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Adult Degenerative Scoliosis

Escoliose degenerativa do adulto

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Abstract

Populational aging increases the incidence of musculoskeletal degenerative processes, such as adult scoliosis (AS). Adult scoliosis is defined as a spinal deformity in the coronal plane with a Cobb angle $> 10°$. Adult scoliosis may be iatrogenic or result from a degenerative process (scoliosis *de novo*) or a pre-existing scoliosis.

Adult scoliosis is a potentially limiting condition that affects a heterogeneous group of patients. Clinical treatment proved to be ineffective and surgery is often indicated. The present paper reviews AS pathophysiology, clinical presentation and diagnosis, in addition to surgical indications and the main techniques currently used.

Keywords

- scoliosis/physiopathology
- scoliosis/therapy
- intervertebral disc degeneration
- adult

Resumo

O envelhecimento da população aumenta a incidência dos processos degenerativos osteomusculares, como a escoliose do adulto (EA). A EA é definida como uma deformidade da coluna no plano coronal com ângulo de Cobb$> 10°$ e pode ocorrer devido a um processo degenerativo (escoliose *de novo*), evolução de uma escoliose pré-existente ou de forma iatrogênica.

A EA é uma doença potencialmente limitante que acomete um grupo heterogêneo de pacientes. O tratamento clínico se mostrou pouco efetivo e a indicação cirúrgica é frequente. No presente artigo, é apresentada uma revisão sobre a fisiopatologia, a manifestação clínica e o diagnóstico da EA. Também são apresentadas as indicações cirúrgicas e as principais técnicas utilizadas atualmente.

Palavras-chave

- escoliose/fisiopatologia
- escoliose/terapia
- degeneração do disco intervertebral
- adulto

Introduction

Brazil is in the midst of a demographic transition due to populational aging.[1] The proportion of people >65 years old went from 3.5% in 1970 to 5.5% of the population in 2000. It is estimated that the elderly will account for 19% of the Brazilian population in 2050.[2]

This phenomenon has significant implications for health care; most importantly, it increases the incidence and the prevalence of musculoskeletal degenerative processes, including adult scoliosis (AS). In different studies, the prevalence of vertebral deformities in people >65 years old ranges from 32 to 68%.[3]

Adult scoliosis is defined as a spinal deformity featuring a Cobb angle $> 10^o$ in the coronal plane in a skeletally mature patient.[4] Adult scoliosis may result from a spinal degenerative condition (referred to as scoliosis de novo), progression of a pre-existing scoliosis during childhood/adolescence

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(adult idiopathic scoliosis [AIS]), systemic diseases and previous spine surgery.[5]

Its debilitating effect on the general health of the patients must be highlighted. Bess et al[6] observed that patients with vertebral deformity present a higher prevalence of psychiatric conditions and worse quality of life in comparison to same-age counterparts or people with general chronic diseases, such as diabetes and high blood pressure. The limitation imposed by the severe coronal and sagittal imbalanceis similar to that associated with cancer, visual impairment or restricted use of the upper and lower limbs.

The number of patients with AS submitted to surgery increases every year; today, AS correction presents the highest proportional growth among spine surgical procedures.[7] The treatment of AS becomes a challenge due to its high surgical complexity, clinically compromised patients and high health costs.

Pathophysiology

It is believed that disc degeneration triggers AS. As people age, the intervertebral disc loses proteoglycans due to the increased activity of proteases, leading to a decrease in osmotic pressure and disc hydration.[8] It has been shown that, starting at 15 years old, annular lesions are common and compromise disc biomechanics. This process results in disc height loss and disc inability to perform its stabilizing role, leading to facet joints overload.[9]

Facet joints overload is often asymmetrical, which contributes to the progressive deformity and increases the likelihood of associated central and foraminal stenosis. Axial rotation is especially known to compromise the spinal ligamentous complex, resulting in laterolisthesis.[9,10]

A number of factors are related to AS development, including liposubstitution of paravertebral muscles, disc impairment due to smoking, obesity, genetic inheritance, development of neurodegenerative conditions and senile changes in balance and mobility.[3,10,11]

Osteoporosis was thought to be implicated in AS development; however, this assumption has been refuted by most current studies, which suggest that the prevalence of osteoporosis is similar among AS patients and the general population. There was no correlation between the degree of osteopenia and curve magnitude. It was revealed that bone mineral density is higher on the concave side of the curve and on the ipsilateral femur when compared with the other side.[12]

Clinical Presentation

Clinical presentation is variable due to the heterogeneity of patients. Symptoms of central stenosis with neurogenic claudication are reported in up to 90% of patients. Patients with adult degenerative scoliosis also experience symptom relief when they sit and support the trunk with the upper limbs.[9,13]

Low back pain is present in 60 to 80% of patients, mainly on the convex side of the curve, and it is caused by degenerative changes and muscle fatigue resulting from sagittal/coronal imbalance. Radiculopathy at one or multiple levels affects 47 to 78% of the patients, and it results from facet hypertrophy at the concave side of the curve and laterolisthesis.[14]

Postural changes resulting from a fixed deformity or compensatory mechanisms are frequent and must be evaluated routinely. Trunk inclination, pelvic and scapular asymmetries, hypo-/hyperkyphosis, hips, knees and ankles flexion and extension degree when standing and walking, in addition to horizon line evaluation, are the main points of analysis.[15]

Pain, neurological complaints and limitations in daily living activities are more commonly reported in AS patients compared to adolescent patients, in whom the aesthetic deformity and curve progression are the main reasons for dissatisfaction.[16]

Adult scoliosis due to a degenerative process, referred to as *scoliosis de novo*, affects both genders similarly; it often starts at 50 years old and has relevant clinical repercussions when the patient is $\sim$ 70.5 years old. The condition affects 32 to 68% of individuals $>$65 years old.[10,11] It typically involves the lumbar spine with a Cobb angle $<$ 40°. The association with laterolisthesisis frequent, and a compensatory thoracic curve is occasionally seen.[10] Compared to adult idiopathic scoliosis, curves resulting from scoliosis de novopresent less angulation, but greater progression (1.64°/year versus 0.82°/year).[17]

Adult idiopathic scoliosis is observed in patients with preexisting scoliosis, mainly females, and it occurs in two main patterns. One group shows steady progression after skeletal maturity; in the other group, however, the curve starts to progress around the 4th and 5th decades of life, after menopause.[17] Compared to scoliosis de novo, AIS presents less central stenosis, larger Cobb angles (mean value, $>$ 50°) and more frequent compensatory thoracic curves, butlaterolisthesis/spondylolisthesis rates and coronal/sagittal imbalanceare less common.[14]

Rotational deformityis observed throughout the lumbar spine in AIS, but it is limited to the apex of the curve and accompanied by laterolisthesis in scoliosis de novo.[14]

Radiological evaluation

An orthostatic spinal panoramic radiography is the primary test for AS diagnosis and classification. Although the evaluation of such cases has been mainly performed on the coronal plane, sagittal balance has been deemed important in recent decades, and its routine study is essential.[18]

Adequate radiographic images are crucial; they must include the region from the skull base, proximally, to the femoral heads, distally. Whenever possible, the patient should be in orthostasis with no support, allowing the evaluation of any compensatory mechanism. Patients unable to walk must be radiographed while sitting down.

Deformity flexibility or the presence of structured curves can be assessed using dynamic radiographs under inclination or traction. This information can help preoperative planning, predicting which techniques will be required for proper deformity correction and any intraoperative challenges.

At the coronal plane, it is recommended to measure the Cobb angle measurement in all curves, identify terminal, stable and neutral vertebrae and assesscoronal balance (through the distance between a plumb line in C7 and a

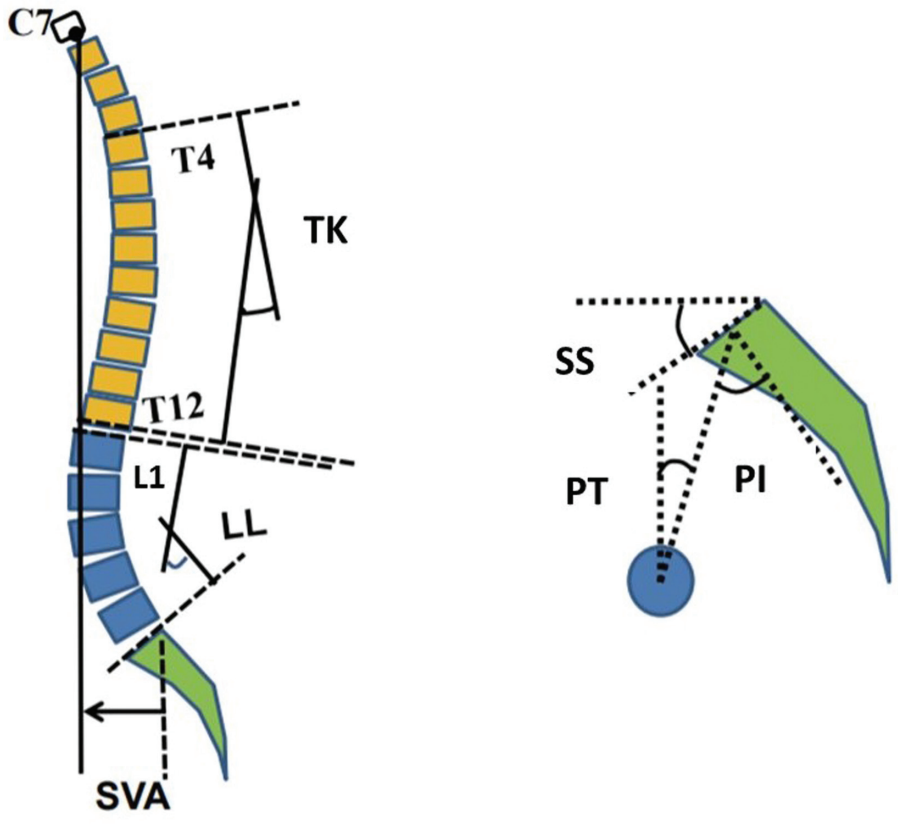

Fig. 1 SVA, Sagittal vertical axis; LL, Lumbar Lordosis; TK, Thoracic Kyphosis; SS, Sacral slope; PT, Pelvic Tilt; PI, Pelvic incidence.

central sacral vertical line) and pelvic obliquity (if present, rule out a potential lower limb discrepancy).[10]

At the sagittal plane (►**Figure 1**), the global sagittal balance must be evaluated using the distance between a plumb line in C7 and another vertical line passing through the posterosuperior border of S1. Spinopelvic parameters, lumbar lordosis and thoracic kyphosis must also be assessed.[10]

On radiographic analysis, the increased apical vertebra rotation (≥ grade 3 according to the Nash-Moe method)Cobb angles > 30º, intervertebral discs asymmetry above and below apical vertebra, laterolisthesis > 6 millimeters and interiliac line (line between the upper aspects of both iliac crests) sectioning L5 instead of L4 are predictive of curve progression. The presence of anterior osteophytes increases spinal stability.[19]

Table 1 Radiographic Parameter Thresholds Predictive of an Oswestry Disability Index Score of 40[20]

Radiographic parameter	RadiographicalThreshold	r
PI-LL	11º	0.45
PT	22º	0.38
SVA	46mm	0.47

Abbreviations: PI, pelvicincidence; LL, lumbarlordosis; PT, pelvictilt; SVA, sagittal vertical axis.

The evaluation of spinopelvic parameters is essential for the classification and determination of the best surgical strategy (►**Table 1**). According to the Oswestry Disability Index (ODI), a pelvic tilt (PT) of 22°, sagittal vertical axis (SVA) of 46 mm and pelvic incidence minus lumbar lordosis (PI-LL) of 11° are predictive of disability (ODI> 40) and considered sagittal modifiers for the SRS-Schwab classification.[20]

A supplementary study using computed tomography (CT) and magnetic resonance imaging (MRI), even though unable to identify dynamic orthostatic factors, is beneficial because it allows three-dimensional (3D) image reproduction and shows details of bone components and intraand extravertebral soft tissues. Computed tomography is better to detailbone features, including facet arthrosis, vertebral rotation and pedicle diameter. On the other hand, MRI provides information on disc involvement, central and foraminal stenosis and paravertebral muscles liposubstitution.[15]

Biplane imaging devices with 3D capacity are relatively new and promising diagnostic methods with lower radiation rates. This equipment provideswhole-body images, including the head, the spine, the pelvis and the lower limbs, optimizing the analysis of the overall balance of the patient.[21]

Classification Systems

The SRS-Schwab is the classification method currently used due to its descriptive power, reproducibility and correlation with quality of life (►**Figure 2**).[20] Initially, the Cobb angle must be measured at the coronal plane and the deformityis

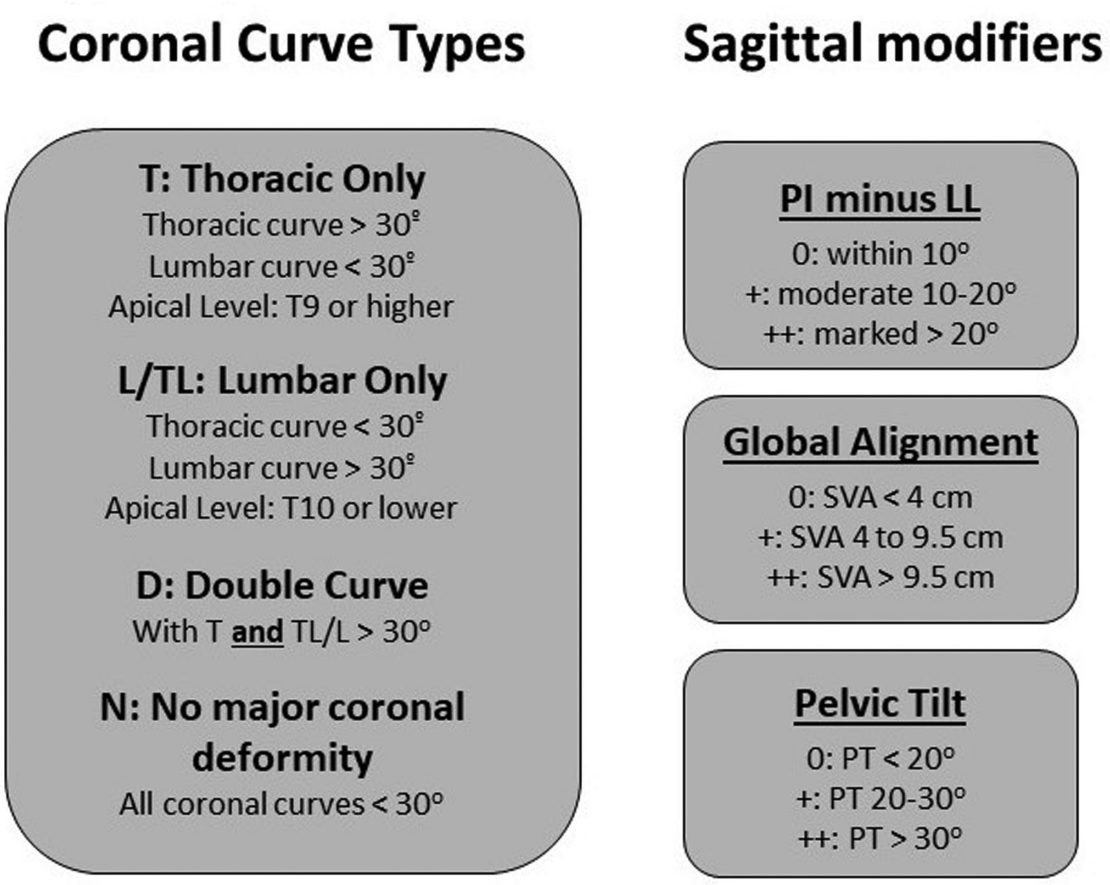

Fig. 2 SRS-SchwabClassification.[20] PI, Pelvic incidence; LL, Lumbar lordosis; SVA, Sagittal vertical axis; PT, Pelvic Tilt.

characterized. Next, the sagittal plane is assessed through three sagittal modifiers.

As previously mentioned, the presence of a "+" or "++" score in any sagittal modifieris predictive of worse clinical performance.

Comparison of results obtained with different techniques is severely limited due to the wide variety of osteotomies and terminologies for AS treatment. To overcome this problem, Schwab et al proposed an anatomical classification of osteotomies based on the resection site (►**Figure 3**).[22]

Anterolateral interbody fusion has gained popularity in the last decade. Although it was initially used for indirect decompression, anterolateral interbody fusion became part of the therapeutic arsenal for adult deformities. In anterior column realignment (ACR) procedures, a section of the anterior longitudinal ligament(ALL)is added to increasing their corrective power.[23]

Since ACR procedures provide mobility to the three Denis columns, it is a minimally invasive technique to correct adult deformities that were previously exclusively treated with osteotomies.[23]

To facilitate the communication between surgeons and standardize ACR interventions in clinical research, Uribe et al proposed a new classification based on an anatomical classification for osteotomies (►**Figure 4**).[23]

Grade A is unique since it is corrected through an anterior or lateral approach, with no posterior osteotomies. In these cases, angular correction is achieved with all section and a 20° or 30° hyperlordotic cage is used. Approximately 7.8° of lordosis per segment is achieved with 30° cages.[23] Further grades are based on the performance of posterior osteotomies (Schwab modifier) and ACRroute (approach modifier).

Treatment

Clinical Treatment

Despite the absence of consistent scientific evidence to warrant their indication, nonsurgical methods often are the first line of treatment. Studies recommending physical therapy, stretching, manual therapy and local heat application for AS patients are scarce, with evidence level IV.[24] Acupuncture and cognitive behavioral therapy may be considered in cases of chronic pain. The use of vests was not deemed effective.[25]

Medical treatment is based on analgesics, non-steroidal anti-inflammatory drugs, anticonvulsants and antidepressants. The assessment of bone mineral density must be performed routinely, and specific treatment must be instituted if osteoporosis is diagnosed. Epidural and trigger point infiltrations or peripheral nerve blocks are beneficial as therapeutic evidence and provide short and medium-term pain relief, although further studies on their long-term effects are required.[26]

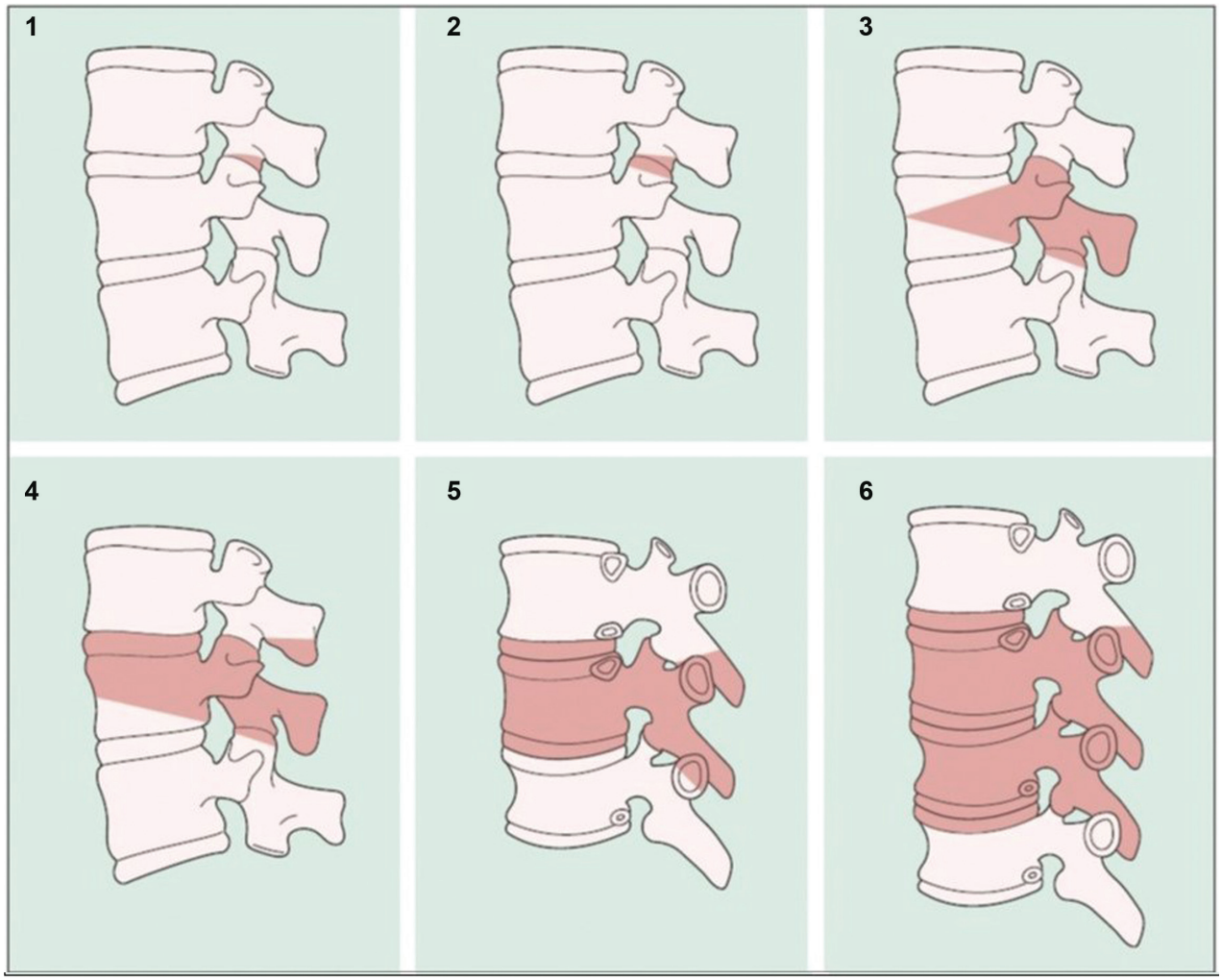

Fig. 3 A graduated and simplified anatomically based osteotomy classification system by Schwab et al.[22] Grade 1: partial facet joint; Grade 2: complete facet joint; Grade 3: pedicle and partial body; Grade 4: pedicle, partial body, and disc; Grade 5: complete vertebra and discs; Grade 6: multiplevertebrae and discs.

Clinical treatment has better results in patients with mild, nonprogressive deformities and few symptoms. In a multicenter study, Passias et al[27] compared clinical, surgical and clinical-to-surgical (crossover) treatments and observed that participants who opted for surgery had more limitations and worse performance in pain/quality of life scores.

Surgical Treatment

The main indications for surgery are daily living activity limitations, pain, neurological symptoms, confirmed curve progression and conservative treatment failure[25] In radiographic terms, surgical intervention is recommended in lumbar curves >30° to 40°, 6 mm laterolisthesis, curve progression >10° or subluxation >3 mm[9]

The main points to considerfor surgical indication are the reestablishment of global (mostly sagittal) balance parameters and neurological decompression. The high prevalence of comorbidities in this population, surgical complexity and expectations of the patients about their treatment must also be considered.

Most studies comparing clinical and surgical adult deformity treatment favor surgical intervention. Operated patients show statistically significant improvement in quality of life, pain, performance and less chance of clinical deterioration compared to those submitted tothe conservative treatment.[28]

Surgical treatment may be performed using several techniques, which were hierarchically subdivided by Silva and Lenke[9] in six groups: I, decompression alone; II, decompression andlimited instrumented posteriorspinal fusion; III, decompression and lumbar curve instrumented fusion; IV, decompression with anterior and posterior spinal instrumented fusion; V, thoracic instrumentation and fusion extension; and VI, inclusion of osteotomies for specific deformities.

