[15]
Our study reported some general complications restricted to the octogenarian group. Biau et al.,[17] however, found no differences when analyzing the general complications (cardiac, urinary, neuropsychiatric, thromboembolic events, and decubitus ulcers). Fang et al.,[8] that subdivided the sample into five subgroups according to age, observed that complications following TKA increased progressively with aging. Our results are aligned with Tay et al.,[9] which found that aging increases comorbidities and consequently decrease physical capacity. Thus, as an elderly patient has a smaller physiological reserve, surgical aggression is enhanced.
Falls from standing height are the main factor of hospital readmission within the first 90 days.[18] We had two cases of periprosthetic fracture from falling from standing height during the first postoperative year. The elderly commonly presents loss of muscle mass and bone quality, as well as altered balance, enhancing the risk of fractures. Driesman et al.[19] showed that joint replacement, whether in the hip or knee, reduces the risk of falls –in the elderly, the major cause of osteoporotic fractures and clinical depreciation. Thus, debating on the risk-benefit of total knee arthroplasty in octogenarians is up-to-date and of collective interest.
Rubin et al.[20] concluded that no evidence states that elderly patients with comorbidities are associated with increased complications. This literature review article shows that this line of research is open for further studies and that the subject still comprises numerous controversies.

CONCLUSION

Complications following TKI are age-group related, and their incidence is significantly higher within octogenarians.

AUTHOR'S CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. GGAS: data collection and drafting of the article; RSCR: data collection and drafting of the article; RSPA: statistical analysis, surgery performance, article organization and final text review; JMB: article review and intellectual concept; RSMC: data collection and project elaboration; EBS: intellectual concept, assistance in project elaboration, and final text review.

REFERENCES

1. Diduch DR, Insall JN, Scott WN, Scuderi GR, Font-Rodriguez D. Total knee replacement in young, active patients: long-term follow-up and functional outcome. J Bone Joint Surg Am. 1997;79(4):575-82.
2. Gomes M, Ramacciotti E. Profilaxia da doença tromboembólica no paciente idoso. Colégio Brasileiro de Cirurgiões. Programa de Auto-Avaliação em Cirurgia. 2002;(2):2.
3. Leme LEG, Sitta MC, Toledo M, Henriques SS. Cirurgia ortopédica em idosos: aspectos clínicos. Rev Bras Ortop. 2011;46(3):238-46.
4. Morrey BF, Adams RA, Ilstrup DM, Bryan RS. Complications and mortality associated with bilateral or unilateral total knee arthroplasty. J Bone Joint Surg Am. 1987;69(4):484-8.
5. Ayers DC, Dennis DA, Johanson NA, Pellegrini VD Jr. Instructional course lectures, The American Academy of Orthopaedic Surgeons – common complications of total knee arthroplasty. J Bone Joint Surg Am. 1997;79(2):278-311.
6. Pugely AJ, Martin CT, Gao Y, Mendoza-Lattes S, Callaghan JJ. Differences in short-term complications between spinal and general anesthesia for primary total knee arthroplasty. J Bone Joint Surg Am. 2013;95(3):193-9.
7. Kennedy JW, Johnston L, Cochrane L, Boscainos PJ. Total knee arthroplasty in the elderly: does age affect pain, function or complications? Clin Orthop Relat Res. 2013;471(6):1964-9.
8. Fang M, Noiseux N, Linson E, Cram P. The effect of advancing age on total joint replacement outcomes. Geriatr Orthop Surg Rehabil. 2015;6(3):173-9.
9. Tay KS, Cher EWL, Zhang K, Tan SB, Howe TS, Koh JSB. Comorbidities have a greater impact than age alone in the outcomes of octogenarian total knee arthroplasty. J Arthroplasty. 2017;32(11):3373-8.
10. van den Belt L, van Essen P, Heesterbeek PJ, Defoort KC. Predictive factors of length of hospital stay after primary total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2015;23(6):1856-62.
11. Parry MC, Smith AJ, Blom AW. Early death following primary total knee arthroplasty. J Bone Joint Surg Am. 2011;93(10):948-53.
12. Seo JG, Moon YW, Cho BC, Kim SC, Ko YH, Jang SP, et al. Is total knee arthroplasty a viable treatment option in octogenarians with advanced osteoarthritis? Knee Surg Relat Res. 2015;27(4):221-7.
13. Stroh DA, Delanois R, Naziri O, Johnson A, Mont M. Total knee arthroplasty in patients over 80 years of age. J Knee Surg. 2011;24(4):279-83.
14. Austin DC, Torchia MT, Moschetti WE, Jevsevar DS, Keeney BJ. Patient outcomes after total knee arthroplasty in patients older than 80 years. J Arthroplasty. 2018;33(11):3465-73.
15. Kreder HJ, Berry GK, McMurtry IA, Halman SI. Arthroplasty in the octogenarian: quantifying the risks. J Arthroplasty. 2005;20(3):289-93.

16. Kodaira S, Kikuchi T, Hakozaki M, Konno S. Total knee arthroplasty in Japanese patients 80 years or older. Clin Interv Aging. 2019:14:681-8.
17. Biau D, Mullins MM, Judet T, Piriou P. Is anyone too old for a total knee replacement? Clin Orthop Relat Res. 2006;(448):180-4.
18. Pitter FT, Jørgensen CC, Lindberg-Larsen M, Kehlet H, Lundbeck Foundation Center for Fast-track Hip and Knee Replacement Collaborative Group. Postoperative morbidity and discharge destinations after fast-track hip and knee arthroplasty in patients older than 85 years. Anesth Analg. 2016;122(6):1807-15.
19. Driesman A, Paoli AR, Wiznia DH, Oh C, Mahure SA, Long WJ, et al. Total joint arthroplasty is associated with a decreased risk of traumatic falls: an analysis of 499,094 cases. J Am Acad Orthop Surg [Internet]. 2019 Dec 6 [accessed on 2020 Apr 22]:[about 9 p.]. Available from: https://journals.lww.com/jaaos/Abstract/9000/Total_Joint_Arthroplasty_Is_Associated_With_a.99227.aspx.
20. Rubin LE, Blood TD, Defillo-Draiby JC. Total Hip and Knee Arthroplasty in Patients Older Than Age 80 Years. J Am Acad Orthop Surg. 2016;24(10):683-90.

DOI: http://dx.doi.org/10.1590/1413-785220202804233122

ORIGINAL ARTICLE

COMPARISON OF BICONDYLAR TIBIAL PLATEAU FRACTURES WITH DOUBLE OR SINGLE LATERAL LOCKED PLATE

COMPARAÇÃO DE FRATURAS DO PLANALTO TIBIAL BICONDILAR COM DUPLA PLACA OU PLACA BLOQUEADA LATERAL ÚNICA

Matheus Manolo Arouca[1], *Guilherme Henrique Ricardo da Costa*[1], *Marcos Camargo Leonhardt*[1], *Dennis Barbosa*[1], *Jorge dos Santos Silva*[1], *Kodi Edson Kojima*[1]

1. Universidade de São Paulo, Medical School, Institute of Orthopedics and Traumatology, São Paulo, SP, Brazil.

ABSTRACT

Objective: To compare postoperative radiographic outcomes of Schatzker type V and VI tibial plateau fractures treated with double-plate or single lateral locked plate. Methods: Sixty-three patients operated from December 2011 to February 2016 were selected, 47 from the double-plate group and 16 from the single lateral locked plate group. Minimum follow-up for all patients was 6 months. Fracture reduction evaluation was based on radiographic parameters: joint reduction, sagittal alignment, coronal alignment, and condylar width. Results: Radiographic evaluation showed no statistical difference in the immediate or late postoperative periods. Conclusion: Despite the reduced sample, this study is aligned with current results published in the medical literature. The severity of Schatzker type V and VI tibial plateau fractures can be minimized by the correct indication for the implant regarding fracture morphology. ***Level of Evidence III, Retrospective comparative study.***

Keywords: Tibial Fractures. Fracture Fixation, Internal. Orthopedic Fixation Devices.

RESUMO

Objetivo: Comparar desfechos radiográficos pós-operatórios de fraturas do planalto tibial Schatzker V e VI tratados com dupla placa ou placa bloqueada única lateral. Métodos: Foram selecionados 63 pacientes operados no período de dezembro de 2011 a fevereiro de 2016, sendo 47 do grupo dupla placa e 16 do grupo placa bloqueada lateral única. Todos os pacientes tiveram seguimento mínimo de seis meses. A avaliação da redução das fraturas foi baseada nos parâmetros radiográficos: redução articular, alinhamento sagital, alinhamento coronal e largura condilar. Resultados: A avaliação radiográfica não demonstrou diferença estatística no pós-operatório imediato nem no tardio. Conclusão: Apesar da amostra reduzida, o estudo vai ao encontro dos resultados mais atuais publicados na literatura médica. A gravidade das fraturas do planalto tibial Shatzker V e VI pode ser minimizada com a correta indicação do implante segundo a morfologia da fratura. ***Nível de Evidência III, Estudo retrospectivo comparativo.***

Descritores: *Fraturas da Tíbia. Fixação Interna de Fraturas. Dispositivos de Fixação Ortopédica.*

Citation: Arouca MM, Costa GHR, Leonhardt MC, Barbosa D; Silva JS, Kojima KE. Comparison of bicondylar tibial plateau fractures with double or single lateral locked plate. Acta Ortop Bras. [online]. 2020;28(4):182-5. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Tibial plateau fractures account for 1 to 2% of all fractures and approximately 8% of fractures in the elderly, according to data from international literature. They have a bimodal distribution, affecting elderly over 60 years old in a mild pattern, due to falls at the same level, and young adults in more severe patterns, involving traffic trauma or fall from great-heights.[1] The management of high-energy tibial plateau fractures, characterized by joint comminution, meta-diaphyseal disjunction and soft tissue injury,[2] remains challenging. Fractures that involve the two plateaus, medial and lateral, are called bicondylar. According to the most frequently used classification system, these lesions are framed as Schatzker V and VI; or Type C as per the AO/OTA CLASSIFICATION (Arbeitsgemeinschaft für Osteosynthesefragen / Orthopaedic Trauma Association).[2,3]

Bicondylar tibial plateau fractures are treated with techniques that stabilize both the medial and lateral columns, to reconstruct the articular surface and prevent varus collapse resulting from medial column failure. Initially, surgical procedures were performed by a single anterior incision. Both the medial and lateral plates were inserted by this route. However, double-route technique with tibial fixation spread out, using the medial and lateral support plates with conventional implants. For presenting less complications, this technique was established as the gold standard.[4] Yet, the incidence of soft tissue-related complications is still meaningful.

Recently, the use of anatomical lateral locked plates has been an advance for the treatment of bicondylar tibial plateau fractures. Single lateral incision improves soft tissue preservation, reduces surgical time, and favors the outcomes.[5-8] However, the literature

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

The study was conducted at Universidade de São Paulo, Medical School, Hospital das Clínicas, Institute of Orthopedics and Traumatology.
Correspondence: Matheus Manolo Arouca. Rua Oscar Freire, 1753, ap 21B, São Paulo, SP, Brazil, 05409-011. matheus.m.arouca@gmail.com

Article received on 01/17/2020, approved on 02/10/2020.

both corroborates and contradicts this perspective.[9-12] Among others, tibial fixation using lateral locked plate causes the highest rates of loss of reduction, vicious consolidation and complaints related to the synthesis material.[9,10,12] Furthermore, other studies showed no significant difference of infectious character between the surgical methods, nor in surgical and hospitalization periods.[9] Thus, this study aims to demonstrate that the single lateral locked plate should be considered in the osteosynthesis of Schatzker type V and VI tibial plateau fractures.

MATERIALS AND METHODS

The study identified and evaluated, in a retrospective and non-randomized way, adults with Schatzker type V and VI tibial plateau fractures submitted to internal fixation using double or lateral single locked plate in the proximal region of the tibia. In total, 89 patients operated from December 2011 to February 2016 were selected. This study was approved by the Ethics Committee, registered in *Plataforma Brasil*, under the CAAE No: 75439717.4.0000.0068.

The study included patients with Schatzker type V and VI tibial plateau fracture at any age, who agreed to participate in the study by signing the informed consent form.

Exclusion criteria were: the presence of other fractures or associated neurovascular injuries, bilateral tibial plateau fracture, fracture progression over 30 days, pathological fractures, fractures with no clinical indication for the procedure, lack of adequate radiographic documentation for evaluation, and refusal to sign the informed consent form.

After applying the inclusion and exclusion criteria, 63 patients were selected.

Patients' medical records were evaluated to collect demographic data and mechanism of injury, and determine time and type of fracture, type of internal fixation and associated lesions.

Minimum follow-up for all patients was 6 months. Anteroposterior radiographs and affected knee profile were performed in the immediate postoperative period and after 6 months. To evaluate the quality of fracture reduction, four radiographic parameters were used: joint reduction, sagittal alignment, coronal alignment and condylar width. Secondary loss of reduction was characterized as 5°change in the medial proximal tibial angle and/or slope in the immediate postoperative period and 6 months later.

Parameters were considered satisfactory only if: joint reduction presented a gap or interval of ≤ 2 mm,[13,14] coronal alignment had a medial proximal tibial angle of 87 ± 5°,[14,15] sagittal alignment had 9° ± 5°[16] posterior angle of the proximal tibia,[6] and 0 to 5 mm condylar width[14] (Figure 1).

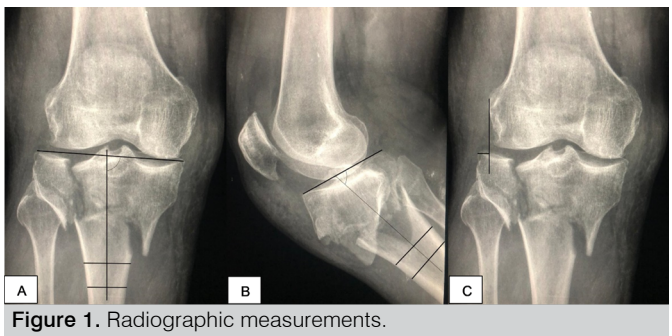

Figure 1. Radiographic measurements.
A: coronal alignment of medial proximal tibial (Slope); B: sagittal alignment of proximal tibial; C: condylar width.

Fixation using double or single lateral locked plate was not randomized. Single lateral locked plate was chosen for indication criteria in the literature: the presence of large and non-marginal medial fragment, medial condyle in bone-contact, lack of fractures in the coronal plane, lack of osteoporosis, and lateral locked plaque availability.[6-8]

Single lateral locked plate osteosynthesis is a surgical technique with anterolateral approach. The incision is based over Gerdy's tubercle, once joint capsule is inserted and ipsilateral meniscus is superiorly folded through its suture, exposing the articular surface. The tibialis anterior muscle and neurovascular bundle are moved aside and protected for surgical follow-up. The double-plate technique is a posteromedial approach parallel to the posteromedial border of the proximal tibia at least 5 cm distal from the anterolateral incision. The interval between semimembranosus muscles and the medial head of the gastrocnemius was identified. After moved aside from its structures, pes anserinus (goosefoot) was disinserted and then moved aside from the gastrocnemius. If needed, semimembranosus could have been disinserted to expose the posteromedial tibial plateau. Smaller fragments were temporarily stabilized with Kirschner wires, and joint sags greater than 2 mm were anatomically reduced using fluoroscopy. If needed, autologous cancellous bone graft was used. Final assembly used medial/lateral support plate.

