ISSN 0102–3616

SBOT
SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

RBO

REVISTA BRASILEIRA DE ORTOPEDIA

VOLUME 56 • N° 4 • JULY/AUGUST 2021

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OPEN ACCESS

Thieme

ISSN 0102-3616

Brazilian Orthopaedic Journal

Indexed in PubMed/PubMed Central (2015), SciELO (2007), ScopusTM (2011), LILACS (1992) and affiliated to Associação Brasileira de Editores Científicos (ABEC).

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RBO
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ISSN 0102-3616

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Updating on Bone and Soft Tissue Sarcomas Staging*

Atualização no estadiamento dos sarcomas ósseos e das partes moles

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Rev Bras Ortop 2021;56(4):411–418.

Abstract

Bone and soft tissue sarcomas consist of a heterogeneous group of malignant tumors of mesenchymal origin that can affect patients from any age. The precise staging of these lesions determines the best therapeutic strategies and prognosis estimates. Two staging systems are the most frequently used: the system proposed by the University of Florida group, led by Dr. William F. Enneking (1980) and adopted by the Musculoskeletal Tumor Society (MSTS), and the system developed by the American Joint Committee on Cancer (AJCC) (1977), currently in its 8th edition (2017). This paper updates the reader on the staging of bone and soft tissue sarcomas affecting the musculoskeletal system.

Keywords
- neoplasm staging
- sarcoma
- neoplasms, connective tissue
- neoplasms, bone tissue
- diagnostic imaging
- pathology, surgical

Resumo

Os sarcomas ósseos e das partes moles consistem em grupo heterogêneo de neoplasias malignas de origem mesenquimal que podem ocorrer em qualquer faixa etária. O estadiamento preciso destas lesões determina as melhores estratégias terapêuticas e estimativas de prognóstico. Dois sistemas de estadiamento são os mais frequentemente empregados no manejo destas neoplasias: o sistema proposto pelo grupo da Universidade da Flórida, liderado pelo Dr. William F. Enneking (1980), adotado pela *Musculoskeletal Tumor Society* (MSTS) e o sistema desenvolvido pela *American Joint Committee on Cancer* (AJCC) (1977) que se encontra em sua 8ª edição (2017). O presente artigo busca atualizar o leitor a respeito do estadiamento dos sarcomas ósseos e das partes moles que acometem o sistema musculoesquelético.

Palavras-chave
- estadiamento de neoplasias
- sarcoma
- neoplasias de tecido conjuntivo
- neoplasias de tecido ósseo
- diagnóstico por imagem
- patologia cirúrgica

* Study performed at Oncologic Orthopedic Group, Orthopedic Service, Santa Izabel Hospital, Santa Casa de Misericórdia da Bahia, Salvador, BA, Brazil, and at the Traumatology and Orthopedics Service, Hospital Clementino Fraga Filho, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

received
September 25, 2019
accepted
February 20, 2020
published online
September 30, 2020

DOI https://doi.org/10.1055/s-0040-1710331.
ISSN 0102-3616.

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Introduction

Bone and soft tissue sarcomas affect, respectively, 1 and 5 subjects per 100,000 people/year. Together, they account for ~ 1% of all malignancies in humans.[1]

Since the most frequent clinical manifestations of bone and soft tissue sarcomas are pain and a mass at the affected segment, respectively, orthopedic surgeons often are the first specialists to evaluate affected patients. In case of clinical suspicion, specialized management, through appropriate imaging tests for staging and planning, in addition to a biopsy, will allow accurate and timely diagnosis and fast start of an adequate treatment, which is critical to preserve the affected limb and cure the disease.

By definition, sarcomas potentially develop metastases,[2] which impact the prognosis.

Staging consists in approaching the patient from the initial examination to the histological diagnosis and definitive classification of a tumor.[2]

For decades, staging has been a critical tool to estimate prognosis, support therapy-related decisions and stratify patients into risk categories for clinical trials.[2,3] The Union for International Cancer Control (UICC) defined the main goals of staging: guide therapeutic planning; estimate prognosis; help evaluate treatment outcomes; make interinstitutional communication effective; and contribute to scientific research.[4]

Cancer staging is considered essential for disease control.[5] Several systems have been described to stage primary malignant tumors of musculoskeletal system.[3–12] However, the system proposed by William F. Enneking et al. and adopted by the Musculoskeletal Tumor Society (MSTS)[6] and the system developed by the American Joint Committee on Cancer (AJCC)[8,9] are the most used in the clinical practice. The present paper aims to update the reader on bone and soft tissue sarcomas staging, using the Enneking/MSTS system[6] and the TNM classification (AJCC), in its 8th edition (2017).[8,9]

Role of Imaging and Pathology in Evaluating Bone and Soft Tissue Sarcomas

Musculoskeletal tumors are diagnosed in at least one of the following clinical scenarios: pain, bony prominence, palpable soft tissue mass, pathological fracture, or incidental finding on imaging studies.[12]

Clinical history and physical examination are often sufficient to raise suspicion on a musculoskeletal tumor, although radiographic examination is the most common test to reveal it.[13,14]

Imaging is used for detection, diagnosis and differential diagnosis, as well as evaluation (staging) of primary malignant musculoskeletal tumors.[13]

Conventional, orthogonal radiographs provide information regarding appearance, intraosseous extension, tumor matrix, and margins between the tumor and host bone. Cortical destruction and periosteal reaction are associated with invasive bone tumors.[14,15] In soft tissue tumors, radiographs allow the detection and definition of the mineralization pattern of a lesion, aiding the diagnosis/differential diagnosis with other tumors or pseudotumoral lesions (ossifying myositis, tumor calcinosis, vascular malformations, gout, extraskeletal mesenchymal chondrosarcoma, extraskeletal osteosarcoma, liposarcoma and synovial sarcoma); in addition, they reveal valuable information on tumor density (adipocytic tumors) and possible underlying bone involvement.[14,16]

In view of a bone or soft tissue lesion with clinical and radiographic characteristics denoting biological aggressiveness, additional imaging tests are required[12] to determine local extension, distant spread (metastases) and histological diagnosis (►**Figure 1**).

Local Staging

Local extension of a sarcoma is defined by the involved anatomical spaces. Understanding the relevant topographic anatomy is crucial to define the best therapeutic approach to each clinical situation.[17]

In appendicular segments, joint capsule and cartilage, cortex, periosteum fascial septa, muscle origins and attachments act as natural barriers to tumoral dissemination, defining compartments; a tumor confined to a compartment is considered intracompartmental, which is a stage below to a lesion surpassing such barriers to become extracompartmental. Sarcomas grow centrifugally through lower resistance areas and they are partially contained by a pseudocapsule, in which they can remain confined. Malignant cells, however, tend to extend themselves beyond these limits; if this occurs, but the tumor remains confined to a given anatomical compartment, the lesion is deemed extracapsular and intracompartmental; if the lesion invades an adjacent compartment, it is classified as extracompartmental.[18]

The multiplanar assessment and soft tissue enhancement provided by magnetic resonance imaging (MRI) or, if this modality is contraindicated or unavailable,[8,11] computed tomography (CT) with contrast media, made these imaging tests indispensable to local staging[19]; occasionally, MRI and CT can be requested together, as they provide additional information that helps delineating the lesions under study.[17] It is worth mentioning that these tests must be performed before biopsy to avoid artifacts interfering with image interpretation.[20]

Magnetic resonance imaging is considered superior to CT for the local staging of bone sarcomas and constitutes the mainstay in imaging evaluation of soft tissue sarcomas.[20] Regarding lesion morphology, the main factors for staging are size and local extension,[21] which are best assessed by gadolinium-enhanced MRI using advanced perfusion and diffusion techniques[19] to determine lesion configuration, location, depth, size and local extension, as well as its relationship with adjacent muscles, muscle compartments, fascial planes, neurovascular structures, joints and organs (►**Figures 2** and **3**).[15,18] It is mandatory to image the entire affected anatomical segment (whole bone) to define intramedullary involvement extension and identify eventual discontinuous bone tumors (skip metastasis), which presence has important prognostic implications.[6,11,14,15,20]

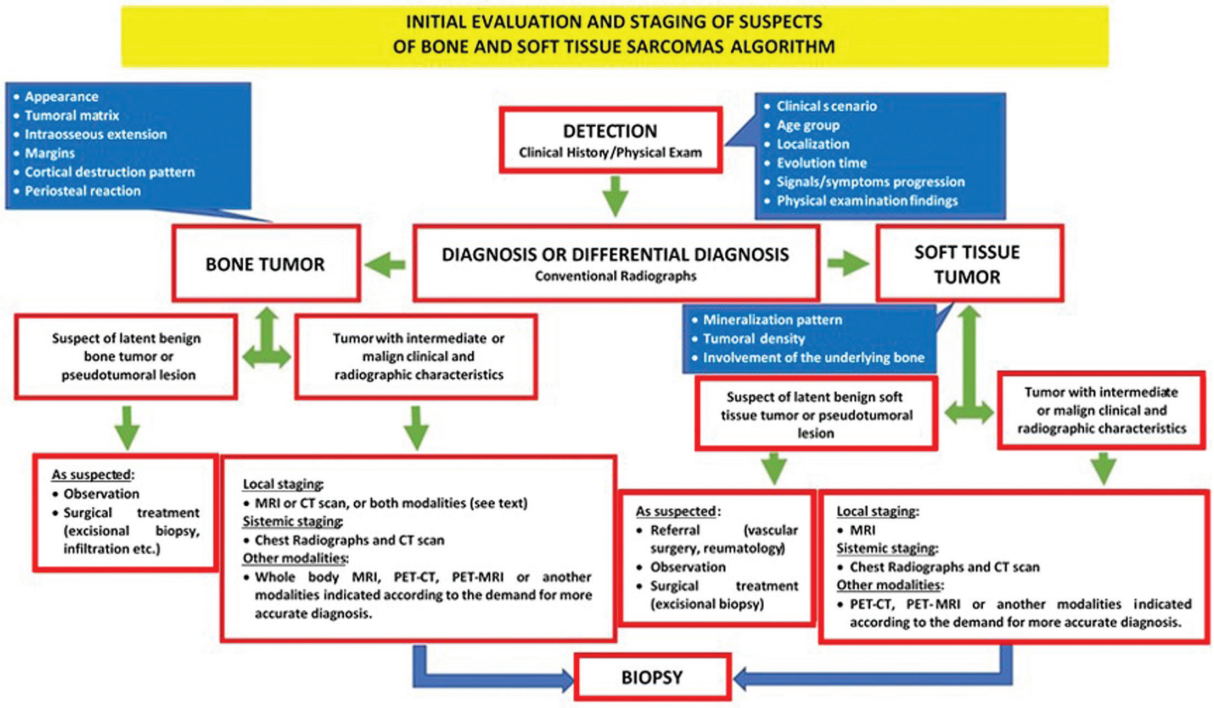


Fig. 1 Algorithm for initial evaluation and imaging staging of suspected bone and soft tissue sarcomas.

The choice for MRI or CT in bone sarcoma evaluation may be based on radiographic findings. In cases with cortical destruction and extracompartmental tumor, MRI is the preferred modality because it provides excellent soft tissue enhancement and it is better in determining extraosseous tumoral extension compared with CT.[19] Magnetic resonance imaging allows more accurate staging due to its multiplanar (sagittal, coronal, axial and oblique) imaging ability and the lack of CT-associated beam hardening artifacts from cortical bone.[19] Although rarely useful in specific diagnoses, CT is indicated when there is no radiographic evidence of tumor extension to soft tissues, as it improves calcification visualization, periosteal reaction detection, cortical subtle invasion or destruction and intraosseous extension determination.[3,19] Computed tomography is also useful to delineate tumors in complex anatomical structures such as the axial skeleton and the pelvic and scapular girdles, in addition to allow a better and more understandable demonstration of surface bone sarcomas, such as parosteal osteosarcoma or juxtacortical chondrosarcoma, through three-dimensional reconstruction.[19]

Systemic Staging

Distant spread is the main prognostic factor for bone and soft tissue sarcomas. Sarcomas have preferential hematogenous diffusion pathways, and the lungs and the skeleton are the most frequent sites for metastatic development. Although less frequent, lymphatic involvement has prognostic importance, and some histological subtypes of soft tissue sarcomas (such as synovial sarcoma, epithelioid sarcoma, clear cell sarcoma and angiosarcoma) usually affect locoregional lymph nodes.[14,22]

Lung evaluation uses chest X-rays in two views, and/or, preferably,[8] high-resolution chest CT, which is more sensitive for lesion detection.[2,11,14]

The National Comprehensive Cancer Network (NCCN) recommends abdominal and pelvic CT for staging some soft tissue sarcomas which tend to metastasize to those

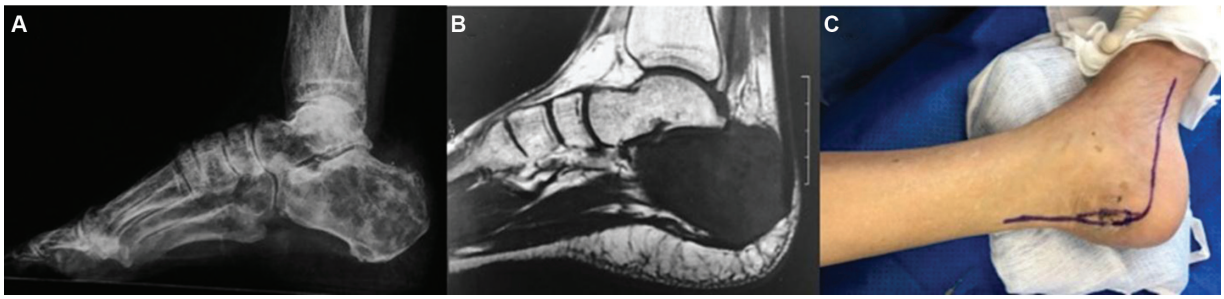


Fig. 2 Conventional calcaneal osteosarcoma. (**A**) Lateral radiography showing calcaneal lytic and sclerotic areas. (**B**) Sagittal magnetic resonance imaging in T1-weighted sequence showing diffuse hyposignal in the calcaneus with no extracompartmental tumor. (**C**) Surgical approach for calcaneus resection. Musculoskeletal Tumor Society (MSTS) staging, IA; American Joint Committee on Cancer (AJCC) staging, IIA.

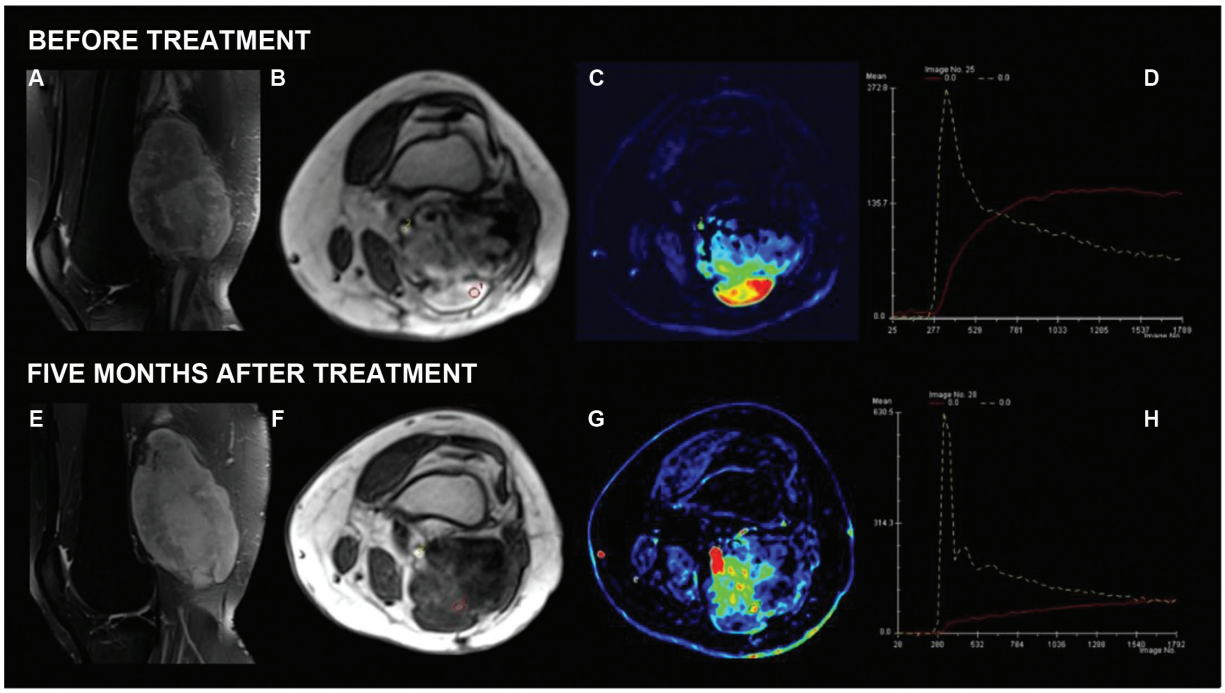


Fig. 3 High-grade pleomorphic sarcoma at the right knee. Proton density sequences with fat suppression in the sagittal plane before treatment (**A**) showing a heterogeneous lesion in the posterior compartment. Axial dynamic study (**B**) and color map (**C**) showing early enhancement in the posterior and superficial portion of the lesion (red line in **D**). Five months after treatment, a conventional magnetic resonance imaging does not show a significant change in lesion signal intensity (**E**). However, the dynamic axial study (**F**) and color map (**G**) show a change in the pattern of lesion enhancement (red line in **H**), indicating good therapeutic response. Histological analysis showed more than 90% of tumor necrosis. American Joint Committee on Cancer (AJCC) staging, IIIA.

sites, including myxoid liposarcoma, epithelioid sarcoma, leiomyosarcoma and angiosarcoma.[14,23,24]

Bone scintigraphy must be included in bone sarcoma staging to scan the skeleton for similar lesions or metastatic bone disease.[2,8] Bone scanning is not routinely indicated in the initial staging of soft tissue sarcomas.[14]

The routine indication of full body MR,[2] PET-CT[2,8] or PET-MR[2] it is still under scrutiny for bone and soft tissue sarcomas staging. However, when necessary, additional imaging modalities can be used to assess suspicious sites since the exact staging of the disease impacts the treatment and clinical outcome.[2]

Histological Diagnosis

Biopsy completes the clinical staging process,[8] confirming the diagnosis and determining the histological grade of the sarcoma through anatomopathological examination, complemented by immunohistochemistry and molecular biology when required.

In patients with suspected sarcoma, biopsy must be performed preferably at a referral center with expertise in treating this tumor.[8] Imaging evaluation must precede the biopsy.[8,20]

A tumor sample must be obtained through percutaneous biopsy with a core needle guided by the appropriate imaging method (ultrasound, CT, fluoroscopy, etc.), or incisional biopsy. Biopsy location must be carefully planned to allow resection of the entire path along with the surgical specimen at the time of definitive tumor resection.[8]

Subtype and histological grade may predict the tumor biological behavior, a variable with greatest impact on the risk for metastatic dissemination and overall survival.[11] The histological grade correlates with tumor cell proliferation pattern, mitotic activity and metastatic potential.

Histologically, sarcomas are classified as high or low grade according to cell atypia, number of mitosis figures, necrosis degree and vascularization.[22] Low-grade lesions often present lower biological activity, minimal metastatic potential, require less radical surgical treatment, and are not indicated for adjuvant chemotherapy and/or radiotherapy, since these treatments are usually ineffective due to reduced cell proliferation. On the other hand, high-grade lesions often require more radical local and systemic treatment due to their aggressive biological behavior.[22]

Musculoskeletal Tumor Society (MSTS) Staging System

In 1980, the MSTS adopted the surgical staging system for musculoskeletal system sarcomas created in Gainesville, 1977, by the University of Florida group led by Dr. William F. Enneking, from data collected between 1968 and 1976.[5,6] This system is based on the definition of tumor extension in relation to anatomical limits and histological grading, bringing together the most important prognostic factors in a concise classification to estimate survival, guide surgical treatment and indicate potential adjuvant therapies.[5,6] Since it is based on surgical observations, MSTS parameters are intuitive, facilitating operative planning. The MSTS staging

system is the most used system by orthopedic oncologists, but it is less employed in soft tissue sarcomas staging, especially by clinical oncologists, oncologic surgeons and other specialists.[11]

This system combines three variables: histopathological grade (I = low grade, II = high grade), local extension beyond the original compartment (A = intracompartmental, B = extracompartmental) and the presence of distant metastases (III) (►**Table 1**).[5,6] Low-grade (I) lesions correspond to Broder class 1 or 2 (low mitotic rate, low nucleus/cytoplasm ratio, limited pleomorphism, low risk [<25%] for metastases). High-grade lesions (II) correspond to Broder class 3 and 4 (mitotic figures, prominent nuclei, pleomorphism, higher incidence of metastases). Subcategories A (intracompartmental) and B (extracompartmental) are defined by imaging of the affected segment. Stage III represents any tumor with distant metastasis at imaging modalities.[5,6]

Staging determines surgical resection extension, considering the feasibility of obtaining adequate oncological margins. A high-grade lesion usually is more biologically aggressive and, therefore, it is more likely to invade surrounding tissues, increasing the risk for local recurrence and metastasis; in such cases, adjuvant therapies are recommended to eradicate tumor cells that would remain after surgical resection.[6]

The main disadvantages of the MSTS system are: 1. it does not include tumor size, implicated as an important prognostic factor for several subtypes of soft tissue sarcomas (larger lesions tend to have greater metastatic potential and may benefit from neoadjuvant chemotherapy)[5]; 2. it has limited discriminatory prognostic power for the intermediate strata due to its simplified variable dichotomization (histological degree, local and distant extension), tending to group most osteosarcomas and Ewing sarcomas at the same stage; osteosarcomas are usually classified as stage IIB; for Ewing sarcomas, the limitation is more evident because this is a high-grade malignancy and the histological grade is not a variable, preventing their classification as IA[10]; 3. skull-originated lesions have different clinical behavior and cannot be classified using this system[5]; 4. it does not consider the presence of a continuous epidural compartment in spinal tumors, a variable with neurological implications (possible spinal cord and spinal roots sacrifice and need for stabilization).[5]

American Joint Committee (AJCC) on Cancer Staging System

The staging system proposed by the AJCC for musculoskeletal sarcomas, since its original description as the Manual for Staging of Cancer (MSC) in 1977,[25] was updated and refined based on the evolution of scientific evidence on the prognosis and survival associated with such tumors.

Primary Malignant Bone Tumors Staging (AJCC)

The MSC, on its 1st edition (1977),[25] recommended a protocol for primary malignant bone tumors developed by the Task Force On Primary Malignant Bone Tumor to record patient identification, history, clinical data, imaging (radiographs), pathological reports, histological (World Health Organization [WHO] classification of primary bone tumors and pseudotumor lesions) and recurrences or metastases during follow-up. It did not indicate a specific system for sarcoma staging, but it suggested that prospective clinical studies, with a greater number of cases, would allow the creation of a satisfactory clinical classification for staging and outcomes recording in the future.

Starting at its 2nd edition[26] (1983), the MSC included a system for staging such tumors based on the TGNM method: tumor size (T), histological grade (G), presence or not of regional lymph node metastasis (N) and presence or not of distant metastasis (M). At this point, stages were already defined (IA, IB, IIA, IIB, III, IVA, IVB), and a prognostic grading was attributed based on the combined evaluation of these variables.

Up to its 6th edition (2002),[21] the MSC defined tumor extension as contained or not in the host bone, like the Enneking/MSTS system. The size of eight centimeters became the cutoff point between the T1 and T2 designations, replacing tumor extension classification as intra- or extracompartmental. The choice was controversial[27] because it was based on the literature regarding Ewing sarcoma, limited to osteosarcoma. Later studies confirmed its value in Ewing sarcoma staging[28] and, to date, the MSC recommends that the size of nine centimeters is the best prognostic indicator for osteosarcoma. The addition of the T3 designation for skip metastasis[9,16] was another modification – Wuisman et al.[29] compared 224 patients without skip metastasis at diagnosis with 23 patients who presented such lesions. Twenty two of these 23 individuals had local recurrence or distant

Table 1 Staging system adopted by the Musculoskeletal Tumor Society for malignant musculoskeletal tumors based on the surgical degree, local extension and the presence or not of metastases

Stage	Grade	Site	Metastasis
IA	Low (G1)	Intracompartmental (T1)	M0
IB	Low (G1)	Extracompartimental (T2)	M0
IIA	High (G2)	Intracompartimental (T1)	M0
IIB	High (G2)	Extracompartmental (T2)	M0
III	Any G	Any T	Regional or distant metastasis

Source: Enneking et al.[6]

metastasis and died; adjuvant chemotherapy did not improve their prognosis. The 3rd update consisted of differentiating metastases according to location, distinguishing between pulmonary (IVA) and extrapulmonary (IVB) lesions based on evidence that bone sarcomas with pulmonary metastases had better prognostic compared to those with metastases at other sites[30,31]–multiple lung metastases were associated with a worse prognosis, although this variable was not included in any staging system.[11,30]

In its 7th edition (2010), the MSC[32] restricted the definition of stage III only to grade 3 (poorly differentiated) and grade 4 (undifferentiated) tumors. The same staging was employed, regardless of the primary site, for bone and soft tissue sarcomas.

The 8th (current) MSC edition,[9] published in 2017, brought new changes. The main one was the inclusion of defined axial skeleton segments as part of the (T) classification, with three sites for bone sarcomas: (i) appendicular skeleton, trunk, skull and facial bones; (ii) spine and (iii) pelvis. Although it does not affect tumor staging, this inclusion allowed the determination of a structure for future research to improve the system – studies have shown evidence that bone sarcomas with axial location have markedly worse prognosis.[33]

Bone and soft tissue sarcomas have been described separately, according to primary sites, mainly due to differences in prognosis and treatment strategy (►**Table 2**). The histopathological grade (G) was also changed, from four to three levels, with stage III reserved for G2-G3 (high grade tumors) and eliminating the G4 designation, as recommended by the American College of Pathologists, which uses the system from the *Fédération Nationale des Centers de Lutte Contre le Cancer* (FNCLCC) to classify soft tissue sarcomas.[9] This change provided uniformity to bone and soft tissue sarcomas classification.[11]

Soft Tissue Sarcoma Staging (AJCC)

The AJCC staging system for soft tissue sarcomas is the most used to stratify prognoses and define the approach to these tumors. It considers additional factors to estimate prognosis and enables better interdisciplinary communication. In contrast to bone sarcomas, which have few histological subtypes, the numerous subtypes of soft tissue sarcomas require a more complex staging.[11]

Since its 1st edition (1977),[25] the MSC included the TGNM system for staging these tumors; based on the combined assessment of these variables, stages IA, IB, IIA, IIB, IIIA, IIIB, IIIC, IVA and IVB were defined, each with an assigned prognostic score. This classification remained in its 2nd edition (1983)[26] and presents gradual changes since the 3rd edition (1988)[34] to reflect new clinical evidence.

The AJCC manual, in its 6th edition,[21] considered angiosarcoma and malignant mesenchymoma as exceptions and removed them, while gastrointestinal stromal tumor (GIST) and Ewing soft tissue sarcoma were added. Moreover, G1-2, T2b, N0 M0 tumors were reclassified as stage I instead of stage II.

In its 7th edition, the AJCC manual[32] removed fibromatosis, Kaposi sarcoma, infantile fibrosarcoma and GIST from the system. N1 disease was reclassified as stage IIIB instead of stage IV based on level IV evidence – the classic study by Fong et al.[35] demonstrated that patients with soft tissue sarcomas and positive lymph nodes have a survival rate similar to those with locally advanced disease, but better than those with distant metastases.[35–37] The histological grading system was also changed to three levels, as recommended by the College of American Pathologists, based on level II evidence that the FNCLCC system predicts survival with significant accuracy.[38] The tumor depth variable was also removed from the classification for staging and prognosis determination[11]; the recommendations for describing tumors as superficial or deep to the fascia were maintained, but considered irrelevant in staging. Rydholm et al.[39] showed that depth was a prognostic factor when analyzed regardless of tumor size. Since other studies suggested worse survival with deeper tumors, it remained part of the staging process for soft tissue sarcoma for decades; however, when more detailed analyzes were performed, depth proved to be a variable of confusion,

Table 2 American Joint Committee on Cancer (AJCC) classification for bone sarcomas. Prognostic stage groups for bone sarcomas in the appendicular skeleton, trunk, skull and facial bones (there are no AJCC prognostic stage groups for spinal and pelvic tumors)

Stage	Primary tumor (T)	Regional lymph node (N)	Distant metastasis (M)	Histological grade (G)
IA	T1	N0	M0	G1 or GX
IB	T2 or T3	N0	M0	G1 or GX
IIA	T1	N0	M0	G2 or G3
IIB	T2	N0	M0	G2 or G3
III	T3	N0	M0	G2 or G3
IVA	Any T	N0	M1a	Any G
IVB	Any T	N1	Any M	Any G
	Any T	Any N	M1b	Any G

Abbreviations: G1, Well-differentiated, low-grade tumor; G2, moderately differentiated, high-grade tumor; G3, poorly differentiated, high-grade tumor; GX, the grade cannot be determined; M0, without distant metastases; M1a, distant metastases (lung); M1b, distant metastases (bones or other distant sites); N0, without regional lymph node metastases; N1, regional lymph node metastases; T0, there is no evidence of a primary tumor; T1, tumor $\leq$ 8cm; T2, tumor $>$ 8 cm; T3, discontinuous tumors at the primary bone site; TX, the primary tumor cannot be accessed.
Source: Amin MB, Edge S, Greene F, Byrd DR, Brookland RK, Washington MK, et al., eds. AJCC Cancer Staging Manual. 8th ed. Switzerland: Springer; 2017.[8]

Table 3 American Joint Committee on Cancer classification for soft tissue sarcomas located on the trunk and extremities. Prognostic stage groups

Stage	Primary tumor (T)	Regional lymph node (N)	Distant metastasis (M)	Histological grade (G)
IA	T1	N0	M0	G1, GX
IB	T2, T3, T4	N0	M0	G1, GX
II	T1	N0	M0	G2, G3
IIIA	T2	N0	M0	G2, G3
IIIB	T3, T4	N0	M0	G2, G3
IV	Any T	N1	M0	Any G
	Any T	Any N	M1	Any G

Abbreviations: G1, total differentiation, mitotic count and necrosis score 2 or 3; G2, total differentiation, mitotic count and necrosis score 4 or 5; G3, total differentiation, mitotic count and necrosis score 6, 7 or 8; GX, the grade cannot be determined; M0, without distant metastases; M1, distant metastases; N0, without regional lymph node metastases or unknown lymph node status; N1, regional lymph node metastases; T0, there is no evidence of a primary tumor; T1, tumor $\leq$ 5 cm in its largest dimension; T2, tumor $>$ 5 cm and $\leq$ 10 cm in its largest dimension; T3, tumor $>$ 10 cm and $\leq$ 15 cm in its largest dimension; T4, tumor $>$ 15 cm in its largest dimension; TX, the primary tumor cannot be accessed.
Source: Amin MB, Edge S, Greene F, Byrd DR, Brookland RK, Washington MK, et al., eds. AJCC Cancer Staging Manual. 8th ed. Switzerland: Springer; 2017.[8]

because size is the true independent factor associated with worst prognosis.[33]

The 8th MSC edition (2017)[9] describes four tumor sites for soft tissue sarcomas: (i) extremities and trunk; (ii) retroperitoneum; (iii) head and neck and (iv) visceral sites. All references to lesion depth were removed[6] due to level II evidence published by Maki et al[23] confirming that this variable was not an independent risk factor after multivariate analysis. Another modification was to increase the number of tumor size categories from two ($\leq$5 cm or $>$5 cm) to four ($\leq$5 cm, $>$5/$\leq$ 10 cm, $>$10/$\leq$ 15 cm, $>$15 cm). The decision to group T3 and T4 ($>$10/$\leq$ 15 cm and $>$15 cm) in stage IIIB was corroborated by level II evidence from a study involving 1,091 patients that showed that tumors sized $\leq$5 cm, $>$ 5/$\leq$ 10 cm and $>$15 cm have markedly different mortality rates; this study showed no significant difference in survival between categories $>$5/$\leq$ 10 cm and $>$10/$\leq$ 15[40,41]; nevertheless, a size categorization in four levels was included according to data published by Maki et al,[23] who demonstrated significant differences in local recurrence free global survival between the four groups and a survival plateau in 10 cm tumors. This finding was supported by a recent study, in which nomograms were used to predict overall survival; for any unit change in tumor size $>$10 cm, there was a markedly lesser effect on survival when compared with the effect on tumor survival $<$10 cm.[24] In this same edition, N1 disease associated with trunk and extremities tumors was reclassified as stage IV, probably because their prognosis is closer to any TN0M1 metastatic disease than any TN0M0; these cases, however, remain as IIIB for tumors located at other sites[41] (►**Table 3**).

Final Considerations

The domain of knowledge about the staging systems for bone and soft tissue sarcomas, as well as imaging, diagnostic methods and histological grading for classifying such tumors, is critical not only for specialists directly involved in the treatment of affected patients, but also for orthopedic surgeons who are often responsible for their first care, which quality has the potential to interfere with the clinical outcome.

Conflict of Interests

The authors have no conflict of interests to declare.

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Extremities Soft Tissue Sarcomas, more Common and as Dangerous as Bone Sarcomas*

Sarcomas de partes moles nos membros, mais comuns e tão graves quanto os sarcomas ósseos

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Rev Bras Ortop 2021;56(4):419–424.

Abstract

Musculoskeletal sarcomas are rare diseases that require attention. They often present high degree of malignancy at diagnosis and, if underestimated, they can evolve aggressively locally and systemically. They present as soft tissue sarcoma and bone sarcomas, with soft tissue being four to five times more common. Most soft tissue sarcomas occur in the extremities. The most common subtypes in children and adolescents are rhabdomyosarcoma and synovial sarcoma; in adults, undifferentiated pleomorphic sarcoma, liposarcoma, leiomyosarcoma, myxofibrosarcoma and synovial sarcoma; all with a high degree of histological malignancy. Many soft tissue sarcomas are confused with benign soft tissue tumors, 100 times more common, so they are resected without the necessary planning, resulting in amputation of a limb that could have been preserved. As in all cancers, the most important prognostic factor is metastatic disease. When it is present, the overall survival rate falls around 20 to 30%. Survival rates are generally similar between bone and soft tissue sarcomas. So soft tissue sarcomas, in addition to being more prevalent, are as aggressive as bone sarcomas, deserving a lot of attention from orthopedic surgeons, who are often the first line of care of carriers of these tumors.

Keywords

- epidemiology
- early detection of cancer
- metastasis
- neoplasm
- bone tissue
- prognostic factors
- soft tissue sarcoma

Resumo

Os sarcomas musculoesqueléticos são doenças raras que exigem atenção. Frequentemente, apresentam alto grau de malignidade ao diagnóstico e se subestimados podem evoluir de forma agressiva local e sistemicamente. Apresentam-se como sarcoma de partes moles e sarcomas ósseos, sendo os de partes moles quatro a cinco vezes mais comuns. A maioria dos sarcomas de partes moles ocorre nos membros. Os subtipos mais comuns nas crianças e adolescentes são o rabdomiossarcoma e o sarcoma

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received
September 24, 2019
accepted
February 20, 2020
published online
September 25, 2020

DOI https://doi.org/10.1055/s-0040-1712136.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Palavras-chave
- epidemiologia
- detecçãoprecoce de cancer
- metástase
- neoplasia
- tecidoósseo
- fatoresprognósticos
- sarcoma de tecidos moles

sinovial, nos adultos o sarcoma pleomórfico indiferenciado, lipossarcoma, leiomiossarcoma, mixofibrossarcoma e sarcoma sinovial; todos de alto grau de malignidade histológica. Muitos sarcomas de partes moles são confundidos com tumores benignos de partes moles, 100 vezes mais comuns, por isso são ressecados sem o planejamento necessário, acarretando amputação de um membro que poderia ter sido preservado. Como em todos os cânceres, o fator prognóstico mais importante é a doença metastática. Na sua vigência, a taxa de sobrevida global cai em torno de 20 a 30%. As taxas de sobrevida no geral são parecidas entre os sarcomas ósseos e de partes moles. Portanto o sarcoma de partes moles, além de mais prevalente, mostra-se tão agressivo quanto os sarcomas ósseos. Por isso merece muita atenção dos ortopedistas, que frequentemente são a primeira linha de atendimento dos portadores destes tumores.

Introduction

Musculoskeletal sarcomas are rare diseases of mesenchymal origin that may appear at any age and that may develop anywhere in the body. These neoplasms are classified as soft tissue sarcomas (STS) or bone sarcomas.

In 2013, the World Health Organization (OMS) described more than 50 types of soft tissue sarcomas and about 30 types of bone sarcomas.[1] Sarcomas are a heterogeneous group of more than 100 tumors.[2]

Epidemiology

Despite this great variety, musculoskeletal sarcomas account for less than 1% of adult malignant tumors and around 15% of pediatric malignant tumors[1,3–5]; therefore, STS account for less than 1% if all malignant tumors. Bone sarcomas are even more rare and account for around 0.2%.[1,6] Therefore, STS occur 4 to 5 times more often than bone sarcomas. The worldwide incidence rate of STS varies from 1.8 to 5.0 per 100,000 persons/year.[7] They may appear at any age, although over 65% of these sarcomas occur in patients over the age of 65.[5] According to the Scandinavian Sarcoma Group (SSG) from 1987 to 2011, 6.027 cases of soft tissue sarcoma were registered, that is, a rate of 1.5 to 2.0 per 100.000 inhabitants/year.[8] In Japan, the Bone and Soft Tissue Tumor Registry (BSTT), the specific cancer registration body throughout the country for bone and soft tissue tumors registered, from 2006 to 2012, 44,709 patients with benign and malignant musculoskeletal tumors. Out of these cases, 2,773 were of malignant bone tumors and 8,228 were of malignant soft tissue tumors.[9,10] In 2004, around 8,700 new STS cases were diagnosed in the US and 1,500 in the United Kingdom.[5] In Europe, the incidence of sarcomas in general is 6 cases per 100,000, with 28,000 cases per year. In 2008, STS accounted for almost 87% of all sarcomas.[11] The American Cancer Society estimates that in 2019 there will be approximately 1,762,450 new cases of cancer diagnosed in the US, leading to 606,880 deaths.[4] Out of these cases, around 3,500 will affect bones and joints and 1,660 will lead to death; the incidence of soft tissue tumors will be 12,750 cases, with approximately 5,270 deaths.[4]

A general orthopedic surgeon will find during his or her career at least one osteosarcoma or Ewing sarcoma.[12] Because there is a higher prevalence of STS, a general orthopedist will probably see four or more of these neoplasms.

Clinical Aspects

Musculoskeletal sarcomas are a heterogeneous group of tumors with different clinical manifestations, locations, evolutions and managements. Approximately 75% of STS are located in the extremities and girdles. The thigh is the most commonly affected location.[1] About 10% of the cases affect the trunk and retroperitoneum.[1]

The most frequent malignant soft tissue tumors in children and adolescents are rhabdomyosarcoma and synovial sarcoma.[13] The most frequent STS in adults are the undifferentiated pleomorphic sarcoma, liposarcoma, leiomyosarcoma, myxofibrosarcoma and synovial sarcoma.[1,6] Metastatic disease is the major cause of death related to sarcomas. Metastasis of soft tissue sarcomas and high grade bone sarcomas disseminate to the lungs through the blood.[14] As around three quarters of STS are histologically classified as having a high grade of malignancy,[1] during the diagnosis investigation and staging, it is expected that 10% of patients will have metastasis, predominantly to the lungs.[1] During the follow up period, about 50% of STS patients develop distant metastasis with an average global survival of 12 to 18 months. From the patients with metastasis, less than 20% will be alive in two years.[15] In addition to the presence of metastases, the surgical margins of these sarcomas have a great impact on the prognosis.[16,17]

Although less frequent in the pediatric group, STS may affect this age range. Approximately 50% of the cases of STS in the pediatric group are rhabdomyosarcomas, of which the subtypes embrionary (head, neck and genitourinary tract) and alveolar (thorax and extremities) are the most common. Rhabdomyosarcoma botryoid and other subtypes are less frequent.[18] The main characteristic of embrionary rhabdomyosarcoma is its bimodal presentation, that is, it has its peaks of incidence in patients with ages 2 to 6 and 15 to 19.[18,19] The alveolar subtype is the most common in adolescents.[18]

The greatest problems related to the approach to STS result from mistaken concepts that are still part of clinical

medical practice. One of them is that malignant soft tissue tumors should be painful, grow rapidly and be deep. Actually, they may grow slowly, be painless and located on the surface.[20] For this reason, the clinical condition may go on for a long time and, even in developed countries, referral to reference services may take from 6 to 14 months.[21]

Diagnosis and staging

In oncology centers of reference, patients are cared by different teams of highly specialized professionals. The same service will carry out tests for local and distant staging. For this, magnetic resonance imaging (MRI) is mandatory. Most patients still need a biopsy. However, biopsies cannot be performed in soft tissue tumors that show clearly fatty content on MRI. In 2018, the 8th edition of the Cancer Manual Staging of the American Joint Committee on Cancer (AJCC) updated the staging system for evaluation of soft tissue tumors (TNM system). This system considers the histologic grade of the tumor, its extent, the presence of lymph nodes and the presence of metastases. There is no longer any differentiation between superficial and deep tumors. The extent (T) has four levels (T1 to T4): the tumor is smaller than 5 cm (T1), the tumor is larger than 5 cm but not more than 10 cm (T2), the tumor is larger than 10 cm but not more than 15 cm (T3) and the tumor is larger than 15 cm (T4), the spread to nearby lymph nodes (N) and the spread to distant sites (M). In sarcomas, the involvement of lymph nodes is defined as systemic involvement by the neoplasm and has the same importance as a distant metastasis. Therefore, N0 and M0 means no systemic involvement, but N1 or M1 is considered systemic involvement. Patients are classified in 4 stages, from I to IV, with some subdivisions. Tumors that present N1 or M1 are classified in stage IV, the most advanced.[22]

The Birmingham group described a criterion that estimates the probability of malignancy in soft tissue tumors: the tumor is larger than 4.3 cm (the size of a golf ball), progressively increases in size, is located under the fascia and is painful.

The two first of these criteria are the most important.[23] If three or four criteria are positive, there is a possibility of more than 80% of the soft tissue lesion's being malignant.[24]

The imaging test of choice to evaluate a soft tissue lesion is the MRI of the affected segment after a gadolinium contrast injection. The MRI enables us to evaluate the features of the tumor, its extent and define the best location to carry out the biopsy. The main characteristics to be considered in an MRI are: whether the tumor is solid and if there is fat tissue. Therefore, any soft tissue lesion that is not cystic and does not show any sign of homogeneous fat in the MRI should be potentially treated as a sarcoma (►**Figure 1**). The surgeon must plan the surgical approach and biopsy technique to allow for resection of the entire tract in block, together with the tumor. Consequently, procedures with transversal incision techniques or following lines of force should be avoided when performing biopsies on extremities. The biopsy incision must follow the line of the muscle fibers and violate the smallest possible number of compartments (►**Figure 2**). Currently, many biopsies are performed with needles and guided by ultrasound or computerized tomography (TC) imaging. This demands a rapport between the surgeon and interventionist radiologist to guarantee that the procedure be performed through the proper access.

Staging must be conducted before resection of the tumor, and the physician must request at least a thoracic computerized tomography to track any lung metastasis.[25] Several services of reference in oncology offer PET-CT scans using 18F-fluorodeoxyglucose (18F-FDG) for staging. The PET-CT scan evaluates the glucose metabolism and the more aggressive the tumor the more glucose it will absorb. Because it evaluates the entire body, in addition to the lungs, the PET-CT scan changes the staging grade when it detects metastases of doubtful diagnosis inside or outside the lungs. In addition, the standard uptake value (SUV max) showed in the PET-CT may predict not only the biological activity but also the grade of the tumor. This has become a useful prognostic factor in reviewing the survival rate of patients with STS. The PET-CT scan also plays an important role in the evaluation of the response to chemotherapy and in planning the amount of radiotherapy. Because it allows for early evaluation of the aggressiveness of the tumor, the PET-CT scan may indicate more aggressive resections with proper margins while at the same time avoiding unnecessary biopsies.[3,11,26]

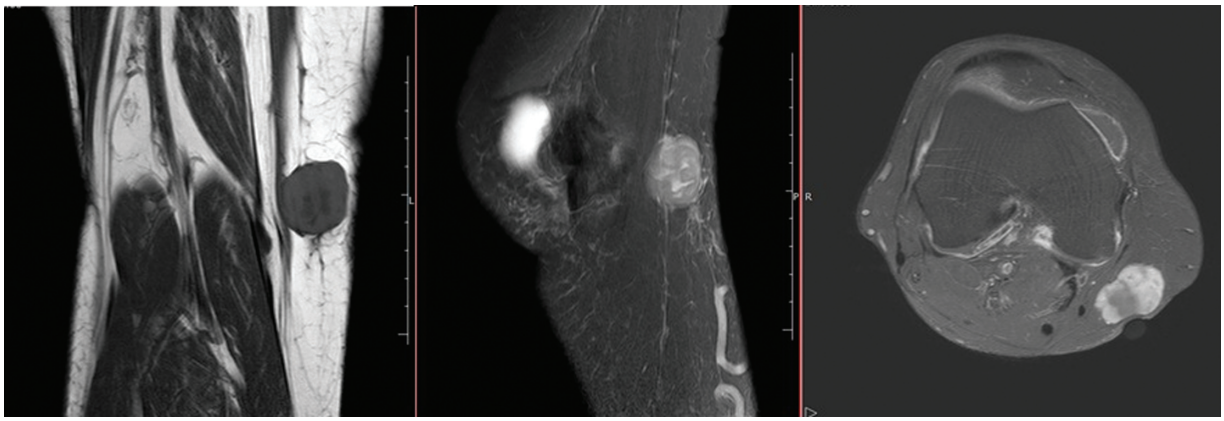


Fig. 1 Knee magnetic resonance imaging cuts. ((A)) coronal sequence T1, ((B)) Sagital SPAIR T2, ((C)) axial T1 post GD. Note that the lesion is solid, relatively small, size close to that of a golf or table tennis ball. This is a high-grade soft tissue sarcoma.



Fig. 2 Photo of the same patient in ►**Figure 1**. Posterior region of the right knee of a patient submitted to an open biopsy with inadequate access route. It's possible to observe a transverse scar that will need to be completely resected. Skin closure may be compromised.

Despite the attempts to avoid unnecessary biopsies, this procedure is still indicated for the vast majority of patients. The material for anatomopathological examination must be evaluated by a pathologist with experience in musculoskeletal tumors. Currently, pathologists supplement their histopathology analysis with a panel of immunohistochemical markers. Molecular tests have been used to supplement the diagnosis. Regardless of the need to molecular testing to support certain diagnoses, the detailed genetic analysis of the tumor tissue of a patient may have important implications in the therapy.[27] Techniques such as Fluorescent In Situ Hybridization (FISH) and Next Generation Sequencing (NGS) are slowly showing the existence, within the same diagnosis, of different subtypes of tumor, with patterns which are often similar and which will probably need target therapies for their treatment, probably generating a positive impact on survival.[2,27]

Treatment

Treatment of STS depends essentially on histological grading, tumor's location and its extent. Protocols use neoadjuvant (preoperative) or adjuvant chemotherapy and combine surgical treatment with radiotherapy before or after surgery. Resection of soft tissue sarcomas seeks to achieve microscopic surgical margins, free of tumor cells.[16] The resection margins of sarcomas are currently defined as R0 (negative microscopic margin) , R1 (positive microscopic margin), R2 positive macroscopic positive margin, that is, evident residual tumor remaining). The extent of the R0 margin is not important provided that there is no residual tumor,[16] that is, there is no difference between a slim margin and three-centimeter margin. Despite the incessant search to preserve the extremity with STS, amputation is still indicated in cases where the free microscopic surgical margins (R0) cannot be reached without the resection of the tumor affecting critical structures such as the large neurovascular bundles. As mentioned before, patients submitted to unplanned resection of a STS using transversal access have greater possibility of having to undergo amputation. It is essential to expand the surgical margins in patients submitted to unplanned resections of sarcomas. This second procedure will bring the survival prognosis of patients submitted to unplanned procedures close to that of patients submitted to a planned treatment.[28]

Patients with rhabdomyosarcoma frequently have metastasis when diagnosed, and for such reason need neoadjuvant systemic treatment. Polychemotherapy is the foundation for treatment of rhabdomyosarcoma and should be used in all patients. Normally, STS respond well (80–90%) to chemotherapy and radiotherapy. As a consequence, resection becomes a more conservative procedure and the radiotherapy doses are reduced to limit the risk of sequellae.[13]

Prognosis

Benign soft tissue tumors, such as lipomas, are 100 times more frequent that soft tissue sarcomas.[23] Because they are rare, many physicians and patients do not recognize STS, which contributes to delays in the investigation and diagnosis. This leads to an increase in the extent of the lesions. Tumors of less than 5 cm and depth are bad prognostic factors.[29] In addition, the greater incidence of benign soft tissue tumors frequently leads to unplanned resections of sarcomas, which leave residual tumor. Hanasilo et al. report that services of reference receive up to 50% of new cases of patients with STS who were submitted to unplanned resections, and 90% of these patients have a residual tumor.[28] After an unplanned resection, there is a greater risk of complications and an amputation may be needed to obtain a margin free of tumor cells.[23,30,31]

Global survival of patients with musculoskeletal tumors depends on several factors, such as the tumor's histological subtype, degree of malignancy, age of the patient, location, extent, surgical margins achieved, the presence of metastasis, adjuvant/neoadjuvant chemotherapy and radiotherapy.

Baptista et al.[32] report that in patients diagnosed with non-metastatic synovial sarcoma the prognostic factors unfavorable to survival were the high histological grade, location (tumors close to the knee or elbow) and spontaneous necrosis

of the tumor greater than 25%. Local relapse had no influence on survival rates. Zumarraga et al.[33] reported that in patients with myxofibrosarcoma a worse global survival prognosis was related to the histological grade of the tumors, compromised margins, local relapse and distant metastasis. Wu et al.[34] report that myxoid liposarcomas age (over 30), male sex, tumor grade (high grade) and size of the tumor (greater than 10 cm) were independent prognostic factors for global survival and in the specific disease in patients with STS in the extremities. Tsuda et al.[35] reported that in patients aged 65 and over negative surgical margins were related to a greater survival rate. Nakamura et al.[36] reported that the presence of a systemic inflammation is associated with a worse prognosis. Increase in the levels of C-Reactive Protein (CRP), hypoalbuminemia and anemia reflect the tumor's aggressive behavior. The first two serum markers may be useful to predict the survival of patients with metastatic disease at the time of diagnosis. Ishihara et al. reported that the histological grade of malignancy (high grade), the extent of the tumor (greater than 10 cm) and metastases change the prognosis. Local relapse is not actually related to the occurrence of metastases, extent of the tumor, histological grade and death.[37]

Patients with rhabdomyosarcoma have, in general, a global survival of 70% in 5 years. In several pediatric series, patients older than 10 years of age were reported as having a worse prognosis than that of younger children.[13] In bone tumors (osteosarcoma and Ewing sarcoma), metastatic disease reduced global survival rate to between 20% and 30%. About 15 to 20% of the patients with osteosarcomas and 15% to 35% of the patients with Ewing sarcoma already had macroscopic evidence of metastasis when diagnosed.[38–42] Literature shows that soft tissue tumors are tumors with a high metastatic potential and great chance of local relapse if not properly resected.[16,17] Approximately 10% of the patients present metastasis when diagnosed and about 50% of the patients with STS will develop them. Less than 20% of these patients will be alive in 2 years. Therefore, as most STS occur in the extremities, orthopedists are likely to the first professionals to approach these lesions.

Final Considerations

In conclusion, it is important that any soft tissue tumor be submitted to proper imaging evaluation and, in the tumor is solid and non-fatty, it must be biopsied with a proper technique before undergoing a resection without planning, which may compromise the patient's treatment and prognosis.

Conflict of Interests

The authors have no conflict of interests to declare.

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Pharmacological Treatment of Sarcopenia

Tratamento medicamentoso da sarcopenia

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Rev Bras Ortop 2021;56(4):425–431.

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Abstract

Sarcopenia has been acquiring a growing importance in the scientific literature and in doctors' offices. As the population ages, it becomes increasingly essential to know, prevent, and treat this clinical condition. The purpose of the present review is to bring up the current evidence on the diagnosis of this pathology, in a practical way, as well as the main current treatment options.

Keywords

- sarcopenia/diagnosis
- sarcopenia/therapy
- leucine
- creatine
- testosterone

Resumo

A sarcopenia vem ganhando cada vez mais importância na literatura científica e nos consultórios médicos. Com o envelhecimento da população, essa condição clínica se torna cada vez mais imprescindível de se conhecer, se prevenir e de se tratar. O objetivo desta revisão é trazer as evidências atuais sobre o diagnóstico dessa patologia, de forma prática, bem como as principais opções atuais de tratamento.