Decompression alone is best indicated in patients with neurological symptoms, stable lumbar curves (Cobb <30°, <2 mm laterolisthesisand anterior osteophytes) and no axial pain.[14] In similar cases with potential instability and requiring extensive decompression, arthrodesis only of the addressed segment must be considered if sagittal and coronal balance are spared.[29]

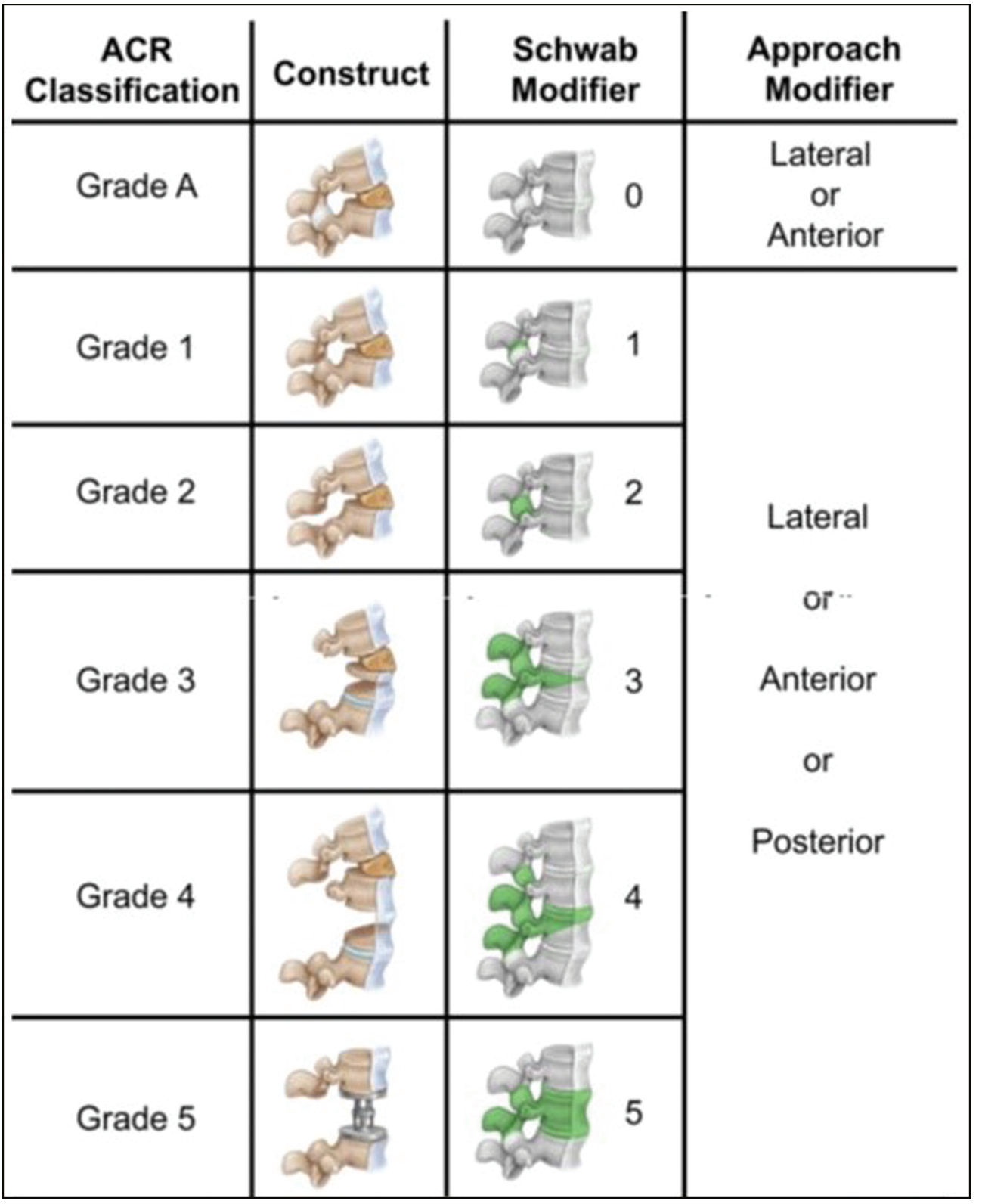

Fig. 4 Anterior column realignment classification.[23]

In patients at risk of pseudoarthrosis and at long lumbar fusion planning, the association of interbody arthrodesis is beneficial, especially at lower lumbar levels, when lumbosacral fusion is performed[9] Anterior and lateral approach techniques, in addition to providing direct and indirect decompression by foraminal distraction, allow the use of larger cages with lower risk of plateau fracture (subsidence) and potential for angular correction insagittal and coronal planes.[10,29]

Arthrodesis extension to the thoracic spine may be required in the presence of significant global imbalance associated with increased thoracic kyphosis to reducethe

chance of proximal junctional kyphosis. T10 or cephalic fusion is preferred due to the stability conferred by the articulation of the respective (true) ribs to the sternum at such levels, which is not observed with floating ribs (T11 and T12).[9,30]

Cases with rigid deformities (<30% correction on dynamic radiographs) or previous arthrodesis with significant sagittal imbalance are eligible for osteotomies. Osteotomies restore vertebral balance and decrease the burden on bone/hardware interface and the chance of mechanical failure.[9] Even though these procedures increase surgical time, bleeding and perioperative morbidity, sagittal balance correction proved to be the single factor with best impact on postoperative outcomes.[19]

The following principles are recommended for choosing arthrodesis levels:[10]

§ *Do not stop at the apex of the curve*
§ *Do not stop at* an area of kyphosis
§ Include severe lateral subluxation
§ *Include spondylolisthesis or retrolisthesis*
§ Upper instrumented vertebra should ideally be horizontal
§ Iliac fixation should be strongly considered in longfusions

Surgical Techniques

Posterolateral fusion (PLF) has shorter surgical time, bleeding and postoperative complications compared to transforaminal interbody lumbar fusion (TLIF). However, TLIF showed better sagittal correction and better clinical outcomes regarding pain and satisfaction.[31] In general, surgeries with interbody arthrodesis for AS have better clinical outcomes than strict PLF[32]

Anterior lumbar interbody fusion (ALIF) has the advantage of anterior release and decompression optimization due to the placement of larger intervertebral implants, enabling greater sagittal corrections and lower subsidence rates when compared to posterior techniques.[33] It is suitable for L4-L5 and especially L5-S1 levels due to the local vascular anatomy. Vascular and visceral injury,as well as retrograde ejaculation, are potential complications[32]

Lateral lumbarinterbodyfusion (LLIF) has gained popularity in recent years and allows T12-L1 to L4-L5 correction in the sagittal and coronal planes with robust implants, such as ALIF; in addition, it is surgically easier in patients with previous abdominal surgeries or who are obese. Its disadvantages are the difficult access to the L5-S1 disc due to the iliac crest, the long learning curve and the risk of psoas weakening and lumbar plexus damage.[19]

In a prospective multicenter study with 107 patients undergoing LLIF due to adult degenerative scoliosis, Philips et al[34] reported improvement in ODI score, visual analog scale (VAS) and SF-36 quality of life questionnaire. The average Cobb angle corrected from 20.9° to 13.5° in the postoperative period and remained at 15.2° after 2 years of follow-up. In patients with reduced lumbar lordosis, the average Cobb angle went from 27.7° to 33.6° in 2years.

The prolonged surgical time and high perioperative morbidity rate associated with classic procedures led to the current effort to develop minimally invasive (MIS) techniques, which had encouraging preliminary results.

Complications

In a case review conducted by the Scoliosis Research Society (SRS), the rate of surgical complications in AS is 13.4%, although other studies reported rates up to 40%. Dura-mater damage, implant failure, superficial and deep wound infection and neurological deficits are the most frequent injuries.[35] Obese, smoking, osteoporotic and elderly patients (> 65 years) are at additional risk.[11]

Proximal junctional kyphosis occurs in 20 to 40% of patients; its presentation may be early or late. Current techniques are associated with lower pseudoarthrosisrates, ranging from 4 to 24% according to recent studies. Reoperation rates range from 16.7% within 90 days to 40% in 11 years.[11]

Given the clinical characteristics of this group, systemic complications such as acute myocardial infarction, pneumonia, adynamic ileum, deep vein thrombosis and urinary tract infection are not uncommon.

Final Considerations

Adult degenerative scoliosis is a potentially limiting disease that affects a heterogeneous group of patients with important clinical limitations. Clinical treatment proved to be ineffective and surgical indication is frequent. It represents a challenge to spine surgeons due to its complexity and increased prevalence.

Clinical and radiological evaluation must carefully determine the real origin of the symptoms. Decompression of neurological structures and maintenance of sagittal and coronal balance, whenever possible, must be the main therapeutic goals.

Minimally invasive techniques are being developed and their improvement might reduce the incidence of postoperative complications and provide better results. As such, further studies are required to attest the real benefit of these procedures in AS treatment.

Note

This is an "Update Article", with no requirement for approval by the Research Ethics Committee.
The authors attest that the present study was carried out without the direct participation of human beings.
Study developed at the Division of Vertebral Spine Surgery, Department of Orthopedics and Traumatology of the Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, BR.

Conflict of Interests

The authors haveno conflict of interests to declare.

References

1 Wong LL, Carvalho JA. O rápido processo de envelhecimento populacional do Brasil: sérios desafios para as políticas públicas. Rev Bras Estud Popul 2006;23(01):5–26

2 Nasri F. O envelhecimento populacional no Brasil. Einstein (Sao Paulo) 2008;6(Suppl 1):S4–S6
3 Schwab F, Dubey A, Gamez L, et al. Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. Spine (Phila Pa 1976) 2005;30(09):1082–1085
4 Aebi M. The adult scoliosis. Eur Spine J 2005;14(10):925–948
5 Youssef JA, Orndorff DO, Patty CA, et al. Current status ofadult-spinaldeformity. Global Spine J 2013;3(01):51–62
6 Bess S, Line B, Fu KM, et al; International Spine Study Group. The Health Impact of Symptomatic Adult Spinal Deformity: Comparison of Deformity Types to United States Population Norms and Chronic Diseases. Spine (Phila Pa 1976) 2016;41(03):224–233
7 McCarthy I, Hostin R, O'Brien M, Saigal R, Ames CP. Health economicanalysisofadultdeformitysurgery. Neurosurg Clin N Am 2013;24(02):293–304
8 Vernon-Roberts B, Moore RJ, Fraser RD. The natural history of age-related disc degeneration: the influence of age and pathology on cell populations in the L4-L5 disc. Spine (Phila Pa 1976) 2008;33 (25):2767–2773
9 Silva FE, Lenke LG. Adult degenerative scoliosis: evaluation and management. Neurosurg Focus 2010;28(03):E1
10 York PJ, Kim HJ. Degenerative Scoliosis. Curr Rev Musculoskelet Med 2017;10(04):547–558
11 Diebo BG, Shah NV, Boachie-Adjei O, et al. Adultspinaldeformity. Lancet 2019;394(10193):160–172
12 Routh RH, Rumancik S, Pathak RD, Burshell AL, Nauman EA. The relationship between bone mineral density and biomechanics in patients with osteoporosis and scoliosis. Osteoporos Int 2005;16 (12):1857–1863
13 Grubb SA, Lipscomb HJ, Suh PB. Results of surgical treatment of painful adult scoliosis. Spine (Phila Pa 1976) 1994;19(14):1619–1627
14 Cho KJ, Kim YT, Shin SH, Suk SI. Surgical treatment of adult degenerative scoliosis. Asian Spine J 2014;8(03):371–381
15 Smith JS, Shaffrey CI, Fu KM, et al. Clinical and radiographic evaluation of the adult spinal deformity patient. Neurosurg Clin N Am 2013;24(02):143–156
16 Bess S, Boachie-Adjei O, Burton D, et al. International Spine Study Group. Pain and disability determine treatment modality for older patients with adult scoliosis, while deformity guides treatment for younger patients. Spine (Phila Pa 1976) 2009;34(20): 2186–2190
17 Marty-Poumarat C, Scattin L, Marpeau M, Garreau de Loubresse C, Aegerter P. Natural history of progressive adult scoliosis. Spine (Phila Pa 1976) 2007;32(11):1227–1234
18 Schwab FJ, Blondel B, Bess S, et al; International Spine Study Group (ISSG). Radiographical spinopelvic parameters and disability in the setting of adult spinal deformity: a prospective multicenter analysis. Spine (Phila Pa 1976) 2013;38(13):E803–E812
19 Kim W, Porrino JA, Hood KA, Chadaz TS, Klauser AS, Taljanovic MS. Clinical Evaluation, Imaging, and Management of Adolescent Idiopathic and Adult Degenerative Scoliosis. CurrProbl Diagn Radiol 2019;48(04):402–414
20 Schwab F, Ungar B, Blondel B, et al. Scoliosis Research Society-Schwab adult spinal deformity classification: a validation study. Spine (Phila Pa 1976) 2012;37(12):1077–1082
21 Somoskeöy S, Tunyogi-Csapó M, Bogyó C, Illés T. Accuracy and reliability of coronal and sagittal spinal curvature data based on patient-specific three-dimensional models created by the EOS 2D/3D imaging system. Spine J 2012;12(11):1052–1059
22 Schwab F, Blondel B, Chay E, et al. The comprehensive anatomical spinal osteotomy classification. Neurosurgery 2014;74(01): 112–120
23 Uribe JS, Schwab F, Mundis GM, et al. The comprehensive anatomical spinal osteotomy and anterior column realignment classification. J Neurosurg Spine 2018;29(05):565–575
24 Teles AR, Mattei TA, Righesso O, Falavigna A. Effectiveness of Operative and Nonoperative Care for Adult Spinal Deformity: Systematic Review of the Literature. Global Spine J 2017;7(02): 170–178
25 Haldeman S, Nordin M, Chou R, et al. The Global Spine Care Initiative: World Spine Care executive summary on reducing spine-related disability in low- and middle-income communities. Eur Spine J 2018;27(Suppl 6):776–785
26 DePalma MJ, Slipman CW. Evidence-informed management of chronic low back pain with epidural steroid injections. Spine J 2008;8(01):45–55
27 Passias PG, Jalai CM, Line BG, et al. International Spine Study Group. Patient profiling can identify patients with adult spinal deformity (ASD) at risk for conversion from nonoperative to surgical treatment: initial steps to reduce ineffective ASD management. Spine J 2018;18(02):234–244
28 Sengupta D. Adult Spinal Deformity. In: Rao R, Smuck M, editors. Orthopaedic knowledge update: spine. 4th ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2012:349–367
29 Cho KJ, Suk SI, Park SR, et al. Short fusion versus long fusion for degenerative lumbar scoliosis. Eur Spine J 2008;17(05): 650–656
30 Fu X, Sun XL, Harris JA, et al. Long fusion correction of degenerative adult spinal deformity and the selection of the upper or lower thoracic region as the site of proximal instrumentation: a systematic review and meta-analysis. BMJ Open 2016;6(11):e012103
31 Li FC, Chen QX, Chen WS, Xu K, Wu QH, Chen G. Posterolateral lumbar fusion versus transforaminal lumbar interbody fusion for the treatment of degenerative lumbar scoliosis. J Clin Neurosci 2013;20(09):1241–1245
32 Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg 2015;1(01):2–18
33 Rao PJ, Loganathan A, Yeung V, Mobbs RJ. Outcomes of anterior lumbar interbody fusion surgery based on indication: a prospective study. Neurosurgery 2015;76(01):7–23
34 Phillips FM, Isaacs RE, Rodgers WB, et al. Adult degenerative scoliosis treated with XLIF: clinical and radiographical results of a prospective multicenter study with 24-month follow-up. Spine (Phila Pa 1976) 2013;38(21):1853–1861
35 Sansur CA, Smith JS, Coe JD, et al. Scoliosis research society morbidity and mortality of adult scoliosis surgery. Spine (Phila Pa 1976) 2011;36(09):E593–E597

Degenerative Lumbar Spinal Stenosis

Estenose degenerativa do canal lombar

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Abstract

Degenerative lumbar spinal stenosis is the most frequent cause of low back pain and/or sciatica in the elderly patient. Epidemiology, pathophysiology, clinical manifestations and testing are reviewed in a wide current bibliographic investigation. The importance of the relationship between clinical presentation and imaging study, especially magnetic resonance imaging (MRI), is emphasized. Prior to treatment indication, it is necessary to identify the precise location of pain, as well as the differential diagnosis between neurological and vascular lameness. Conservative treatment combining medications with various physical therapy techniques solves the problem in most cases, while therapeutic testing with injections, whether epidural, foraminal or facetary, is performed when pain does not subside with conservative treatment and before surgery is indicated. Injections usually perform better results in relieving sciatica symptoms and less in neurological lameness. Equine tail and/or root decompression associated or not with fusion is the gold standard when surgical intervention is required. Fusion after decompression is necessary in cases with segmental instability, such as degenerative spondylolisthesis. When canal stenosis occurs at multiple levels and is accompanied by axis deviation, whether coronal and/or sagittal, correction of axis deviations should be performed in addition to decompression and fusion, especially of the sagittal axis, in which a lumbar lordosis correction is required with techniques that correct the rectified lordosis to values close to the pelvic incidence.

Keywords

- arthrodesis
- intermittent claudication
- decompression
- stenosis
- low back pain

Resumo

A estenose degenerativa do canal vertebral lombar é a causa mais frequente de dor lombar e/ou ciática no paciente idoso; sua epidemiologia, fisiopatogenia, manifestações e testes clínicos são revistos em ampla investigação bibliográfica atual. A importância da relação entre a clínica e o estudo por imagens, principalmente a ressonância magnética (RM), é ressaltada. Antes da indicação do tratamento, é necessário identificar a localização precisa da dor, bem como o diagnóstico diferencial entre a claudicação neurogênica e a vascular. O tratamento conservador associando

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medicações com as diversas técnicas fisioterápicas resolve o problema na maioria dos casos, já o teste terapêutico com os bloqueios, seja epidural, foraminal ou facetário, é realizado quando as dores não cedem com o tratamento conservador e antes da indicação da cirurgia. Os bloqueios costumam dar melhores resultados no alívio dos sintomas de ciatalgia e menos no quadro de claudicação neurogênica. A descompressão da cauda equina e/ou radicular associada ou não à artrodese é o padrão ouro quando a intervenção cirúrgica é necessária. A artrodese após a descompressão é necessária nos casos com instabilidade segmentar, como na espondilolistese degenerativa. Quando a estenose de canal acontece em múltiplos níveis e vem acompanhada de desvio de eixo, seja coronal e/ou sagital, deve ser realizada, além das descompressões e artrodese, a correção dos desvios de eixo, principalmente o eixo sagital, quando a correção da lordose lombar se impõe com técnicas que corrigem a lordose retificada para valores próximos à incidência pélvica.

Palavras-chave
- artrodese
- claudicação intermitente
- descompressão
- estenose
- dor lombar

Introduction

Lumbar spinal stenosis is defined as the narrowing of any vertebral canal, foramina or lateral recess leading to a clinical presentation of low back pain that can radiate to the buttocks and lower limbs and presenting well-defined precipitating and relief causes related to the compression of neurovascular structures within the lumbar canal.

Spinal stenosis causes

A. Congenital conditions, such as short pedicles or joint facets in anomalous orientation

B. Acquired conditions:

1. As a consequence of injuries: vertebra fracture with bone fragment projecting into the spinal cavity, vertebral dislocation;
2. Bone tumors or metastases from soft tissue neoplasia invading the spinal cavity;
3. Hematomas from different origins;
4. Abscess due to an infection originating in the vertebral body or intervertebral disc;
5. Several bone-metabolic or endocrine diseases such as acromegaly, renal osteodystrophy and hypoparathyroidism;
6. Other deforming bone diseases such as Paget disease, achondroplasia, rheumatoid arthritis, ankylosing spondylitis and diffuse idiopathic bone hyperostosis;
7. Iatrogenic conditions: postdecompression or bone resection surgery;
8. Degenerative disease due to degenerative discopathy and facet arthrosis (the most common cause).

C. Mixed causes: congenital stenosis associated with acquired stenosis: for example, short-pedicled spine cavity stenosis associated with disc arthrosis.

The present review focuses on lumbar spinal stenosis with a degenerative origin.

Epidemiology

Although the degenerative process affects virtually all spines after the 5th and 6th decades of life, only ~6% of adults suffer from symptomatic lumbar spinal stenosis.[1,2]

Degenerative spinal cavity stenosis associated with congenital conditions (such as a short pedicle or joint facets in sagittal orientation) may result in clinical manifestations in people aged 30 to 40 years old.[3]

Lumbar spinal stenosis is the most common cause of lumbar spine diseases in patients > 65 years old requiring surgical treatment; it is estimated that ~0.1% of the population will need some procedure to treat degenerative lumbar spine conditions.[4]

Vertebral spinal cavity anatomy

The main limits of the vertebral spinal cavity include, anteriorly, the intervertebral disc and the vertebral body; laterally, the two pedicles and the interapophyseal joints along with their capsules; and posteriorly, laminas and ligamentum flavum.

In central stenosis, the spinal cavity narrows anteriorly due to the protrusion of an intervertebral disc and osteophytes in the posterior region of the vertebral bodies and, later, by the indentation of the ligamentum flavum, which is thickened. The spinal cavity space decreases with lumbar spine extension and increases with its flexion, characterizing the dynamic component of the symptomatology of spinal cavity stenosis.[5]

Lateral recess stenosis presents with interapophyseal joint capsules hypertrophy; in more advanced states, the projection into the spinal cavity of osteophytes from the upper facets of the lower vertebra is the main cause, resulting in dural sac and adjacent radicular compression.

In foraminal stenosis, intervertebral disc protrusion is associated with an osteophyte formed at the upper articular apophysis of the lower vertebra, compressing the emerging

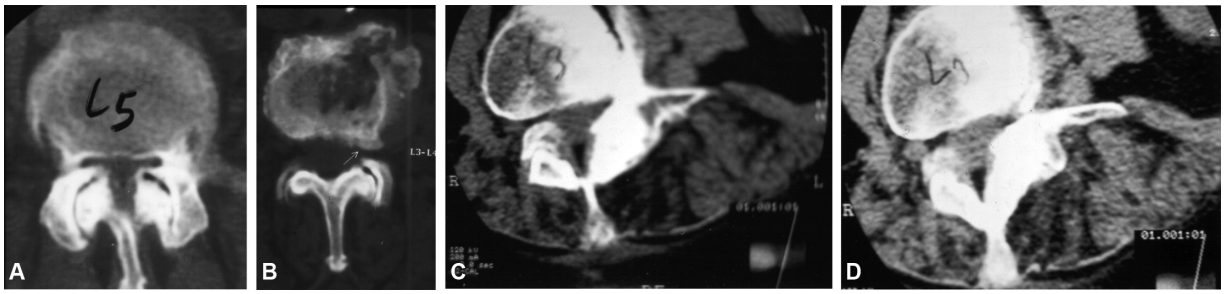

Fig. 1 Axial computed tomography images showing: Central stenosis from (A) lateral recess and (B) foramen; (C and D) Degenerative scoliosis with vertebral rotation and laterolysthesis with foraminal stenosis.

nerve root. This is more frequent in the lower lumbar spine, where the foramen diameter is anatomically decreased and the nerve root diameter is increased, rendering the spine more susceptible to compressions even by smaller osteophytes (►**Figure 1**).

Clinical presentation and natural history

Most stenosis cases become symptomatic after the 6th decade of life; symptoms are usually insidious and related to L3-L4 and L4-L5 degeneration. In early stages, the majority of cases report recurrent low back pain that, over time, becomes permanent. This symptom is generally related to disc degeneration, in its various stages, and to the onset of facet arthrosis, characterized by synovitis.

In its evolution, low back pain can radiate to the flanks and gluteal region and, eventually, to the nerve root path, characterizing the probable association with a herniated disc or even foraminal or lateral recess stenosis.

In central stenosis, the classic symptom is neurogenic claudication, with lower limb pain, paresthesia and decreased strength in an insidious, slow progression. These symptoms are associated with walking or standing up and are relieved when the patient sits down, leans forward or lies down.[6]

Symptoms can be better understood using the degenerative cascade reported by Kirkaldy-Willis et al,[7] which describes the evolution of the degenerative process both at intervertebral discs, joint facets and vertebral bodies levels.

A possible cause of degenerative lumbar stenosis is the sagittal orientation of joint facets, which can also result in congenital stenosis.[8]

The final stage of the degenerative process consists in ankylosis of the compromised segment(s), which can result in worse clinical symptoms, with pain even during rest, and more severe neurological alterations, such as cauda equina syndrome or neurogenic bladder.

Physical exam

Physical examination findings in central spinal stenosis are often poor and not characteristic.

Lameness can manifest itself when the examiner asks the patient to walk or to extend the spine. In advanced stages, there is often lumbar lordosis rectification and sagittal balance loss, in which the patient bents forward.

Eventually, the patient may show radicular symptoms and signs in cases of foraminal stenosis, or a herniated disc associated with radiological signs of foraminal or lateral recess stenosis. Most of the time, there is no sign of radicular irritation or a positive Laségue sign.

Potential strength decreases in certain muscle groups, and corresponding changes in sensitivity and reflex responses, in a metameric distribution, are rarely present, depending on the location and degree of lumbar spinal stenosis.