Statistical analysis was performed using Stata 13.0 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP). Descriptive statistics for quantitative parameters was performed by calculating mean, standard deviation, mean standard error, median, minimum and maximum values, and sample sizes. Chi-square test was used to compare two distributions of qualitative samples. To compare two groups of quantitative distributions, Student's t test (parametric) was used for samples that may approach normal distribution, whereas Mann-Whitney U test (nonparametric) was used for those that may not. The results were considered statistically significant when $p < 0.05$.

RESULTS

From December 2011 to February 2016, 89 patients underwent surgical treatment for tibial plateau fracture. Of these, fifteen patients were excluded for lacking adequate radiographic documentation, ten for undergoing another osteosynthesis, and one for presenting complications that lead to amputation. From the 63 remaining, 47 were inserted in the double-plate group and 16 in the single lateral locked plate osteosynthesis group.

Table 1 show patient's demographic characteristics according to group. Fractures were classified as types V and VI, according to the Schatzker classification system, by identifying the mechanisms of injury and whether lesions were closed or exposed.

Table 1. Patient's demographic data according to group.

Parameter	Double-plate group (N = 47)	Single lateral plate group (N = 16)	P-value
Age (years)	42.4 (±13.70)	46.5 (±17.45)	0.340

Double-plate group showed a greater balance regarding the number of patients classified with Schatzker V or VI (44.7 and 55.3%, respectively) than single lateral plate group (18.75% Schatzker V and 81.25% Schatzker VI), with a $p = 0.08$.

Patients were also categorized according to mechanism of injury (Table 2), with $p = 0.22$, and fracture exposure (Table 3), with $p = 0.57$.

Table 2. Mechanisms of injury.

Mechanism	Double-plate group (N = 47)	Single lateral plate group (N = 16)
Motorcycle	25 (53%)	7 (43.75%)
Motor vehicle	1 (2.1%)	0 (0%)
Fall at same level	5 (10.6%)	0 (0%)
Run over	3 (6.4%)	4 (25%)
Crush	1 (2.1%)	0 (0%)
Fall from height	10 (21.3%)	3 (18.75%)
Blunt trauma	4 (4.25%)	1 (6.25%)
Bicycle	0 (0%)	1 (6.25%)

Table 3. Exposure of fractures

Exposed	Double-plate group (N = 47)	Single lateral plate group (N = 16)
Yes	8 (17.0%)	3 (18.75%)
No	39 (83%)	13 (81.25%)

In the immediate postoperative period (Table 4), double-plate group had a higher number of patients with joint step-off (29.8%) than the single lateral plate group (6.25%), but without statistical significance ($p = 0.088$). Whereas 59.55% of patients in the double-plate group evolved with joint degeneration in the late postoperative follow-up (Table 5), 31.25% of single lateral plate group did, without statistical significance ($p = 0.275$).

Table 4. Patient's radiographic data according to group in the immediate postoperative period.

Parameter	Double-plate group (N = 47)	Single lateral plate group (N = 16)	P-value
Immediate joint step-off	Yes: 14 (29.8%) No: 33% (70.2)	1 (6.25%) 15 (93.75%)	0.088
Immediate coronal	88.7 (± 2.48)	89.2 (± 2.64)	0.545
Immediate sagittal	7.2 (± 4.10)	7,0 ± 2.94	0.850
Immediate enlargement	Yes: 8 (17%) No: 39 (83%)	1 (6.25%) 15 (93.75%)	0.275

Table 5. Patient's radiographic data according to group in the late postoperative period.

Parameter	Double-plate group (N = 47)	Single lateral plate group (N = 16)	P-value
Late joint step-off	Yes: 28 (59.55%) No: 19 (40.45%)	5 (31.25%) 11 (68.75%)	0.080
Late coronal	88.8 (± 3.55)	89.2 (± 2.46)	0.630
Late sagittal	7.6 (± 4.46)	6.6 (± 4.18)	0.410
Late enlargement	Yes: 11 (23.9%) Not: 35 (76.1%)	1 (6.25%) 15 (93.75%)	0.123

Immediate enlargement was more frequent within the double-plate group (17%) than within the single lateral plate group (6.25%), although without statistical significance, as well as late enlargement ($p = 0.123$), and angular measurements in immediate and late coronal and sagittal sections. The double-plate group had a 1.3° immediate varus and a 1.2° late varus. Tibial slope in the sagittal plane was 7.2° immediate and 7.6° late. The single lateral plate group presented a varus of 0.8° for both immediate and late. Tibial slope in the sagittal plane was 7.0° immediate and 6.6° late.

DISCUSSION

Fixation with double-plate of Schatzker type V and VI fractures is a gold standard procedure.[4] However, the use of lateral locked plates is gradually spreading and gaining some indications within the literature. Yao et al.[6] and Weaver et al.[8] have reached satisfactory results by using it in the presence of tibial condyles in bone-contact, simple trait fractures in the sagittal plane with large and non-marginal medial fragment, and lack of osteoporosis. Furthermore, Yoo et al.[17] reports the inability of the single lateral locked plate to fix posteromedial fragments, requiring the support of an additional medial plate.[17] Citak et al.[18] has also obtained good results in the absence of posteromedial fragments, 33% of the cases in their series. Jiang et al.[11] have published a randomized trial of bicondylar tibial plateau fractures, concluding that, despite the greater misalignment found within this group, single lateral plates are an option. Moreover, other studies[5,9,10] showed better radiographic results, less bleeding, and soft tissue devitalization. Finally, Chang et al.[19] concluded in a meta-analysis with 559 patients that single lateral locked plate takes less surgical and bonding time, less skin necrosis and higher rate of loss of reduction; other complications and radiographic results showed no statistically significant difference. These studies reproducibility has not yet been widely documented.

There was no randomization in our study. The surgical technique was indicated based on the most favorable procedure to the fracture, considering already published knowledge: presence of large and non-marginal medial fragment, medial condyle in bone-contact, lack of fractures in the coronal plane, lack of osteoporosis, and lateral locked plaque availability.[6-8]

The analyzed radiographic variables (coronal and sagittal alignments, condylar enlargement and joint reduction) showed statistically significant difference between the immediate postoperative period and after six months of follow-up, and the absolute results were satisfactory. Yao et al.[6,7] obtained the same results using lateral plate for large and non-comminuted medial fragments. These results corroborate lateral locked plate indications.[6,8,18] The single lateral locked group showed a greater late varus collapse in studies that, unlike the aforementioned, were randomized.[10,11] However, the joint step-off should be considered a common denominator for both groups studied. Double-plate group had 14 patients (29.5%) that evolved with loss of anatomical reduction of the joint six months after surgery whereas lateral locked plaque group had four (25%). This could be justified by the instability caused by joint incongruity with physiological load alterations. Manidakis et al.[20] report 27.3% residual varus in the 20-month follow-up. Neogi et al.[10] and Jiang et al.[11] report a greater poor alignment by single lateral locked plate, which is not confirmed in this study.

CONCLUSION

Despite the reduced sample, this study is aligned with current results published in the medical literature. The severity of Schatzker type V and VI tibial plateau fractures can be minimized by the correct indication for the implant. In this context, the use of the single lateral locked plate is a good option in the presence of large and non-marginal medial fragment, medial condyle in bone-contact, lack of fractures in the coronal plane and lack of osteoporosis, whereas the double-plate is still the gold standard for the restoration of cases of complex fragmentation.

Further studies with greater sample, randomization and follow-up periods are needed to confirm this hypothesis.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. MMA: data acquisition, data interpretation, writing of the work, final approval of the manuscript version; GHRC: data acquisition, writing; MCL: surgeries, critical review of intellectual content; DB: surgeries, conception; JSS: conception, critical review of intellectual content; KEK: conception, surgeries, critical review of intellectual content.

REFERENCES

1. Moore TM, Patzakis MJ, Harvey JP. Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. J Orthop Trauma. 1987;1(2):97-119.
2. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture: the Toronto experience 1968-1975. Clin Orthop Relat Res. 1979;(138):94-104.
3. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, et al. Fracture and dislocation classification compendium – 2007: Orthopaedic Trauma Association classification, database and outcomes committee. J Orthop Trauma. 2007;21(10 Suppl):S1-133.
4. Georgiadis GM. Combined anterior and posterior approaches for complex tibial plateau fractures. J Bone Joint Surg Br. 1994;76(2):285-9.
5. Lee MH, Hsu CJ, Lin KC, Renn JH. Comparison of outcome of unilateral locking plate and dual plating in the treatment of bicondylar tibial plateau fractures. J Orthop Surg Res. 2014;9:62.
6. Yao Y, Lv H, Zan J, Zhang J, Zhu N, Ning R, et al. A comparison of lateral fixation versus dual plating for simple bicondylar fractures. Knee. 2015;22(3):225-9.
7. Yao Y, Lv H, Zan J, Li J, Zhu N, Jing J. Functional outcomes of bicondylar tibial plateau fractures treated with dual buttress plates and risk factors: a case series. Injury. 2014;45(12):1980-4.
8. Weaver MJ, Harris MB, Strom AC, Smith RM, Lhowe D, Zurakowski D, et al. Fracture pattern and fixation type related to loss of reduction in bicondylar tibial plateau fractures. Injury. 2012;43(6):864-9.
9. Lee TC, Huang HT, Lin YC, Chen CH, Cheng YM, Chen JC. Bicondylar tibial plateau fracture treated by open reduction and fixation with unilateral locked plating. Kaohsiung J Med Sci. 2013;29(10):568-77.
10. Neogi DS, Trikha V, Mishra KK, Bandekar SM, Yadav CS. Comparative study of single lateral locked plating versus double plating in type C bicondylar tibial plateau fractures. Indian J Orthop. 2015;49(2):193-8.
11. Jiang R, Luo CF, Wang MC, Yang TY, Zeng BF. A comparative study of Less Invasive Stabilization System (LISS) fixation and two-incision double plating for the treatment of bicondylar tibial plateau fractures. Knee. 2008;15(2):139-43.
12. Higgins TF, Klatt J, Bachus KN. Biomechanical analysis of bicondylar tibial plateau fixation: how does lateral locking plate fixation compare to dual plate fixation? J Orthop Trauma. 2007;21(5):301-6.
13. Brown TD, Anderson DD, Nepola JV, Singerman RJ, Pedersen DR, Brand RA. Contact stress aberrations following imprecise reduction of simple tibial plateau fractures. J Orthop Res. 1988;6(6):851-62.
14. Honkonen SE. Indications for surgical treatment of tibial condyle fractures. Clin Orthop Relat Res. 1994;(302):199-205.
15. Cooke TD, Li J, Scudamore RA. Radiographic assessment of bony contributions to knee deformity. Orthop Clin North Am. 1994;25(3):387-93.
16. Paley D, Herzenberg JE, Tetsworth K, McKie J, Bhave A. Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am. 1994;25(3):425-65.
17. Yoo BJ, Beingessner DM, Barei DP. Stabilization of the posteromedial fragment in bicondylar tibial plateau fractures: a mechanical comparison of locking and nonlocking single and dual plating methods. J Trauma. 2010;69(1):148-55.
18. Citak C, Kayali C, Ozan F, Altay T, Karahan HG, Yamak K. Lateral locked plating or dual plating: a comparison of two methods in simple bicondylar tibial plateau fractures. Clin Orthop Surg. 2019;11(2):151-8.
19. Chang H, Zhu Y, Zheng Z, Chen W, Zhao S, Zhang Y, et al. Meta-analysis shows that highly comminuted bicondylar tibial plateau fractures treated by single lateral locking plate give similar outcomes as dual plate fixation. Int Orthop. 2016;40(10):2129-41.
20. Manidakis N, Dosani A, Dimitriou R, Stengel D, Matthews S, Giannoudis P. Tibial plateau fractures: functional outcome and incidence of osteoarthritis in 125 cases. Int Orthop. 2010;34(4):565-70.

DOI: http://dx.doi.org/10.1590/1413-785220202804233302

ORIGINAL ARTICLE

ANALYSIS OF FATTY DEGENERATION OF THE TRAPEZIUS MUSCLE AFTER USE OF ACCESSORY NERVE

ANÁLISE DA DEGENERAÇÃO GORDUROSA DO MÚSCULO TRAPÉZIO APÓS USO DO NERVO ACESSÓRIO

Lucas Seiki Yamauti[1], *Danielle Tiemi Simão*[1], *João Carlos Rodrigues*[1], *Luiz Koiti Kimura*[1], *Rames Mattar Junior*[1]

1. Universidade de São Paulo, Hospital das Clínicas, Medical School, Institute of Orthopedics and Traumatology, Hand and Microsurgery Group, São Paulo, SP, Brazil.

ABSTRACT

Objective: To investigate, through magnetic resonance imaging, the occurrence of fatty degeneration of the trapezius in adult patients undergoing nerve transfer procedure, using the spinal accessory nerve. Methods: A total of 13 patients meeting the criteria of unilateral brachial plexus injury and more than one year of postoperative care after nerve transfer surgery underwent an MRI scan of the trapezius. A T1-weighted 3D sequence was used, with the IDEAL technique using 8.0 mm cut thickness, 8.0 mm cut spacing, TR of 100 ms, TE of 3.45 ms, flip angle of 10 degrees, 20 cuts, on the sagittal plane. The images of the upper, transverse and lower parts of the trapezius muscle were then classified according to the degree of fatty degeneration, compared with the contralateral side, using the Goutallier score. Results: For the upper trapezius there was a change of the degeneration state in 23% ($p = 0.083$), for the transverse section there was a change in 84.6% ($p = 0.003$), for the lower one there was a change in 92.3% ($p = 0.002$). Conclusion: The upper trapezius did not undergo significant degeneration after transfer. The lower and transverse trapezius suffered fatty degeneration in most patients, indicating severe functional impairment. ***Level of Evidence IV, Case series.***

Keywords: Accessory Nerve. Nerve Transfer. Muscle, Skeletal/Innervation. Magnetic Resonance Imaging.