Palavras-chave

- sarcopenia/diagnóstico
- sarcopenia/terapia
- leucina
- creatina
- testosterona

Introduction

In 1989, Irwin Rosenberg proposed the term sarcopenia as an age-related decrease in skeletal muscle mass.[1] It was not just the creation of a new word. It was the finding of a pathology still unknown. The concept of sarcopenia is not yet widely known by the medical profession, especially by orthopedists. It is usually accompanied by physical inactivity, reduced mobility, slow gait, and low physical resistance, which are also common features of frailty syndrome.[2] In addition, ageing and physical disability are also related to increased fat mass, particularly visceral fat,[3] which is an important factor in the development of metabolic syndrome and cardiovascular diseases.[4] Therefore, sarcopenia with obesity in the elderly can synergistically increase its effect on metabolic, and cardiovascular disorders, and mortality, in addition to physical disability.[5]

A progressive loss of muscle mass occurs from approximately 40 years of age. This loss was estimated at around 8% per decade until the age of 70, after which the loss increases to 15% per decade.[6] There is also loss of muscle strength. A 10 to 15% loss of leg strength per decade is observed up to 70 years of

received
October 21, 2019
accepted
January 27, 2020
published online
September 22, 2020

DOI https://doi.org/10.1055/s-0040-1709732.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

age, after which a more rapid loss occurs, ranging from 25 to 40% per decade.[7] It is estimated that a 10.5% reduction in the prevalence of sarcopenia could lead to a reduction in health care costs of $ 1.1 billion per year in the United States.[8]

The prevalence of sarcopenia in the world population varies substantially, as this is closely correlated with the definition of this pathology.[9] In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) published a definition of sarcopenia that aimed to promote advances in the identification and care of people with sarcopenia. In early 2018, the Working Group met again (EWGSOP2) to update the original definition to reflect the scientific and clinical evidence that was built in the last decade.[10]

These researchers identified a strong correlation between sarcopenia and negative clinical outcomes. Initially, sarcopenia was associated only with elderly individuals, but it is now recognized that the development of sarcopenia starts before ageing. They also started to consider it a muscle failure, whose main symptom is weakness. Loss of strength has become more important than measuring muscle mass as a trigger for diagnostic investigation. This fact alone will greatly change the prevalence of this disease.

The association of sarcopenia with lower muscle mass and worse muscle performance of sick patients (low muscle quality) remains important, but these parameters should now be used mainly in clinical research or in the confirmation of some cases of the disease. This is due to the fact that both muscle mass and muscle quality are technically difficult to measure accurately, as they depend on more complex diagnostic tools and cost more than the measurement of muscle strength, which can be done with the Five Times Sit to Stand Test (5XSTT).[11]

The reduction in muscle mass and strength with advancing age is associated with some comorbidities, including type 2 diabetes, cancer, metabolic syndrome,[12] reduced mobility, and physical disability, in addition to mortality.[13] It is also correlated with an increased risk of falls and fractures.[14] Current estimates suggest that about 200 million people worldwide have sarcopenia to a degree that could affect their health over the next 4 decades.[15] In financial terms, sarcopenia is costly for health systems. The presence of sarcopenia increases the risk of hospitalization and increases the cost of care during hospitalization.[16]

Skeletal muscle mass is maintained, in large part, by combined changes in the rate of muscle protein synthesis[12] and the rate of muscle protein destruction.[17] Protein intake and resistance exercise are potent stimuli for synthesis; however, when combined, there is synergistic interaction between these stimuli, which leads to an accumulation of skeletal muscle mass.[18] Currently, there are data that suggest that ageing leads to an attenuated response of synthesis (and possible increased destruction) to the intake of amino acids[19] and to exercise.[20]

Assessment and Diagnosis of Sarcopenia

To identify individuals at risk for sarcopenia, the EWGSOP2 recommends using the Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls (SARC-F) questionnaire (**Annex 1**) or clinical research to find symptoms associated with sarcopenia.[21] The EWGSOP2's current definition of probable sarcopenia is low muscle strength. If, in addition, the patient has low muscle volume or low muscle quality, his diagnosis of sarcopenia will be confirmed. The combination of the three factors will lead to the diagnosis of severe sarcopenia.[10]

To assess the evidence of probable sarcopenia, EWGSOP recommends the use of grip strength or the 5XSTT, with specific cutoff points for each test.

The 5XSTT has a very simple application. It consists of making the patient get up and sit on a chair five times, without supporting or unbalancing. The grading of the actions is done by time. The patient must do the 5 repetitions in less than 15 seconds.[11]

The grip strength test is the method most widely cited in the literature on the subject. It consists of a portable dynamometer that measures the handgrip strength in kilograms (kg) in an easy-to-apply test that lasts a few minutes. Usually, the test is done in both hands, alternately, with three repetitions on each side.[22] The form suggested by the American Society of Hand Therapists[23] is with the patient seated, with the elbow flexed in a 90 degrees position. As cut-off points, the standard established by the EWGSOP2 is 16 kg for women and 27 kg for men.[11]

For the confirmation of sarcopenia, the detection of the smallest muscle volume should be performed. Dual-energy X-ray absorptiometry (DXA) is considered one of the ideal methods for assessing muscle mass.[24] It has the advantage of speed in its realization and minimal exposure to radiation, determining the amounts of muscle mass (lean) and fat mass with accuracy.[25]

In order to determine the severity of the disease, a performance assessment must be made. The method recommended by the EWGSOP2 is the gait test, due to its simplicity. This test consists of covering 400 m, previously marked by the examiner, in which only gait speed is assessed.[11]

Treatment

Currently, there are no viable pharmaceutical interventions to slow the progression of sarcopenia. Some articles cite hormone replacement with testosterone, but more evidence is needed on this, as we will see below.[26]

Resistance Training

Resistance training (RT) is a highly effective strategy to compensate for sarcopenia and has numerous beneficial effects. The main relevant results for this review are obvious increases in muscle mass, strength and functional performance in older individuals.[27] Resistance exercise stimulates the synthesis of new muscle protein by the action of the mTORC1 (mechanistic target of rapamycin complex 1) protein.

A recent meta-analysis of randomized controlled trials found that dietary protein supplementation during RT (over 6 weeks) resulted in greater gains in lean mass and body strength than RT alone in young and elderly adults.[18]

Contrary to belief and prescriptive guidelines for the elderly, it is not necessary to lift heavier loads to induce muscle hypertrophy. A scientific article showed similar gains

in muscle mass in young adults after 12 weeks of low-load, high-repetition or high-load and low-repetition RT.[28]

Resistance training is effective in terms of muscle mass gain and to prevent skeletal muscle loss, in addition to promoting strength gains and functional improvement. Although recent meta-analyses have found greater strength gains with higher intensity RT,[27,28] it is suggested that these differences are functionally unimportant because they did not translate into differences in functional performance in elderly patients.

Protein Supplementation

Protein consumption, especially those composed of essential amino acids, that is, those that our bodies cannot form endogenously, can act synergistically with resistance exercise to improve the response of muscle protein synthesis.[29] We know that protein can act independently of exercise to increase protein synthesis rates; however, the protein's ability to stimulate the creation of these new muscle proteins is diminished in the elderly.[19] In fact, in older adults, the intake of 35 and 40 g of protein at rest[30] and after resistance exercises,[31] compared to 20 g in young individuals,[32] was necessary to stimulate muscle synthesis as much as possible. Recently, an attempt was made to define the protein dose, relative to body mass, required per meal in young and elderly individuals. Briefly, data from the literature already published investigating the effects of protein dose-response on muscle in young and elderly individuals were analyzed. The finding of this study confirmed different needs for protein doses in young and elderly individuals, so the synthesis was stimulated to the maximum by 0.24 g of protein per kg per meal in young individuals, and 0.40 g of protein per kg per meal in elderly individuals.[19]

Additional evidence supporting recommendations for higher protein intake in older adults comes from studies showing that, in elderly patients, the highest protein intake is protective against loss of lean mass.[33] Furthermore, the addition of 15 g of protein for breakfast and lunch, which increased the protein content of these meals to at least 25 g, increased strength and physical performance in frail elderly people.[34]

Leucine

The quality of protein supplementation is a result of its amino acid content, digestibility, and bioavailability. Although several amino acids are needed to allow muscle protein synthesis,[35] leucine is the key amino acid that leads to the beginning of this synthesis.[36]

The stimulatory impact of the branched-chain amino acid leucine on muscle tissue is associated with leucine's ability to activate the mTORC1 protein, which, subsequently, targets signaling protein kinases that facilitate translation initiation and stimulation of protein synthesis.[37]

The potency of leucine was demonstrated when individuals consumed a lower protein dose (6 g), which previously proved to be less effective in muscle stimulation;[38] however, with the addition of leucine, this effectively led to the same response in muscle tissue as with a higher protein dose (25 g) in young individuals.[39] Likewise, after a resistance exercise session, the addition of leucine to a protein and carbohydrate drink improved muscle synthesis in a more significant way than the protein and carbohydrate drink alone.[40] These findings indicate that proteins with a higher leucine content would be more effective than those with a lower leucine content for muscle tissue. This may be particularly true in elderly patients, in whom there appears to be reduced sensitivity to leucine.[41]

β-hydroxy-β-methyl butyrate

β-hydroxy-β-methyl butyrate (β-HMB) is a leucine metabolite that also has anabolic properties. In a recent systematic review of studies involving β-HMB, Molfino concluded that a meta-analysis of the effects of β-HMB in the elderly was not possible, mainly because of the heterogeneity of the studies and the lack of studies between isolated β-HMB and a placebo.[42] However, a recent review states that supplements with essential amino acids plus β-HMB show good effects in improving the muscle mass and function parameters.[43]

Oral supplementation with β-HMB increases plasma and intramuscular concentrations of this substance.[44] β-HMB fame of being an exercise substitute comes from studies that show its effectiveness in preventing muscle mass loss at rest. For example, supplementation with 3 grams of β-HMB for 5 days before and during 10 days of bed rest in elderly patients attenuated muscle losses.[45] Such findings may have clinical relevance for those individuals who experience periods of short-term muscle disuse, for example, hospitalization. However, his most important reports are of improved muscle function and strength when combined with resistance exercise.[46]

Interestingly, a study shows that leucine (3.42 g) is at least as powerful, when compared in grams, as the β-HMB.[47] It is also important to realize that the change in muscle protein synthesis in response to the intake of β-HMB is not always detected by articles in the literature.[45]

In the longest study of supplementation of β-HMB more amino acids published so far, Baier reported that the elderly who received the combination of β-HMB (2 g) more protein supplementation showed greater gains in body muscle composition than those who received only amino acids. These authors reported greater gains after 12 months of supplementation. It is important to note that there were no associated functional gains (such as strength) compared to the control group, only differences in body composition.[48]

Creatine

Creatine is a nitrogenous organic acid that exists naturally in the body, being synthesized in the liver and kidneys from some amino acids. It is stored in the muscle and acts as a quick reserve of energy during high-intensity exercise. It is reversibly converted to phosphocreatine by creatine kinase during periods of low muscle activity. At the beginning of high-intensity exercise, phosphocreatine donates a high-energy phosphate to adenosine diphosphate (ADP), serving as a quick source of anaerobic energy to support exercise; however, it runs out quickly.

Its main function is to be an important reserve of energy in transitions from rest to workloads, being particularly important in short-term muscle contractions (less than 30 seconds), high intensity activities, such as running and resistance exercise, and allowing high muscle power to be obtained.[49]

The benefits of creatine are not limited to athletes, but also to elderly patients. Some studies,[47] but not all,[50] investigated the effects of creatine supplementation alone and found positive effects on strength and functional performance in the elderly. A recently completed meta-analysis showed that creatine consumed concomitantly with RT had a greater effect than RT alone on improving body composition, strength, and functional performance in elderly men and women.[51] This meta-analysis was based on the results of 8 randomized, placebo-controlled studies, which included a total of 252 elderly people. Although there was a disparity in results between trials, general creatine supplementation increased total body fat-free mass, the strength of the pectorals on the bench press, and the number of times a subject could lift from the chair over a period of 30 seconds by 2 repetitions more than just with the RT. These findings confirm the role of creatine intake (5 g) paired with RT to alleviate sarcopenia.

As mentioned earlier, not all studies have shown a greater effect of creatine alone or when added to RT to improve body composition, strength and/or performance,[50] indicating some degree of variability in response to creatine between assays or subjects. As such, the recommended strategies for using creatine for sarcopenic elderly are to consume 5 g of creatine along with a progressive RT program, recognizing that those with naturally higher muscle creatine before supplementation will not respond to supplementation.

Testosterone and Analogs

Androgens are steroid hormones synthesized mainly in the gonads and adrenal glands, such as dihydrotestosterone, dehydroepiandrosterone, androstenediol, androstenedione, and testosterone. Among them, testosterone is the main androgen that promotes male characteristics, in addition to facilitating protein synthesis.[52]

Anabolic androgenic steroids (AAS) are considered a synthetic therapeutic class of testosterone analogs. Some examples are nandrolone decanoate, oxandrolone, stanozolol, methandrostenolone, boldenone acetate and testosterone enanthate.

Elderly people around 80 years old show a decline in testosterone levels and adrenal androgens with age, with a relationship between drop in testosterone and decline in muscle mass and strength evidenced by epidemiological studies.[53] Thus, it seems logical to investigate the use of testosterone or the like for the treatment or prevention of sarcopenia.

There are two mechanisms of testosterone for increasing lean mass and increasing muscle strength: the direct and the indirect. The direct occurs through the interaction with the androgenic receptors of the cell cytoplasm. This interaction causes a signal for protein synthesis. Another possibility of increasing lean muscle mass and strength by testosterone directly is in the better use of amino acids and in the greater expression of androgenic receptors in muscle tissue. In the indirect form, there is a greater affinity of testosterone with glucocorticoid receptors, thus suggesting an antagonistic action to glucocorticoids. Another indirect action on muscle tissue hypertrophy occurs similarly to the insulin process (IGF-1), that is, as a growth factor, this can be seen in the elderly treated with testosterone, in whom there are increased levels of mRNA of IGF-1 in muscle tissue.[53]

A meta-analysis of 29 randomized clinical trials, with periods of 9 months of testosterone administration, with a mean age of 64.5 years and without RT, showed an increase of 1.6 Kg of lean muscle mass (2.7% of initial lean mass) and a 6.2% reduction in the percentage of initial fat.[54] Another article researched which dosage of anabolic steroids would allow better muscle hypertrophy. Men without comorbidities aged between 60 and 75 years were studied, divided into groups that received 25, 50, 125, 300 or 600 mg of intramuscular testosterone enanthate. At the end of 20 weeks, it was observed, by means of imaging exams and muscle biopsy, the increase in the area of the muscle cross section with the administration of dosages of 300 mg and 600 mg of testosterone enanthate, in addition to a greater number of satellite cells in the region. However, there was no test regarding strength and function.[55]

We must emphasize that this class of medications is only indicated for patients with androgenic deficiency and serum levels below the reference values. Even so, there is a risk to be weighed. A study with testosterone administration in the elderly from 65 to 75 years old, who had mobility limitations and had free testosterone below the normal level, but with a tendency to cardiovascular diseases, had to be stopped prematurely due to increased cardiovascular risks. Therefore, safety in individuals with a history of heart disease or stroke is low, and its recommendation should be avoided.[56] As for prostate cancer, the patient should be investigated, and its existence discarded before the start of therapy. It is known that one of the side effects of using testosterone supplementation is an enlarged prostate. However, in a study carried out over a period of 52 weeks, no changes were observed by blood methods (prostate specific antigen - PSA) and digital rectal examination.[57]

The most common adverse effects found with the use of testosterone analogs are: increased risk of thrombotic events, such as myocardial infarction or stroke; left ventricular hypertrophy; sudden death; increased aggressiveness and withdrawal symptoms that may include severe depression, addiction, suppression of gonadal steroidogenesis, amenorrhea, clitoral hypertrophy, testicular atrophy, disproportionate growth of the prostate, acne, deepening of the voice in women and infections at the application site.[58]

Conclusion

The pharmacological treatment of sarcopenia still has a lot to evolve. Currently, its diagnosis and importance are the focus of most research, and treatment remains largely based on

resistance exercises and some supplements. We hope that in the next decade this picture will change substantially.

Conflict of Interests

The author declares that there are no conflicts of interest.

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Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls + calf circumference (CC)

SARC-F + CC

How much difficulty do you have in lifting and carrying 5 kg		
[0] None	[1] Some	[3] A lot or unable
How much difficulty do you have walking across a room?		
[0] None	[1] Some	[3] A lot, use aids or unable
How much difficulty do you have transferring from a chair or bed?		
[0] None	[1] Some	[3] A lot or unable without help
How much difficulty do you have climbing a flight of 10 stairs?		
[0] None	[1] Some	[3] A lot or unable
How many times have you fallen in the past year?		
[0] None	[1] 1-3 falls	[3] 4 or more falls

+

Average of the two measurements of the right calf:_____cm	
[0] Women ≥ 33cm	[0] Men ≥ 33cm
[10] Women < 33cm	[10] Men < 33cm
Sum of points (0-20)_____	Sarcopenia ≥11 points

J Am Med Dir Assoc. 2016 Dec 1:17(12):1136-1141

Annex 1 SARC-F questionnaire (based on Barbosa-Silva et al).[21] Abbreviations: CC, calf circumference; SARC-F, Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls.

Oxidative Stress and Abnormal Tendon Sonographic Features in Elite Soccer Players (A Pilot Study)

Estresse oxidativo e características ultrassonográficas do tendão anormal em jogadores de futebol de elite (um estudo piloto)

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Rev Bras Ortop 2021;56(4):432–437.

Abstract

Objective Sound experimental data suggest that oxidative stress plays an important role in the pathogenesis of tendinopathies. However, this hypothesis in humans remains speculative given that clinical data are lacking to confirm it. Recently, a new methodology has allowed to quantify the oxidative stress in vivo by measuring the concentration of hydroperoxides of organic compounds, which have been utilized as an oxidative stress-related marker in several pathologic and physiologic conditions. Given the reliability of this test and the lack of information in subjects with tendinopathies, the aim of the present study was to assess the oxidative stress status in elite professional soccer players with and without ultrasonographic features of tendon damage.

Methods In 73 elite players, blood metabolic parameters were evaluated and oxidative stress was measured by means of a specific test (expressed as U-Carr units). Therefore, an ultrasonographic evaluation of the Achilles and patellar tendons was performed.

Results No significant relationships were observed between metabolic parameters and oxidative stress biomarkers. The Achilles and patellar tendons showed a normal echographic pattern in 58 athletes, and sonographic abnormalities in 15. The athletes with ultrasonographic alterations, compared to those with normal US picture, showed significantly higher U-Carr levels ($p = 0.000$), body mass index (BMI) values ($p = 0.03$) and were older ($p = 0.005$). The difference in U-Carr values among the subjects remained significant also after adjustment for age and BMI.

Conclusion The results of the present study support the hypothesis that oxidative substances, also increased at systemic and not only at local level, may favor tendon damage.

Level of Evidence IV (pilot study).

Keywords
- Achilles tendon
- football
- oxidative stress
- patellar tendon
- ultrasonography

received
April 18, 2020
accepted
September 17, 2020
published online
February 10, 2021

DOI https://doi.org/10.1055/s-0040-1721364.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Dados experimentais ultrassonográficos sugerem que o estresse oxidativo desempenha um papel importante na patogênese das tendinopatias. No entanto, essa hipótese permanece especulativa em humanos, dado que faltam dados clínicos para comprová-la. Recentemente, uma nova metodologia permitiu quantificar o estresse oxidativo *in vivo* medindo a concentração de hidroperóxidos de compostos orgânicos, que tem sido utilizada como um marcador relacionado ao estresse oxidativo em várias condições patológicas e fisiológicas. Dada a confiabilidade desse teste e a falta de informação em sujeitos com tendinopatias, o objetivo do presente estudo foi avaliar o status de estresse oxidativo em jogadores profissionais de elite com e sem características ultrassonográficas de dano tendinoso.

Métodos Em 73 jogadores de elite foram avaliados parâmetros metabólicos e o estresse oxidativo foi medido por meio de um teste específico (expresso como unidades U-Carr). Por isso, foi realizada uma avaliação ultrassonográfica dos tendões de Aquiles e patelar.

Resultados Não foram observadas relações significativas entre parâmetros metabólicos e biomarcadores de estresse oxidativo. Os tendões de Aquiles e patelar mostraram um padrão ecográfico normal em 58 atletas, e anormalidades ultrassonográficas em 15. Os atletas com alterações, em comparação com aqueles com quadro normal, apresentaram níveis significativamente mais elevados de U-Carr ($p = 0{,}000$), índice de massa corporal (IMC) ($p = 0{,}03$) e eram mais velhos ($p = 0{,}005$). A diferença nos valores de U-Carr entre os sujeitos permaneceu significativa também após ajuste por idade e IMC.

Conclusão Os resultados deste estudo corroboram a hipótese de que as substâncias oxidativas, também aumentadas a nível sistêmico e não apenas a nível local, podem favorecer danos no tendão.

Nível de Evidência IV (estudo piloto).

Palavras-chave

- tendão de Aquiles
- futebol
- estresse oxidativo
- tendão patelar
- ultrassonografia

Introduction

Several experiments performed in cell cultures and animals show that oxidative stress (OS) plays a major role in the pathogenesis of tendinopathies.[1] Indeed, mechanical overload stimulates the production of reactive oxygen species (ROS), which, in combination with lifestyle and hereditary factors, influence tendon integrity and contribute to degeneration.[2]

However, despite the experimental evidence, this hypothesis in humans remains speculative given that clinical data are lacking. Recently, a simple methodology has been introduced to evaluate ROS in the blood. The Diacron - reactive oxygen metabolites (d-ROMs) test can quantify the OS by measuring the concentration of hydroperoxides of organic compounds (lipids, proteins, nucleic acids), and it has been established as an OS-related marker in the clinic.[3]

By means of this method, an OS increase has been demonstrated in several pathologic conditions: cardiac heart failure, acute myocardial infarction, hypertension, peripheral artery disease, renal insufficiency, eclampsia, rheumatoid arthritis, knee osteoarthritis, pulmonary fibrosis, chronic lymphatic leukemia, hypothyroidism, hypopituitarism, diabetes, dyslipidemia, hyperuricemia, metabolic syndrome, obesity, as well as in physiologic situations (aging, menstrual cycle, menopause, strenuous exercise).[4–19]

Given the reliability of the d-ROMs test and the lack of information about subjects with tendinopathies, the aim of the present study was to assess the OS status in elite professional soccer players with and without ultrasonographic features of tendon damage.

Methods

The present observational pilot study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments; informed written consent for participation was obtained from each patient. Institutional ethics committee approval was not required due to the nature of the study.[20]

Elite professional soccer players (Italian second division), enrolled during two consecutive agonistic seasons (2017–2018 and 2018–2019), participated in the study.

At baseline, demographic and anthropometric data were collected. The height and weight of each participant were measured, and the body mass index (BMI) was then calculated. Standard blood tests were performed, including blood glucose, total cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, uric acid, and albumin. Blood samples were collected in the morning, after an overnight fast, at least 2 days after a period of avoidance from training or official games.

The d-ROMs test was conducted by the Free Radical Analytical System (Diacron, Grosseto, Italy), as reported previously.[3] Briefly, in a pipette, 25 µL of the serum sample were mixed with an acetic acid buffered solution (pH 4.8), and chromogenic substrate was added to the mixture. The mixture was then centrifuged and incubated in the thermostatic block of the system. The absorbance was recorded at 505 nm. The measurement is expressed in U Carr, and 1 U Carr corresponds to 0.08 mg/dl H_2O_2 (hydrogen peroxide).

Therefore, players underwent an ultrasound (US) and color Doppler (CD) evaluation of the Achilles and patellar tendons, using a high-resolution, multi-frequency (6-15 MHz) linear array transducer (MyLab 30 Gold, Esaote, Genova, Italy). Following a standard protocol,[21] longitudinal and transverse scans of both tendons were taken. The presence of dishomogeneous hypo- or hyperechoic thickening, diffuse or focal, of the tendon, associated with loss of the normal fibrillar pattern and/or irregularity of the tendon margins, was considered as sign of degeneration.

According to an arbitrary, but suitable for clinical purpose, classification, based on the structural abnormalities, the tendons were then stratified for severity as "mild" (one area of disorganized echotexture, i.e., focal dishomogeneous area with loss of fibrillar pattern), "moderate" (some areas of disorganized echotexture, i.e., dishomogeneous hypo- or hyperechoic tendon damage with altered fibrillar pattern), and "severe" (diffuse disorganized echotexture and hypo- or hyperechoic areas with irregularity of tendon margins and/or calcifications).[21]

The presence of neovascularization was investigated by means of Color Doppler (CD) and graded as (0), (1 +), (2 +), (3 +) according to a semi-quantitative estimate of the number of vessels. When no vessels were visible, the estimation was 0. When there were one or two small vessels mostly in the anterior part of the tendon, the estimation was (+1). When there were several irregular vessels throughout the tendon, the estimation was (+2) to (+3).[21] To avoid artifacts, sensitivity was optimized for low flow, and the gain was set just below the noise level.

Statistical Analysis

Using the Pearson correlation coefficient, the relationship between U Carr units and anthropometric and biochemical variables was assessed. Therefore, the subjects were divided in 2 groups (with and without sonographic lesions) and compared. Data are reported as mean ± standard deviation. The two-sample Student t-test was used to compare continuous variables, when the distribution of data was normal; the Wilcoxon's rank sum test was used otherwise. The significance level was determined at $p < 0.05$.

Results

Seventy-three players were included in the study. Anthropometric and laboratory data are shown in ►**Table 1**. No significant relationship was observed between these parameters and OS bio-markers. The US evaluation of Achilles and patellar tendons showed a normal echographic pattern in 58 athletes, and sonographic abnormalities in 15 (10 Achilles and 5 patellar [9 mild and 6 moderate]).

Table 1 Demographic, anthropometric, and metabolic characteristics of participants

	Mean ± SD	Correlation with U-Carr (r-value)
Age (years)	25.3 ± 5.1	0.1171
Height (cm)	182.1 ± 5.7	0.0451
Weight (kg)	75.1 ± 5.2	0.0317
BMI	22.6 ± 1.2	0.1004
Blood glucose (mg/dL)	76.6 ± 9.5	0.0291
Uric acid (mg/dL)	5.5 ± 0.7	0.0738
Cholesterol total (mg/dL)	173.1 ± 26.8	0.1178
Colesterol HDL (mg/dL)	55.7 ± 11.1	0.1295
Triglycerides (mg/dL)	83.7 ± 46.5	0.0819
Albumin (g/dL)	4.5 ± 2.3	0.0886
Oxydative stress (U-Carr)	320.1 ± 67	

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein; SD, standard deviation.

Neovessels were found in 4 athletes (grade 1 in 3 players, grade 2 in 1). Out of these 15 subjects, 4 had suffered of tendinopathy in the past but had healed completely after conservative treatments.

As shown in ►**Table 2**, the athletes with sonographic lesions, compared to those with normal US picture, were older ($p = 0.005$) and showed significantly higher levels of U-Carr ($p = 0.000$) and BMI values ($p = 0.03$). The difference in U Carr remained significant also after adjustment for age and BMI.

Discussion

Tendinopathies recognize several etiopathogenetic factors. In particular, mechanical overload, by means of the increased metabolism, hyperthermia, and repetitive ischemia/riperfusion, can expose the tendons to OS. A further possibility is that the tendons are indirectly influenced by changes in ROS metabolism in other nearby tissues, such as in exercising muscles. Indeed, resting muscles generate both intra- and extra-cellular superoxide, the production of both being enhanced during contraction.[1,22] In turn, the OS, in combination with lifestyle and hereditary factors, may orchestrate tendon degeneration.[2]

Several experiments performed in animals and cell cultures support the OS hypothesis. Rats submitted to patellar window injury from weeks 3 to 5 postsurgery received 3 weekly subcutaneous injections of H_2O_2 into the tendon. On week 6, specimens were harvested for histology. In comparison to controls receiving saline, the rat treated with H_2O_2 showed

Table 2 Demographic, anthropometric and metabolic characteristics of players with and without US alterations

	US alteration	No US alterations	*p*
Number	15	58	
Age (years)	28.6 ± 5.9	24.5 ± 4.5	0.005
Height (cm)	180.2 ± 5.3	182.6 ± 5.8	0.1
Weight (kg)	74.7 ± 4.8	75.2 ± 5.4	0.7
BMI	23.2 ± 1	22.5 ± 1.2	0.03
Blood glucose (mg/dL)	80.6 ± 8.1	75.6 ± 9.6	0.06
Uric acid (mg/dL)	5.8 ± 6	5.5 ± 7.6	0.1
Total Cholesterol (mg/dL)	183.9 ± 17.9	170 ± 28.2	0.08
HDL Cholesterol (mg/dL)	56.5 ± 13.5	55.5 ± 10.5	0.7
Triglycerides (mg/dL)	95.2 ± 85.8	80.8 ± 29.7	0.2
Albumin (g/dL)	4.5 ± 2.1	4.5 ± 0.2	0.6
Oxydative stress (U-Carr)	393 ± 65.5	301.3 ± 53.5	0.000*

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein; US, ultrasound.
*p = age and BMI adjusted.

impaired tendon healing and developed tendinopathic changes.[23]

Guaraldo et al.[24] submitted young and old rats to swimming exercise, and found an increased OS activity, which was more pronounced in old animals. Yuan et al.,[25] exposing cultured human rotator cuff tendon fibroblasts to H_2O_2 to create an *in vitro* OS situation, observed a pronounced apoptosis, via several pathways including the release of cytochrome-c from mitochondria to cytosol and the activation of caspase-3.

In Lee's et al.[26] experiments, tendon-derived stem cells were exposed to oxidative damage. H_2O_2 promoted apoptosis, suppressed cells viability and migration, and inhibited clonogenicity; pro-antocianine had a protective effect, mediated by an increased expression of glutamate-cysteine ligase regulatory subunit, hemoxygenase-1, and NADPH: quinone oxidoreductase via upregulating the Nrf-2 signaling pathway.[27]

An elegant study by Chen et al.[28] showed that H_2O_2 treatment of human tendon stem cells resulted in ROS accumulation and loss of self-renewal capacity, cell stemness, and differentiation capability. Starvation and the mTOR inhibitor rapamycin increased autophagic activity, reduced ROS generation, and maintained self-renewal capacity, cell stemness, and differentiation capability. Moreover, these protective effects of starvation and rapamycin were curtailed by autophagy inhibition. These results indicate that autophagy protected human tendon stem cells against OS-induced damages through suppression of ROS accumulation.

These studies support the hypothesis that OS is deleterious for cell recruitment and tendon healing, which explains why antioxidant supplementation in the early stages is beneficial.[27]

Despite the experimental evidence, applying the OS hypothesis to clinical tendinopathies remains speculative given that data in humans are lacking to confirm it. The d-ROMs test allows to quantify the OS *in vivo* and has been used successfully in a wide range of pathologic and physiologic conditions: namely, cardiac heart failure, acute myocardial infarction, hypertension, peripheral artery disease, renal insufficiency, eclampsia, rheumatoid arthritis, knee osteoarthritis, pulmonary fibrosis, chronic lymphatic leukemia, diabetes, dyslipidemia, hyperuricemia, obesity, metabolic syndrome, hypothyroidism, hypopituitarism, aging, menstrual cycle, and menopause.[4–19] Regarding the present research, it is important to remark that increased OS has been found during strenuous exercise.[13,16]

Our study is the first, to our knowledge, to address the relationship between OS and tendon disorders in humans. In athletes belonging to a professional soccer society, we found that OS was neither related to age nor to blood glucose, total and HDL cholesterol, triglycerides, uric acid, and albumin. Although the literature reports increased OS in elderly individuals[17,22] and in subjects with increased blood levels of metabolic parameters,[12,13,16] this relationship could be observed in our athletes, whose biochemical parameters, in agreement with Tamae et al.,[29] fell into a small range of juvenile values.

The main finding of the present study was the observation of higher OS levels in players with ultrasonographic tendon abnormalities. This result supports the hypothesis that oxidative substances, also increased at systemic and not only at local level, may favor tendon damage. The origin of the increased ROS blood levels remains elusive. We suppose that the athletic overuse contributed to ROS production, given that the athletes with ultrasonographic abnormalities were older in comparison with those with a normal US pattern and, therefore, had submitted their muscles and tendons to strenuous exercise for more years. In this framework, the higher BMI values could be included, because of the increased load on the lower limb tendons.[2] Alternatively, it could be hypothesized that the OS could be related to a deficit of antioxidant enzymes, such as superoxide dismutase, glutathione peroxidase and catalase.[29] Indeed, ROS are normally produced by muscles and tendons and play a physiologic role (i.e., cell signaling), but when an imbalance between the systems occurs, their level increases and they work as an aggressor.

Taking everything into account, it must be underlined that the observation of US abnormalities does not mean *per se* a clinical pathology. Indeed, these lesions do not imply a certain risk for future symptomatic tendinopathies and may remain stable or sometimes regress to normality.[30]

Given the presence of several limitations, the above speculation must be viewed with criticism and caution, and the results must be considered as preliminary. The sample size was small and the design was cross-sectional;

because only men were included, the results cannot necessarily be extrapolated to women.

The US evaluation was performed by a single researcher, and this can be a limiting factor because the component of subjectivity inherent to the US methodology. However, all the US examinations were performed by a physician with 15 years of experience in musculo-skeletal ultrasonographic methodology. In this respect, it has been demonstrated that the inter-observer's reliability in detecting tendon pathologic findings is excellent.[22]

Finally, and more importantly, the measurement of blood levels of anti-oxidants, and of OS markers other than d-ROMs, was not performed.

For these reasons, this must be considered as a pilot study, which, however, paves the way for more in-depth research. Actually, it needs confirmation from a prospective trial in a larger population, measuring additional markers, mainly those exploring the individual antioxidant status. In case our results should be confirmed, it will be possible to target a subset of individuals in whom OS plays a pathogenetic role in tendon degeneration. Moreover, it would be interesting to assess whether these subjects could benefit from an antioxidant supplementation, whose efficacy has been clearly demonstrated in different conditions and in strenuous exercise.[31]

Conclusion

The results of the present study support the hypothesis that oxidative substances, also increased at systemic and not only at local level, may favor tendon damage.

Note

The present work was developed at the Delfino Training Center (Città Sant'Angelo [Pescara]) and Centro Analisi Biochimiche dello Sport, (Lanciano [Chieti]), Italy.

Financial Support

There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests

The authors have no conflict of interests to declare.

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The Role of the Resident Doctor in Orthopedics and Traumatology in a Large Hospital of the Unified Health System: What is the User's view?*

A atuação do médico residente em ortopedia e traumatologia em um hospital de grande porte do sistema único de saúde: Qual a visão do usuário?

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Rev Bras Ortop 2021;56(4):438–445.

Abstract

Objective To assess the knowledge of patients seen at a teaching hospital about the academic and professional training of the resident doctor in orthopedics and traumatology, as well as his area of expertise, and determine the perception of the patients of comfort and safety in relation to being assisted by the resident doctor at different stages of treatment.

Methods A cross-sectional study was conducted with patients admitted to a large orthopedics hospital of the Brazilian Unified Health System (SUS, in the Portuguese acronym). Data were collected through the application of a questionnaire containing 19 objective questions that assessed sociodemographic parameters and the perception of the patient of the performance of the resident. The data were analyzed to assess the frequency of responses obtained.

Results 152 participants were evaluated, predominantly male (62.6%) and aged between 36 and 55 years old (41.3%). Only 43.3% were aware of the academic background of the resident. Patients reported feeling safer and more comfortable being assisted by the doctor together with the resident in the outpatient consultation (43.3%), in the nursing ward (39.3%) and during surgery (61%). As for the performance of the resident, 80.2% stated that the resident doctor improves communication between the patient and the main surgeon; however, only 11% said they would feel safe and comfortable being cared for exclusively by residents in the surgical environment, if allowed.

Keywords
- resident doctor
- orthopedics
- traumatology
- orthopedic surgery

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received
April 29, 2020
accepted
July 6, 2020
published online
December 16, 2020

DOI https://doi.org/10.1055/s-0040-1718513.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion The participation of resident physicians in the care is well received by the patients if they are in the company of the attending physician. Patients identify residents as a facilitating bridge in the communication with attending physicians.

Resumo

Objetivo Avaliar o conhecimento de pacientes atendidos em um hospital-escola acerca da formação acadêmica e profissional do médico residente em ortopedia e traumatologia, bem como sua área de atuação, e determinar a percepção de conforto e segurança do paciente em relação a ser assistido pelo médico residente em diferentes etapas do tratamento.

Métodos Foi realizado um estudo transversal com pacientes internados em um hospital de ortopedia de grande porte do Sistema Único de Saúde (SUS). Os dados foram coletados a partir da aplicação de um questionário contendo 19 questões objetivas que avaliaram parâmetros sociodemográficos e a percepção do paciente quanto à atuação do residente. Os dados foram analisados de forma a avaliar a frequência das respostas obtidas.

Resultados Foram avaliados 152 participantes, predominantemente do sexo masculino (62.5%) e com idade entre 36 e 55 anos (41,3%). Apenas 43,3% tinham conhecimento sobre a formação acadêmica do residente. Os pacientes relataram se sentir mais seguros e confortáveis em serem assistidos pelo médico em conjunto com o residente na consulta ambulatorial (43,3%), na enfermaria (39,3%) e durante a cirurgia (61%). Quanto à atuação do residente, 80,2% afirmaram que o médico residente melhora a comunicação entre o paciente e o cirurgião principal, entretanto e apenas 11% disseram se sentir seguros e confortáveis sendo cuidados exclusivamente por residentes no ambiente cirúrgico, caso fosse permitido.

Conclusão A participação de médicos residentes nos cuidados é bem recebida pelos pacientes, desde que em companhia do médico assistente. Os pacientes identificam nos residentes uma ponte facilitadora na comunicação com os médicos assistentes.

Palavras-chave
- médico residente
- ortopedia
- traumatologia
- cirurgia ortopédica

Introduction

In recent years, the practice of overlapping surgeries, which consists of a main surgeon coordinating two or more operating rooms at the same time, has been the subject of extensive debates between the medical community and society,[1–3] besides gaining more and more space in the main journals around the world.[4–8] This practice, although not legally permitted in Brazil, is quite common in academic medical centers, being essential for the training of residents and presenting benefits such as reduced waiting time for patients to undergo surgery, decrease in surgical costs, optimization of hospital revenues, in addition to promoting the development of skills and autonomy of resident doctors and increasing the number of doctors involved in patient care.[3,5]

Although more extensive research is needed on this topic, studies suggest that there is no increased risk and complications involving such practice.[3,9] A decrease in the rates of general complications and no impact on complications of surgical wounds was found in surgeries performed with the participation of resident doctors in orthopedics and traumatology, despite prolonged surgical times.[10]

However, although some studies have addressed the impact of resident participation in surgeries and procedure outcomes, including overlapping surgeries,[8,11] few studies have investigated the patient's perception of the participation of the resident physician in their treatment.[12] Thus, the purpose of the present study is to identify the knowledge of the patients about the academic and professional training of the resident doctor in orthopedics and traumatology, as well as to evaluate the perception of these patients in relation to the care of residents in the surgical, outpatient and nursing wards environment.

Materials and Methods

Study Design

A cross-sectional study was carried out, based on consecutive convenience sampling, including patients admitted to a large hospital in the Brazilian Unified Health System (SUS, in the Portuguese acronym) in the period between May 2019 and July 2019. The present study was approved by the Ethics and Research Committee of the institution (CAAE. 12159819.9.0000.5273)

Study Population

Patients of both gender, aged >18 years old and literate, who were in preoperative hospitalization for the treatment of traumatic orthopedic injuries were included. Sedated,

comatose, and patients with cognitive impairment were excluded, as well as those who refused to complete the Free Informed Consent Form.

Preparation and Application of the Questionnaire

To conduct the study, a questionnaire was elaborated, containing 19 objective questions, addressing questions related to the sociodemographic aspects of the participants, to the knowledge about the academic background of the residents and about the perception about the participation of the resident in the treatment (►**Annex 1**).

The study was conducted in a single phase, in which the sample was subjected to a cross-sectional analysis through the application of the questionnaire during hospitalization.

Results Analysis

For the analyses, the frequency of responses and the correlation between the sociodemographic variables and selected questions were determined. Statistical analyses were performed using the software GraphPad Prism version 7.0 (GraphPad Software, San Diego, CA, USA). The chi-squared test was used to verify possible associations between categorical variables and, when necessary, the Fisher exact test was used. A p-value of 0.05 was considered significant.

Results

A total of 152 patients were included, who were in preoperative hospitalization for orthopedic trauma surgery. The sociodemographic characteristics of the sample are presented in ►**Table 1**. Most of the participants were male (62.5%, n = 95), aged between 36 and 55 years old (41.3%, n = 62), completed high school (30.9% n = 47) and reported having a monthly family income of up to BRL 1,499.99 (68.4%, n = 91). Only 5.3% (n = 8) of the participants worked as health professionals, and 30% of them (n = 45) were directly related to health professionals.

As for the expectations of the patients, most reported that they expected to meet both the primary physician (72%, n = 108) and the resident physician (82.6%, n = 124) every day during hospitalization. When asked about the academic background of the resident doctor, 43% (n = 62) knew how to answer correctly, identifying the resident as a doctor in a specialization period in orthopedics and traumatology. Of the 57% (n = 82) who did not understand the real academic background of these professionals, 34% (n = 49) believed that the resident doctor was an orthopedic and traumatologist at the beginning of his career, 14% (n = 20) believed that the resident was a medical student, and the remaining 9% (n = 13) attributed other definitions to these professionals or did not know how to answer (►**Table 2**).

Participants were also asked about their perception of the participation of the resident doctor in different stages of their treatment. Regarding the outpatient consultation, 43.3% (n = 65) said they preferred that the service was performed jointly by the main physician and the resident, while only 17.3% (n = 26) reported feeling safe to be seen only by the resident at this point. Regarding care in the nursing ward, while 39.3% (n = 59) said they preferred joint care between the primary physician and the resident, 30.6% (n = 46) reported feeling safe and comfortable being assisted only by the resident doctor. The perception of the patients about being care by the resident doctors in the operating room revealed that most participants (61%, n = 91) would prefer to be assisted together by the resident doctor and the main surgeon, while only 11% (n = 16) of those studied said they felt safe and comfortable being assisted exclusively by residents, if allowed (►**Table 3**).

Finally, 68.5% (n = 109) of the participants said they believed that a greater number of doctors involved in their care could improve the quality of the assistance offered. As for the role of the resident in the communication between the surgeon and the patient, 80.2% (n = 118) stated that the

Table 1 Sociodemographic characteristics of the sample

Answers	N (%)
Age	
18 to 35 years old	45 (30%)
36 to 55 years old	62 (41.3%)
56 to 75 years old	33 (22%)
> 76 years old	10 (6.6%)
Gender	
Male	95 (65.5%)
Female	57 (37.5%)
Education	
Incomplete elementary school	44 (29.8%)
Complete elementary school	17 (11.1%)
Incomplete high school	33 (21.7%)
Complete high school	47 (30.9%)
Incomplete higher education	5 (3.2%)
Complete higher education	6 (3.9%)
Monthly income	
Up to R$ 1,499.99	91 (68.4%)
R$ 1,500 to R$ 2,999	26 (19.5%)
R$ 3,000 to R$ 4,999	7 (5.2%)
R$ 5,000 to R$ 9,999	7 (5.2%)
> R$ 10,000	2 (1.5%)
Works as a health professional	
Yes	8 (5.3%)
No	143 (94.7%)
Has a first-degree relative who works as a health professional	
Yes	45 (30%)
No	105 (70%)
Underwent previous surgical procedure	
Yes	109 (72.2%)
No	42 (27.8%)

Table 2 Assessment of patient expectations and assessment of knowledge about resident training

Answers	N (%)
Do you expect to meet the main surgeon every day during hospitalization?	n = 150
Yes	108 (72%)
No	42 (28%)
Do you expect to meet the resident doctor every day during hospitalization?	n = 150
Yes	124 (82.6%)
No	26 (17.3%)
What do you know about the academic and professional training of the resident doctor in orthopedics and traumatology?	n = 144
He is still a medical student in training	20 (13.8%)
He is a doctor specializing in orthopedics and traumatology	62 (43.0%)
He is a physician specialized in orthopedics and traumatology at the beginning of his career	49 (34.0%)
Other	13 (9.0%)
Are you able to identify the main surgeon responsible for your care?	n = 151
Yes	50 (33.1%)
No	101 (66.2%)
Are you able to identify the resident doctor involved in your care?	n = 147
Yes	21 (14.3%)
No	126 (85.7%)

resident doctor improves this communication, while only 1.3% (n = 2) said that the presence of the resident worsens the communication between patient and surgeon. When asked about the relationship between the presence of residency programs and the care received during hospitalization, 85.5% (n = 124) of the participants reported receiving more attention in hospitals with a medical residency program, 4.1% (n = 6) reported receiving less attention in teaching hospitals and 10.3% (n = 15) had no previous hospitalizations in hospitals without a medical residency program (►**Table 4**).

We found no association between gender, age or income and the feeling of comfort and security in being attended by the resident. However, this analysis revealed that the perception of comfort regarding the performance of the resident varied in relation to the stage of care and the level of education of the patients, where we identified a relationship between the lowest level of education and the highest perception of comfort in being assisted only by the resident doctor in outpatient consultations ($p = 0.04$) and in the ward ($p = 0.03$). This association was not observed in relation to the isolated performance of the resident physician in the surgical environment, since, regardless of the level of education, patients reported requiring the presence of the main physician during the procedure ($p = 0.27$).

Discussion

In Brazil, the practice of overlapping surgeries is quite common in academic hospitals, where the main surgeon can start a new procedure in another operating room without having finished the first, leaving the resident physician to complete the noncritical parts of the procedure. In these teaching hospitals, the participation of the resident doctor in the various stages of patient care is essential for their training;[13] however, there are still no national studies that aim to understand the view of the patient about the performance of the resident physician during his treatment.

The present study shows that the resident doctor has an important role in facilitating communication between the patient and the main surgeon, and, although less than half of the participants know about the academic background of the residents, in general, they were safe and comfortable being assisted by resident doctors in the company of the main surgeon.

It is noteworthy that, in our sample, only 33% of the patients were able to identify the surgeon responsible for their treatment and an even lower percentage was able to identify the resident doctor, even though we were unable to

Table 3 The patient's perception of the resident's participation

	Answer							
	Safe and comfortable to be attended only by the resident		Prefer to be attended by the main doctor together with the resident		Prefer to be attended only by the main physician		Unable to give an opinion	
Patient's perception of the resident's participation	n	%	n	%	n	%	n	%
Outpatient consultation	26	17.3	65	43.3	17	11.3	42	28
Nursing Ward	46	30.6	59	39.3	9	6	36	24
Surgery	16	10.7	91	61	14	9.4	28	18.7

Table 4 The resident's role in patient care

Answers	N (%)
Believes that the involvement of a high number of doctors can improve the quality of care	n = 150
Yes	109 (68.5%)
No	18 (11.3%)
Does not have an opinion	23 (14.4%)
Role of the resident in the communication between the patient and the primary surgeon	n = 147
Improves communication	118 (80.2%)
Worsens communication	2 (1.3%)
Does not change communication	27 (18.3%)
Regarding the care received in a teaching hospital compared to hospitals without a medical residency program	n = 145
I received more care in hospitals with a medical residency program	124 (85.5%)
I received less attention in hospitals with a medical residency program	6 (4.1%)
No previous hospitalization	15 (10.3%)

assess whether the patients were able to identify the surgeon or the resident with accuracy. This finding differs from the results found by Cowles et al.,[12] who performed a similar study in an academic hospital and found that 86% of the patients knew how to identify the doctor in charge of their treatment. We believe that the high number of doctors involved in the treatment of patients, combined with the lack of knowledge about the performance of the resident may have contributed to this confusion.

Our results show that the perception of comfort and safety with the participation of the resident varies according to the treatment stage, with the performance of the resident, alone, being well accepted in the nursing ward, where, among the patients who had an opinion about the theme, $\sim$ 40% reported feeling safe to be seen only by the resident, but not in the outpatient consultation or during surgery, where the percentages found were 24% and 13%, respectively. Other studies have reported similar results, showing that patients feel comfortable being assisted by the resident outside the surgical environment, but not during surgery.[12,14] Despite the result, it is important to note that previous studies have shown that the participation of residents in the surgical procedure, whether general or orthopedic, is not associated with increases in mortality rates or general complications, being safe for patients.[10,15,16]

Interestingly, when patients were stratified in terms of education level, we found that those who had not completed high school felt more comfortable about being seen only by the resident doctor in the outpatient consultation or in the ward. However, we did not find, among the factors evaluated in the present study, reasons that justified this difference.

Our results also show that, although only a small portion of patients feel safe to be assisted only by the resident in the surgical environment, 75% of those who had an opinion on this issue said they preferred the procedure to be performed by the surgeon together with the resident doctor, indicating a willingness to contribute to the technical training of the resident, as noted in other studies.[12] We believe that one of the reasons for the preference for the joint action of the main doctor and the resident doctor is because the participants point out that the presence of the resident doctor facilitates communication between doctor and patient, a result similar to that found by Cowles et al.[12] The role of the residents in communication can be fundamental for establishing the relationship of trust between doctor and patient, a factor that is fundamental for treatment adherence and compliance, and that positively correlates with patient satisfaction with treatment.[17]

In general, our results corroborate the study by Cowles by finding that the academic hospital environment is well tolerated by patients, since most participants said they believed that the greatest number of doctors could improve the quality of care received and reported having received more attention during hospitalization in hospitals with medical residency.[12]

One of the main limitations of the present study is the fact that it was performed with patients from a single teaching hospital and with patients treated by the same orthopedic specialty. Despite this, we believe that the results of these studies can be extrapolated once they reflect common perceptions of patients, regardless of the type of treatment they will be submitted to. Thus, our results are relevant because they bring out the view of the user of the public health system of the country, thus leading to broader discussions about the role of the resident and the practice of overlapping surgeries.

Conclusion

Although part of the users of the SUS do not understand exactly the real professional training of the resident doctor in orthopedics and traumatology, the participation of residents, together with the responsible doctor, is well tolerated in the various stages of care provided to patients. Our results place residents as important actors in the doctor-patient relationship and suggest a willingness of patients to contribute to the education of residents, reinforcing the mission of teaching hospitals, to create favorable conditions for health education without losing focus on the excellence of the assistance provided to patients.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Annex 1 Data Collection Form

RESEARCH PROJECT INFORMATION:	
Title:	PERFORMANCE OF THE RESIDENT PHYSICIAN IN ORTHOPEDICS AND TRAUMATOLOGY IN A LARGE HOSPITAL OF THE UNIFIED HEALTH SYSTEM. WHAT IS THE USER'S VIEW?
Responsible Researcher:	
Center or Sector:	Specialized Care Center (CAE) TRAUMA

DATA TO COLLECT			
Participant initials:	_____	**Medical record:**	_____

1) **Age:**
( ) 18 to 35 years old
( ) 36 to 55 years old
( ) 56 to 75 years old
( ) more than 76 years old

2) **Gender:**
( ) Male
( ) Female

3) **Education level:**
( ) Incomplete elementary school
( ) Complete elementary school
( ) Incomplete high school
( ) Complete high school
( ) Incomplete higher education
( ) Complete higher education

4) **Monthly income:**
( ) up to R$1,499.99
( ) R$1,500.00 to 2,999.99
( ) R$3,000.00 to 4,999.99
( ) R$5,000.00 to 9,999.99
( ) more than R$10,000.00

5) **Do you work as a health professional?**
( ) Yes
( ) No

6) **Do you have a first-degree relative who works as a health professional?**
( ) Yes
( ) No

7) **Have you ever been subjected to any surgical procedure before this hospitalization?**
( ) Yes
( ) No

8) **Do you know who is the main surgeon responsible for your care during this hospitalization?**
( ) Yes
( ) No
Doctor's name:

9) **Do you expect to meet the main surgeon every day during your stay?**
( ) Yes
( ) No

10) **Do you know who are the resident doctors involved in your care?**
( ) Yes
( ) No
Names of doctors:

11) **Do you expect to meet resident doctors every day during your stay?**
( ) Yes
( ) No

12) **What do you know about the academic and professional training of the resident doctor in orthopedics and traumatology?**
( ) It is still a medical student in training
( ) It is a doctor specializing in orthopedics and traumatology
( ) It is a physician specialized in orthopedics and traumatology at the beginning of his career
( ) Other:

13) **What is your level of comfort and safety being assisted by a resident doctor in a medical consultation?**
( ) I feel safe and comfortable being attended only by a resident doctor
( ) I prefer that the consultation in the office is done jointly by a resident doctor and the main surgeon
( ) I prefer that the service in the office is done only by the main surgeon
( ) I don't have an opinion on this question

14) **What is your level of comfort and safety being assisted by a resident doctor on a visit to the nursing ward?**
( ) I feel safe and comfortable being visited only by a resident doctor
( ) I prefer the visit to be made together by a resident doctor and the main surgeon
( ) I prefer the visit to be made only by the main surgeon
( ) I don't have an opinion on this question

15) **What is your level of comfort and safety being operated by a resident doctor?**
( ) I feel safe and comfortable being operated only by a resident doctor
( ) I prefer the surgical procedure to be done together by a resident doctor and the main surgeon
( ) I prefer the surgical procedure to be done only by the main surgeon
( ) I don't have an opinion on this question

16) **Do you believe that a high number of doctors involved in your care can improve the quality of medical care?**
( ) Yes
( ) No
( ) I don't have an opinion on this question

17) **What is the role of the resident doctor in the communication between you and the main surgeon?**
( ) Improves the communication between me and my main surgeon
( ) Worsens the communication between me and my main surgeon
( ) Does not alter the communication between me and my main surgeon

18) **Regarding the care received by the medical team:**
( ) I received more attention in this hospital when compared to previous admissions to other hospitals without a medical residency program
( ) I received less attention in this hospital when compared to previous admissions to other hospitals without a medical residency program
( ) I had no previous hospitalizations in other hospitals without a medical residency program

19) If permitted by our legislation, you would feel safe being operated by a resident doctor without the full supervision of a more experienced surgeon?
( ) Yes
( ) No
( ) I don't have an opinion on this question

Place and date	Signature and stamp of the researcher responsible for data collection:
Rio de Janeiro, _____, _____	_____

Sagittal Plane Alignment and Functional Outcomes Following Surgery for Scheuermann Kyphosis*

Alinhamento do plano sagital e resultados funcionais após cirurgia para a cifose de Scheuermann

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Rev Bras Ortop 2021;56(4):446–452.