In an international consensus, a group of 279 specialists from 29 countries concluded that 7 clinical signs and symptoms are required to be 80% sure of the presence of lumbar spinal stenosis based on history and physical examination, namely: gluteal region or lower limbs pain when walking; symptoms relief at anterior flexion; relief when using a supermarket cart or riding a bicycle; sensory or motor disturbances when walking; normal or symmetrical peripheral pulses; lower extremities weakness; and low back pain.[9]

Occasionally, lumbar spinal stenosis is concomitant with cervical or dorsal spinal stenosis; signs of cervical radiculopathy or myelopathy predominate in such cases are characterized by spasticity, hyperreflexia, clonus and loss of balance.

Differential diagnosis between neurogenic and vascular claudication

The differential diagnosis between neurogenic and vascular claudication must be defined at the time of the physical examination of the patient. Treatment must only start after this differentiation.

Most vascular (ischemic) lameness cases present with calf pain with potential proximal extension. The arterial pulses of the lower limbs are often diminished, while aortic, femoral, popliteal, posterior tibial and dorsalis pedis arteries must be searched by palpation or auscultation.

The patient usually reports that symptoms are aggravated and relieved by activities in any position. Relief has nothing to do with flexion or extension. Riding a bicycle worsens symptoms of vascular stenosis, which does not happen in cases of neurogenic stenosis due to trunk flexion.

If vascular alterations are suspected, specific tests to investigate arterial and venous peripheral circulation must be requested.

In elderly patients, it is also important to exclude peripheral neuropathies, especially in diabetics. These neuropathies are mainly characterized by feet hypoesthesia, reduced vibratory sensitivity, nocturnal "burning" and lack of correlation with physical activity. In such cases, an electroneuromyography exam must be requested to establish the differential diagnosis.

Delamarter et al[10] and Rydevik et al[11] described the electrophysiological changes in nerve roots resulting from vascular congestion by extrinsic compression, as occurs in spinal stenosis. These authors attempted to demonstrate that most stenosis signs and symptoms are caused by a vascularization disturbance of the nervous structures, associated with inflammatory alterations, rather than compression itself. Thus, it can be concluded that the signs and symptoms from the result of degenerative spinal cavity stenosis are caused by a sum of mechanical, vascular and neurological changes.

Lumbar stenosis imaging

Lumbar stenosis is a clinical and radiological syndrome; the following information must be provided to radiologists in case of suspicion of lumbar stenosis: first, whether or not the patient meets stenosis criteria; second, in case there is a stenosis, detailed information about its location and the factor(s) causing it. This information is required to recommend appropriate treatment options.

The North American Spine Society guidelines state that imaging is the main noninvasive test for lumbar spinal stenosis diagnosis but does not provide radiological criteria for the condition. Most specialists in musculoskeletal radiology use qualitative criteria for lumbar spinal stenosis diagnosis. According to Genevay et al,[12] there are several criteria to describe lumbar spinal stenosis; however, they are not always clearly defined, potentially hindering a reliable diagnosis.

Qualitative criteria used for lumbar spinal stenosis diagnosis include:

- Disc protrusion
- Perineural fat fading
- Joint facet degeneration and hypertrophy
- Lack of fluid around the cauda equina
- Ligamentum flavum hypertrophy
- Cauda equina roots redundancy and serpentine shape
- Epidural lipomatosis[13] (►**Figure 2A**)

Plain radiography

Spinal stenosis can be strongly suspected on plain radiographs of patients with back pain. The anteroposterior (AP) diameter of the vertebral canal increases caudally and it must be considered abnormal if it is < 12 mm at the lumbar spine[14] and < 10 mm at the cervical spine.[15,16]

Magnetic resonance imaging and computed tomography

Magnetic resonance imaging (MRI) is suggested as the most appropriate noninvasive test to confirm the presence of anatomical narrowing of the vertebral canal or radicular impingement in patients with clinical suspicion of lumbar spinal stenosis. Lumbar spinal stenosis can be diagnosed based on the AP diameter of the spinal canal or the cross-sectional area of the dural sac.

The cross-sectional area of the dural sac is considered normal if it is > 100 mm^2 at its narrowest point; it is stenotic if it measures between 76 and 100 mm^2 and severely stenotic if it is < 76 mm^2. Magnetic resonance imaging and computed tomography (CT) allow the direct visualization of central and lateral canals. Magnetic resonance imaging has the added benefit of soft tissue visualization.[17]

Evaluation of the vertebral canal – diagnostic criteria

- Bony canal AP diameter < 10 mm at the cervical spine or < 12 mm at the lumbar spine;
- The cross-sectional area of the dural sac at its narrowest point is considered stenotic if it measures between 76 and 100 mm^2 and severely stenotic if it is < 76 mm^2.

Evaluation of the neuroforamen and lateral recess – diagnostic criteria

- Foraminal AP diameter < 3 mm in sagittal imaging is considered a diagnostic factor for stenosis;

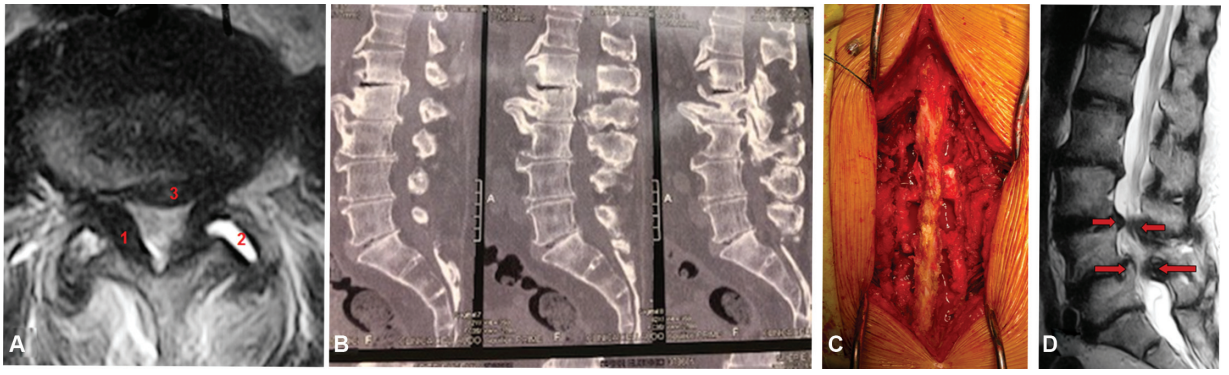

Fig. 2 (A) Axial magnetic resonance imaging (MRI) showing spinal stenosis with ligamentum flavum thickening (1), facet arthrosis with synovitis (2) and disc protrusion (3). (B) Sagittal computed tomography (CT) scan showing L1-L2-L3-L4 spinal stenosis. (C) Surgical photography: three-level decompression using the conventional laminectomy technique plus lateral recess resection and bilateral foraminotomy. (D) Sagittal MRI showing degenerative L3-L4 and L4-L5 stenosis with degenerative spondylolisthesis in L4-L5.

- Lateral recess height < 3 mm or a lateral recess angle $< 30°$ are also evidence of spinal stenosis.

Functional spine stenosis

Functional spine stenosis is more important than bony spine stenosis in clinical presentation.[14] Functional spine stenosis is produced by several soft tissue components, such as disc protrusion; ligament hypertrophy; synovial cysts; and instabilities, which determine neurological symptoms and manifestations, often not demonstrated in imaging studies. Orthostatic scans (orthostatic MRI) and functional studies (dynamic radiographs) can help to confirm the stenosis diagnosis at imaging.

More recent neurography exams (specialized nerve resonance) can provide specific quantitative information about physiological root and ganglia changes through water diffusion from axons, contributing to a better understanding of symptoms and clinical correlation.

Lumbar spinal stenosis: conservative treatment

In 1993, Onel et al[17] published their experience with conservative treatment in a prospective study including 145 patients with lumbar spinal stenosis

Conservative treatment consisted of physical therapy with thermal analgesia plus exercises and calcitonin. The patients showed statistically significant improvement, except for deep reflex changes. The authors concluded that conservative treatment may be the method of choice in older patients and those without clinical conditions for decompression surgery.

If neurogenic claudication is not severe and there are no symptoms of motor deficit, the initial treatment must attempt to relieve pain with rest and changes in daily activities. Initially, analgesics and nonsteroidal anti-inflammatory drugs are recommended, possibly associated with muscle relaxants. In this phase, physical therapy with thermal analgesia, transcutaneous nerve stimulation (TENS) and light mobilization exercises with stretching and progressive muscle strength for postural correction can be performed for pain relief. Acupuncture, chiropractic procedures and McKenzie exercises can also be used for pain relief. None of these methods has proven superiority over another, and none provides significant neurogenic claudication improvement.[18,19]

If there is a history of lower limb chronic pain, paresthesia, dysesthesia, or neuropathic pain, this treatment can be associated with tricyclic antidepressants and/or anticonvulsants such as gabapentin or pregabalin. Pregabalin is the drug of choice in neuropathic pain, with $\sim$ 40% of patients reporting relief.[20]

In addition, analgesics, anti-inflammatories and anticonvulsants do not demonstrate great efficacy in neurogenic claudication improvement. Steroids may be indicated in case of radicular irritation worsening, always for a brief period of time to reduce the risk of side effects; narcotic analgesics can also be used.

Epidural block with steroid injection into the epidural space relieves spinal stenosis symptoms; this treatment is more efficient in radiculopathies than in neurogenic claudication, although there are no studies demonstrating its long-term effectiveness. Riew et al reported that 71% of patients who initially agreed with surgery gave up on it after being subjected to a selective injection of betamethasone and bupivacaine into nerve roots.[21]

These blocks can be performed via interlaminar or caudal approaches and, when radicular pain predominates, a selective transforaminal injection into the nerve root with steroids and bupivacaine performed under fluoroscopic guidance is indicated.

Conservative or surgical treatment?

A study by Johnsson et al[22] reported the conservative treatment outcomes in a group of 49 patients, revealing that only 18% of them required surgical treatment.

Zaina et al[23] evaluated the effectiveness of the different surgical techniques and compared them with different types of conservative treatment for lumbar spinal stenosis; these authors concluded that it is impossible to say which therapy (surgical or conservative) is best due to the wide variety of performed approaches.

Patients usually opt for surgical treatment when the clinical presentation is aggravated by symptoms of radicular involvement, as in lateral recess stenosis.[24]

Outcomes from surgical decompression associated or not with arthrodesis are superior in the first postoperative years and usually converge after 8 years of surgery.[25,26]

Based on the various studies, it can be concluded that conservative treatment is the method of choice at an early stage for both radicular symptoms and neurogenic claudication, as long as there is no neurological impairment with motor deficit and progressive worsening for the former, or lameness at a short walking test for the latter. In such cases, surgical treatment is recommended.[27]

Surgical treatment

Surgical treatment for lumbar spinal stenosis is indicated in cases of conservative treatment failure. It is also indicated in cases with very acute symptoms and radicular involvement associated with dermatome sensorial and motor changes and progressive worsening of severe neurogenic claudication. In these circumstances, symptoms must be related to imaging findings, which will guide the type of surgery to be performed regarding the segment and area requiring decompression.

It is also important to assess the need for decompression and arthrodesis in a situation of clinical and/or radiological instability, especially when imaging studies reveal a diagnosis of degenerative spondylolisthesis. The need for decompression associated with arthrodesis and deformity correction must be determined in both coronal and sagittal axis at the time of strategic planning for surgical intervention. The goal of surgical treatment is to improve function, relieve pain and reduce or prevent neurological deficit. To do so, neural structures decompression is required, and its

extension will be determined by signs, symptoms and imaging findings from each case. Even when low back pain is important compared to radicular symptoms, pain relief is achieved in most cases undergoing decompression.[28]

Vertebral canal decompression can be performed with several techniques. The gold standard is the open technique with laminectomy or laminotomy, in which laminae are resected or opened; next, the ligamentum flavum, usually thickened, is resected, exposing the nervous structures under compression. Laminotomy can be unilateral, bilateral or divide the spinous process. The latter decreases paravertebral musculature injury, reducing postoperative complications related to hematomas, seromas and infections and trunk extensor musculature atrophy.[29,30] The dural sac is decompressed after its exposure and removed to allow the resection of the lateral recess and foramen opening to decompress an adjacent and/or emerging nerve root (►**Figures 2B** and **2C**). Such decompression can also be achieved with minimally invasive techniques.[31]

A bilateral foraminal decompression, if required, can be performed using several approaches: bilateral opening; unilateral opening to reach both lateral recesses and foramina; or unilateral approach, reaching the contralateral side using the endoscopic over-the-top technique (►**Figure 2**).[32]

Today, there is a lot of discussion about outcomes from open techniques compared to minimally invasive techniques. Evidence from systematic reviews and meta-analyzes suggest that the unilateral laminectomy technique for minimally invasive bilateral decompression is associated with less blood loss and shorter hospital stay, with similar complications and long-term results compared with the open technique.[33]

Pure foraminal stenosis can be resolved surgically with an open technique using laminectomy or a percutaneous endoscopic technique with osteophytes resection or discectomy.[34]

Decompression surgery and arthrodesis

The need for arthrodesis after decompression due to lumbar spinal stenosis depends basically on the presence of clinical and/or radiological segmental instability

Radiological parameters must be considered when accompanied by an indicative clinical presentation of spine stenosis, remembering that variations occasionally exist with no significant symptoms.[35,36]

Arthrodesis surgery associated with decompression is also indicated when a bilateral resection of $> 50\%$ of the facets is required to decompress neurological structures, leading to the risk of iatrogenic instability, or in the presence of progressive degenerative scoliosis with coronal and sagittal axis deviation and spinal stenosis at several levels.[37]

Degenerative spondylolisthesis

Many symptomatic cases of lumbar spinal stenosis present with degenerative spondylolisthesis at imaging studies. The degree of facet and disc degeneration leading to listhesis varies significantly in each case and there are different degrees of upper vertebra slipping over lower vertebra in the AP or lateral direction. This translation can lead to nerve roots compression at the foramen or the lateral recess; in addition, it may decrease the diameter of the vertebral canal, leading to central stenosis (►**Figure 2D**).

Decompression is sufficient in most cases requiring surgical treatment for degenerative spondylolisthesis. For broader facet resection or if there is evidence of clinical or radiological instability, decompression is associated with arthrodesis.[38]

A meta-analysis from Martdjetko et al[39] on studies published from 1970 to 1993 about degenerative spondylolisthesis surgery showed better outcomes in patients undergoing decompression and arthrodesis, either in situ or instrumented, compared to those submitted only to decompression.[40]

Arthrodesis associated with decompression for degenerative spondylolisthesis can be performed using an open posterolateral route or a minimally invasive technique – transforaminal lumbar interbody fusion (TLIF) or minimally invasive (MIS) TLIF. Published reports did not find major differences in outcomes from both techniques, except for the shortest hospitalization time, the least amount of bleeding and the least degree of pain in patients undergoing MIS TLIF.[41]

A mini-open arthrodesis using the transmuscular posterolateral approach (Wiltse technique), which is less expensive and has the same outcomes as MIS TLIF, is the preference of the authors.[42,43]

Interspinous devices

These devices intend to promote, through minimally invasive (mini-open) techniques, distraction between spinous processes to restore foraminal height and stabilize the affected segment. Several works were published when these devices were first introduced, showing promising results, superior to those obtained with the simple decompression technique.[44–46]

However, in recent years, systematic reviews and meta-analyzes have questioned these outcomes, and the North American Spine Society stated that there is insufficient evidence to indicate the use of interspinous devices, which are considered an investigational technique.[47–50]

Degenerative scoliosis

Degenerative scoliosis is the most advanced stage of the Kirkaldy-Willis degenerative cascade.

Coronal axis deformity is not usually accentuated in these circumstances and, in general, the Cobb angle is not superior to 30°. Sagittal axis deformity develops due to a progressive loss of lumbar lordosis, with consequent axial imbalance.

The spinopelvic relationship must be studied not only to assess the degree of sagittal axis imbalance, but also the degree of pelvic version, which may have increased to compensate such imbalance. It is also important to determine the lumbar lordosis discrepancy to the degree of pelvic incidence to plan the surgery that will eventually be required

in case of worsening symptoms of pain, muscle fatigue, loss of strength and progressive walking difficulty. Restoring lumbar lordosis is the main goal when correcting degenerative scoliosis, associated with neural elements decompression and arthrodesis (►**Figure 3A–F**).[51–55]

Today, to decrease the risk of complications, the association of a minimally invasive anterior (anterior lumbar interbody fusion [ALIF]), lateral (extreme lateral interbody fusion, [X-LIF]) or oblique (oblique lateral interbody fusion [OLIF]) arthrodesis[56–59] with posterior fixation is recommended

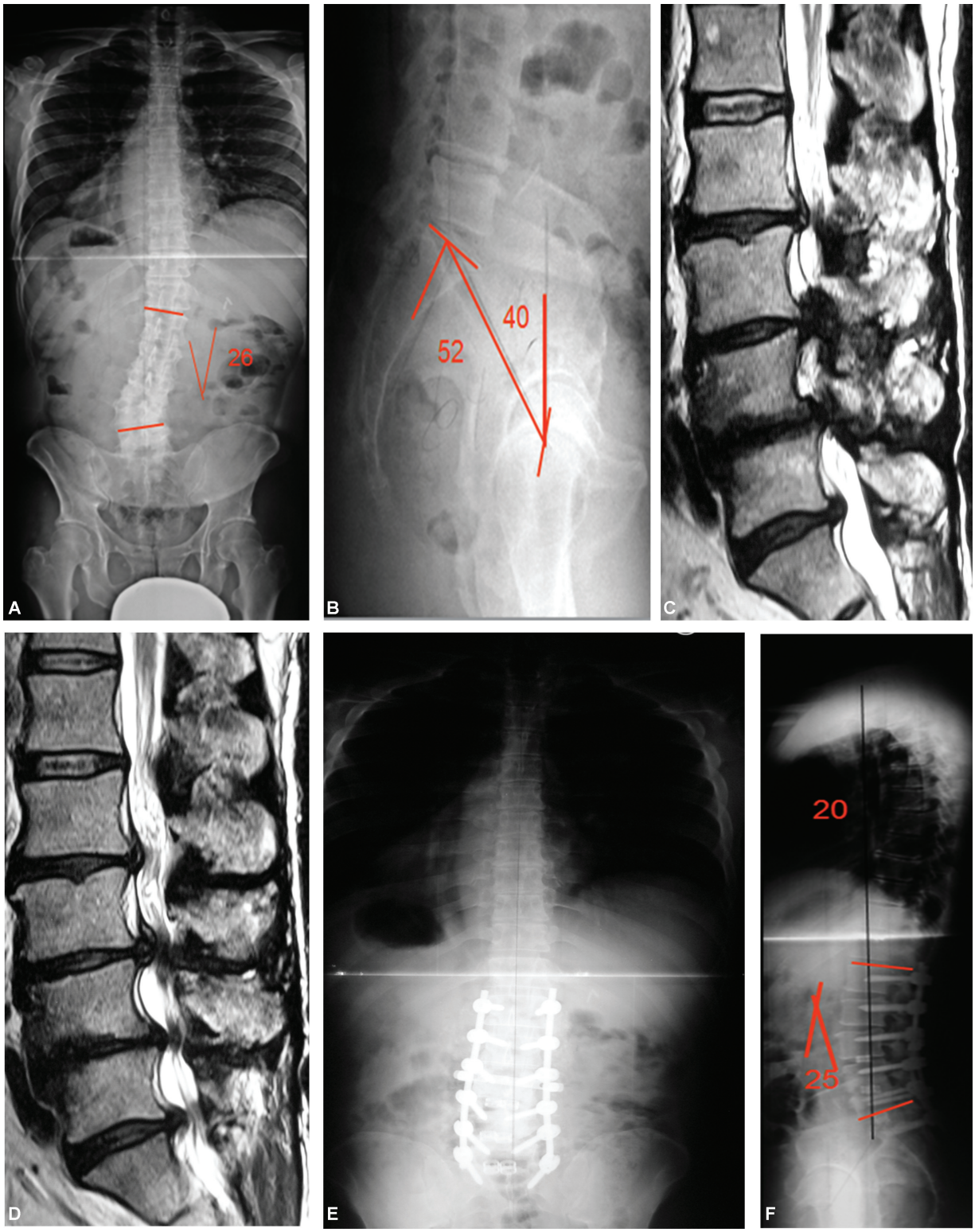

Fig. 3 Degenerative scoliosis: (A and B) Radiography: degenerative scoliosis with decreased lumbar lordosis and increased pelvic version. (C and D) Sagittal magnetic resonance imaging: L2 to S1 spinal stenosis. (E and F) Postoperative radiography: deformities correction with increased lumbar lordosis and decreased pelvic version.

when a large increase in lumbar lordosis is required, instead of posterior subtraction pedicular osteotomy.

Final considerations

It is crucial to know the pathophysiology of spinal stenosis and to determine the precise location of the cause of pain using clinical and imaging findings to indicate a conservative or surgical treatment. As for surgical treatment, knowing when to indicate only decompression or to associate it to arthrodesis is essential to obtain the best outcome.