RESUMO

Objetivo: Através de imagens de ressonância magnética, investigar a ocorrência de degeneração gordurosa no músculo trapézio em pacientes adultos submetidos a procedimento de transferência de nervo envolvendo o nervo espinal acessório. Métodos: 13 pacientes com lesão do plexo braquial unilateral e mais de um ano de cirurgia de transferência de nervo utilizando o nervo espinal acessório foram submetidos a exame de ressonância magnética do músculo trapézio. Foi obtida uma sequência 3D ponderada em T1, com a técnica IDEAL, espessura de corte de 8,0 mm, espaçamento entre os cortes de 8,0 mm, TR de 100 ms, TE de 3,45 ms, flip angle de 10 graus e 20 cortes, no plano sagital. As imagens das porções superior, transversa e inferior do músculo trapézio foram classificadas de acordo com o grau de degeneração gordurosa e comparadas com o lado contralateral, utilizando o score de Goutallier. Resultados: Para o trapézio superior houve mudança no estado de degeneração em 23% ($p = 0,083$), para o trapézio transverso houve mudança em 84,6% ($p = 0,003$), e para o trapézio inferior houve mudança em 92,3% ($p = 0,002$). Conclusão: O trapézio superior não sofreu degeneração significativa após transferência. Os trapézios inferiores e médios sofreram degeneração gordurosa na maioria dos pacientes, indicando comprometimento funcional severo. ***Nível de Evidência IV, Série de casos.***

Descritores: *Nervo Acessório. Transferência de Nervo. Músculo Esquelético/Inervação. Imagem por Ressonância Magnética.*

Citation: Yamauti LS, Simão DT, Rodrigues JC, Kimura LK, Mattar R Jr. Analysis of fatty degeneration of the trapezius muscle after use of accessory nerve. Acta Ortop Bras. [online]. 2020;28(4):186-9. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

The accessory spinal nerve originates from cranial and spinal nerve roots in the posterior cranial fossa and innervates the sternocleidomastoid and the trapezius. After providing innervation to the sternocleidomastoid, the nerve descends obliquely into the posterior triangle of the neck. It branches (two to three branches in most cases) in the upper portion, before entering the trapezius. Intramuscularly, the nerve follows an oblique caudal course toward the middle and lower portion of the trapezius, branching to the muscle throughout its course.[1]

The accessory spinal nerve is often sacrificed and used in surgeries to repair brachial plexus lesions.[2] Brachial plexus injury is usually caused by high-energy trauma, mainly involving the

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

The study was conducted at Universidade de São Paulo, Hospital das Clínicas (HCFMUSP), Medical School, Institute of Orthopedics and Traumatology, Hand and Microsurgery Group.
Correspondence: Lucas Seiki Yamauti. Rua Doutor Ovídio Pires de Campos, 333, São Paulo, SP, Brazil, 05403-010. lucasyamauti.abc@gmail.com

Article received on 01/23/2020, approved on 02/10/2020.

traction mechanism, causing partial or total ruptures of nerve roots in the cervical spine and leading to severe dysfunction of the affected upper limb.[3]

The accessory spinal nerve is used in nerve transfers in the repair of high brachial plexus lesions and also as a motor nerve in free muscle flaps, usually with the aim of regaining shoulder and elbow function.[4,5] This is due to the fact that the accessory spinal nerve is purely motor and close to the brachial plexus in the suprascapular region.[6]

It is possible to preserve function of the upper trapezius in nerve transfers, when the accessory spinal nerve is sectioned distal to the point of branching in the upper portion.[1]

The literature shows that partial or even total function of the trapezius can be maintained after injury to the accessory spinal nerve, since the trapezius also receives direct innervation of cervical roots.[1,7-9] Therefore, there is still no understanding of how the trapezius evolves, especially its transverse and inferior portions, after the use of the accessory spinal nerve in nerve transfers.

The aim of this study is to investigate, through magnetic resonance imaging, the occurrence of fatty degeneration of the trapezius (upper, transverse and inferior portions) compared to the contralateral side, in patients submitted to the nerve transfer procedure using the accessory spinal nerve.

MATERIALS AND METHODS

Study design

Thirteen adult patients with total or partial traumatic injury of the brachial plexus, with preserved trapezius and submitted to sacrifices and uses of the accessory spinal nerve, more than one year after surgery, underwent magnetic resonance imaging of the trapezius muscle after signing the informed consent form.

Patients with indication for muscle transfers were prioritized for gaining external rotation of the shoulder and requiring detailed evaluation of trapezius trophism.

Positioning and acquisition of images

All images were obtained in a device with a magnetic field of 1.5 T (HDXT, General Eletric, Milwaukke, USA).

To acquire the images, the patients were positioned in horizontal supine position, with the cervical-thoracic transition located in the isocenter of the equipment using a 16-channel cardiac coil (General Eletric, Milwaukke, USA). Initially, a tri-planar locator image was obtained with the echo gradient technique, echo time (ET) of 5 ms and repetition time (TR) of 15 ms. Next, a 3D sequence weighted in T1 was obtained, with the IDEAL technique (iterative decomposition of water and fat, with echo asymmetry) using cutting thickness of 8.0 mm, spacing between the cuts of 8.0 mm, TR of 100 ms, ET of 3.45 ms, flip angle (FA) of 10 degrees, 20 cuts, oriented in the sagittal plane, favoring both the trapezius on the same side of the accessory nerve sacrificed, and the contralateral side without the lesion, using as reference its muscular origin in the spine and its distal insertion in the clavicle and spine of the scapula.

Image analysis

As a method to evaluate the evolution of the trapezius, for each patient, we used the classification of Goutallier et al.[10] modified by Fuchs et al.[11] for magnetic resonance imaging on the side where there was brachial plexus injury and on the side where there was no lesion, as control.

Classification consists of five stages ranging from Stage 0 (normal muscle) to Stage 4 (more fat than muscle). The classification is described in Table 1.

Table 1. Description of the classification of Goutallier et al.[10] modified by Fuchs et al.[11]

Stage	0	I	II	III	IV
Description	Completely normal, no fat bands.	Muscle with some fat bands.	Important fatty infiltration, but there is more muscle than fat.	Muscle and fat in equal amounts.	More fat than muscle.

The magnetic resonance images of the trapezius of the patients were evaluated by two observers, working independently and classified according to Goutallier et al.[10] Side images were classified with brachial plexus injury/sacrifice of the accessory spinal nerve and the uninjured side. Then a consensus was established after a meeting with the two observers, reanalyzing the images, and reaching a single classification for cases that were initially classified in different stages by them.

Statistical analysis method

The data, the characteristics of patients and the Goutallier classification of the control (non-operated) side as well as the operated side were stored in an Excel spreadsheet® for Mac and later imported into the SPSS25 software® for MAC.

Categorical data were described by their frequency and their respective proportion and the continuous data by the mean and its respective standard deviation.

To verify whether there was a change in the Goutallier score between the sides of the 13 individuals analyzed, an inferential analysis was performed, using the nonparametric test for paired measurements, Wilcoxon Signed-Rank test. It was accepted as a statistically significant difference when the p value ≤ 0.05.

The study was approved by the Ethics Committee of the Institution under number 1188 IOT Protocol and the Free and Informed Consent Form was signed by all participants.

RESULTS

Of the 13 study participants, 12 were male and one female, representing a percentage of 92.3% male and 7.7% female.

The mean age was 40.62 ± 10.67 years.

Nine patients (69.2%) presented high partial brachial plexus injury and four patients (30.8%) presented complete brachial plexus injury.

The mean time between brachial plexus injury and surgery with the use of accessory spinal nerve was 10.85 ± 10.22 months.

The mean time of postoperative care in procedures that used the accessory spinal nerve was 73.23 ± 46.26 months.

Eleven patients (84.5%) underwent an accessory spinal nerve transfer to the suprascapular nerve and two patients underwent a free functional muscle transfer procedure with the gracilis muscle, using the accessory spinal nerve as the motor nerve.

Fatty degeneration of the trapezius was evaluated in the three portions of the muscle individually (upper trapezius, transverse trapezius and inferior trapezius) and on both sides, with the control being the side whose accessory spinal nerve was not sacrificed.

The results of fatty degeneration according to the classification of Goutallier et al.[10] modified by Fuchs et al.[11] are shown in Table 2.

Table 2. Results of the analysis of fatty degeneration of the trapezius according to the classification of Goutallier et al.[10] modified by Fuchs et al.[11]

Goutallier Classification	0	1	2	3	4	p-value
Upper trapezius (Control) n (%)	13 (100%)	0	0	0	0	0.083
Upper trapezius (Operated) n (%)	10 (76.9%)	3 (23.1%)	0	0	0	
Transversal trapezius (Control) n (%)	13 (100%)	0	0	0	0	0.003
Transversal trapezius (Operated) n (%)	2 (15.4%)	3 (23%)	0	4 (30.8%)	4 (30.8%)	
Lower trapezius (Control) n (%)	13 (100%)	0	0	0	0	0.002
Lower trapezius (Operated) n (%)	1 (7.7%)	1 (7.7%)	1 (7.7%)	2 (15.4%)	8 (61.5%)	

Upper trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 23% of the individuals, from stage 0 to stage 1 (Figure 1). This observed modification was not statistically significant, with p = 0.083.

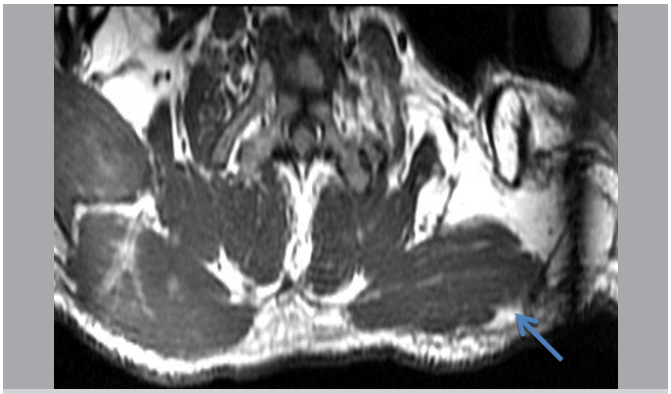

Figure 1. Axial cut image of the upper trapezius with injury to the right side of the image, rated as Goutallier score 1.

Transversal trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 84.6% of the individuals, from stage 0 to stage 1 (Figure 1). With 23% for stage 1 and 61.6% for stage 3 (Figure 2) or 4. This observed modification was not statistically significant, with p = 0.003.

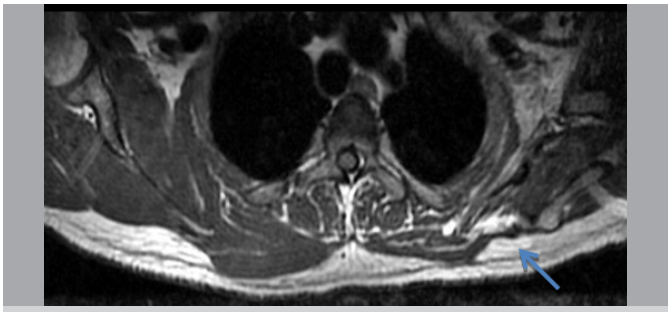

Figure 2. Axial cut image of the transversal trapezius with injury to the right side of the image, rated as Goutallier score 3.

Lower trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 92.3% of the individuals, from stage 0 to stage 1 (Figure 1). With 76.9% representing stage 3 or 4 (Figure 3A-B). This observed modification was statistically significant, with p = 0.002.

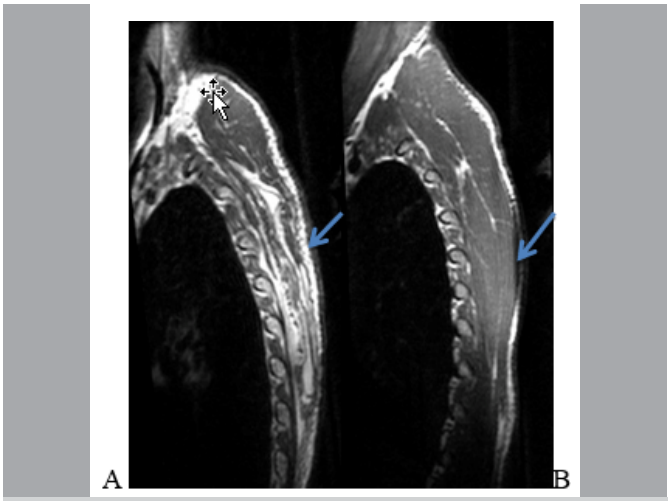

Figure 3. (A) Sagittal cut of the lower trapezius muscle rated Goutallier score 4. (B) Image of the control/contralateral side, without brachial plexus lesion/accessory spinal nerve sacrifice

DISCUSSION

In traumatic brachial plexus injuries, there is a prevalence of involvement in males (about 89%), with an age range between 14 and 63 years and an average of 29 years.[3] In the present study, 92.5% were male aged between 29 and 64 years and mean 40.62 ± 10.67 years. The mean time between brachial plexus injury and surgery with the use of accessory spinal nerve was 10.85 ± 10.22 months. The time was longer (over one year) in both cases in which the accessory spinal nerve was used as a motor nerve for free muscle transfer (gracilis muscle to brachial biceps muscle).

For nerve transfer procedures it is established that the maximum acceptable time is up to one year of brachial plexus injury.[2]

The 11 cases that underwent an accessory spinal nerve transfer procedure to the suprascapular nerve were operated less than one year after brachial plexus injury, as the literature suggests.

The minimum evaluation time established of one year after surgery is due to evidence that, after one year of nerve injury, irreversible loss of motor neural plaques occurs due to degeneration and fibrosis.[12] As the aim of this study is to evaluate fatty degeneration, we consider that after one year of sacrifice of the accessory spinal nerve, the areas innervated by it have already suffered degeneration, remaining only nerve stimuli by the direct cervical branches.

Magnetic resonance imaging was chosen as it was capable of identifying and quantifying, in a noninvasive way, the morphology and muscular physiology. It is an examination already used in other studies to evaluate the appearance of the denervated muscle, which presents as characteristic the fatty degeneration.[13-15] There is no previous study using magnetic resonance imaging to assess fatty degeneration of the trapezius after use or injury of the accessory spinal nerve.

The classification of Goutallier et al.[10] was originally developed for chronic ruptures of the rotator cuff tendons. Muscle tissue, after chronic rupture of the tendon, is known to atrophy and retract,

and there's replacement of tissue by fat due to disuse. Subacute and chronic lesions of motor nerves are also known to evolve with atrophy and fatty replacement after nerve stimulation ceases, as demonstrated in studies of the evolution of the denervated muscle through magnetic resonance imaging.[13] Although the pattern of tissue alterations in chronic lesions of the rotator cuff tendons and denervation are proven to be different,[16] there is no validated classification for muscular alterations on magnetic resonance imaging after chronic injury of motor nerves.

There are several anatomical studies in the literature that evaluate trapezius innervation. Although they prove the relationship between the cervical roots and the trapezius, the results are very inconsistent. The point at which most studies converge is that direct innervations from cervical roots to the trapezius usually come from spinal nerves C3 and C4, but they cannot prove whether the transverse and lower portions of the muscle remain functional after a complete section of the accessory spinal nerve.

In the study by Soo et al.,[8] in 29 of the 32 dissections performed, one or more connections were found between the roots of C2 and C3 with the accessory spinal nerve that were proximal in relation to the level of accessory section in nerve transfers. In Dailana et al.[1] these connections were found in only five of the 20 dissections. In the most recent study by Tubbs et al.[7] with dissection of 15 cadavers and using both sides, there was involvement of cervical roots in all cases. These motor fibers ran either independently or made connections to the accessory spinal nerve. Usually the fibers that originated from the roots of C2-C3 joined with the accessory spinal nerve before penetrating the muscle. The fibers resulting from the roots of C3 or C4 ran independently in the muscle.[7] Kim et al.[17] performed dissection of 24 patients with head and neck cancer, followed by electrical stimulation of the roots of C2, C3 and C4. C2 stimulation was responsive in the upper and transverse trapezius at 4 and 8%, respectively. C3 and C4 obtained non-constant responses, but the C4 nerve was the one that transmitted the most response in the muscle, compared to the other roots.[17] Pu et al.[9] conducted a study with electroneuromyography applied intraoperatively of the dissection of 34 necks. After complete sectioning of the accessory spinal nerve, stimulation of the C2 produced contractions in the entire muscle in one case and in the transverse and inferior portions in two cases. Contributions of C3 and C4 produced contractions in the upper and transverse portions in some patients but in none of the cases in the lower portion. It was found that, in most cases, C2 innervates the trapezium through communication with the accessory nerve and C3 and C4 innervate the muscle independently. In addition, it was found that the main innervation of the lower portion is the accessory spinal nerve.[9]

In the results of this study, the upper trapezius was little or not affected at all by the sacrifice of the accessory spinal nerve, and only 23.1% presented mild alterations in relation to the contralateral side. This corroborates Tubbs et al.[7] and Dailiana et al.,[1] because the upper trapezius can be preserved if the accessory spinal nerve is sectioned distal to the point where there was branching in the upper trapezius, a technique we routinely adopt in our service.