Abstract

Objective To evaluate and correlate the pelvic parameters, the sagittal balance (SB), and the functional outcome of the patients submitted to surgical treatment for Scheuermann hyperkyphosis (SK).

Methods Patients submitted to surgery between January 2005 and December 2016 were included. The following radiographic measurements were obtained: thoracic kyphosis (TK); lumbar lordosis (LL); SB; pelvic incidence (PI); pelvic tilt (PT); and sacral slope (SS). Complications during the follow-up period were recorded.

Results A total of 19 patients were included (16 males): the mean preoperative kyphosis was of 83°, and the postoperative kyphosis was of 57°. The mean preoperative lumbar lordosis was of 66°, with a postoperative spontaneous correction of 47°. Regarding the preoperative pelvic parameters, the average PI, PT and SS were of 48°,10° and 39° respectively. In the postoperative period, these values were of 50°, 16° and 35° respectively. The preoperative SB was neutral, and it was maintained after the surgical correction. Concerning complications during the follow-up period, three junctional kyphosis were observed–two requiring revision surgery, one nonunion, and one dehiscence of the surgical wound. Regarding the functional results, the average score on the Scoliosis Research Society-22 (SRS-22) patient questionnaire was of 4.04, and we verified that the SB obtained in the postoperative period had no influence on the functional outcome ($p = 0.125$) nor on the postoperative LL ($p = 0.851$).

Keywords
- Scheuermann disease
- spine
- thoracic vertebrae
- spinal fusion
- kyphosis

* *Work developed at Centro Hospitalar Universitário de São João, Porto, Portugal.*

received
June 26, 2020
accepted
September 16, 2020

DOI https://doi.org/10.1055/s-0041-1724078.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion We verified a spontaneous improvement in the lumbar hyperlordosis at levels not included in the fusion after correction of the TK. Although the postoperative functional results were globally high, we did not find any statistically significant relationship with TK nor LLs. high PI is associated with a greater rate of complications regarding the proximal junctional kyphosis (PJK), and these pelvic parameters should be considered at the time of the SK surgical treatment.

Resumo

Objetivo Avaliar e correlacionar os parâmetros pélvicos, o equilíbrio sagital (SB), e o resultado funcional dos pacientes submetidos ao tratamento cirúrgico da hipercifose de Scheuermann (SK).

Métodos Foram incluídos pacientes submetidos à cirurgia entre janeiro de 2005 e dezembro de 2016. Foram obtidas as seguintes medidas radiográficas: cifose torácica (TK); lordose lombar (LL); SB; incidência pélvica (PI); inclinação pélvica (PT); e inclinação sacral (SS). Complicações foram registradas durante o período de seguimento.

Resultados Foram incluídos 19 pacientes (16 homens): a cifose pré-operatória média foi de 83°, e, após a cirurgia, de 57°. A LL média pré-operatória foi de 66°, com uma correção espontânea pós-operatória de 47°. Quanto aos parâmetros pélvicos pré-operatórios, as médias de PI, PT e SS foram de 48°, 10° e 39°, respectivamente. No pós-operatório, esses valores foram de 50°, 16° e 35°, respectivamente. O SB pré-operatório foi neutro e mantido após correção cirúrgica. Quanto às complicações durante o período de seguimento, foram observadas três cifoses juncionais – duas necessitando de cirurgia de revisão, uma má consolidação, e uma deiscência de sutura. Em relação aos resultados funcionais, a pontuação média no questionário de 22 itens da Scoliosis Research Society (SRS-22) foi de 4,04, e verificou-se que o SB no pós-operatório não teve influência no desfecho funcional ($p = 0{,}125$), nem na LL pós-operatória ($p = 0{,}851$).

Palavras-chave
- doença de Scheuermann
- coluna vertebral
- vértebras torácicas
- fusão espinhal
- cifose

Conclusão Verificamos uma melhora espontânea da hiperlordose lombar em níveis não incluídos na fusão após a correção da TK. Embora os resultados funcionais pós-operatórios tenham sido globalmente elevados, não encontramos nenhuma relação estatisticamente significativa com a TK nem com a LL. A PI elevada está associada a maior complicação da cifose juncional proximal (PJK), e esses parâmetros pélvicos devem ser considerados no momento do tratamento cirúrgico da cifose de Scheuermann.

Introduction

Scheuermann hyperkyphosis (SK) is a deformity in the sagittal plane with an incidence that ranges from 0.4% to 8%, with a slightly higher male prevalence, and it is currently the most common cause of rigid hyperkyphosis in the pediatric population.[1,2]

The diagnosis is often made in adolescents presenting with chronic symptoms of mild back pain and a typical cosmetic deformity of the thoracic or thoracolumbar spine. According to Sorensen,[3] the radiographic criteria for diagnosis include thoracic kyphosis (TK) $> 40°$ or thoracolumbar kyphosis (TLK) $> 30°$, and at least 3 consecutive vertebral bodies with a minimum of 5° of wedging.

The goal of the surgical treatment in cases of SK is not only the correction of deformity, but also a symptomatic and cosmetic improvement. A large number of studies report radiographic outcomes, but most of them focus mainly on spinal parameters without including the pelvic assessment and its relationship with the sagittal balance (SB) and quality of life. The pelvic incidence (PI) is a key characteristic of the pelvis, which is defined as an anatomical feature unique to each individual that becomes set at the end of growth and that determines the relative position of the sacral plate in relation to the femoral heads. The sacral slope (SS) is the angle of the sacral plateau to the horizontal plane, and it determines the position of the lumbar spine since the sacral plateau forms the base of the spine. The pelvic tilt (PT) is defined by the angle between a vertical line through the femoral head and a line from the mid-sacral plateau and femoral head, and it determines the spatial orientation of the pelvis. The PT is a positional parameter, as well as the SS. The possibility of rotation of the pelvis around the axis of the femoral heads is one of the best mechanisms of regulation of the SB.[4]

Clinical expertise and current literature[5] suggest that the reestablishment of a physiological SB is extremely important and should guide the surgical corrections. The understanding of spinopelvic parameters and their importance in spine biomechanics has gained relevance, and several articles[6] have tried to describe them and their relationship, but there is limited data regarding the response of spinopelvic parameters and sagittal plane alignment of the spine to surgical the treatment for SK. The aim of the present study is to evaluate and correlate the pelvic parameters, the SB and the functional outcome of the patients submitted to surgical treatment for SK.

Material and Methods

The records of patients submitted to SK correction at our institution between January 2005 and December 2016 were retrieved from our database. The diagnosis was based on the radiological criteria provided by Sorensen.[3] Patients with congenital spine deformities, neuromuscular or syndromic disease, previous spine surgery, spine tumor, postural kyphosis or primary deformity of scoliosis, spondylolisthesis, or spondylolysis were excluded. The indication for surgery was a TK or TLK with a curve $> 70°$ with persistent back pain, with no satisfactory response to the conservative management. To be included in the study, all the patient parameters had to be available, and the follow-up had to be complete. All patients underwent a posterior-only correction procedure with periapical osteotomies and pedicle-screw fixation by the same surgical team consisting of two senior surgeons. The upper limit of instrumentation was the proximal-end Cobb vertebra and the lower instrumented vertebra was the sagittal stable vertebra or the first lordotic vertebra ,according to a previously discussed decision. During surgery, care was taken to preserve the supraspinous and interspinous ligaments, the spinous processes of the upper limit of instrumentation, and the level immediately above it. Ambulation without a brace is accomplished on the first or second day after surgery.

Radiographic measurements were obtained through longstanding spine radiographs before surgery and throughout the follow-up. In each patient the following parameters were measured: TK; lumbar lordosis (LL); SB; PI; PT; SS. All measurements were performed by two physicians, and their mean values were recorded (►**Fig. 1**).

The other imaging parameters recorded were the number of instrumented vertebrae, the level of distal fusion, and the complications during the follow-up period, such as the radiographic junction kyphosis – defined as the caudal endplate of the uppermost instrumented vertebra (UIV) to the cephalad endplate of two suprajacent vertebrae above the UIV and the same for the last instrumented inferior vertebra.[7]

The Scoliosis Research Society-22 (SRS-22) patient questionnaire, translated to our native language, was filled out by all patients.

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, US) software, version 21.0 for Windows. The Student *t*-test was used to assess the differences in mean values between the groups for normally distributed continuous variables. The statistical comparisons between the groups preoperatively and postoperatively were performed using the Mann-Whitney U test. The paired samples *t* test was used for the comparison of preoperative and postoperative measurements. Values of $p < 0.05$ were considered statistically significant.

The authors obtained approval form the institutional review board for all aspects of the present study.

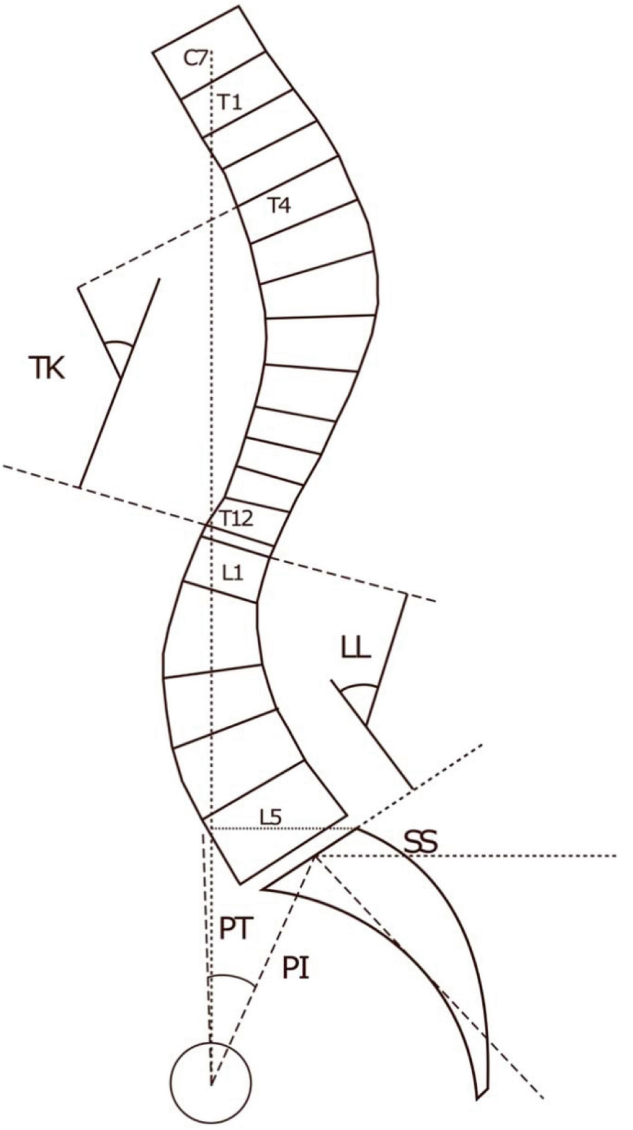


Fig. 1 Pre- and postoperative measurements: thoracic kyphosis (TK) - the angle between the superior endplate of T4 to the inferior endplate of T12; lumbar lordosis (LL) - the angle between the upper endplate of L1 and the upper endplate of S1; sagittal balance - the distance between the C7 plumb line and the posterosuperior corner of S1; pelvic incidence (PI) - the angle between the line perpendicular to the sacral endplate at its midpoint and the line connecting the point to the middle axis of the femoral heads; pelvic tilt (PT) - the angle between the line connecting the midpoint of the sacral endplate to the middle axis of the femoral heads and a vertical line; sacral slope (SS) - the angle between the sacral endplate and the horizontal plane.

Results

A total of 19 patients (3 female and 16 male patients; average age at surgery: 18.4 years) who underwent SK correction

surgery were included. The follow-up time varied from 2 to 12 years, with a mean time of 6 years. The apex of the deformity was in the thoracic spine, following this distribution: T7–6 cases; T8–9 cases; T9–4 cases. A mean of 11 levels were fused, and the level of distal fusion was L1 in 3 cases, L2 in 10 cases, L3 in 5 cases, and L4 in 1 case, and all patients underwent a posterior-only procedure. The mean preoperative kyphosis was of 83°, with a mean correction to 57°. The mean preoperative lumbar lordosis was 66°, with a postoperative spontaneous correction to 47°.

Regarding the preoperative pelvic parameters, the average PI, PT and SS were of 48°, 10° and 39° respectively, and, in the postoperative period, these values were of 50°, 16° and 35° respectively. The mean preoperative SB, assessed by the distance from the C7 plumbline to the posterosuperior S1 vertebral body was neutral (negative trend of -8mm) and it was maintained after the surgical correction (-7mm) (►**Fig. 2**).

Concerning the complications during the follow-up period, a total of three junctional kyphosis were observed (two proximal and one distal) – two requiring revision surgery, one nonunion, and a dehiscence of the surgical wound. The functional scores assessed by the SRS-22 questionnaire were of 4.0 on average. Relating the SRS-22 scores with the imaging parameters, we verified that the SB obtained in the postoperative period had no influence on the functional outcome ($p = 0{,}125$) nor on the postoperative LL ($p = 0{,}851$). Although there was a trend towards lower SRS-22 scores with increased postoperative kyphosis, this score did not significantly affect the functional outcome ($p = 0.079$) (►**Table 1**).

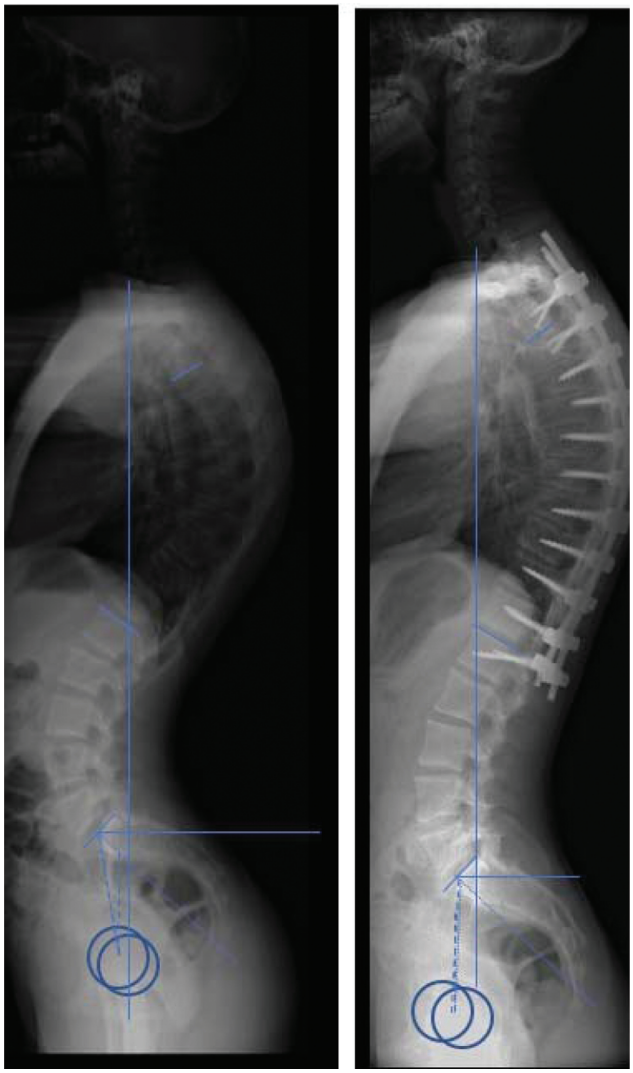


Fig. 2 Clinical case - male, 17 years old. He maintained the neutral sagittal alignment. Improvement in postoperative kyphosis and lumbar lordosis from 80° to 56° and 84° to 55° respectively.

Discussion

The surgical treatment of SK does not consist solely in the correction of the TK, but it is rather a challenge of balance through the sagittal alignment.

Sagittal spinopelvic parameters were evaluated in many areas of spinal deformity, including early-onset scoliosis,[8] spondylolisthesis,[9] and adolescent idiopathic scoliosis.[10] However, there is a paucity of literature on sagittal spinopelvic alignment in SK.

Sagittal spinopelvic alignment was linked to health-related quality of life, mainly because the global sagittal imbalance and its compensatory mechanisms were associated to increased energy consumption, which negatively influences the quality of life.[11,12]

The pathological increase in TK in SK leads to a compensatory development of a lumbar hyperlordosis with the aim of reaching a new state of balance.

In the present study, the mean values of preoperative TK and LL were pf 83° and 66° respectively. After surgical correction of hyperkyphosis, the mean value of LL was of 47 °, so there was a spontaneous improvement in the lumbar hyperlordosis at levels not included in the fusion, as described in the literature[13–17] and also verified by Ashraf et al.[16] in a retrospective study of 18 patients submitted to surgical treatment.

We report that the mean preoperative values of PI, PT and SS were of 48°, 10° and 39° respectively. These are consistent with the previous reports by Mac-Thiong et al.,[18] who described average values of PI, PT and SS as 49°, 8° and 41° respectively, for normal children and adolescents. These observations are consistent with those of the study published by Cahill et al,[19] who evaluated the differences in spinopelvic parameters among patients with SK and unaffected normal controls, allowing us to conclude that there was no statistically significant difference in the pelvic parameters. Therefore, this suggests that SK is not driven by an inherent problem in the pelvic anatomy resulting in abnormal mechanics in the thoracic or thoracolumbar spine with subsequent secondary vertebral wedging, but rather that the anatomic changes observed at the apex of the deformity in SK are in fact the primary pathologic process.[19]

The postoperative SB is an important predictor of functional results when depicting the muscular forces acting on the spine and the associated energy spent.[20] In the present study, the mean values of the SB remained within the normal range before and after surgery, which was also described by Guler et al.[21] after surgical correction of SK.

Table 1 Distribution of postoperative sagittal balance, kyphosis and lumbar lordosis results and functional outcome

Case	Final sagittal balance	Postoperative kyphosis (degrees)	Postoperative lumbar lordosis (degrees)	SRS-22
1	Neutral	42	27	3.5
2	Negative	65	22	3.7
3	Neutral	52	47	4.12
4	Negative	51	37	4.05
5	Neutral	59	47	3.27
6	Neutral	67	45	4
7	Neutral	67	21	4.63
8	Negative	30	23	4.5
9	Positive	69	68	4.2
10	Neutral	41	47	3.8
11	Neutral	74	56	4.05
12	Negative	63	52	4.5
13	Neutral	56	55	4.27
14	Positive	51	62	4.45
15	Negative	67	49	4.1
16	Neutral	69	45	3.2
17	Negative	49	68	4.4
18	Neutral	60	71	4.8
19	Positive	53	64	3.27

Abreviatura: SRS-22, Scoliosis Research Society-22 patient questionnaire.

In the postoperative period, the mean values of the pelvic parameters were of 50° for PI, 16° for PT, and 35° for SS. Although PI is a morphological parameter and therefore should not change, this difference is acceptable, and it can be explained by the subjectivity of the measurements on the radiographs. Regarding PT, it ranges from 0° to 25°, which can justify the increase of pre- to postoperative values, and can be due to the inclusion of patients who had some complications during follow-up. Ultimately, in the postoperative period, the mean values remained within normal limits, which enables the described ratio of pelvic incidence to remain equal to the sum of the PI tilt and the SS.[4] Other formulas attempt to correlate the sagittal spinal and pelvic parameters in SK. For instance, Berderman et al.[22] described a new correlation between parameters such as TK or TLK, PI and LL, and concluded that (TK - 45°) + (TLK - 0°) + (PI - LL), if kept within ± 10°, is a valuable formula to evaluate the global SB in patients with skeletally-mature SK.

The level of distal fusion in SK is a controversial topic, and there must be a balance between minimizing the risk of developing distal junctional problems and preserving the levels of motion.[23] Besides the usual discussion between extending the fusion to the sagittal stable vertebra or the first lordotic vertebra, Zhu et al.[24] suggest the type of SK curve should also be considered, stating that the biomechanics of each curve is different. These authors[24] suggest that in the thoracolumbar curve type, a shorter fusion should be performed, while in the thoracic one, this instrumentation should be extended until the sagittal stable vertebra. In the present study, only the thoracic curves were included, and the level of distal fusion mostly coincided with the sagittal stable vertebra (15 versus 4 cases).

The occurrence of complications regarding the surgical treatment of SK has been the object of study of several published works,[25] in which a global rate of 14% was reported.

Besides the choice of fusion level, prevention of the development of junctional kyphosis includes, nowadays, the study of spinopelvic parameters, whose results may explain this development.

Junctional kyphosis has incidences that can reach 30%, depending on the study population,[26] and although proximal junctional kyphosis (PJK) is more common, distal junctional kyphosis (DJK) is more often implicated in the revision surgery.

While relating the development of DJK with the spinopelvic parameters, Ghasemi et al.[27] suggested that there is an increased risk of developing DJK among younger patients, and concluded that patients with higher degrees of TK correction and with more negative absolute SB values had a higher risk of developing this developing complications. However, in the case of DJK in the present study, we did not observ any of these conditions, as this patient had a TK within the preoperative mean values (80°) and a normal SB (+ 10mm), and, regarding his age at the time of surgical correction, he was also close the mean value (18 years).

Concerning PJK, Sardar et al.[28] report that a larger TK both before surgery and at the final follow-up tend to be associated with the development of PJK, and this complication was also

found to be directly correlated with the magnitude of the PI.[28] In the two cases of PJK in the present study, we found high PI values (59° and 60°), which is in agreement with previously described.

Scheuermann hyperkyphosis is associated with worsening of the quality of life and diminished SRS-22 scores in all domains when compared with other spine deformities, such as adolescent idiopathic scoliosis, as reported by Lonner et al.[29] This impairment can be explained by the energy-consuming and often painful compensatory mechanisms while trying to preserve an adequate global SB.[11] Glassman et al.[30] found that positive SB was linearly correlated with the severity of the back pain, and is the radiographic measurement most frequently associated with adverse outcomes. Moreover, they also state that a successful long-term outcome after TK correction surgery may be more accurately predicted by the restoration of the sagittal plane alignment rather than through an isolated correction of the TK. The mean score of the patients included in the present study was 4 (maximum score: 5), which revealed a good overall functional result. However, when trying to relate these SRS-22 scores with the SB, no statistically significant relationship was established, even though these scores were within the normal range. The SRS-22 scores were not influenced by TK nor LL, albeit we report a trend to lower scors on the SRS-22 with higher degrees of postoperative TK.

There are some limitations to the present study. Firstly, the small sample. Secondly, the retrospective character of the analysis made. Thirdly, all procedures were performed in the same hospital and by the same surgical team.

Conclusion

The surgical treatment of SK aims not only to correct the deformity but also to achieve a global spine balance. We verified a spontaneous improvement inlumbar hyperlordosis at levels not included in the fusion after correction of the TK. Although the postoperative functional results were globally high, we did not find any statistically significant relationship with TK nor LL, even though we reported a trend towards lower socres on the SRS-22 with higher degrees of postoperative TK. Postoperative complications like junctional kyphosis are related not only to factors that are already known – such as the magnitude of curve correction and the selection of fusion levels – but also to new parameters such as sagittal plane alignment. High PI is associated with greater complications regarding the PJK, and these pelvic parameters should be considered at the time of SK surgical treatment, as we concluded. Nevertheless, further studies are needed in this field.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Effectiveness of Fluoroscopy-Guided Percutaneous Vertebral Biopsy*

Eficácia da biópsia vertebral percutânea guiada por fluoroscopia

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Rev Bras Ortop 2021;56(4):453–458.

Abstract

Objective To define the effectiveness of fluoroscopy-guided percutaneous vertebral biopsy.

Methods Prospective study of patients with vertebral destruction syndrome at one institution. Percutaneous transpedicular vertebral biopsies guided by fluoroscopy were performed, and bony tissue and intervertebral disc tissue were extracted; histopathology and microbiology studies were also performed. Age, sex, vertebral segment, neurologic status, and biopsy and culture results were analyzed.

Results The average age of the patients was 53.8 years (range: 2 to 83 years), and the main spine segment was the lumbar segment in 62% of the cases. According to the impairment scale of the American Spinal Injury Association (ASIA), preoperatively, 49% of the patients were classified as Asia E, and 100% had pain. Definitive etiology was identified in 83% of the sample. The etiology was grouped into three categories: infectious, neoplasia, and degenerative (osteoporotic). The infectious group was composed of 36% of the patients, in whom *Staphylococcus aureus* was the most common agent identified; in 34.9% the sample, the etiology was neoplastic, most commonly multiple myeloma and metastatic disease due to prostate cancer; 21.7% of the patients had osteoporosis. The average surgical time was of 47.5 minutes, the average blood loss was of 10 mL. No complications were reported.

Keywords

- spine
- lumbar vertebrae
- biopsy
- spinal neoplasms

* *Work developed at Hospital Regional de Alta Especialidad del Bajío, Universidad de Guanajuato, Guanajuato, Mexico.*

received
March 19, 2020
accepted
July 6, 2020

DOI https://doi.org/10.1055/s-0040-1718950.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion Transpedicular percutaneous biopsy guided by fluoroscopy had an effectiveness of 83% for the etiological diagnosis of vertebral destruction syndrome in the present series. It should be considered a useful minimally-invasive procedure, which is easy, economical, and reproducible, with low risk of short- and long-term complications.

Resumo

Objetivo Definir a eficácia da biópsia vertebral percutânea guiada por fluoroscopia.
Métodos Este é um estudo prospectivo de pacientes com síndrome de destruição vertebral em uma instituição. Os pacientes foram submetidos a biópsias vertebrais transpediculares percutâneas guiadas por fluoroscopia, com obtenção de tecido ósseo e tecido do disco intervertebral, para estudo histopatológico e microbiológico. Idade, sexo, segmento vertebral, estado neurológico, e resultados de biópsia e de cultura foram analisados.
Resultados A idade média dos pacientes foi de 53,8 anos (gama: 2 a 83 anos), e o principal local acometido da coluna foi a segmento lombar, em 62% dos casos. Segundo a escala de disfunção da American Spinal Injury Association (ASIA), no pré-operatório, 49% dos pacientes foram classificados como ASIA E, e 100% apresentavam dor. A etiologia definitiva foi identificada em 83% dos pacientes. A etiologia foi agrupada em três categorias: infecciosa, neoplásica, e degenerativa (osteoporótica). O grupo infeccioso era composto por 36% dos pacientes da amostra, e *Staphylococcus aureus* foi o agente mais comumente identificado; em 34,9% dos casos, a etiologia era neoplásica, principalmente mieloma múltiplo e doença metastática por câncer de próstata; 21,7% dos pacientes apresentavam osteoporose. O tempo cirúrgico médio foi de 47,5 minutos, e a perda média de sangue foi de 10 mL. Nenhuma complicação foi relatada.
Conclusão Nesta série, a biópsia percutânea transpedicular guiada por fluoroscopia teve 83% de eficácia no diagnóstico etiológico da síndrome de destruição vertebral. Este procedimento minimamente invasivo deve ser considerado bom, fácil, barato e reprodutível, com baixo risco de complicações em curto e longo prazos.

Palavras-chave
- coluna vertebral
- vértebras lombares
- biópsia
- neoplasias da coluna vertebral

Introduction

Vertebral biopsy is essential in the diagnosis and planning of the definitive management of vertebral destruction syndrome.[1,2] The etiology spectrum for this disabling condition can be divided into neoplastic, infectious or metabolic (osteoporosis) causes. Robertson and Ball[3] were the first to report the use of percutaneous vertebral biopsy, Ottolenghi[4] and Valls et al.[5] performed aspiration biopsy of the vertebral body, and, finally, Craig,[6] in 1956, developed a trephine for biopsy. Subsequently, the use of open biopsy has progressively decreased over time.

Percutaneous biopsy is a minimally-invasive, fast, low-cost, and minimally-complicated technique that enables vertebral bony and soft tissue to be obtained for histopathology and microbiology analyses. There are series that were able to identify an infectious causative agent in 60% of spine infections with this technique; in other papers, a histopathological conclusive diagnosis was obtained in 55% to 90% of the cases;[7] these results raise doubts about its diagnostic utility.

The use of transpedicular instrumentation systems as well as kyphoplasty and percutaneous instrumentation have made the vertebral biopsy technique a practical method for the spine specialist. At our hospital, since the establishment of the Spine Surgery Department, 11 years ago, percutaneous vertebral biopsy guided by fluoroscopy has been performed in patients with vertebral destruction syndrome; the present study assesses the effectiveness of this technique.

The objective of the present paper is to define the effectiveness of fluoroscopy-guided percutaneous vertebral biopsy in the diagnostic approach of vertebral destruction syndrome.

Patients and Methods

A prospective study was performed in a single reference center, from January 2008 to March 2012, in a cohort of 100 patients chosen through the convenience method. All patients were sent from secondary-care hospitals from 7 different states in the country to be evaluated by the Spine Surgery Department as outpatients, and they were admitted until a procedure was scheduled or as needed. Those patients who presented vertebral destruction syndrome, without a definitive diagnosis, who accepted the percutaneous biopsy procedure and signed the informed consent were included; patients who had a history of prior surgery, who already had

a diagnosis of primary disease directly related to vertebral destruction syndrome were excluded. Moreover, those with medical restrictions regarding being placed in a ventral position (hemodynamically decompensated chronic obstructive pulmonary disease, pregnancy, morbid obesity) were also excluded. All patients underwent a preset study protocol with basic laboratory exams such as blood count, blood chemistry, serum electrolytes, coagulation times, and special serum analysis, such as the rate of erythrocyte sedimentation, febrile reactions, Bence Jones protein, among others. Anteroposterior and lateral simple radiographs, computed tomography, both simple and contrasted, nuclear magnetic resonance, and bone scans were also obtained.

Biopsy Technique

After anesthesia, the patients were placed on ventral recumbency position on the pectoral and iliac regions in a conventional surgical bed, with the thoracic limbs directed upwards in the soldier position. Under the arc of fluoroscopy in a C-model Arcadis Orbis (Siemens, Munich, Germany), the area to undergo the biopsy was located and marked on the skin, and submitted to asepsis and antisepsis, and to the placement of sterile fields. The anteroposterior fluoroscopic image corroborated the the affected segment, and the pedicle was located. A 5-mm skin incision was made for the passage of the trocar. The tissues inside the trocar were discarded. An 11G caliber Jamshidi (CareFusion, San Diego, CA, US) biopsy needle was inserted in the pedicle, and the fluoroscopic image was altered to the profile view as needed. The needle was introduced in the pedicle and in 80% of the vertebral body. Two samples were obtained: one by aspiration, and the other through bone puncture (►**Fig. 1**). The needle was removed, as well as the bone-tissue cylinder, which was immediately sent to the pathology and microbiology service. The trocar was extracted, and the surgical technique was performed again to obtain another sample with the same pedicle entry site, but trying another path toward the vertebral body. After hemostasis and washing, the wound was closed according to the Sarnoff technique with 3/0 nylon thread, an covered with a sterile patch. After the end of the surgical procedure, the patients were placed on supine on a transfer stretcher. After anesthetic reversal and removal of the orotracheal tube, all patients were sent to a conventional recovery area.

Statistics

Descriptive statistics were performed to determine the average and standard or median deviations and percentiles for the numerical variables according to their distribution, as well as the frequencies for the nominal variables. The sensitivity and specificity of the fever in every etiologic group were analyzed. Finally, the effectiveness of the test was determined.

Results

Among the 100 patients included, 57 of them were men (57%), while 43 patients were women (43%), aged between 2 and 83 years (average of 53.85 years; standard deviation: 17.5). The age distribution was mainly patients between the ages of 51 and 60 years, with 29 cases (29%), followed by patients aged between 61 and 70, with 28 cases (28%), and the groups aged between 41 and 50 years, and between 71 and 80 years, both with 12 patients (12%) each. The location of the vertebral destructive lesion had the following distribution; cervical in 2 patients (2%), thoracic in 35 patients (35%), lumbar in 56 patients (56%), thoracolumbar in 2 patients (2%), lumbosacral in 4 patients (4%), and sacral in 1 patient (1%) (►**Table 1**). Upon admission to the study, a spinal neurological examination was performed to classify the patients according to the American Spinal Injury Association (ASIA scale); the most common classification was ASIA E (49%), followed by ASIA D (27%), and ASIA A (12%). Regarding the sensitivity below the injury, 12 patients

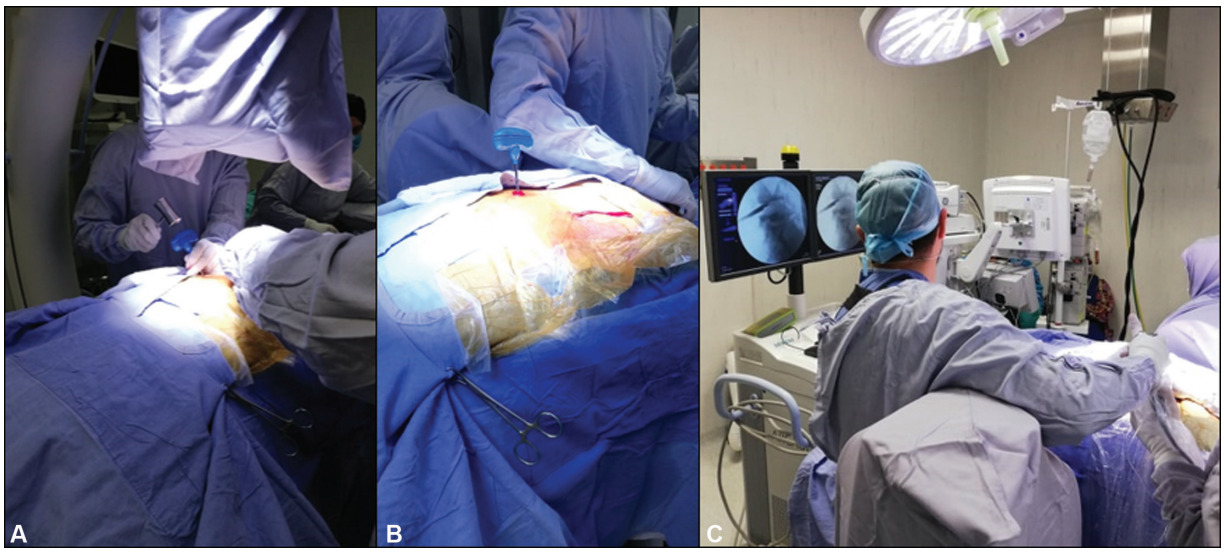


Fig. 1 Biopsy technique. (**A**) Insertion of the biopsy needle (Jamshidi), fluoroscopy in anteroposterior position; (**B**) fluoroscopy in lateral position to confirm the correct needle placement; (**C**) collection of bone and intervertebral disc cylindrical samples.

Table 1 Patient description and results

CASE	SEX	AGE	SEGMENT	ASIA	FEVER	REPORT	ETIOLOGY	CASE	SEX	AGE	SEGMENT	ASIA	FEVER	REPORT	ETIOLOGY
1	F	64	L	C	YES	NSI	I	**51**	F	63	L	C	NONE	NSI	I
2	F	51	L	E	NONE	OT	M	**52**	M	56	L	E	NONE	NM	I
3	M	48	T	A	NONE	M	N	**53**	M	65	T	L	YES	NSI	I
4	F	42	T	E	NONE	M	N	**54**	F	75	L	E	NONE	NSI	–
5	M	69	T	D	NONE	PN	N	**55**	F	69	T	C	NONE	PN	N
6	M	45	L	D	YES	M	N	**56**	M	65	L	C	NONE	PN	N
7	M	58	T	D	NONE	NSI	–	**57**	F	53	T	A	NONE	PN	N
8	F	58	L	D	NONE	OT	M	**58**	M	56	T	A	NONE	NSI	I
9	M	59	T	C	NONE	NSI	–	**59**	M	2	T	E	NONE	GR	I
10	M	63	L	D	NONE	TB	I	**60**	M	49	T	D	NONE	NSI	–
11	M	37	L	D	YES	NSI	–	**61**	F	64	L	E	NONE	OT	M
12	F	57	L	E	NONE	OT	M	**62**	F	59	LS	D	NONE	NSI	I
13	M	67	T	E	NONE	OT	M	**63**	M	46	L	E	NONE	NSI	I
14	F	51	C	E	NONE	M	N	**64**	M	46	L	E	NONE	NSI	I
15	M	71	L	E	NONE	NSI	–	**65**	M	75	L	D	NONE	NSI	I
16	M	55	L	E	YES	NSI	I	**66**	M	74	T	E	NONE	OT	M
17	F	34	T	E	NONE	GR	I	**67**	M	74	T	A	NONE	NSI	–
18	M	60	T	E	NONE	M	N	**68**	F	16	L	E	NONE	NSI	I
19	F	40	T	B	NONE	M	N	**69**	M	18	T	E	NONE	TB	I
20	M	15	L	A	NONE	PN	N	**70**	M	28	L	E	NONE	NSI	I
21	F	44	C	D	NONE	M	N	**71**	M	65	L	E	NONE	NSI	I
22	M	58	L	D	YES	NSI	I	**72**	M	59	L	D	NONE	NSI	I
23	M	16	T	E	NONE	NSI	I	**73**	M	68	L	C	NONE	NSI	I
24	M	18	T	E	NONE	GR	I	**74**	F	62	S	E	NONE	NSI	–
25	F	58	T	B	NONE	NSI	–	**75**	M	49	T	A	NONE	PN	N
26	M	64	L	D	YES	NSI	I	**76**	M	64	L	E	NONE	PN	N
27	M	64	T	E	NONE	M	N	**77**	F	23	LS	E	YES	NSI	I
28	F	31	TL	D	NONE	NSI	–	**78**	F	71	LS	E	YES	NSI	I
29	M	18	L	D	YES	GR	I	**79**	F	67	L	E	NONE	OT	M
30	M	67	L	D	YES	NSI	I	**80**	M	24	L	D	NONE	NSI	I
31	M	59	T	A	NONE	GR	I	**81**	F	65	T	A	NONE	NSI	I
32	F	63	L	E	NONE	GR	I	**82**	M	54	L	E	NONE	NSI	–
33	M	83	T	D	NONE	PN	N	**83**	F	67	L	E	NONE	NSI	–
34	M	54	L	D	NONE	PN	N	**84**	F	67	L	E	NONE	OT	M
35	F	13	L	D	NONE	PN	N	**85**	F	61	L	E	NONE	OT	M
36	M	57	L	C	NONE	NSI	I	**86**	M	56	L	D	NONE	PN	N
37	M	57	T	A	NONE	M	N	**87**	F	71	L	E	NONE	OT	M
38	M	10	L	A	NONE	PN	N	**88**	M	41	L	E	NONE	M	N
39	F	79	L	E	NONE	OT	M	**89**	F	71	L	E	NONE	OT	M
40	F	40	T	A	NONE	NSI	–	**90**	F	64	L	E	NONE	NSI	I
41	F	70	L	E	NONE	OT	M	**91**	F	54	L	E	NONE	NSI	–
42	M	53	L	D	NONE	OT	M	**92**	M	44	LS	E	NONE	NSI	–
43	M	55	L	D	NONE	OT	M	**93**	F	59	L	C	NONE	NSI	I
44	F	47	L	D	NONE	NSI	I	**94**	F	78	L	E	NONE	OT	M
45	F	51	T	E	NONE	M	N	**95**	M	71	T	A	NONE	M	N
46	M	54	T	D	NONE	PN	N	**96**	M	69	T	D	NONE	PN	N
47	M	70	L	E	NONE	NSI	–	**97**	F	67	L	E	NONE	PN	N
48	M	25	TL	E	NONE	GR	I	**98**	F	67	L	D	NONE	PN	N
49	M	54	T	C	NONE	GR	I	**99**	F	57	T	E	NONE	OT	M
50	M	43	T	C	NONE	M	N	**100**	F	78	L	E	NONE	OT	M

Abbreviations: ASIA, American Spinal Injury Association; C, cervical; F, female; GR, granulomatous reaction; I, infectious; L, lumbar; LS, lumbosacral; M, male; M, metabolic; M, metastasis; N, neoplastic; NM, negative to malignancy; NSI, non-specific inflammation; OT, osteoporotic tissue; PN, primary neoplasm; TB, tuberculoma; T, thoracic; TL, thoracolumbar.

(12%) were found with anesthesia. Pain was the predominant symptom in 98 (98%) patients. Fever was only present in 11 (11%) patients. After defining the etiology, an analysis of in the infectious group showed 22.2% of sensitivity and 95.3% of specificity. Of these, 10 patients (10%) developed a causative agent in the cultures: 7 (7%) with *Staphylococcus aureus*, 1 (1%) with *Brucella abortus*, and 2 (2%) with microbiota agents. The Bence Jones protein was positive in 3 patients (3%), all of them with a definitive diagnosis of multiple myeloma.

The definitive diagnosis was obtained in 83 out of 100 patients, obtaining an effectiveness of 83% (►**Table 2**).

Overall, 36 patients (36%), presented a conclusive diagnosis with positive cultures, with the isolation of *S. aureus* in 17 patients (17%) followed by *B. abortus* in 10 patients (10%), and *M. tuberculosis* in 9 patients (9%).

In total, 29 patients (29%) presented a disease with a neoplastic etiology confirmed on the histopathological analysis; the most common primary tumor was multiple myeloma, with 9 cases (9%), followed by 2 patients (2%) with plasmacytoma, 2 (2%) with Ewing tumor, 1 case (1%) of neuroblastoma, 1 case (1%) of giant-cell tumor, and 1 case (1%) of chondroma. Regarding tumors of metastatic origin, prostate-cancer metastasis was diagnosed in 4 patients (4%), as well as lung cancer metastasis in 3 cases (3%); the remaining tumors found were breast, ovarian, and esophageal cancers, and basal-cell and bile-duct carcinomas.

Table 2 Distribution of etiologic groups, microbial agents, and histopathology conclusion

ETIOLOGIC GROUP	CASES	N
INFECTIOUS	**43.37%**	36
Staphylococcus aureus	38.63%	17
Brucella abortus	22.72%	10
Mycobacterium tuberculosis	20.45%	9
Escherichia coli	2.27%	1
NEOPLASTIC	**34.94%**	29
PRIMARY TUMOR	55.1%	16
MULTIPLE MYELOMA	31.03%	9
PLASMACYTOMA	6.89%	2
EWING TUMOR	6.89%	2
NEUROBLASTOMA	3.44%	1
GIANT-CELL TUMOR	3.44%	1
CHONDROMA	3.44%	1
METASTASIS	44.82%	13
PROSTATE	13.79%	4
LUNG	10.34%	3
ESOPHAGUS	6.89%	2
BREAST	3.44%	1
OVARY	3.44%	1
BILLIARY TRACT	3.44%	1
SKIN (BASOCELLULAR CANCER)	3.44%	1
METABOLIC	**21.69%**	18
OSTEOPOROSIS	100%	18

In total, 18 patients (18%) were included in the osteoporosis etiology group due to the absence of microbiological development in the cultures and findings compatible with chronic degenerative changes, such as significant trabecular decrease in the histopathological study.

Overall, the average surgical time was of 47.5 minutes, with an average transoperative bleeding of 10 mL.

The patients with infectious etiology received antibiotics prescribed by the hospital's infectiology service. The patients with vertebral osteoporosis were submitted to kyphoplasty, and those in the neoplasm group were classified according to the Tokuhashi score to decide whether the surgery should be performed or not, and they were sent to the oncology service to undergo chemotherapy or radiotherapy.

Discussion

The use of higher-definition imaging studies, such as computed tomography and magnetic resonance as well as the use of nuclear medicine, has allowed the spine specialist to detect with much more sensitivity smaller lesions that occur in patients with specific symptoms, enabling the performance of less invasive surgical approaches, such as percutaneous biopsy, instead of open biopsy. Even though open biopsies are associated with a longer surgical time, greater risk of bleeding, higher number of complications, and sometimes it is not possible to obtain an adequate biopsy by a traditional posterior access to the vertebral body, they are still considered the "gold standard." With the improvement in the different types of vertebral instrumentation, the increasing use of transpedicular systems, and, lately, of the percutaneous transpedicular instrumentation make the technique of percutaneous vertebral biopsy an option that can be easily used by the spinal surgeon. Since there are more morphometric reports about the strength, structure, and anatomical situation with respect to the spinal level, it is known that a pedicle larger than 3 mm is able to safely house a needle for vertebral biopsy.[8]

B. Marré reported that, in 22 patients, he obtained 95% of diagnostic effectiveness, and microbiological identification in 50% of the cases. Rosales-Olivares et al.[7] reported diagnosis in only 55% of the cases studied by histopathology, and they concluded that, given the poor percentage obtained in their series of only 20 patients, "percutaneous fluoroscopy-guided biopsy is not a useful method in our environment"; this discrepancy with other works may be due to the small sample of patients, and although the methodology followed is not specified, it remains an operator-dependent technique. In general, the methodology of the study is not enough to rule out this technique. On the other hand, in the present series of 100 cases, a definitive etiological diagnosis was obtained in 83 patients (83%), which positions this modality of percutaneous biopsy technique as an effective tool within the vertebral destruction syndrome study protocol, given its wide availability and reproducibility.

Currently, there are works describing other imaging techniques used, such as tomography, with a reported effectiveness of 90.4%[9] to 94.4% for the histopathological analysis.[10] However, in our environment, even today, the availability of the tomography equipment for surgical procedures continues to be complicated given the number of other diagnostic procedures performed in imaging services. Thus, alternative methods, such as fluoroscopy, which has greater accessibility, continue to be part of our diagnostic arsenal for the diagnosis of patients with vertebral destruction syndrome. However, such methods should be compared to other minimally-invasive techniques.

Although the present series has considerable sample of patients in a prospective design, a comparative analysis of at least two different biopsy techniques is necessary to sustain stronger evidence-based recommendations.

Conclusion

Percutaneous transpedicular fluoroscopy-guided biopsy is an effective method (83%) for the etiological diagnosis of vertebral destructive syndrome. It is a minimally-invasive procedure, with little intraoperative bleeding, minimal surgical time, short hospital stays, cheap, and feasible to the surgeon at any hospital with an image intensifier C arm.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declared.

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Evaluation of the Interobserver Agreement of the Fraser and Blake & McBryde Classifications for Floating Knee*

Avaliação da concordância interobservador das classificações de Fraser e Blake & McBryde para joelho flutuante

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Rev Bras Ortop 2021;56(4):459–462.

Abstract

Objective To evaluate the interobserver agreement of two classifications for floating knee: Fraser and Blake & McBryde.

Method Thirty-two observers, subdivided according to the degree of titration (26 resident physicians and 6 orthopedic physicians specialized in orthopedic trauma), classified 15 fractures of the ipsilateral femur and tibia. Interobserver agreement was evaluated by using the Kappa coefficient.

Result When evaluating the agreement between the 9 R1, a Kappa index of 0.58 was obtained for the Fraser classification and of 0.46 for the Blake & McBryde classification. Among the 7 R2, a rate of 0.59 was obtained for the Fraser rating and 0.51 for the Blake & McBryde rating. Among the 10 R3, the agreement index was higher for both classifications: 0.72 for the Fraser and 0.71 for the Blake & McBryde classification. Considering the 3 groups (R1, R2, R3) as one large group, the general Kappa index was calculated, which resulted in 0.63 for the Fraser classification and 0.56 for the Blake & McBryde classification. In the group of trauma and orthopedic knee specialists, in turn, an agreement of 0.597 was obtained for the Blake and McBryde classification and of 0.843 for the Fraser classification.

Conclusion Comparatively, the two classifications presented a weak to moderate degree of agreement. Fraser classification had better agreement in both groups. The agreement was higher when evaluating orthopedic trauma physicians.

Keywords
- tibia fractures/ classification
- validation studies
- evaluation

* *Work developed in the Department of Orthopedics and Traumatology, Instituto Doutor José Frota, Fortaleza, Ceará, Brazil.*

received
December 8, 2019
accepted
March 17, 2020
published online
October 2, 2020

DOI https://doi.org/10.1055/s-0040-1713388.
ISSN 0102-3616.

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Resumo

Objetivo Avaliar a concordância interobservador de duas classificações para joelho flutuante: Fraser e Blake & Mcbryde.

Método Trinta e dois observadores, subdivididos de acordo com o grau de titulação (26 médicos residentes e seis médicos ortopedistas especialistas em trauma ortopédico) classificaram 15 fraturas de fêmur e tíbia ipsilaterais. A concordância interobservador foi avaliada pelo coeficiente Kappa.

Resultado Ao avaliar a concordância entre os 9 R1, obteve-se índice Kappa para classificação de Fraser de 0,58 e para a classificação de Blake & McBryde de 0,46. Entre os 7 R2, obteve-se índice de 0,59 para a classificação de Fraser e 0,51 para a classificação de Blake & McBryde. Entre os 10 R3, o índice de concordância foi maior para as duas classificações: 0,72 para a classificação de Fraser e 0,71 para a de Blake & McBryde. Considerando os 3 grupos (R1, R2, R3) como um só grande grupo, calculou-se o índice Kappa geral, que teve como resultado 0,63 para a classificação de Fraser e 0,56 para a classificação de Blake & McBryde. No grupo dos traumato-ortopedistas especialistas em joelho, por sua vez, obteve-se uma concordância para a classificação de Blake e McBryde de 0,597 e para a de Fraser de 0,843.

Conclusão Comparativamente, as duas classificações apresentaram grau de concordância fraco a moderado. A classificação de Fraser teve melhor concordância em ambos os grupos. A concordância foi maior quando se avaliou médicos ortopedistas especialistas em trauma ortopédico.

Palavras-chave

- fraturas da tíbia/classificação
- estudos de validação
- avaliação

Introduction

Floating knee is a term that refers to ipsilateral fractures of the femur and tibia. It is due to high-energy traumas, such as traffic accidents,[1] with motorcycle accidents having special importance in our reality. Although its exact incidence is unknown, it is noted that it is a generally rare condition. However, there has been an increase in the number of floating knee cases in recent years, which is proportional to the increase in the number of patients affected by high-energy trauma.[2]

Due to their mechanism of trauma (high energy), episodes of floating knee are often associated with other injuries of traumatology and orthopedic importance, such as fractures at other sites or knee ligament injuries. In addition, for the same reason, there may also be life-threatening injuries, such as head, thoracic or abdominal trauma.[2] The severity of these lesions is reflected in mortality, which ranges from 5 to 15%, according to the literature. Studies also show many open fractures (59–67% of cases) and a high number of cases (20–30%) that require amputation.[3]

Thus, often, in cases of instability, complex joint fractures or severe soft-tissue injuries, the principles of orthopedic damage control may be the safest solution initially. Thus, the definitive fixation, which usually requires a long surgical time, needs to be postponed until the conditions are better for the patient.[4]

It is also important to emphasize that several complications associated with floating knee cases are reported, such as infections, excessive blood loss, fat embolism, delayed consolidation, pseudarthrosis, joint stiffness, prolonged hospitalization, and inability to sustain weight.[1]

In order to establish treatment, as well as in several other trauma injuries, it is of paramount importance that there is an adequate classification of each case. Classification systems have the purpose of facilitating the communication between physicians, assisting in documentation and research, estimating prognosis and guiding therapy.[5]

In their original article, Blake & McBryde, the first to describe the floating knee frame, elaborated the first classification. They divided the traumatological lesion into types I, when both diaphyses are fractured (true floating knee), IIA, when there are fractures involving the knee joint, and IIB, when fractures involve the hip or ankle joint.

In 1978, Fraser et al.,[6] in turn, classified it differently, dividing it into types I (both diaphyses affected), IIA (fractures of the femoral diaphysis and tibial plateau), IIB (fractures of the tibia diaphysis and intra-articular distal femur), and IIC (intra-articular fractures of the knee in the femur and tibia).

To this end, the objective of this study was to evaluate the interobserver agreement of the two best known classifications for floating knee, Fraser and Blake & McBryde, in order to analyze the degree of reliability of these classifications.

Methods

The present study consists of a cross-sectional, observational and quantitative study. The epidemiological study is said to be cross-sectional when factor and effect are observed at the same historical moment. In observational studies, there is no manipulation of the study factor by the researcher. We used radiographs in the anteroposterior incidences and profile of patients treated at the hospital, in the period between

January and May 2013, with ipsilateral fractures of the tibia and femur, accounting for a total of 25 fractures, which, after the exclusion criteria, were summarized to 15. The exclusion criterion was inadequate radiographic documentation, such as poor or incomplete quality radiographs.

The radiographs were randomly organized, and, with them, a Power Point (Microsoft Corp., Redmond, WA, USA) slide-test presentation was prepared. This test was applied to 26 traumatology and orthopedic residents in our institution. Among the tested, there were residents of the 1st, 2nd and 3rd years, 9 R1, 7 R2 and 10 R3. The application of the test occurred during a theoretical session that they participate in weekly (orthopedics and traumatology integrated residency). At the time of the evaluation, each resident received an illustrative picture containing the two classifications (Fraser and Blake & McBryde) and a template to mark the subtype that they judged corresponding to each of the cases. For each case displayed, there was a maximum time of 2 minutes for the answers.

Subsequently, the same test was applied with six trauma and orthopedic knee specialists. The evaluation with the specialists occurred under the same conditions as that performed with the residents regarding the time and sequence of radiographs.

To assess the degree of agreement, we used the Kappa statistical index, according to the interpretation of Landis and Koch (< 0 = without agreement; 0.0–0.20 = slight agreement; 0.21–0.40 = weak; 0.41–0.60 = moderate; 0.61–0.80 = substantial; > 0.81 = excellent).[7] This is a coefficient of agreement that corrects the error due to chance and is used to determine intra- and interobserver variation, being used when two observers separately classify a sample of objects using the same category scale.[8]

The medical records and the corresponding radiographs used in the present study were from the Medical Archive Center (NUAME, in the Portuguese acronym) of the IJF.