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

References

1 Eisenstein S. The morphometry and pathological anatomy of the lumbar spine in South African negroes and caucasoids with specific reference to spinal stenosis. J Bone Joint Surg Br 1977; 59(02):173–180
2 Paine KW. Clinical features of lumbar spinal stenosis. Clin Orthop Relat Res 1976;(115):77–82
3 Grobler LJ, Robertson PA, Novotny JE, Ahern JW. Decompression for degenerative spondylolisthesis and spinal stenosis at L4-5. The effects on facet joint morphology. 1993;18(11):1475–1482
4 Turner JA, Ersek M, Herron L, Deyo R. Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. 1992;17(01): 1–8
5 Schönström N, Lindahl S, Willén J, Hansson T. Dynamic changes in the dimensions of the lumbar spinal canal: an experimental study in vitro. J Orthop Res 1989;7(01):115–121
6 Amundsen T, Weber H, Lilleås F, Nordal HJ, Abdelnoor M, Magnaes B. Lumbar spinal stenosis. Clinical and radiologic features. 1995; 20(10):1178–1186
7 Kirkaldy-Willis WH, Wedge JH, Yong-Hing K, Reilly J. Pathology and pathogenesis of lumbar spondylosis and stenosis. 1978;3 (04):319–328
8 Liu X, Zhao X, Long Y, Huang K, Xie D, Wang F, et al. Facet Sagittal Orientation: Possible Role in the Pathology of Degenerative Lumbar Spinal Stenosis. 2018;43(14):955–958
9 Tomkins-Lane C, Melloh M, Lurie J, et al. ISSLS Prize Winner: Consensus on the Clinical Diagnosis of Lumbar Spinal Stenosis: Results of an International Delphi Study. 2016;41(15):1239–1246
10 Delamarter RB, Bohlman HH, Dodge LD, Biro C. Experimental lumbar spinal stenosis. Analysis of the cortical evoked potentials, microvasculature, and histopathology. J Bone Joint Surg Am 1990; 72(01):110–120
11 Rydevik B, Brown MD, Lundborg G. Pathoanatomy and pathophysiology of nerve root compression. 1984;9(01):7–15
12 Genevay S, Atlas SJ, Katz JN. Variation in eligibility criteria from studies of radiculopathy due to a herniated disc and of neurogenic claudication due to lumbar spinal stenosis: a structured literature review. 2010;35(07):803–811
13 Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J; Lumbar Spinal Stenosis Outcome Study Working Group Zurich. Radiologic criteria for the diagnosis of spinal stenosis: results of a Delphi survey. Radiology 2012;264(01):174–179
14 Gopinathan P. Lumbar spinal canal stenosis-special features. J Orthop 2015;12(03):123–125
15 Castillo M, Keith Smith J, Mukherji Suresh K. The spine. In: Lee JKT, Segal SS, Stanley RJ, Heiken JP, editors. Computed body tomography with MRI correlation. 3rd. Philadelphia: Lippincott-Raven; 1998:1451–1454
16 Verbiest H. Neurogenic Intermittent Claudication with Special Reference to Stenosis of the Lumbar Vertebral Canal in Hand Book of Clinical Radiology. Amsterdam: North Holand pub co.; 1976;611:e807
17 Onel D, Sari H, Dönmez C. Lumbar spinal stenosis: clinical/radiologic therapeutic evaluation in 145 patients. Conservative treatment or surgical intervention? 1993;18(02):291–298
18 Tomkins CC, Dimoff KH, Forman HS, et al. Physical therapy treatment options for lumbar spinal stenosis. J Back Musculoskeletal Rehabil 2010;23(01):31–37
19 Donelson R, Silva G, Murphy K. Centralization phenomenon. Its usefulness in evaluating and treating referred pain. 1990;15(03): 211–213
20 Moore RA, Straube S, Wiffen PJ, Derry S, McQuay HJ. Pregabalin for acute and chronic pain in adults. Cochrane Database Syst Rev 2009;(03):CD007076
21 Riew KD, Yin Y, Gilula L, et al. The effect of nerve-root injections on the need for operative treatment of lumbar radicular pain. A prospective, randomized, controlled, double-blind study. J Bone Joint Surg Am 2000;82(11):1589–1593
22 Johnsson KE, Udén A, Rosén I. The effect of decompression on the natural course of spinal stenosis. A comparison of surgically treated and untreated patients. 1991;16(06):615–619
23 Zaina F, Tomkins-Lane C, Carragee E, Negrini S. Surgical Versus Nonsurgical Treatment for Lumbar Spinal Stenosis. 2016;41(14): E857–E868
24 Kurd MF, Lurie JD, Zhao W, et al. Predictors of treatment choice in lumbar spinal stenosis: a spine patient outcomes research trial study. 2012;37(19):1702–1707
25 Atlas SJ, Keller RB, Wu YA, Deyo RA, Singer DE. Long-term outcomes of surgical and nonsurgical management of lumbar spinal stenosis: 8 to 10 year results from the maine lumbar spine study. 2005;30(08):936–943
26 Malmivaara A, Slätis P, Heliövaara M, et al; Finnish Lumbar Spinal Research Group. Surgical or nonoperative treatment for lumbar spinal stenosis? A randomized controlled trial. 2007;32 (01):1–8
27 Amundsen T, Weber H, Nordal HJ, Magnaes B, Abdelnoor M, Lilleâs F. Lumbar spinal stenosis: conservative or surgical management?: A prospective 10-year study. 2000;25(11):1424–1435
28 Srinivas S, Paquet J, Bailey C, et al. Effect of spinal decompression on back pain in lumbar spinal stenosis: a Canadian Spine Outcomes Research Network (CSORN) study. Spine J 2019;19(06): 1001–1008
29 Rajasekaran S, Thomas A, Kanna RM, Prasad Shetty A. Lumbar spinous process splitting decompression provides equivalent outcomes to conventional midline decompression in degenerative lumbar canal stenosis: a prospective, randomized controlled study of 51 patients. 2013;38(20):1737–1743
30 Cho DY, Lin HL, Lee WY, Lee HC. Split-spinous process laminotomy and discectomy for degenerative lumbar spinal stenosis: a preliminary report. J Neurosurg Spine 2007;6(03): 229–239
31 Lee CH, Choi M, Ryu DS, et al. Efficacy and Safety of Full-endoscopic Decompression via Interlaminar Approach for Central or Lateral Recess Spinal Stenosis of the Lumbar Spine: A Meta-analysis. 2018;43(24):1756–1764
32 Siepe CJ, Sauer D, Michael Mayer H. Full endoscopic, bilateral over-the-top decompression for lumbar spinal stenosis. Eur Spine J 2018;27(Suppl 4):563–565
33 Rosen DS, O'Toole JE, Eichholz KM, et al. Minimally invasive lumbar spinal decompression in the elderly: outcomes of 50 patients aged 75 years and older. Neurosurgery 2007;60(03): 503–509
34 Woo YH, Jung HT, Kim IB, Sun WS, Jung DW. Percutaneous Transforaminal Endoscopic Decompression for Lumbar Foraminal Stenosis. J Clin Exp Orthop3:42

35 Leone A, Guglielmi G, Cassar-Pullicino VN, Bonomo L. Lumbar intervertebral instability: a review. Radiology 2007;245(01):62–77
36 da Costa LM, Hennemann AS, de Abreu MR, Antoneli PH. Correlação entre instabilidade radiográfica e presença do sinal de modic. Coluna/Columna 2011;10(02):132–135
37 Hansraj KK, O'Leary PF, Cammisa FP Jr, et al. Decompression, fusion, and instrumentation surgery for complex lumbar spinal stenosis. Clin Orthop Relat Res 2001;200(384):18–25
38 Schroeder GD, Kepler CK, Kurd MF, et al. Rationale for the Surgical Treatment of Lumbar Degenerative Spondylolisthesis. 2015;40 (21):E1161–E1166
39 Mardjetko SM, Connolly PJ, Shott S. Degenerative lumbar spondylolisthesis. A meta-analysis of literature 1970-1993. 1994;19 (20, Suppl)2256S–2265S
40 McAnany SJ, Baird EO, Qureshi SA, Hecht AC, Heller JG, Anderson PA. Posterolateral Fusion Versus Interbody Fusion for Degenerative Spondylolisthesis: A Systematic Review and Meta-Analysis. 2016;41(23):E1408–E1414
41 Hammad A, Wirries A, Ardeshiri A, Nikiforov O, Geiger F. Open versus minimally invasive TLIF: literature review and meta-analysis. J Orthop Surg Res 2019;14(01):229
42 Pakzaban P. Modified Mini-open Transforaminal Lumbar Interbody Fusion: Description of Surgical Technique and Assessment of Freehand Pedicle Screw Insertion. 2016;41(18):E1124–E1130
43 Ge DH, Stekas ND, Varlotta CG, et al. Comparative Analysis of Two Transforaminal Lumbar Interbody Fusion Techniques: Open TLIF Versus Wiltse MIS TLIF. 2019;44(09):E555–E560
44 Zucherman JF, Hsu KY, Hartjen CA, et al. A multicenter, prospective, randomized trial evaluating the X STOP interspinous process decompression system for the treatment of neurogenic intermittent claudication: two-year follow-up results. 2005;30(12):1351–1358
45 Kuchta J, Sobottke R, Eysel P, Simons P. Two-year results of interspinous spacer (X-Stop) implantation in 175 patients with neurologic intermittent claudication due to lumbar spinal stenosis. Eur Spine J 2009;18(06):823–829
46 Richter A, Schütz C, Hauck M, Halm H. Does an interspinous device (Coflex) improve the outcome of decompressive surgery in lumbar spinal stenosis? One-year follow up of a prospective case control study of 60 patients. Eur Spine J 2010;19(02):283–289
47 Strömqvist BH, Berg S, Gerdhem P, et al. X-stop versus decompressive surgery for lumbar neurogenic intermittent claudication: randomized controlled trial with 2-year follow-up. 2013;38 (17):1436–1442
48 Poetscher AW, Gentil AF, Ferretti M, Lenza M. Interspinous process devices for treatment of degenerative lumbar spine stenosis: A systematic review and meta-analysis. PLoS One 2018;13(07):e0199623
49 Gazzeri R, Galarza M, Alfieri A. Controversies about interspinous process devices in the treatment of degenerative lumbar spine diseases: past, present, and future. BioMed Res Int 2014; 2014:975052
50 Gazzeri R, Galarza M, Neroni M, et al. Failure rates and complications of interspinous process decompression devices: a European multicenter study. Neurosurg Focus 2015;39(04): E14
51 Yong-Hing K, Kirkaldy-Willis WH. The pathophysiology of degenerative disease of the lumbar spine. Orthop Clin North Am 1983; 14(03):491–504
52 Roussouly P, Gollogly S, Berthonnaud E, Dimnet J. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. 2005;30(03): 346–353
53 Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. 2005;30(06):682–688
54 Kim YJ, Bridwell KH, Lenke LG, Rhim S, Cheh G. An analysis of sagittal spinal alignment following long adult lumbar instrumentation and fusion to L5 or S1: can we predict ideal lumbar lordosis? 2006;31(20):2343–2352
55 Rose PS, Bridwell KH, Lenke LG, et al. Role of pelvic incidence, thoracic kyphosis, and patient factors on sagittal plane correction following pedicle subtraction osteotomy. 2009;34(08): 785–791
56 Mundis GM, Akbarnia BA, Phillips FM. Adult deformity correction through minimally invasive lateral approach techniques. 2010;35 (26, Suppl)S312–S321
57 Phillips FM, Isaacs RE, Rodgers WB, et al. Adult degenerative scoliosis treated with XLIF: clinical and radiographical results of a prospective multicenter study with 24-month follow-up. 2013; 38(21):1853–1861
58 Amaral R, Marchi L, Oliveira L, et al. Opção minimamente invasiva lateral para artrodese intersomática tóraco-lombar. Coluna/Columna 2011;10(03):239–243
59 Abbasi H, Miller L, Abbasi A, Orandi V, Khaghany K. Minimally invasive scoliosis surgery with oblique lateral lumbar interbody fusion: single surgeon feasibility. Cureus 2017;9(06):e1389

Update on Cervical Hernia Treatment: Conservative Management and Indications of Different Surgical Techniques

Atualização no tratamento da hérnia discal cervical: Manejo conservador e indicações de diferentes técnicas cirúrgicas

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Summary

Cervical and root pain due to herniated disc is one a common cause of a visit to an orthopedic surgeon. It is important to know how to diagnose, treat and initially.[Q2] What are the best options to treat a herniated disc nowadays? The present article reviews the literature and updates on the clinical and surgical treatment of cervical disc herniation.

Keywords

- cervical vertebrae
- intervertebral disc displacement/diagnosis
- intervertebral disc displacement/therapy
- intervertebral disc displacement/surgery

Resumo

A dor cervical e radicular devido à hérnia de disco é uma causa comum de uma visita a um cirurgião ortopédico. É importante saber diagnosticar, tratar e inicialmente.[Q3] Quais são as melhores opções para tratar a hérnia de disco hoje em dia? Este artigo faz uma revisão da literatura e atualização sobre o tratamento clínico e cirúrgico da herniação do disco cervical.

Palavras-chave

- vértebras cervicais
- deslocamento do disco intervertebral/diagnóstico
- deslocamento do disco intervertebral/terapia
- deslocamento do disco intervertebral/cirurgia

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Introduction

Cervical disc disease may have different forms of presentation, such as cervicalgy, radiculopathy, and myelopathy, and this differentiation by the orthopedist is important to guide the treatment.

Cervicalgy, or cervical pain, is the most prevalent symptom of cervical disc syndrome, presenting a lifetime prevalence of 48.5 to 66.7%, depending on the study analyzed.[1,2]

Cervical radiculopathy may be of compressive or inflammatory etiology, due to cytokines released due to disc herniation and rupture of the fibrous annuity.[3] It may present as brachialgia, sensory alteration, motor alteration, scapular pain, and headache.[4]

Myelopathy caused by disc herniation with anterior compression of the medulla may present with gait and sphincter alterations as well as with signs of first motor neuron involvement.

The pathophysiological process that encompasses cervical disc disease begins in the third decade of life, with disc vascularization reduction and increased sclerosis of the terminal plates, thus facilitating disc wear and decreasing the formation of proteoglycans. Once this process is started, there is a change in the load absorption by the disc, promoting fissures in the annulus and, finally, disc herniation or collapse.[5,6]

It is important to emphasize that physical examination provides us with valuable information in the etiological investigation and location of the disease in the cervical spine.

We should always characterize cervical pain, if it has associated muscle contracture, if pain worsens with cervical extension or flexion, and pain's duration.

Root pain usually follows a pattern of distribution on the examination (►**Table 1**), which should be investigated step by step and may present worsening during the Spurling test and improvement in shoulder abduction.

Looking for findings of myelopathy is essential since it can often take time to present symptoms, and the outcome can be catastrophic. We should always evaluate reflexes, gait, muscular trophism, and Hoffman signal presence.

The complementary tests available for diagnostic confirmation and understanding of the cervical disease in question are: anteroposterior, profile, flexion and extension profile radiographies; computed tomography; and magnetic resonance imaging (MRI).

Provocative discography, which has been used in the past, is less and less indicated due to its limited accuracy, with high false-positive rates that can reach up to 50%, and with the possibility of early degeneration at control levels.[7]

Recently, with a better understanding of cervical and global sagittal alignment in the promotion of cervical diseases, as well as in surgical planning and its correlation with the clinical outcome, cervical and panoramic spine radiographs became important tools, requiring radiological measurements in addition to cervical lordosis, such as: the vertical sagittal axis (VSA) of the cervical spine, T1 inclination and neck tilt, which are parameters similar to those described for spinopelvic alignment[8,9] (►**Figure 1**).

Treatment

There are several treatment options for cervical disc herniation, including drug treatment; non-interventional treatment, which includes physiotherapy, acupuncture, immobilization, and traction; interventional treatment of pain, which includes neural and facet blocks; and surgical treatment, which is indicated in cases of non-treatable radiculopathy or myelopathy[7] (**Chart 1**).

Making an analogy with conservative drug treatment for lumbosciatalgia, the best options are common analgesics, such as parecetamol and dipyrone associated or not with opioids, and targeted use of nonsteroidal antiinflammatory drugs (NSAIDs). The use of oral corticosteroids should be avoided, since it has not been shown to have benefits in the control of root pain.[10]

In the present day, controlled skeletal traction and strengthening exercises continue to be one of the best methods for pain relief in short and medium term, being more efficient than stretching. Skeletal traction can be performed in ventroflexion or slight cervical extension, initially with 4 to 7 kg and with possible load increment. No serious complications were seen with the use of traction.[11–13]

Interventional Treatment

In cases refractory to conservative treatment, therapeutic blocks can be performed to control root and axial pain. Basically, three types of blockage are used: selective foraminal block, translaminar epidural block, and facet blocks.

Fluoroscopy-guided selective foraminal block has good effectiveness in the treatment of root pain, with successful pain relief rates of around 81% for brachialgia and 66% for cervicalgia, and can thus avoid surgeries. Occurrences of severe complications are little reported, so these can be considered safe procedures.

Table 1 Distribution of the vicarious-brachial root dysfunction

Root	Pain localization	Motor dysfunction	Sensory dysfunction	Reflection
C5	Shoulder and arm	Deltoid, supraspinatus, infraspinatus and biceps.	Proximal and lateral shoulder	Bicipital
C6	Radial part of the forearm	Wrist biceps and extensors	Radial part of the forearm	Styloradial
C7	Dorsal part of the forearm	Fist triceps and flexors	Index finger and middle finger	Tricipital
C8	Ulnar part of the forearm	Hand intrinsics	Ring and ulnar hand edge	—

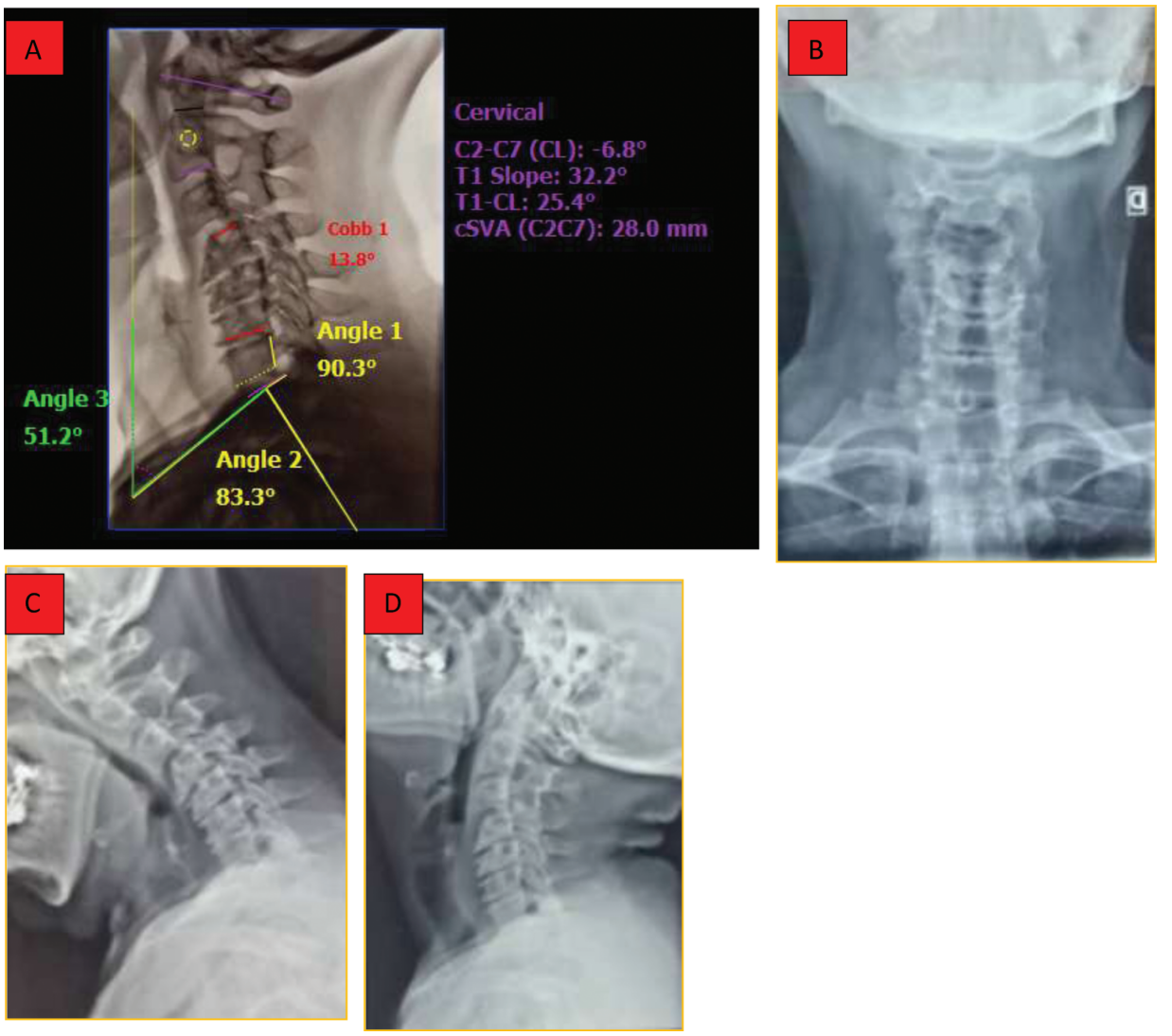

Fig. 1 Radiographic parameters of cervical sagittal alignment. (A) Profile radiography with measurements of sagittal alignment of the cervical spine; (B) Radiography in anteroposterior incidence; (C) Radiography in profile with cervical flexion; (D) Radiography in profile with cervical extension; (E) Computed tomography of the cervical spine; (F-G) Magnetic resonance imaging of the cervical spine.

Box 1[Q4] Cervical disc hernia treatment options

Conservative treatment	Interventionist treatment	Surgical treatment
• Drug therapy	• Foraminal block	• Posterior discectomy + foraminotomy
• Physical therapy	• Translaminar epidural block	• Anterior discectomy + arthrodesis
• Traction		• Cervical disc arthroplasty
• Strengthening		

On the other hand, interlaminar epidural cervical block, according to the literature, presents a moderate success rate for root pain relief, and, with some reports of quadriparesis or cervical spinal cord injury, it is not considered for routine use.[14–18]

Surgical Treatment

Surgical treatment of cervical disc herniation is indicated in cases of failure of conservative treatment or when signs and symptoms of myeloradicular compression are identified, that may cause excruciating, recurrent or major or compressive neurological deficit.

The main objective to be achieved, regardless of the surgical technique to be used, is the decompression of neural structures.

It should be emphasized that the current evidence does not support the surgical treatment of axial pain without root symptoms, either by arthrodesis or cervical disc arthroplasty, because they present unsatisfactory clinical results in the

subaxial region. Therefore, surgical treatment should be reserved for cases of spinal or root compressive syndromes.

Among the surgical treatment options available, the surgeon can choose from the following techniques: posterior discectomy associated with foraminotomy, open or minimally invasive; previous cervical approaches to decompression associated or not with cervical arthrodesis; or the use of cervical disc arthroplasties.

Posterior Discectomy

Posterior discectomy, abandoned in the past due to neurological complications and tissue aggression in open surgeries, is regaining ground in selected cases of posterolateral or foraminal herniations that present with radiculopathy, using minimally invasive methods with tubular or endoscopic reformers.

Posterior foraminal decompression, described by Scoville in 1944, has been improved; however, the basic precepts of partial preservation of articular facets to avoid instability, in addition to contraindications for its use in central disc hernias and posterior longitudinal ligament calcification, should be respected.

Thus, the use of endoscopic scans for this purpose has been shown to be effective, with a reduction of 87 to 97% of root pain.[19–23]

Current evidence suggests that the risks of minimally invasive surgery may not outweigh its benefits, and that the routine use of these techniques require more detailed studies with a better level of evidence. However, with adequate training and careful selection of patients, the new technologies have proven safe and promising.[24]

Anterior Cervical Discectomy and Arthrodesis

In 1958, Cloward described the first anterior discectomy and cervical arthrodesis with iliac crest structural graft, and, respecting the appropriate evolutions in the technique, this is still widely recognized as the gold standard for the surgical treatment of cervical disc herniation (►**Figure 2**). Currently, titanium or polyetereterketone (PEEK) spacers (cages) and plates are used, with the aim of ensuring greater stability, restoring cervical lordosis, decreasing subsidence rates and increasing osteointegration.[25]

Recent randomized studies, systematic reviews and meta-analysis, comparing the use of stand-alone cages and surgeries using cages and plates, demonstrated advantages in the adjunct use of plates and screws, such as: greater immediate biomechanical stability, higher arthrodesis rates, cervical lordosis and cervicalgia improvement, and lower subsidence rates. However, non-statistically significant complications may occur more frequently when using plates and screws, such as dysphagia and failure of synthesis material.

Despite the improvement of cervical pain in studies with the use of plaque, functional results are similar in both groups.[27]

In order to reduce tissue aggression, dysphagia, and adjacent level syndrome, blocked cages were developed using anchors or screws.

In the current literature, studies demonstrate that the use of blocked cages, compared to that of plate, present shorter surgical time, decreased blood loss and lower incidence of dysphagia in the late postoperative period, as well as less adjacent level ossification. However, the evaluation of clinical, functional, radiological, and subsidence rates were similar in both techniques.[28,29]

In patients with misalignment of the cervical sagittal plane and cervicobrachialgia, the maintenance or improvement of cervical alignment, especially cervical lordosis, T1 slope, and cervical lordosis discrepancy with T1 slope (CL–TS), showed good correlation with clinical and functional results, with arthrodesis being the most indicated in these cases.[30]

Arthroplasty

In order to preserve cervical mobility at the operated level, prevent adjacent level syndrome and improve clinical results, cervical intervertebral disc arthroplasty has been used in recent years (►**Figure 3**).

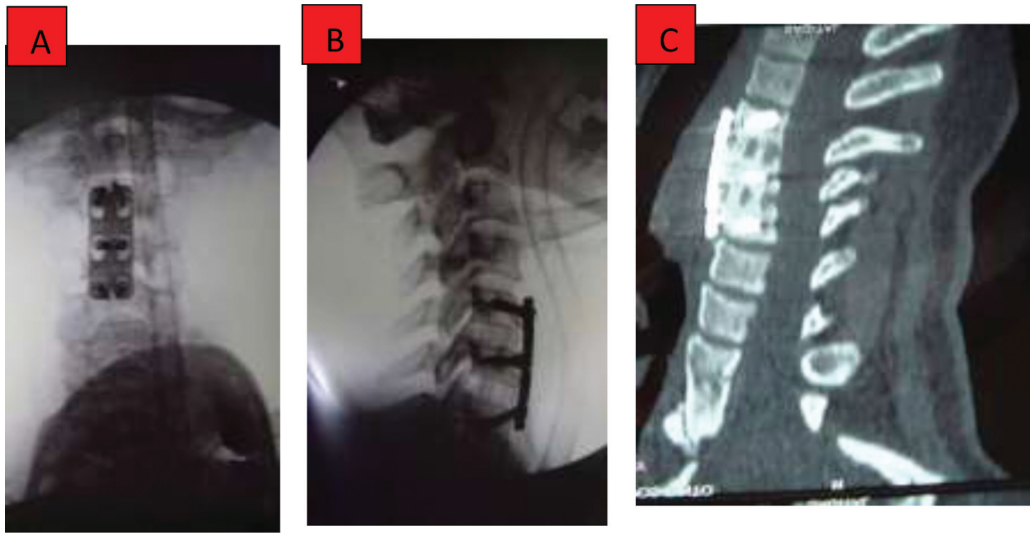

Fig. 2 Anterior cervical arthrodesis with plate and cage in polyetheretherketone. (A) Intraoperative imaging in anteroposterior incidence; (B) Intraoperative profile image; (C) Computed tomography showing consolidation.