The transverse and lower portions of the trapezius were classified as Goutallier stage 3 or 4, in 61.6% and 76.9% of the operated sides, respectively. Goutallier et al.[10] identified that lesions of stages 3 and 4 correlate with severe functional impairment. Therefore, despite occurring in the minority of cases, these portions of the muscle may eventually remain functional and capable of being used in other procedures for the treatment of brachial plexus lesions, such as lower trapezius transfer to external rotators.

This study has some limitations as it has a small number of patients. Brachial plexus injury is a rare lesion, and the inclusion criteria used did not allow for a very large number of patients.

In addition, the Goutallier classification was not designed for denervations but for chronic injuries in the rotator cuff tendon. In the absence of a validated classification in the literature to assess fatty degeneration after denerving a muscle, we believe that this adaptation allows us to reliably evaluate fatty degeneration resulting directly from denervation, as we compare it with the healthy contralateral muscle.

CONCLUSION

The upper trapezius does not undergo significant fatty degeneration after surgeries to repair brachial plexus lesions using the accessory spinal nerve. On the other hand, the middle and lower portions suffered significant fatty degeneration in most patients, indicating severe functional impairment after use of the accessory spinal nerve.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. LSY: was responsible for the data collection, compilation and analysis, acquisition and interpretation of scientific content and writing of the manuscript; DTS: was responsible for the intellectual and scientific design of the study, critical review and approval of the final version of the manuscript. JCR: was responsible for guidance, discussion of the study design, technical procedures and image acquisition; LKK: was responsible for discussing the design of the study and reviewing the scientific content; RMJ: supervision of the article.

REFERENCES

1. Dailiana ZH, Mehdian H, Gilbert A. Surgical anatomy of spinal accessory nerve: is trapezius functional deficit inevitable after division of the nerve? J Hand Surg Br. 2001;26(2):137-41.
2. Wolfe S, Hotchkiss R, Pederson W, Kozin S, Cohen M. Green's operative hand surgery. 7th ed. Philadelphia: Elsevier; 2017.
3. Smania N, Berto G, La Marchina E, Melotti C, Midiri A, Roncari L, et al. Rehabilitation of brachial plexus injuries in adults and children. Eur J Phys Rehabil Med. 2012;48(3):483-506.
4. Chuang DC, Carver N, Wei FC. Results of functioning free muscle transplantation for elbow flexion. J Hand Surg Am. 1996;21(6):1071-7.
5. Bertelli JA, Ghizoni MF. Results of spinal accessory to suprascapular nerve transfer in 110 patients with complete palsy of the brachial plexus. J Neurosurg Spine. 2016;24(6):990-5.
6. Rui J, Zhao X, Zhu Y, Gu Y, Lao J. Posterior approach for accessory-suprascapular nerve transfer: an electrophysiological outcomes study. J Hand Surg Eur Vol. 2013;38(3):242-7.
7. Tubbs RS, Shoja MM, Loukas M, Lancaster J, Mortazavi MM, Hattab EM, et al. Study of the cervical plexus innervation of the trapezius muscle. J Neurosurg Spine. 2011;14(5):626-9.
8. Soo K-C, Hamlyn PJ, Pegington J, Westbury G. Anatomy of the accessory nerve and its cervical contributions in the neck. Head Neck Surg. 1986;9(2):111-5.
9. Pu YM, Tang EY, Yang XD. Trapezius muscle innervation from the spinal accessory nerve and branches of the cervical plexus. Int J Oral Maxillofac Surg. 2008;37(6):567-72.
10. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures: pre- and postoperative evaluation by CT scan. Clin Orthop Relat Res. 1994;(304):78-83.
11. Fuchs B, Weishaupt D, Zanetti M, Hodler J, Gerber C. Fatty degeneration of the muscles of the rotator cuff: assessment by computed tomography versus magnetic resonance imaging. J Shoulder Elbow Surg. 1999;8(6):599-605.
12. Tung TH, Mackinnon SE. Nerve transfers: indications, techniques and outcomes. J Hand Surg Am. 2010;35(2):332-41.
13. Kamath S, Venkatanarasimha N, Walsh MA, Hughes PM. MRI appearance of muscle denervation. Skeletal Radiol. 2008;37(5):397-404.
14. Zhang J, Zhang G, Morrison B, Mori S, Sheikh KA. Magnetic resonance imaging of mouse skeletal muscle to measure denervation atrophy. Exp Neurol. 2008;212(2):448-57.
15. 1Weber MA, Wolf M, Wattjes MP. Imaging patterns of muscle atrophy. Semin Musculoskelet Radiol. 2018;22(3):299-306.
16. Gerber C, Meyer DC, Flück M, Valdivieso P, von Rechenberg B, Benn MC, et al. Muscle degeneration associated with rotator cuff tendon release and/or denervation in sheep. Am J Sports Med. 2017;45(3):651-8.
17. Kim JH, Choi KY, Lee KH, Lee DJ, Park BJ, Rho YS. Motor innervation of the trapezius muscle: Intraoperative motor conduction study during neck dissection. ORL J Otorhinolaryngol Relat Spec. 2014;76(1):8-12.

DOI: http://dx.doi.org/10.1590/1413-785220202804229355

ORIGINAL ARTICLE

ELASTOGRAPHIC ANALYSIS OF THE SUPRASPINATUS TENDON IN DIFFERENT AGE GROUPS

ANÁLISE ELASTOGRÁFICA DO TENDÃO SUPRA-ESPINAL EM DIFERENTES FAIXAS ETÁRIAS

César Rubens da Costa Fontenelle[1], *Márcio Schiefer*[2], *Pietro Mannarino*[1,2], *Isac Borges Lacerda*[1], *Francisco José Thomé Machado*[1], *Raphael Gonçalves dos Santos Farias*[1], *Viviane Bastos de Oliveira*[3], *Liliam Fernandes de Oliveira*[3]

1. Universidade Federal do Rio de Janeiro, Hospital Universitário Clementino Fraga Filho, Orthopedic Trauma Service, Rio de Janeiro, RJ, Brazil.
2. Universidade Federal do Rio de Janeiro, Department of Orthopedics and Traumatology, Medical School, Rio de Janeiro, RJ, Brazil.
3. Universidade Federal do Rio de Janeiro, Biomed Engineering Program, Rio de Janeiro, RJ, Brazil.

ABSTRACT

Objective: To compare the mechanical properties of the supraspinatus tendon in different age groups using Supersonic Shearwave Imaging (SSI) elastography. Methods: We evaluated 38 healthy individuals of both genders, 20 being in the range of 20 to 35 years and 18 being over 60 years. The shear modulus of the supraspinatus tendon was measured by SSI elastography, always on the right side. Means between age groups were compared and statistically analyzed using the Shapiro-Wilk normality test followed by the student's t-test and were established as a statistically significant value of $p \leq 0.05$. Results: A statistically significant difference was observed when the mean values of the shear modulus of the supraspinatus tendon of young adults (23.98 ± 9.94 KpA) were compared with those of older adults (17.92 ± 6.17 KpA). Conclusion: We found a difference between the means of the shear modulus measured by the SSI elastography, showing a significant decrease of the shear modulus with the chronological age progression. ***Level of Evidence III, Diagnostic Studies – Investigating a Diagnostic Test.***

Keywords: Rotator Cuff. Shear Strength. Aging. Elasticity Imaging Techniques. Diagnostic Imaging.

RESUMO

Objetivo: Comparar as propriedades mecânicas do tendão supraespinal em diferentes grupos etários, utilizando a elastografia Supersonic Shearwave Imaging (SSI). Métodos: Foram avaliados 38 indivíduos saudáveis de ambos os sexos, sendo 20 na faixa de 20 a 35 anos e 18 acima dos 60 anos de idade. Foi aferido o módulo de cisalhamento do tendão supraespinal por elastografia SSI, sempre do lado direito. As médias entre os grupos etários foram comparadas e analisadas estatisticamente, sendo utilizado o teste de normalidade Shapiro-Wilk seguido do student t-test e estabelecido como valor de significância estatística um $p \leq 0,05$. Resultados: Foi evidenciada diferença estatisticamente significativa quando comparadas as médias do módulo de cisalhamento do tendão supraespinal dos adultos jovens (23,98 ± 9,94 KpA) com a dos idosos (17,92 ± 6,17 KpA). Conclusão: Houve diferença entre as médias do módulo de cisalhamento medido pela elastografia com SSI, demonstrando diminuição significativa do módulo de cisalhamento com a progressão da idade cronológica. ***Nível de Evidência III, Estudos diagnósticos – Investigação de um exame para diagnóstico.***

Descritores: *Manguito Rotador. Resistência ao Cisalhamento. Envelhecimento. Técnicas de Imagem por Elasticidade. Diagnóstico por Imagem.*

Citation: Fontenelle CRC, Schiefer M, Mannarino P, Lacerda IB, Machado FJT, Farias RGS, Oliveira VB, Oliveira LF. Elastographic analysis of the supraspinatus tendon in different age groups. Acta Ortop Bras. [online]. 2020;28(4):190-4. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Rotator cuff injuries, especially supraspinatus muscle tendon (SP), are among the most prevalent in upper limbs.[1] Its etiology is multifactorial, including degenerative, traumatic and inflammatory causes.[2] Yamamoto et al.[1] underwent ultrasonography of 1,366 individuals aged between 22 and 87 years (mean age 57.9 years) and observed a high prevalence of rotator cuff injuries, reaching 20.7%.[1] In addition to being very prevalent, such injuries may disable the individuals, because pain intensity can withdrawal they from sports and work activities.[2-4]

The prevalence of rotator cuff disease increases with age. Sher et al.5 underwent magnetic resonance imaging in asymptomatic individuals and found rotator cuff injuries in 4% of patients under 40 years old and in 54% of those aged 60 years or older.[5] Tempelhof et al.[6]

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

The study was conducted at the Universidade Federal do Rio de Janeiro.
Correspondence: Márcio Schiefer. Rua Nóbrega, 62, apto. 602, Niterói, RJ, Brazil, 24220320. marcioschiefer@hotmail.com

Article received on 09/29/2019, approved on 12/12/2019.

carried out shoulder ultrasonography of 411 asymptomatic volunteers and found a global prevalence of rotator cuff injury of 23%. This study also reported that the prevalence of this injury increased with age, with 13% of the individuals with 50 years or older, 20% in the sixth decade and 31% in the seventh decade.[6]

Although magnetic resonance imaging is the most widespread imaging method for assessing changes in rotator cuff tendons, elastrography has been shown to be as effective as the first in diagnosis and characterization of these alterations.[7,8] In a wide-ranging literature review, Washburn et al.[9] showed that elastography was used in studies of various structures, including the calcaneus, patellar, quadriciptal and rotator cuff tendons.[9]

There are two main modalities of elastography: compression (EC) and shear (ES). ES provides noninvasive estimation of tissue mechanical properties. The technique involves a mechanical disturbance in the tissue with an impulse of forces generating a shear wave, visualizing the displacements of tissue and then estimating the speed of the local shear wave (LSW), estimating the "flight time" of this wave. Soft tissue LSW measurements can be interpreted as an indirect evaluation of the shear modulus.[10]

When compared to isolated ultrasonography, ES potentially increases the sensitivity and diagnostic accuracy of tendinopathies, in addition to detecting pathological changes earlier, enabling the prediction of which tendons are at risk of injury and evaluation of the recommended treatments.[11]

Objective

This study aims to compare mechanical properties of the supraspinatus tendon in two distinct age groups, using the measurement of the tendon shear modulus by elastography.

MATERIALS AND METHODS

Sample

This study had the ethical guidelines analyzed by the Research Ethics Committee of the Hospital, with approval recorded by The Embodied Opinion No.1,674,064 of August 8, 2016. The volunteers were recruited by convenience sampling and 38 participants were divided into two groups: one of young adults aged between 20 and 35 years (n = 20) and the other for older adults over 60 years of age (n = 18). All subjects agreed to participate in the study signing a free and informed consent form. The groups are clearly distinct from each other. Studies aforementioned show that the prevalence of rotator cuff ruptures is low in under 40 years old individuals and high in those over 60 years of age. This fact was used as criterion for defining age groups.

Anamnesis and physical examination were performed in the candidates, and presenting the right upper limb as dominant was the inclusion criteria. Patients with current or previous shoulder symptoms, those with a history of diseases and/or previous shoulder surgeries, as well as those with known systemic disease were excluded. Patients with ultrasound evidence of supraspinatus rupture were also excluded.

Elastog raphy

For the shear modulus collection, the equipment (Figure 1) Aixplorer, v9 (Supersonic Shearwave Imaging, Aix-in-Provence, France), with Super Linear Transducer TM SL 10-2, width of 40mm, 256 pizoelectric elements, operating in the ranges of 2 to 10 MHz and lateral resolution of -6dB: 0.3mm was used. The participants were placed in the sitting position, with the back of the right hand resting on the lumbar region, to evidence the supraspintus tendon, with the left upper limb extended along the body, hips and knees flexed at 90º and feet supported to the ground (Figure 2).[12] The volunteers kept their muscles relaxed throughout the examination.

Figure 1. Ultrasound device with elastrography imaging activation mode. Aixplorer, v9 (Supersonic Shearwave Imaging, Aix-in-Provence, France).
Source: photo archive of the service.

Figure 2. Patient's exam positioning, sitting, with the back of the right hand resting on the lumbar region.

An experienced radiologist in the acquisition of musculoskeletal ultrasound images acquired the images using the transducer longitudinally to the fibers, adopting minimal compression and gel for the best acoustic coupling (Figure 3). A total of three images were acquired to determine the reliability of the method.[12] Before activating the elastography mode, supraspinatus tendon was assessed for its integrity and the best ultrasound image was chosen. Then elastographic mode was activated, with the elastogram in the range of 0-800-kPa. A rectangular, mapping area was selected, demonstrating the tendon boundaries and surrounding structures, positioned in the central region of the tendon (Figure 4).[13]

Figure 3. Transducer positioned longitudinally to supraspinatus fibers.

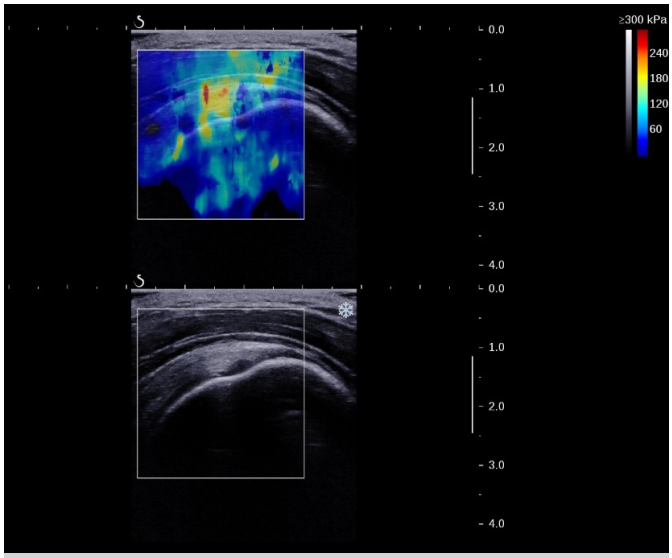

Figure 4. Elastographic image of the supraspinatus tendon, measured in kilopascal (kPa).

Image processing was implemented in a MATLAB routine (Mathworks, Massachusetts, USA), to estimate the shear modulus, measured in kilopascal (kPa). In this routine, a circle was manually traced in the mapping area, defining the central region of the tendon as a region of interest. The shear modulus was obtained from each region of interest in each image.