The project was submitted to the approval of the Research Ethics Committee, in accordance with Resolution 196/96 of the National Health Council (guidelines and regulatory standards for research involving human beings) under number 87963018.2.0000.5047. The study was informed to patients and observers and a consent form was requested.

Results

When evaluating the agreement between the 9 R1, a Kappa index of 0.58 was obtained for the Fraser classification and of 0.46 for the Blake & McBryde classification. Among the 7 R2, a Kappa index of 0.59 was obtained for the Fraser classification and 0.51 for Blake & McBryde. Among the 10 R3, the agreement index was higher for both classifications: 0.72 for the Fraser classification and 0.71 for Blake & McBryde. Considering the 3 groups (R1, R2, R3) as one large group, the overall Kappa index was calculated, resulting in 0.63 for the Fraser classification and 0.56 for the Blake & McBryde classification (►**Table 1**).

In the group of trauma and orthopedic knee specialists, in turn, the agreement obtained for the classification of Blake & McBryde was of 0.597 and for the Fraser classification, 0.843 (►**Table 2**).

Table 1 Agreement assessment among traumatology and orthopedic residents for the classifications of floating knee (Fraser and Blake & McBryde), according to the Kappa index

YEAR OF RESIDENCE	NUMBER OF RESIDENTS	FRASER CLASSIFICATION	BLAKE & MCBRYDE CLASSIFICATION
1°	9	0.58	0.46
2°	7	0.59	0.51
3°	10	0.72	0.71

Table 2 Evaluation of agreement between orthopedists specialized in knee trauma for the classifications of floating knee (Fraser and Blake & McBryde), according to the Kappa index

NUMBER OF SPECIALISTS	FRASER CLASSIFICATION	BLAKE & MCBRYDE CLASSIFICATION
6	0.597	0.843

Discussion

Classifications in orthopedics and traumatology are tools that help to standardize an international language in the approach to injuries. The proposal of the adoption of a classification system involves its reproducibility capacity, simplicity and ease of memorization, helping in the choice of appropriate therapy and in the prognostic prediction of the lesion.[9]

It is believed that this is the first study that evaluates the degree of agreement between the most used classifications for floating knee. The most important finding of this study was that the Fraser classification presented a higher degree of agreement in relation to the Blake & McBryde classification both among residents and orthopedists. In addition, the only excellent agreement for floating knee was the Fraser classification among knee orthopedists ($K = 0.843$).

Unlike other studies that compared the agreement between very popular classifications in orthopedics, such as Lauge-Hansen and Weber for ankle fractures,[10] Neer for fracture of the proximal humerus,[11] and Garden for femoral neck fractures,[12] that obtained weak agreement according to the Kappa index, the present study showed that all groups, including in 1st-year residents, obtained at least moderate level of agreement for both classifications evaluated. This information reinforces the reproducibility of both Fraser and Blake & McBryde classifications.

The importance of classification in orthopedics and, more specifically, in cases of floating knee can be represented in the study by Demirtas et al.,[13] who, using the classification of Blake & McBryde, demonstrated that associated fractures,

and rate of complications and quality of life can be estimated from the classification. Therefore, an accuracy when classifying cases of floating knee may have value in the search for certain associated lesions and have prognostic value.

Although some publications point out that the Blake & McBryde classification was evidenced as the most recognized and most used one,[14] the authors' opinion is that the Fraser classification should be of choice in cases of floating knee. This is due to the fact that, in addition to being more reproducible as shown in the results, several studies point to the presence of intra-articular fracture as one of the main prognostics factors,[15–18] and the Fraser classification offers greater detail of intra-articular trait.

To minimize the risk of bias, we used the Kappa method. However, we highlight as a limitation of the study that the sample of knee-specialist orthopedists is smaller than that of residents, which makes it difficult to compare agreement between these groups. We can mention as another limitation, the non-performance of intraobserver comparison. Finally, case samples (N) could be more expressive.

Conclusion

The only excellent agreement for floating knee was the Fraser classification among knee specialist orthopedists. Substantial agreement was obtained among 3rd-year orthopedic residents for both Fraser and Blake & McBryde classifications. All other evaluations of agreement between the evaluated groups were considered moderate.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors declare that have no conflict of interests.

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Predictive Factors for Blood Transfusion after Total Knee Arthroplasty*

Fatores preditivos de hemotransfusão após artroplastia total de joelho

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Rev Bras Ortop 2021;56(4):463–469.

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Abstract

Objectives The present paper aims to (1) verify the incidence and volume of blood transfusion among patients undergoing unilateral cemented total knee arthroplasty (TKA) in a single Brazilian reference center; (2) identify pre and perioperative variables to determine subjects with higher risk (i.e., predictive factors) for blood transfusion within 48 hours following surgery; (3) estimate the risk of blood transfusion during the first 48 hours after the procedure.

Methods The initial sample consisted of all patients undergoing TKA from August 2010 to August 2013. After applying the exclusion criteria, 234 patients aged 30 to 83 years old and diagnosed with primary or secondary osteoarthritis due to rheumatoid arthritis remained in the study.

Results Preoperative hemoglobin levels $\leq$ 12.3 g/dL and ischemia time $\geq$ 87 minutes were independent predictors for post-TKA blood transfusion, with a relative risk of 2.48 and 1.78, respectively. Approximately half of the TKA patients (51.3%) presenting these two variables required a blood transfusion.

Conclusion The incidence of post-TKA blood transfusion was 33.7%. On average, each transfused patient received 480 mL of packed red blood cells. Preoperative hemoglobin levels $\leq$ 12.3 g/dL ($p < 0.001$) and ischemia time $\geq$ 87 minutes ($p < 0.047$) were independent predictors for blood transfusion in TKA using a pneumatic cuff, with a relative risk of 2.48 and 1.78, respectively. Age, gender, diagnosis, or body mass index were not considered independent predictors for the need for blood transfusion up to 48 hours after the procedure.

Keywords
- arthroplasty, replacement, knee
- blood transfusion
- osteoarthritis, knee

Resumo

Objetivos O presente estudo teve como objetivos (1) verificar a incidência e o volume de transfusão sanguínea entre os pacientes submetidos à artroplastia total do joelho

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received
December 13, 2019
accepted
June 1, 2020
published online
November 2, 2020

DOI https://doi.org/10.1055/s-0040-1715511.
ISSN 0102-3616.

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(ATJ) unilateral cimentada em um único centro de referência nacional; (2) identificar variáveis pré e perioperatórias que nos permitam identificar os indivíduos sob maior risco (fatores preditores) quanto à necessidade de transfusão sanguínea nas 48 horas subsequentes à realização da cirurgia; (3) estimar o risco de transfusão sanguínea durante as primeiras 48 horas após o procedimento.

Métodos A amostra inicial foi constituída por todos os pacientes submetidos à ATJ entre agosto de 2010 e agosto de 2013. Após aplicação dos critérios de exclusão, permaneceram no estudo 234 pacientes com idade entre 30 e 83 anos, portadores de osteoartrose primária ou secundária a artrite reumatoide.

Resultados A análise dos resultados mostrou que valores de hemoglobina pré-operatória $\leq$ 12,3 g/dL e tempo de isquemia $\geq$ 87 minutos são preditores independentes para hemotransfusão após ATJ, com risco relativo de 2,48 e 1,78, respectivamente. Aproximadamente metade dos pacientes (51,3%) submetidos a ATJ com essas duas variáveis necessitaram de hemotransfusão.

Conclusão A incidência de transfusão sanguínea após ATJ foi de 33,7%. Em média, cada paciente foi transfundido com 480 mL de concentrado de hemácias. Concentração de hemoglobina pré-operatória $\leq$ 12,3 g/dL ($p < 0,001$) e tempo de isquemia $\geq$ 87 minutos ($p < 0,047$) foram preditores independentes para hemotransfusão em ATJ sob uso de manguito pneumático, com risco relativo de 2,48 e 1,78, respectivamente. A idade, o gênero, diagnóstico ou índice de massa corpórea não foram considerados preditores independentes para a necessidade de hemotransfusão até 48 horas após o procedimento de artroplastia.

Palavras-chave
- artroplastia do joelho
- transfusão de sangue
- osteoartrite do joelho

Introduction

Total knee arthroplasty (TKA) is often associated with visible, significant blood loss, possibly exceeding 1,500 mL.[1] In addition, such volume losses are also underestimated, because they disregard blood leakage to traumatized soft tissues, hematoma formation in joint cavity, and hemolysis. About 80% of this occult bleeding occurs within 24 hours and correspond to up to 50% of the actual total blood loss.[1–3]

Volume losses of such magnitude usually result in blood transfusion requirement in 7.1 to 67% of patients.[4–9] Although the incidence of blood transfusion-related complications has decreased in recent decades, this is not a risk-free procedure.[8–12] Allogeneic blood transfusion is also associated with an increased risk of postsurgical infection when orthopedic implants are used. This evidence, however, remains inconclusive and needs further studies.[10–17]

Therefore, prior identification of patients with a higher risk of receiving a blood transfusion after TKA can help change pre, intra, and postoperative care.[7]

As such, the present study aims to: (1) determine blood transfusion incidence and volume among patients undergoing unilateral cemented TKA in a single center; (2) identify predictive factors regarding the need for blood transfusion within 48 hours following TKA; (3) estimate the risk of blood transfusion during the first 48 hours after the procedure.

Material and Methods

After approval by the Research Ethics Committee of the institution, we performed a retrospective evaluation of medical records from all patients undergoing cemented unilateral TKA by two surgeons between August 2010 and August 2013.

Patients undergoing unicompartmental knee arthroplasty (UKA), UKA conversion to TKA, bilateral surgery or TKA revision, and those with coagulopathies or under preoperative anticoagulant therapy were excluded from the sample. No patient donated blood prior to the surgery.

The study included both male and female patients, aged 30 to 83 years old, diagnosed with primary osteoarthritis (OA) or rheumatoid arthritis (RA). All procedures were performed through a medial parapatellar approach after spinal anesthesia with peripheral sciatic and femoral nerve block. The surgeries were performed under a 300 mm Hg pressure ischemia applied before incision. After cementing the P. F. C. Sigma Knee System (DePuy-Synthes Companies, Warsaw, IN, USA) implants with posterior stabilization and pa + tellar replacement, the ischemia was released for hemostasis with a monopolar electrocautery alone. No hemostatic drugs were administered. A single 4.8-mm drain was used in all patients for 24 hours. Antimicrobial prophylaxis was performed with cefazolin (2 g, intravenously during anesthetic induction) and sustained for 24 hours (1 g, intravenous, every 8 hours). Deep vein thrombosis was prevented with low molecular weight heparin (Clexane Sanofi-Avenitis, Sao Paulo, SP, Brazil) subcutaneously administered in a single daily dose of 40 mg, starting 12 hours within surgery, and sustained for 10 days.

The following preoperative variables were surveyed: gender, age, diagnosis, body mass index (BMI) according to the World Health Organization (WHO) criteria from 2000, surgical risk according to the American Society of Anesthesiology (ASA) criteria and hemoglobin (Hb) level measured 24 hours

before surgery. Ischemia time was assessed intraoperatively. In the immediate postoperative period, determined as the first 48 hours following surgery, the lowest Hb level and the total volume of transfused allogeneic blood products were recorded.

The need for allogeneic blood transfusion during surgery was determined by the anesthesiologist, who did not play a role in this study. The postoperative blood transfusion requirement was determined by the assistant team as per the proper protocol adopted by the institution, which states that patients with Hb level greater than 10 g/dL do not need it. Blood transfusion is recommended for patients with Hb levels between 6 and 7 g/dL. For Hb values between 7 and 10 g/dL, the decision is individually tailored. Next, patients were divided into two groups, according to the need for blood products transfusion: the transfused group (T group, n = 79) and non-transfused group (nT group, $n = 155$).

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-Wilks normality tests were applied to ascertain the normal distribution of a variable.

The existence of a significant relationship between the studied variables and post-TKA blood transfusion requirement were evaluated by the following methods: (1) Student *t*-test for numerical data comparison and Mann-Whitney test for independent samples; (2) inferential analysis using the Spearman correlation coefficient to determine the degree of association between hemoglobin level range (ΔHb), ischemia time, and transfused volume; (3) χ^2 or Fisher exact test for categorical data comparison; and (4) logistic regression analysis to assess the simultaneous influence of predictor variables. The variable-selecting process was stepwise forward at a 5% level.

A receiver operator characteristic (ROC) curve determined the accuracy of the model in predicting blood transfusion requirement. This graphical representation is built with sensitivity/specificity fractions at several cutoff points for each variable, illustrating system performance and its discrimination threshold. In addition, the ROC curve allows the identification of the best cutoff point.

Statistically significant differences were determined by *p*-values < 0.05. All calculations were performed by an independent statistician, using SAS version 6.11 statistical software (SAS Institute, Inc., Cary, NC, USA).

Results

Allogeneic Blood Transfusion Incidence and Volume

The initial sample consisted of 237 patients. After excluding 3 patients for hemophilia, 234 patients remained in the study, with a mean age of 66.6 ± 9.1 years old (range, 30 to 83 years old). Of this total, 81.6% (191/234) were women. As for diagnosis, 83.8% (196/234) had idiopathic OA and 16.2% (38/234) had RA.

The incidence of post-TKA blood transfusion was 33.7% (79/234). On average, each patient was transfused with 480 mL (1.6 units) of packed red blood cells. About half (50.6%) of the transfused patients received a total of 600 mL of blood products, while 35 (44.3%) subjects required 300 mL, and only 5.1% (4/79) of the patients needed more than 2 units of blood products.

Table 1 Patients characteristics and clinical numerical variables ($n = 234$)

	T group ($n = 79$)	nT group ($n = 155$)	*p*-value
Age*	67.6 ± 9.3	66.1 ± 9.0	0.23
Gender**			
Male	10 (12.7%)	33 (21.3%)	0.10
Female	69 (87.3%)	122 (78.7%)	
Diagnosis**			
RA	10 (12.7%)	28 (18.5%)	0.25
OA	69 (87.3%)	123 (81.5%)	
BMI (kg/m^2)*	30 ± 5.4	30.2 ± 5.3	0.71
ASA**			
1	3	11	0.49
2	75	139	
3	1	5	

Abbreviations: RA, rheumatoid arthritis; ASA, American Society of Anesthesiology; BMI, body mass index; OA, osteoarthrosis.
Numerical data expressed as mean ± standard deviation values. Categorical data expressed as frequency and percentage values.
T Group= received postoperative blood transfusion, nT Group= received no postoperative blood transfusion.
*Student's *t*-test for independent samples or Mann-Whitney test.
**χ^2 or Fisher exact test.

►**Table 1** summarizes the general characteristics of patients allocated to the T (transfused) and nT (non-transfused) groups. There was no difference between groups regarding age, gender, diagnosis, BMI, and surgical risk according to the ASA score (►**Table 1**).

Predictive Factors for Allogeneic Blood Transfusion Requirement

Univariate analysis of clinical and surgical parameters revealed that post-TKA blood transfusion requirement was related to pre- and postoperative low hemoglobin levels. In addition, transfused patients were subjected to a longer ischemia time ($p < 0.0014$). Other variables, such as diagnosis, gender, age, BMI, and ASA-based surgical risk, were not related to the need for postoperative blood transfusion (►**Tables 2** and **3**).

Both male and female patients from the T group presented significantly lower pre- and postoperative Hb levels when compared to the nT Group. Similarly, the Hb level range (absolute and relative ΔHb) was significantly higher in comparison to both male and female subjects from the nT group (►**Table 4**).

In transfused patients (T group), considering the pre and postoperative Hb level ranges (ΔHb), there was a significant correlation between absolute ΔHb ($r_s = 0.18$; $p = 0.006$) and relative ΔHb ($r_s = 0.17$; $p = 0.007$) with ischemia time.

Table 2 Univariate analysis of numerical parameters ($n = 234$)

Variable	T group ($n = 79$)		nT group ($n = 155$)		p-value[a]
Age (years old)	67.6 ± 9.3	(40–83)	66.1 ± 9.0	(30–82)	0.23
BMI (kg/m^2)	30.0 ± 5.4	(20.8–44.9)	30.2 ± 5.3	(15.0–43.8)	0.71
Ischemia time (minutes)	94.5 ± 21.0	(50–150)	87.0 ± 20.2	(40–135)	0.0014

T group= received postoperative blood transfusion, nT Group= received no postoperative blood transfusion. Data expressed as mean ± standard deviation values; range is showed within parenthesis.
[a]Student *t*-test for independent samples.

Table 3 Univariate analysis of categorical parameters

Variable	T group ($n = 79$)		nT group ($n = 155$)		p-value[a]
Gender					
Male	10	12.7%	33	21.3%	0.10
Female	69	87.3	122	78.7	
Diagnosis					
OA	69	87.3	122	78.7	0.25
RA	10	12.7	33	21.3	
Surgical Risk					
ASA 1	3	3.9	11	7.1	0.49
ASA 2	74	94.9	139	89.7	
ASA 3	1	1.3	5	3.2	

Abbreviations: RA, Rheumatoid Arthritis; OA, osteoarthrosis.
T group= received postoperative blood transfusion, nT Group= received no postoperative blood transfusion.
[a]χ^2 or Fisher exact test.

Absolute ΔHb ($r_s = 0.24$; $p = 0.0002$) and relative ΔHb ($r_s = 0.35$; $p = 0.0001$) were significantly correlated with the final volume of transfused blood products when pre and postoperative Hb level ranges were considered. There was also a significant correlation ($r_s = 0.16$; $p = 0.013$) between ischemia time and the volume of transfused blood products.

In addition, ischemia time was related to a higher drop in absolute and relative Hb values. Reduced Hb levels and ischemia time were directly related to a higher volume of transfused blood products in TKA perioperative period.

A subsequent multivariate logistic regression analysis assessed the simultaneous influence of predictor variables on the need for blood transfusion. This evaluation confirmed the preoperative Hb level ($p < 0.0001$) and ischemia time as independent predictive factors for postoperative blood transfusion requirement. Other variables did not present a significant independent contribution at a 5% level.

Receiver operator characteristic curves for Hb levels and ischemia time identified the cutoff value for post-TKA blood transfusion as preoperative Hb levels ≤ 12.3 g/dL. This test presented 62.0% sensitivity and 61.9% specificity. For ischemia time, the cutoff value was ≥ 87 minutes, with 62.0% sensitivity and 51.6% specificity (►**Figure 1**).

At logistic regression after cutoff values identification, preoperative Hb levels ≤ 12.3 g/dL ($p < 0.001$) and ischemia time ≥ 87 minutes ($p < 0.047$) were independent predictors for blood transfusion in TKA using a pneumatic cuff, with respective relative risk values of 2.48 and 1.78.

Table 4 Hemoglobin (Hb) levels and range (Δ) according to gender-stratified transfusion

Variable	T group		nT group		p-value[a]
Male gender	$n = 10$		$n = 33$		
Preoperative Hb (g/dL)	12.9 ± 0.7	(11.8–14.1)	13.8 ± 1.4	(11.2–16.7)	0.046
Postoperative Hb (g/dL)	8.0 ± 1.1	(6.7–10)	9.9 ± 1.5	(7.3–14.2)	0.0007
Δ Hb (g/dL)[1]	5.0 ± 1.1	(6.7–3)	4.0 ± 1.3	(6.7–1.1)	0.033
Δ Hb (%)[2]	38.3 ± 8.0	(50–24)	28.7 ± 8.7	(48–9.4)	0.003
Female gender	n = 69		n = 122		
Preoperative Hb (g/dL)	11.9 ± 1.3	(9.3–14.8)	12.4 ± 1.2	(8.7–16.1)	0.002
Postoperative Hb (g/dL)	7.8 ± 1.0	(5.8–10.9)	9.1 ± 1.4	(6.1–12.3)	0.0001
Δ Hb (g/dL)[1]	4.1 ± 1.6	(7.4–1.3)	3.3 ± 1.4	(8.2–1.1)	0.0005
Δ Hb (%)[2]	34.0 ± 10.5	(54–12.7)	26.5 ± 9.8	(51–9.1)	0.0001

Abbreviation: Hb, hemoglobin.
T group = received postoperative blood transfusion, nT Group= received no postoperative blood transfusion. Data expressed as mean ± standard deviation values; range is showed within parenthesis.
[1]Absolute Δ = preoperative Hb – postoperative Hb.
[2]Relative Δ (%) = absolute Δ / preoperative Hb *100.
[a]Student *t*-test for independent samples.

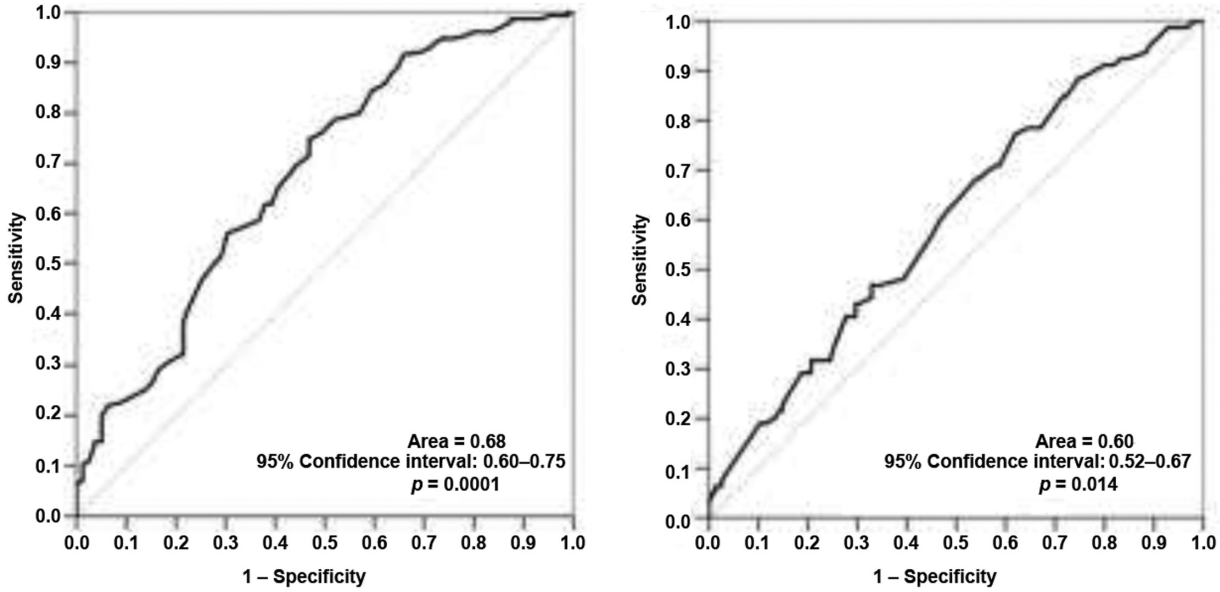


Fig. 1 Global accuracy according to the receiver operator characteristic curve for preoperative hemoglobin value (**A**) and ischemia time (**B**) for blood transfusion after total knee arthroplasty under ischemia with a pneumatic cuff.

Risk of Post-TKA Allogeneic Blood Transfusion

Based on the logistic regression model, the probability of a patient undergoing TKA requiring blood transfusion within 48 hours after the procedure is calculated using the following formula:

$$\mathrm{Pr_{est}\ (hemotransfusão)} = \frac{e^{3{,}7596 - (0{,}5178 \times \text{Hb pré em g/dL}) + (0{,}0211 \times \text{tempo de cirurgia min})}}{1 + e^{3{,}7596 - (0{,}5178 \times \text{Hb pré em g/dL}) + (0{,}0211 \times \text{tempo cirurgia min})}}$$

►**Table 5** presents the estimated probability of transfusion according to the relevant parameters.

Discussion

The present study is a cross-sectional evaluation of 234 patients undergoing TKA demonstrating that preoperative Hb levels ≤12.3 g/dL and ischemia times ≥ 87 minutes are independent predictors for postprocedural blood transfusion.

Even though TKA surgeries are usually associated with high total blood loss, the literature reports widely variable blood transfusion rates. In our sample, transfusion was performed in 33.7% of the patients within 48 hours after surgery. Although this result is similar to those described in a large series,[9] the adoption of conservative institutional criteria for blood transfusion may reduce this rate. Ballantyne et al.[17] identified a reduction in the incidence of blood transfusion after unilateral TKA from 31 to 11.9% after adopting a more rigorous institutional protocol, in which blood transfusion was indicated only in patients with postoperative Hb levels < 8.5 g/dL or those with acute anemia symptoms.

Table 5 Estimated probability of blood transfusion according to the logistic model

Preoperative hemoglobin level ≤ 12.3 g/dL	Ischemia time ≥ 87 minutes	Estimated probability (%)	95% Confidence interval
No	No	19.3	12.4–28.9
No	Yes	29.9	20.8–40.8
Yes	No	37.2	26.4–49.4
Yes	Yes	51.3	40.0–62.6

Predictive models to identify patients most likely to need postoperative blood transfusion are essential for the rational management of blood components.[7] As such, we sought to assess pre and perioperative variables in the Brazilian population that would allow the identification of subjects at higher risk for requiring blood transfusion within 48 hours after TKA.

The most consistent independent predictor of postoperative blood transfusion requirement was a preoperative hemoglobin level up to 12.3 g/dL. Based on this value, the relative risk of transfusion was 2.48, therefore suggesting that patients with this Hb level are 2.48 times more likely to require a blood transfusion after undergoing TKA compared to subjects with higher levels. Salido et al.[18] also identified a preoperative Hb level below 13 g/dL as a blood transfusion predictor in patients undergoing total hip arthroplasty (THA) or TKA, with a relative risk similar to the one observed by us (2.51). The percentage of patients within this range of preoperative Hb values that received blood transfusions (69%) was also similar to the value detected in our series (62%). Similar results were noted by Guerin et al.,[19] who identified a 4-fold higher risk of transfusion in patients with preoperative Hb levels < 13 g/dL; in addition, this risk was exacerbated in both ASA 3 and 4 patients.[9]

In our study, another independent predictive factor for blood transfusion was ischemia time ≥ 87 minutes, resulting in a relative risk of 1.78. Noticewala et al.[20] showed that total

surgical time alone (and not ischemia time) is an independent predictive factor for post-TKA blood transfusion requirement. Although Salido et al.[18] reported that a surgical time of 91.1 minutes was associated with a greater need for blood transfusion, this finding has not been confirmed as an independent predictive factor.

Prasad et al.[3] confirmed a greater need for post-TKA blood transfusion in patients with RA. However, Ogbemudia et al.[21] identified low Hb level as a predictive factor for transfusion in patients with RA. In our study, similarly to Noticewala et al.,[20] RA was not an independent predictive factor. However, as also noted by Ogbemudia et al.,[21] low Hb levels in these patients was a risk factor for postoperative blood transfusion.

Hart et al.[6] reported age as an independent predictor, with a 10.2-fold increase in the risk of transfusion for each decade of life. Our results did not confirm the relationship between age and post-TKA transfusion requirement.

The patient's gender and age were not independent predictors for post-TKA blood transfusion. Although our female subjects usually had lower Hb levels, consistent with the findings of Ogbemudia et al.[21], there was no relationship between gender and transfusion requirement.

Another frequently investigated parameter is BMI. Lower BMI values are associated with lower[13,14] or higher[22] transfusion requirement. Salido et al.[18] described body weight as an independent predictor for postoperative blood transfusion requirement, with a relative risk of 1.05. In RA patients, BMI was associated with a greater need for blood transfusion.[21] Similarly to Bong et al.,[23] we did not observe a relationship between BMI and the need for postoperative transfusion.

The literature points to a consensus that patients presenting an ASA score greater than 2 often require transfusion,[6,7,9,11,15] demonstrating that, compared to subjects with ASA 1 and 2 scores, those with ASA 3 and 4 scores have a 3-fold higher independent risk for postoperative blood transfusion. We did not observe a relationship between surgical risk (ASA) and the need for blood transfusion, which can be explained by the reduced number of ASA 3 or 4 participants.

Preoperative identification of patients most likely needing a post-TKA blood transfusion is pivotal in the Brazilian public health scenario. Thus, we developed a model to estimate the relative risk of blood transfusion requirement. A ROC curve was constructed to determine the accuracy of this model in predicting which patients were at higher transfusion risk after TKA. The discriminatory power of our model, estimated by the Hb ROC curve (area under the curve [AUC], 0.68), although regular, presented statistical significance with 62.0% sensitivity and 61.9% specificity. In the ROC curve for ischemia time (AUC, 0.60), the predictive power of our equation was low, but it presented statistical significance, with 62.0% sensitivity and 51.6% specificity. Other predictive models under similar conditions showed greater discriminatory power than our equation, with an AUC value of 0.74[22] or 0.99[24] and 71%[22] or 90% sensitivity.[18] However, the specificity of this last report (52.5%) was similar to the one found in our study (51.6%).[20]

We believe, however, that before using the equation in the decision-making process, it is important to validate it in other institutions for possible mode adjustments.

Our study has some limitations. Despite the existence of clinical and laboratory parameters in the transfusion protocol, the view of specialists (anesthesiologists, intensivists, clinicians, and surgeons) may have specified the transfusion indication in some patients, which is a limitation of this work. Another important limitation refers to the non-performance of sample calculation; nevertheless, we believe that the fact that our sample consists of an expressive number of patients from a single tertiary reference center in the treatment of highly complex orthopedic diseases gives relevance to our findings. Still, we emphasize the need for additional prospective studies to corroborate our results and guide the most appropriate treatment for patients in preoperative TKA programming with Hb levels < 12.3 g/dL. Likewise, effective measures are required to reduce bleeding in patients submitted to surgeries with an ischemia time > 87 minutes.

Conclusion

The incidence of post-TKA blood transfusion was 33.7%. On average, each transfused patient received 480 mL of packed red blood cells.

Preoperative hemoglobin levels ≤ 12.3 g/dL ($p < 0.001$) and ischemia time ≥ 87 minutes ($p < 0.047$) were independent predictors for blood transfusion in TKA using a pneumatic cuff, with a relative risk of 2.48 and 1.78, respectively.

Age, gender, diagnosis, or BMI were not considered independent predictors for the need for blood transfusion up to 48 hours after the procedure.

Financial Support

There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests

The authors declare that there is no conflict of interests.

Acknowledgments

We thanks our orthopedic colleagues Diego Perez da Motta and Daniel Ramallo for their collaboration in patient care.

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Treatment of Chondral Knee Lesions with Autologous Chondrocytes Embedded in a Fibrin Scaffold. Clinical and Functional Assessment*

Tratamento de lesões condrais no joelho com condrócitos autólogos embebidos em arcabouço de fibrina. Avaliação clínica e funcional

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Rev Bras Ortop 2021;56(4):470–477.

Abstract

Objective The aim of our study is to analyze the clinical and functional results obtained using autologous chondrocytes embedded in a fibrin scaffold in knee joint injuries.

Methods We included 56 patients, 36 men and 20 women, with a mean age 36 years. Six of the patients were professional athletes, with single knee injuries that were either chondral or osteochondral (43 chondral, 9 osteochondral, 2 cases of osteochondritis dissecans and 2 osteochondral fractures), 2 to 10 cm^2 in size and $\leq$ 10 mm deep, with no signs of osteoarthritis. The location of the injury was in the patella (8), the medial femoral condyle (40) and lateral femoral condyle (7) and one in the trochlea. The mean follow-up was 3 (range: 1–6) years. The clinical course was assessed using the Cincinnati and Knee Injury and Osteoarthritis Outcome (KOOS) scores, 6 and 12 months after surgery. The paired Student t-test was used to compare pre-and postoperative results.

Results Six months after the implant, patients resumed their everyday activities. On the assessment scores, their condition was improving in comparison with their presurgical state ($p < 0.05$). They were also able to carry out their sporting activities more easily than prior to surgery ($p < 0.05$).

Conclusion The seeding of chondrocytes in fibrin may provide a favorable micro-environment for the synthesis of extracellular matrix and improved the clinical condition and activity of the patients 1 year after surgery.

Keywords
- cartilage
- knee
- scaphoid bone
- chondrocytes
- fibrin

* *Work developed at the CEU-San Pablo University School of Medicine, IMMA, Boadilla del Monte, Madrid, Spain.*

received
January 5, 2020
accepted
July 6, 2020
published online
October 29, 2020

DOI https://doi.org/10.1055/s-0040-1716764.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo O objetivo do nosso estudo é analisar os resultados clínicos e funcionais do tratamento de lesões nas articulações do joelho com condrócitos autólogos embebidos em arcabouço de fibrina.

Métodos O estudo foi realizado com 56 pacientes (36 homens e 20 mulheres) com idade média de 36 anos; 6 indivíduos eram atletas profissionais. Os pacientes apresentavam lesões únicas, condrais ou osteocondrais (43 condrais, nove osteocondrais, 2 casos de osteocondrite dissecante e duas fraturas osteocondrais) no joelho, com 2 a 10 cm^2 de tamanho e $\leq$ 10 mm de profundidade, sem sinais de osteoartrite. As lesões estavam localizadas na patela (8), no côndilo femoral medial (40), no côndilo femoral lateral (7) e na tróclea (1). O período médio de acompanhamento foi de 3 anos (faixa de 1–6 anos). A evolução clínica foi avaliada pelos escores de Cincinnati e *Knee Injury and Osteoarthritis Outcome* (KOOS), 6 e 12 meses após a cirurgia. O teste t de Student pareado foi utilizado para comparação dos achados pré e pós-operatórios.

Resultados Os pacientes retomaram suas atividades diárias 6 meses após o implante. Os escores avaliados demonstraram a melhora em comparação ao estado pré-cirúrgico ($p < 0,05$). Além disso, os pacientes conseguiram realizar suas atividades esportivas com mais facilidade do que antes da cirurgia ($p < 0,05$).

Conclusão A cultura de condrócitos em fibrina pode proporcionar um microambiente favorável para a síntese de matriz extracelular e melhorar a condição clínica e a atividade dos pacientes 1 ano após a cirurgia

Palavras-chave

- cartilagem
- joelho
- osso escafoide
- condrócitos
- fibrina

Introduction

Chondral and osteochondral joint injuries lead to degeneration of the joint, which may ultimately require a prosthesis.[1] Cartilage is a tissue of low cellular density, which needs some support to achieve repair or regeneration.[2,3] To this end, surgical approaches based on regenerative techniques make use of bioengineering to develop new hyaline cartilage tissue (autologous chondrocyte implant [ACI], mesenchymal stem cells [MSCs] chondrocytes in different scaffolds [MACI])[2] and can be performed through open surgery, mini-arthrotomies, or arthroscopy.

Autologous chondrocyte implantation (ACI) has developed from the implantation of cultured cells in the lesion itself, as a cellular suspension,[4] to the inclusion of cultured cells in biodegradable scaffolds,[5,6] which permit synthesis of extracellular matrix and cell differentiation. Although the number of cells is homogeneous across publications, the type of matrix used varies greatly.

A further aspect to consider in this type of treatment is that during cell growth, under certain conditions, the cells may change their morphology and phenotype, expressing transcription factors, such as the gene Sox9, and producing col2 or synthesis of col1, col3, or col10, which synthesize an extracellular matrix with poor biomechanical conditions,[7] and are differentiated into a tissue that is also of low quality to perform the function of the hyaline cartilage.[8] But if the chondrocytes are seeded in a chondrotropic environment, they can redifferentiate to develop hyaline cartilaginous tissue.[9]

Regenerative techniques are associated with high economic costs and high morbidity and have not always been found to obtain better results in the long term.[10,11] The aim of our study is to analyze the clinical results obtained in patients with chondral injuries treated with cultured autologous chondrocytes seeded in a fibrin scaffold.

Material and Methodology

A prospective study of 56 patients, 36 men and 20 women, operated on between April 2014 and October 2017, on the grounds of pain, joint lock, and functional limitations in the knee. Their mean age was 36 years (SD: 13; range: 16–64), and they had a mean follow-up of 27 (standard deviation [SD]: 16; range: 12–72) months. There were 32 injuries to the left knee and 24 to the right. The lesions were located as follows: 43 chondral, 9 osteochondral, 2 cases of osteochondritis dissecans and 2 osteochondral traumatisms. The location of the lesions were 8 cases in the patella, the distal femur, 40 cases in the medial femoral condyle and 7 cases in the lateral femoral condyle and, finally, 1 case in the trochlea. Forty-three of the patients took part actively in sporting activities, and 6 were professional athletes.

The inclusion criteria were: patients aged between 16 and 65 years with no signs of osteoarthritis or rheumatic disease, being operated on for the 1st time with single lesions, either chondral or osteochondral, between 2 and 10 cm^2 in size, in which the bone lesion was $\leq$ 10 mm deep. The exclusion criteria are patients with osteoarthritis grade II or above in the Kellgren-Lawrence scale, with morbid obesity (BMI $>$ 40) and patients with valgus or varum deformity $>$ 10°.

The operation was performed from 1 to 6 years after symptoms appeared, although in most cases this period was

2 to 4 years. On 5 occasions, the cartilage injury was associated with a meniscus or anterior cruciate ligament torn; this was repaired in the same operation. The mechanical axis was studied in the lower limbs looking for valgus or varum deformation. No corrective osteotomy was performed.

We evaluated the patients using the Cincinnati and Knee Injury and Osteoarthritis Outcome (KOOS) knee scores, during the preoperative period and 6 and 12 months after the operation. We measured the range of mobility and the presence of crepitation and took anterior-posterior and sagittal standing X-rays, and MRI of the knee at each assessment. We evaluated the range of mobility in the pre and postoperative periods separately of the two scales.

Cartilage Obtaining Procedure

The specimen of cartilage was obtained from the intercondylar fossa by an arthroscopic procedure using an osteochondral autologous transplantation system (OATS), (Artrex, Karisfeld, Germany), 8 mm in diameter. The extracted cartilage was stored in physiological saline solution supplemented with 0.05 mg gentamicin. In our tissue engineering laboratory, we expanded and maintained the chondrocytes in vitro, according with the recommendations from the bone and bank tissue.

Chondrocyte Culture

This was performed using a modified version of the technique devised by Visna et al.[6] We sectioned the joint cartilage obtained into small cubes sized 1 to 3 mm^3 in a class II laminar flow bell. The cartilage fragments were treated with trypsin (GIBCO-BRL Life Technologies, Grand Island, NY, USA). For digestion of the chondral matrix, they were treated with type II collagenase (GIBCO-BRL Life Technologies). The chondrocytes obtained were inoculated into 75 cm^2 culture flasks (NUNC Creek Drive, Rochester, NY, USA) for in vitro growth. The medium used was Opti-MEM (GIBCO-BRL Life Technologies), supplemented with 10% autologous human serum (AHS) and gentamicin. The cultures were kept in a controlled atmosphere with 5% CO_2 and a relative humidity of 100%. When the monolayer cultures reached between 70 and 80% confluence, the cells were detached and incubated in trypsin-EDTA (GIBCO-BRL Life Technologies).

To seed the chondrocytes in a three-dimensional scaffold, we used a fibrin-based glue. We followed the manufacturer's instructions, and before the fibrinogen and thrombin provided in the container were mixed, we added the chondrocytes so that they would be suspended in the fibrin. When 80% confluence was estimated, the cells were lifted with 0.25% trypsin-EDTA, counted in a Neubauer chamber using the trypan blue method, and subcultured in three fractions to encourage cell propagation and allow new cultures to be established, until 15 million cells were obtained. Microbiological tests were performed to ensure that the cultures contained no contamination. This number of chondrocytes was obtained in 26 days and in 15 $\times$ 75 cm^2 culture flasks. Subsequently, the cells were seeded in the three-dimensional fibrin scaffold, which was placed in a mold and set in for 5 minutes.

Surgical Technique (►Fig. 1)

Surgery was performed the day after the cells were seeded. An arthrotomy was performed and the injured area was exposed. Then, the loose osteochondral fragments were removed and the scar tissue in the bed of the lesion was curetted. One mm was removed from the edges of the joint cartilage surrounding the lesion, and small perforations were made in the subchondral bone plaque, without removing it, so that the biological glue would facilitate the anchoring of the bone implant.

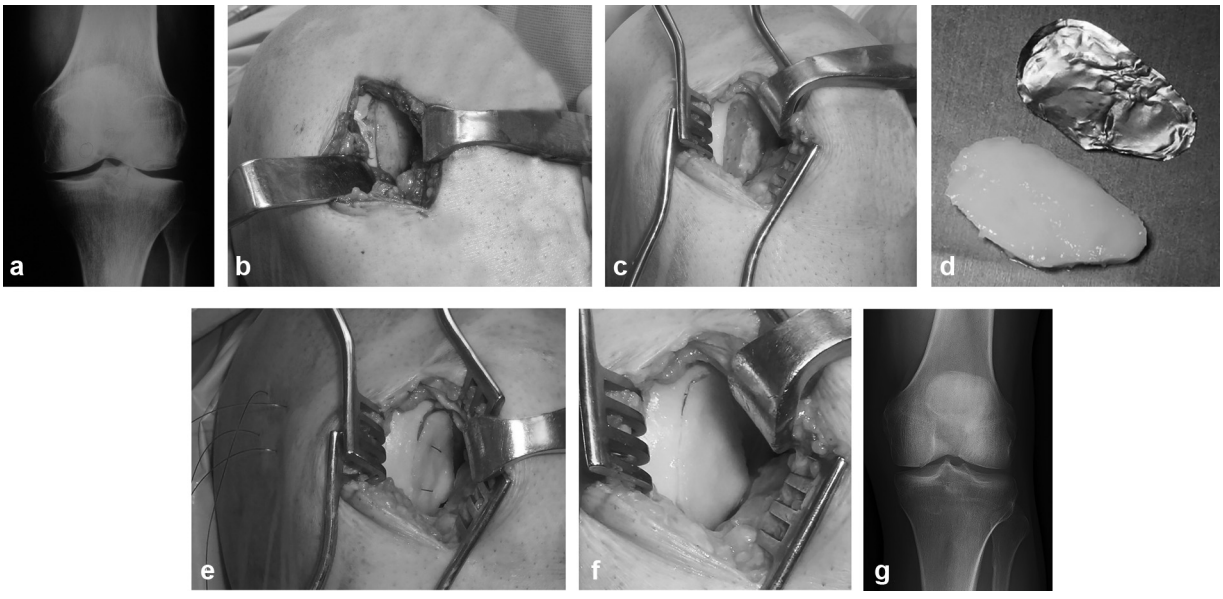


Fig. 1 (a) Preoperative X-ray, (b) An arthrotomy was performed and the injured area was exposed. (c) Loose osteochondral fragments were removed and the scar tissue in the bed of the lesion was curetted and small perforations were made in the subchondral bone plaque, without removing it, so that the biological glue would facilitate the anchoring of the bone implant. (d) An aluminum template to build a mold of the same morphology as the injury was used, (e) sutures were switched for re-absorbable sutures. (f) Once the implant had been placed, the transosseous sutures were removed, and a layer of fibrin glue was injected on the joint surface of the graft, (g) 12 months control X-ray.

We used an aluminum template to build a mold of the same morphology as the injury, and we designed the size and shape of the implant, ensuring that the edges were in contact with those of the recipient bone defect. We inserted 2.4 mm titanium surgical anchors (MiniFasTak®, Arthrex, Naples, Flo, U.S.A) at the edges of the lesion, switching the sutures for PDS II [polydioxanone] sutures with re-absorbable threads (Ethicon Inc., Sommerville, NJ, USA). When we inserted the anchors at the edges of the defect, we threaded the suture through the implant itself (Condrograft®, Banco de Huesos, UANL, Monterrey Mexico), which was in contact with the subchondral bone, and then again through its superior aspect, making sure that it was close to the other side of the hole. We made a transosseous tunnel toward the free side of the condyle. Through this tunnel we inserted the thread used to suture the implant. Once the anchors had been positioned and the thread had been inserted through the transosseous tunnel, we identified the suture threads to knot them, which we did without exerting pressure, until the next stage of fixation was completed.

To achieve full integration of the fibrin graft, we used Tissucol biological fibrin glue (Baxter Biosciences, Vienna, Austria), which formed a stable clot without affecting the seeded cells and encouraged their integration into the healthy cartilaginous tissue and the migration of the cells in the graft.

When we applied the Tissucol, a layer formed on the defect, and, immediately after this, we inserted the graft, keeping it in position using the trans-osseous sutures, lowering it and positioning it manually while pulling on the transosseous sutures so that the edges of the graft were in contact with the sides of the defect. Once the Condrograft had been placed in its definitive position inside the lesion, we proceeded to remove the transosseous sutures, without excessive force, in the direction of the free aspect of the femoral condyle. Finally, we put a layer of glue on the joint surface of the graft and in the place where it joined the normal cartilage.

After closing the wound by planes, we locked the knee joint in extension for 8 hours, to allow the Tissucol to set completely.

Postoperative Care

Passive mobility was allowed 8 hours after the surgery, and active mobility at 48 hours. After 10 days, partial walking was permitted, using crutches, and with progressive load-bearing. After 6 weeks, we allowed plantigrade locomotion bearing 75% of the body weight. The physiotherapy protocol concluded 18 weeks after the operation, when the crutches were removed, and the patient could bear full weight.

Magnetic Resonance Imaging Data Acquisition

Magnetic resonance images were acquired using a 1.5-Tesla GE (General Electric Healthcare, Milwaukee, WI, USA). Three clinically appropriate scans (3D FS FGRE, dual echo spin echo [FSE]and two-dimensional fast spin echo[2D FSE]) were acquired for each study participant. All images were reviewed by an experienced radiologist to confirm the absence of pathology.

Two imaging sequences were used. Two-dimensional dual-echo images were acquired to calculate, pixel-wise, T2 relaxation maps, proton density (PD). The 3D FS FSPGR images were segmented using a semi-automated atlas-based method (QMetrics, Inc., Rochester, NY, USA). Images were segmented, as previously described, into bone, cartilage, and cartilage sub-regions using eight atlases. This approach produced eight separate segmentations that were compared on a voxel-by-voxel basis to create one segmentation map. Cartilage segmentations were obtained for the medial weight-bearing and lateral weight-bearing regions of the femur, and medial and lateral tibial cartilage. Cartilage segmentation maps were used to determine the volume (mm3) and mean thickness (mm) of each region of interest. This method yielded test-retest precision of cartilage thickness values of 0.014mm (0.6%) at the femur in images obtained with a 1.5T MRI[12] (►**Fig. 2**).

Statistical Analysis

A descriptive statistical analysis was performed, and we used the paired Student t-test to compare the pre and postoperative scores.

Results

Prior to surgery, most patients reported pain and inflammation that stopped them from being able to carry out their normal activities.

During the postoperative period, the patients performed normal daily life and work activities as well as light exercise, and one third of them felt that their knee was normal and that they could perform demanding exercises and tasks. An improvement was observed in the perception of symptoms after the surgery, although the difference was not significant. The patients' overall scores on the Cincinnati and KOOS

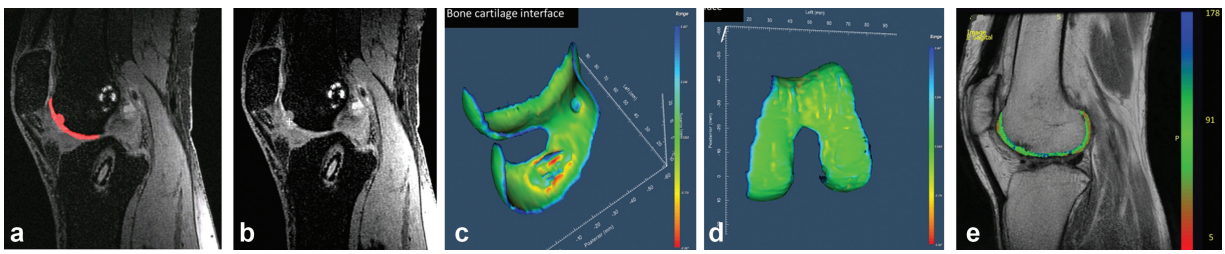


Fig. 2 (a,b) Preoperative sagittal view of femoral condyle cartilage 3D FS FGRE, (c,d) 3D rendering of surface curvature. The bone cartilage interface shows the extension of the chondral lesion. The articular surface shows smooth cartilage. (e) Sagittal view of T2 mapping cartilage estimated from 2D FSE (dual echo spin echo). Normal cartilage T2 range from 20 to 100 milliseconds.

Table 1 Cincinnati and Knee Injury and Osteoarthritis Outcome scores follow-up development

Follow-up (months) Postoperative	Cincinnati X (SD) range	KOOS X (SD) range
Preoperative	53.2 (16.96) 10–79	56.04 (15.29) 22.6–76.19
< 6	88.69 (13.03) 42–100	86.57 (11.46) 52.38–97.6
7–14	85 (16.54) 55–100	87.47 (16.17) 40.48–98.8
15–24	82.38 (16.16) 46–100	89.85 (8.47) 66.07–98.8

Abbreviations: KOOS, Knee Injury and Osteoarthritis Outcome; SD, standard deviation.

(►**Table 1**) showed an improvement over time, although no further differences were detected after the first 6 months (►**Fig. 3a**). The mobility varied after the treatment, being considered normal after 6 months postsurgery.

The functional assessment of everyday activities before surgery showed that 50% of the patients could walk less than 1 block and had limitations when it came to climbing upstairs or crouching. In the postoperative period, after 6 months had passed, 75% of patients were able to carry out their daily activities normally. We observed a clinical improvement in walking, going upstairs, sitting and kneeling 6 months after surgery ($p < 0.05$) (►**Table 2**) (►**Table 3**). As far as sports activities were concerned, we observed a clear improvement in the patients' capacities in the postoperative period as compared with the preoperative tests ($p < 0.05$) (►**Fig. 3b**).

There was no difference in the clinical scores between women and men during follow-up (►**Table 2**) on any of the scales. The osteochondral lesions were found to have better results than the chondral lesions in the last check-up at 24 months (►**Table 2**) (►**Table 3**). Perhaps the osteochondral lesions have better results than the chondral ones because the chondral lesions have more subchondral sclerosis making more deformity in the implantation site. Furthermore, the osteochondral lesions have migrations of bone marrow cells, ensuring a more complete fixation of the bioimplant matrix in the bone.

Of the 43 patients who took part in sports activities, 15 (34.88%) continue with this. Of the 6 professional athletes, 5 continued and 1 had to give up sports.

We found 6 complications (10.71%), half of which were related to the arthrotomy. There were three cases of arthrofibrosis, one of which was accompanied by a complex regional pain syndrome. The arthrofibrosis was treated with arthroscopic arthrolysis and mobilization under anesthesia. The patient with the complex regional pain syndrome had an interconsultation with the pain medicine department and was treated by them, without improvement. The patient ended receiving a unicondylar knee prosthesis. Three other patients with the graft in the medial condyle still had pain, and after a second look, we observed, in two cases, total delamination of the graft, while in the other there was complete loss of the implant. Since the wound was open, we implanted a fresh osteochondral allograft from the bone bank in the three cases.

According to the patient satisfaction score, 16 (28.6%) were very satisfied, 30 (53.6%) satisfied and would recommend the operation, 8 (14.3%) were unsatisfied, and 2 (3.5%) were disappointed. These last two patients were the ones with the severest complications: one with arthrofibrosis and the other with delamination of the graft.

Discussion

The MACI technique is well-documented for the repair of chondral lesions, and a second indication, when other treatment fails, for use in 2 to 10 cm^2 lesions in well-aligned legs of young, active patients.

The most widely used algorithms are based on the location, size and depth of the lesion, and the patient's level of activity.[13,14] The size of the lesion and the patient's level of activity are the most important factors when determining the correct course of treatment. The criteria for ensuring good results are as follows: patients should be young, not obese, non-smokers, with no previous surgery in the area, with defects in the femoral condyle or trochlea without signs of degeneration.[11] The lesion should be $\leq 10\ cm^2$ in size.

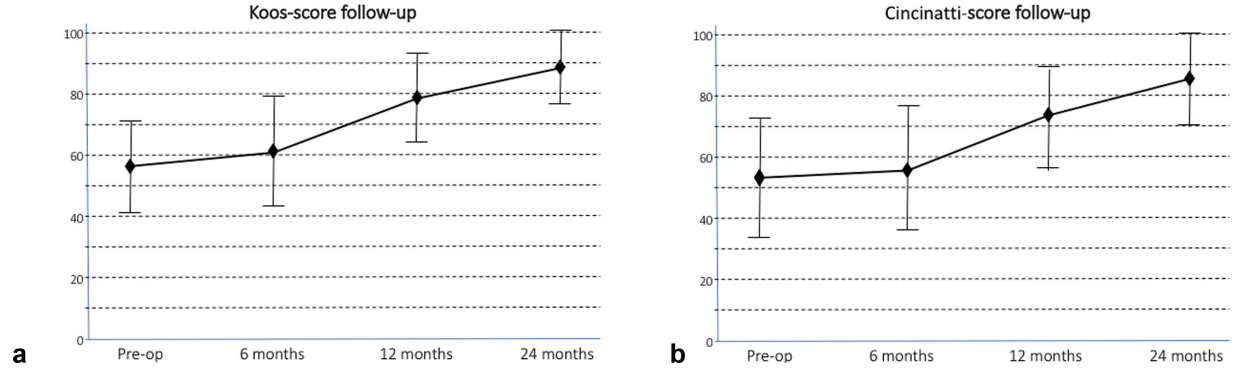


Fig. 3 (a) The Knee Injury and Osteoarthritis Outcome score and (b) the Cincinnati score showed an improvement over time, although no further differences were detected after the first 6 months.