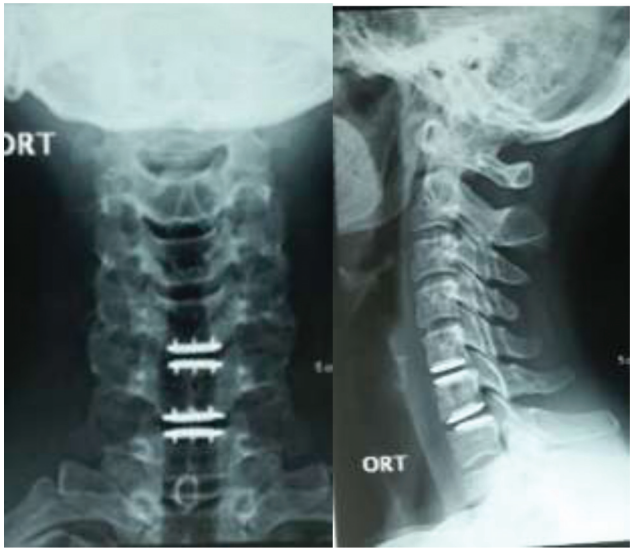

Fig. 3 Cervical disc arthroplasty. (A) Radiography in anteroposterior incidence; (B) Profile radiography.

Numerous models of prostheses, whether constrict, non-constrict and semi-constrict; made of metal-metal or polyurethane nuclei, all of them maintain the same indications of anterior cervical arthrodesis, presenting the following contraindications: surgery at three or more levels, cervical instability, osteopenia, active infection, and kyphotic deformity.[31]

Some studies demonstrate the superiority of the prosthesis, indicating the decrease in the rate of reoperation at the operated level, decrease in the incidence of syndrome of the adjacent level, and maintenance of the arch of motion of the cervical spine among the advantages, despite the appearance of relevant heterotopic ossification, which occurs in around 23% of the cases, without compromising the best clinical and functional results when compared to the anterior cervical arthrodesis [33]

However, other randomized studies question the effectiveness of arthroplasty when compared to anterior cervical discectomy associated or not with intersomatic fusion, with similar functional results between techniques, showing no superiority of one over the other.[33]

Final Considerations

Patients with cervical disc herniation may present with a myriad of radiological findings that may have clinical correlation or not. In the failure of conservative treatment, image-guided blocks can be used for the treatment of radiculopathy, and if surgical intervention is required, we must carry out a correct planning, based on the presence of discopathy, myelopathy, cervical alignment, and the presence or not of instability.

After a careful evaluation of the clinical picture, the choice of surgical procedure should be based on available hospital resources, surgeon's experience, and literature with the best level of evidence; thus, it will be possible to indicate the best surgical technique: discectomy/posterior foraminotomy, anterior arthrodesis, or arthroplasty.

Conflict of Interests

The authors declare that there is no conflict of interests.

References

1 Côté P, Cassidy JD, Carroll L. The Saskatchewan Health and Back Pain Survey. The prevalence of neck pain and related disability in Saskatchewan adults. Spine 1998;23(15):1689–1698
2 Fejer R, , Ko Kyvik, J Hartvigsen. The prevalence of neck pain in the world population: a systematic critical review of the literature. Eur Spine J 2006;15(06):834–848
3 Kang JD, Georgescu HI, , L McIntyre-Larkin, Stefanovic-Racic M, Evans CH. Herniated cervical intervertebral discs spontaneously produce matrix metalloproteinases, nitric oxide, interleukin-6, and prostaglandin E2. Spine 1995;20(22):2373–2378
4 Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol 2010;24(06):783–792
5 Clark CR, Benzel EC, Eds. The cervical spine. Philadelphia: Lippincott Williams & Wilkins; 2005
6 Taylor TK, Melrose J, Burkhardt D, et al. Spinal biomechanics and aging are major determinants of the proteoglycan metabolism of intervertebral disc cells. Spine 2000;25(23):3014–3020
7 Manchikanti L, Abdi S, Atluri S, et al. An update of comprehensive evidence-based guidelines for interventional techniques in chronic spinal pain. Part II: guidance and recommendations. Pain Physician 2013;16(2, Suppl)S49–S283
8 Pratali RR, Hennemann SA, Amaral R, et al. Standardized terminology of vertebral deformity from adult to Portuguese brazil. Column/Columna 2015;14(04):281–285
9 Ames CP, Blondel B, Scheer JK, et al. Cervical radiographical alignment: comprehensive assessment techniques and potential importance in cervical myelopathy. Spine 2013;38(22, Suppl 1): S149–S160
10 Goldberg H, Firtch W, Tyburski M, et al. Oral steroids for acute radiculopathy due to a herniated lumbar disk: a randomized clinical trial. JAMA 2015;313(19):1915–1923
11 Im Moustafa, Diab AA. Multimodal treatment program comparing 2 different traction approaches for patients with discogenic cervical radiculopathy: a randomized controlled trial. J Chiropr Med 2014;13(03):157–167
12 Yang JD, Tam KW, Huang TW, Huang SW, Liou TH, Chen HC. Intermittent Cervical Traction for Treating Neck Pain: A Meta-analysis of Randomized Controlled Trials. Spine 2017;42(13): 959–965
13 J Ylinen, Takala EP, Nykänen M, et al. Active neck muscle training in the treatment of chronic neck pain in women: a randomized randomized controlled trial. JAMA 2003;289(19):2509–2516
14 Ma DJ, Gilula LA, Riew KD. Complications of fluoroscopically guided extraforaminal cervical nerve blocks. An analysis of 1036 injections. J Bone Joint Surg Am 2005;87(05):1025–1030
15 Abbasi A, Malhotra G, Malanga G, Elovic EP, Kahn S. Complications of interlaminar cervical epidural steroid injections: a review of the literature. Spine 2007;32(19):2144–2151
16 Bose B. Quadriparesis following cervical epidural steroid injections: case report and review of the literature. Spine J 2005;5(05): 558–563
17 Hodges SD, Castleberg RL, Miller T, Ward R, Thornburg C. Cervical epidural steroid injection with intrinsic spinal cord damage. Two case reports. Spine 1998;23(19):2137–2142, discussion 2141–2142
18 Ludwig MA, Burns SP. Spinal cord infarction following cervical transforaminal epidural injection: a case report. Spine 2005;30 (10):E266–E268

19 Wb Scoville. Recent developments in the diagnosis and treatment of cervical ruptured intervertebral discs. Proc Am Fed Clin Res 1945;2:23
20 Song Z, Zhang Z, Hao J, et al. Microsurgery or open cervical foraminotomy for cervical radiculopathy? A systematic review. Int Orthop 2016;40(06):1335–1343
21 O'Toole JE, Sheikh H, Eichholz KM, Fessler RG, Perez-Cruet MJ. Posterior cervical endoscopic foraminotomy and discectomy. Neurosurg Clin N Am 2006;17(04):411–422
22 Gala VC, , Je O'Toole, JM Voyadzis, Fessler RG. Posterior minimally invasive approaches for the cervical spine. Orthop Clin North Am 2007;38(03):339–349, abstract v
23 Zdeblick TA, Zou D, Warden KE, McCabe R, Kunz D, Vanderby R. Cervical stability after foraminotomy. Biomechanical in vitro analysis. J Bone Joint Surg Am 1992;74(01):22–27
24 Evaniew N, Khan M, Drew B, Kwok D, Bhandari M, Ghert M. Minimally invasive versus open surgery for cervical and lumbar discectomy: a systematic review and meta-analysis. CMAJ Open 2014;2(04):E295–E305
25 Rb Cloward. The previous approach for removal of ruptured cervical disks. J Neurosurg 1958;15(06):602–617
26 Song KJ, Taghavi CE, Lee KB, Song JH, Eun JP. The efficacy of plate construct augmentation versus cage alone in anterior cervical fusion. Spine 2009;34(26):2886–2892
27 Oliver JD, Goncalves S, Kerezoudis P, et al. Comparison of Outcomes for Previous Cervical Discectomy and Fusion With and Without Previous Plate Fixation: A Systematic Review and Meta-Analysis. Spine 2018;43(07):E413–E422
28 Nambiar M, Phan K, , Je Cunningham, Yang Y, Turner PL, Mobbs R. Locking stand-alone cages versus previous plate constructs in single-level fusion for degenerative cervical disease: a systematic review and meta-analysis. Eur Spine J 2017;26(09): 2258–2266
29 Nemoto O, Kitada A, Naitou S, Tachibana A, Ito Y, Fujikawa A. Stand-alone anchored cage versus cage with plating for single-level anterior cervical discectomy and fusion: a prospective, randomized, controlled study with a 2-year follow-up. Eur J Orthop Surg Traumatol 2015;25(Suppl 1):S127–S134
30 Iyer S, Nemani VM, Nguyen J, et al. Impact of Cervical Sagittal Alignment Parameters on Neck Disability. Spine 2016;41(05): 371–377
31 Koreckij TD, Gandhi SD, Park DK. Cervical Disk Arthroplasty. J Am Acad Orthop Surg 2019;27(03):e96–e104
32 Hisey MS, Bae HW, Davis RJ, et al. Prospective, Randomized Comparison of Cervical Total Disk Replacement Versus Previous Cervical Fusion: Results at 48 Months Follow-up. J Spinal Disord Tech 2015;28(04):E237–E243
33 Vleggeert-Lankamp CLA, Janssen TMH, van Zwet E, et al. The NECK trial: Effectiveness of anterior cervical discectomy with or without interbody fusion and arthroplasty in the treatment of cervical disc herniation; a double-blinded randomized controlled trial. Spine J 2019;19(06):965–975

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Combined Reconstruction of the Anterior Cruciate Ligament and Anterolateral Ligament Injury Compared to the Isolated Reconstruction of the Anterior Cruciate Ligament: A Meta-Analysis*

Reconstrução combinada do ligamento cruzado Anterior e lesão do ligamento anterolateral comparada à reconstrução isolada do ligamento cruzado anterior: Uma metanálise

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Abstract

The present research aims to compare the outcomes from the combined reconstruction of the anterior cruciate ligament (ACL) and of the anterolateral ligament (ALL) with the standard isolated ACL reconstruction in patients with chronic ACL injury. To do so, a meta-analysis was carried out to determine whether the combined ACL and ALL reconstruction would lead to a significant improvement in knee function according to the International Knee Documentation Committee (IKDC), the Lysholm test and KT-2000 evaluation scores and lower graft rupture rates in comparison with isolated reconstruction. To identify randomized controlled trials (RCTs) comparing the combined ACL and ALL reconstruction with the isolated ACL reconstruction, papers published between 2010 and 2019 were searched in the MEDLINE, EMBASE, SPORTDiscus, LILACS and Cochrane Central Register of Controlled Trials databases, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. The stability of the knee joint is only marginally improved with the combined reconstruction of ACL and ALL, and both reconstruction techniques show functional results. The main outcomes sought were patient function and graft stability and rupture rates after ACL reconstruction. Out of the 421 studies identified, 6 were included in our meta-analysis. Study quality (internal validity) was assessed using the Cochrane risk-of-bias tool; in general, the studies included presented moderate-quality

Keywords

- anterior cruciate ligament
- anterolateral ligament
- ligament injury
- rupture
- chronic lesion

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evidence. The graft rupture rate was higher in patients undergoing isolated ACL reconstruction (relative risk, 0.22; 95% confidence interval, 0.12 to 0.41; $p < 0.00001$).

Resumo

O objetivo da presente pesquisa é comparar, por meio de uma metanálise, os resultados da reconstrução combinada do ligamento cruzado anterior (LCA) e do ligamento anterolateral (LLA), comparado com a reconstrução isolada padrão, em pacientes com lesão crônica do ligamento cruzado anterior. Buscando alcançar o objetivo da pesquisa, foi realizada uma meta-análise para determinar se a combinação da reconstrução combinada LCA e LLA levaria à melhoria significativa da função do joelho, medida pelos escores de avaliação International Knee Documentation Committee (IKDC), Lysholm, KT-2000 e menor taxa de ruptura do enxerto, em comparação com a reconstrução isolada. Para identificar ensaios clínicos randomizados (ECR) comparando a reconstrução combinada do LCA e LLA com a reconstrução isolada do LCA, foram pesquisados artigos publicados entre 2010 e 2019 nas bases MEDLINE, EMBASE, SPORTDiscus, LILACS e Cochrane Central RegisterofControlledTrials e seguiram os critérios de Itens de Relatórios Preferidos para Revisões Sistemáticas e Metanálises (PRISMA). A estabilidade da articulação do joelho é apenas marginalmente aprimorada com a reconstrução combinada de LCA e LLA, e ambas as técnicas de reconstrução mostram resultados funcionais. Os principais desfechos procurados foram a função do paciente e as taxas de estabilidade e ruptura do enxerto após a reconstrução do LCA. Dos 421 estudos identificados, 6 estudos foram incluídos em nossa meta-análise. A qualidade do estudo (validade interna) foi avaliada usando o instrumento Cochrane risco-de-viés; em geral, foi encontrada uma qualidade moderada de evidências dos estudos incluídos. Os pacientes submetidos à reconstrução isolada do LCA mostraram maior taxa de ruptura do enxerto (RR 0,22; índice de confiança [IC]95%: 0,12–0,41; $p< 0,00001$).

Palavras-chave
- ligamento cruzado anterior
- ligamento anterolateral
- lesão ligamentar
- ruptura
- lesão crônica

Introduction

Anterior cruciate ligament (ACL) ruptures are among the most common knee injuries; the number of ACL reconstructions has increased in recent decades, reaching $\sim$ 130,000 procedures per year.[1]

Studies have shown that the incidence of ACL reconstruction has increased over the years, particularly in women and people < 20 years old or ≥ 40 years old. However, recent researches and cost-reducing measures can improve treatment in such groups through prevention and positive results. Nevertheless, surgeons must be aware that ACL reconstruction can result in damage.[1]

Anterior cruciate ligament reconstruction aims to restore knee function and stability; however, rotational stability may not be completely restored using the standard isolated reconstruction.[2]

Anterior cruciate ligament reconstruction is one of the most common procedures in orthopedic surgery. Nonetheless, even with surgical techniques and advancements in implants, some patients still present residual postreconstruction anterolateral rotational laxity.[3]

Although individual studies have not shown the superiority of combined ACL reconstruction over the isolated reconstruction in terms of function and stability, biomechanical principles suggest that a combined approach may be useful; therefore, grouping randomized clinical studies available through a meta-analysis can be enlightening.

According to Saithna et al.,[4] combined ACL and anterolateral ligament (ALL) reconstruction is associated with a significant reduction in ACL graft rupture rates and a very low rate of complications, but with an increased risk of reoperation.

Persistent rotational instability after isolated, standard ACL reconstruction has been widely described, and it has been shown to maintain a direct correlation with worse postoperative results.[5] Anterolateral ligament injury has a relevant role in the genesis of knee rotational instability.[3,6]

Many anatomical publications have defined the ALL as a distinct ligament.[6] Nonetheless, some authors have proposed the association of ACL and ALL reconstruction in disabled individuals to further increase postoperative knee stability.[7]

After many years of vigorous debate in the literature, a panel of international and clinical researchers who are experts in ACL surgery has finally reached a consensus: the ALL does exist.[8]

The ALL was first described in 1879 by Dr. Paul Segond as a "resistant, pearly fibrous band" that could result in an

avulsion fracture of the tibial plateau when the knee was submitted to forceful internal rotation, the so-called Segond fracture (1879).

In the early 19th century, French anatomists Vallois and, later, Jost, took an interest in the anterolateral structures of the knee. Next, in 1976, Hughson and colleagues described a "middle third of the lateral capsular ligament," renewing the interest on these knee structures.[9,10] After numerous studies, the ALL received several different names, confounding the anterolateral anatomy of the knee.[11]

Anterior cruciate ligament specialists have not reached a consensus regarding the reliability of combined reconstruction due to the controversy involving both ALL anatomy and biomechanics.[12,13] Clinical trials with a high level of evidence and long-term follow-up can be useful in determining the reliability of combined procedure at the clinical setting.

As such, the present research aims to compare, through a meta-analysis, the outcomes from the combined ACL and ALL reconstruction with the standard isolated ACL reconstruction in patients with chronic ACL injury.

The present study hypothesizes that patients undergoing combined ACL and ALL reconstruction have less residual laxity and better clinical outcomes when compared to those submitted to isolated ACL reconstruction.

Methodology

To identify randomized controlled trials (RCTs) comparing combined ACL and ALL reconstruction with isolated ACL reconstruction, the MEDLINE, EMBASE, SPORTDiscus, LILACS and Cochrane Central Register of Controlled Trials databases were queried following the Preferred Reporting Items for Systematic Reviews and Meta-analyzes (PRISMA) criteria (►**Figure 1**).

Two authors searched independently the electronic databases between April and June 2019. Trials in progress and recently completed were identified at ClinicalTrials.gov. We did not apply any language-based restrictions and translation services were used when necessary. References from relevant papers were checked for completeness. Conference summaries (available online from 2010 to 2019) from the International Society for Arthroscopy, Knee Surgery and Orthopedic Sports Medicine, the American Orthopedic Society of Sports Medicine, and the American Academy of Orthopaedic Surgeons were also included.

Our bibliographic research identified a total of 421 studies; after excluding obviously irrelevant and duplicate reports, 10 papers were retrieved for evaluation. We recognized two reports from the same study; although we have combined useful data from both papers, the most relevant information was extracted from the full-text report.[8] We excluded another study that was not an RCT. The remaining

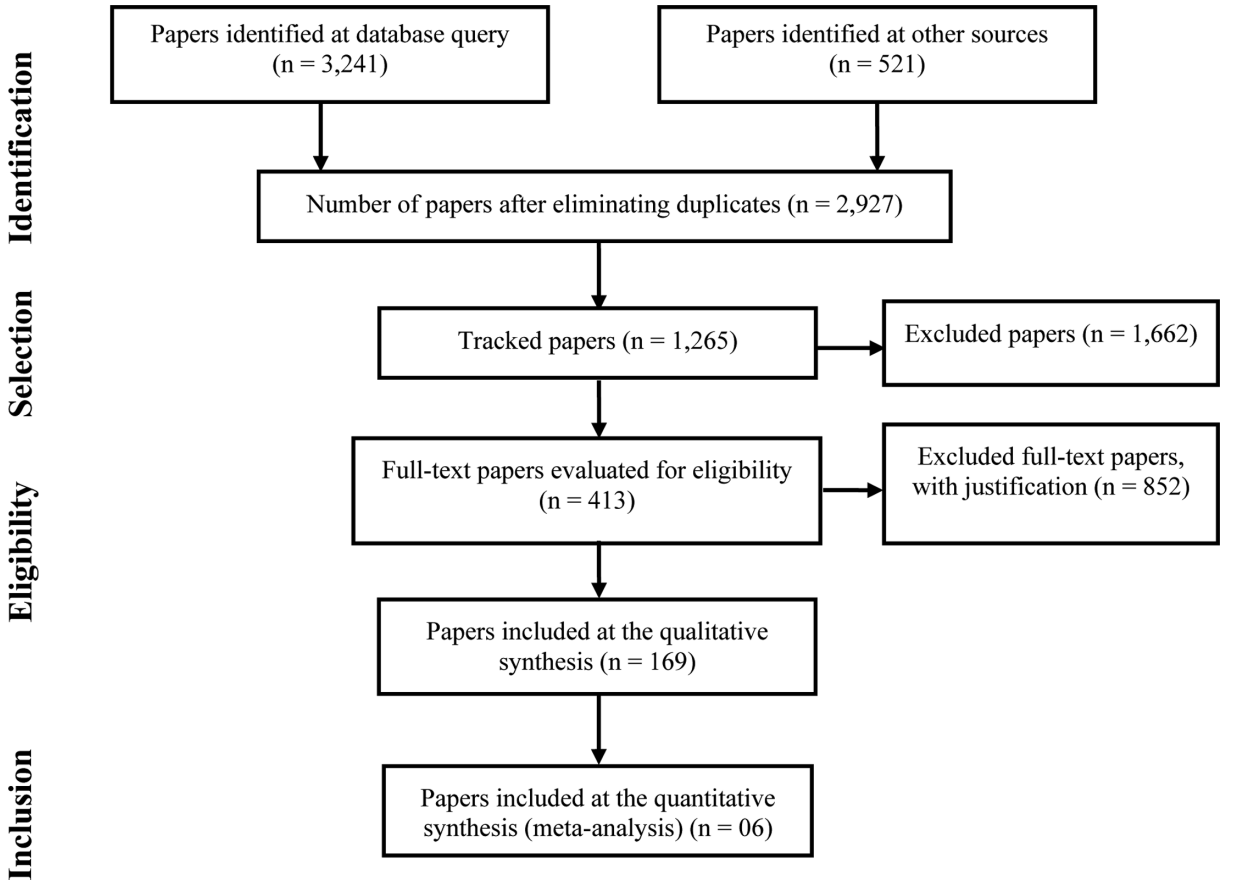


Fig. 1 Flow chart according to PRISMA.

six papers met the inclusion criteria for our systematic review.[3]

Study quality (internal validity) was assessed using the Cochrane risk-of-bias tool.[11] According to this tool, the included studies usually presented moderate quality.

All statistical analyzes were performed using the Review Manager 5.3 statistical software (RevMan 5.3; Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark).[14] Treatment effects were expressed as risk ratios (RRs) for dichotomous results and mean differences for continuous results at 95% confidence intervals (95% CI). A fixed-effect meta-analysis was performed for data considered to be homogeneous. The heterogeneity of the treatment effects was assessed visually by observing CIs on forest plots, in addition to their direction and magnitude. In addition, I^2 statistics were calculated for an objective assessment of heterogeneity.

Subgroup analysis was performed when possible. Publication bias was assessed by visual inspection of funnel charts from primary results. Assessments may not be accurate due to the small number of attempts. Studies are well distributed throughout the plot and publication bias is not a major concern. As a safety measure, we searched the gray literature on this subject to find works with non-relevant or negative results.

The main results sought were patient function, stability and graft rupture after ACL reconstruction. Of the 421 studies identified, 6 papers were included (n = 776 participants; follow-up, 12–84 months; male-to-female ratio, 2.17:1) in our meta-analysis.

No study provided evidence level 1. Two papers reached evidence level 2 due to randomization. The remaining studies had evidence levels 3 and 4.

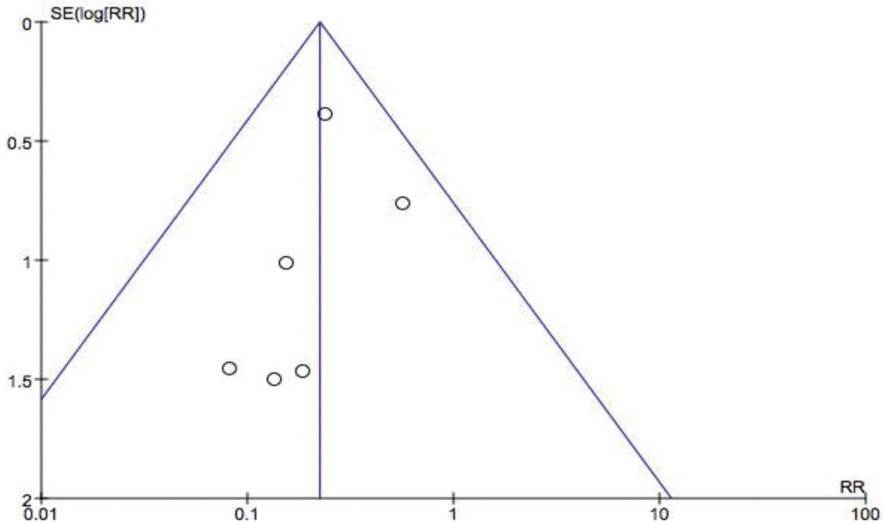
Results

All six selected papers followed up on ACL and ALL reconstruction techniques. Together, these studies included 776 patients, 402 of whom underwent ACL and ALL reconstruction. One paper compared ACL reconstruction alone with ACL and ALL reconstruction. Another study compared three ACL reconstruction techniques: reconstruction with a single band, reconstruction with a double band and anatomical reconstruction with a single band associated with ALL reconstruction. A third study also compared three anatomical ACL reconstruction techniques: using a patellar tendon graft, quadruple graft from flexor tendons and flexor tendons graft combined with ALL reconstruction.