Statistical analysis

Intraclass correlation coefficient ($ICC_{2,1}$) was applied to evaluate the measurements reliability performed on the same day. The Shapiro-Wilk normality test was performed. After confirming the normality of the shear modulus, Student t-test was performed for independent samples comparing means of both young and older adults groups, as well as for the comparison between women and men. All statistical treatment was performed by the commercial package GraphPad Prism 5.0 (Graphpad software inc., USA) with 5% statistical significance.

RESULTS

$ICC_{2,1}$ estimation indicated reliable measurements (Table 1). A significant difference was found between the means of the supraspinatus tendon shear modulus of youth groups when compared to the older adults ($p = 0.033$) (Figure 5). The mean age in the groups of young and older adult was, respectively, 28.05 and 67.9 years. The group of young individuals was composed of four women and 16 men, while the older adults group was composed of 11 women and seven men. There was no significant difference in shear modulus found in women and men ($p = 0.891$) (Figure 6).

Table 1. Results of the calculation of the intraclass correlation coefficient (ICC) performed using a single rater, absolute agreement and two-way mixed effect model.

Measure	Intraclass correlation coefficient	95% confidence interval		F Test	
		Inferior Limit	Superior Limit	Value	P value
Shear Modulus	0.726	0.452	0.863	3.652	<0.001

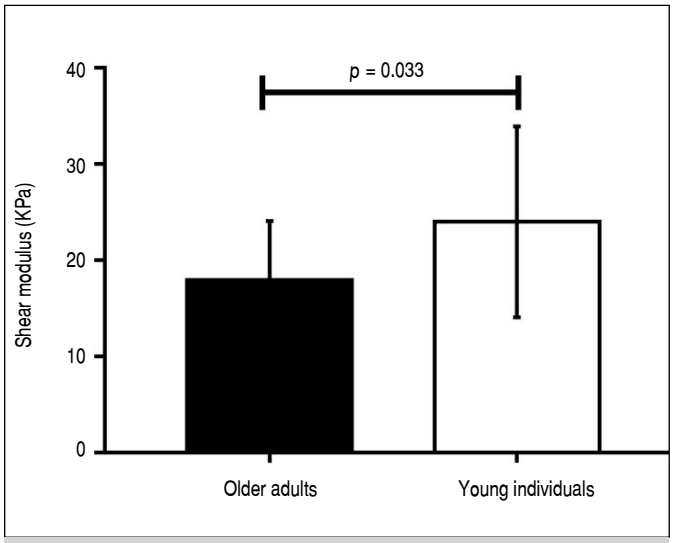

Figure 5. Mean and standard deviation of the shear modulus of older adults and young individuals ($p = 0.033$).

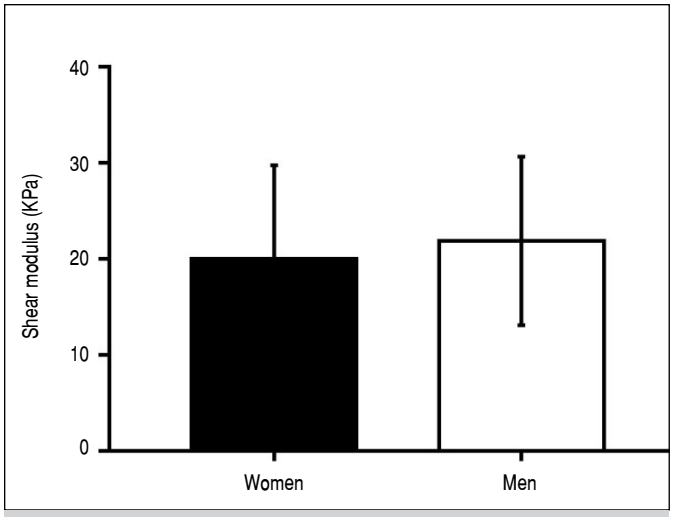

Figure 6. Mean and standard deviation of the shear modulus of women and men.

DISCUSSION

This study showed that the supraspinatus tendon shear modulus varies with advancing age. In fact, younger patients, between 20 and 35 years of age, presented a mean shear modulus of 23.28 ± 9.94 kPa, higher than in the group over 60 years of age, which was 17.92 ± 6.17 kPa. Thus, supraspinatus tendon was shown to have a larger, firmer shear modulus among young patients, while in older adults the tendon was less rigid. In fact, with aging, rotator cuff tendons undergo structural changes, such as loss of fibrillar pattern and microruptures, which decreases their compressive strength.[14] Consequently, the compression exerted by the transducer will cause greater tissue deformation, which was measured by the smaller tendon shear modulus in the group of individuals over 60 years of age. This finding agrees with previous studies. In a cadaveric study, Klauser et al.[15] observed a correlation between histological and sonographic findings of calcaneus tendons. They observed that the progression of tendon degeneration was accompanied by the "softening" of the tendon to elastography. Studies about supraspinatus tendon, such as ours, also revealed that degenerative tendinopathy is associated with greater capacity of tendon deformation during elastographic evaluation.[16-19] On the other hand, Baumer et al.[20] evaluated the influence of age on supraspinatus tendon shear modulus in individuals of different ages and observed that older individuals had stiffer tendons. However, unlike our study, the measurement was carried out in the intra-muscular portion of the tendon, which does not allow the isolated evaluation of the tendon itself, but also involves the muscle belly itself. In a study that correlated elastographic results with magnetic resonance findings, Lee et al.[21] also observed greater stiffness in tendons with tendon disease. However, differently from our study, the elastographic technique was based on the stretch ratio (*strain ratio*), in which the tendon elasticity is measured by taking the elasticity of another tissue as a reference, which may generate less accurate results.

A study with cadavers showed that aging can alter biomechanical properties of the myotendinous unit of the rotator cuff.[8] However, the identification of these changes *in vivo* is not yet well established. Although MRI is the most widely applied method to assess rotator cuff injuries, it is not able to provide accurate information on the mechanical properties of tendons. In this context, elastography can help in the evaluation of such properties. Lee et al.,[21] in 2015, showed that elastographic findings correlate with MRI findings in patients with rotator cuff tendinosis, but they did not include patients with tendon rupture. In 2014, Seo et al.,[22] compared the results of elastography with those of MRI and ultrasonography, finding a good correlation between methods. In 2017, Krepkin et al.,[23] conducted a pilot study comparing MRI images obtained on T2 with the findings of shear wave elastography, observing good correlation. In relation to MRI, elastography has some additional advantages. Besides being also a noninvasive method, it is easy to perform, relatively inexpensive and it can be carried out with the patient in a comfortable position, being more easily tolerated by them. Furthermore, elastography proved to be a reproducible method in different studies.[20,24]

The evaluation of the tendon mechanical properties can bring important information and practical implications. Extensive rotator cuff injuries may be irreparable and some prognostic factors are useful to identify these injuries, among which, patient's age, size of the injury, duration of symptoms, acromion-umeral distance less than seven millimeters, reduction of range of motion, muscle strength equal to or less than grade 3, intraoperative difficulties; surgeon's experience, patient expectation; atrophy and fatty infiltration of the muscle belly involved. Such factors are not definitive to determine the possibility and feasibility of repairing a given lesion, even when associated, as this information does not directly relate to the elasticity and/or stiffness of the ruptured tendon. Therefore, the estimation of the shear modulus can add information in determining the repair condition of a rotator cuff injury.[8] Moreover, some patients may present signs of rotator cuff dysfunction even without having complete injury of one or more tendons. They are patients whose tendons are inserted, but already have some degree of atrophy and fatty infiltration of the muscle belly. These patients may suffer dynamic rise of the umeral head, with secondary subacromial impact and worsening of anatomical tendons conditions. In these cases, by evaluating a mechanical property of the tendon, elastography can also bring valuable information before a tendon rupture occurs. A possible clinical application for this situation would be the preference for reverse to anatomical arthroplasty in a patient with shoulder arthrosis and rotator cuff tendons inserted, although very biomechanically compromised.[25]

Although there is still a lack of standardization to adequately evaluate the reproducibility of the results, elastography is very promising. Notably, tendons may have different elasticity modules.[26] Therefore, it would be necessary multiple studies like this, in a larger population, divided into age groups, so that a value of the shear modulus could be found for each group and thus quantify and qualify the aging of the tendon based on its stiffness.

Negative points and limitations should be highlighted in this study. The heterogeneous gender distribution between groups may have caused some result bias, since, for example, the mean shear modulus, having been lower in older adults, may have been caused by the fact that there were more female individuals in this group. However, the comparison of the shear modulus between men and women did not show significant difference. Another point would be the fact that SSI elastography is a method that measures only the shear modulus in anisotropic tissues, such as tendinous tissue, not contemplating other mechanical properties of the tendon. However, there is an intimate relationship between shear modulus and tissue stiffness, which allows further analysis of this important biomechanical valence with elastographic data.

CONCLUSION

The modulus of supraspinatus tendon shear was significantly higher in young people, suggesting deterioration of biomechanical properties of the tendon in older adults.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. CRCF: work conception, data interpretation and final critical review of the manuscript; MS: data interpretation and writing of the manuscript; PM: conception of work and data interpretation; IBL: selection of volunteers, data collection and review; FJTM: selection of volunteers, data collection and review; RGSF: selection of volunteers, data collection and review; VBO: examinations, statistical analysis and interpretation of results; LFO: work conception, results interpretation and final critical review of the manuscript.

REFERENCES

1. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg. 2010;19(1):116-20.
2. Murthi AM. Rotator cuff tears and cuff tear arthropathy. In: Lieberman JR, editor. AAOS comprehensive orthopaedic review. Rosemont: American Academy of Orthopaedic Surgeons; 2009. p. 817-26.

3. Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT 3rd, et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br J Sports Med. 2008;42(2):80-92.
4. Longo UG, Berton A, Ahrens PM, Maffulli N, Denaro V. Clinical tests for the diagnosis of rotator cuff disease. Sports Med Arthrosc Rev. 2011;19(3):266-78.
5. Sher JS, Uribe JW, Posada A, Murphy BJ, Zlatkin MB. Abnormal findings on magnetic resonance images of asymptomatic shoulders. J Bone Joint Surg Am. 1995;77(1):10-5.
6. Tempelhof S, Rupp S, Seil R. Age-related prevalence of rotator cuff tears in asymptomatic shoulders. J Shoulder Elbow Surg. 1999;8(4):296-9.
7. Yamaguchi K, Tetro AM, Blam O, Evanoff BA, Teefey SA, Middleton WD. Natural history of asymptomatic rotator cuff tears: a longitudinal analysis of asymptomatic tears detected sonographically. J Shoulder Elbow Surg. 2001;10(3):199-203.
8. Giambini H, Hatta T, Rezaei A, An KN. Extensibility of the supraspinatus muscle can be predicted by combining shearwave elastography and magnetic resonance imaging-measured quantitative metrics of stiffness and volumetric fat infiltration: a cadaveric study. Clin Biomech. 2018;57:144-9.
9. Washburn N, Onishi K, Wang JHC. Ultrasound elastography and ultrasound tissue characterisation for tendon evaluation. J OrthopTranslat. 2018;15:9-20.
10. Prado-Costa R, Rebelo J, Monteiro-Barroso J, Preto AS. Ultrasound elastography: compression elastography and shear-wave elastography in the assessment often do in injury. Insights Imaging. 2018;9(5):791-814.
11. Bercoff J, Tanter M, Fink M. Supersonic shear imaging: a new technique for soft tissue elasticity mapping. IEEE Trans Ultrason Ferroelectr Freq Control. 2004;51(4):396-409.
12. Baumer TG, Davis L, Dischler J, Siegal DS, van Holsbeeck M, Moutzouros V, et al. Shear wave elastography of the supraspinatus muscle and tendon: repeatability and preliminary findings. J Biomech. 2017;53:201-4.
13. Gennisson JL, Deffieux T, Fink M, Tanter M. Ultrasound elastography: principles and techniques. Diagn Interv Imaging. 2013;94(5):487-95.
14. Matsen FA 3rd, Titelman RM, Lippitt SB, Wirth MA, Rockwood CA. Rotator cuff. In: Rockwood CA, Matsen FA 3rd, Lippitt SB, Wirth MA, editors. The shoulder. 3rd ed. Philadelphia: Saunders; 2004. p. 812-7.
15. Klauser AS, Miyamoto H, Tamegger M, Faschingbauer R, Moriggl B, Klima G, et al. Achilles tendon assessed with sonoelastography: histologic agreement. Radiology. 2013;267(3):837-42.
16. De Zordo T, Chhem R, Smekal V, Feuchtner G, Reindl M, Fink C, et al. Real-time sonoelastography: findings in patients with symptomatic Achilles tendons and comparison to healthy volunteers. Ultraschall Med. 2010;31(4):394-400.
17. Kocyigit F, Kuyucu E, Kocyigit A, Herek DT, Savkin R, Aslan UB. Investigation of biomechanical characteristics of intact supraspinatus tendons in subacromial impingement syndrome: a cross-sectional study with real time sonoelastography. Am J Phys Med Rehabil. 2016;95(8):588-96.
18. Hou SW, Merkle AN, Babb JS, McCabe R, Gyftopoulos S, Adler RS. Shear wave ultrasound elastographic evaluation of the rotator cuff tendon. J Ultrasound Med. 2017;36(1):95-106.
19. Vasishta A, Kelkar A, Joshi P, Hapse R. The value of sonoelastography in the diagnosis of supraspinatus tendinopathy: a comparison study. Br J Radiol. 2019;92(1095):20180951.
20. Baumer TG, Dischler J, Davis L, Labyed Y, Siegal DS, van Holsbeeck M, et al. Effects of age and pathology on shear wave speed of the human rotator cuff. J Orthop Res. 2018;36(1):282-8.
21. Lee YH, Kim S, Lim D, Song HT, Suh JS. MR quantification of the fatty fraction from T2-corrected Dixon Fat/Water Separation Volume-interpolated Breathhold Examination (VIBE) in the assessment of muscle atrophy in rotator cuff tears. Acad Radiol. 2015;22(7):909-17.
22. Seo JB, Yoo JS, Ryu JW. Sonoelastography findings of supraspinatus tendon in rotator cuff tendinopathy without tear: comparison with magnetic resonance images and conventional ultrasonography. J Ultrasound. 2014;18(2):143-9.
23. Krepkin K, Bruno M, Raya JG, Adler RS, Gyftopoulos S. Quantitative assessment of the supraspinatus tendon on MRI using T2/T2 mapping and shear-wave ultrasound elastography: a pilot study. Skeletal Radiol. 2017;46(2):191-9.
24. Itoigawa Y, Sperling JW, Steinmann SP, Chen Q, Song P, Chen S, et al. Feasibility assessment of shear wave elastography to rotator cuff muscle. Clin Anat. 2015;28(2):213-8.
25. Steen BM, Cabezas AF, Santoni BG, Hussey MM, Cusick MC, Kumar AG et al. Outcome and value of reverse shoulder arthroplasty for treatment of glenohumeral osteoarthritis: a matched cohort. J Shoulder Elbow Surg. 2015;24(9):1433-41.
26. Coombes BK, Tucker K, Vicenzino B, Vuvan V, Mellor R, Heales L, et al. Achilles and patellar tendinopathy display opposite changes in elastic properties: a shear wave elastography study. Scand J Med Sci Sports. 2018;28(3):1201-8.