Table 2 Knee Injury and Osteoarthritis Outcome score development for the general population, by gender (women and men) and type of injury (chondral or osteochondral)

	Preoperative X (SD) range	6 months X (SD) range	12 months X (SD) range	24 months X (SD) range
General	56.04 (15.29) 22.6–76.19	62.52 (18.62) 30.3–94.59	78.63 (14.43) 35.12–96.43	88.11 (12.23) 40.48–98.8
Women	58.27 (15.29) 25–75.59	67.99 (18.09) 36.9–92.26	78.78 (15.27) 39.88–95.27	87.33 (17.13) 98.8–50.59
Men	54.8 (15.37) 22.6–76.19	59.48 (18.46) 30.3–94.59	78.55 (14.17) 35.12–96.43	88.54 (12.32) 40.48–98.8
Cartilage injury				
Chondral	55.93 (14.36) 25–76.19	63.51 (17.19) 30.3–92.2	78.89 (13.12) 39.88–96.43	88.73 (9.99) 50.6–98.8
Osteochondral	59.97 (20.44) 22.6–75	63.82 (22.7) 36.9–94.59	84.22 (11.67) 59.52–94.59	93.36 (4.39) 85.71–98.8

Abbreviation: SD, standard deviation.

Table 3 Cincinnati score development for the general population, by gender (women and men) and type of injury (chondral or osteochondral)

	Preoperative X (SD) range	6 months X (SD) range	12 months X (SD) range	24 months X (SD) range
General	53.2 (16.96) 10–79	56.4 (19.30) 19–86	74.75 (16.85) 19–93	85.07 (15.41) 42–100
Women	50.9 (18.9) 10–71	59 (19.5) 19–84	71.75 (21.4) 19–93	81.7 (18.55) 46–100
Men	54.5 (15.93) 10–79	54.94 (19.33) 19–93	76.42 (13.75) 38–93	86.94 (13.27) 42–100
Cartilage injury				
Chondral	53.35 (16.98) 10–78	56.7 (19.36) 19–86	75.3 (16.97) 19–93	84.93 (14.35) 46–100
Osteochondral	53.11 (20.25) 10–79	59 (20.1) 34–80	78.56 (10) 60–93	92.78 (5.65) 82–100

Abbreviation: SD, standard deviation.

Natural polymer and synthetic biodegradable scaffolds have been used, with high porosity, a large cell contact surface, a stable structure, three-dimensional shape and biocompatible composition. Different types of materials have been proposed, such as collagen-1,[3] hyaluronic acid,[5] collagen-3,[15] or fibrin.[6] Fibrin scaffolds are formed when two components derived from blood plasma come together (thrombin and fibrinogen) to build a specific matrix that offers a good environment for chondrocytes to proliferate.[8,16,17]

Injuries to the medial femoral condyle generally obtained better results, after a 3-year follow up, than those in the lateral condyle, but not than those in the patella.[18] In our study, we had results similar to those in the literature. We think that these results are due to the characteristics of the location of the lesions. The medial femoral condyle is the anatomical site that carries more load, when compared with other sites, making the lesions a reflect of the load. The bicondylar lesions show an arthropathy of the two compartments, making the postoperative evolution less successful. The femoropatellar articulation is not a direct load site. The main function of this articulation is a pulley mechanism, which makes flexoextension movements of the knee easy to perform. Furthermore, the patella is intimately associated with the trochlear groove of the femur, facilitating the implantation of the Chondrograft.

Age is a factor that may be related to the degenerative process or may have a negative impact on the joint.[19] The best results are obtained with patients under the age of 30.[20,21] Although, the majority of the studies shows the age of the patients as an important factor for the prognostic of the procedure, we didn't find any relation in our study. With our results, the viability of the chondrocytes and the conditions of the patients were the two major factors for the treatment success, more than age.

The waiting time before surgery has also been found to have an influence on the outcome,[18,19] although other factors influence the final result, such as the stability of the knee joint, the state of the menisci and ligaments, the patient's

weight (the best results are obtained when BMI < 30), and the alignment of the lower extremity.

In our study, we modified the technique developed by Visna et al.,[6] performing 1 or 2 passes to obtain 15×10^6 cells, in 26 days, ensuring that the chondrocytes preserved their capacity for redifferentiation when they were seeded in the scaffold. We cultured the chondrocytes in the patient's own serum to reduce the risk of hypersensitivity to bovine products and to infection. Our aim was to achieve regeneration of the joint surface through regeneration of the hyaline cartilage, which is translated clinically into elimination of pain and inflammation, and functional improvement.

In a multi-center study, Micheli et al.[22] found that 94% of grafts survived 3 years after surgery, in 50 patients with a mean age of 36 years and an average lesion of 4.2 cm^2. Moseley et al.[23] confirmed that after 10 years, 69% of operations had improved results, with a failure rate of 17% and 12.5% who remained unchanged.

In the series described by Marcacci et al.[5] of patients receiving MACI and arthroscopic follow-up, they found that four patients had fibrocartilage and six had fibrous-hyaline cartilage. The presence of hyaline cartilage was evident in 11 patients. Of the 23 patients followed by Roberts et al.,[24] 7 had fibrocartilage and only 5 patients had regenerated hyaline cartilage after a long follow-up period. In their other cases, they observed fibro-hyaline-type cartilage covering the lesion. Tins et al.[25] presented similar results: 12 months after surgery, they found fibrocartilage in 25 out of 39 cases, while 10 had hyaline-fibrous tissue and only 4 had hyaline cartilage.

We have not performed biopsies to our patients, but we sustain that chondrocyte go through a process of redifferentiation over prolonged periods of time, and to prevent this, we recommend storing chondrocytes in viscous media so that the cells are kept suspended apart.

Even though two studies compared the initial technique, the autologous chondrocyte culture implant (ACI), with the second generation of MACI, but found no significant differences,[26,27] it seems to us that the original technique has to be in disuse because it is more aggressive and the evolution is more uncertain.

Furthermore, the MACI has decreased the complications of the ACI, although Bartlett et al.[26] performed a prospective, randomized study comparing MACI and ACI in 91 patients. Both groups were found to have similar results 2 years after surgery, and both techniques resulted in an improvement 1 year after surgery. The incidence of hypertrophy was low, only 9% (4/44) in the ACI group, and 6% (3/47) in the MACI group, while 9% of the patients had to have a second operation. Areas of fibrocartilage were also found when using MACI, possibly due to the low cellular density and poor proliferative capacity.

It is possible to question the advisability of using such techniques based on biotechnology, which are more expensive and demanding than simpler techniques, such as microfractures. Knutsen et al.,[21] in a study of 40 patients, found no biological or histological differences after 2 years between patients treated with microfractures and those treated using ACI. After 5 years, the results were similar, but there were early signs of degeneration in 30% of the patients who had been treated with microfractures.[10] Saris et al.[19,28] also compared microfractures with ACI, with a follow-up period of 36 months, in 118 randomized patients. The general KOOS score was similar in both groups, although the results for pain and quality of life were better in the ACI group. The histological evaluation was also better in the ACI group, and the subchondral bone reaction was also worse in the group treated with microfractures. After longer follow-up, the KOOS score was found to be more positive in the ACI group. Similarly, Basad et al.,[29] in a 2-year randomized study, observed better results with MACI than with microfractures.

Our results were better with the osteochondral lesions than with the chondral ones; this is because the chondral lesions have more subchondral sclerosis, thus presenting more deformity in the implantation site. Furthermore, the osteochondral lesions have migrations of bone marrow cells, ensuring a more complete fixation of the bioimplant matrix in the bone.

As far as complications are concerned, Vascellari et al.[30] found no complications in 30 patients after a 70-month follow-up. In our study, we used fibrin glue to anchor the cells adequately,[6] distributing them homogeneously and keeping them at all levels within the graft. This technique is currently classified as third generation and offers a favorable chondrogenic environment. Six months after the implant, most patients had resumed their everyday activities and were able to work and practice normal-to-moderate exercise. One third of the patients took part in sports activities, and 83% of the patients described their operated knee as normal. Currently, 75% of the patients indicated that they could walk, go upstairs, and kneel normally, without any kind of problem.

One limitation of the present study is the lack of biopsy and magnetic resonance imaging data. We have focused on the clinical aspects of this condition, and on the state of the patients and their everyday life. Although the follow-up period was long enough, it would be useful to have studies with a longer follow-up timeframe to find out how many of these patients needed further operations or joint replacements.

Seeding chondrocytes in a fibrin scaffold can provide a favorable micro-environment for synthesizing extracellular matrix and allows us to halt the advance of disease, so that joint mobility can be restored, and pain reduced, and the patient can resume the daily activities at an early stage.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors declare that there is no conflict of interests.

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Epidemiology of Dupuytren disease and Patients Undergoing Selective Fasciectomy

Epidemiologia da doença de Dupuytren e de pacientes submetidos a fasciectomia seletiva

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Rev Bras Ortop 2021;56(4):478–484.

Abstract

Objective To describe the epidemiological and clinical profile of patients with Dupuytren disease treated by selective fasciectomy and the factors associated with the severity of the disease.

Methods Retrospective descriptive observational study involving 247 patients with Dupuytren disease, from 2013 to 2019. Multivariate logistic regression was performed for data analysis.

Results Most patients were male (83.8%), self-declared white (65.2%), alcoholics (59.6%) and 49% were smokers, with a mean age of 66 ± 9 years old, with 77.2% presenting symptoms of the disease after the age of 51 years old. Approximately 51.9, 29.6 and 17.3%, respectively, had arterial hypertension, diabetes mellitus and dyslipidemia comorbidities. Bilateral involvement of the hands was observed in 73.3% of the patients. The rate of intra- and post-selective fasciectomy complications was of 0.6 and 24.3%, respectively, with 5.2% of the patients needing reintervention after 1 year of follow-up. After multivariate analysis, males were associated with bilateral involvement of the hands (odds ratio [OR] = 2.10; 95% confidence interval [CI]: 1.03–4.31) and with a greater number of affected rays (OR = 3.41; 95% CI: 1.66–7.03). Dyslipidemia was associated with reintervention (OR = 5.7; 95% CI = 1.03–31.4) and bilaterality with a higher number of complications (35.7 versus 19.7%).

Keywords
- dupuytren disease
- fasciectomy
- risk factors
- operative complications
- reintervention

Study developed at Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro, RJ, Brazil.

received
April 22, 2020
accepted
September 17, 2020
published online
March 22, 2021

DOI https://doi.org/10.1055/s-0040-1721839.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Conclusion A low rate of reintervention and operative complications was observed in patients with Dupuytren disease treated by selective fasciectomy. Male gender was associated with severe disease (bilaterality and more than two affected rays), and dyslipidemia with reintervention.

Objetivo Descrever o perfil epidemiológico e clínico dos pacientes com doença de Dupuytren tratados por fasciectomia seletiva e os fatores associados com a gravidade da doença.

Metodologia Estudo observacional descritivo retrospectivo envolvendo 247 pacientes com doença de Dupuytren, no período de 2013 a 2019. Foi realizada regressão logística multivariada para análise dos dados.

Resultados A maioria dos pacientes era do sexo masculino (83,8%), autodeclarados brancos (65,2%), etilistas (59,6%), e 49% eram tabagistas. A média de idade foi de 66 ± 9 anos, sendo que 77,2% apresentaram os sintomas da doença após os 51 anos. Aproximadamente 51,9, 29,6, e 17,3%, respectivamente, apresentaram hipertensão arterial, diabetes mellitus e dislipidemia. O acometimento bilateral das mãos foi observado em 73,3% dos pacientes. A taxa de complicações intra- e pós-fasciectomia seletiva foi de 0,6 e 24,3%, respectivamente, sendo que 5,2% dos pacientes necessitaram de reintervenção após 1 ano de acompanhamento. Após análise multivariada, o sexo masculino foi associado com acometimento bilateral das mãos (odds ratio [OR] = 2,10; intervalo de confiança [IC] 95%: 1,03–4,31) e com maior número de raios acometidos (OR = 3,41; IC 95%: 1,66–7,03). A dislipidemia foi associada com a reintervenção (OR = 5,7; CI 95%: 1,03–31,4) e a bilateralidade com maior número de complicações (35,7% *versus* 19,7%).

Conclusão Foi observada uma baixa taxa de reintervenção e complicações operatórias nos pacientes com doença de Dupuytren tratados por fasciectomia seletiva. O sexo masculino foi associado com o quadro grave da doença (bilateralidade e mais de dois raios acometidos), e a dislipidemia com a reintervenção.

Palavras-chave
- doença de Dupuytren
- fasciectomia
- fatores de risco
- complicações operatórias
- reintervenção

Introduction

Dupuytren disease or contracture figures among the most common human connective tissue disorders.[1] It is characterized by a progressive, irreversible fibroblast proliferation affecting the palmar fascia, resulting in its gradual thickening, which causes a flexion contraction of the fingers.[2] Initially, it presents as subcutaneous nodules, followed by fibrous cords, which account for contractures.[3]

The incidence of Dupuytren disease ranges from 3 to 40%. It often affects males[4] > 50 years old, with a higher prevalence in Caucasians.[5] In addition, its incidence is high among patients with a history of smoking and alcohol use, metabolic disorders, or those treated with antiretrovirals or anticonvulsants.[5] Therefore, its etiology is multifactorial, associated with both intrinsic and extrinsic factors.[3]

Today, several treatment options are available, including percutaneous fasciotomy, fasciotomy using collagenase (from *Clostridium histolyticum*), partial or selective fasciectomy, total fasciectomy, and dermofasciectomy.[6] However, the recurrence rate of the disease is high.[7] Surgical intervention is indicated after functional impairment,[8] and it is typically recommended for patients with at least 30° of metacarpophalangeal joint contracture and/or proximal interphalangeal joint contracture associated with functional impairment.[9]

Selective fasciectomy is the most frequently performed surgical procedure for Dupuytren disease, and it is deemed the gold standard for the primary release of flexion contracture.[10] The literature is inconsistent in defining the percentage of contracture correction and recurrence rate, making it difficult to assess the effectiveness and safety of surgical interventions for Dupuytren disease.[11] In addition, an important aspect for surgical treatment evaluation is patient satisfaction after the intervention, which is not always related to a greater flexion contracture correction, hindering the comparison of therapeutic options.[12]

The present study aimed to describe the epidemiological and clinical profile of patients with Dupuytren disease surgically treated with selective fasciectomy. In addition, the present study attempted to determine the frequency of surgical complications, the need for new surgical procedures, and potential factors associated with the clinical characteristics of this condition.

Materials and Methods

This is a retrospective observational descriptive study of a sample of patients with Dupuytren disease who were seen and surgically treated by the Hand Surgery Service of a tertiary hospital from the Brazilian Unified Health System

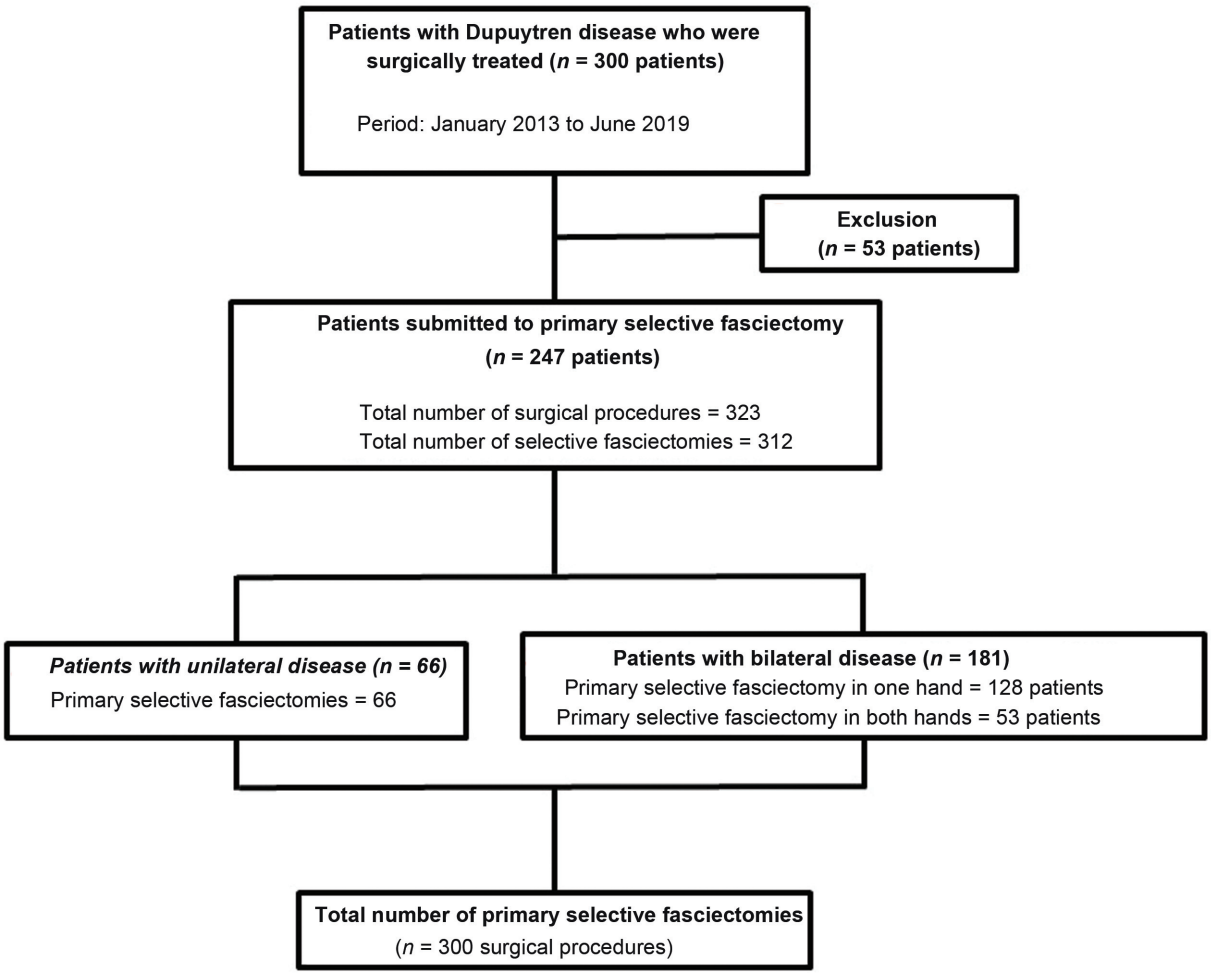


Fig. 1 Flowchart to select patients with Dupuytren disease surgically treated by primary selective fasciectomy.

(SUS, in the Portuguese acronym), from January 1, 2013 to June 30, 2019. The study protocol was approved by the Institutional Research Ethics Committee (3.100.284/2018).

Selective fasciectomy was the main treatment option for Dupuytren disease during the study period, corresponding to 96.6% of the procedures performed in these patients. To homogenize the sample, patients with Dupuytren disease diagnosis confirmed by a hand surgeon were treated with an isolated primary selective fasciectomy (►**Figure 1**) ($n = 247$). This was the first surgical approach for disease treatment, and no other procedures were performed, including capsulotomies or tenotomies. Patients previously submitted to surgical treatment and those with unavailable information in medical records were excluded.

Demographics were obtained through an active search in medical records, and the following information was recorded in a data collection instrument: (i) sociodemographic features, such as gender, age, self-declared skin color, weight, height, smoking and alcohol intake; (ii) positive history for diabetes mellitus, dyslipidemia, epilepsy, cardiovascular diseases, hypertension, HIV seropositivity, Ledderhose disease, Peyronie disease, adhesive shoulder capsulitis or hand trauma; and (iii) clinical presentation of Dupuytren disease: unilateral or bilateral involvement, affected rays, presence of Garrod dorsal nodules, age at onset of symptoms, positive family history for the disease, intra- and postoperative complications, length of follow-up after primary selective fasciectomy, and the need for a new surgical approach to treat a complication associated with the initial selective fasciectomy or due to recurrence of flexion contracture in the fingers, which is deemed a reintervention. Postoperative complications included an extension deficit with no report of any apparent cause, such as scar retraction, pain, or other intercurrence, in the medical record.

Surgery was indicated for functional impairment,[8] metacarpophalangeal joint flexion contracture $> 30°$ and/or proximal interphalangeal joint contracture (►**Figure 2A**). Selective fasciectomy was performed with limb exsanguination using a pneumatic cuff. The volar face of the hand was incised as popularized by Bruner, extending to the affected radius (►**Figure 2B**). After mobilization of skin flaps, neurovascular bundles and the thickened palmar fascia were dissected, identified, and protected. Next, the affected fascia was excised (►**Figure 2C**). This specimen (►**Figure 2D**) was sent for histopathological study, confirming the characteristic changes associated with Dupuytren disease. A dressing and a volar plaster cast were applied to maintain extension of the fingers. The plastered immobilization was removed when the first dressing was changed, around the end of the 1st week. Then,

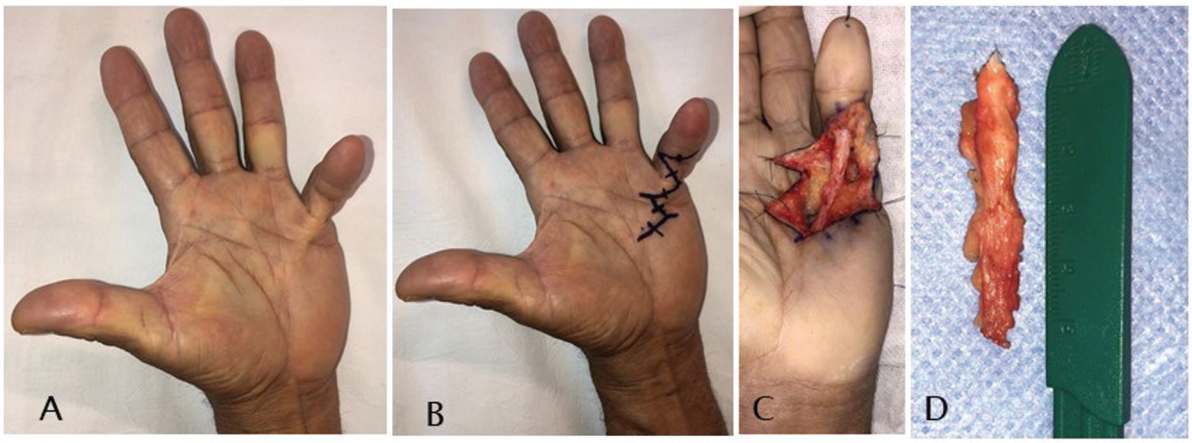


Fig. 2 Selective fasciectomy in a patient with Dupuytren disease. (**A**) Flexion contracture of the little finger. (**B**) Surgical planning. (**C**) Palmar fascia thickening with chord formation. (**D**) Excised palmar fascia segment.

passive and/or active finger mobility was initiated by the team of occupational therapists specialized in hand surgery. None of the included patients used orthosis during the postoperative period.

Continuous variables were presented as mean ± standard deviation (SD). Factors associated with clinical characteristics of Dupuytren disease were determined based on odds ratios (ORs) and their respective 95% confidence intervals (CIs) estimative using the multivariate logistic regression method. This univariate analysis considered both the biological importance and the degree of statistical significance; *p-values* ≤ 0.25 and ≤ 0.10, respectively, were required for regression model input and maintenance. The analyzes were performed using IBMSPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA), and statistical significance was set as $p < 0.05$.

Results

The majority of the 247 patients with Dupuytren disease treated with selective fasciectomy were male, self-declared white (►**Table 1**), reporting alcohol use (59.6%) and/or smoking (49.0%). Their mean age was 66.3 ± 9.2 years old (minimum, 31 and maximum, 94). Most subjects (84.4%) had a body mass index (BMI) ranging from 18.5 to 29.9 kg/m^2. As for comorbidities associated with Dupuytren disease, 29.6% of the patients had diabetes mellitus, 17.3% dyslipidemia, 6.6% epilepsy, and 2.5% cardiovascular diseases; less than 1% were HIV-positive. In addition, 51.9% of the subjects reported high blood pressure.

Bilateral hand involvement was observed in 73.3% of the patients. The little (35.0%) and ring (34.7%) fingers were the most affected rays, followed by the thumb, middle and index fingers, with 15.1, 12.1 and 3.1% of involvement, respectively. In addition, 37.2 and 38.9% of the patients had, respectively, 1 and 2 affected rays. The remaining patients had 3 (18.4%) or more affected rays (5.5%). About 11.1% of the patients also had a previous history of hand trauma, 19.7% of Ledderhose disease, 7.5% of Peyronie disease (considering the 207 affected men), 7.2% of adhesive shoulder capsulitis, and 27.8% of Garrod dorsal nodules, affecting most the index finger (33.4%), followed by the middle and ring (25.9% each) fingers, the little finger (11.1%) and the thumb (3.7%). A family history of Dupuytren disease was reported in 18.5% of the cases, and 3.7% of the patients had ≥ 3 affected relatives.

In total, 300 selective fasciectomies were performed as the first surgical approach in these 247 patients with Dupuytren disease. Patients with bilateral involvement ($n = 181$) underwent primary selective fasciectomy in each hand ($n = 53$) at

Table 1 Demographics from the 247 patients with Dupuytren disease

Variables	Dupuytren ($n = 247$)
	n (%)
Age (years old)	
≤ 40	2 (0.8)
41–50	6 (2.4)
51–60	53 (21.5)
61–70	110 (44.5)
71–80	62 (25.1)
81–90	13 (5.3)
≥ 91	1 (0.4)
Gender	
Female	40 (16.2)
Male	207 (83.8)
Skin color[a]	
White	161 (65.2)
Brown	58 (23.5)
Black	27 (10.9)
Yellow	1 (0.4)

[a]Skin color was self-reported according to the classification used by the Brazilian Institute of Geography and Statistics (IBGE, in the Portuguese acronym) census.

different times (►**Figure 1**). Considering patients with a minimum follow-up period of 1 year, the frequency of reintervention was 5.2%. The following reinterventions were performed during the study: surgical dressing due to surgical wound complication; selective fasciectomy associated with volar capsutolomy at the proximal interphalangeal joint, and z-plasty for scar contracture; selective fasciectomy associated only with volar capsulotomy of the proximal interphalangeal joint; 5th finger amputation; and isolated selective fasciectomies.

Regarding intraoperative complications of selective fasciectomies, 2 cases of digital nerve injury (0.6%) were recorded. Another case of digital nerve injury was recorded during the reintervention of a patient who underwent a new selective fasciectomy. All three cases were primarily repaired but presented some sensorial loss in the affected finger. A total of 73 complications were recorded after the 300 primary selective fasciectomies (24.3%). The most common complication was a deficit in complete extension of the affected finger (50.7%), followed by joint stiffness (24.7%) and skin necrosis (8.2%). The remaining complications totaled 16.4% (►**Figure 3**).

Factors associated with the severity of Dupuytren disease were determined at a multivariate analysis. Male gender was associated with bilateral hand involvement and the number of affected rays (►**Table 2**). Dyslipidemia was associated with reintervention ($p = 0.04$; OR = 5.7; 95%CI: 1.03–31.4). Patients with bilateral involvement had a higher number of postoperative complications (35.7 versus 19.7% in patients with unilateral involvement, OR = 2.27; 95%CI = 1.15–4.46). Other evaluated factors (age, skin color, alcohol intake, smoking, diabetes mellitus, dyslipidemia, epilepsy, HIV and surgical complications) were not significantly associated with bilateral disease, number of affected rays (1 ray versus ≥ 2 rays), age at disease onset ($\leq$50 years old versus $\geq$ 51 years old) or need for reintervention.

Discussion

Dupuytren disease is common in the hand surgery specialist office. However, several aspects remain inconsistent, including its etiology and the most appropriate treatment option for the clinical presentation.

Classically, Dupuytren disease mainly affects white males, $>$ 50 years old,[5,13,14] and its prevalence increases with age.[13] We noted a predominance of white or brown individuals, aged $>$ 50 years old. A 5:1 ratio between men and women was observed, which is consistent with previous descriptions (5.9:1).[13] Moreover, males were associated with an approximately two-fold higher risk for the most severe disease (bilateral involvement and more than two affected rays). Hindocha et al.[15] reported that bilateral presentation and male gender are associated with a greater recurrence of Dupuytren disease after surgical treatment.

Bilateral disease involving the little and ring fingers was commonly observed in our sample, which is consistent with the literature.[5,6,13,16] Garrod dorsal nodules were more frequent in the index finger, as previously described.[17] These nodules have been associated with an increased risk of Dupuytren diathesis.[18]

Alcohol intake and smoking have been associated with Dupuytren disease.[5,13,19] The cause and the mechanisms of such associations remain unclear. Most patients have a history of alcohol intake and smoking; however, in a greater proportion than evidenced by Mansur et al.[5] when evaluating a smaller number of Brazilian patients ($n = 58$) with Dupuytren disease (9 and 22%, respectively, compared with 60 and 49% in our study). Smoking and alcohol intake are associated with the need for surgical treatment for Dupuytren disease.[13] Since our sample consisted only of patients undergoing surgical treatment, potentially with more severe presentations, the prevalence of alcoholics and smokers is higher when compared with the data described by Mansur et al.[5]

Among conditions associated with Dupuytren disease, 29.6% of the patients presented diabetes mellitus. In a series with only 58 cases of Brazilian patients with Dupuytren disease, Mansur et al.[5] found a 44.8% prevalence of diabetes, with 62% of insulin-dependent subjects. Recently, a meta-analysis observed an approximately three-fold risk association between Dupuytren disease and diabetes mellitus.[20] Although the molecular mechanism involved in both

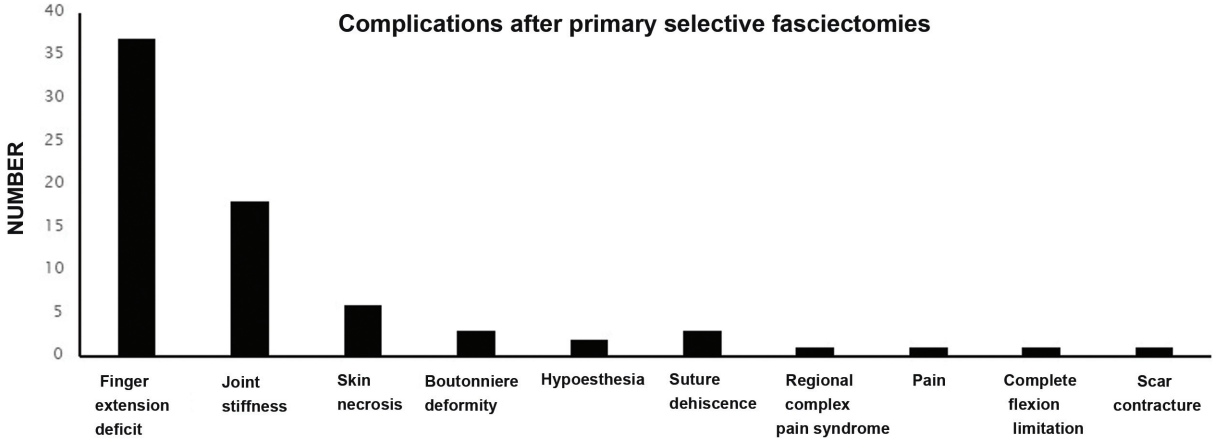


Fig. 3 Number of postoperative complications in patients with Dupuytren disease treated with selective fasciectomy.

Table 2 Multivariate analysis of factors associated with Dupuytren disease

Variables	Unilateral ($n = 66$)	Bilateral ($n = 181$)	*p-value*[a]	Adjusted odds ratio (95% confidence interval)
Gender	***n* (%)**			
Female	16 (24.2)	24 (13.3)	0.04	1[b]
Male	50 (75.8)	157 (86.7)		2.10 (1.03–4.31)[c]
	1 ray ($n = 71$)	**$\geq$ 2 rays ($n = 176$)**		
Gender				
Female	20 (28.2)	20 (11.4)	0.001	1[b]
Male	51 (71.8)	156 (88.6)		3.41 (1.66–7.03)[d]

[a]Pearson chi-squared test (X^2).
[b]Reference value.
[c]Multivariate analysis adjusted for gender and postoperative complications.
[d]Multivariate analysis adjusted for gender, epilepsy, and postoperative complications.

conditions has been widely studied,[20] it is suggested that the metabolites generated by diabetes mellitus stimulate the development of myofibroblasts, the main cell type involved in Dupuytren disease.[21] In addition, the majority of patients had arterial hypertension, consistent with the aforementioned study from Mansur et al.,[5] in which 55% of the subjects presented it.[5] Both conditions mainly affect elderly patients, but the cause of the association between arterial hypertension and Dupuytren disease has not been described in the literature.

The rate of reintervention after the surgical treatment for Dupuytren disease depends on several factors, including contracture severity and the type of procedure performed. The observed reintervention rate (5.2%) was consistent with a recent description in the American population, which evaluated 132 selective fasciectomies and detected a reintervention rate of 4%.[22] The multivariate analysis revealed an association between dyslipidemia and a higher rate of reintervention. Dyslipidemia has been associated with Dupuytren disease,[23] suggesting the need to consider this condition in patients with palmar fibromatosis for proper treatment planning

In a comprehensive review, Denkler[24] reported that the rate of surgical complications after primary selective fasciectomy ranged from 4 to 39%.[24] We observed a low rate of intraoperative complications, consisting only of digital nerve injury (0.6%). According to the literature, the average rate of digital nerve injury is $\sim$ 3%.[24,25] The most common postoperative complications included wound healing issues, ranging from 0 to 86%.[24] However, in our sample, the most common postoperative complication was a complete extension deficit, followed by joint stiffness. In addition, patients with bilateral involvement had an approximately two-fold higher risk of postoperative complications, as the contracture may have been aggravated by the longer waiting time for surgical treatment of the contralateral hand. Ribak et al.[6] described a case of transient digital nerve paresthesia and type I regional complex pain syndrome as complications after resection of the affected fascia during a study comparing selective and percutaneous fasciectomy. In addition, they observed no significant differences between groups submitted to different fasciectomies regarding the Tubiana classification, time to resume professional activities and disease recurrence.[6]

Since this is a retrospective study, the absence of a standardized electronic medical record system and the lack of determining the degree of flexion contracture of the fingers to aid disease recurrence identification after selective fasciectomy are our main limitations. However, the sample size, as well as information confirmation through a double database check contribute to the robustness of our results, which can be used to build a database of different populations to identify disease-associated factors. Together, this information can assist in prognosis and postoperative follow-up, suggesting the need for early referral to a specialist, even with no functional limitation of the hand, which is the main determinant for the surgical treatment of Dupuytren disease.

Conclusion

Selective fasciectomy showed a low rate of reintervention and surgical complications. Male gender was associated with bilateral hand involvement and a higher number of affected rays, while dyslipidemia was associated with reintervention.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of interests
The authors have no conflict of interests to declare.

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Methodological Quality Analysis of Systematic Review for the Treatment of Rotator Cuff Disease*

Análise da qualidade metodológica de revisões sistemáticas para tratamento de disfunções do manguito rotador

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Rev Bras Ortop 2021;56(4):485–489.

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Abstract

Objective To evaluate the methodological quality of systematic reviews for the surgical and nonsurgical treatment of individuals with rotator cuff syndrome; to compare, through the *Assessing the methodological quality of systematic reviews* (AMSTAR) instrument, the quality of studies found in the Cochrane Library, PubMed (Publisher *Medline*), EMBASE andQinsightdatabases.

Methods This is a descriptive and comparative cross-sectional study, in which two independent authors analyzed, through the AMSTAR instrument, the methodological quality of Cochrane and non-Cochrane systematic reviews on the treatment of individuals diagnosed with rotator cuff syndrome.

Results A total of 76 systematic reviews were evaluated by the AMSTAR instrument. The overall mean score was 6.1 (±2.1) and the mean per database was 9.1 (±0.9) for the Cochrane reviews and 5.7 (±1.8) for the non-Cochrane reviews. The lowest-scoring item of AMSTAR was 11, related to the display of the conflict of interests of the publication. In a comparative analysis of the final variable score, there was a statistical difference between the Cochrane and non-Cochrane studies.

Conclusion According to the present study, systematic reviews using the Cochrane methodology have a better methodological quality compared to non-Cochrane studies on the treatment of rotator cuff dysfunctions.

Keywords

- rotator cuff
- methodology
- systematic review

Resumo

Objetivo Avaliar a qualidade metodológica das revisões sistemáticas para tratamento cirúrgico e não cirúrgico de indivíduos com síndrome do manguito rotador; comparar, através do instrumento *Assessingthemethodologicalqualityofsystematic reviews*(AMSTAR, na sigla em inglês), a qualidade dos estudos encontrados nas bases de dados Cochrane Library, PubMed (*Publisher Medline*), EMBASE e Qinsight.

* Work developed at the Universidade Federal de São Paulo, Santos, SP, Brazil.

received
October 29, 2019
accepted
February 20, 2020
published online
May 29, 2020

DOI https://doi.org/10.1055/s-0040-1710334.
ISSN 0102-3616.

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Métodos Trata-se de um estudo transversal descritivo e comparativo, em que dois autores independentes analisaram, por meio do instrumento AMSTAR, a qualidade metodológica das revisões sistemáticas Cochrane e nãoCochrane sobre tratamento de indivíduos com diagnóstico de síndrome do manguito rotador.

Resultados 76 revisões sistemáticas foram avaliadas pelo instrumento AMSTAR. O escore médio geral foi de 6,1(±2,1) e a média por base de dados foi 9,1(±0,9) para as revisões Cochrane e 5,7(±1,8) para as não Cochrane. O item de menor pontuação do AMSTAR foi 11, relacionada à exibição dos conflitos de interesse da publicação. Em uma análise comparativa do escore da variável final, houve uma diferença estatística entre os estudos Cochrane e nãoCochrane.

Conclusão De acordo com o presente estudo, revisões sistemáticas utilizando a metodologia Cochrane têm uma melhor qualidade metodológica em comparação com estudos nãoCochrane sobre o tratamento de disfunções do manguito rotador.

Palavras-chave
- manguito rotador
- metodologia
- revisão sistemática

Introduction

Systematic reviews of randomized clinical trials present the highest level of scientific evidence for clinical decision-making.[1,2] The aim of these studies is to clarify the divergences found in the literature, so that it is possible to answer a specific question and synthesize the findings of primary studies. A good methodological design of these studies is essential so that more assertive interventions become possible.[1,2] Currently, ~ 24 instruments are validated and used to determine the level of reliability of scientific studies, such as *Preferred reporting items for systematic reviews and meta-analyses* (PRISMA) and *Assessing the Methodological Quality of Systematic Reviews* (AMSTAR).[3] The AMSTAR is a validated measurement tool that assesses the methodological quality of systematic reviews.[3] It has 11 domains that evaluate the methods of construction of systematic reviews.[4,5]

The scientific literature indicates numerous forms of treatment for the various types of injuries that affect the musculoskeletal system, such as rotator cuff dysfunctions. Thus, it is important to select works with good foundation, high methodological rigor and reliable sources of information for greater efficacy at the time of the therapeutic approach.[6,7] Evidence indicates that systematic reviews using the methodology proposed by the Cochrane collaboration have a greater methodological rigor when compared to studies that do not adopt this methodology.[8,9] Thus, the aim of the present research was to evaluate the methodological quality of Cochrane and non-Cochrane systematic reviews on the treatment of individuals with rotator cuff dysfunctions and to compare, through AMSTAR, the quality of studies found in the Cochrane, PubMed (Publisher: Medline),EMBASE and Qinsight databases

Methods

This is a descriptive and comparative cross-sectional investigative study.

Only systematic reviews were included, with Cochrane and non-Cochrane methodology, involving any type of primary studies. The term "PICOS" (population or problem/intervention/control/outcome/study design) was used as a basis. There was no restriction on the language and date of publication of the studies.

Systematic reviews were included in which the research subjects were individuals> 16 years old, diagnosed with rotator cuff syndrome (impact syndrome, subacromial bursitis, tendinosis or tendinopathy of cuff structures rotator, partial or total rupture of rotator cuff and tendinosis structures or calcifying tendinopathy of rotator cuff structures) regardless of the time of disease evolution, treated non surgically or surgically. Only studies that did not have diagnostic confirmation of the disease were excluded.

The search was performed by two authors using the official Medical Subject Heading (MESH) terms– (*rotatorcuff, shoulder impingement syndrome, shoulder joint*) in the following databases: Cochrane Library, PubMed, EMBASE and Qinsight. There were no restrictions on the language and date of publications during the search process. Search strategies were translated for eachdatabase. The studies were selected by a single evaluator respecting the inclusion criteria described. Initially, after searching all databases, duplicates were removed, then the articles were analyzed based on their titles and abstracts; when the information contained in these two items was not sufficient, it was left for the analysis of the text in full. After these steps, with the final number of studies selected, a download was performed for follow-up with the evaluations with AMSTAR.

Two independent reviewers (Kriebel C. F. and Estevam J. A.) evaluated the methodological quality of the systematic reviews selected using the AMSTAR as an instrument.[3,5] This tool has 11 domains that investigate the following aspects:

1) Presence of a previous protocol with ethical approval and predetermined research objectives
2) Extraction and evaluation of the material performed by two independent evaluators
3) Comprehensive bibliographic search in at least two databases

4) Inclusion of gray literature as a criterion
5) Presence of list or references of included and excluded studies
6) Presence of list or references of the studies included in the research
7) Methodological evaluation of each included study and documentation of the results obtained
8) Critical formulation of conclusions based on methodological analysis
9) Evaluation of the heterogeneity of each study
10) Evaluation of publication bias with the presence of available graphs or tests
11) Mention of the conflicts of interests of the publication and the studies included.

Each question has four answer options, which are: 1) Yes; 2) No; 3) Cannot answer and 4) Does not apply. For the calculation of the final score, only the positive answers (Yes) counted, assigning 1 point for each positive answer of the questionnaire.[3,5]

The information regarding the systematic reviews included in the present study was recorded in Excel software (Microsoft Corporation, Redmond, WA, USA) for the creation of the database. The collected material was analyzed in software R version 3.4.0 (RFoundation for Statistical Computing, Vienna, Austria) Variance analysis with a fixed factor and tukey fixed comparison method were used. A significance number was used for the present study where $p < 0.05$. Excel software tools[6] we reapplied to measure some variables such as mean, standard deviation and percentage of grades obtained by studies after evaluation with AMSTAR.

The present study was submitted to the research ethics committee of the Universidade Federal de São Paulo, with approval on 07/16/2017 - CEUAxnumber5960140717

Results

A total of 76systematic reviews were analyzed in different databases, namely: 9 Cochrane systematic reviews that used the methodology proposed by the Cochrane organization and published in the Cochrane Library, 26 systematic reviews not indexed in the Cochrane database but which described

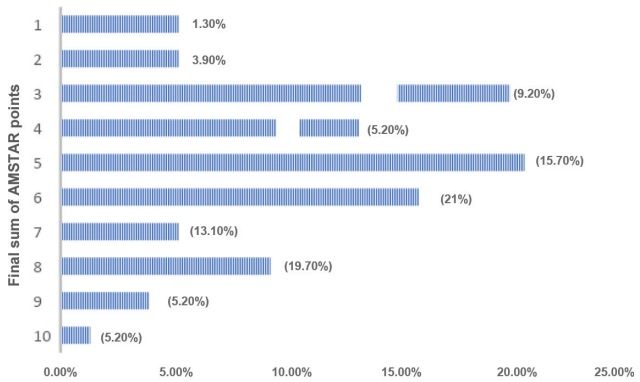


Fig. 1 Percentage of studies that received scores from the Amstar instrument evaluation.

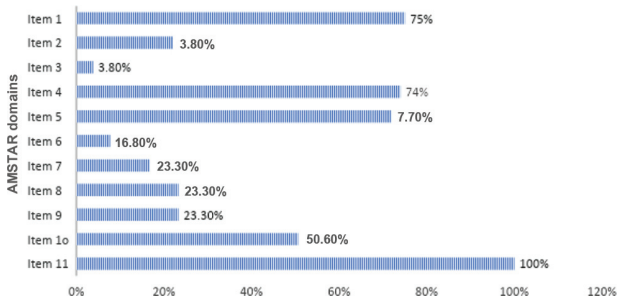


Fig. 2 Items with the lowest overall score according to the Amstar instrument.

that their methods follow the Cochrane methodology, 6 reviews indexed in Embase, 26 reviews indexed in Pubmed and 10 reviews indexed in Qinsite.

After statistical analysis, it was observed that the mean score for the 76 studies was 6.1 (±2.1), with 9.1 (±0.9) being the mean of the studies with Cochrane methodology and indexed in the Cochrane database, and 5.7 (±1.8) for the other studies.

►**Figure 1** presents the analysis of the methodological quality of these systematic reviews, the percentage of scores obtained by the studies from the analysis made with AMSTAR.

Data on AMSTAR domains with the lowest scores among all papers are shown in ►**Figure 2**.

►**Figure 3** shows the average of the scores obtained by the studies after applying the AMSTAR instrument.

To compare the quality of systematic reviews in relation to the final scores, the variance analysis model with a fixed factor and tukey multiple comparison method were used. These data are described in ►**Table 1**.

Discussion

Systematic reviews evaluating randomized clinical trials have the best level of scientific evidence. They are research models that offer individuals a synthesis of data, in order to base, theoretically, clinical practices, and guide the construction of new projects; for this, it is important that this material is clear, explicit and reproducible; in addition, to add value to the instrument, primary studies must have high methodological rigor. Only in this way will clinical decision-making be possible based on scientific evidence.[10,11]

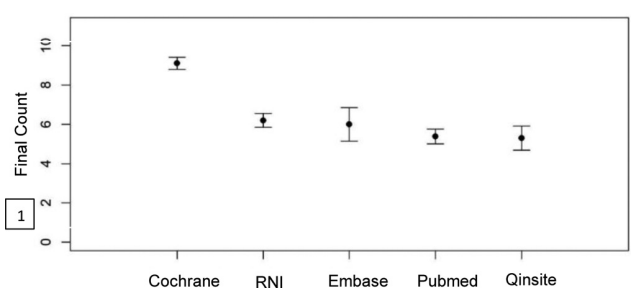


Fig. 3 Average profiles of the studies, according to the final score obtained by the Amstar instrument.

Table 1 Result of comparison between systematic reviews

Comparisons		Descriptive level
RNI	Cochrane	0.001
Embase	Cochrane	0.014
Pubmed	Cochrane	0.001
Qinsite	Cochrane	0.001
Embase	RNI	0.999
Pubmed	RNI	0.494
Qinsite	RNI	0.672
Pubmed	Embase	0.943
Qinsite	Embase	0.943
Qinsite	Pubmed	0.999

The present study evaluated 76 systematic reviews on the treatment for rotator cuff dysfunctions, selected in different databases. There are consistent data that demonstrate a higher methodological quality of studies using the methodology proposed by the Cochrane collaboration for systematic reviews in comparison with studies that do not follow this methodology, a finding that corroborates a study that compared, using this same instrument, the quality of Cochrane and non-Cochrane systematic reviews related to health interventions.[12]

Some challenges were encountered when evaluating systematic reviews. It is noted that non-Cochrane methodology reviews have limited information, insufficient or missing data, which makes it difficult for AMSTAR to determine points, such as quality analysis of all included primary studies, design of the writing based on an initial protocol, publication bias, list of papers that were excluded from the systematic review, a comprehensive search in the literature and analysis of conflicts of interests of publications.

In the scientific literature there are studies that stimulate discussions about the domains of AMSTAR.[10,11] The description of each item is thorough and allows the reader to understand the importance of analyzing each topic.

Item 11 of the AMSTAR checklist refers to the declaration of conflict of interests; the authors must clearly and objectively expose any source of funding or support for the research; for scoring, reports on all possible sources of funding should be required because they minimize a potential influence and judgments. In this regard, all the studies evaluated in the present study brought inconsistent information, thus it is suggested a better clarification of this item to allow deeper evaluations. The second item with the lowest score refers to the requirement of an initial research protocol, which would help to delimit the studies that were included and excluded and the quality of these. This domain is important because it identifies possible deviations in the protocol, reducing the risks of publication bias. All studies with Cochrane methodology for systematic reviews use an *a priori* protocol, but the non-Cochrane studies did not specify the use of this in their reviews, compromising the result of the evaluation. Increasing the search for unpublished literature, published or not, enriches the work. Many authors did not include in their reviews the gray literature (type of unconventional publication); some publications emphasize that more comprehensive studies allow a general analysis on a given theme.[10]

In general, the reviews with Cochrane methodology positively meet the criteria established in AMSTAR, so the quality of these reviews is significantly better compared with works extracted from Pubmed, Qinsite and Embase databases. Similar conclusions were published when evaluating the methodological rigor of Cochrane and non-Cochrane systematic reviews on oral health treatments.[13]

Evidence-based clinical decision-making necessarily depends on the quality of reviews and a high methodological rigor of these publications.[14] In thepresentstudy, it is noted that many systematic reviews do not meet the established methodological standards, thus producing unreliable evidence. The eligibility criteria should be clearly defined, and the methodology should include data on the study population, details of interventions, evaluation methods and the challenges encountered in implementation, so that reproduction and clinical applicability of the conducts are possible.

Study Limitations

The present study used the first version of the Amstar instrument (2007), because the selection and analysis of the studies were published before the publication of Amstar 2.

Conclusion

Based on the results of the present study, it is possible to conclude that systematic reviews with Cochrane methodology have a better scientific quality than the ones with non-Cochrane methodologies. It is necessary to increase the rigor in scientific publications, so that evidence-based clinical practices are better conducted. Further studies are needed to stimulate discussion about the quality of studies published in various databases.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Surgical Treatment of Comminuted Midshaft Clavicle Fracture by Minimally Invasive Technique: Description and Preliminary Results*

Tratamento cirúrgico da fratura multifragmentada da diáfise da clavícula pela técnica minimamente invasiva: Descrição e resultados preliminares

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Rev Bras Ortop 2021;56(4):490–496.

Abstract

Objective The present paper aimed to evaluate functional and radiographic outcomes from a group of patients with comminuted midshaft clavicle fracture who were surgically treated using a minimally invasive technique and followed-up for a minimum period of 12 months.

Methods Longitudinal, observational study with 32 consecutive patients (31 males; mean age, 41 years old) with comminuted midshaft clavicle fracture who were surgically treated using the minimally invasive osteosynthesis technique with a 3.5-mm reconstruction plate in the upper position. Patients were clinically and radiologically evaluated for a minimum follow-up period of 12 months.

Results In 30 patients (93.72%), fracture consolidation occurred in an average time of 17 weeks (range, 12 to 24 weeks). The mean follow-up time was 21 months (range, 12 to 45 months). No implant break or pseudoarthrosis were recorded. There was no complaint of paresthesia around the surgical incisions. The surgically-treated shoulder presented lower passive elevation and longer clavicle length ($p < 0.05$) compared with the contralateral shoulder. Functional evaluation revealed an average Disability of Arm, Shoulder and Hand (DASH) score of 1.75, which is considered satisfactory. Age > 60 years old had a negative correlation with DASH score ($p < 0.05$).

Conclusion The minimally invasive osteosynthesis technique was satisfactory for the treatment of comminuted midshaft clavicle fracture, with a high consolidation rate and a low complication rate.

Keywords
- clavicle
- fractures, bone
- treatment outcome
- minimally invasive surgical procedures

* *Study developed at Hospital Universitário da Universidade Federal de Juiz de Fora, Juiz de Fora, MG, Brazil.*

received
November 1, 2019
accepted
May 5, 2020
published online
September 24, 2020

DOI https://doi.org/10.1055/s-0040-1714226.
ISSN 0102-3616.

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Resumo

Objetivo Avaliar os resultados funcionais e radiográficos do tratamento cirúrgico realizado em um grupo de pacientes com fratura multifragmentada da diáfise de clavícula, pela técnica minimamente invasiva, em seguimento mínimo de 12 meses.

Métodos Estudo observacional longitudinal de 32 pacientes consecutivos (31 do sexo masculino, idade média 41 anos) com fratura multifragmentada da diáfise da clavícula tratados cirurgicamente pela técnica minimamente invasiva de osteossíntese com placa de reconstrução de 3,5 mm na posição superior, avaliados clínica e radiologicamente, com seguimento mínimo de 1 ano

Resultados Trinta pacientes (93,72%) evoluíram com consolidação da fratura em tempo médio de 17 semanas (entre 12 e 24 semanas). O tempo de seguimento médio foi de 21 meses (variando de 12 a 45 meses). Não houve quebra de implantes ou pseudoartroses. Não houve queixa de parestesia na região das incisões cirúrgicas. O ombro tratado cirurgicamente apresentou menor elevação passiva e maior comprimento da clavícula ($p < 0,05$) em relação ao contralateral. Na avaliação funcional, encontramos um valor médio de Disfunções do Braço, Ombro e Mão (DASH, na sigla em inglês) = 1,75, sendo o mesmo considerado satisfatório. Idade > 60 anos apresentou correlação negativa com escore DASH ($p < 0,05$).

Conclusão A técnica minimamente invasiva de osteossíntese mostrou-se satisfatória para o tratamento da fratura multifragmentada da diáfise da clavícula, com elevada taxa de consolidação e baixo índice de complicações.