All statistical analyzes were performed using the Review Manager statistical software (RevMan 5.3; The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). Treatment effects were expressed as RRs for dichotomous outcomes and mean differences for continuous outcomes at 95% CI. A fixed-effect meta-analysis was performed for data considered homogeneous. Treatment effects heterogeneity was assessed visually by observing CIs over forest plots in addition to their direction and magnitude. In addition, I^2 statistics were calculated for an objective assessment of heterogeneity. High heterogeneity was indicated by the absence of overlapping CIs in forest plots and I^2 values $> 50\%$; in such cases, reasons for heterogeneity were investigated. Subgroup analysis was performed when feasible.

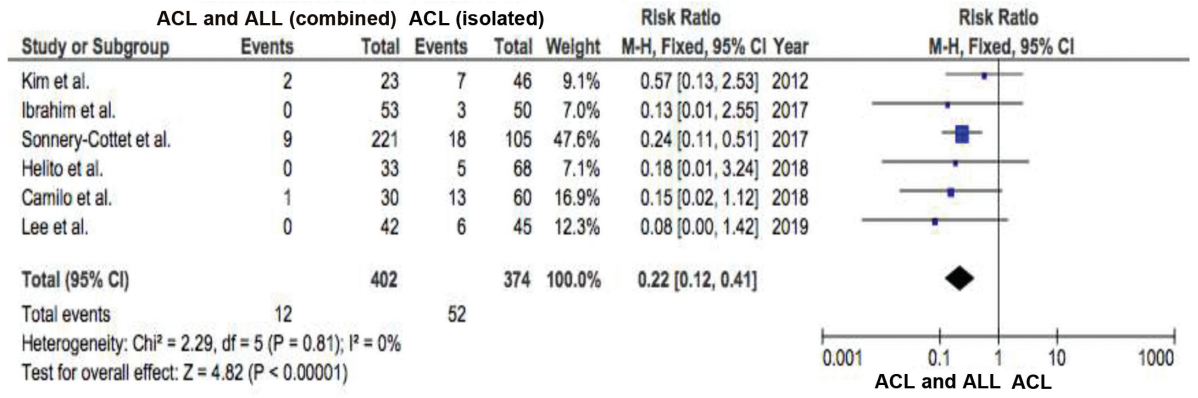
Funnel graphs show standard errors (SE) and RRs for graft rupture cases. Publication bias was assessed by visual inspection of funnel graphs from primary outcomes (►**Figure 2**). Assessments may not be accurate due to the small number of attempts. Studies are well distributed throughout the plot and the publication bias is not a major concern. As a safety measure, we researched the gray literature regarding this subject to find papers with nonrelevant or negative outcomes.

Regarding graft ruptures (►**Figure 3**), the forest plot graph shows a significant difference ($p < 0.05$) in the number of cases that underwent ACL reconstruction alone and those



Source: Figure prepared by the authors (2019).

Fig. 2 Funnel graph showing standard error (SE) and risk ratio (RR) for graft rupture.



Source: Figure prepared by the authors (2019).

Fig. 3 Forest plot graph from the meta-analysis of graft rupture cases. ACL, Anterior cruciate ligament; ALL, anterolateral ligament; 95%CI, 95% confidence interval.

submitted to combined ACL and ALL reconstruction; therefore, the graft rupture rate is significantly higher in patients undergoing isolated ACL reconstruction (RR, 0.22; 95%CI: 0.12–0.41; $p < 0.00001$).

Side-by-side mean difference (and standard deviation) in tibial anterior translation, measured with a KT-2000 arthrometer, was significant ($p < 0.05$) in patients submitted to isolated ACL reconstruction compared with those undergoing combined ACL reconstruction (RR, -0.65; 95%CI: -0.78–-0.51; $p < 0.00001$). Thus, mean tibial anterior translation is significantly lower in patients undergoing combined ACL reconstruction.

In summary, when assessing ligament laxity using a KT-2000 arthrometer, combined ACL and ALL reconstruction allows less tibial anterior translation than isolated ACL reconstruction (►**Figure 4**).

Average Lysholm test scores did not differ significantly ($p > 0.05$) in patients undergoing isolated ACL reconstruction compared with those submitted to combined ACL reconstruction (RR, 1.11; 95%CI: -0.20–2.42; $p = 0.10$).

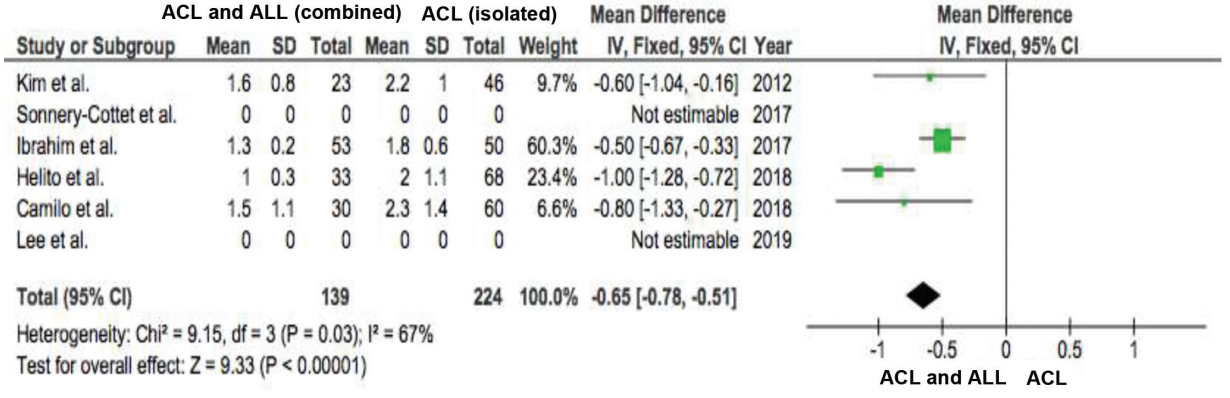
Mean subjective International Knee Deocumentation Committee (IKDC) questionnaire scores did not differ significantly ($p > 0.05$) in patients undergoing isolated ACL reconstruction compared with patients undergoing combined ACL reconstruction (RR, 1.05; 95%CI: -0.47–2.56; $p = 0.17$).

Discussion

The main finding of this meta-analysis was that, compared only to isolated ACL reconstruction, combined ACL and ALL reconstruction did not result in significant differences in knee function.

Relatively consistent results from isolated ACL reconstruction have been reported and show knee function recovery in most patients. However, rotational stability may not be restored by reconstruction alone. The main finding of our meta-analysis was that, compared with isolated ACL reconstruction, combined ACL and ALL reconstruction did not result in significant differences in knee function. Although knee stability was superior in the combined ACL reconstruction group, IKDC and Lysholm test results were only marginally improved.

Based on ligament laxity assessed using a KT-2000 arthrometer, combined ACL and ALL reconstruction allows less anterior translation than isolated ACL reconstruction. In



Source: Figure prepared by the authors (2019).

Fig. 4 Forest Plot graph from the meta-analysis comparing KT-2000 arthrometer test results after anterior cruciate ligament reconstruction. ALL, Anterolateral ligament; 95% CI, 95% confidence interval.

addition, graft failure rate improved after the combined ACL procedure.

Helito et al.[3] showed evidence that combined ACL and ALL reconstruction in patients with chronic ACL injury is an effective and safe solution, leading to good functional outcomes with no complication rate increase. The clinical relevance of this finding was the possibility of indicating this type of procedure in patients presenting with >12 months after surgical injury.[3]

Similar results were also noted by Saithna et al., with clinical outcomes of advanced ACL reconstruction demonstrating a significant reduction in ACL rupture currents and improved rates of return to sports compared with isolated ACL reconstruction.[4]

This finding is supported by laboratory studies showing that the association of ACL reconstruction and lateral extra-articulatory symptoms are procedures that protect from the accumulation of ACL loads and are the most reliable normal knee kinematics recovery compared with isolated ACL reconstruction.

An improvement in graft failure rate after combined ACL and ALL reconstruction has also been reported by Helito el al.[3] In their cohort with a minimum follow-up period of 2 years, the graft failure rate was 0 and 7.3% in patients submitted to ACL and ALL and ACL reconstruction, respectively ($p> 0.05$).

Sonnery-Cottet et al., in a large prospective comparative series of 502 ACL reconstructions with 1 from 3 different surgical techniques and a minimum follow-up of 2 years, demonstrated significantly reduced rates of ACL graft rupture in a high-risk population (young, athletic patients) after combined ACL and ALL reconstruction compared to a paired cohort undergoing isolated ACL reconstruction.[11]

Inderhaug et al. have shown that, despite numerous technical descriptions of anterolateral procedures, knowledge is limited as to the effect of knee flexion angle during graft fixation.[15]

To determine the effect of knee flexion angle during graft fixation on the tibiofemoral joint kinematics for a modified Lemaire tenodesis or combined ALL and ACL reconstruction, Inderhaug et al. showed that, for combined ACL and anterolateral deficiency, isolated ACL reconstruction was associated with a residual laxity both in anterior translation and internal rotation.[15] Anterior translation was restored for all combinations of ACL and anterolateral procedures. Combined ACL and ALL reconstruction restored the intact knee kinematics when the graft was fixed in full extension, but the combined procedure left residual laxity in internal rotation ($p = 0.043$) when the graft was fixed at 30° and 60°. The combined ACL reconstruction and modified Lemaire procedure restored internal rotation regardless of knee flexion angle during graft fixation. When the combined ACL reconstruction and lateral procedure states were compared with the isolated ACL reconstructed state, a significant reduction in internal rotation laxity was observed with the modified Lemaire tenodesis, but not with ALL reconstruction.

In summary, the aforementioned biomechanical study demonstrated that, in a combined ACL and anterolateral lesion, an isolated ACL reconstruction cannot restore normal knee stability.[15]

Based on the assessment of ligament laxity using a KT-2000 arthrometer, Kim and colleagues observed that the combined reconstruction of ACL and the posterolateral corner allowed less anterior translation than isolated ACL reconstruction.[5] However, they failed to identify significant differences between the two groups regarding functional outcomes.

Ibrahim et al. showed that combined ACL and ALL reconstruction was effective in improving subjective and objective outcomes.[16] These findings, however, were not significantly superior to isolated ACL reconstruction, except for knee fatigue test results. This may indicate that ALL reconstruction should not be performed routinely in patients undergoing ACL reconstruction.

Final Considerations

Knee joint stability improved only marginally with combined ACL and ALL reconstruction; both reconstruction techniques resulted in similar functional outcomes.

Combined ACL and ALL reconstruction significantly reduced ligament laxity assessed with a KT-2000 arthrometer; in addition, it was associated with a lower graft rupture rate compared with isolated ACL reconstruction, although there were no significant differences in functional test results between the two groups.

The main limitations of the present study included the reduced amount of papers selected for the present meta-analysis and their moderate quality.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. Am J Sports Med 2014;42(10):2363–2370
2 Rezende FC. Reconstrução combinada intra e extra-articular versus reconstrução intra-articular isolada do ligamento cruzado anterior: revisão sistem [tese]. São Paulo: Universidade Federal de São Paulo (UNIFESP); 2016
3 Helito CP, Camargo DB, Sobrado MF, et al. Combined reconstruction of the anterolateral ligament in chronic ACL injuries leads to better clinical outcomes than isolated ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 2018;26(12):3652–3659
4 Saithna A, Thaunat M, Delaloye JR, Ouanezar H, Fayard JM, Sonnery-Cottet B. Combined ACL and anterolateral ligament reconstruction. JBJS Essential Surg Tech 2018;8(01):e2
5 Kim SJ, Choi DH, Hwang BY. The influence of posterolateral rotatory instability on ACL reconstruction: comparison between isolated ACL reconstruction and ACL reconstruction combined with posterolateral corner reconstruction. J Bone Joint Surg Am 2012;94(03):253–259
6 Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J. Anatomy of the anterolateral ligament of the knee. J Anat 2013; 223(04):321–328
7 Dodds AL, Halewood C, Gupte CM, Williams A, Amis AA. The anterolateral ligament: Anatomy, length changes and association with the Segond fracture. Bone Joint J 2014;96-B(03):325–331

8 Tulloch S, Getgood A. Consideration of lateral augmentation in anatomic anterior cruciate ligament reconstruction. Ann Joint 2019;4:15
9 Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee ligament instabilities. Part II. The lateral compartment. J Bone Joint Surg Am 1976;58(02):173–179
10 Cavaignac E, Faruch M, Wytrykowski K, et al. Ultrasonographic Evaluation of Anterolateral Ligament Injuries: Correlation With Magnetic Resonance Imaging and Pivot-Shift Testing. Arthroscopy 2017;33(07):1384–1390
11 Sonnery-Cottet B, Saithna A, Cavalier M, et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 years: a prospective comparative study of 502 patients from the SANTI study group. Am J Sports Med 2017;45(07):1547–1557
12 Guenther D, Rahnemai-Azar AA, Bell KM, et al. The anterolateral capsule of the knee behaves like a sheet of fibrous tissue. Am J Sports Med 2017;45(04):849–855
13 Kittl C, El-Daou H, Athwal KK, et al. The role of the anterolateral structures and the ACL in controlling laxity of the intact and ACL-deficient knee. Am J Sports Med 2016;44(02):345–354
14 Geeslin AG, Moatshe G, Chahla J, et al. Anterolateral Knee Extra-articular Stabilizers: A Robotic Study Comparing Anterolateral Ligament Reconstruction and Modified Lemaire Lateral Extra-articular Tenodesis. Am J Sports Med 2018;46(03):607–616
15 Inderhaug E, Stephen JM, Williams A, Amis AA. Anterolateral Tenodesis or Anterolateral Ligament Complex Reconstruction: Effect of Flexion Angle at Graft Fixation When Combined With ACL Reconstruction. Am J Sports Med 2017;45(13):3089–3097
16 Ibrahim SA, Shohdy EM, Marwan Y, et al. Anatomic reconstruction of the anterior cruciate ligament of the knee with or without reconstruction of the anterolateral ligament: a randomized clinical trial. Am J Sports Med 2017;45(07):1558–1566

Electromyography of the Pectoralis Major Muscle after Surgical Reconstruction of Chronic Tendon Rupture*

Eletromiografia do músculo peitoral maior após reconstrução cirúrgica da ruptura crônica do tendão

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Abstract

Objective To evaluate the electrophysiological activity of the injured pectoralis major (PM) muscle of operated patients who perform weightlifting, more specifically bench press exercises, especially the activity of the clavicular and sternocostal portions of the PM.

Methods All athletes in study I (10 patients) had unilateral complete ruptures during bench press exercises and a history of use of anabolic steroids, an association that is described in up to 86.7% of PM tendon ruptures. The control group included 10 men without PM tendon injury who did not perform bench press exercises. Description of the cross-sectional design. The *p*-values were obtained by multiple comparisons with Bonferroni correction.

Results In the comparison between the control (C) group and the weightlifters during the postoperative period (POS), we found no evidence of differences in any measurements obtained in the clavicular and sternocostal portions of the PM muscle: clavicular average level ($p = 0.847$); clavicular standard deviation (SD) ($p = 0.777$); clavicular area ($p = 0.933$); clavicular median ($p = 0.972$); sternocostal average level ($p = 0.633$); sternocostal SD ($p = 0.602$); sternocostal area ($p = 0.931$); and sternocostal median ($p = 0.633$).

Conclusion In the present study, the electromyographic activity of the PM muscle in weightlifters (bench press exercise) who underwent surgery was within the normal parameters for the clavicular and sternocostal portions studied.

Keywords
- pectoralis muscles/injuries
- electromyography
- athletic injuries
- weightlifting/injuries

* *Study conducted at the Department of Orthopedics and Traumatology, Universidade Federal de São Paulo, São Paulo, Brazil.*

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Resumo

Objetivo Avaliar a atividade eletrofisiológica do músculo peitoral maior (PM) lesionado de pacientes operados que realizam halterofilismo, mais especificamente exercícios de supino, especialmente a atividade das porções clavicular e esternocostal do PM.

Métodos Todos os atletas no estudo I (10 pacientes) tiveram rupturas completas unilaterais durante o exercício de supino, e tinham histórico de uso de esteroides anabolizantes, associação descrita em até 86,7% das rupturas tendinosas do PM. O grupo controle incluiu 10 homens sem lesão no tendão do PM que não realizaram exercícios de supino. Descrição do projeto transversal. Os valores de *p* foram obtidos por múltiplas comparações com a correção de Bonferroni.

Resultados Na comparação entre o grupo controle (C) e os halterofilistas durante o pós-operatório (POS), não foram encontradas diferenças nas medidas obtidas nas porções clavicular e esternocostal do músculo PM: nível médio clavicular ($p = 0,847$); desvio padrão (DP) clavicular ($p = 0,777$); área clavicular ($p = 0,933$); mediana da clavícula ($p = 0,972$); nível médio esternocostal ($p = 0,633$); DP esternocostal ($p = 0,602$); área esternocostal ($p = 0,931$); e mediana esternocostal ($p = 0,633$).

Conclusão Neste estudo, a atividade eletromiográfica do músculo PM em atletas de halterofilismo (exercício de supino) que foram submetidos a cirurgia esteve dentro dos parâmetros normais para as porções claviculares e esternocostais estudadas.

Palavras-chave

- músculos peitorais/lesões
- eletromiografia
- lesões atléticas
- levantamento de peso/lesões

Introduction

Rupture of the pectoralis major (PM) muscle has become increasingly common due to the association among gym use, use of anabolic steroids, and the male sex (there are no reports of PM rupture in females).[1,2] In the case of gym users or athletes, the chronic stages of PM injury may result in significant loss of adduction (from 10% to 50%) and important cosmetic deformity of the hemithorax.[3–14]

Surgical treatment has been recommended in these patients to reestablish function and esthetics.[2] In general, the sternocostal portion is typically compromised in athletes and bodybuilders (bench-press injury). Injuries of the clavicular portion of the PM tendon vary in terms of the extent of damage and the number of patients affected, but this type of injury is characterized by a functional loss of residual strength that functionally limits this population of athletes and gym users.[9,10,14,15] A return to regular physical activities usually occurs in more than 90% of the patients (our studies) after PM tendon repair and surgical reconstruction, which are major surgeries that require the use of a tendon graft for reconstruction.

Even with good clinical and functional outcomes during the postoperative period of PM tendon surgery, questions have persisted about the electrophysiological activity of the injured muscle.

Electromyography (EMG) enables the extracellular recording of the bioelectric activity generated by muscle fibers. It is performed using a surface electrode, which measures the electrical activity of several motor units at the same time.[16] Despite capturing the electrical activity generated by the recruitment of the motor units and not the muscle strength,[17] the literature suggests a good correlation between the number of activated motor units and the muscle strength. Thus, this method plays an important role in illustrating the electrophysiological profile of injured and reconstructed muscles at the time of examination, and assists in the evolution during physiotherapy and return to sports. The present study aimed to evaluate the PM of operated patients who perform weightlifting, more specifically bench-press exercises, especially the activity of the clavicular and sternocostal portions of the PM.

Although this type of evaluation is increasingly being used in clinical care and scientific research, a consensus on several aspects of the method is lacking. The sensor placement, the number of contractions of phasic fibers, the time of contraction of tonic fibers, the need for concomitant evaluation of synergistic muscles, as well as the possibility of use in special situations should still be standardized.

Materials and Methods

Study Population

We analyzed 20 weightlifters who were previously registered and treated at the Sports Traumatology-Orthopedics Center, according to the Brazil Platform CAAE number 20959813.0.0000.5505.

All athletes in study I (10 patients) had unilateral complete ruptures during bench-press exercises and a history of anabolic steroid use, an association that is described in up to 86.7% of PM tendon ruptures. The control group included ten resistance exercise practitioners without PM tendon injury who did not perform bench-press exercises. The individuals were required to sign an informed consent form.

Inclusion Criteria

Study I

Case Group
This group included ten individuals who were already being monitored at the Sports Medicine outpatient facility, had a history of PM tendon rupture and surgical reconstruction following the standard protocol,[14] performed bench-press exercises at least three times a week pre-injury, had more than ten years of competitive weightlifting experience in bench press, and had a history of anabolic steroid use.

Control Group
This group included ten individuals who were matched regarding gender and age to the case group, and they led sedentary lifestyles or practiced sports sporadically, and had no history of anabolic steroid use.

Exclusion Criteria

Study I excluded individuals with PM tendon injury occurring during sports other than weightlifting, individuals without a history of steroid use, and athletes with a history of chronic disease such as diabetes, nephropathy or other diseases that are known to present with tendinopathy.

Evaluations

Clinical Evaluation

All subjects answered a specific questionnaire evaluating the period of time that they had been performing weightlifting and their use, type and frequency of use of anabolic steroids in the previous 12 months.

On average, patients with chronic PM injury had a 5.5-month waiting period between injury and PM reconstruction surgery with the same operatory technique.[11] The surgical technique used was previously described in our studies,[14] and the rehabilitation protocol used was also standard for this type of injury and surgery.

Electromyography

Visits to the Sports Traumatology-Orthopedics Center were scheduled by phone call, and the individuals underwent EMG, which was collected dynamically using a MegaWin 3.1, ME-6000 T-8-channel, version 3.0, with a system with a calibration frequency of 2,000 Hz, high pass filter of 20 Hz, and low pass filter of 500 Hz.

Disposable, adhesive, passive, monopolar Meditrace electrodes (DBI Medical, São Paulo, SP, Brazil) were used, with solid gel, silver/silver chloride (Ag/AgCl), a capture area of 1 cm, and a distance of 2 cm between the electrodes. The patients were analyzed during bench-press exercises and underwent EMG following the validated protocol, in which electrodes were placed based on tape measurements from the collarbone to the xiphoid process, considering 60% of this length as the PM muscle area. After determining this value, 80% of the width of the PM was calculated by measuring the insertion of the PM from the humerus to the sternum. The result for the 80% of the width was considered the central point, and 1 electrode was placed on each side of this central point following the direction of the muscle fibers on the dominant side. The ground electrode was placed on the medial epiphysis of the clavicle on the dominant side.

The athletes performed a maximum series of each exercise with a load equivalent to the 10-repetition maximum. The order of the exercises was randomized among the individuals. The exercise was performed using the Olympic Bench Press equipment from the FW line. The practitioners were instructed to perform the eccentric phase by directing the bar in a line near the center of the sternum without touching the chest to avoid electrode movement.

A total of twenty athletes were selected for electromyographic measurement in the bench press exercise to evaluate the recruitment of the two main portions of the PM muscle during exercise performed in the postoperative period of PM tendon reconstruction using flexor tendon grafts.

All chronic patients were evaluated by electromyography five months postoperatively

Study Design

Description of the Cross-sectional Design

Methods of Analysis
Numerical variables are described by the mean and standard deviation (SD), and categorical variables are described by absolute and relative frequencies. Generalized estimating equation (GEE) models were fitted considering the dependence between the sides of the same individual. The models were fitted by a gamma distribution and log link function, and the results are presented as the mean estimated values and 95% confidence intervals. The *p*-values were obtained by multiple comparisons with Bonferroni correction.

The analyses were performed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, US) software, version 19, and a significance level of 5% was adopted.

Results

Measurements of the clavicular and sternocostal portions of the PM muscle were obtained using bilateral EMG in weightlifters and controls to compare the groups; the right and left sides were considered replicate measurements of a subject.

One patient was lost during the postoperative period because he did not return for the five-month follow-up evaluation.

Of the patients who underwent surgery, 9 weightlifters who performed bench-press exercises, had unilateral injuries, and a mean age of 36.7 years (SD = 9.1 years) were evaluated. Nine control patients were analyzed for a homogeneous sample of patients between the C group and nine cases. Additionally, nine control patients were evaluated. The measurements were obtained by EMG on the injured sides subjected to reconstruction of the PM with a flexor tendon

Table 1 Measurements of the clavicular and sternocostal portions of the pectoralis major muscle obtained by electromyography in healthy controls and in weightlifters after surgery on the operated and contralateral sides

	Groups			*p*-value	
	Control (C)	Postoperative: operated side (POS)	Postoperative: contralateral side (POCL)	C x POS	POS x POCL
Clavicular					
Average level	293.2 (200.0, 386.3)	273.8 (99.7, 447.8)	203.7 (99.6, 307.7)	0.847	0.058
Standard deviation	104.9 (70.3, 139.5)	96.1 (46.1, 146.1)	72.4 (35.3, 109.6)	0.777	0.002
Area	7,481.4 (4,896.9, 10,065.9)	7,743.2 (2,230.2, 13,256.2)	5,773.1 (2,429.0, 9,117.2)	0.933	0.09
Median	269.9 (174.5, 365.2)	266.0 (76.4, 455.6)	194.7 (90.2, 299.2)	0.972	0.109
Sternocostal					
Average Level	345.0 (204.0, 486.0)	304.4 (216.0, 392.9)	233.2 (160.3, 306.2)	0.633	0.121
Santadard deviation	119.0 (71.3, 166.6)	103.6 (70.7, 136.4)	92.8 (53.0, 132.5)	0.602	0.554
Area	8,314.2 (4,778.2, 11,850.2)	8,125.7 (5,707.6, 10,543.8)	6,471.4 (4,200.6, 8,742.3)	0.931	0.126
Median	335.9 (187.8, 484.0)	292.4 (193.4, 391.5)	215.2 (143.7, 286.8)	0.633	0.091

Notes: The data are expressed in μV as means of estimates and 95% confidence intervals; *p*: multiple comparisons between groups.

graft (postoperative operated side [POS] group: nine measurements) and on the sides contralateral to the operated sides (postoperative contralateral side [POCL] group: nine measurements).