DOI: http://dx.doi.org/10.1590/1413-785220202804233440
Review Article

HEMIEPIPHYSIODESIS USING EIGHT-PLATE VERSUS BLOUNT STAPLE TO CORRECT GENU VALGUM AND GENU VARUM

HEMIEPIFISIODESE COM PLACA EM OITO VERSUS GRAMPO DE BLOUNT PARA CORREÇÃO DO GENO VALGO E GENO VARO

Natasha Vogel Majewski Rodrigues[1], *Roberto Guarniero*[1], *Paulo José Fortes Villas Boas*[2], *Bruno Rodrigues de Miranda*[3], *Nei Botter Montenegro*[1]

[1] *Universidade de São Paulo, Medical School, Institute of Orthopedics and Traumatology, Hospital das Clínicas, São Paulo, SP, Brazil.*
[2] *Universidade Estadual Paulista, Medical School, Botucatu, SP, Brazil.*
[3] *Faculdade de Medicina do ABC, Santo André, SP, Brazil.*

ABSTRACT

Objective: Our objective is to evaluate whether the use of guided growth with eight-plates is more effective than the use of Blount staples for the correction of the idiopathic genu varum or idiopathic genu valgum. Methods: A systematic review (SR) was carried out according to the appropriate methodology for randomized clinical trials (RCTs). We searched seven databases through a previously defined methodology, and we included RCTs, regardless of language, period of publication and status of publication. Results:Resulted in 6830 articles retrieved. Of theses, we identified 14 potential eligible studies. but just one RCT was included for the SR. The included RCT compares the eight-plate and the Blount staple and showed no statistically significant difference for the outcomes of time to correct the deformity, postoperative pain after 24 hours and postoperative pain after 72 hours. The study is of low or very low level of evidence to determine the most effective technique. We didn't find a RCT that compared the correction of the genu varum..Conclusion: Good quality randomized clinical trials comparing Blount staples versus eight-plaque must be performed to determine which technique is superior for coronal plane corrections. ***Level of Evidence I, Systematic review of Level RCTs.***

RESUMO

Objetivo: Avaliar se o uso do crescimento guiado com placas em oito é mais eficaz que os grampos de Blount na correção do geno varo idiopático ou geno valgo idiopático. Métodos: Foi realizada uma revisão sistemática (RS), de acordo com a metodologia apropriada para busca de ensaios clínicos randomizados (ECR). Pesquisamos em sete bancos de dados por meio de uma metodologia definida anteriormente e incluímos ECR, independentemente do idioma, período ou status da publicação. Resultados: Foram recuperados 6830 artigos. Destes, 14 estudos possivelmente elegíveis foram encontrados, mas apenas um ECR foi incluído para a RS. O ECR incluído compara placas em oito e grampos de Blount, não mostrando diferença estatisticamente significante para os resultados de tempo na correção da deformidade, dor pós-operatória após 24 horas e dor pós-operatória após 72 horas. O estudo é de nível baixo ou muito baixo de evidência para determinar a técnica mais eficaz. Não encontramos um ECR que comparasse a correção do geno varo. Conclusão: Ensaios clínicos randomizados de boa qualidade comparando grampos de Blount com oito placas devem ser realizados para determinar qual técnica é superior para correções do plano coronal. ***Nível de Evidência I, Revisão sistemática de ECRC.***

Keywords: Child. Adolescent. Genu Varum. Genu Valgum.

Descritores: *Criança. Adolescente. Genu Varum. Genu Valgo.*

Citation: Rodrigues NVM, Guarniero R, Villas Boas PJF, Miranda BR, Montenegro NB. Hemiepiphysiodesis using eight-plate versus Blount staple to correct genu valgum and genu varum. Acta Ortop Bras [online]. 2020;28(4):195-8. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Frequent complaint at orthopedic departments,[1] genu varum and genu valgum are asymptomatic coronal deformities physiologically present during the child's growth.[1] If pathological, they need correction to reduce psychosocial impact caused by symptoms that may vary from aesthetic discomfort to changes in gait patterns – which may cause difficulty running, knee pain, poor alignment, and patellar or ligament instability.[2] In the long term, this clinical picture may result in early joint degeneration, especially in genu varum deformities.[3]

The most frequent treatment was osteotomy. In 1933, Phemister was first described the hemiepiphysiodesis surgical procedure:[4] a surgery performed at the physeal level that stops growth in the region, which demands a precise timing calculation, as it is non-reversible. In 1945,

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

The study was conducted at Universidade de São Paulo, Medical School, Institute of Orthopedics and Traumatology, Hospital das Clínicas.
Correspondence: Natasha Vogel Majewski Rodrigues. Rua Ovídio Pires de Campos, 333, São Paulo, SP, Brazil, 05403010. natashavogel@hotmail.com

Article received on 01/23/2020, approved on 02/10/2020.

Haas[5] proposed slowing physeal growth with metal wires that, after being broken, would allow its growth to resume. Encouraged by Haas' studies,[5] Blount et al.[6] and Blount[7] described using staples for temporary restriction of longitudinal growth in children's physis, which forwent precise timing calculations before procedure.

Over time, less invasive surgical procedures, performed in shorter time and with lower complication rates, were created for patients with immature skeleton. The "tension band" by plate and screws, described by Peter Stevens in 2006, is currently the most used method.[8] Some authors report lower complication and faster correction rates,[2,9] whereas others highlight its high cost, which can be up to six times higher than staples.[10,11] Both procedures – the one by Blount et al.,[6] Blount[7] and the one by Stevens et al.[9] – are considered temporary methods that gradually correct knee angular deformities.

Although research show that both procedures effectively temporarily stop limb growth, it does not indicate which would be the preferred method. Some authors state that the eight-plate better compress the bone and the epiphyseal cartilage – which avoids extrusion in small children – and has a lower effect on the longitudinal growth of the bone. Others prefer using staples in patients without much remaining growth, as it speeds.[12]

This review aims to evaluate the efficacy of guided growth with eight-plates compared with Blount staples to correct idiopathic genu varum or genu valgum. Primary outcomes are improvement in quality of life; pain score using visual analog scale (VAS) or other knee related symptoms; improvement in limb alignment and function; and adverse events.

MATERIALS AND METHODS

Search strategy

We followed Cochrane guidelines, especially PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).[13] We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE (PubMed), EMBASE (OVID), LILACS (Latin American and Caribbean Health Sciences Literature), Web of Science, Scopus, and World Health Organization (WHO) databases for relevant studies until January 27, 2019. All relevant studies were identified, regardless of period, publication status and language. To guarantee all relevant study was included, we used specific search filters, such as Cochrane Highly Sensitive Search Strategies (HSSS).

Study selection

Retrieved studies were cataloged using EndNote X9.2. Duplicated studies were evaluated using online platform Rayyan QCRI. Two reviewers independently and separately analyzed and reviewed all study titles, abstracts, and keywords. Disagreements were solved through discussion and, whenever necessary, a third reviewer was consulted. We included all randomized controlled trials (RCT) that compared the use of eight-plate with Blount staples to treat idiopathic genu valgum and genu varum in children of both genders, aged 2-18 years old with open physis. For the purpose of this review, we excluded studies using other methods or techniques.

Types of outcome measures

Primary outcomes were improvement in quality of life; postoperative pain score using VAS or other knee related symptoms; improvement in limb alignment and function; and adverse events (material failure, reoperation rate, and superficial or deep infection).

Risk of bias assessment in included studies

Two reviewers (NVMR, BRM) independently analyzed the risk of bias in the included study using the Cochrane Collaboration's Risk of Bias tool,[14] assessing: random sequence generation; allocation concealment; blinding; similarity of baseline outcome measurements; similarity of baseline characteristics; blinding of outcome assessment; incomplete reporting; and other sources. Each of these criteria was explicitly judged by applying low risk of bias, high risk of bias, or unclear risk of bias (lack of precise information or uncertainty over potential bias).

Study quality assessment

We evaluated the overall strength of evidence to each result of the included study using GRADE (Grading of Recommendations Assessment, Development and Evaluation),[15] analyzing: inconsistency, imprecision, indirectness, risk of bias, and potential publication bias. When appropriated, the level of evidence was lowered by one, two, or three levels— from "high quality" to "moderate quality", "low quality", or "very low quality".

RESULTS

Study characteristics

We retrieved and cataloged 6830 papers. Of these, 1956 were duplicates, which left us with 4974 papers. After reading all titles and abstracts, we selected 14 potentially eligible studies, which were retrieved and read. Of these, we included only one RCT.[16] The flow diagram of this systematic review is depicted by Figure 1, as recommended by PRISMA.[13]

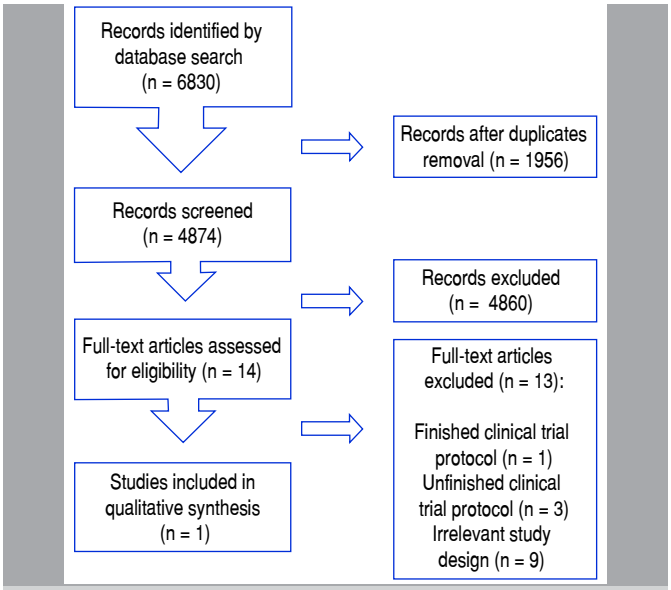

Figure 1. PRISMA flow diagram of the systematic review.

The study included compared both methods relevant in this systematic review: eight-plate and Blount staples. The study evaluated outcomes, total time for correction, and postoperative pain score using visual analog scale (VAS). It included 26 children aged 8-15 with estimated remaining growth of at least 6 months and bilateral genu valgum of at least 7 cm of intermalleolar distance. The study provided outcome data on treatment time of 20 randomized children: 11 boys and 9 girls. Postoperative pain score was evaluated in only 18 children.

Outcomes: total time for correction and percentage of patients with other interventions

The study analyzed correction time in days, counting from the surgery date until implants removal. The criterion for other interventions was intermalleolar distance after implant removal. Treatment time did not vary significantly between groups (340 ± 54 days versus 349 days ± 86 days, 95% CI, average difference of 9 days; P 0.78) (Figure 2).

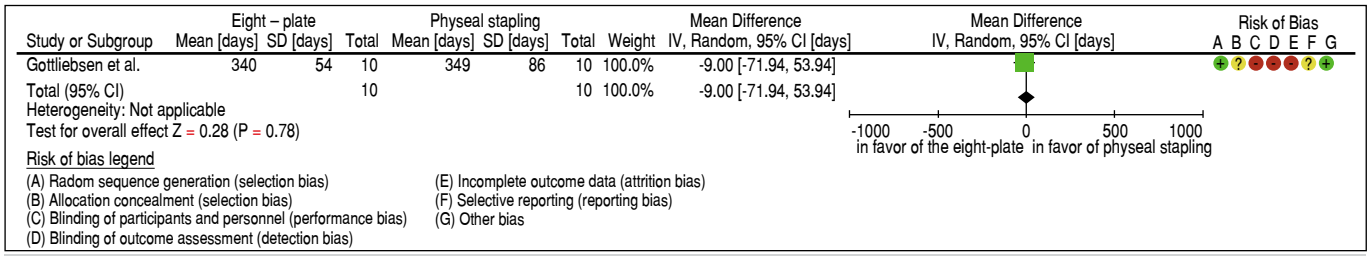

Figure 2. Comparison between two techniques: eight-plate and Blount staples.

Postoperative pain score – 24 hours, VAS (second outcome)

The study used visual analog scale (VAS) validated for children after lower-extremity surgery twice a day for 72 hours (charts were answered by parents). All patients received standardized postoperative pain treatment. We evaluated pain outcome 24 and 72 hours after surgery. Only 18 out of 20 children were evaluated by VAS, which resulted in no significant statistic difference between both groups ($p = 0.83$). In the eight-plate group, the average was 0.56 (minimum value 0.17; maximum value 0.78). In the Blount staples group, the average was 0.54 (minimum value 0.13; maximum value 0.82). However, the sample is underestimated and authors do not describe how patients were divided. Data on variability were not published (standard deviation or confidence interval).

Postoperative pain score – 72 hours, VAS (second outcome)

Only 18 out of 20 children were evaluated using VAS, which resulted in no significant statistic difference between both groups ($p = 0.66$). In the eight-plate group, the average was 0.25 (minimum value 0; maximum value 0.66). In the Blount staples group, the average was 0.30 (minimum value 0; maximum value 0.66). This sample is also underestimated, with no description of how patients were divided. Data on variability were not published (standard deviation or confidence interval).

Adverse events

The study did not observe adverse events such as implant failure, infection or physeal injury.

Risk of bias assessment

Table 1 describes the risk of bias assessment and Figure 3 the authors' judgement.

Table 1. Risk of bias.

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomization done by a third unaffiliated party, who mixed and randomly numbered the envelopes.
Allocation concealment (selection bias)	Unclear risk	Envelopes were mixed and randomly numbered for allocation concealment, but the study does not specify if the envelopes were opaque or sealed.
Blinding of participants and personnel (performance bias)	High risk	Participants and surgeons were not blinded.
Blinding of outcome assessment (detection bias)	High risk	Outcome assessments were not blinded.
Incomplete outcome data addressed (attrition bias)	High risk	Excluded participants did not alter proportion between groups, but there were not enough participants in each group to reach the minimum.
Selective reporting (reporting bias)	Unclear risk	Study protocol was published and all outcomes are described in this review. It lacks enough data to interpret VAS.*
Other potential sources of bias	Low risk	The study was not financed by private companies during or after completion.

Quality of evidence

For treatment outcome, we downgraded the level of evidence by one for risk of bias due to absence of blinding, incomplete follow-up and lack of analysis of intention-to-treat. We also downgraded the level of evidence to imprecise because both groups lacked the estimated sample size.[7]

For pain outcome, we lowered the level of evidence by two due to absence of blinding, incomplete follow-up, lack of analysis of intention-to-treat and selective reporting, as only 18 out of 20 children were evaluated. Although lacking statistic difference, the authors do not describe how patients were divided into groups. We also downgraded the level of evidence to imprecise because the study was completed using a smaller sample size. We concluded that the evidence is of low quality, meaning that confidence in effect is limited or of very low quality. Therefore, confidence in estimated effects is very limited, with an important level of uncertainty in findings.

Potential revision bias

We tried to reduce revision bias by comprehensive search for trials and adherence to our protocol (PROSPERO 2018 CRD42018086661). Even with a comprehensible search strategy, with no linguistic limitations, we may have missed some studies after checking the references of relevant papers. We contacted the author of the included study to retrieve unreported data and he provided supplementary information. We also contacted authors of unfinished studies, but received only one answer.

We found no RCT evaluating genu varum correction by eight-plate or Blount staples, which limited this review. We also need to address potential publication bias, which threatens the validity of systematic reviews, especially those that include few and small clinical trials (Figure 3).

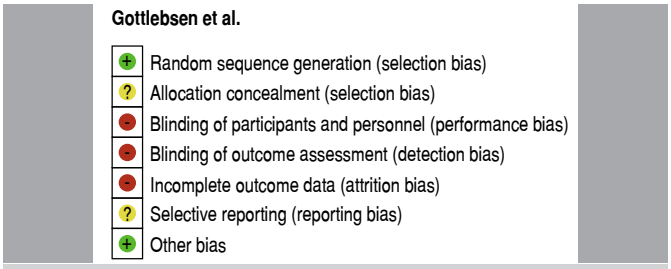

Figure 3. Risk of bias summary: review of authors' judgements about each risk of bias item for the study of Gottliebsen et al.[16]

DISCUSSION

Although the eight-plate is largely used to correct lower limb deformities, this systematic review shows the literature lacks enough randomized controlled trials with high levels of evidence to help establish the best technique to correct idiopathic genu valgum and genu varum.