Palavras-chave

- clavícula
- fraturas ósseas
- resultado do tratamento
- procedimentos cirúrgicos minimamente invasivos

Introduction

Clavicle fractures account for 2.6 to 5% of all fractures in adults;[1–3] ~ 80 to 85% of these injuries affect the middle third of the bone.[1,2] Complex or comminuted midshaft clavicle fractures are commonly caused by high-energy accidents, direct trauma or axial compression.[3,4] Clavicular biomechanics differ from that of long bones and the behavior of clavicle comminuted fractures is poorly studied.[5] According to the literature, the conservative treatment of these fractures is associated with higher pseudoarthrosis rates.[2,6,7] Other studies argue that the surgical treatment leads to improved functional outcomes when compared to the nonsurgical treatment.[6–9] Most Brazilian orthopedists indicate osteosynthesis for deviated and/or comminuted shaft fractures.[10]

The most widely used osteosynthesis method for deviated clavicular shaft fractures is open reduction and internal fixation (ORIF) with plate and screws.[5,9] However, since comminuted fractures require an extensive access to the fracture site, this approach may be associated with high rates of complications, including hypertrophic, painful scars,[4] infection,[11] pseudoarthrosis,[12] implant failure and refracture after implant removal.[13] As advantages, the minimally invasive osteosynthesis (MIO) technique with plates preserves the blood supply at the fracture site[14] and can decrease these complications. Minimally invasive osteosynthesis is commonly used in complex long bone fractures in lower limbs,[15] and has proven applicability in diaphyseal fractures of the upper limbs.[16]

Some authors have described their MIO techniques and outcomes in clavicle comminuted fractures.[17,18] The published studies use implant materials that are not easily accessible to the Brazilian population through the Brazilian Unified Health System (SUS, in the Portuguese acronym). There are no studies in the Brazilian literature regarding the MIO technique with plates to treat such fractures. The present study aims to evaluate clinically and radiographically a group of patients with comminuted midshaft clavicle fracture who were surgically treated using the MIO technique and a 3.5 mm reconstruction plate in the upper position.

Methodology

Longitudinal, observational study, with a retrospective initial survey of patients with comminuted midshaft clavicle fracture who were surgically treated using the MIO technique with plate in the upper position by one of the authors from January 2014 to May 2017 at the university hospital from our institution. The sample size corresponds to the number of patients who were surgically treated in this period and attended the evaluation. The study included patients > 16 years old with comminuted midshaft clavicle fracture type 2B2 according to the Robinson classification[9] who were surgically treated within 21 days after the trauma and were followed-up for a minimum period of 12 months. Patients with open fractures or associated vascular and nerve injuries, fractures extending to joints, fractures and/or discomfort concomitant with shoulder girdle trauma, concurrent fractures in other parts of the upper limb (arm, forearm, wrist and hand), history of previous clavicular fractures or shoulder girdle trauma, pathological fractures, and metabolic and/or congenital diseases were excluded. The final sample consisted of 32 patients. Patients eligible for the study for

meeting inclusion and exclusion criteria were contacted for an interview, in which the study was explained and the informed consent form (ICF) of the study was presented. Subjects who agreed in participating in the study were prospectively submitted to a clinical evaluation, including the Disability of Arm, Shoulder and Hand (DASH) questionnaire,[19] and radiological tests. Functional evaluation included the DASH questionnaire and a physical examination (passive range of motion of the shoulder, subacromial, rotator cuff and acromioclavicular impingement tests, thoracic scapular dyskinesia and force during active elevation measured with a manual dynamometer [Science SuplySolutions # U40812 [Science Supply Solutions, LLC, Bensenville, Illinois, United States of America], graduation 1 kg/10 N]) performed by an examiner not as involved in the surgical procedures as the main surgeon. At the postoperative period, a digital radiographic evaluation of the clavicles was performed in anteroposterior (AP) and modified craniocaudal views for verification purposes; a posteroanterior (PA) chest radiograph was taken to measure the final length of the clavicle according to the criteria by Smekal et al.[20]. In addition, medical records were analyzed on outcomes of the surgical procedure, such as consolidation time, delayed consolidation, pseudoarthrosis, infection, implant loosening, synthesis material failure, residual pain and range of motion.

Surgical technique (adapted from Jung et al.[18]): patient in the beach chair position; the procedure was aided by radioscopy in frontal and modified craniocaudal views of the clavicle with an approximate inclination of 70° (►**Figure 1**). A fracture reduction maneuver (the Kibler maneuver) was performed; the surgeon put the ipsilateral arm to a posterior, slightly superior position, with lateral rotation of the shoulder, approximating the scapula to the rib cage with lateral, superior rotation and posterior scapular inclination (a position mimicking retraction), leading to the indirect clavicle fracture reduction. Using radioscopy, the clavicular length and shape were determined to choose the implant size (3.5-mm, unlocked reconstruction plate). Next, the medial and lateral ends of the clavicle were palpated to locate the sternal and acromial borders, respectively. A transverse incision 1 cm lateral to the sternal border, with ~ 1.5 cm, was performed on the upper surface, with deep plane dissection up to the bone bed (upper clavicle surface). In the lateral region, 1 cm medial from the acromial border, a second incision was made, with the same size, direction and depth, up to the upper clavicle surface. Another bed was prepared at the upper region of the clavicle, from medial to lateral, to pass the implant to an upper position with instruments for blunt dissection (►**Figure 2**). The plate was modeled during surgery (►**Figure 3**), with a medial anterior convexity and a lateral posterior convexity, both at the level of the third most lateral and medial plate holes, following the clavicular shape



Fig. 2 Medial and lateral incisions.

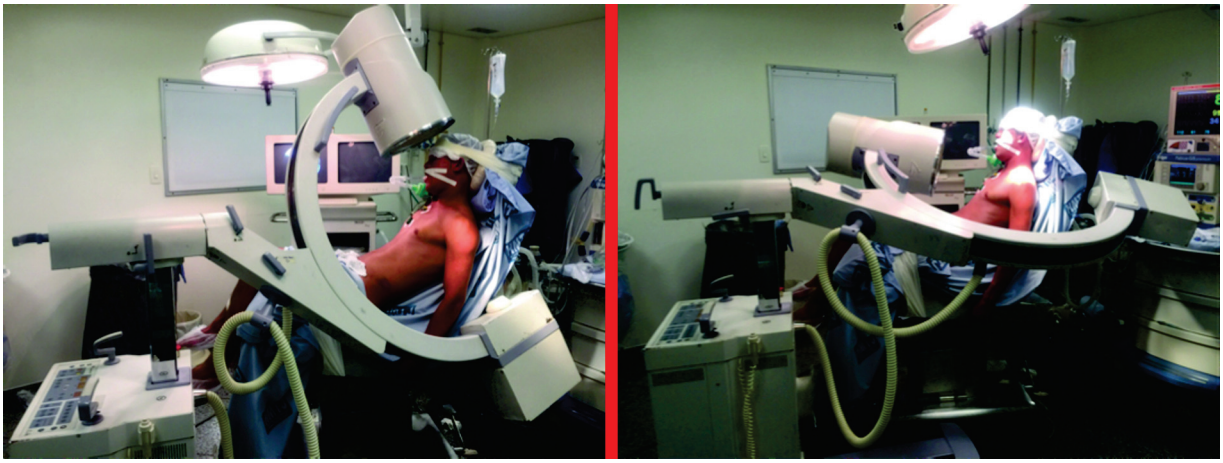


Fig. 1 Radioscopy positioning for superior and anterior views.



Fig. 3 Plate modeling.

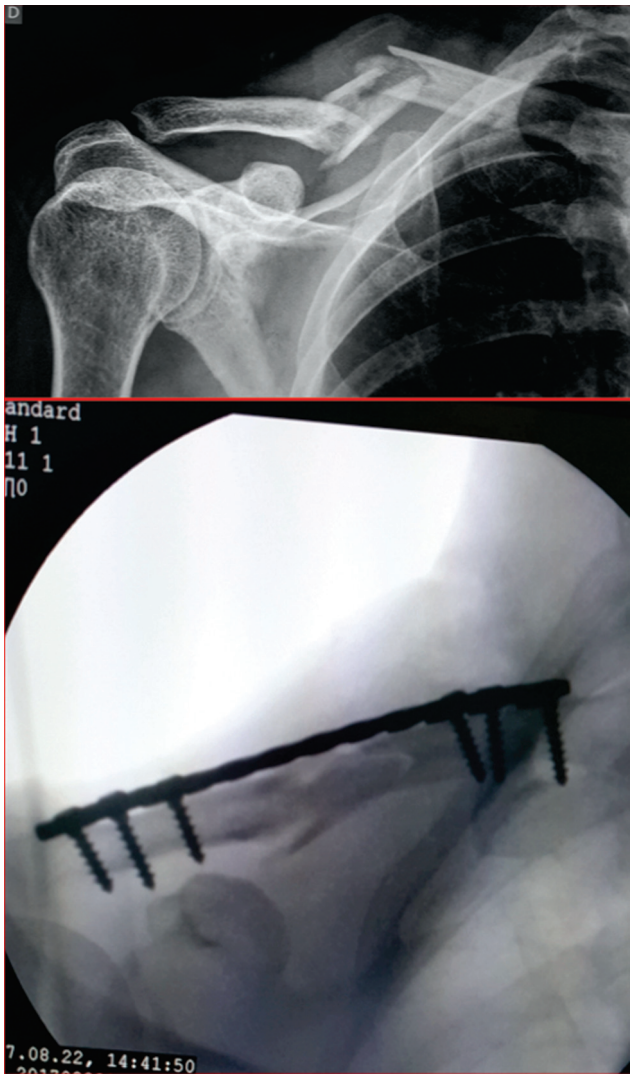


Fig. 4 Before and after fixation with the minimally invasive osteosynthesis (MIO) technique.

determined at radioscopy. The plate was slipped in the supraclavicular tunnel from medial to lateral, with the scapula kept in a retracted position. Provisional fixation was performed with 2.5-mm Kirchner wires (for length evaluation under radioscopy), and the plate was fixated with 3 bicortical screws on each side, alternately, starting from the medial side. Reduction and final plate and screws positioning were verified (►**Figure 4**). Wounds were irrigated with 0.9% saline solution; deep layers were closed with 3.0 mononylon sutures followed by 2.0 intradermal sutures.

After surgery, the limb was kept in a sling for 6 weeks, and full elbow, wrist and hand movements were oriented. Elevation, abduction $> 30°$ and shoulder rotations were discouraged. After 8 weeks, full active shoulder movements were allowed. Return to activities with load and playing sports were allowed after detecting signs of fracture consolidation on control radiographs.

The patients were followed-up on an outpatient basis, with initial visits in 15 and 30 days and, next, monthly visits until the detection of bone consolidation on control radiographs. Bone union was determined by signs of bone callus on both AP and craniocaudal radiographs, and absence of mobility on diaphyseal palpation.

For statistical analysis, descriptive data was expressed as frequency, mean and standard deviation (SD) tables. The Fisher exact test analyzed associations between categorical variables. Paired t-tests compared the operated and nonoperated sides for continuous numerical variables. Error normality was analyzed by box plot, quantile-quantile graph and the Shapiro-Wilk test. The analyses were carried out in R* software (R Foundation, Vienna, Austria) considering a significance level of 5%. The present manuscript was written according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement guidelines for observational studies (►**Annex 1**) and was approved by the institutional ethics committee under the number CAAE 66877517.5.0000.5133.

Results

The sample consisted of 32 patients, with 31 males and mean age of 41 years old (range, 19 to 61 years old). The median follow-up period was of 21 months (range, 12 to 45 months). The fractures were caused mainly by high-energy trauma (motorcycle and car accidents). The average time until the procedure was 9 days. Demographic data of the patients are presented in ►**Table 1**.

Categorical variables obtained during physical examinations revealed no differences between the operated and nonoperated sides. These variables were not associated to

Table 1 Descriptive analysis of sample characteristics

Variable	Frequency (%)
Gender	
Female	1 (3.1)
Male	31 (96.9)
Trauma type	
Motorcycle accident	14 (43.8)
Fall to the ground	9 (28.1)
Car accident	4 (12.5)
Others	5 (15.6)
Side	
Right	10 (31.3)
Left	22 (68.8)
Dominance	
Right	31 (96.9)
Left	1 (3.1)

continuous numerical variables from the physical examination or functional scores. The operated side had statistically significant ($p < 0.05$) lower mean passive elevation and higher mean clavicle length compared with the nonoperated side (►**Table 2**). There was no statistically significant difference regarding the presence or not of scapular dyskinesia when comparing the operated and nonoperated sides.

At the functional evaluation, the mean DASH score was 1.75, which is considered satisfactory. Using a value of 10 points to analyze the least significant clinical difference (MCID),[21] scores were subdivided into satisfactory and unsatisfactory. Patients with an early failure of the fixation method were considered as unsatisfactory outcomes for association analyses. Among patients > 50 years old, 33.3% had unsatisfactory DASH scores (≥ 10), whereas only 4.4% of patients < 50 years old had unsatisfactory scores ($p = 0.0572$) (►**Table 3**). Two patients > 60 years old (100.0%) showed unsatisfactory DASH scores, differing significantly from the group < 60 years old ($p < 0.05$), in which 6.7% of the patients had unsatisfactory scores. Among patients with shorter waiting times until surgery (up to 7 days), no one had unsatisfactory DASH scores; on the other hand, among those who waited > 7 days until surgery, 26.7% had unsatisfactory scores ($p < 0.05$).

Table 3 Analysis of the association between studied variables and Disability of Arm, Shoulder and Hand scores

Variable	n (%)	DASH		*p-value*
		Unsatisfactory	Satisfactory	
		Frequency (%)	Frequency (%)	
Age				
≤ 42 years old (median)	19 (59.4)	1 (5.3)	18 (94.7)	0.2788
> 42 years old	13 (40.6)	3 (23.1)	10 (76.9)	
≤ 50 years old	23 (71.9)	1 (4.4)	22 (95.6)	0.0572
> 50 years old	9 (28.1)	3 (33.3)	6 (66.7)	
≤ 60 years old	30 (93.8)	2 (6.7)	28 (93.3)	0.0121[a]
> 60 years old	2 (6.2)	2 (100.0)	0 (0.0)	
Gender				
Female	1 (3.1)	0 (0.0)	1 (100.0)	1.0000
Male	31 (96.9)	4 (12.9)	27 (87.1)	
Days until surgery				
≤ 7 days (median)	17 (53.1)	0 (0.0)	17 (100.0)	0.0380[a]
> 7 days	15 (46.9)	4 (26.7)	11 (73.3)	
Complaints				
No	20 (62.5)	1 (5.0)	19 (95.0)	0.1361
Yes	12 (37.5)	3 (25.0)	9 (75.0)	
Consolidation				
No	2 (6.2)	2 (100.0)	0 (0.0)	0.0121[a]
Yes	30 (93.8)	2 (6.7)	28 (93.3)	

Abbreviation: DASH, disability of arm, shoulder and hand questionnaire.
[a]Fisher exact test ($p < 0.05$).

Twelve-hole implants were used in 28 patients, and 5 cases (15.6%) required material removal. Consolidation occurred in 30 patients (93.72%) after an average period of 17 weeks, and no pseudoarthrosis or infection was observed. As complications, there were 2 cases of early failure after osteosynthesis; both patients were 61 years old at the time and presented implant loosening, with no plate fracture: 1 within 1 week after surgery (an alcoholic patient) (►**Figure 5**) and the other

Table 2 Comparison between operated and nonoperated side variables

Variable	Total Mean (SD)	Side		*p-value*
		Operated Mean (SD)	Nonoperated Mean (SD)	
Elevation (degrees)	157.67 (7.89)	155.67 (10.73))	159.67 (1.83)	0.0497[a]
Lateral rotation (degrees)	83.83 (11.77)	83.17 (12.49)	84.50 (11.17)	0.4029
Force (Kgf)	11.43 (2.51)	11.23 (2.96)	11.63 (1.99)	0.3662
Clavicle length (cm)	16.23 (1.23)	16.33 (1.26)	16.13 (1.22)	0.0362[a]

Abbreviation: SD, standard deviation.
[a]Paired t-test ($p < 0.05$).

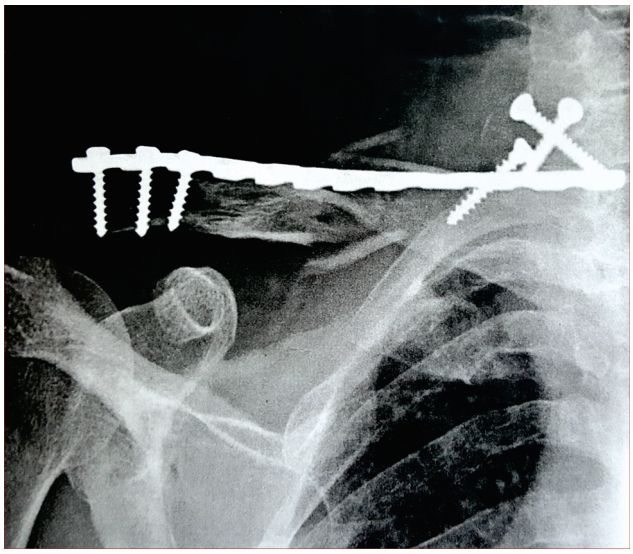


Fig. 5 Detailing of one of the cases with early loosening.

within 8 weeks after surgery (a patient with type 2 diabetes). Both underwent a new surgery for ORIF with plate and screws, but no bone graft, and progressed with fracture consolidation.

The following complications were observed in the study population: pain on exertion (5 patients – 15.6%), plate-related discomfort (6 patients – 18.8%), hypersensitivity (2 patients – 6.2%), and pain at rest (1 patient – 3.1%). Paresthesia around surgical incisions was not reported. The 2 cases of early implant loosening presented unsatisfactory DASH scores (100.0%); in patients with consolidation, however, 93.3% of DASH scores were deemed satisfactory ($p < 0.05$).

Discussion

There was no case of pseudoarthrosis or infection in our sample. We believe that the technique here described spares soft tissues and the fracture focus, contributing to the consolidation rate of 93.72% observed in our sample, similar to that reported by Sohn et al.[22] Our patients presented good clinical, functional and radiographic outcomes, which were in line with the literature. Mirzatolooei[4] observed similar consolidation rates between surgically and clinically treated patients; the former, however, presented lower rates of vicious consolidation and shortening and better DASH scores (mean score, 8.6). This author chose the method of absolute stability and performed fixation with a reconstruction plate in the upper position, obtaining pseudoarthrosis associated with infection.

The rate of early failure was similar to that reported by Wang et al.,[23] who described the same complication, implant loosening, in one of their patients. Our unsatisfactory DASH scores were associated with older age and early fixation failure, and may possibly require an reevaluation of the indication of such technique in this age group; however, due to the observational nature of the study, we cannot say which is the most important factor associated with this complication: bone quality or the use of an unlocked implant.

The MIO technique has the benefit of using smaller incisions, avoiding large exposures that can favor suture dehiscence, infections or pseudoarthrosis.[13] Incisions performed in the lateral and medial regions of the clavicle do not harm the areas supplied by supraclavicular nerves,[24] preventing the development of paresthesia. Other authors corroborate the benefits of the minimally invasive procedure. Jiang et al.[25] compared the outcomes from comminuted fractures of the clavicle treated using the mini-open and ORIF surgical techniques. These authors described that patients treated with the mini-open technique presented less dysesthesia, no hypertrophic scars, better ipsilateral shoulder mobility and no pain. You et al.[26] reported that the MIO technique resulted in a lower rate of paresthesia at the anterior chest and greater patient satisfaction when compared with the traditional surgical method.

Another important analysis refers to implant removal procedures, which are common in patients undergoing clavicle osteosynthesis. In our sample, 15.60% of the patients required implant removal, consistent with the index reported by Sökucu et al.,[8] and lower than the 23% rate observed by Asadollahi et al.[27]

This fracture reduction method is unprecedented and based on retracted scapula positioning, which is described by Kibler et al.,[28] ideal for shoulder function. In this technique, the scapula is externally and superiorly rotated, posteriorly inclined and medially translated in relation to the chest. We believe that this maneuver contributes to the alignment of fractured fragments of the clavicle; such alignment was observed in all patients systematically submitted to the maneuver during surgery. We also observed that additional devices, such as Kirchner wires,[17] traction with a screw outside the plate[18] or small approaches to the fracture site were not required to sustain this position.[23] In addition to the scapular retraction maneuver, the unlocked implant in the superior position also helps to reduce fragments, since cortical screws brings deviated inferiorly fragments towards the plate. Implants in the anteroinferior position or those with superiorly placed locked screws may not be useful to correct these deviations.

We used a 3.5-mm reconstruction plate, as it is an implant easily modeled according to the shape of each clavicle. Some authors[8,25,26] perform the MIO technique with anatomical or premodeled implants, whereas others[17,18,22,23] share our philosophy of individualized reconstruction plate modeling for each case but use locked 3.5-mm reconstruction implants. We prefer to use unlocked implants because of their higher availability in Brazil, especially in the SUS. Alzahrani et al.[29] evaluated 102 patients after clavicle osteosynthesis with 4 different implants (2.7-mm and 3.5-mm reconstruction plates, premolded plate and 3.5-mm locked plate), and reported that, despite biomechanical studies showing different tensile properties, there was no difference between groups regarding consolidation or complication rate. We emphasize that implant breaks were not observed, consistent with Silva et al.,[30] who reported no unlocked reconstruction plate rupture in their study on the surgical treatment of deviated clavicle fractures using these devices or intramedullary nails.[30]

The positive points of our study are the high reproducibility of the technique, attesting its internal validation, with low

complication rates, no implant breaks, high consolidation rates and satisfactory functional scores determined by an independent examiner. The limitations of the study stem from its observational nature, since our controls are the results of similar studies described by other authors. In addition, we believe that our patients had complex comminuted fractures, but we emphasize that there was no analysis of radiographic images for agreement between evaluators on their simple or complex trait, and this can be considered a weakness of the study. Finally, we believe that this technique must be disseminated in Brazil for external validation and subsequent evaluation in studies with higher levels of evidence and comparison with conventional open reduction procedures.

Conclusion

The MIO technique was satisfactory for the treatment of comminuted midshaft clavicle fracture, with a high consolidation rate and a low complication rate.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Evaluation of Biceps Tenotomy or Tenodesis on Fatty Infiltration of the Biceps Muscle

Avaliação da tenotomia ou tenodese bicipital na infiltração gordurosa do músculo bíceps

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Rev Bras Ortop 2021;56(4):497–503.

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Abstract

Objective The objective of the present study was to determine whether there is fatty infiltration (FI) of the biceps brachii muscle mass after tenotomy or tenodesis for the treatment of tendon injuries in the long head of the biceps and to establish a relationship between FI with changes in the length of muscle fibers.

Methods Clinical and imaging analysis of 2 groups of patients (biceps tenodesis [16 patients] and biceps tenotomy [15 patients]). In both groups, we compared the findings on the contralateral side of each patient (control group). All patients had undergone unilateral biceps tenodesis or tenotomy, with postoperative follow-up of > 1 year. Magnetic resonance imaging (MRI) was performed on both arms of each patient following a specific protocol. Strength of elbow flexion was measured with a manual dynamometer, and the results were subjected to statistical analysis.

Results The mean postoperative period before the MRI was 5 years, and no case of FI was observed in the anterior compartment of either arm of the evaluated patients. Seven patients had moderate or severe deformity in the operated arm. We found no significant relationship between arm deformity ($p = 0.077$), flexion strength percentage ($p = 0.07$) or pain on palpation of the bicipital groove ($p = 0.103$).

Conclusion None of the evaluated patients had evidence of FI in the muscle mass of the anterior arm compartment after the procedures. It was not possible to establish a correlation between the discrepancy of the biceps muscle length measured by MRI and the presence of FI in the anterior compartment of the arm.

Keywords
- biceps
- rotator cuff
- tenodesis
- tenotomy

* The present work was developed at the Centro de Traumatologia do Esporte da Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

received
December 1, 2019
accepted
June 1, 2020
published online
September 25, 2020

DOI https://doi.org/10.1055/s-0040-1714231.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo O objetivo do presente estudo foi determinar a existência de infiltração gordurosa (IG) na massa muscular do bíceps braquial após a tenotomia ou tenodese para tratamento de lesão no tendão da cabeça longa do bíceps e estabelecer uma relação entre a IG e alterações no comprimento das fibras musculares.

Métodos Análise clínica e de imagens de 2 grupos de pacientes (submetidos à tenodese do bíceps [16 indivíduos] ou tenotomia do bíceps [15 indivíduos]). Nos dois grupos, os achados foram comparados àqueles do lado contralateral de cada indivíduo (grupo controle). Todos os pacientes foram submetidos à tenodese ou tenotomia unilateral do bíceps, com acompanhamento pós-operatório > 1 ano. Exames de ressonância magnética (RM) foram realizados em ambos os braços de cada paciente de acordo com um protocolo específico. A força de flexão do cotovelo foi medida com dinamômetro manual e os resultados foram submetidos à análise estatística.

Resultados O período pós-operatório médio antes da realização da RM foi de 5 anos, e nenhum caso de IG foi observado no compartimento anterior de ambos os braços dos pacientes avaliados. Sete pacientes apresentaram deformidade moderada ou grave no braço operado. Não houve relação significativa entre deformidade do braço ($p = 0{,}077$), percentual de força de flexão ($p = 0{,}07$) ou dor à palpação do sulco bicipital ($p = 0{,}103$).

Conclusão Nenhum dos pacientes avaliados apresentou evidência de IG na massa muscular do compartimento anterior do braço após os procedimentos. Não foi possível estabelecer uma correlação entre a discrepância do comprimento do músculo bíceps, medido à RM, e a presença de IG no compartimento anterior do braço.

Palavras-chave

- bíceps
- manguito rotador
- tenodese
- tenotomia

Introduction

When the long head of the biceps tendon (LHBT) is ruptured or subjected to tenotomy or tenodesis, retraction of the muscle belly may result in changes in the strength and/or aesthetics of the arm.[1] However, the amount of retraction that is able of causing clinical repercussions is still not well-defined. Muscle atrophy, interstitial fibrosis and fatty infiltration (FI) are frequently associated with chronic rotator cuff injuries. These irreversible structural changes favor the loss of muscle strength and elasticity and are major obstacles to the success of surgical repair of muscles such as the subscapularis, supraspinatus and infraspinatus muscles.[2] Although often studied, it is not well-established whether chronic shortening of the biceps muscle mass can cause a change in the muscle belly similar to that caused by FI in the belly of the rotator cuff muscles in cases of chronic and retracted ruptures.[3,4]

In the mid-1900s, the LHBT was seen as the main source of shoulder pain, and treatment of that pain focused on tenotomy and tenodesis.[5–7] Currently, these procedures for the treatment of LHBT-related injuries are widely performed during shoulder arthroscopies.[8,9] There is no clear consensus regarding the best surgical treatment for LHBT injuries.[10] There is also no consistent method to ensure that appropriate biceps tension has been restored postoperatively.[11]

Our objective was to determine whether FI is present in the muscle of the biceps brachii after the treatment of LHBT injuries (tenodesis or tenotomy) and to establish a relationship between this possible FI with changes in muscle fiber length, the presence of deformities and strength.

Materials and Methods

This was an observational, cross-sectional, case-control study consisting of the clinical and imaging analysis of two groups: one composed of patients undergoing biceps tenodesis in the bicipital groove with an interference screw and another composed of patients undergoing biceps tenotomy. Patients were randomly separated according to sealed envelopes that were opened before each surgery. In both groups, a comparison was made with the findings on the contralateral side of each patient (control group).

The present study was submitted to the ethics committee under the number CAAE 92179218.8.0000.5505, and all patients included in the study signed an informed consent form.

Patient Selection

The patients were selected based on a simple search of the medical records in the private clinic of the investigator. The inclusion criteria were: agreeing and signing the informed consent form, having undergone unilateral biceps tenotomy or tenodesis, and postoperative follow-up of > 1 year.

The exclusion criteria were the presence of rotator cuff or LHBT injury evidenced during the study.

A total of 34 patients agreed to participate in the study. There were 17 patients from the tenodesis group and 17 patients from the tenotomy group. Of these 34 patients, 3

were excluded from the study after the MRI exam (2 in the tenotomy group and 1 in the tenodesis group) because they had clinical and radiological signs of rotator cuff injury (RCI) in the contralateral shoulder, with complaint of arm pain and loss of elbow flexion strength. After exclusions, 16 patients from the tenodesis group and 15 patients from the tenotomy group were evaluated, totaling 31 patients (31 operated arms and 31 contralateral arms for control). All patients had undergone surgery for RCI treatment as the main diagnosis.

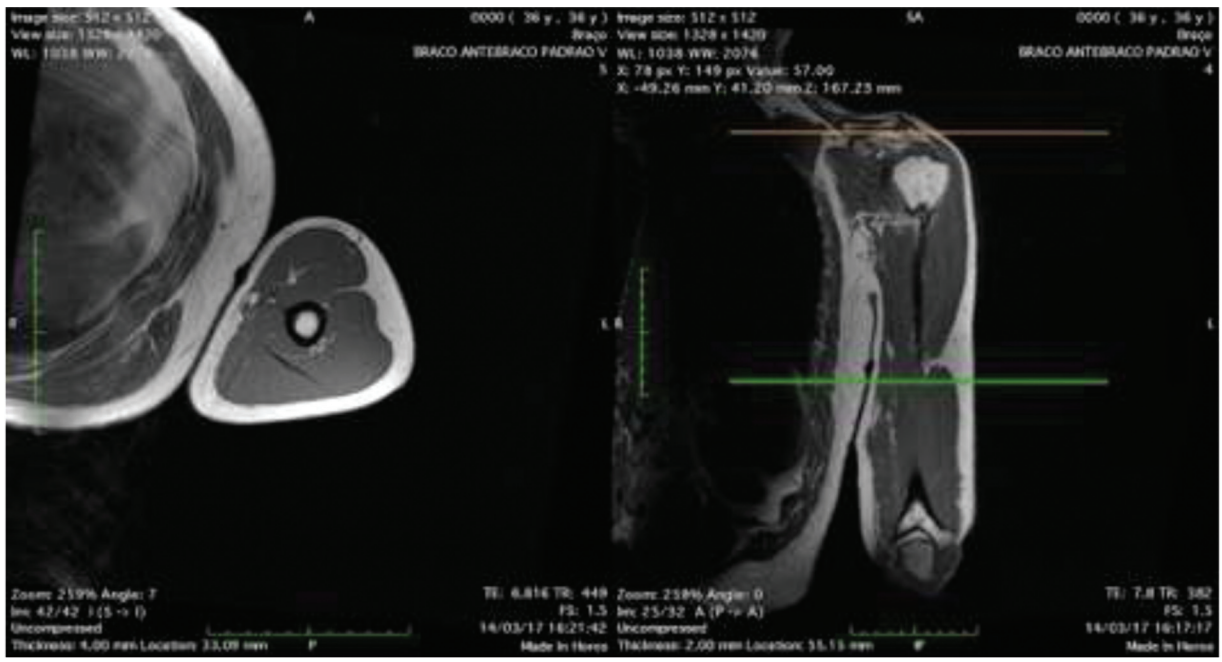
Magnetic resonance imaging

The MRI exams were all performed using a 1.5 Tesla GE Brivo 355 (General Electric, Boston, MA, USA). All patients were imaged in the supine position, with the arms positioned along the body in neutral rotation. T1-weighted coronal and axial images were obtained of both arms of each patient following a specific protocol. The T1-weighted coronal sequences were aligned with the body of the scapula with 3-mm spacing. This sequence identified the apex of the humeral head and the length of the studied humerus, and then half of the length was calculated. A double sequence of T1-weighted axial slices was started from the lower edge of the acromion, with the first sequence with 25 slices at a spacing of 3 mm followed by a second sequence with 35 more slices at a spacing of 4 mm. With this sequence, from a triangulation with the images of the coronal slices, it was possible to evaluate, with the thinner slices (3 mm), the distance between the apex of the humeral head and the first muscle fiber of the long portion of the biceps at the musculotendinous junction (AH-MTJ); that distance was compared with the contralateral side, resulting in the difference in AH-MTJ distance (►**Fig. 1**). In the group of patients subjected to tenodesis, we also assessed the distance between the apex of the humeral head and the interference screw (AH-IS).

Individualizing the muscle belly of the long and short heads of the biceps and separating them from the other muscles of the anterior compartment of the arm cannot be done with MRI, as previously reported.[3,4] For this reason, we comparatively investigated the presence or absence of FI in the muscle mass of the anterior compartment of the arm using the T1-weighted axial section performed as close as possible to half the length of the humerus in both groups. We adapted the existing FI classification,[12] comparing both arms of each patient. This classification suggests 5 FI grades (grade 0: normal; grade 1: some fatty streaks present; grade 2: $< 50\%$ FI; grade 3: 50% FI; grade 4: $> 50\%$ FI),[13] and although this classification is not validated for use with MRI images of the biceps, it was used for this purpose in a recent study.[4] The images were evaluated by an experienced radiologist, trained in the musculoskeletal system and with 15 years of clinical practice.

Clinical Evaluation

The presence of arm deformities was classified as suggested by Scheibel et al.[14] as none, mild, moderate and severe; to facilitate statistical analysis, we subdivided the presence of deformities into 2 groups: satisfactory (none or mild) and unsatisfactory (moderate or severe) (►**Figs. 2** and **3**). Elbow flexion strength was measured with a manual dynamometer (Fabrication Enterprises, White Plains, New York, USA) (Baseline Mechanical Spring Push/Pull Dynamometer-60 Pounds) in both arms of each patient. Pain on palpation of the bicipital groove was evaluated by the examiner by finger compression 5 cm distal to the anterolateral corner of the acromion with the arm in neutral rotation.



Source: Author's archive.

Fig. 1 Distance between the apex of the humeral head and the first muscle fiber of the long portion of the biceps at the musculotendinous junction.



Source: Author's archive.

Fig. 2 Satisfactory deformity.



Source: Author's archive.

Fig. 3 Unsatisfactory deformity.

Statistical Analysis

A descriptive analysis of the variables was performed by constructing box plots and calculating the mean, standard error, standard deviation (SD), variance, coefficient of variation, minimum, 1st quartile, median, 3rd quartile and maximum for all study variables.

Due to the small sample size, the Fisher exact test was used to determine independence between pairs of variables. When the assumptions of a normal distribution of the mean were not met for the two samples or when one of the samples was very small (size equal to two or three), the nonparametric Mann-Whitney test of equality of means was employed for the two groups. If one of the sample sizes was smaller than four, the Mann-Whitney test for the difference of means may not be valid because very small sample sizes are not conducive to rejecting the tested hypothesis.

We calculated the respective descriptive levels (*p-value*) for all the hypothesis tests performed and rejected the hypotheses with descriptive levels lower than the level of significance adopted, which was equal to 0.05. Data analysis was performed using Minitab v.18 (Minitab, LLC., State College, PA, USA).

Results

For the 31 patients evaluated, the mean postoperative period at the time the MRI exam was performed was 5 years: 5.8 years (range, 2 to 11 years) for the tenotomy group and 4.2 years (range, 1 to 9 years) for the tenodesis group. The mean age of the participants was 60 years old (53 to 77 years old) for the tenotomy group and 50.8 years old (33 to 69 years old) for the tenodesis group (►**Table 1**).

Arm Deformity

Among all individuals studied, 7 had unsatisfactory (moderate or severe) deformities in the operated arm. The difference in AH-MTJ distance ranged from - 0.6 cm to 3.1 cm (mean of 0.34 cm). We found no significant relationship between satisfactory deformities and the difference in AH-MTJ distance

Table 1 Sample characteristics

Group	Number of patients	Mean postoperative period	Indication for surgery	Mean age at surgery	Average Distance	Men	Women
Tenotomy	15	5.8 years (2–5 years)	Rotator cuff injury	63 years (53–77 years)	5	3 (20%)	12 (80%)
Tenodesis	16	4.2 years (1–9 years)	Rotator cuff injury	50.8 years (33–69 years)	1	15 (93.5%)	1 (6.5%)

Source: Prepared by the author.

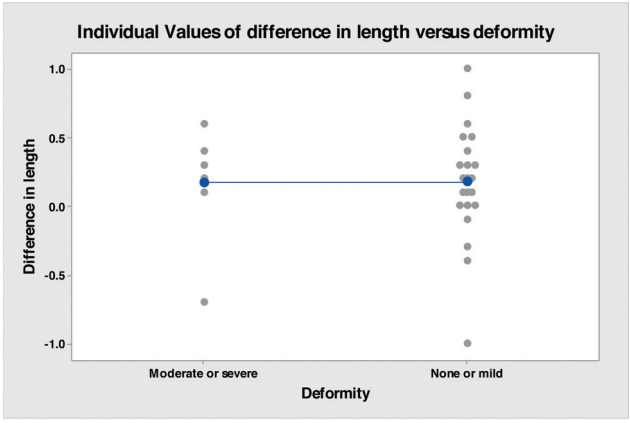


Fig. 4 Individual values of difference in length versus deformity.

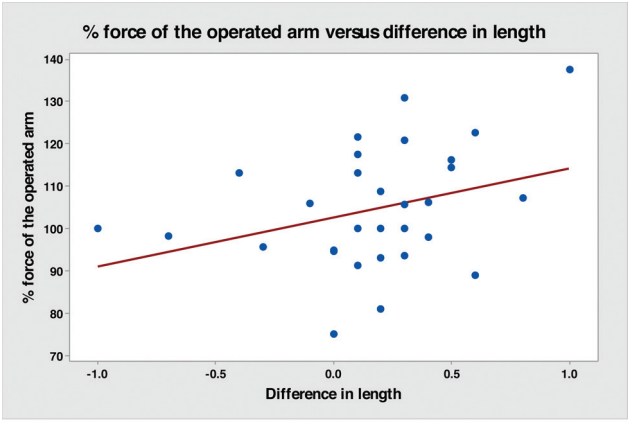


Fig. 6 Percent force of the operated arm versus difference in length.

($p = 0.124$) or between the incidence of unsatisfactory deformities and the difference in AH-MTJ distance ($p = 0.077$). The means of the differences in the AH-MTJ distance were similar for patients who presented satisfactory (0.175 cm) and unsatisfactory (0.171 cm) deformities ($p = 0.984$). Both had normal distribution (►**Fig. 4**).

Fatty Infiltration

No patient in either group exhibited changes in muscle mass of the anterior compartment of the arm, and no case of FI was evident in the T1-weighted axial section at the level of half the total length of the arm. All cases were classified as grade 0. (►**Fig. 5**).

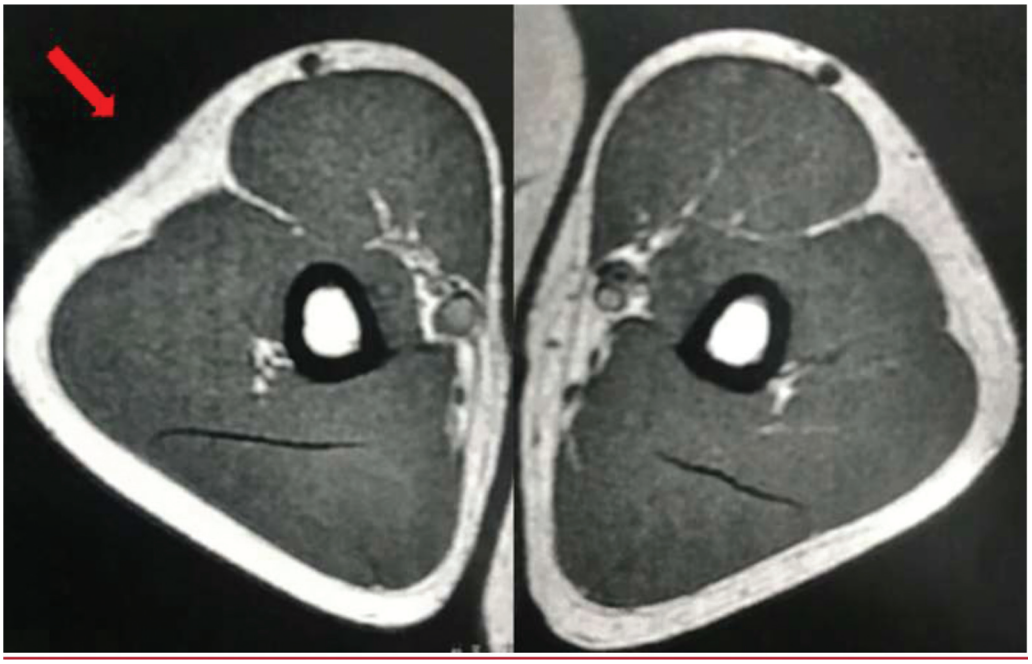
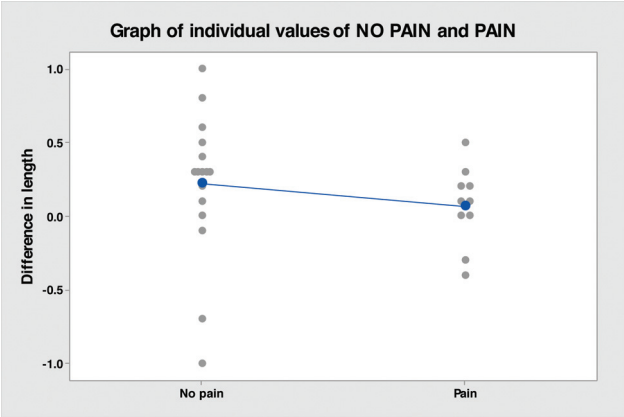


Fig. 5 Fatty infiltration.



Source: Prepared by the author.

Fig. 7 Graph of individual values of no pain and pain.

Flexion Strength

The percent flexion strength of the operated arms did not follow a linear relationship with the difference in AH-MTJ distance ($p = 0.070$) (►**Fig. 6**). There was no difference in the mean percent strength between the groups ($p = 0.399$): 106.7% (range, 92.86 to 137.57%) in the tenodesis group and 102.4% (range, 75 to 130.77%) in the tenotomy group. Both groups presented a normal distribution.

Pain on Palpation of the Intertubercular Groove

We did not find a significant relationship between pain on palpation of the bicipital groove and the difference in AH-MTJ distance ($p = 0.103$) (►**Fig. 7**). There was no significant correlation between the incidence of pain in the bicipital groove and the mean percent elbow flexion strength of the operated arm ($p = 0.062$).

Discussion

We found no evidence of FI in the muscle mass of the anterior compartment of the arms subjected to procedures for the treatment of the LHBT injuries at a mean postoperative follow-up of 5 years. There is no difference in muscle appearance on the MRI after biceps tenotomy or tenodesis. Thus, the variations in the length of the biceps muscle mass found in the present study (difference in AH-MTJ distance) did not contribute to the onset of FI in the muscle belly. It was also not possible to establish a correlation between the discrepancy in biceps length measured on MRI images and residual pain, loss of flexion strength or arm deformity.

Our MRI images were collected from both arms and from all 31 patients, and the muscle mass on the operated side was compared with the muscle mass of the contralateral side, which was free of significant changes in the biceps and in the rotator cuff. We quantitatively investigated the retraction of the muscle belly evaluated and its possible relationship with the presence of FI.

There were seven patients with unsatisfactory (moderate or severe) deformities in the operated arm and the means of the differences in the AH-MTJ distance were similar for patients who presented satisfactory and unsatisfactory deformities. In conclusion, the AH-MTJ distance is not the only aspect that determines the satisfaction of the patient.

In the present study, we performed MRI examinations in both arms of the 31 patients so that we could compare the muscle mass of the anterior compartment of both arms and compare the variation in the length of the biceps muscle mass based on the difference in the AH-MTJ distance. There was no relationship between the difference in the AH-MTJ distance and FI and there was also no relationship between FI and arm deformity. Similarly, in the 31 evaluated patients, there were no signs of FI after a mean postoperative period of 5 years. This finding suggests that chronic biceps injuries can be repaired while maintaining good muscle power and function because the musculature is preserved over the years, even when there is retraction. We also did not find a correlation between FI and arm deformity.

The chronic lack of load and simple tenotomy of the rotator cuff muscles can result in FI and in a significant reduction in muscle volume.[2,15] The long head of the biceps originates in the supraglenoid tubercle proximally, merges with the short head and inserts distally in the tuberosity of the radius, crossing 2 joints; therefore, even if its proximal end is detached, the distal end remains inserted, generating load and activating muscle fibers.

In the case of tenotomy, residual pain may occur because some of the force generated by muscle contraction is not transmitted to a tendon attached to the bone,[3] and an increase in the incidence of cramping pain in the biceps has been reported.[16] In tenodesis, pain may occur due to the permanence of synovitis in the bicipital groove, especially if the fixation is performed at the joint margin or in the most proximal portion of the intertubercular groove.[9] For any technique, when there is excessive retraction of the muscle belly, eventual chronic tension in the common branch of the MCN could be a cause of pain. We did not find a significant relationship between pain on palpation of the intertubercular groove and the difference in AH-MTJ distance ($p = 0.103$). Residual pain related to the biceps may be found in 19% of cases of tenotomy and in 24% of cases of tenodesis.[9] In our study, pain on palpation of the intertubercular groove was present in 10 of the 31 patients, 3 in the tenodesis group (18.75%) and 7 in the tenotomy group (46.6%), but this difference was not significant ($p = 0.135$), possibly due to the sample size.

Our study compared percent elbow flexion strength with the difference in the AH-MTJ distance, and there was no significant relationship ($p = 0.070$). It remains controversial whether there is a clinical difference in the loss of strength after tenotomy and tenodesis.[9] Shank et al.[17] found no difference in strength when comparing the postoperative period after tenodesis and tenotomy. Another study found a 20% loss of elbow flexion strength after tenotomy.[16] Although it was not the objective of our study, we individually compared the results of the 2 groups and found no significant difference in percent elbow flexion strength ($p = 0.311$). The tenotomy group had a mean strength of 102.4% compared with the contralateral side, while the tenodesis group had a mean strength of 106.7%, which was slightly higher.

Our study has some limitations. Initially, considering that the MTJ may extend for ~ 8 cm,[11] we stipulated as the standard measure the first muscle fibers of the biceps identified in the T1-weighted axial section; however, this measure may be subject to individual anatomical variations. To minimize these effects, all MRI exams were performed on the same machine, following the same protocol, and evaluated by the same radiologist. A second limitation was not having performed a histological evaluation of the muscle fibers. Although a histological evaluation is perhaps the gold standard for assessing FI, it would be ethically impossible to perform; in addition, MRI evaluation has been widely used to investigate muscle trophism and is well-established in shoulder and elbow surgery. A third limitation is the use of a manual dynamometer, which is not the perfect tool, but it gives a good idea of the elbow flexion strength. The number of individuals may have been insufficient for some secondary analyses; however, it was absolutely sufficient for the initial and main purpose of evaluating FI of the biceps brachii muscle.

Conclusion

At an average follow-up of 5 years, none of the evaluated patients had evidence of FI in the muscle mass of the anterior compartment of the arm after biceps tenodesis or tenotomy.

There was no difference between tenotomy and tenodesis regarding the muscle mass pattern observed by MRI.

It was not possible to establish a correlation between the biceps muscle length discrepancy measured on MRI, the presence of deformities, strength and the presence of FI in the anterior compartment of the arm.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Percutaneous Hallux Valgus: An Algorithm for the Surgical Treatment*

Hálux valgo percutâneo: Um algoritmo para o tratamento cirúrgico

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Rev Bras Ortop 2021;56(4):504–512.

Abstract

Objective To present the clinical and radiographic results of hallux valgus surgical correction using four percutaneous techniques, chosen according to a predefined radiographic classification.

Methods We prospectively evaluated 112 feet in 72 patients with hallux valgus operated over the course of 1 year. Percutaneous distal soft tissue release (DSTR) and the Akin procedure (DSTR-Akin) were performed in mild cases. In mild to moderate hallux valgus with distal metatarsal joint angle $> 10°$, we added the Reverdin-Isham (RI) osteotomy. In moderate cases with joint incongruity, we performed the percutaneous chevron (PCH). Finally, a Ludloff-like percutaneous proximal osteotomy fixed (PPOF) with a screw was proposed in severe cases with an intermetatarsal angle (IMA) $> 17°$. According to these criteria, 26 DSTRs-Akin, 36 PCHs, 35 RIs, and 15 PPOFs were performed. The mean follow-up was of 17.2 months (range: 12 to 36 months). The mean age at operation was 58.8 years (range: 17 to 83 years), and 89% of the patients were female.

Results The mean preoperative hallux valgus angle (HVA) and the IMA decreased from 21° to 10.2° and from 11.2° to 10.3° respectively in the DSTR-Akin. In the RI, the mean HVA decreased from 26.6° to 13.7°, and the IMA, from 11.2° to 10.3°; in the PCH, the mean HVA decreased from 31° to 14.5°, and the IMA decreased 14.9° to 10.7°; as for the PPOF, the mean HVA decreased from 39.2° to 17.7°, and the IMA, from 11.8° to 6.8°. The average ankle and hindfoot score of the American Orthopaedic Foot and Ankle Society (AOFAS) increased from 49.2 to 88.6. The rate of complications was of 11%.

Conclusion Our treatment protocol does not differ much from the classic ones, with similar results as well. We have as advantages less aggression to soft tissues and better cosmetic results. Level of Evidence: level IV, prospective case series.

Keywords
- hallux valgus
- metatarsal bones
- minimally invasive surgical procedures

* *Work developed at Hospital São Lucas, Santos, SP, Brazil.*

received
April 28, 2020
accepted
September 16, 2020

DOI https://doi.org/10.1055/s-0040-1721367.
ISSN 0102-3616.

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Resumo

Objetivo Apresentar os resultados clínicos e radiográficos da correção cirúrgica de hálux valgo utilizando quatro técnicas percutâneas escolhidas de acordo com uma classificação radiográfica predefinida.

Métodos Avaliamos prospectivamente 112 pés em 72 pacientes com hálux valgo operado em um período de um ano. A liberação de tecido mole distal (LTMD) percutâneo e o procedimento de Akin (LTMD-Akin) foram realizados em casos leves. Em hálux valgo de leve a moderado com ângulo distal da articulação do metatarso acima de 10°, adicionamos a osteotomia de Reverdin-Isham (RI). Em casos moderados com incongruência articular, realizamos o *chevron* percutâneo (CHP). Finalmente, uma osteotomia proximal percutânea fixada (OPPF) com um parafuso, semelhante à de Ludloff , foi proposta em casos graves com ângulo intermetatarsal (AIM) acima de 17°. De acordo com esses critérios, foram realizados 26 LTMDs-Akin, 36 CHPs, 35 RIs e 15 OPPFs. O seguimento médio foi de 17,2 meses (12 a 36 meses). A média de idade em operação foi de 58,8 anos (17 a 83 anos), e 89% dos pacientes eram do sexo feminino.

Resultados A média do ângulo de hálux valgo (AHV) pré-operatório e o AIM diminuíram de 21° para 10,2°, e de 11,2° para 10,3°, respectivamente, em casos de LTMD-Akin. Em casos de RI, a média do AHV diminuiu de 26,6° para 13,7°, e o AIM, de 11,2° para 10,3°; em casos de CHP, o AHV médio diminuiu de 31° para 14,5°, o AIM diminuiu de 14,9° para 10,7°, e a OPPF, de 39,2° para 17,7°, e o AIM 11,8° para 6,8°. A média do escore de tornozelo e retropé da American Orthopaedic Foot and Ankle Society (AOFAS) aumentou de 49,2 para 88,6. A taxa de complicação foi de 11%.

Conclusão Nosso protocolo de tratamento não difere muito dos clássicos, com resultados semelhantes. Temos como vantagem menos agressividade aos tecidos moles e melhores resultados cosméticos. Nível de evidência: nível IV, série de casos prospectivos.

Palavras-chave

- hálux valgo
- ossos do metatarso
- procedimentos cirúrgicos minimamente invasivos

Introduction

Percutaneous surgery is a set of techniques performed with punctiform incisions in order to eneble the performance of osteotomies, exostectomies and capsulotomies, while minimizing aggression to the soft tissues. This surgical approach was developed 65 years ago, but only gained notority after 1985 in the United States,[1] in the 1990s in Europe with Mariano Prado and Pau Golano,[2] and in 2002 in France with the the Groupe de Recherche et d'Etude en Chirurgie Mini-Invasive du Pied (Group of Research and Study in Minimally-Invasive Surgery of the Foot, GRECMIP).[3]

Following a worldwide trend in several areas of orthopedics to reduce incisions and surgical aggression in order to decrease complications and comorbidities, we developed a protocol for hallux valgus (HV) surgery. We used already-defined radiographic criteria, which do not differ much from those used by other authors.[4,5] We used four percutaneous techniques to perform the procedures in an individualized manner, respecting angular changes, particular characteristics and all aspects that may alter the surgical indication, similar to those found in algorithms regarding open procedures.

The objective of the present study is to describe the clinical, functional and radiographic results of the surgical treatment of HV by percutaneous techniques.

Material and Methods

The project was submitted and approved by the institution's Ethics in Research Committee, under number 0001/2020.

We prospectively evaluated 112 feet in 72 patients with HV operated over the course of 1 year by the same surgeon. The surgical indications were based on the severity of the angular radiographic findings, as well as the presence of a congruent metatarsophalangeal (MTP) joint and increased distal metatarsal articular angle (DMAA). Deformity was considered mild when the hallux valgus angle (HVA) was between 12° and 30°, the intermetatarsal angle (IMA) was between 8° and 14°, and the distal metatarsal articular angle (DMAA) was lower than 10°. Moderate HV was considered when the HVA was $\leq$ 40°, and the IMA was between 14° and 17°; mild to moderate HV with an increased DMAA was considered if the DMAA was greater than 10°, with the HVA $\leq$ 40° and the IMA $\leq$ 17°. Severe HV was defined as HVA greater than 40° or IMA greater than 17° (►**Table 1**).