Comparisons between the groups were performed by fitting models considering the dependence between the bilateral measurements of the same individual.

In the comparison between the C and POS groups, we found no evidence of differences (►**Table 1**) in any measurements obtained in the clavicular and sternocostal portions of the PM muscle: clavicular average level ($p = 0.847$); clavicular SD ($p = 0.777$); clavicular area ($p = 0.933$); clavicular median ($p = 0.972$); sternocostal average level ($p = 0.633$); sternocostal SD ($p = 0.602$); sternocostal area ($p = 0.931$) and sternocostal median ($p = 0.633$).

Discussion

The frequency of PM muscle injuries has led to studies on the ability of the repaired or surgically-reconstructed PM muscle to return to adequate functional activity.[2–15]

Isokinetic assessment using torque peak and muscle work in horizontal adduction has been very helpful in obtaining a more objective, albeit indirect, evaluation of PM muscle strength both in the pre- and postoperative periods of chronic injuries that require PM reconstruction. In general, after improvement, the level of muscle strength should normally exhibit a deficit of no more than 15% of that of the contralateral muscle. However, is this improvement due to recruitment of the activity of muscle parts other than the most injured sternocostal portion? The present study helps to better understand these functional aspects during the postoperative period in these patients.

One of the main variables analyzed by EMG is the maximum voluntary contraction (MVC), which is performed by fast-twitch (type II) muscle fibers and is responsible for muscle strength.[1]

In athletes undergoing PM reconstruction, the EMG activity of the PM muscle was not different between the injured and contralateral sides, which may indicate that the reconstructed muscle has a functional capacity to assist in weightlifting activities. Studies on pathological anatomy have shown no significant muscle degeneration, even in chronic cases, at two to five years after a PM injury.

The greater EMG activity on the operated side in the clavicular portion compared to the contralateral portion may be related to the attempt of the muscle portion not affected by the rupture to assist the injured sternocostal portion. Thus, a variance in functional improvement is observed.

These patients were not subjected to isokinetic assessment because the recovery of the strength level between five months and one year after surgery has been well established in other studies published by our research group and other authors. Muscle recovery is obviously variable, but, on average, it enables a sufficient return to competitive activity.

As described, the main objective of the present study was to examine the electrical and functional activity of muscle contraction of the injured musculature and the musculature of the clavicular region. On average, the waiting period was of 5.5 months between injury and PM reconstruction surgery.

All chronic patients were evaluated by EMG five months postoperatively.

It is possible that the time between the EMG, the injury or the postoperative exam may have some impact on the results. In the present study, the average time between the injury and the surgery was of 5.5 months. The EMGs were performed every five months after surgery.

Conclusion

In the present study, the electromyographic activity of the PM muscle in weightlifters (bench-press exercise) who underwent surgery was within normal parameters for the clavicular and sternocostal portions studied.

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

References

1 Auchincloss CC, McLean L. The reliability of surface EMG recorded from the pelvic floor muscles. J Neurosci Methods 2009;182(01):85–96
2 Bak K, Cameron EA, Henderson IJ. Rupture of the pectoralis major: a meta-analysis of 112 cases. Knee Surg Sports Traumatol Arthrosc 2000;8(02):113–119
3 de Castro Pochini A, Andreoli CV, Belangero PS, et al. Clinical considerations for the surgical treatment of pectoralis major muscle ruptures based on 60 cases: a prospective study and literature review. Am J Sports Med 2014;42(01):95–102
4 de Castro Pochini A, Ejnisman B, Andreoli CV, et al. Exact moment of tendon of pectoralis major muscle rupture captured on video. Br J Sports Med 2007;41(09):618–619, discussion 619
5 de Castro Pochini A, Ejnisman B, Andreoli CV, et al. Pectoralis major muscle rupture in athletes: a prospective study. Am J Sports Med 2010;38(01):92–98
6 Ejnisman B, Andreoli CV, de Castro Pochini A, Carrera EF, Abdalla RJ, Cohen M. Ruptura do musculo peitoral maior em atletas. Rev Bras Ortop 2002;37(11):482–488
7 de Figueiredo EA, Terra BB, Cohen C, et al. Footprint do tendão do peitoral maior: estudo anatômico. Rev Bras Ortop 2013;48(06):519–523
8 Fleury AM, Silva AC, de Castro Pochini A, Ejnisman B, Lira CA, Andrade MdosS. Isokinetic muscle assessment after treatment of pectoralis major muscle rupture using surgical or non-surgical procedures. Clinics (São Paulo) 2011;66(02):313–320
9 Lee J, Brookenthal KR, Ramsey ML, Kneeland JB, Herzog R. MR imaging assessment of the pectoralis major myotendinous unit: an MR imaging-anatomic correlative study with surgical correlation. AJR Am J Roentgenol 2000;174(05):1371–1375
10 Ohashi K, El-Khoury GY, Albright JP, Tearse DS. MRI of complete rupture of the pectoralis major muscle. Skeletal Radiol 1996;25(07):625–628
11 Pochini A, Ejnisman B, Andreoli CV, Cohen M. Reconstruction of the pectoralis major tendon using autologous grafting and cortical button attachment: description of the technique. Tech Shoulder Elbow Surg 2012;13(05):77–80
12 Pochini AdeC, Andreoli CV, Ejnisman B, Maffulli N. Surgical repair of a rupture of the pectoralis major muscle. BMJ Case Rep 2015;2015:bcr201320229
13 Pochini AdeC, Ferretti M, Kawakami EF, et al. Analisys of pectoralis major tendon in weightlifting athletes using ultrasonography and elastography. Einstein (Sao Paulo) 2015;13(04):541–546
14 Pochini AC, Rodrigues MSB, Yamashita L, Belangero PS, Andreoli CV, Ejnisman B. Surgical treatment of pectoralis major muscle rupture with adjustable cortical button. Rev Bras Ortop 2017;53(01):60–66
15 ElMaraghy AW, Devereaux MW. A systematic review and comprehensive classification of pectoralis major tears. J Shoulder Elbow Surg 2012;21(03):412–422
16 Vodusek DB. Electromyography. In: Bø K, Berghmas B, Mørkved S, Van Kampen M, editors. Evidence-based physical therapy for the pelvic floor. Philadelphia: Elsevier; 2007:53–63
17 Vodusek DB. The role of electrophysiology in the evaluation of incontinence and prolapse. Curr Opin Obstet Gynecol 2002;14(05):509–514

Finite Element Analysis of a Controlled Dynamization Device for External Circular Fixation

Análise de elementos finitos de um dispositivo de dinamização controlada para fixação circular externa

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Abstract

Objective To virtually prototype a device for external circular fixation of long bone fractures with controlled dynamization made of two different materials and predict their mechanical behavior by using the finite element analysis (FEA) method.

Method A software was used for 3D modeling two metal parts closely attached by a sliding dovetail joint and a high-density silicone damper. Distinctive FEAs were simulated by considering two different materials (stainless steel or titanium), modes (locked or dynamized) and loading conditions (static/point or dynamic/0.5 sec) with uniform 150 kg axial load on top of the device.

Results The finite elements (FEs) model presented 81,872 nodes and 45,922 elements. Considering stainless steel, the maximum stress peak (140.98 MPa) was reached with the device locked under static loading, while the greatest displacement (2.415×10^{-3} mm) was observed with the device locked and under dynamic loading. Regarding titanium, the device presented the maximum stress peak (141.45 MPa) under static loading and with the device locked, while the greatest displacement (3.975×10^{-3} mm) was found with the device locked and under dynamic loading.

Conclusion The prototyped device played the role of stress support with acceptable deformation in both locked and dynamized modes and may be fabricated with both stainless steel and titanium.

Keywords
- fractures, bone
- external fixators
- fracture healing
- dynamization

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Resumo

Objetivo Construir um protótipo virtual de um dispositivo de fixação circular externa para fraturas em ossos longos com dinamização controlada a partir de dois materiais diferentes e prever seu comportamento mecânico por meio da análise de elementos finitos (AEF).

Método Modelos tridimensionais compostos de duas peças metálicas unidas por uma junta deslizante em rabo de andorinha e um amortecedor de silicone de alta densidade foram criados em um *software*. Análises de elementos finitos distintas foram simuladas considerando dois materiais (aço inoxidável ou titânio), modos (bloqueado ou dinamizado) e condições de carregamento (estático/pontual ou dinâmico/0,5 segundo) diferentes com carga axial uniforme de 150 kg na porção superior do dispositivo.

Resultados O modelo de elementos finitos (EFs) apresentou 81.872 nós e 45.922 elementos. Com aço inoxidável, o pico de tensão máxima (140,98 MPa) foi alcançado com o dispositivo bloqueado e sob carga estática, enquanto o maior deslocamento ($2{,}415 \times 10^{-3}$ mm) foi obtido com o dispositivo bloqueado e sob carga dinâmica. Com titânio, o pico de tensão máxima (141,45 MPa) ocorreu com o dispositivo bloqueado e sob carga estática, enquanto o maior deslocamento ($3{,}975 \times 10^{-3}$ mm) foi observado com o dispositivo bloqueado e sob carga dinâmica.

Conclusão O protótipo do dispositivo desempenhou o papel de suporte de tensão com deformação aceitável nos dois modos, bloqueado ou dinamizado, e pode ser fabricado com aço inoxidável ou titânio.

Palavras-chave

- fraturas ósseas
- fixadores externos
- consolidação da fratura
- dinamização

Introduction

The success of biological bone healing seems dependent on a favorable mechanical environment, and, under Wolff's law and Perren's strain theory, several osteosynthesis systems can be used to promote proper stabilization and different types of cell differentiation at the fracture site.[1,2] The relative stability indicated for diaphyseal or comminuted extra-articular fractures allows some controlled mobility at the fracture site and exuberant bone callus formation, which characterizes an indirect or endochondral ossification. To prevent the formation of bulky bone calluses in joint fractures, direct or intramembranous ossification by following absolute fixation with greater stiffness is recommended.[3]

The so-called 'dynamization' refers to the use of external fixation devices to alter the mechanical environment for optimized osteosynthesis. Percutaneous pinning figures as a quick and low-cost method with minimal blood loss, in which external fixators are used to stabilize complex fractures that involve soft tissues or even to progressively correct deformities through stabilization during weight-bearing and mobilization of large joints.[4,5] Moreover, bone callus formation is significantly increased due to the interfragmentary movement, mainly in the optimal range of 0.5 mm for the acceleration of delayed diaphyseal fracture healing.[6] The biocompression theory, which is reported as essential as the osteogenic factors in bone fracture healing, has been proven by finding bone callus in patients with a tibial fracture that were treated with the aid of external fixator to provide good stability and local compression.[7] Accordingly, other authors suggested the use of unilateral external fixators able to promote controlled dynamization in compound fractures and healing delays.[8,9] The use of flexible external fixation to heal long bone fractures has been advocated since 1986 on account of greater mobility and bone callus formation. The first model was employed by Lambotte in 1902, modified by Anderson and Hoffman in 1938, and the classic ring fixator developed by Ilizarov in 1952 remains as a good option due to its versatility, adaptative capacity, low cost, and ability to apply compressive, distractive, or neutral forces on bones.[10–12]

Given the difficulty of conducting clinical investigations on the necessary forces to stimulate bone healing, FEA figures as a useful aid.[13] This method has been widely used in both medical and orthopedic fields since it provides a comprehensive overview of vectors' dissolution in undermined structures, accurate failure detection and still avoids unnecessary costs in cases whereby the failure would only be identified after structural designing or manufacturing.[14] Moreover, the time from the very first conceptual design until production is reduced since the manufacturing of an enormous number of experimental specimens becomes unnecessary. Finite elements analysis provides access to information that is very difficult to obtain in lab conditions, such as the distribution of predicted stress and material strength that are of great importance in the assessment of fatigue resistance.[15,16]

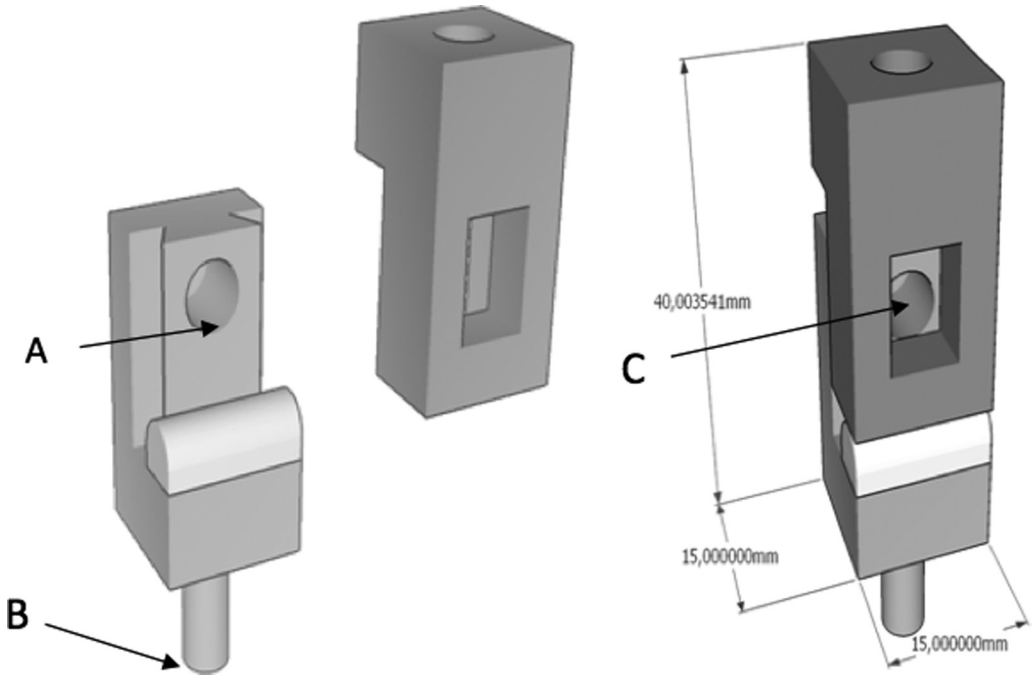

Fig. 1 Geometric modeling. (A) Dovetail slide. (B) Threaded rod. (C) Bolt hole.

Faster consolidation of long bones, better rehabilitation and recovery of the patients are expected due to dynamization, which is still not provided by current external circular fixators. Thus, this study aimed to virtually prototype a device that can connect two rings of standard external circular assembly and promote the dynamization. This prototype was simulated with two different materials, and its mechanical behavior was predicted by using FEA method.

Method

Geometric Modeling

A tridimensional design software (Google SketchUp 2017, Google LLC, Menlo Park, CA, USA) was used to model a device (patent BR 10 2017 018227 4 registered at the National Institute of Industrial Property (INPI, in the Portuguese acronym), consisting of two metal parts closely attached by a sliding dovetail joint and a high-density silicone damper (►**Fig. 1**). The dovetail joint prevents separation of the parts during both torsional and angular movements, while the silicone damper softens and controls axial displacement.

The device was modeled to operate in the locked mode when a single and totally rigid block is formed by screwing both parts together; however, in cases in which dynamization (dynamic mode) is aimed, the physician loosens the bolt to allow sliding movement between the parts and the load is transferred to the bone. A threaded rod is located in the lower part of the device, while the hole observed in the top part allows its versatile attachment to be connected to an external fixator. Moreover, the device has universal applications within different manufacturers due to the standardization of holes, bolts, and rod dimensions.

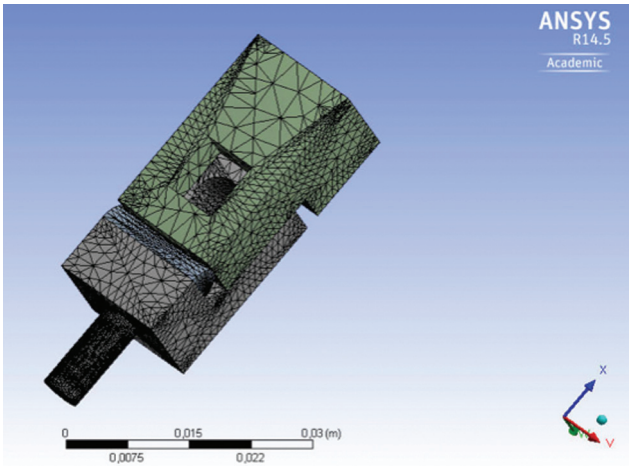

Fig. 2 Finite elements analysis model with 81,872 nodes and 45,922 elements.

Meshing

After geometric modeling, a finite elements (FEs) model was generated by using the Ansys r14.5 software (Ansys Inc., Canonsburg, PA, USA) (►**Fig. 2**). The biomechanical behavior of the device was simulated by considering the physical properties of two different materials indicated by the American Society for Testing and Materials (ASTM) for biomedical applications (stainless steel F138/18Chromium-14Nickel-2.5Molybdenum or titanium F1295/Ti6Al7Nb) in order to predict their feasibility for further machining (►**Table 1**).

Virtual Simulation

By applying a 500 N load, which, in agreement with the FDA (Food and Drug Administration, Department of Health and

Table 1 Physical properties of the materials

Material	Elasticity modulus (MPa)	Poisson ratio	Maximum compression strength (MPa)	Maximum tensile strength (MPa)
Stainless steel	187,500	0.33	800	800
Titanium	113,800	0.34	950	950
Silicone rubber	0.515	0.4	0.0552	0.0552

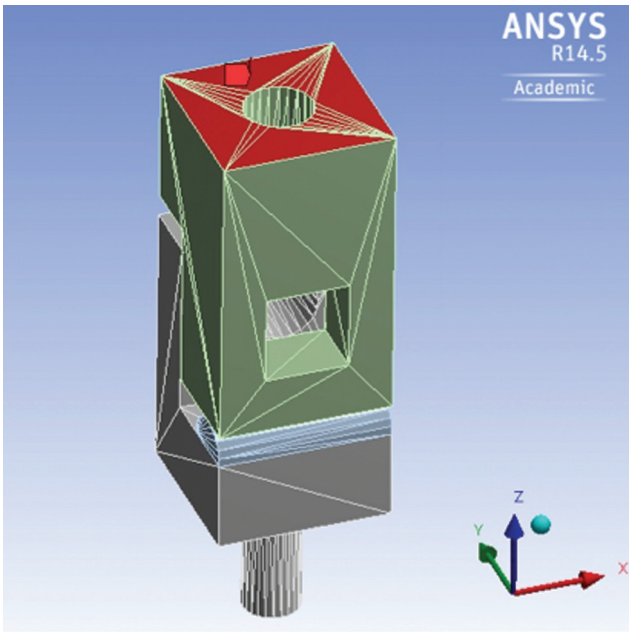

Fig. 3 A 150 kg load was applied to the red area.

Table 2 Results for stainless steel device

Device mode	Locked		Dynamized	
Loading	Static	Dynamic	Static	Dynamic
Maximum stress (MPa)	140.98	80,637	9.2798	9.0956
Maximum displacement (mm)	2.35×10^{-3}	2.41×10^{-3}	2.60×10^{-4}	2.55×10^{-4}

Table 3 Results for titanium device

Device mode	Locked		Dynamized	
Loading	Static	Dynamic	Static	Dynamic
Maximum stress (MPa)	141.45	80.73	9.2015	9.0189
Maximum displacement (mm)	3.86×10^{-3}	3.97×10^{-3}	4.25×10^{-4}	4.17×10^{-4}

Human Services, USA), corresponds to a human body weight of 150 Kg, the model was submitted to the structural analysis of intrinsic displacement, deformation, and fatigue-sensitive site. This load is justified since at least three devices would be simultaneously used in a real-life situation. The load was applied towards the center of the device, on its top surface and with a constant 90° inclination.

In order to simulate both locked (no movement at the fracture site) and dynamic treatment stages (load transfer to the bone and controlled movement are intended), the device was initially tested with both parts completely fixed with one another, and then with the possibility of axial displacement. In both modes, the variables analyzed after loading were the displacement between both device parts and the deformation sites.

The translation resultant between the parts was calculated after applying axial forces with 2 mm as the threshold for acceptable displacement. The deformation thresholds upon axial forces were considered 1 mm for the locked mode and between 1 to 2 mm of compression for the dynamic mode, with re-establishment of the original shape after unloading.[17]

Considering both materials of construction and modes, two distinctive FE analyses were conducted for static (point loading) or dynamic loading (0.5 sec) with uniform 150 kg axial load on top of the device, in order to simulate movement or orthostatic standing, respectively (►**Fig. 3**). The device material (stainless steel or titanium), mode (locked or dynamized), and loading condition (static or dynamic) were addressed as independent variables, while resistance and displacement of components were examined as dependent variables.

Results

In compliance with the sequential development of geometric modeling, meshing, constitutive modeling, boundary conditions and loading conditions, our FE model presented a total of 81,872 nodes and 45,922 elements. The FEA results regarding maximum stress and displacement obtained for each material, mode, and loading condition are described in ►**Tables 2** and **3**, while stress distributions are visualized in ►**Figure 4**.

In the simulation with stainless steel, the maximum stress did not reach one-third of the reported mechanical property, which represents reliability against fatigue failure when the locked device is submitted to maximum static loading (maximum stress peak of 140.98 MPa at the proximal area of the dovetail slot); lower values were found for the other simulations, and the lowest stress peak of 9.0956 MPa was observed for the dynamized device under dynamic loading.

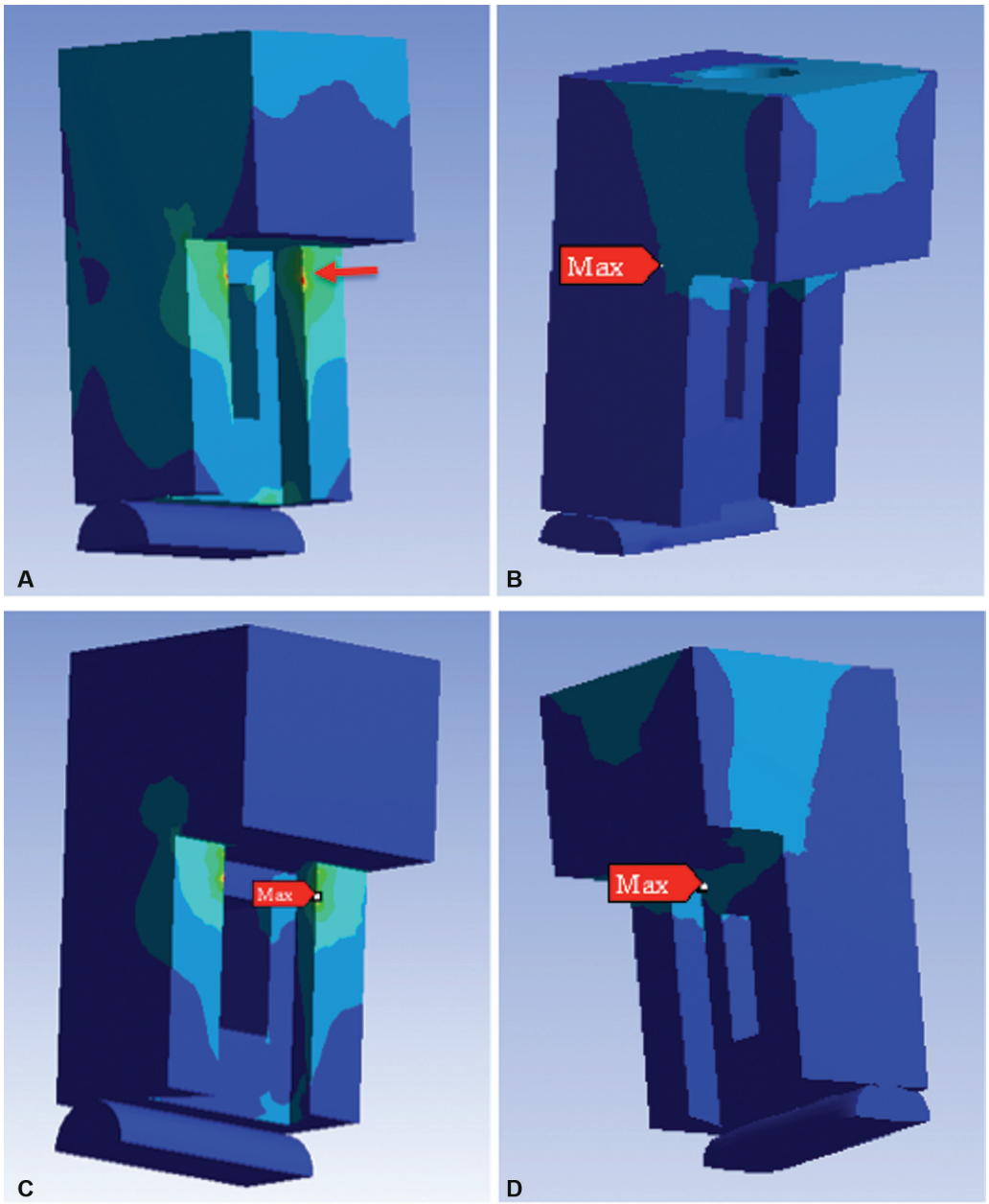

Fig. 4 Finite elements analysis of stress distribution under dynamic loading of the (A) stainless steel device locked, (B) stainless steel device dynamized, (C) titanium device locked and (D) titanium device dynamized. One part of the device was intentionally removed from the image to allow the visualization of the sites of maximum stress peaks (indicated by the red arrows).