Even if our systematic review is similar to some studies[12,17-19] on the similarities between both techniques, we must address some

limitations. First, its high risk of performance, detection, and attrition bias. Second, its low level of evidence for treatment time and third, the very low level of evidence for postoperative pain score 24 and 72 hours after surgery. Other studies[10,17] mention the high costs of the eight-plate; but correction with this method requires less surgical time[18] and is more surgeon-friendly. Radiation exposure[20] must also be considered when choosing an implant technique. Lastly, some important outcomes were unevaluated: quality of life; adverse events in all follow-up phases, including after implant removal for a long-term period; return to normal activities; postoperative rehabilitation; knee related symptoms; range of movement; ligament stability; personal satisfaction with physical appearance; surgical time; radiation exposure during surgery; and total costs of each procedure. An important exclusion criterion was the presence of associated deformities, for this might cause result misinterpretation.

CONCLUSION

More high quality RCTs comparing Blount staples and eight-plates to correct idiopathic genu varum and genu valgum are needed. We found no RCTs comparing both techniques to treat idiopathic genu varum in children. Scientific evidence based on randomized controlled trials is inadequate to decide which method is more efficient to correct idiopathic genu varum and genu valgum in children. More high quality RCTs are needed to help choose the best implant in each case. We suggest that future RCTs follow CONSORT guidelines and report data on outcomes of patients with adverse events.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. NVMR: study design and planning, data collection, bibliographic review, writing of the article, data interpretation, article review and final version approval; RG: article review, final version approval; PJFVB: data interpretation and final version approval; BRM: data interpretation, bibliographic review, article review and final version approval; NBM: article review and final version approval.

REFERENCES

1. Herring JA. Tachdjian´s pediatric orthopaedics. 4th ed. Philadelphia: Saunders Elsevier; 2008.
2. Stevens PM. Guided growth for angular correction: a preliminary series using a tension band plate. J Pediatr Orthop. 2007;27(3):253-9.
3. Sharma L, Song J, Dunlop D, Felson D, Lewis CE, Segal N, et al. Varus and valgus alignment and incident and progressive knee osteoarthritis. Ann Rheum Dis. 2010;69(11):1940-5.
4. Phemister DB. Operative arrestment of longitudinal growth of bones in the treatment of deformities. J Bone Joint Surg Am. 1933;15(1):1-15.
5. Haas SL. Retardation of bone growth by wire loop. J Bone Joint Surg Am. 1945;27(1):25-36.
6. Blount WP, Clarke GR. Control of bone growth by epiphyseal stapling: a preliminary report. J Bone Joint Surg Am. 1949;31A(3):464-78.
7. Blount WP. A mature look at epiphyseal stapling. Clin Orthop Relat Res. 1971;77:158-63.
8. Stevens PM. Guided growth: 1933 to the present. Strategies Trauma Limb Reconstr. 2006;1(1):29-35.
9. Stevens PM, Klatt JB. Guided growth for pathological physes: radiographic improvement during realignment. J Pediatr Orthop. 2008;28(6):632-9.
10. Burghardt RD, Herzenberg JE, Standard SC, Paley D. Temporary hemiepiphyseal arrest using a screw and plate device to treat knee and ankle deformities in children: a preliminary report. J Child Orthop. 2008;2(3):187-97.
11. Burghardt RD, Herzenberg JE. Temporary hemiepiphysiodesis with the eight--plate for angular deformities: mid-term results. J Orthop Sci. 2010;15(5):699-704.
12. Goyeneche RA, Primomo CE, Lambert N, Miscione H. Correction of bone angular deformities: Experimental analysis of staples versus 8-plate. J Pediatr Orthop. 2009;29(7):736-40.
13. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. PLoS Med. 2009;6(7):e1000097.
14. Higgins JPT, Green S, editors. Cochrane handbook for systematic reviews of interventions. London: The Cochrane Collaboration; 2011.
15. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336(7650):924-6.
16. Gottliebsen M, Rahbek O, Hvid I, Davidsen M, Hellfritzsch MB, Møller-Madsen B. Hemiepiphysiodesis: similar treatment time for tension-band plating and for stapling. Acta Orthop. 2013;84(2):202-6.
17. Wiemann JM 4th, Tryon C, Szalay EA. Physeal stapling versus 8-plate hemiepiphysiodesis for guided correction of angular deformity about the knee. J Pediatr Orthop. 2009;29(5):481-5.
18. Jelinek EM, Bittersohl B, Martiny F, Scharfstädt A, Krauspe R, Westhoff B. The 8-plate versus physeal stapling for temporary hemiepiphyseodesis correcting genu valgum and genu varum: a retrospective analysis of thirty five patients. Int Orthop. 2012;36(3):599-605.
19. Kumar A, Gaba S, Sud A, Mandlecha P, Goel L, Nayak M. Comparative study between staples and eight plate in the management of coronal plane deformities of the knee in skeletally immature children. J Child Orthop. 2016;10(5):429-37
20. Masquijo JJ, Lanfranchi L, Torres-Gomez A, Allende V. Guided growth with the tension band plate construct: a prospective comparison of 2 methods of implant placement. J Pediatr Orthop. 2015;35(3):e20-5.

DOI: http://dx.doi.org/10.1590/1413-785220202804224403
Review Article

ORTHOPEDIC RELATED COMORBIDITIES IN SPINAL CORD-INJURED INDIVIDUALS

ASPECTOS ORTOPÉDICOS NO PACIENTE LESADO MEDULAR

Rafaella Camilo de Oliveira[1], Laura Bellintani de Freitas[1], Roberta Rocha Gomes[1], Alberto Cliquet Júnior[2]

1. Universidade Estadual de Campinas, School of Medical Sciences, Campinas, SP, Brazil.
2. Universidade Estadual de Campinas, School of Medical Sciences, Department of Orthopedics and Traumatology, Campinas, SP, Brazil.

ABSTRACT

Objective: This study aims to review, identify and study the determinations of the main orthopedic aspects in SCI patients. Methods: A total of 80 articles from PUBMED and three theses (MSc. /DSc.) were examined. Results: The results refer to the most essential joints. There is a chronic overload on the shoulder girdle due to the use of the upper limb as a supporting joint. The elbow presents osteoarthritis, subclinical, acute and chronic pain, mainly in quadriplegic patients. In the hand and wrist joints there are cases of paralysis, osteoporosis and osteoarthritis. Hips are the main weight-bearing joints while sitting which leads to a substantial degenerative process of this joint. Lastly, on the knee, feet and ankles, spasticity, contractures, osteoporosis and deformities can arise. Conclusion: Along with the increase in cases and research that analyze the alterations that spinal cord-injured individuals suffer, it is necessary to recognize the orthopedic changes to understand their limits and identify the relevance of the rehabilitation program to improve the muscle performance. ***Level of Evidence II, Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease.***

Keywords: Quadriplegia. Spinal Cord Injuries. Chronic Pain.

RESUMO

Objetivo: O objetivo do estudo foi identificar, através de uma revisão sistemática, os aspectos ortopédicos e suas determinações nos pacientes lesados medulares. Métodos: Foram examinados 80 artigos na base Pubmed e três teses de mestrado e doutorado. Resultados: Os resultados obtidos referem-se às principais articulações. No ombro há uma sobrecarga crônica na cintura escapular devido ao uso como articulação de suporte. O cotovelo apresenta alterações osteocartilaginosas e dores subaguda, aguda e crônica principalmente no paciente tetraplégico. Nas articulações da mão e punho, a lesão leva à perda da capacidade de compressão por paralisia, osteoporose e osteoartrite. O quadril constitui a principal articulação de sustentação de peso quando sentado, ocorrendo um processo degenerativo importante nesses pacientes. Nos joelhos, pés e tornozelos surgem espasticidade, contraturas e osteoporose levando a deformidades. Conclusão: Devido ao aumento de casos e de pesquisas que analisam as alterações que os lesados medulares sofrem, se faz necessário o conhecimento das alterações ortopédicas do lesado medular para compreendermos a sua limitação e identificar a relevância do programa de reabilitação para melhora da performance muscular. ***Nível de Evidência II, Estudos Prognósticos – Investigação do efeito de característica de um paciente sobre o desfecho da doença.***

Descritores: *Quadriplegia. Traumatismos da Medula Espinal. Dor Crônica.*

Citation: Oliveira RC, Freitas LB, Gomes RR, Cliquet A Jr. Orthopedic related comorbidities in spinal cord-injured individuals. Acta Ortop Bras. [online]. 2020;28(4):199-203. Available from URL: http://www.scielo.br/aob.

INTRODUCTION

Spinal cord injuries (SCI) cause the loss of motor, sensory and autonomic functions below the injured level, damaging social, physical and psychological functions. Trauma is the most common cause of this condition. In Brazil, it mainly occurs due to car accidents, gunshot injuries and falls; the most affected group are males, aged 15 to 40 years. Morbidity characteristics of the disease further aggravate the patient's psychological condition,[1] as they frequently are younger and have an active lifestyle.

Spinal injuries lead to disuse of the affected limbs, which may generate spasticity, osteoarthritis, muscle hypotrophy, venous thrombosis, osteoporosis etc.

The number of cases of such injuries has been increasing, reaching almost 10,000 new cases per year in Brazil, a very high incidence

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

The study was conducted at Universidade Estadual de Campinas, School of Medical Sciences, Campinas, SP, Brazil.
Correspondence: Rafaella Camillo de Oliveira. Rua Reginaldo Sales, 97, Campinas, SP, Brazil, 13041780. rafaella.unicamp@gmail.com

Article received on 05/23/2019, approved on 02/10/2020.

when compared to other countries using WHO standards. The longer survival of victims of traumatic spinal cord injury is related to the training of multidisciplinary teams from first care to restructuring of the patient in society.[2] Due to this increase in cases, its study and treatment has been undergoing great technological and medical advances, with alternatives that improve quality of life. This study aimed to conduct a systematic review of the literature of the Laboratory of Biomechanics and Rehabilitation of the Locomotor Apparatus of the Universidade Estadual de Campinas (Unicamp) to identify the main orthopedic aspects in spinal cord injuries. The identification of such aspects in choice of treatment improves the quality of life of these patients.

MATERIALS AND METHODS

Between October and December 2018, we carried out a systematic review that included master's and doctoral theses defended in the Graduate Program in Surgery at FCM/Unicamp as well as articles available in the Pubmed databases on quadriplegic and paraplegic patients of the Spinal Rehabilitation Outpatient Clinic - HC. This type of review allows the study, evaluation and synthesis of the evidence already available on the subject. The indexing terms used were 'SCI'; 'pain'; 'tetraplegic'.

We raised 80 articles and 3 theses. Of these, we selected only those that contained orthopedic aspects of spinal cord injuries in their titles and abstracts. The articles and theses selected were fully read. Inclusion criteria were allusion to the spine, shoulders, elbows, wrists, hands, hips, knees, ankles and feet of those with spinal injuries. We excluded those that did not address the causes, consequences and repercussions of a spinal cord injury on the axial and appendicular skeleton as well as therapeutic proposals for these impacts.

RESULTS

Shoulder

Spinal cord injury patients are strictly dependent on their upper limbs to perform daily activities. Whether for wheelchair propulsion, body support or weight transfer. These patients use their upper limbs as supporting joints; as such, this daily requirement causes a chronic overload on the shoulder girdle, aggravated by the muscular weakness due to spinal injury itself, high body-mass index, prolonged injury time, and injury level.[3]

The main complaint of these patients is shoulder pain, whose etiology is multifactorial. The most affected structures are the supraspinatus tendon, bursae and the acromioclavicular joint (Figure 1).[3] Main pathologies of the shoulder include bursitis, rotator cuff rupture, tendinopathies, anterior instability, osteoarthrosis, osteonecrosis and osteoporosis of the acromioclavicular joint.[4] Tendinopathies and decreased acromioclavicular space are caused by mechanisms that have not yet been explained of change in blood supply in these areas.[4]

There is a distinction regarding the etiology of pain in the shoulders of patients with spinal injuries. Among the recently injured, pain is possibly related to the attempt of mobilization of the upper limbs unfit to their conditioning. Complaints in patients with longer injury time are usually related to overload of the osteoarticular system of the shoulder girdle.[5]

Pain may be present in subclinical, acute and chronic forms. All of them can be evidenced by radiography, a low-cost and efficient noninvasive method. If necessary, magnetic resonance imaging (MRI) can be performed to complement analysis.[5,6] Detection of lesions in early stages is essential for good prognosis of the upper limbs in patients with spinal injuries. On the other hand, shoulder strengthening, and stabilization of the scapula are important as preventive factors for major injuries. Sport is a very effective therapeutic proposal in developed scenarios.[6]

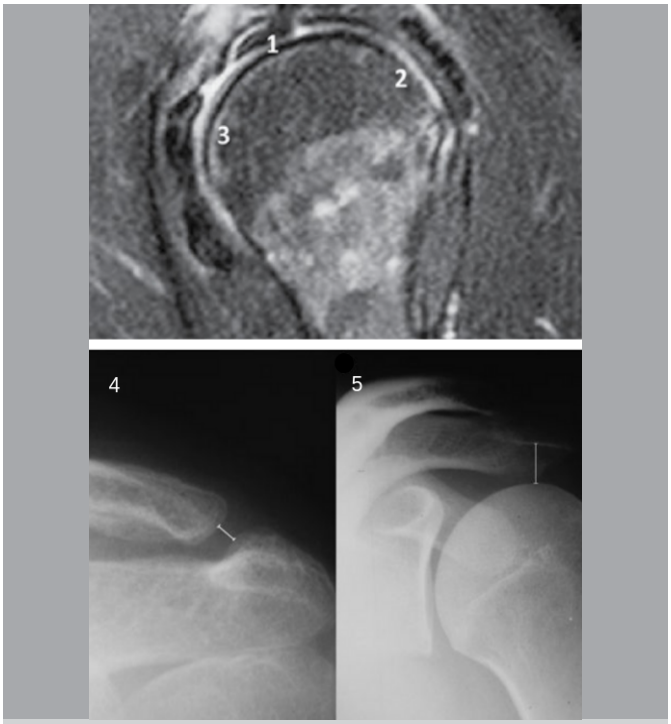

Figure 1. T2 sagittal section of the left shoulder. (1) Peritendinous hypersignal in the supraspinatus and liquid in the subacromial and subdeltoid bursa; (2) Infraspinatus ligament. X-ray of the left shoulder. Hypersignal of the rotator cuff, between the insertion of the supraspinatus; (3) and subscapular ligaments; (4) ACJ space: distance between the medial tip of the acromion and the lateral edge of the clavicle; (5) Acromio-umeral space.[5,6]

Elbow

The elbow is a relevant joint as it is responsible for the movement of the forearm and hand. Patients with spinal injuries with clinical and physical alterations in this joint become totally dependent on third parties.[7]

The prevalence of pain and injury to the elbows is reported in 5% to 16% of the literature. Many factors are capable of triggering elbow pain, among them ulnar mononeuropathy by nerve compression resulting in cubital tunnel syndrome – prevalent in 22%-45% of spinal cord injuries – osteoarthritis, lateral epicondylitis and olecranon bursitis.[8] The etiology of pain in these cases is described as a compilation of inflammatory, degenerative and hypertrophied processes resulting from the manifestation of the organism to protect against joint injuries by increasing its load.