The HVA is the angle formed by the middle axis of the diaphysis of the proximal hallux phalanx and the mechanical axis of the first metatarsus. The IMA is the angle formed between the mechanical axis of the first and second metatarsi, and the DMAA is the angle formed between the line perpendicular to the articular surface of the head of the first metatarsus and the long axis of the first metatarsus. All angular

Table 1 Radiographic features and proposed procedure

	Mild hallux valgus	Mild to moderate hallux valgus with high distal metatarsal articular angle	Moderate hallux valgus	Severe hallux valgus
Angle	Intermetatarsal angle $< 14°$	Intermetatarsal angle: 8° to 17°	Intermetatarsal angle: 12° to 17°	Intermetatarsal angle $> 17°$
	Hallux valgus angle $< 30°$	Hallux valgus angle: 12° to 40°	Hallux valgus angle: 20° to 40°	Hallux valgus angle $> 30°$
		distal metatarsal articular angle $> 10°$	Joint incongruence	
Technique	Percutaneous distal soft tissue release and Akin procedure	Reverdin-Isham	Percutaneous Chevron	Proximal Percutaneous Osteotomy

measurements were performed digitally on anteroposterior weight-bearing x-rays using a commercially-available software (Directview, Carestream, NY, US) (►**Fig. 1A, B** and **C**). The patients were evaluated using the ankle and hindfoot score of the American Orthopaedic Foot and Ankle Society (AOFAS),[6] followed by clinical and radiographic analyses, as well as an analysis of the degree of subjective satisfaction of Johnson,[7] each performed before and after surgery.

The statistical analysis was performed with the Eviews 11 (IHS Markit, London, UK) software for Windows, and the paired Student *t*-test was used to evaluate the results with a significance level < 0.05.

In mild HV, we percutaneously performed exostectomy, distal soft tissue release (DSTR) and Akin osteotomy[8] (DSTR-Akin). The surgery was performed under locoregional or spinal anesthesia, with the patient in supine position and the feet overhanging the end of the table, with the operated foot supported on the image intensifier. Tourniquet was not necessary.

An incision was made in the plantar base of the exostosis of the first metatarsus with the Beaver 64 (BVI, Waltham, MA, US) scalpel. Afterwards, we removed the periosteum, with the scraper or scalpel, and performed an exostectomy using a 3.1-mm wedge burr. The bone was removed from the joint by manual compression or with a scraper, and, sometimes, with saline solution. Next, we made a dorsolateral incision in the metatarsophalangeal joint of the hallux to perform the tenotomy of the aductor tendon of the hallux and lateral capsulotomy (►**Fig. 2A** and **B**). To do so, we moved the finger medially; promoting a varus of the hallux, introducing the Beaver scalpel with the cutting face aimed laterally and deeply, and performed lateral capsulotomy and tenotomy. Finally, we performed a medial incision at the base of the proximal phalanx and, with the wedge 3.1-mm burr, an incomplete osteotomy was performed to obtain a closing wedge after a manual compression. The osteotomy was stable, and no fixation was necessary (►**Fig. 1C**).

In mild to moderate deformities with altered DMAA, we performed the Reverdin-Isham[1,3] (RI) technique. We performed exostectomy as previously described, followed by osteotomy using the same approach. We introduced a Shannon burr from dorsal to plantar at 45 degrees of lateral

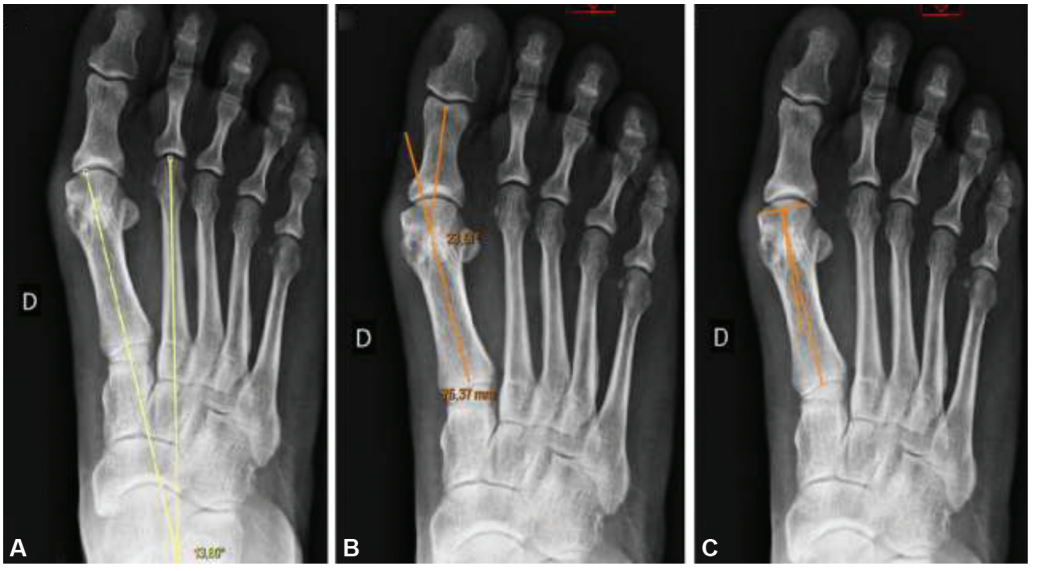


Fig. 1 Angular measurements. (**A**) Hallux valgus angle (HVA); (**B**) intermetatarsal angle (IMA); (**C**) distal metatarsal articular angle (DMAA).

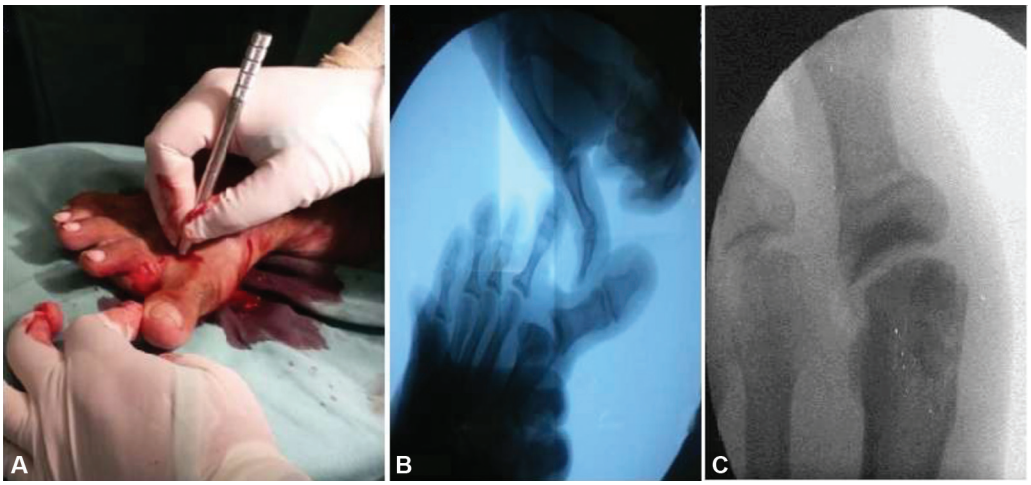


Fig. 2 (A) Dorsolateral incision in the metatarsophalangeal joint of the hallux; (B) fluoroscopy after adductor tendon tenotomy and capsulotomy; (C) Akin procedure on the image intensifier.

inclination on the metatarsal head and cut the bone, taking care to preserve the lateral cortical. This enables the performance of a varus osteoclasia, closing the osteotomy and correcting the DMAA, while maintaining stability (►**Fig. 3**). Next, we performed the release of lateral soft tissues and Akin osteotomy, as previously described.

In cases of moderate HV with joint incongruity, we performed the percutaneous chevron (PCH) technique as described by Vernois.[9] We incised the base of the medial exostosis with the Beaver scapel. With a 20-mm long Shannon burr, a v-shaped osteotomy was performed with the apex slightly dorsal in relation to the center of the shaft. The first dorsal cut was perpendicular to the ground, and the second, at 90°, parallel to the floor. (►**Fig. 4A, B** and **C**). The burr should be parallel to the distal joint in the horizontal plane. With a Kirschner (K) wire or lever, the first metatarsal head was moved laterally and fixed with 1 or 2 screws with 3 mm in diameter. An exostectomy was performed if necessary, followed by the release of lateral soft tissues and the Akin procedure.



Fig. 3 Reverdin-Isham (RI) techinique associated with exostectomy, tenotomy and Akin osteotomy.

In cases of severe HV, percutaneous proximal osteotomy fixed (PPOF) with a screw, similar to the Ludloff osteotomy,[10] was performed. The Beaver 64 scalpel was used to create a proximal and lateral incision, 1 cm distal from the metatarsocuneiform joint. We detached the periosteum, and, with the Shannon 2 × 20-mm burr, performed an oblique distal plantar to dorsal proximal osteotomy (►**Fig. 5A**). With a K wire attached below the metatarsal head, the first metatarsus was moved laterally and secured with a 3.0-mm screw (►**Fig. 5B**). After this, we performed the percutaneous exostectomy, the lateral release of soft tissues, and the Akin procedure, as described.

The bandage is made with gauze and adhesive tape, keeping the toe in a neutral position with 10° of flexion. The tapings were changed weekly, for 4 weeks, and immediate loading with rigid shoes was allowed as tolerated. When the pathology was bilateral, the patients were operated on both feet. Angular measurements were taken and questionnaires were applied at six weeks, six months and one year.

Results

In total, 72 (112 feet) patients, with an average age of 58.8 years (range: 17 to 83) were submitted to surgery, and 89% were female. They were divided in the 4 aforementioned categories, and 26 DSTRs-Akin (23.2%), 36 PCHs (32.1%), 35 IRs (31.25%), and 15 PPOFs (13.4%) were performed. A total of 54 (48%) feet required additional procedures to correct other associated deformities. We performed distal minimally-invasive metatarsal osteotomies in 26 feet, corrective fifth-bunion osteotomies in 14 feet, corrective osteotomies of toe deformities in 34 feet, neurolysis in 1 foot, and calcaneal osteotomies for flat feet on 2 patients.

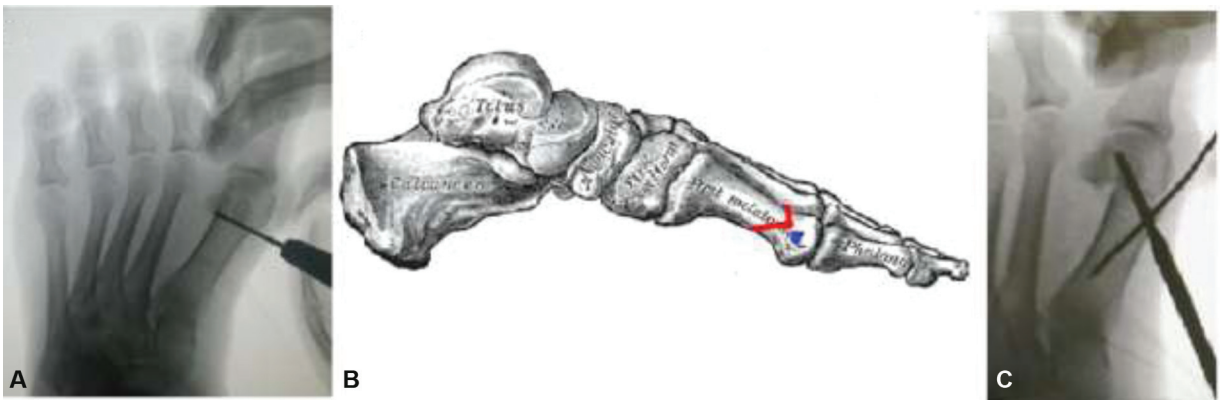


Fig. 4 (A) Fluoroscopy control showing the position of the burr, parallel to the articular surface of the first metatarsus during the first cut for the chevron osteotomy; (B) the red line shows the directions for the chevron cut; (C) fixation of the percutaneous chevron with one screw. A Kirschner wire is used to assist on the reduction.

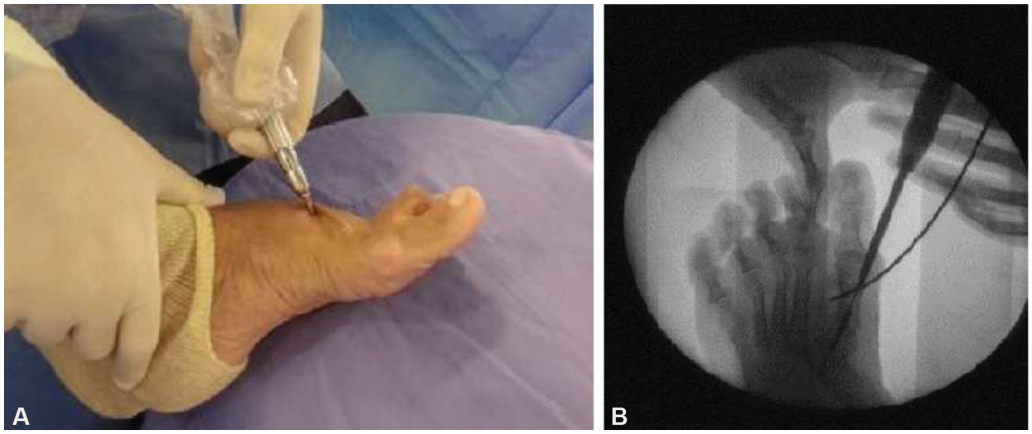


Fig. 5 (A) Position of the burr to perform the Ludloff osteotomy; (B) fixation of the osteotomy with one screw. A Kirschner wire is used to help translate the metatarsal head.

The average follow-up was of 17.2 months (range: 12 to 36 months). The mean preoperative HVA was of 35.1° (range: 13° to 51°); postoperatively, it was of 12.3° (range: 0° to 28°). Therefore, a mean correction of 22.8° was obtained, with the difference being statistically significant ($p < 0.05$). The mean preoperative IMA was of 13.7° (6° - 23°) and of 9.3° (5° to 19°) postoperatively, with a mean correction of 4.4° ($p < 0.05$). The mean preoperative AOFAS was of 49.2 (34 to 60), and, at the last follow-up, it was of 88.6 (45 to 100), with a mean increase of 39.4 points ($p < 0.05$).

When the groups were analyzed separately, in the cases of mild HV (►**Fig. 6A** and **B**), the mean preoperative HVA wasof 21° (range: 15° to 27°), and, at the last follow-up, it was of 10.2° (range: 4° to 21°). The mean angular correction was of 10.8° (range: 7° to 20°). The mean preoperative IMA was of 11.2° (range: 6° to 15°), and, at the last follow-up, it was of 10.3° (8° to 13°), with an average correction of 0.9° (range: 0° to 2°). The mean preoperative AOFAS was of 55.6 (range: 34 to 65), and, postoperatively, it was pf 94.2 (range: 77 to 100).

In the cases submitted to RI (►**Fig. 7A** and **B**), the mean preoperative HVA was of 26.5° (range: 18° to 36°), and, in the postoperative period, it was of 13.7° (range: 6° to 21°), with 12.8° of average correction. The mean IMA was of 13.4° (range: 11° to 17°) preoperatively, and 12.6° (range: 7° to 17°) postoperatively, with a mean correction of 0.8°. The average AOFAS score increased from 52.4 (range: 44 to 60) to 85.3 (range: 70 to 100) points. In the moderate cases with articular incongruity in which PCH was indicated (►**Fig. 8A** and **B**), the HVA decreased from 31° (range: 26° to 40°) to 14.5° (range: 3° to 26°), with a mean correction of 16.5°. The IMA decreased from 14.9° (range: 9° to 17°) to 10.7° (range: 8° to 16°), with a mean correction of 4.2°. The average AOFAS score increased from 42 to 87.1 points.

In severe cases, submitted to PPOF (►**Fig. 9A** and **B**), the mean preoperative HVA decreased from 39.2° (range: 30° to 51°) to 17.7° (range: 8° to 28°), with a mean correction of 21.5°. The mean preoperative IMA decreased from 18.4° (range: 15° to 23°) to 11.8° (range: 7° to 17°), with a mean correction of 6.8°. The mean preoperative AOFAS was of 41.8 (range: 34 to 50) and increased to 88 (range: 70 to 100) points at the last follow-up. One patient was dissatisfied with the outcome due to recurrence.

Regarding the complications, there were 6 cases in which removal of the screw was needed (3 PCHs and 3 PPOFs), 1 case of fistula (PCH), 3 cases of joint stiffness (2 RIs and 1 PCH), 2 cases of residual edema after 1 year of the surgery (PPOF), 2 cases of transfer metatarsalgia (1 PCH and 1 PPOF), 2 asymptomatic non-unions of metatarsal osteotomy after



Fig. 6 (A) Pre-operative mild case; (B) pos-operative (exostectomy + distal soft tissue release + Akin) mild case.

1 year, and 1 broken burr that could not be removed. Two patients presented a symptomatic callus, caused by dorsal dislocation of first metatarsal head (1 RI and 1 PPOF), there was 1 recurrence in less than 1 year (PPOF), and 1 non-transient neuropathy (DSTR-AKIN). These represent 18% of all cases. The percentage of complications was proportionally higher in the severe cases (33%; PPOF) followed by the moderate cases (18%; PCH), intermediate cases (17.6%; RI), and mild cases (12%; DSTR-Akin).

Discussion

Several techniques for the surgical treatment of HV have been described. We do not believe that a single technique can solve all cases. The present study is based on modern treatment concepts, which have originated protocols based on clinical and radiographic changes.[11,12] Our protocol is based on the criteria and techniques already established regarding open procedures. The main difference is the application of this protocol with percutaneous techniques and stable fixation, preserving the local biology.[13]

In mild cases, we chose to perform the DSTR-Akin, according to Kayali et al.,[14] as the release of soft tissues rebalances the deforming forces and enables the achievement of good corrections. This procedure is performed only when the AIM is lower than 15°. In the present study, there was no recurrence after up to 28.6 months of follow-up. Colloff and Weitz[15] and Martinez-Nova et al.[16] also performed DSTR-Akin percutaneously in the treatment of mild to moderate HV, with similar results in the short term. Pansini et al.[17] used the Akin osteotomy in 89.1% of HV surgeries, highlighting the importance of this procedure for the correction of the deformity in combination with other techniques.

We obtained similar results compared to those already published in the literature, in which the Austin technique is the most popular.[18,19] Basile et al.[20] compared the Akin procedure associated with chevron with DSTR-Akin and described similar results, with a mild radiographic advantage for the chevron with the Akin prodedure.

In mild to moderate cases, which require DMAA correction, we considered the biplane chevron[21] the most appropriate open technique. We performed the RI[4] technique with good results, as already described in the literature in a multicenter study.[5]

In cases of moderate to severe HV with joint incongruity, we chose the percutaneous chevron procedure, as described by Vernois and Redfern.[22] Marijuschkin et al.[23] demonstrated the advantage of this technique with a low rate of complications and a high rate of patient satisfaction compared to conventional techniques. Lam et al.,[24] in a comparative study with the scarf osteotomy, highlighted an advantage in surgical time and postoperative pain. Brogan et al.[25] compared the conventional



Fig. 7 (A) Pre-operative moderate case with altered DMAA; (B) post-operative RI procedure with exostectomy + tenotomy + Akin.



Fig. 8 (A) Pre-operative moderate case with articular incongruence; (B) post-operative percutaneous chevron.

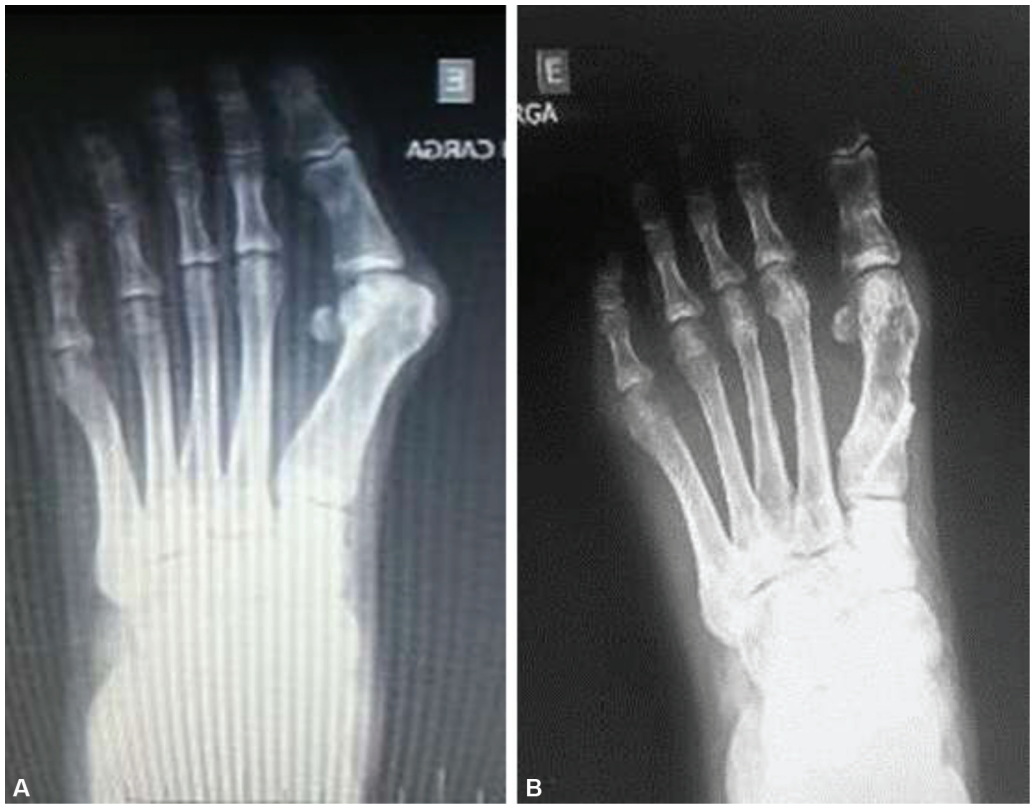


Fig. 9 (A) Pre-operative severe halux valgus; (B) post-operative Ludloff-like osteotomy.

Table 2 Pre and post-operative HVA and IMA values with average correction and AOFAS score

	Results							
Procedure	Initial HVA	Final HVA	(AC) HVA	Initial IMA	Final IMA	(AC) IMA	Initial AOFAS	Final AOFAS
DSTR-Akin	21°	10,2°	10,8°	11,2°	10,3°	0,9°	55.6	94.2
Reverdin-Isham	26,5°	13,7°	12,8°	13,4°	12,6°	0,8°	52.4	85.3
Percutaneous Chevron	31°	14,5°	16,5°	14,9°	10,7°	4,2°	42	87.1
PPOF	39,2°	17,7°	21,5°	18,4°	11,8°	6,8°	41.8	88
Total	35,1°	17,2°	22,8°	13,7°	9,3°	4,4°	49.2	88.6

Abbreviations: AC, average correction; AOFAS, ankle and hindfoot score of the American Orthopaedic Foot and Ankle Society; IMA, intermetatarsal angle; DSTR-Akin, distal soft tissue release and the Akin procedure; HVA, hallux valgus angle; PPOF, percutaneous proximal osteotomy fixed with a screw.

chevron and PCH, and stated there were no differences in complications and results, suggesting a short-term advantage for the PCH.

In severe cases, we chose the PPOF with screws, similar to the Ludloff osteotomy, enabling IMA correction. According to Saxena and McCammon,[26] who performed the conventional Ludloff osteotomy, this technique offers the advantage of better stability than the proximal chevron and crescent osteotomy. Lavigne et al.[27] described a triple percutaneous osteotomy for the correction of severe deformities, making 3 fixed shortening wedges, which was not our choice due to great technical difficulty. Vernois and Redfern[13] performed PCH and oblique incomplete first metatarsal base osteotomies for the treatment of severe HV, both with good results; these might also be good options. Regarding the open techniques, Mann et al.[28] performed proximal osteotomy and lateral release with similar results and with 28% elevation of the metatarsal head, high complications typical ofsevere cases. Considering the Ludloff osteotomy, Myerson[29] described complications in 22 of 75 feet, and considered these goods results, with good radiographic corrections and good patient satisfaction.

Percutaneous surgery has many advantages, especially considering its minimally-invasive characteristics. As presented by Lara et al.[30] it is less painful than open surgery, and has better cosmetic results and very similar overall results. These could be confirmed in our results by the elevated patient satisfaction and high AOFAS scores.

The present study has a few limitations regarding its case series design. On one hand, we did not have an open surgery

control group, and the follow-up was limited. On the other hand, it is a prospective work with a significant number of patients operated in a one-year period by the same surgeon. We believe that further research is necessary to establish this protocol, but the present study is a start, and it shows that the percutaneous techniques, with all of their benefits, could be performed in place of open procedures, with very similar results. In future studies, we suggest a longer follow-up in order to evaluate potential recurrence and a larger sample to confirm the protocol.

Conclusion

The surgical techniques herein described were effective in the treatment of HV with an improvement in the AOFAS score, high patient satisfaction, and good radiographic correction.

With the percutaneous and conventional surgeries, physicians are able to treat HV regarding the peculiar characteristics of each case, considering the radiographic and clinical knowledge already acquired with the classic studies. The percutaneous approach has as the advantage of being less aggressive to the soft tissues, providing better cosmetic results and less painful recovery.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Measuring Acetabular Version after Total Hip Arthroplasty: A Comparison of Two Radiographic Methods*

Medição da versão acetabular após artroplastia total do quadril: comparação de dois métodos radiográficos

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Rev Bras Ortop 2021;56(4):513–516.

Abstract

Objective The objective of the present work was to compare the measurement of acetabular component version on anteroposterior (AP) and on cross-table radiographs after total hip arthroplasty (THA).

Methods Radiographs of 60 hips with a primary THA were selected. Version was calculated on the AP radiograph using the Lewinnek method and, on the cross-table, using the Woo and Morrey direct method.

Results Mean and standard deviation (SD) were different on both radiographs, being $9.7° \pm 5.5°$ on the AP, whereas in the cross-table the measurements were $20.6° \pm 8.4°$ ($p < 0.001$). Minding our aim of 10°, the cross-table measurements were statistically different from it ($p < 0.001$), while the AP measurement did not differ ($p = 0.716$).

Conclusion The present study showed that the best way to correctly evaluate the acetabular component positioning following a THA is by measuring anteversion and abduction on an AP radiograph after confirming, in a cross-table radiograph, that the component is not retroverted.

Keywords
- arthroplasty, replacement, hip
- acetabulum
- radiography

Resumo

Objetivo O objetivo do presente trabalho foi comparar a medição da versão do componente acetabular em radiografias em incidência anteroposterior (AP) e *cross-table* após artroplastia total do quadril (ATQ).

Métodos Foram selecionadas radiografias de 60 quadris com ATQ primário. A versão foi calculada na radiografia AP usando o método de Lewinnek e, na *cross-table*, usando o método direto do Woo e Morrey.

* *Work developed at the Department of Orthopedics and Traumatology, Hospital Beatriz Ângelo, Loures, Portugal.*

received
March 10, 2020
accepted
September 16, 2020
published online
March 22, 2021

DOI https://doi.org/10.1055/s-0040-1721360.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resultados A média e o desvio padrão (DP) foram diferentes em ambas as radiografias, sendo $9,7° \pm 5,5°$ no AP, enquanto na *cross-table* foram $20,6° \pm 8,4°$ ($p < 0,001$). Considerando nosso objetivo de 10°, as medidas da *cross-table* foram estatisticamente diferentes dele ($p < 0,001$), enquanto a medição AP não diferiu ($p = 0,716$).

Conclusão O presente estudo mostrou que a melhor maneira de avaliar corretamente o posicionamento do componente acetabular após uma ATQ é medindo a anteversão e a abdução em uma radiografia AP após confirmar, em uma radiografia *cross-table*, que o componente não é retrovertido.

Palavras-chave
- artroplastia de quadril
- acetábulo
- radiografia

Introduction

Stability is one of the most important factors and objectives in a total hip arthroplasty (THA) and, to achieve it, correct component placement is of paramount importance.[1] An important cause of dislocation has been shown to be poor acetabular component positioning, which also leads to a limited range of motion and increased polyethylene wear.[2–4] Acetabular position is defined by its abduction and its version.[5] Abduction is defined as the angle between the face of the cup and the transverse axis, whereas version is defined as the angle between the axis of the component and the coronal plane.[5] The importance of these parameters lie in the recognition that subtle orientation differences can lead to a higher rate of dislocations.[6] Lewinnek et al. have suggest that an ideal cup should have an abduction of 40° and an anteversion of 15°.[7] While acetabular abduction is relatively easy to measure on anteroposterior (AP) radiographs, the same is not true for version. Numerous studies have focused on different methods to measure version on radiographs, although not all have been shown to be consistent and accurate[5,7–12] An ideal method should be accurate, reproducible, and feasible within a day-to-day practice. To measure abduction, a pelvis AP radiograph is used, whereas to measure version, the methods consist of different mathematical equations that use AP radiographs or a direct measure on a cross-table radiograph.[5,7–12] Although it is true that the measurement of version is made simple with cross-table radiographs, these radiographs are often dependent on good quality images, which can be compromised by contralateral hip joint stiffness.[13]

The objective of the present work was to compare the measure of acetabular component version on an AP radiograph using the Lewinnek method and the direct measure on a cross-table radiograph. Our hypothesis is that the cross-table radiograph is more influenced by patient positioning, what could lead to an incorrect measure of acetabular version.

Material and Methods

Between June 2018 and July 2018, patients who attended our hospital were screened for inclusion in the present study. The inclusion criteria were previously primary THA for primary coxarthrosis done at our institution. Patients with a history of instrumented spine surgery were excluded. Selected patients underwent a pelvic AP and a cross-table radiograph. The present study was approved by the institution's ethics committee and informed consent was obtained from all patients. In all patients, the same acetabular component was used (Epifit, Smith & Nephew, London, United Kingdom). We use the alignment guide, according to the surgical technique, to place the acetabular component in 10° of anteversion.

All radiographs were taken in the same radiology department according to a standard protocol. Pelvic AP radiographs were done in the supine position, with both hips extended, with a source-image distance of 100 cm from the film, perpendicular to the patient, centered on the superior aspect of the pubic symphysis. Cross-table lateral radiographs were taken with the contralateral hip flexed as much as possible up to 90°, with the central ray angled perpendicularly to the long axis of the neck of the femur (45° cephalad), parallel to the examination table. All images were acquired, and all measurements were made using the Picture Archiving and Communication System (PACS) software (syngo.plaza, Siemens Healthineers, Erlangen, Germany).

Version was calculated on the AP radiograph using the Lewinnek method.[7] In this method, the ellipse formed by the acetabular component is used so that version $= \sin^{-1}$ (short axis/long axis) (►**Fig. 1**) On the cross-table radiograph, version was the measured angle between a line perpendicular to the examination table and a tangential line to the

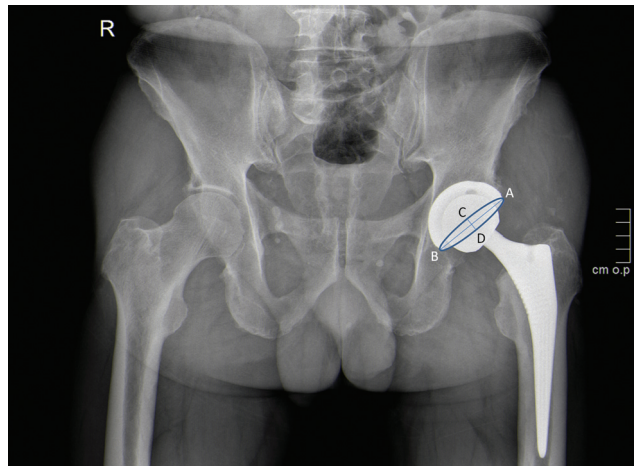


Fig. 1 Representation of the Lewinnek method: version $= \sin^{-1}$ (AB / CD).

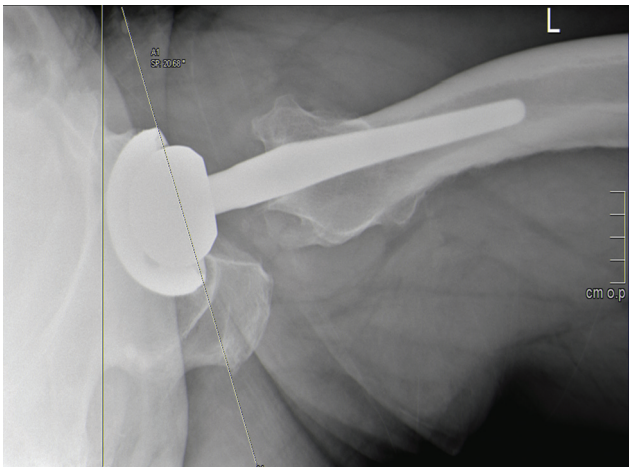


Fig. 2 Representation of the Woo and Morrey method: version = angle between a perpendicular line and a tangential line to the opening face of the acetabular component.

opening face of the acetabular component as described by Woo et al.[4] (►**Fig. 2**). Cross-table radiographs were also analyzed with the objective of excluding retroversion, which would be undetectable in the AP radiographs.

The normality of the data was tested with the Kolmogorov-Smirnov test. The data were compared and analyzed using the Student *t*-test for one and dependent samples, and the Mann-Whitney or the Wilcoxon test, according to the normality of the data. The correlation of data was analyzed with the Pearson or Spearman correlation coefficient according to its normality. Nominal variables were compared using the chi-squared test. P-values < 0.05 were considered significant. Dedicated statistical software (IBM SPSS Statistics for Windows, Version 21, IBM Corp., Armonk, NY, USA) was used.

Results

We identified and included 54 patients (60 hips). There were 36 men and 18 women and the average age of the patients at surgery was 68,5 years old. No differences were found between the measurements and age or gender. The mean follow-up was of 45.3 months (24–71 months).

For the anteversion measure by the Lewinnek method on AP radiographs, the mean and standard deviation (SD) were $9.7° \pm 5.5°$ (2°–21°). For the anteversion measure on cross-table radiographs, it was $20.6° \pm 8.4°$ (0°–40°). As such, no cases of retroversion were present. There was a positive correlation between both methods ($n = 60$, $r = 0.642$, $p < 0.0001$). However, both measures gave statistically different results ($p < 0.001$). The mean and SD for the difference of both methods was $10.8° \pm 6.6°$ (-13°–29°). Minding our aim of 10° of anteversion, we tested both measurements against that value and found the cross-table measurement to be statistically different from it ($p < 0.0001$), while the AP measurement did not differ ($p = 0.716$).

Discussion

Following THA, there are several imagological exams that can be performed to assess the status of the arthroplasty and evaluate the position of the components. Although those exams, such as computed tomography (CT) scans, can be more accurate, they represent increased costs and radiation for the patient. Therefore, traditional radiography continues to be the most important exam in the follow-up of arthroplasties.

Component positioning is essential for its stability, function and longevity.[2,3,7] However, how to achieve it, namely, how much acetabular anteversion to give, remains controversial. Various authors recommend between 0° and 30° of anteversion.[1,14,15] At our center, we aim for an anteversion of 10°. While the Lewinnek concept of safe zone has guided acetabular component positioning for many years, there is evidence that an important proportion of THAs dislocate within that safe zone[16,17] Furthermore, acetabular anteversion should not be analyzed on its own, as combined femoral and acetabular anteversion might better predict dislocation risk.[18] On the other hand, other authors try to place the acetabular component in an anatomic position according to specific patient anatomic references (such as the transverse acetabular ligament).[19,20] Which of the two methods produce better results, however, is still a matter of debate. Surgeons should keep in mind that the stability of a THA is an interplay between specific patient anatomy and component positioning, and is also dependent on proper restoration of soft tissue tension and balance.

While it is easy to measure acetabular abduction, the same is not true for anteversion. Nho et al. studied various methods and concluded that the Lewinnek, Hassan and Liaw methods, based on AP radiographs, were similar to measurements made on CT scans.[10] In their study, they also included the Woo et al. method for cross-table radiographs, which also gave similar results.[10] However, another study by Arai et al. found a difference of 5° between AP and cross-table measurements.[13] Furthermore, and perhaps more clinically relevant, they also found a correlation between a contralateral stiff hip and the measurement of acetabular version on the cross-table radiograph due to pelvic tilting.[13]

In our study, we found a mean acetabular anteversion of $9.7° \pm 5.5°$ while using the Lewinnek method on an AP radiograph, which is not significantly different from our aim of 10°. On the other hand, using the cross-table radiograph, we measured an anteversion of $20.6° \pm 8.4°$ which significantly differs from our surgical target. Both measurements were statistically different from one another. We also note a wider range of measurements in the cross-table radiographs (40° versus 19°). We found a moderate correlation between both methods, which is below expectations when measuring the same parameter.

Cross-table radiographs, when proper positioning is stressed, have been shown to accurately determine acetabular anteversion.[21] However, given the results of the present study, we believe that this method is prone to inaccuracy, due to poor positioning, probably related to contralateral hip or lumbar stiffness. Additionally, it is our opinion that pelvic tilt is harder to detect on cross-table radiographs than on AP incidences, which precludes negligent errors in the later, but not in the former radiographs. Notwithstanding, AP radiographs have some limitations because retroversion cannot be detected, and

the apex of the ellipse is somewhat difficult to identify when a metal liner is used.

Regarding the limitations of our study, a measurement standard, such as a CT scan, could further strengthen our conclusions.

Conclusion

The present study showed that the best way to correctly evaluate the acetabular component positioning following a THA is by measuring anteversion and abduction on an AP radiograph after confirming, in a cross-table radiograph, that the component is not retroverted.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Enhancing Preoperative Planning in Orthopedic Trauma Surgery Using a Presentation Software*

Aprimoramento do planejamento pré-operatório na cirurgia de trauma ortopédico usando um software de apresentação

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Rev Bras Ortop 2021;56(4):517–522.

Abstract

Preoperative planning (PP) is critical to ensure a successful outcome in orthopaedic trauma surgery. Since it was first described thirty years ago, no modifications have been made to the original preoperative planning (OPP) technique, which was written by hand using pen and paper. We believe that the use of presentation software (such as Microsoft PowerPoint, Microsoft Corp., Redmond, WA, US) can ease, improve and update the OPP and complement three-dimensional PP. The objective of the present paper is to describe our method for PP using a presentation software (PS).

Keywords

- preoperative care
- orthopedics
- trauma
- surgery
- education

Resumo

O planejamento pré-operatório (PP) é fundamental para garantir um resultado bem-sucedido na cirurgia de trauma ortopédico. Desde que foi descrita pela primeira vez há trinta anos, não foram feitas modificações na técnica de planejamento pré-operatório original (PPO), que foi escrita à mão usando caneta e papel. Acreditamos que o uso de um software de apresentação (como o Microsoft PowerPoint, Microsoft Corp., Redmond, WA, EUA) pode facilitar, melhorar e atualizar o PPO e complementar o PP tridimensional. O objetivo deste artigo é apresentar nosso método de PP por meio de software de apresentação (SA).

Palavras-chave

- cuidados pré-operatórios
- ortopedia
- trauma

* *Work developed at the Department of Trauma and Orthopedic Surgery, Fundación Santa Fe, Bogotá, Colombia.*

received
April 28, 2020
accepted
September 16, 2020
published online
April 15, 2021

DOI https://doi.org/10.1055/s-0040-1721833.
ISSN 0102-3616.

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Introduction

Preoperative planning (PP) is an essential step in orthopedic trauma surgery.[1–3] It enables the surgeon to reflect on the case in an environment free of pressure.[4] It also helps to select the materials and implants needed for fracture reduction and fixation, and can therefore help anticipate problems, providing the opportunity to design alternative plans. To summarize, PP saves time and minimises complications, which translates into better patient outcomes.[1,5]

The original preoperative planning (OPP) technique[6] includes four sequential stages:

1. *Reconstruction* involves identifying and reassembling the fracture fragments, which are drawn on tracing paper using the uninjured side as a template.
2. *Decision-making* involves defining the surgical indication and addressing issues such as approach and fixation methods to minimise the damage to soft tissue.
3. *Fixation*. Implants are selected and templated physically on the previous drawing to enable the surgeon to determine their function, length and size, and whether they need to undergo modifications.
4. *Surgical tactic*: It is developed in four stages: listing the required *equipment*, *preparation* (surgical team, anesthesia, antibiotics, tourniquet, expected blood loss, estimated surgical time), a *stepwise list* of the whole procedure, and a *postoperative regime*.

The OPP yields three documents: the surgical tactic, the annotated drawing, and the equipment list.

This simple and reproducible method, which remains valid today, established the principles of PP in orthopedic trauma. We believe that this process can be updated and enhanced by the use of a ubiquitous digital tool such as a presentation software (PS).

Technique for PPPS

Preoperative planning with a presentation software (PPPS) follows the same principles as the OPP. We would encourage the reader to refer to the complementary videos to better understand the following processes.

Materials required for the PPPS:

1. Hardware: either PC (Windows or Linux), Mac, IOS and/or Android devices.
2. Software: PSs, such as PowerPoint, Keynote etc. The authors used Microsoft PowerPoint (Microsoft Corp., Redmond, WA, US), version 16.27 for Mac.

Basic Settings (►Video 1)

Video 1

Introduction to the PPPS and reconstruction. Online content including video sequences viewable at: https://s20.video-stream-hosting.de/tvg/ejournal/10.1055-s-00042410/10-1055-s-0040-1721833-rbo-20-00126-v1_360p.mp4.

Table 1 Presentation Layout for the preoperative planning with a presentation software

- **Title slide** Keywords and date identifying the case
- **Medical history** Patient information and mechanism of injury
- **Soft-tissue status** Pictures of the involved area
- **Layout of the operating theater** Single slide showing staff and theater layout (►**Fig. 1**)
- **Imaging**
- **Reconstruction**
- **Decision-making**
- **Fixation**
- **Surgical tactic**
◦ Equipment
◦ Preparation
◦ Stepwise plan

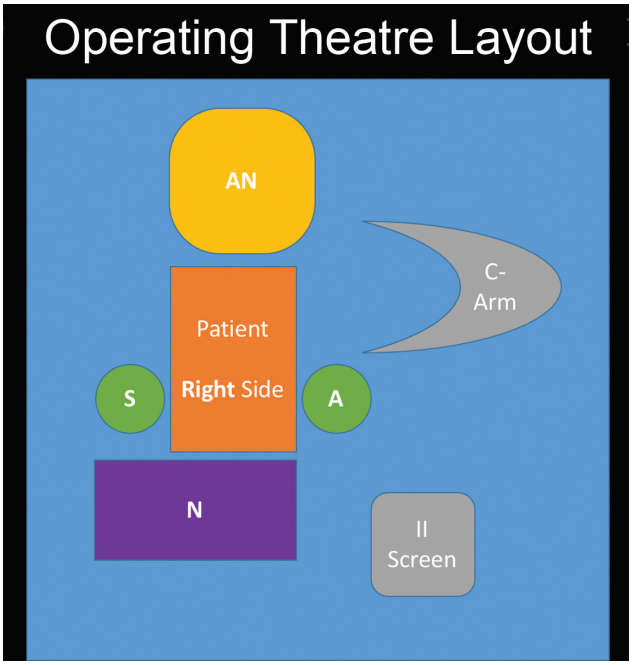


Fig. 1 Slide representing the layout of the operating theater. As it can be seen by the operating room personnel, it improves team communication and saves time. S = surgeon; A = assistant; N = nurse; AN = anesthesiologist; II screen = image intensifier screen.

Once the program is open, change the *Design* and select the black slide background with a white font, as this increases the contrast of the radiographs. Add the slides corresponding to the proposed PPPS layout (►**Table 1**) and operating theater layout (►**Fig. 1**).

Imaging

Preoperative relevant radiographs, computed tomography (CT) and/or magnetic resonance imaging (MRI) frames are



Fig. 2 Orthogonal views of a distal humerus fracture (**A**). The same images after applying the following commands: *Picture Format* > *Artistic Effects* > *Glow Edges* (**B**).

added to the presentation. Most picture archiving and communication system (PACS) viewers enable the user to export and save the images in generic format (.jpeg, .png, .tiff). This is our preferred method because the quality of the image is much higher. The alternative is to paste a screenshot of the images onto a slide and crop them (*Picture format* > *Crop*). We display orthogonal views of the fracture in one slide, which will then be used as a model to reconstruct and fix the fracture (►**Fig. 2A**). The quality of the images can be enhanced if needed using *Picture Format* > *Corrections* > *Sharpen 50%*.

Reconstruction (►Video 1)

To identify fracture fragments, the presentation software offers two options. The first is to select each image and go to *Picture Format* > *Artistic Effects* > *Glow Edges*. This effect simulates hand-drawing (►**Fig. 2B**). The second option is to use the *Draw* tool, which enables the surgeon to draw directly onto the image.

Fracture fragments can then be individually isolated by selecting the image and clicking on *Picture Format* > *Remove Background*. This enables the surgeon to delineate each fragment separately using both *Mark Areas to Keep* and *Mark Areas to Remove* (►**Fig. 3 A, B, C, D**). After all main fracture fragments are isolated images, they can be pasted onto a new slide and manipulated by dragging and rotating them, so the fracture can be reduced and reconstructed (►**Fig. 3E**). Alternatively, if contralateral radiographs are available, these can be mirrored, and the fracture can be reconstructed over them.

Fixation (►Video 2)

Video 2

Fixation and equipment list. Online content including video sequences viewable at: https://s20.video-stream-hosting.de/tvg/ejournal/10.1055-s-00042410/10-1055-s-0040-1721833-rbo-20-00126-v2_360p.mp4.



Fig. 3 An anteroposterior view of the fracture is cropped and pasted as a separate image (**A**). Using *Background Removal*, the distal (**B**, **C**) and proximal fragments (**D**) are delimited. Both images are fitted in together to reconstruct the fracture (**E**).

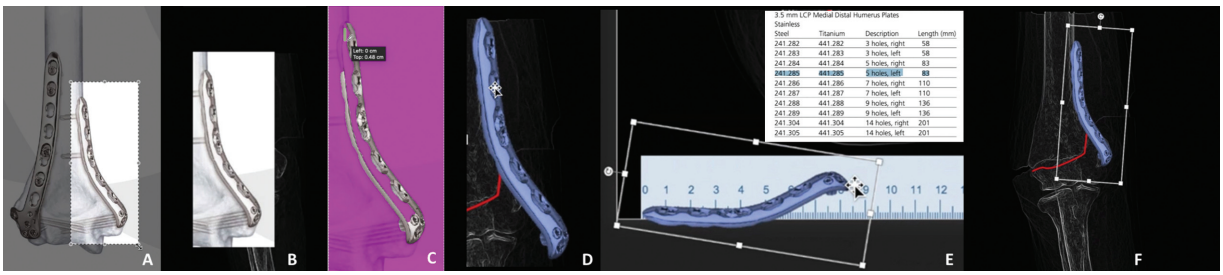


Fig. 4 A screenshot of the implant (medial distal humerus plate) from the operative technique is taken (**A**). The image is pasted onto a slide (**B**) and edited to have its background removed (**C**) and its color changed (**D**). The edited image is superimposed on the ruler to be accurately scaled, according to the implant's size chart (E). The final image is adjusted to fit the reconstructed fracture (**F**).

To design the fixation construct, the surgeon must have access to the implant surgical operative technique manual. Most can be downloaded in pdf format. These manuals contain both dimensions of the implants and pictures of them in various planes. These pictures are captured with screenshots (►**Fig. 4A**), pasted on a separate slide (►**Fig. 4B**), and modified to remove their background (*Picture Format* > *Remove Background*, ►**Fig. 4C**). Following the OPP guidelines, the color of the implant can be changed to blue (*Picture Format* > *Color*, ►**Fig. 4D**). For a more accurate prediction of the size, an image of a ruler is downloaded, and the implant is superimposed over the ruler until it matches its actual size (►**Figs. 4E** and **5C**). Note that preoperative radiographs must be taken with a radiologic marker to accurately scale the image. Finally, the implant image can be adjusted to fit the preoperative radiograph in *Format Picture* > *3D rotation* (►**Figs. 4F** and **5**). **If many implants will be used, the *Transparency* tool (*Format Picture* > *Transparency*) enables the visualization of many implants in different layers (►Fig. 5D).** Alternatively, fixation can be quickly schematized using the *Draw* tool.

Surgical Tactic (►Video 2)

Add slides describing how the proposed fixation is going to be achieved, the list of materials, tools and implants needed, and the postoperative plan given the proposed construct stability.

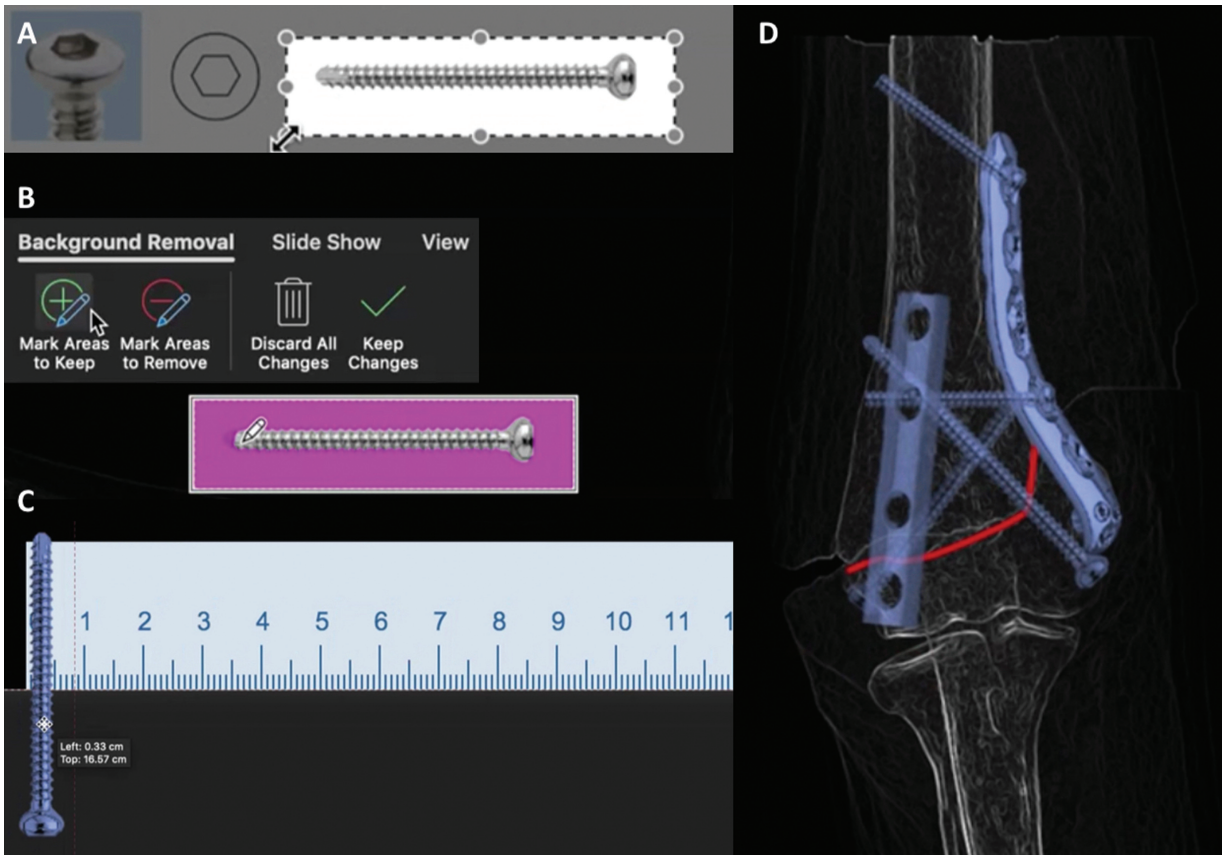


Fig. 5 *Fixation* stage of a 3.5-mm cortical screw in the preoperative planning with a presentation software. A screenshot from the surgical technique manual is cropped (**A**) and pasted on a slide to have its background removed (**B**). The color of the image is changed to blue and placed over a ruler to scale its diameter (**C**). The one-third tubular plate and the screws are shown over the reconstruction after applying the *Transparency* tool (**D**).

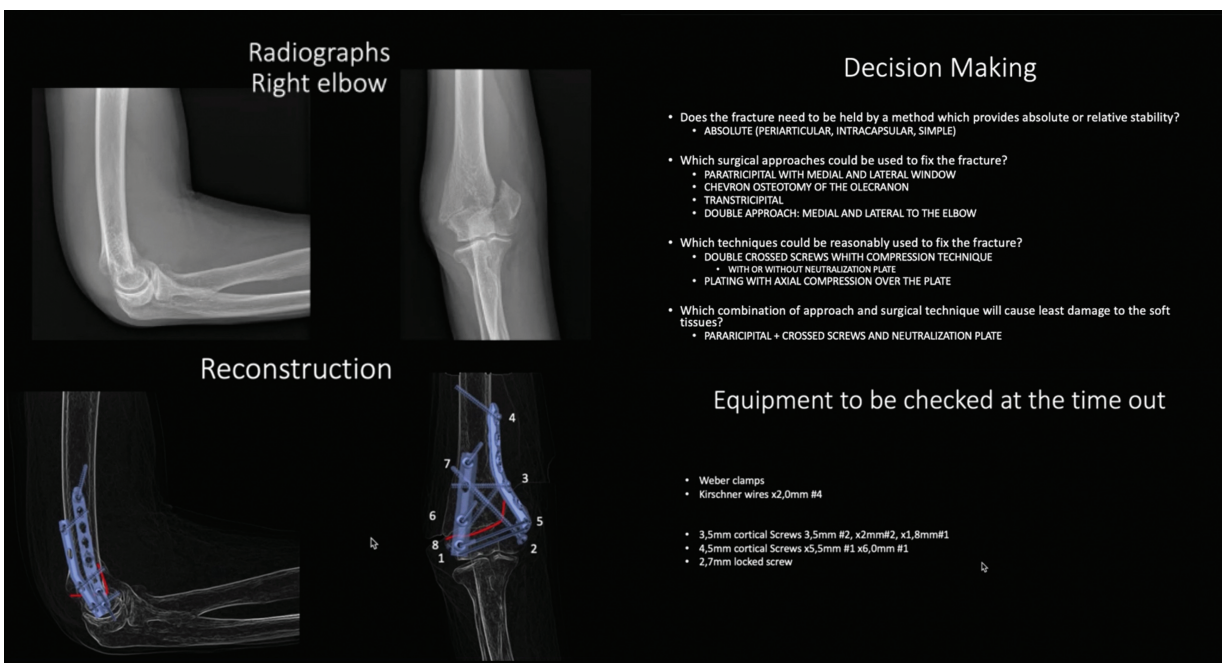


Fig. 6 Key slides from the final result of the PPPS.

The final product of the PPPS is a presentation containing the preoperative status, the desired postoperative reduction and reconstruction of the fracture, the fixation strategies, and a rehabilitation plan (►**Fig. 6**).

Discussion

Because the OPP was initially designed to be done on paper, it requires physical materials, such as radiographs, implant templates, tracing paper, and colored pens. These are cheap, and, in theory, are available throughout the world. However, most hospitals currently use PACS to store radiological imaging, so acetate radiographs are rarely available. In practice therefore, the OPP requires the surgeon to print the radiographs, which affects the accuracy of the PP. Printed templates are also often unavailable. All four authors of the present study had trouble finding these in different countries. The OPP also requires artistic skills and can be quite time consuming, especially when the surgeon needs to create many hand-drawn copies.

The PS is widely available in most hospitals and surgeons' own devices, being familiar to most orthopedic surgeons. The PPPS can be performed on nearly any device with a PS. The presentations can be kept online, making them easy to access and share. This is a significant advantage over the OPP. Furthermore, there is no image degradation when the surgeon experiments with the digital radiological images in the PS. The "duplicate slide" tool also eliminates the need to make many hand-drawn copies. We are aware, however, that the process of copying, pasting and cropping images can be quite repetitive. Nevertheless, we have found two important reasons for its use. Firstly, especially true when CT scans are available, the exercise of selecting the best cuts and capturing them enables ample image visualization, providing the surgeon with a good mental three-dimensional image of the fracture. Secondly, the process becomes "automatic" after a few attempts at the PPPS, and much faster as a result. In our experience, it takes 5 to 15 minutes to prepare a presentation, depending on the case. Most operating theaters now have a computer in which the PPPS can be displayed before the case starts. Staff can access and browse both the theater layout and equipment list, which saves time and improves team communication.

Specialized software (TraumaCad [Brainlab AG, Munich, Germany], PeekMed [PeekMed, Braga, Portugal] etc.) has also been developed for the PP. These are wonderful and accurate tools, but they are not as easily accessible and widely used as a simple **PPPS**. Based on the authors' experience, they are largely unavailable in Central and South America, Asia, Africa, and southern Europe. They also require in-hospital PACS integration and specialized hardware to function properly.

In our opinion, the main advantage of the PPPS is the educational opportunity it provides. It enables the surgeon to include pictures or videos of the patient's clinical assessment (such as, wounds, unusual physical examination findings etc.). Its format makes discussion with the colleagues easier. In addition, the PPPS goes beyond the PP. Once the case has ended, intraoperative fluoroscopy can also be added to the PPPS. The surgeon can identify pitfalls *a posteriori* by reviewing the case. Old plans can also be useful when planning new cases with a similar injury. Finally, it is helpful for the follow-up of the patient in the clinic and for monitoring purposes (such as the status of the soft tissues). All of these features make the PPPS particularly useful for teaching and self-guided learning.

Reviewing the literature,[1–3,7] we have found that there is a significant gap between the OPP and three-dimensional PP (3D-PP), which has established a new paradigm in PP, by enabling the surgeon to touch the fracture fragments, apply reduction techniques in advance, and preoperatively measure and fit implants. Although the 3D-PP is rapidly evolving,[8] its availability and practical application are still restricted. It requires advanced imaging techniques (CT, MRI), so its applicability to diaphyseal fractures or simple articular fractures is limited. The environmental costs of producing a significant amount of thermoplastic fibers, the material used by 3D printers, should also be kept in mind. On the other hand, the PPPS can be used for every fracture with simple imaging, and could complement both PP using specialized software and 3D-PP.

Conclusion

To conclude, the PPPS enhances and updates known methods of PP. It is an inexpensive, straightforward, and widely accessible technique, providing the surgeon with a comprehensive summary case in a digital presentation, with an incalculable educational and documental value.

Disclosures

Alejandro Ordas-Bayon, David Cabrera, Karl Logan and Rodrigo Pesántez certify that they have no financial conflict of interests (such as consultancies, stock ownership, equity interest, patent/licensing arrangements etc.) in connection with the present article.

Conflict of Interests

The authors have no conflict of interests to declare.

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Superior Mesenteric Artery Syndrome – An Uncommon Complication After Surgical Corrections of Spinal Deformities

Síndrome da artéria mesentérica superior – Uma complicação incomum após correções cirúrgicas de deformidades da coluna

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Rev Bras Ortop 2021;56(4):523–527.

Abstract

Vascular compression of the third part of the duodenum by the superior mesenteric artery results in an unusual occlusion of the duodenal transit known as superior mesenteric artery syndrome. This syndrome can occur after surgeries to correct spinal deformities in a rate ranging from 0.5% to 4.7%. It results from a positional alteration of the artery emergency point due to a change in trunk length after surgery. It is associated with risk factors such as low body mass index and weight loss. Patients usually present with intestinal occlusion, abdominal pain, nausea, bilious vomiting, and early satiety. Superior mesenteric artery syndrome must be recognized early to institute an adequate treatment, which can be clinical (with gastric tube for decompression and nutritional support) or require a surgical procedure. Secondary complications related to superior mesenteric artery syndrome include delayed surgical and nutritional recovery, healing problems, and prolonged hospitalization. The present study aims to report a case of superior mesenteric artery syndrome in a patient with neuromuscular scoliosis secondary to a transverse myelitis who underwent surgical treatment for spinal deformity correction.

Keywords

- superior mesenteric artery syndrome/complications
- intestinal obstruction
- spinal fusion
- scoliosis/surgery

Resumo

A compressão vascular da terceira parte do duodeno pela artéria mesentérica superior resulta no desenvolvimento de uma condição incomum de oclusão do trânsito duodenal conhecida como síndrome da artéria mesentérica superior. Este fenômeno pode acontecer após cirurgias de correção de deformidades da coluna, e sua taxa de

received
May 27, 2020
accepted
September 16, 2020

DOI https://doi.org/10.1055/s-0040-1722258.
ISSN 0102-3616.

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ocorrência é de ~ 0,5 a 4,7% dos casos. Isso ocorre em virtude da alteração do posicionamento do ponto de emergência da artéria, decorrente da mudança do comprimento do tronco após a cirurgia, e está associado a fatores de risco, como baixo índice de massa corpórea e perda ponderal. Os pacientes costumam se apresentar com um quadro de oclusão intestinal, com dor abdominal, náusea, vômito bilioso e saciedade precoce. O reconhecimento desta condição é importante para instituir o tratamento adequado, que varia do tratamento clínico, com sondagem e descompressão gástrica associados a suporte nutricional; à necessidade de abordagem cirúrgica. Complicações secundárias relacionadas à síndrome da artéria mesentérica superior incluem: recuperação cirúrgica e nutricional retardadas, problemas com a cicatrização e hospitalização prolongada. O objetivo do presente estudo é relatar um caso de síndrome da artéria mesentérica superior, ocorrido em um paciente com escoliose neuromuscular secundária a sequela de mielite transversa, submetido ao tratamento cirúrgico da deformidade da coluna.

Palavras-chave
- ► síndrome da artéria mesentérica superior/ complicações
- ► obstrução intestinal
- ► fusão vertebral
- ► escoliose/cirurgia

Introduction

Vascular compression of the third part of the duodenum by the superior mesenteric artery (SMA) results in an unusual condition of duodenal transit occlusion known as superior mesenteric artery syndrome (SMAS). Its etiology is linked to the anatomical relationship of the third part of the duodenum with the aortomesenteric angle.[1] Obstruction is caused by an extrinsic compression created by the upper mesenteric neurovascular bundle and the base of the small intestinal mesentery root that intersect anteriorly to the duodenum.[2]

The SMA exits the aorta at the L1 vertebral body level. It is surrounded by adipose and lymphatic tissue, forming a 45° to 60° angle with the aorta. The duodenum usually crosses the aorta at the L3 level, and it is suspended by the Treitz ligament. An imbalance between these structures can lead to SMAS[3] (►**Figure 1**).

The incidence of SMAS after surgical procedures for spinal deformities correction ranges from 0.5 to 4.7%. Teenager, asthenic and tall patients are mostly affected.[1] These patients are believed to have a lower amount of retroperitoneal fat, with no "fat pad" between the duodenum and the mesenteric artery.[4]

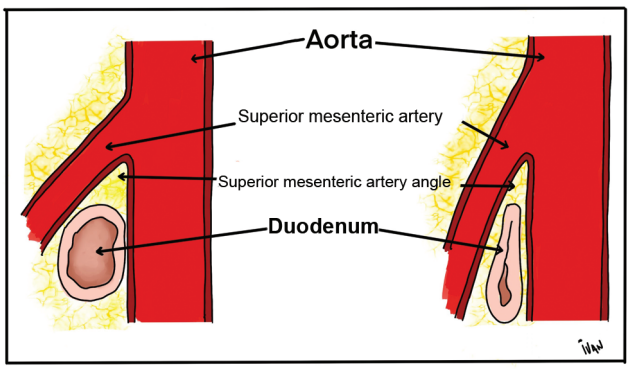


Fig. 1 Illustration of the anatomical relationship of the third portion of the duodenum with the superior mesenteric artery and the obstruction observed in the superior mesenteric artery syndrome.

Clinically, SMAS typically presents as abdominal pain, nausea, bilious vomiting, and early satiety. Its main differential diagnosis is paralytic ileus.[4] Secondary SAMS-related complications include delayed surgical and nutritional recovery, healing problems, and prolonged hospitalization.[5]

The present study aims to report a case of SMAS in a patient with neuromuscular scoliosis who underwent surgical treatment for spinal deformity correction.

Case Report

A 12-year-old male patient, admitted with viral transverse myelitis sequelae and diplegic sensory-motor impairment.

At follow-up, the patient presented with progressive neuromuscular scoliosis requiring surgical treatment. At the time, he had 63° scoliosis (T2 to L2) and 37° kyphosis at the thoracolumbar transition (T10 to L2). On admission, the patient had a body mass index (BMI) of 15.87 (thinness), and had lost 13 kg in the previous 2 years (►**Figures 2** and **3**).

Posterior spinal T2-S1 arthrodesis was performed uneventfully, and the patient presented with progressive clinical improvement during the first postoperative days. On the 9th day after surgery, vomiting and fever started. On the 11th postoperative day, the patient presented with recurrent vomiting in addition to abdominal distension and loss of appetite. An abdominal tomography showed a large gastric distension extending to the third portion of the duodenum. An SMAS diagnosis was considered based on the anatomical region with reduced intestinal transit (►**Figure 4**).

A nasogastric catheterization yielded an initial outflow of 1,200mL of bile-like fluid and partial relief of symptoms. However, the patient did not show any improvement in the following days, and a surgical intervention was indicated by the general surgery team. The patient underwent an upper digestive endoscopy, revealing a large amount of stasis fluid from the esophagus to the duodenum, in addition to a complete obstruction of the duodenal lumen in its third portion and a pulse attributed to the SMA, which compressed the duodenum. A supraumbilical median laparotomy was

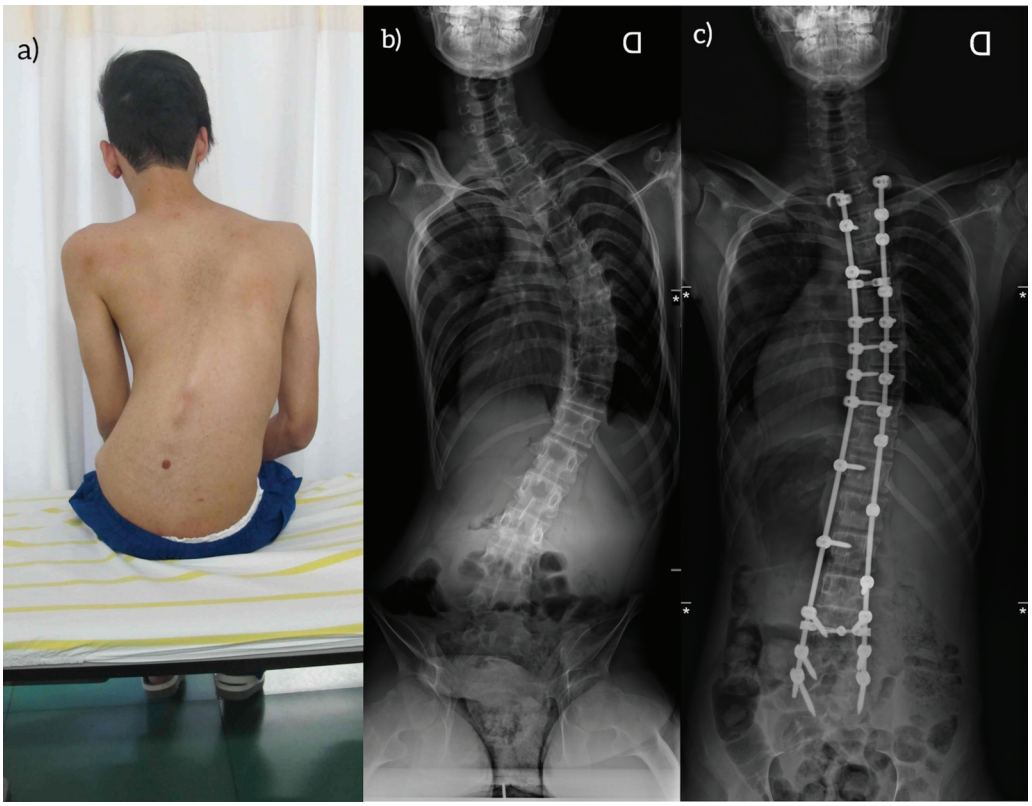


Fig. 2 (a) Preoperative clinical image. (b) Preoperative panoramic radiography of the spine. (c) Postoperative panoramic radiography.

performed with a duodenojejunal shunt about 20 cm after the angle of Treitz (►**Figure 5**).

The postoperative evolution was satisfactory. Fluid intake was initiated on the 6th postoperative day, and the nasogastric tube was removed on the 8th day. On the 11th day, oral liquid feeding was started, slowly progressing to soft and solid foods. After 17 days, the patient was discharged from the hospital. At the first return visit, 7 days after discharge, he weighed 46.3 kg. After 4 months, he weighed 50 kg, with a normal intestinal rhythm and no food intolerance. At the 8th month, he was weighing 54 kg, totaling a weight gain of 7.7 kg, and did not present any gastrointestinal symptoms.

Discussion

Nausea and vomiting are frequent in patients undergoing spinal arthrodesis for scoliosis correction. These symptoms may result from analgesic medications such as opioids, or even may be due to paralytic ileus, which is common after major surgery. Paralytic ileus usually resolves within 5 to 7 days.[6]

The combination of surgical spinal deformity correction with previous weight loss increases the risk for SMAS. The symptoms of SMAS usually appear 6 to 8 days after surgery and, in contrast to paralytic ileus, often include air-fluid sounds.[7] Later cases were also described, with onset of symptoms within 40 days.[3]

Conservative treatment for SMAS consists of nasogastric decompression, nutritional support, and correction of fluid and electrolytic disorders. When tube drainage decreases to < 100 mL in 8 hours, oral fluid administration can start, slowly progressing to soft foods in small amounts and more frequent feeds.[4,8]

Most SMAS patients progress satisfactorily with conservative treatment. Children usually present a more favorable evolution than adults, with symptoms improvement in 2 to 3 days of gastric decompression.[5,6] If the symptoms persist, surgical treatment must be considered, and the main options are gastrojejunostomy or duodenojejunostomy.

Superior mesenteric artery syndrome can occur both in surgical kyphoscoliosis correction and during the conservative treatment of deformities with plaster vests, when it is referred to as "plaster syndrome." It is not clear why vest immobilization results in vascular compression of the duodenum. The first case of mesenteric vascular compression associated with a plaster vest was described by Willett, in 1878, using a Sayre plaster on a 17-year-old boy. Since then, new cases have been reported with different spinal deformities. Evarts et al.[9] described 18 patients with SMAS during the treatment of spinal deformities. The authors warned for the need to suspect SMAS in symptomatic patients using plastered vests, Milwaukee-type vests, halo-femoral traction or submitted to surgical correction.[4,9–11]

Altiok et al. conducted a retrospective study reviewing 2,939 records and found 17 SMAS cases. The authors evaluated the influence of vertebral translation and derotation maneuvers on SMAS incidence and concluded that the new correction procedures did not eliminate it. Spinal correction per se leads to its elongation, which changes the anatomical environment of the SMA.[4]

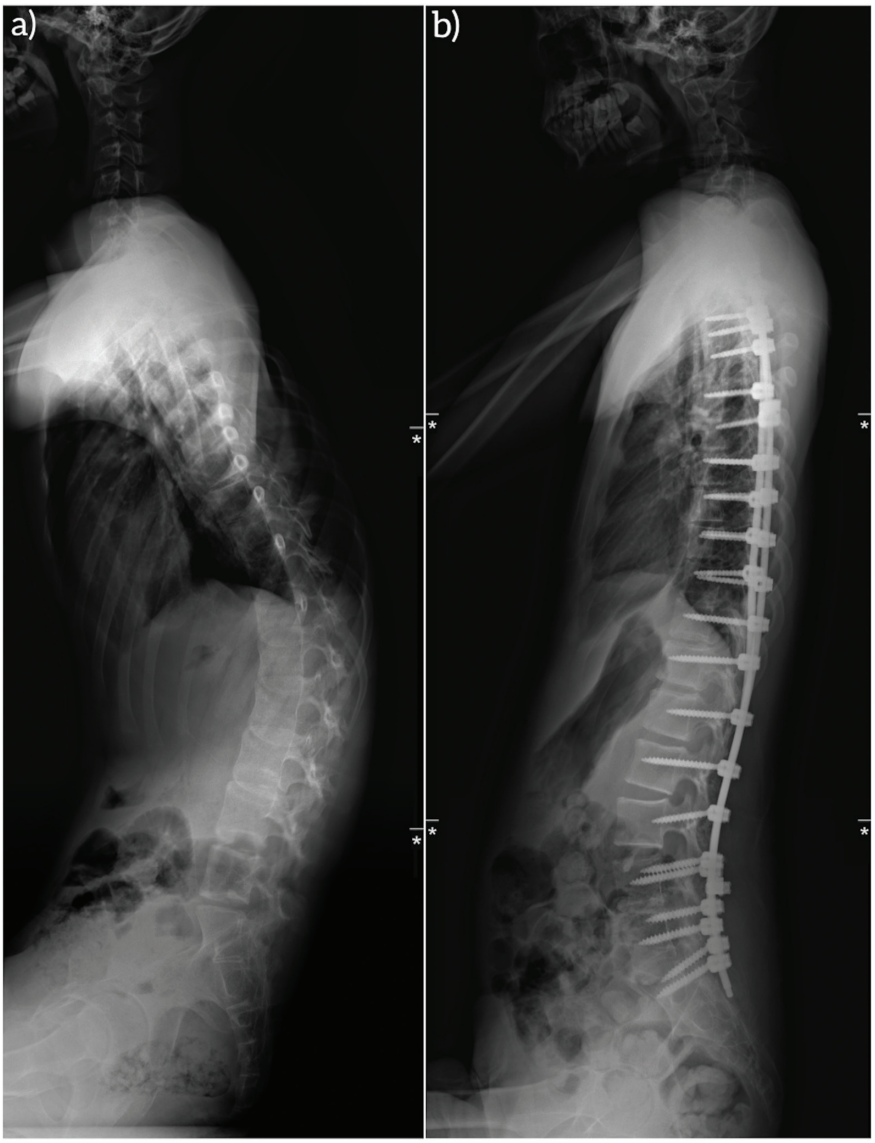


Fig. 3 (a) Preoperative, lateral panoramic radiograph of the spine. (b) Postoperative radiograph.

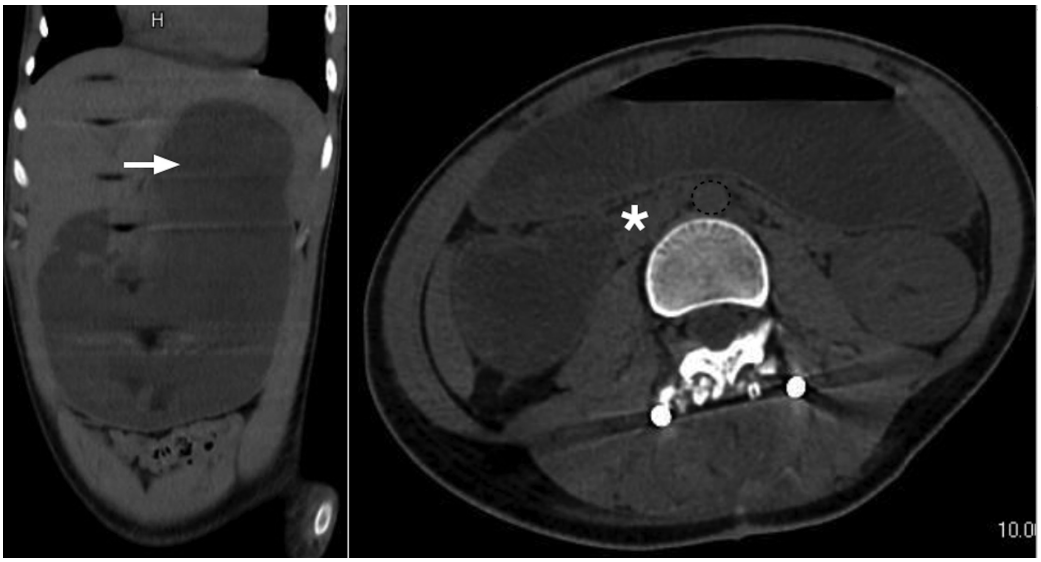


Fig. 4 Coronal and axial computed tomography scans of the abdomen (white arrow – gastric distension; white asterisk – tapering of the third portion of the duodenum).

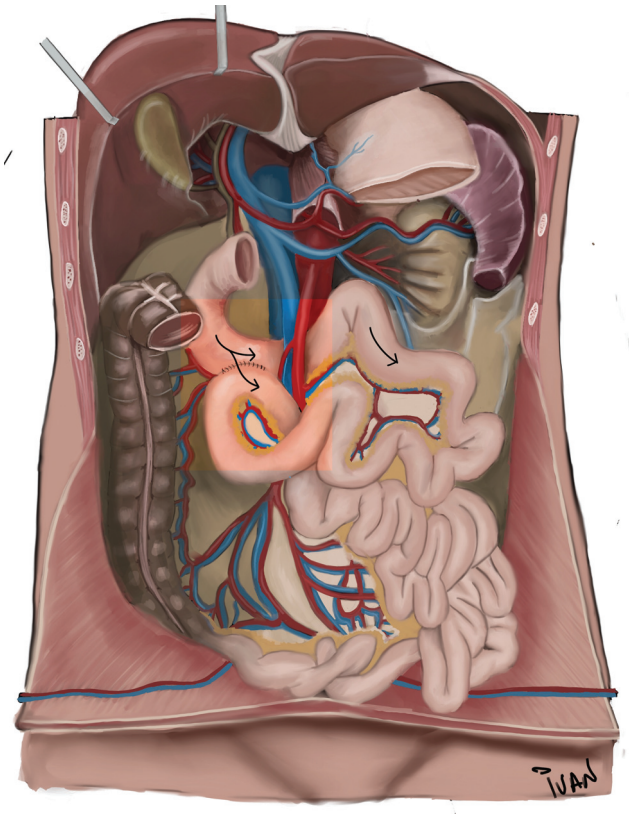


Fig. 5 Illustration showing the duodenojejunal shunt with intestinal transit redirection.

Braun et al.[12] observed that patients with a BMI lower than the 25th percentile for age, those with a more rigid thoracic curve (< 60% correction on side-bending radiographs) and those with a laterally displaced lumbar curve (lumbar modifier of the Lenke classification, type B or C) are at greater risk for SMAS development after deformity correction.[12,13] Carelli et al.[11] reported two cases of SMAS after sagittal spinal deformities correction, in which the conservative treatment of the intestinal occlusion was successfully for the resolution of symptoms. The authors believe that the incidence of SMAS must be higher than what is described, with most cases presenting spontaneous resolution.

Superior mesenteric artery syndrome, although uncommon, is a complication of spinal deformities correction. It is important that the medical team be aware of the syndrome and have a high degree of suspicion in patients with gastrointestinal symptoms to avoid delays in diagnosis and treatment that could result in unfavorable outcomes.

Note
Study developed at the Orthopedics Department, Rede Sarah de Hospitais de Reabilitação, Brasília, DF, Brazil.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Traumatic Isolated Thumb Carpometacarpal Joint Dislocation - Report of Two Clinical Cases*

Luxação traumática isolada da articulação trapézio-metacárpica - Relato de dois casos clínicos

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Rev Bras Ortop 2021;56(4):528–532.

Abstract

Isolated thumb carpometacarpal joint dislocation is a rare lesion that accounts for less than 1% of all hand lesions.

The authors present two cases of traumatic isolated thumb carpometacarpal joint dislocation. One of them was treated with closed reduction and cast immobilization, and the other was treated with closed reduction, Kirschner-wires pinning, and cast immobilization.

The first patient had a good functional outcome and showed no signs of thumb carpometacarpal instability. The patient treated with Kirschner wires presented signs of clinical instability and radiological subluxation.

Isolated thumb carpometacarpal dislocation is a rare lesion that can cause joint instability, which interferes with the normal function of the hand and can lead to articular degenerative changes.

The best management of this lesion is still controversial, since there is lack of evidence in the literature showing superiority of one treatment over the other.

Keywords

- joint dislocations
- thumb
- hand

Resumo

A luxação traumática isolada da articulação trapézio-metacárpica é uma lesão rara que faz parte de menos de 1% de todas as lesões de mãos.

Os autores apresentam dois casos de luxação traumática isolada da articulação trapézio-metacárpica. Um dos casos foi tratado com redução fechada e imobilização com gesso, e o outro foi tratado com redução fechada, fixação com fios Kirschner, e imobilização com gesso.

O primeiro paciente teve um bom resultado funcional e não mostrou sinais de instabilidade trapeziometacarpal. O paciente tratado com fios Kirschner apresentou sinais de instabilidade clínica e subluxação radiológica.

A luxação isolada da articulação trapeziometacarpal é uma lesão rara que pode causar instabilidade articular que interfere com a funcionalidade normal da mão e pode resultar em mudanças articulares degenerativas.

O melhor manejo dessa lesão ainda é controverso, já que ainda faltam evidências na literatura que mostrem a superioridade de um tratamento em relação ao outro.

Palavras-chave

- luxação articular
- polegar
- mão

* Work developed at the Centro Hospitalar de Entre Douro e Vouga (CHEDV), Santa Maria da Feira, Portugal.

received
July 30, 2019
accepted after revision
December 12, 2019
published online
May 29, 2020

DOI https://doi.org/10.1055/s-0040-1702950.
ISSN 0102-3616.

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Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

Isolated thumb carpometacarpal joint dislocation is a rare lesion that accounts for less than 1% of all hand lesions.[1–4] The most common mechanism of injury involves an axial force applied on a partially flexed thumb.[1–3,5,6]

The gold standard treatment remains unclear. Treatment choices range from closed reduction and cast immobilization and closed reduction and pinning with Kirschner wires (K-wires) to open reduction with capsular repair and ligament reconstruction.[1–10]

The first carpometacarpal joint is a saddle-shaped joint that is responsible for the extraordinary mobility and important function of the thumb.[1] If this dislocation is misdiagnosed or inadequately treated, it can lead to chronic mechanical instability, hand disability, and articular degenerative changes.[4,9]

The authors present two cases of traumatic isolated thumb carpometacarpal joint dislocation. One of them was treated with closed reduction and cast immobilization, and the other was treated with closed reduction, K-wires pinning, and cast immobilization.

Case Report 1

A 25-year-old male fell while riding a bicycle and injured his left hand.

He presented to the emergency department complaining of pain, deformity, and edema in his left thumb.

Oblique and anteroposterior hand X-rays revealed an isolated carpometacarpal dislocation of the thumb (►**Fig. 1**).

Closed reduction was easily performed, and the joint was immobilized with a cast splint for 4 weeks.

At the 3 months follow-up, the patient was asymptomatic, showed no instability signs, and presented total range of motion and normal grip strength.

The 6-months follow-up X-ray showed no signs of subluxation or articular degenerative changes (►**Fig. 2**).

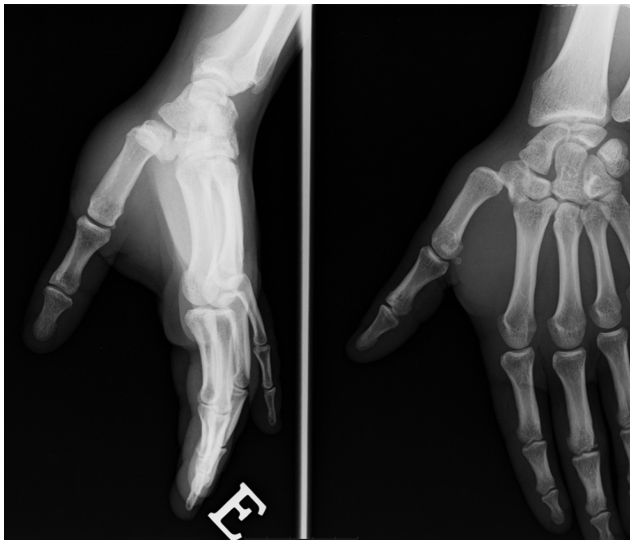


Fig. 1 Isolated carpometacarpal dislocation of the thumb.



Fig. 2 Six-month follow-up.

Case Report 2

A 56-year-old male was admitted in the emergency department after falling and injuring the left hand while playing soccer.

He complained of pain and deformity in his left thumb. Anteroposterior, lateral and oblique hand radiographs showed a trapeziometacarpal dislocation, without fracture signs (►**Fig. 3**).

Closed reduction, K-wire pinning, and cast immobilization were performed under general anesthesia (►**Fig. 4**). The immobilization device was removed 5 weeks later, and the patient started functional rehabilitation.

The 1-year follow up X-ray showed a trapeziometacarpal subluxation, and dorsal-volar instability was evident on clinical examination (►**Fig. 5**). Open reduction with capsular-ligament reconstruction was advised, but the patient refused surgical treatment.

Discussion

The first carpometacarpal joint presents a unique configuration that allows a wide range of stable motion, including flexion/extension, abduction/adduction and opposition/retropulsion.[1,5] A screw-home torque mechanism (metacarpal internal rotation, tightening of the dorsoradial ligaments and locking of the metacarpal volar beak into trapezium) is responsible for the dynamic force that transforms a lax static joint to a stable congruent joint in opposition, permitting a strong pinching and grasping.[1] Joint stability depends on articular congruency, capsule integrity ,and volar/dorsal ligaments function.[4]

There is much controversy in the literature about which of the 16 exiting ligaments is the most important stabilizer of trapeziometacarpal joint. First, the anterior oblique ligament was thought to be the primary stabilizer, but later, Harvey and Bye[11] and Pagalidis et al[12] defended that the most important ligament was the posterior oblique ligament. The biggest cadaveric study conducted by Strauch et al[13] showed that the dorsoradial ligament complex is the main responsible for the joint stability, confirming what Shah and

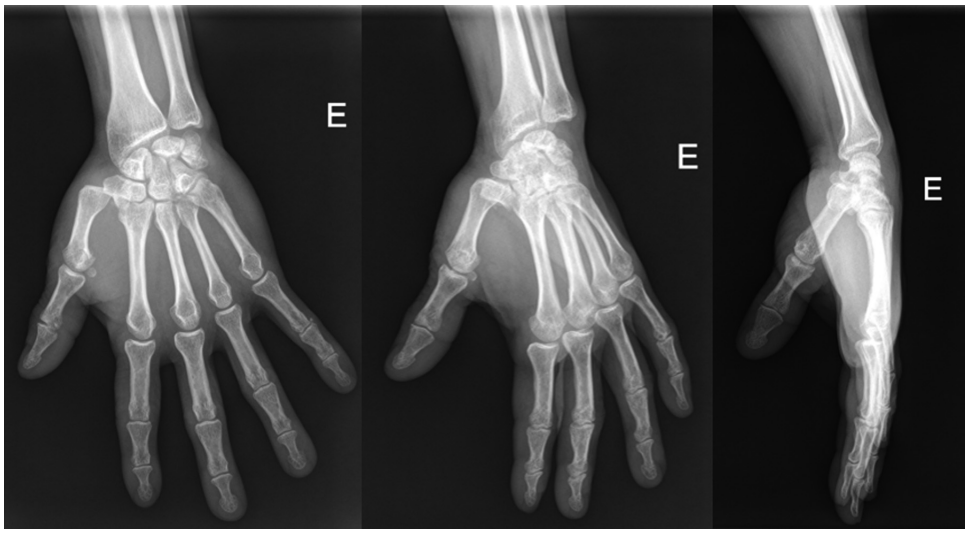


Fig. 3 Isolated trapeziometacarpal dislocation.



Fig. 4 Postoperative X-ray.



Fig. 5 Trapeziometacarpal subluxation at the 1- year follow-up.

Patel[14] said in 1983. Both patients discussed presented dorsal dislocation, but the authors could not specify which ligament was ruptured because they used closed treatment techniques.

Hand or thumb X-rays are usually sufficient to diagnose carpometacarpal dislocations, but associated lesions must be ruled out carefully. Computed tomography could be used to exclude bone associated lesions. Ultrasonography and magnetic resonance imaging are useful for evaluating ligamentous injuries and for surgical planning.[9]

The treatment of choice in this kind of lesion is still in debate (►**Table 1**.)[1,4–10,14–21] Closed reduction and immobilization is advocated by some authors, such as Kahn et al[20] and Bosmans et al,[1] who showed good functional outcome without recurrence of instability, like the authors described in the first clinical case. Closed reduction and pinning with K-wires is a technique that presents variable results, with some cases of follow-up subluxation and instability, similar to the patient referred in clinical case 2. Open reduction and repair or reconstruction of the capsule and ligaments are described by numerous authors with different techniques, but they are insufficient for primary surgical treatment recommendation.[22]

The authors think that a careful instability evaluation after closed reduction is essential for the treatment choice. Khan et al[20] defend that failure to maintain closed reduction, acute instability, significant swelling, or delayed presentation are surgical treatment indications.

A surgical step-wise approach may be a wise choice, selecting ligament reconstruction in case of loss of reduction after K-wire pinning.

Table 1 Literature references

Literature references		Treatment	Patient complains	Radiographs
Shah and Patel[14]	1983	2 open reductions and K-wires pinnings	No	Subluxation
		1 closed reduction and K-wires pinning	No	–
		1 open reduction	No	–
Chen[15]	1987	1 ligament reconstruction	No	–
Watt and Hopper[16]	1987	9 closed reductions and cast immobilizations	3 mild symptoms	2 subluxations, 1 persistent luxation
		3 closed reductions and K-wires pinnings	2 mild discomfort	1 subluxation
Jakobsen and Elberg[17]	1988	1 closed reduction and K-wires pinning	No	Subluxation
Simonian and Trumble[18]	1996	8 closed reductions and K-wires pinnings	3 pain	4 subluxations
		9 ligament reconstructions	1 mild discomfort	3 joint narrowings
Kural et al[19]	2002	1 closed reduction and cast immobilization	No	–
Khan et al[20]	2003	2 closed reductions and cast immobilizations	No	–
Bosmans et al[1]	2008	closed reduction and cast immobilization	No	–
Fotiadis et al[6]	2010	1 ligament reconstruction	No	–
Jeong et al[4]	2012	1 closed reduction and K-wires pinning	No	–
		1 ligament reconstruction	Stiffness	–
Chan[8]	2013	1 closed reduction and cast immobilization	No	–
Iyengar et al[10]		1 closed reduction and K-wires pinning	Pain	Subluxation
McCarthy and Awan[7]	2014	1 closed reduction and cast immobilization	No	–
Ansari et al[9]	2014	3 ligament reconstructions	1 Mild pain	–
Annappa et al[3]	2015	1 ligament reconstruction	No	–
Lahiji et al[5]	2015	5 ligament reconstructions	No	–
		1 closed reduction and cast immobilization	No	–
Slocum et al[21]	2019	1 closed reduction and cast immobilization	No	–

Abbreviation: K-wires, Kirschner wires.

Conclusion

Isolated thumb carpometacarpal dislocation is a rare lesion that can cause joint instability, which interferes with the normal function of the hand and can lead to articular degenerative changes.

The current literature is insufficient to choose one treatment option over the other and therefore; thus, the best management of this lesion is still controversial. The authors believe that the treatment of choice depends on anatomic restauration and joint instability degree.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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Osteochondral Segond Fracture Associated with Fibular Head Avulsion Fracture – "Arcuate Sign"*

Fratura osteocondral de Segond associada a fratura avulsão da cabeça da fíbula – "Sinal do arqueado"

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Rev Bras Ortop 2021;56(4):533–536.

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Abstract

A deviated osteochondral fracture of the anterolateral tibia associated with fibular head avulsion in a 50-year-old patient is reported. In general, avulsion fracture of the iliotibial tract is associated with injuries in the cruciate ligament, in the meniscus and in lateral knee structures, as in the case herein reported.

Keywords

- knee injuries
- tibial fractures
- femoral fractures

Resumo

Uma fratura osteocondral desviada da tíbia anterolateral associada a avulsão da cabeça da fíbula em um paciente de 50 anos é relatada. A fratura avulsão do trato iliotibial em geral está associada a lesões do ligamento cruzado, do menisco e das estruturas laterais do joelho, como no caso em questão.

Palavras-chave

- lesões no joelho
- fraturas da tíbia
- fraturas do fêmur

Introduction

Avulsion knee fractures are due to high-energy trauma. Among these lesions, Segond fracture and the "arcuate sign" avulsion of the head of the fibula stand out. The term *Segond fracture* is used to describe an avulsion of the anterolateral tibia, and *arcuate sign* refers to fibular head avulsion, since in these lesions there is the avulsion of the arched complex, which consists of the fabellofibular, popliteal fibular and lateral collateral ligaments.[1–4] The mechanism of injury involves a varus stress and internal rotation of the tibia. These lesions, if not recognized and treated, lead to chronic knee instability.

Case Report

A 50-year-old male patient, victim of a motorcycle hit-and-run presented to the emergency sector complaining of pain and increased volume in the left knee.

* *Work developed at Hospital Maria Amélia Lins, Belo Horizonte, MG, Brazil.*

received
September 6, 2019
accepted
November 29, 2019
published online
March 23, 2020

DOI https://doi.org/10.1055/s-0040-1702956.
ISSN 0102-3616.

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Physical examination

The motion range of the knee was limited to 40° of flexion due to pain and joint stroke; the patient had pain at palpation of the anterolateral proximal tibia and fibular head. He presented +3 aperture in the varus stress at 0° and 30° of flexion and without opening in the valgus stress. The Lachman test was positive, and the reverse Lachman was negative, and did not present posterior tibia fall. The neurovascular examination did not present alterations.

Imaging exam

Radiographs of the knee were performed in the anteroposterior (AP) and profile incidences, and a huge opening of the lateral joint space was evidenced, with a large bone fragment of the anterolateral tibia and a small avulsion of the fibular head (►**Fig. 1 A** and **B**)

Due to knee instability, transarticular external fixation of the knee was performed in the emergency room (►**Fig. 1 C**)

Surgical Technique

The surgical procedure was performed twelve days after the injury, after improvement of the soft-tissue edema. After spinal anesthesia, the external fixator was removed, and a new physical examination of the knee was performed, showing positive anterior drawer and Lachman, negative posterior drawer and sag test, positive +3 varus stress at 0° and 30° of flexion, and negative valgus stress. Stress radiographs using an image intensifier were obtained, and they revealed an enormous opening of the lateral joint space, and posterior stress drawer showed no posterior translation of the tibia (►**Fig. 2 A** and **B**).

Lateral surgical access was performed between the head of the fibula and the Gerdy tubercle towards the lateral epicondyle. A huge osteochondral fragment diverted from the anterolateral tibia was verified and inserted into the iliotibial tract, measuring 3 cm x 1.5 cm. The anterior horn and lateral meniscus body were shifted to the intercondylar eminence, and there was avulsion of the collateral ligament of the fibular head. A small bone fragment of the fibular styloid avulsed with the femoral biceps tendon (►**Fig. 3 A-C**). ►**Figure 3 B** shows the osteochondral fragment of the anterolateral tibia that was fixed after anatomical reduction with Hebert screws as described subsequently.

The fixation of the osteochondral fragment of the anterolateral tibia was performed with three Hebert screws; the lateral meniscus was sutured and the lateral collateral ligament and the femoral biceps tendon were reinserted into the fibula with two anchors. Lateral retinaculum was repaired (►**Fig. 4 A-D**).

After surgery, the support was removed for six weeks, and we used an unarticulated brace that was removed daily to enable knee movement restricted to 90° of flexion in the first 4 weeks. After six months of surgery, the patient is without complaints to perform his daily life and work activities, with a range of motion from 0° to 120°, without opening in the knee varus stress. We decided not to reconstruct the anterior cruciate ligament in the first surgical period due to the increased possibility of postoperative joint stiffness. Reconstruction of this ligament will be performed in the second

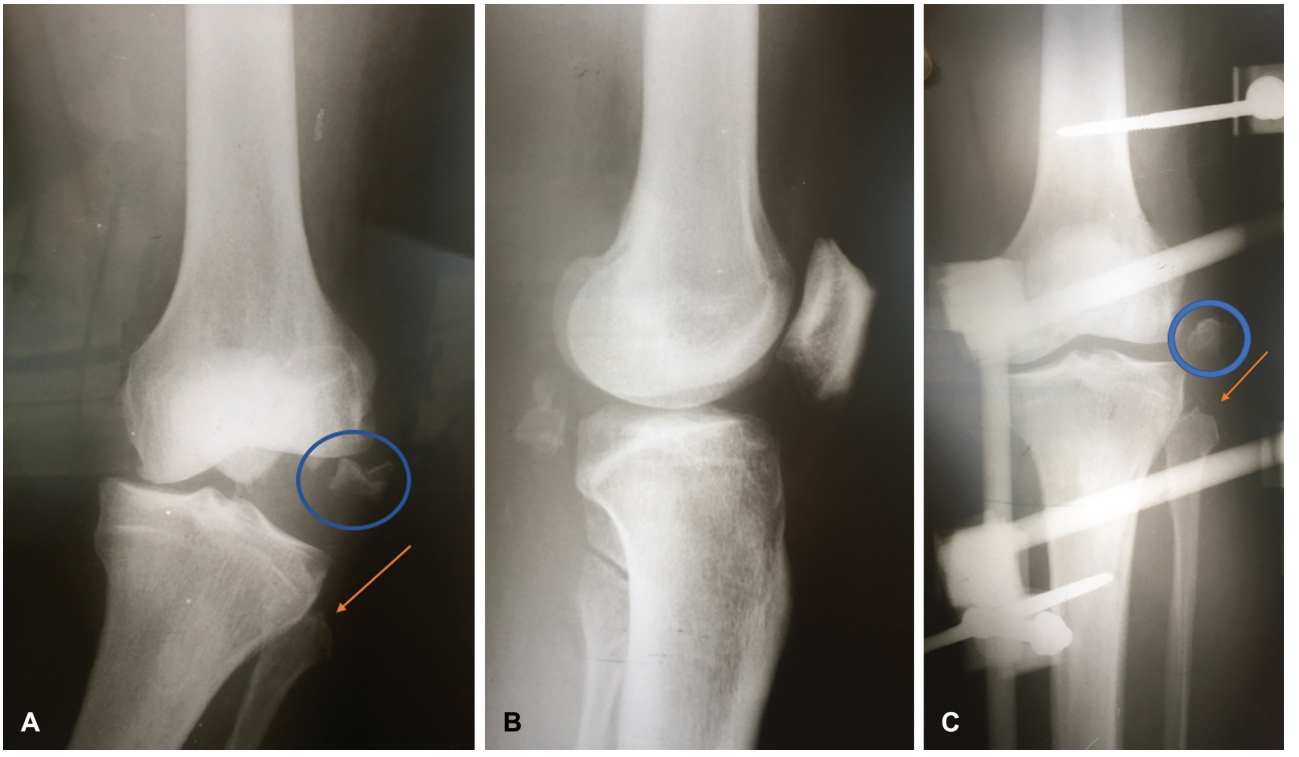


Fig. 1 (**A**) Anteroposterior (AP) radiograph of the opening of the lateral joint space and bone fragment of the anterolateral tibia (circle) and avulsion of the head of the fibula (arrow). (**B**) Profile radiograph. (**C**) Radiograph after transarticular external fixation.

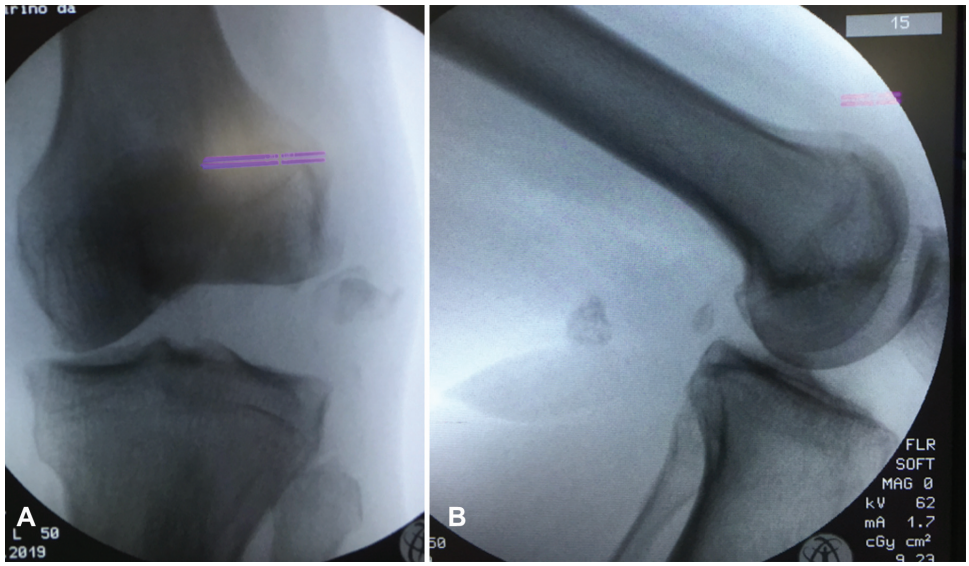


Fig. 2 (A) Imaging exam under varus stress showing an enormous opening of the lateral joint space and in (B) the posterior drawer under stress without posterior translation of the tibia.

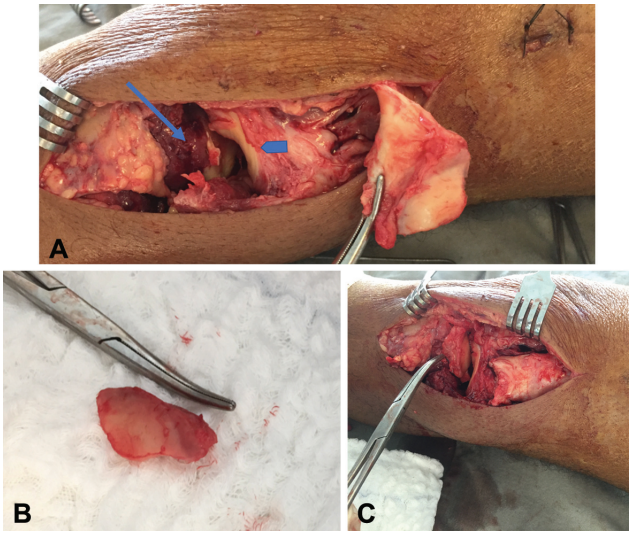


Fig. 3 (A) Osteochondral fragment inserted into the iliotibial tract and (B) osteochondral fragment of the anterolateral tibia. (C) Fragment repositioned on the tibial plateau. The arrow indicates a bone defect on the tibial plateau, and the arrowhead indicates the lateral meniscus.

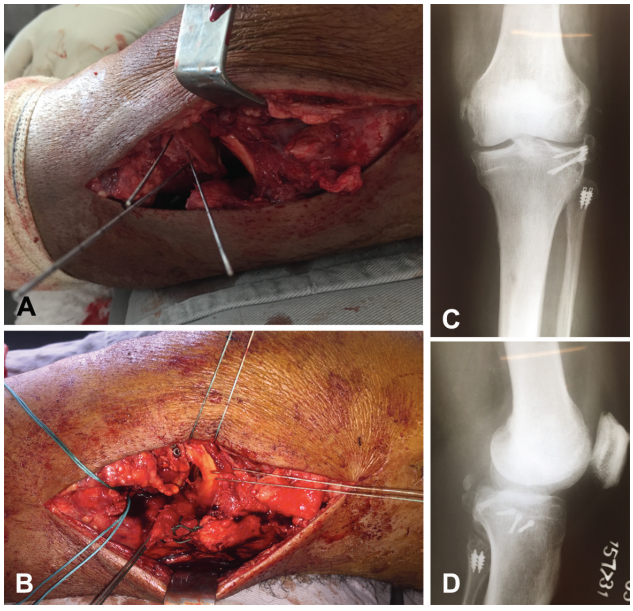


Fig. 4 (A) Fixation of the osteochondral fragment with Hebert screws. (B) Repair of the lateral meniscus, of the lateral collateral ligament, and of the femoral biceps tendon. (C and D) Postoperative AP and profile radiographs.

half of the treatment if the patient complains of knee instability.

Discussion

The present article reports a rare event that is a large osteochondral fragment of the diverted anterolateral tibia, Segond fracture, associated with avulsion fracture of the head of the fibula, arcuate sign, which led to enormous knee-joint instability.

The iliotibial tract, the lateral collateral ligament, the femoral biceps tendon, and the joint capsule are responsible for lateral-knee stability. The term *Segond fracture* is used to describe an avulsion of the anterolateral tibia into which iliotibial-tract fibers and the anterolateral ligament are inserted. The arcuate sign describes an avulsion fracture of the proximal fibula into which the popliteal fibular, fabellofibular and lateral collateral ligaments are inserted. The mechanism of injury involves varus stress and internal rotation of the tibia.[5–8] These lesions, if not recognized and treated, lead to chronic knee instability.

The isolated lesion of the iliotibial tract is rare because it involves a mechanism in which only forces in varus are acting, and it is known that, during trauma, multidirectional forces are responsible for the injury. Segond fractures are more frequently associated with injuries in the cruciate ligament, in the meniscus and in lateral knee structures, as in the case in question.[9]

No studies were found in the literature that revealed an association of Segond fracture and avulsion fracture of the head of the fibula. Fay et al[10] reported a case of a deviated Segond fracture associated with anterior cruciate ligament injury and proximal insertion injury of the lateral collateral ligament without arcuate sign, but the postoperative follow-up period or follow-up radiographs were not performed.

A case of deviated Segond fracture associated with fibula avulsion fracture was herein reported. The recognition and treatment of these lesions in the acute phase leads to good functional results.

Financial Support
There was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

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- Other footnotes for tables should be indicated in the table using superscript letters in alphabetical order.
- Any abbreviations used in the table should be explained at the end of the table in a footnote.

Videos

- The following formats are acceptable: *.avi, *.mov and *.mpg.
- For supplementary videos, the length should not exceed 4 minutes, and a legend of no more than 40 words per video or per sequence is required (it should also be included in the main document).
- If including a voice over, it must be in clear English. Be precise, informative, and clear in your speech. Re-record audio in post-production for sound quality.

Supplementary Material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

DIGITAL ARTWORK PREPARATION

General Guidelines

- It is best to use Adobe Photoshop to create and save images, and Adobe Illustrator for line art and labels.
- Do not submit art created in Microsoft Excel, Word, or PowerPoint. These files cannot be used by the typesetter.
- Save each figure in a separate file.
- Do not compress files.
- All black-and-white and color artwork should be at a resolution of 300 dpi (dots per inch) in TIFF format. Line art should be 1,200 dpi in EPS or TIFF format. Contact the Production Editor at Thieme if you are unsure of the final size.
- It is preferable for figures to be cropped to their final size (approximately 3½ inches for a single column and up to 7 inches for a double column), or larger, and in the correct orientation. If art is submitted smaller and then has to be enlarged, its resolution (dpi) and clarity will decrease.

  Note: Lower resolutions (less than 300 dpi) and JPEG format (.jpg extension) for grayscale and color artwork are strongly discouraged due to the poor quality they yield in printing, which requires 300 dpi resolution for sharp, clear, detailed images. JPEG format, by definition, is a lower resolution (compressed) format designed for quick upload on computer screens.

Black-and-White Art

- Black-and-white artwork can be halftone (or grayscale) photographs, radiographs, drawings, line art, graphs, and flowcharts. Thieme will only accept digital artwork.
- If possible, do not send color art for conversion to black-and-white. Do the conversion yourself so that you can check the results and confirm in advance that no critical details are lost or obscured by the change to black-and-white.
- For best results, line art should be black on a white background. Lines and type should be clean and evenly dark. Avoid screens or cross-hatching, as they can darken or be uneven in printing and lead to unacceptable printing quality.

Color Art

- All color artwork should be saved in CMYK, not RGB.

Art Labels

- Arrows, asterisks, and arrowheads (or other markers) should be white in dark or black areas and black in light or white areas, and large in size. If not, these highlighting marks may become difficult to see when figures are reduced in size during the typesetting process.

- Use 1-point (or thicker) rules and leader lines.
- Capitalize the first word of each label and all proper nouns. Consider using all capitals if you need a higher level of labels.
- Where there are alternate terms or spellings for a named structure, use the most common one and make sure it is consistent with what is used in the text.
- Avoid using multiple fonts and font sizes for the labels; use only one or two sizes of a serif font.

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