Overload during transfers and in wheelchair use is the cause of the main clinical and anatomical changes, similarly to the shoulder. In one of the reviewed studies, we found that alterations commonly present as decreased active range of motion (ROM) and muscle and osteocartilaginous alterations (Figure 2b and 2c).

Quadriplegic patients have a significant loss of control and motor strength, besides presenting a lower range of motion than paraplegics.[7] A study shows that muscle function (dynamometry) of elbow extensors is better correlated with functional tests than elbow flexors. Thus, we can affirm that there is a predominance of independence of elbow extension. However, the extensor muscles of the forearm still have less strength than the flexors, especially in patients with high quadriplegic (C5-C6) (Figure 2a).[9]

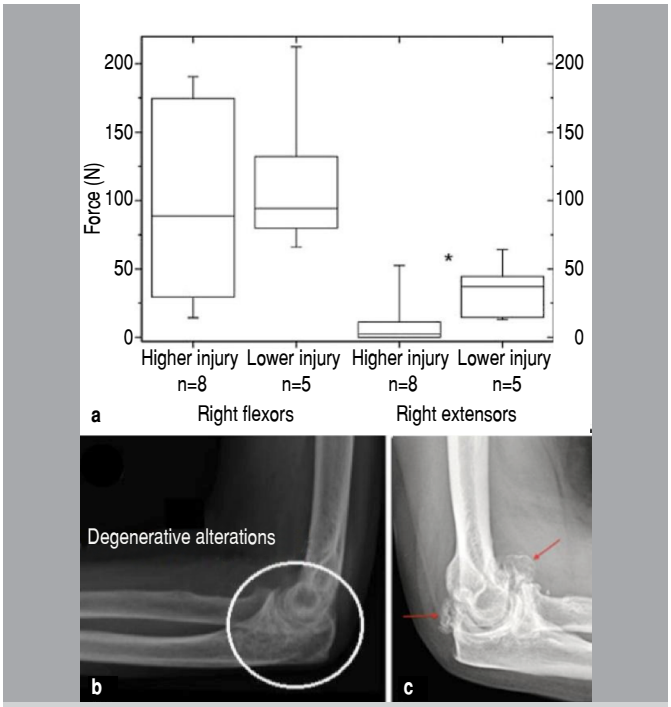

Figure 2. a: Strength measurements of the flexor and extensor muscles of the right upper limb in quadriplegic patients with high and low lesion; b: Presence of changes in the articular surface of the left elbow; c: Joint destruction and presence of free bodies (see red arrow).[7,9]

Hand and wrist

Hands are essential elements in planning, coordinating and executing daily activities with objects. After spinal cord injury there are ruptures and reorganizations of neuronal circuits in cervical vertebrae that lead to impairment of the upper extremities.[10] That is, the connection between the supraspinal centers and the muscles is lost, leading to paralysis of the upper limb and loss of movement, which results in the loss of independence. Lesions between C1-C4 result in loss of complete motor function of the upper limbs, while in C5 there is loss of function from the elbow to the distal end and in C6 only paralysis of the hands.[11]

In most cases, the patient has a certain degree of muscle strength that allows the positioning of the hand in space through shoulder and arm movements, but the hand grip function is compromised. Neuromuscular Electrical Stimulation (NMES) acts on the paralyzed muscles of the spinal cord injury and promotes rapid muscle fatigue, favoring joint movements and preventing joint stiffness.[12] This procedure can be used as a rehabilitation tool, enabling the return of movements such as holding and releasing objects. This can provide the return of the individual's activities and their independence. A research was carried out that evaluated the capacity of NMES with surface electrodes and concluded that it is possible to understand the muscles affected by fixed stimulation of an open circuit, in addition to demonstrating positive feedback from patients when exercising simple activities.[13]

Hips

In paraplegic or quadriplegic patients with spinal injuries, the hip is the main weight-bearing joint since these patients begin to use the wheelchair as the main mean of accommodation and locomotion. Therefore, the mechanical requirement, due to the axial load, is immense. At the same time, patients face the immobility inherent to the sitting position, which determines marked disuse of this joint, accelerating the degeneration and hindering rehabilitation.

Osteoarticular alterations observed are heterotopic ossification, which is the most prevalent, narrowing of the hip joint space, ectopic calcifications and morphological changes in the femoral head and acetabulum.[14]

An effective and low-cost method to monitor the wear on hips of a patient with spinal injuries is X-ray imaging.[4,15]

Early detection of symptoms can help a good prognosis and improve the quality of life of these patients in their daily activities and rehabilitation processes. For this reason, radiological monitoring of the hips of people who have suffered spinal injuries is suggested.[4]

Knee

In about 70% of spinal cord injuries there is a motor disorder due to involvement of the upper motor neuron, known as spasticity. Increased muscle tonus, stretch reflex and resistance to passive movement are debilitating consequences that worsen the quality of life of patients.[16] In contrast, spasticity delays atrophy when compared to other muscle groups.[17] Unfortunately, spastic symptoms are not adequately treated and diagnosed in the population with spinal cord injury, since they are diverse and their etiology uncertain. Knowledge of spastic alterations was approached in a study with patients with spinal injuries in order to evaluate how much the Pendular Test is influenced by posture, concluding that positions in which the rectus femoral muscle is more relaxed there is less spasticity. Meanwhile, supine and semi-supine postures increase blood pressure and pain in patients with injury above T6 (autonomic dysreflexia).[17] Another related study was prepared to evaluate the effect of neuromuscular electrical stimulation on spasticity in patients with spinal cord injury and concluded that it is effective by reducing spasticity, but with short duration. Figure 3a – before NMES, there are disorganized movements and less wave amplitude, explained by the absence of muscle control. While, in Figure 3b – after NMES, we can observe more coordinated movements and larger amplitudes, defined as decreased spasticity. The long-term effects of neuromuscular electrical stimulation have not been evaluated.

Considering the increase in life expectancy of patients with spinal injuries simultaneous to the advance of technological developments in therapy, researchers investigated whether the locomotor training program, capable of promoting gait, causes moderate and severe knee injuries. Since there are no complaints of pain in this joint in spinal cord injuries due to lack of sensitivity, it is necessary to use imaging tests to know probable changes. In this study, magnetic resonance imaging was the examination of choice. The authors concluded that patients undergoing training should be monitored in order to prevent future injuries. And that despite presenting abnormalities in MRI (Figure 3c and 3d), there was not enough pathological information to support the interruption of the training program.[14]

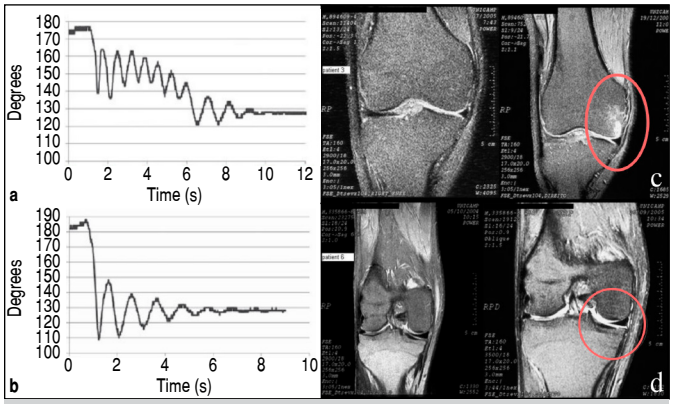

Figure 3. a: Graph representing the variation in degrees of spasticity in the pendular test before the NMES; b: Similar graph in 'a', but after NMES; c: MRI scan with contusion of the medial bone (red circle); d: MRI points to medial meniscus injury with internal decrease.[17,18]

Foot and ankle

The ankle is a joint formed by the distal articular surface of the tibia and foot. The heel bone is articulated with the foot and tarsal bones and its contact with the ground constitutes the posterior support of the foot. The tarsal bone is articulated anterior to the fourth and fifth metatarsals. The five metatarsal bones connect the tarsal bones to the phalanges, located distally. The articulation between the bases of the proximal phalanges and the metatarsal heads brings static and dynamic stability, along with muscular balance of the foot.[18]
The ankle is a fundamental joint for gait. Gait is the displacement of the body from one place to another. The foot also participates, since the friction between it and the ground modifies acceleration and deceleration, affecting gait.

There are few studies describing the changes in the feet and ankle of spinal injury patients. Spasticities, contractures and osteoporosis arise due to spinal cord injury and disuse of the limbs, which can lead to deformities.
The feet and ankles of spinal injury patients still have normal anatomical aspects, although there are alterations (Figure 4a and 4b). These are a consequence of the absence of tactile, proprioceptive and pain sensitivity. An example are overload ulcers, Charcot arthropathy (consequent of repetitive microtraumas), the accentuation of deformities due to muscle imbalances and fractures due to low bone density. The latter, known as osteoporosis, occurs due to the absence of mechanical stress and neurological and hormonal alterations. In the feet, mainly, this hinders the possibility of returning to walking.

A

	Normal angle (degrees)	Wider angle with tendency to the following deformities:	Narrower angle with tendency to the following deformities:
Hallux valgus	15	Hallux valgus	Hallux varus
Foot joints	9	Metatarsus varus	Metatarsus valgus
Anteroposterior Kite angle	30	Adduction	Abduction
Calcanean angle	30	Cavus/supine	Plane/prone
Lateral Kite angle	30	Cavus	Plane
Moreau-Costa-Bertani's angle	4 a -4	Cavus/supine	Plane/prone
Tibiocalcaneal angle	90	Calcaneous foot	Equine

B

Figure 4. A: deformities found in the feet and their relationship of angles with deviations; B: Bilateral flat feet.[12]

The use of NMES as a treatment allows patients to remain in an orthostatic position and thus perform movements, helping to keep the feet and ankles of spinal injuries planted and in an appropriate position for walking, which may lead to the reacquisition of autonomous gait.[12]

DISCUSSION

Due to the high medical and technological development, the life of these patients has changed profoundly in recent decades.[19] However, sequelae after spinal injuries bring several comorbidities that influence lifestyle.
Therefore, the understanding of the orthopedic aspects of each patient is fundamental for adaptation within the training and rehabilitation of the locomotor system. In this review, most of the anatomical and functional characteristics, as well as their alterations, were presented in order to discuss the relationship of the structure with the condition of the patient and all the main repercussions of a spinal cord injury.
Many pertinent aspects about the main structures of these conditions have not yet been fully explored, such as limb disuse of a quadriplegic or paraplegic patient and the mechanism of this impairment, as well as the most effective diagnostic methods and therapeutic proposals with lower associated cost. Considering that spinal cord injury is a delicate clinical condition and its traumatic expression is a public health problem in Brazil, greater scientific production on this subject is essential.

CONCLUSION

The correct and early diagnosis of possible malfunctions and subsequent intervention, whether with Neuromuscular Electrical Stimulation, physical therapy exercises and the practice of physical activity, are essential for the good prognosis of the patient.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. RCO: review of the study, bibliographic survey, review of bibliography, data collection, data analysis, writing, formatting; LBF: review of the study, bibliographic survey, review of bibliography, data collection, data analysis, writing, formatting; RRG: review of the study, bibliographic survey, review of bibliography, data collection, data analysis, writing, formatting; ACJ: review of the study and final approval of the study.

REFERENCES

1. Rabeh SAN, Caliri MHL. Capacidade funcional em indivíduos com lesão de medula espinhal. Acta Paul Enferm. 2010;23(3):321-7.
2. Mateo S, Roby-Brami A, Reilly KT, Rossetti Y, Collet C, Rode G. Upper limb kinematics after cervical spinal cord injury: a review. J Neuroeng Rehabil. 2015; 12:9.
3. Lins C, Castro A, Medina GIS, Azevedo ERFBM, Donato BS, Chagas MSS, et al. Alternative scapular stabilization exercises to target strength, endurance and function of shoulders in tetraplegia: A prospective non-controlled intervention study. J Spinal Cord Med. 2019;42(1):65-76.
4. Grynwald J, Bastos JML, Costa VBA, Rimkus CM, Cliquet A Jr. Radiographic assessment of hips in patients with spinal cord injury. Acta Ortop Bras. 2012;20(1):31-3.
5. Medina GIS, Nascimento FB, Rimkus CM, Zoppi Filho A, Cliquet A Jr. Clinical and radiographic evaluation of the shoulder of spinal cord injured patients undergoing rehabilitation program. Spinal Cord. 2011; 49:1055-61.

6. Alves AP, Terrabuio AA Jr., Pimenta CJ, Medina GIS, Rimkus CM, Cliquet A Jr. Clinical assessment and magnetic resonance imaging of the shoulder of patients with spinal cord injury. Acta Ortop Bras. 2012;20(5):291-6.
7. Casimiro FG, Oliveira GF, Tenório PHM, Gagliardi IC, Zoppi Filho A, Cliquet A Jr. Clinical and radiographic evaluation of elbows from spinal cord injuried patients. Acta Ortop Bras. 2016;24(2):77-80.
8. Paralyzed Veterans of America Consortium for Spinal Cord Medicine. Preservation of upper limb function following spinal cord injury: a clinical practice guideline for health-care professionals. J Spinal Cord Med. 2005;28(5):434-70.
9. Vargas Ferreira VM, Varoto R, Azevedo Cacho ÊW, Cliquet A Jr. Relationship between function, strength and electromyography of upper extremities of persons with tetraplegia. Spinal Cord. 2012;50(1):28-32.
10. Zariffa J, Steeves J, Pai DK. Changes in hand muscle synergies in subjects with spinal cord injury: characterization and functional implications. J Spinal Cord Med. 2012;35(5):310-8.
11. Hoshimiya N, Naito A, Yajima M, Handa Y. A multichannel FES system for the restoration of motor functions in high spinal cord injury patients: a respiration-controlled system for multijoint upper extremity. IEEE Trans Biomed Eng. 1989;36(7):754-60.
12. Bittar CK. Reabilitação de lesados medulares com estimulação elétrica neuromuscular: avaliação óssea e aspectos clínico e radiográfico dos pés e tornozelos [dissertation]. Campinas: Unicamp; 2011. 133 p.
13. Ferrari de Castro MC, Cliquet A Jr. Artificial grasping system for the paralyzed hand. Artif Organs. 2000;24(3):185-8.
14. Ferro FP, González HJN, Ferreira JM, Cliquet A Jr. Electrical stimulation and treadmill gait in tetraplegic patients: assessment of its effects on the knee with magnetic resonance imaging. Spinal Cord. 2008;46(2):124-8.
15. Cacho EWA, Oliveira R, Ortolan RL, Varoto R, Cliquet A Jr. Upper limb assessment in tetraplegia: clinical, functional and kinematic correlations. Int J Rehabil Res. 2011;34(1):65-72.
16. Azevedo ER, Maria RM, Alonso KC, Cliquet A Jr. Posture influence on the pendulum test of spasticity in patients with spinal cord injury. Artif Organs. 2015;39(12):1033-7.
17. Tancredo JR, Maria RM, Azevedo ERFBM, Alonso KC, Varoto R, Cliquet A Jr. Análise clínica da espasticidade em indivíduos com lesão medular. Acta Ortop Bras. 2013;21(6):310-4.
18. Novak EM, Giostri GS, Nagai A. Terminologia anatômica em ortopedia. Rev Bras Ortop. 2008;43(4):103-7.
19. Faria F. Lesões vértebro-medulares: a perspectiva da reabilitação. Rev Port Pneumol. 2006;12(1 Suppl. 1):S45-53.