In addition, the greatest displacement for the stainless steel device was observed under dynamic loading and with the device locked (2.415×10^{-3} mm); however, this value remained well below the pre-established 1-mm threshold. Displacement was even smaller when dynamization was activated, and the lowest value was observed for static loading (2.60×10^{-4} mm) with a uniform displacement of the dovetail slide; the reliability in promoting controlled axial displacement without interference from device deformation ranged from 1.3477 to 2.3562 safety margin.

Considering titanium as the material of construction, the observed maximum stress was 6.7 times lower than the material property threshold; the highest value (141.45 MPa) was found for the locked device under static loading (maximum stress peak located at the proximal area of the dovetail slot), and the lowest value was observed for the dynamized device under dynamic loading (9.0189 MPa). The locked device under dynamic loading resulted in the greatest displacement (3.975×10^{-3} mm) at the proximal area of the dovetail slot with a 10.9 safety margin, while the dynamized device under static loading resulted in the lowest displacement (4.256×10^{-4} mm), and the maximum stress peak was located at the proximal area of the dovetail slot. Considering that these values were below the pre-established 1-mm threshold, the effectiveness of the device in supporting axial loading without interference from deformation or mobility was demonstrated.

Discussion

The present study aimed at developing an effective, more accessible, and low-cost device for controlled dynamization to improve the use of a widely known external circular fixator, similar to that introduced by Ilizarov.[10] The device for external circular fixation was simulated with materials of different physical properties widely used for osteosynthesis: highly rigid stainless steel and titanium with high tensile and compressive strengths.[18]

Concerning different loading during movement or orthostatic standing, our findings reinforced the reliability of the prototyped device on the control of compression and axial displacement. The simulations with stainless steel consistently resulted in higher maximum displacement than titanium; however, these values were always well below the pre-established threshold, thus ensuring effectiveness and safety for realistic axial loading up to 500 N.[19] The analysis of maximum stress varied according to the device dynamization; higher values were found for the locked titanium device in both static and dynamic loading. In contrast, the dynamized stainless steel device showed higher maximum stress in both static and dynamic loading conditions; albeit, these values were lower than one third of the material property.[18] Therefore, both materials of construction were considered equally safe in terms of resistance and overload. In addition to the possibility to be assembled with an external circular fixator without altering its initial functionality, the controlled dynamized device modifies the load distribution for the desired period without needing further surgery.

Although these FEA results support the use of this device for bone fracture healing, our findings must be interpreted with caution, and randomized controlled clinical trials are needed to relate these findings to the clinical function.

Conclusion

It can be concluded that the prototyped device played the role of stress support without deformation in both locked or dynamized modes and may be fabricated with both stainless steel and titanium.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Wolff J. Das Gesetz der Transformation der Knochen. Berlin: Hirschwald; 1892
2 Perren S, Boitzy A. Cellular differentiation and bone biomechanics during the consolidation of a fracture. Clin Anat 1978;1:13–28
3 Glatt V, Matthys R. Adjustable stiffness, external fixator for the rat femur osteotomy and segmental bone defect models. J Vis Exp 2014;9(92):e51558
4 Compton J, Fragomen A, Rozbruch SR. Skeletal Repair in Distraction Osteogenesis: Mechanisms and Enhancements. JBJS Rev 2015;3(08):pii: 01874474–201508000–00002
5 Henderson DJ, Rushbrook JL, Stewart TD, Harwood PJ. What Are the Biomechanical Effects of Half-pin and Fine-wire Configurations on Fracture Site Movement in Circular Frames? Clin Orthop Relat Res 2016;474(04):1041–1049
6 Frost HM. Bone "mass" and the "mechanostat": a proposal. Anat Rec 1987;219(01):1–9
7 Lazo-Zbikowski J, Aguilar F, Mozo F, Gonzalez-Buendia R, Lazo JM. Biocompression external fixation. Sliding external osteosynthesis. Clin Orthop Relat Res 1986;(206):169–184
8 Marsh JL, Nepola JV, Wuest TK, Osteen D, Cox K, Oppenheim W. Unilateral external fixation until healing with the dynamic axial fixator for severe open tibial fractures. J Orthop Trauma 1991;5 (03):341–348
9 Barquet A, Massaferro J, Dubra A, Milans C, Castiglioni O. The dynamic ASIF-BM tubular external fixator in the treatment of open fractures of the shaft of the tibia. Injury 1992;23(07): 461–466
10 Foxworthy M, Pringle RM. Dynamization timing and its effect on bone healing when using the Orthofix Dynamic Axial Fixator. Injury 1995;26(02):117–119
11 Moss DP, Tejwani NC. Biomechanics of external fixation: a review of the literature. Bull NYU Hosp Jt Dis 2007;65(04):294–299
12 Fragomen AT, Rozbruch SR. The mechanics of external fixation. HSS J 2007;3(01):13–29
13 Roseiro LM, Neto MA, Amaro A, Leal RP, Samarra MC. External fixator configurations in tibia fractures: 1D optimization and 3D analysis comparison. Comput Methods Programs Biomed 2014; 113(01):360–370
14 Lotti RS, Machado AW, Mazzieiro ET, Landre Júnior J. Scientific application of finite elemento method. Rev Dent Press Ortodon Ortop Facial 2006;11:35–43
15 Easley SK, Pal S, Tomaszewski PR, Petrella AJ, Rullkoetter PJ, Laz PJ. Finite element-based probabilistic analysis tool for orthopaedic applications. Comput Methods Programs Biomed 2007;85(01): 32–40
16 Kluess D, Souffrant R, Mittelmeier W, Wree A, Schmitz KP, Bader R. A convenient approach for finite-element-analyses of orthopaedic implants in bone contact: modeling and experimental validation. Comput Methods Programs Biomed 2009;95(01): 23–30
17 Burgers PT, Van Riel MP, Vogels LM, Stam R, Patka P, Van Lieshout EM. Rigidity of unilateral external fixators–a biomechanical study. Injury 2011;42(12):1449–1454
18 Gao Y, Jin Z, Wang L, Wang M. Finite element analysis of sliding distance and contact mechanics of hip implant under dynamic walking conditions. Proc Inst Mech Eng H 2015;229(06): 469–474
19 Pan M, Chai L, Xue F, Ding L, Tang G, Lv B. Comparisons of external fixator combined with limited internal fixation and open reduction and internal fixation for Sanders type 2 calcaneal fractures: Finite element analysis and clinical outcome. Bone Joint Res 2017; 6(07):433–438

Evaluation of Polyethylene Wear in a Brazilian Ultracongruent Knee Prosthesis with a Rotating Platform*

Avaliação do desgaste do polietileno de uma prótese de joelho nacional ultracongruente de base rotatória

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Abstract

Objective To evaluate the wear of polyethylene in a Brazilian ultracongruent knee prosthesis with a rotating platform (Rotaflex, Víncula, Rio Claro, SP, Brasil).

Methods We used the test method with the loading and preparation parameters mentioned in the standards regulation *ISO 14243-1:2009*, and the measurement methods mentioned in the standards regulation *ISO 14243-2:2009*, for the evaluation of the wear behavior of a Brazilian prosthesis with a rotating platform. The equipment used for the wear test was the ISO 14243–1 gait simulator (EndoLab, Riedering, Germany).

Results After 10 million cycles, the evaluation of the polyethylene wear showed a regular appearance of surface wear at a mean rate of 2.56 mg per million cycles.

Conclusion The wear of the polyethylene of the evaluated prosthesis was minimal after the tests performed and with safety limits higher than those recommended by biomechanical engineering.

Keywords
- arthroplasty, replacement, knee
- knee prosthesis
- prosthesis design
- prosthesis failure

Resumo

Objetivo Avaliar o desgaste do polietileno de uma prótese de joelho brasileira ultracongruente de base rotatória (Rotaflex, Víncula, Rio Claro, SP, Brazil).

Métodos Utilizou-se o método de ensaio com os parâmetros de carregamento e preparação citados na norma *ISO 14243-1:2009*, e os métodos de medição citados na norma *ISO 14243-2:2009*, para a avaliação do comportamento de desgaste de uma prótese nacional com base rotatória. O equipamento utilizado para o teste de desgaste foi o simulador de marcha ISO 14243–1 (EndoLab, Riedering, Alemanha).

* *Work developed at the Knee Group, Department of Orthopedics and Traumatology, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo (HCFMUSP), São Paulo, SP, Brazil, and at Faculdade de Medicina, Universidade de Campinas, Campinas, SP, Brazil.*

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Palavras-chave
- artroplastia do joelho
- prótese do joelho
- desenho de prótese

Resultados Após 10 milhões de ciclos, a avaliação do desgaste do polietileno mostrou uma aparência regular do desgaste da superfície com taxa média de 2,56 mg por milhão de ciclos.

Conclusão O desgaste do polietileno da prótese avaliada foi mínimo após os ensaios realizados e com os limites de segurança superiores aos preconizados pela engenharia biomecânica.

Introduction

The aging of the population and the higher prevalence of patients with osteoarthritis has increased the frequency of indications for total knee arthroplasty (TKA).[1,2] Total knee arthroplasty can be defined as a highly-complex surgical procedure for the treatment of arthrosis that is capable of demonstrating satisfactory and long-lasting data on the improvement in pain, quality of life and patient functional outcomes, as well as in the correction of deformities and instabilities with origins related to degenerative processes that compromise the knee joint.[3] This procedure has excellent postoperative results in relation to implant survival, with rates higher than 95% in at least 10 years of follow-up.[4]

Polyethylene wear can produce debris that influences the release of prosthetic components. Total knee arthroplasty with a rotating platform has theoretical biomechanical advantages over a fixed-platform design.[5] These advantages include an improvement in kinematics by increasing the range of motion, facilitating axial rotation, better distribution of stress between the femoral and tibial components, and reduction in release forces at the implant interface with the bone.[6–8] Many variables can influence the frictional wear behavior of polyethylene, like the design of the prosthesis, the raw material used, and the surgical technique applied and the patient's morbidities, such as the activity level and body mass. The objective of the present study was to evaluate the wear of polyethylene of a Brazilian ultracongruent knee prosthesis with a rotating platform (Rotaflex, Víncula, São Paulo, SP, Brasil).

Materials and Methods

We used the test method with the standard parameters for loading and preparation listed in the norm *ISO 14243-1:2009– Implants for Surgery – Wear of Total Knee Joint Prostheses – Part 1: Loading and Displacement Parameters for Wear Testing Machines with Load Control and Corresponding Environmental Conditions for Tests (Accredited)*, and the measurement methods mentioned in the norm *ISO 14243–2:2009 Implants for Surgery – Wear of Total Knee Joint Prostheses – Part 2: Methods of Measurement (Accredited)*. For the evaluation of the wear behavior, the Rotaflex prosthesis was used.[9,10]

In total, 3 simultaneous tests were performed in the ISO 14243–1 knee joint gait simulator (EndoLab, Riedering, Germany) in 5 systems, totaling 15 components (►**Figures 1** and **2**).

In the simulations, the implant was attached to the extension device. A cyclical flexion-extension variation from 0° to 58° was applied (►**Table 1**). An axial force ranging from 168 N to 2,600 N was also applied, depending on the degree of flexion, simulating a normal human walk (►**Table 1**). The tibial base was free to accommodate to the femoral component under the influence of applied contact forces, with this movement having all degrees of freedom, except the flexion-extension angle, which followed the specified cyclic variation. With this simulation, the applied contact force actions were: axial force, anteroposterior (AP) force, and tibial rotation torque. The femoral and tibial metal components, as well as the polyethylene, were immersed in a fluid medium simulating human synovial fluid throughout the test, which was carried out in a controlled environment, simulating the physiological conditions.

The wear assessment followed the *ISO 14243–2:2009* norms, with 10 million cycles and measurements taken at every millionth cycle. In accordance with the aforementioned norms, the wear was assessed by analyzing the loss of mass.

Results

After 10 million cycles, the qualitative analysis of the polyethylene surface showed an appearance of regular wear, with polished and matte areas (►**Figure 2**). This regular wear pattern indicates an intrinsic stability of the prosthetic components (►**Figure 3**).

The quantitative result of mass wear for every millionth cycle is found in ►**Table 1**. ►**Figure 3** expresses the results mentioned in ►**Table 2**.

The mean wear rate was 2.56 mg per millionth cycle, which was determined after 10 million cycles (►**Figure 1**).

Discussion

Total knee arthroplasty aims to promote pain relief and improve function in a lasting way. However, surgery can fail for a number of reasons, such as loosening of the components, infection, instability, and persistent pain, for example.[11] In order to reduce the wear of the polyethylene and consequently the production of debris, a tibial component with a rotating platform was created, in which the polyethylene can move rotationally over the tibial component, hypothetically reducing its friction and wear.[6,7,12]

In a study,[11] the authors state that prostheses with ultracongruent rotational support have the advantage of

Fig. 1 Representation of the individual test chamber.

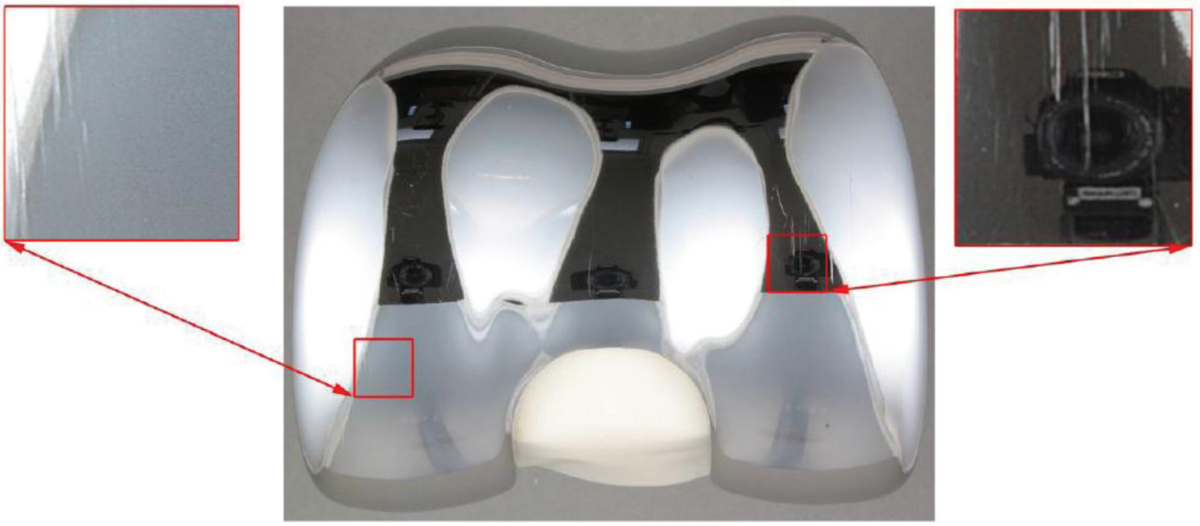

Fig. 2 Qualitative virtual analysis of the wear.

standardizing the contact pressures between components, thus reducing the formation of polyethylene particles and, consequently, osteolysis, in addition to the better adaptation of the extensor mechanism to possible imperfections in the rotational positioning of the tibial component.[11] An in-vivo video-fluoroscopic study, followed by three-dimensional reconstruction of the images obtained, comparing prostheses with fixed and mobile bases, with the same origin and design, showed that the femorotibial contact surface is twice as large in prostheses with rotational support when compared to those with fixed support.[13] In this study, the authors noted that the good results were similar in both models, but, both objectively and subjectively, the mobile platform was judged to be the closest to the normal knee.[13]

The high durability of prostheses with a rotating polyethylene component is well elucidated in the literature, and the prostheses can last for more than 20 years in 97.7% of cases.[14]

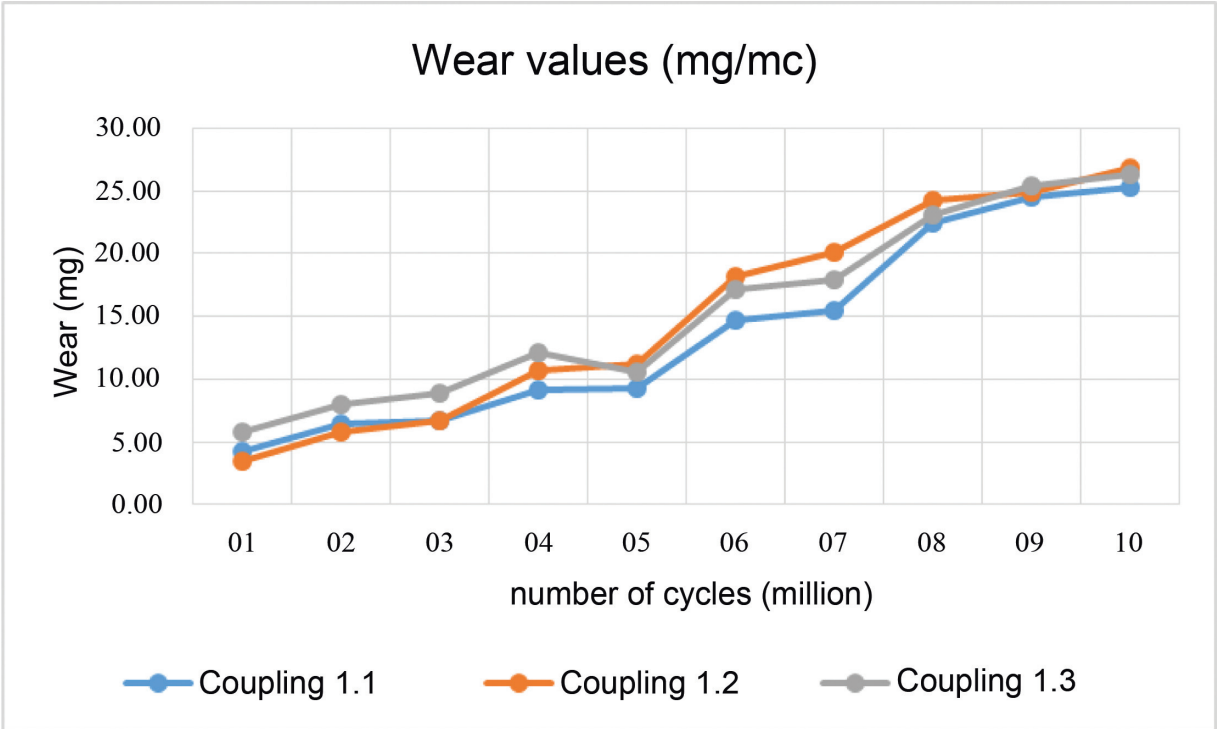

Fig. 3 X-UHMWPE insert wear versus number of cycles.

Table 1 Loading parameters

Parameter	Values according to ISO 14243–1
Flexion/Extension	0° to 58°
Axial force	168 N to 2,600 N
Anteroposterior force	-265 N to 110 N
Torque	−1 Nm to 6 Nm
Frequency	1 Hz
Test fluid	Calf serum
Movement restriction - anteroposterior* (contrary to the positive anteroposterior movement)	9.3 N/mm
Movement restriction - anteroposterior* (contrary to the negative anteroposterior movement)	44 N/mm
Restriction of tibial rotation**	0.36 Nm/°

Notes: *The system's anteroposterior movement restriction is 0 when the total knee joint is equal to or close to 2.5 mm in any direction from the reference position. **The tibial rotation restriction of the system is 0 when the total knee joint is equal to or close to +/- 6° in any direction from the reference point.

Schmidt et al[15] studied the wear rate of polyethylene in different models of prostheses already commercialized and established in the market, and they found values of volumetric wear that ranged from 1.9 mg/mc to 14.6 mg/mc. In the present study, the result obtained of 2.67 mg/mc of volumetric wear after 10 million test cycles, compared to the values found by Schmidt et al,[15] demonstrated that the Rotaflex system approaches the lowest rate found (1.9 mg/mc). In addition, the 2.67 mg/mc of wear of the polyethylene component measured in this Brazilian prosthesis obtained a wear resistance performance 5.47 times higher than the maximum published values.

Conclusion

The wear of the polyethylene of the evaluated prosthesis was minimal after the tests performed with safety limits higher than those recommended by biomechanical engineering.

Table 2 Wear data of the X-UHMWPE tested (polyethylene) inserts

Coupling	1.1		1.2		1.3	
	Mass		Mass		Mass	
Cycles (million)	X-UHMWPE 1.1 insert (g)	X-UHMWPE 1.1 insert (mg)	X-UHMWPE 1.2 insert (g)	X-UHMWPE 1.2 insert (mg)	X-UHMWPE 1.3 insert (g)	X-UHMWPE 1.3 insert (mg)
0.0	44.71242	0.00	44.48231	0.00	44.66329	0.00
0.5	44.70981	3.91	44.48121	2.41	44.65973	4.86
1.0	44.71073	4.24	44.48138	3.48	44.66000	5.84
2.0	44.71047	6.47	44.48102	5.81	44.65979	8.01
3.0	44.71210	6.71	44.48202	6.69	44.66085	8.83
4.0	44.71149	9.18	44.47986	10.70	44.65949	12.06
5.0	44.71378	9.30	44.48183	11.14	44.66343	10.52
6.0	44.71097	14.74	44.47747	18.13	44.65948	17.09
7.0	44.71004	15.47	44.47531	20.08	44.65842	17.95
7.5	44.71357	17.77	44.47810	23.13	44.66167	20.54
8.0	44.70607	22.38	44.47417	24.17	44.65625	23.06
9.0	44.70556	24.50	44.47504	24.90	44.65551	25.40
10.0	44.70660	25.23	44.47497	26.75	44.65645	26.24

Conflict of Interests

The authors declare that there are no conflict of interests.

References

1 Jämsen E, Jäntti P, Puolakka T, Eskelinen A. Primary knee replacement for primary osteoarthritis in the aged: gender differences in epidemiology and preoperative clinical state. Aging Clin Exp Res 2012;24(06):691–698

2 Hernandez AJ, Camanho GL, Pécora JR. Artrodese do joelho: gênese e soluções. São Paulo: Atheneu; 2010

3 Ferreira MC, Oliveira JCP, Zidan FF, Franciozi CEDS, Luzo MVM, Abdalla RJ. Total knee and hip arthroplasty: the reality of assistance in Brazilian public health care. Rev Bras Ortop 2018;53(04):432–440

4 McLaughlin JR, Lee KR. Hybrid total knee arthroplasty: 10- to 16-year follow-up. Orthopedics 2014;37(11):e975–e977

5 Tirico LEP, Pasqualin T, Pécora JO, Gobbi RG, Pécora JR, Demange MK. Estudo da estabilidade dos componentes na artroplastia total do joelho sem cimento. Acta Ortop Bras 2012;20(04):230–234

6 Kim YH, Park JW, Kim JS, Kulkarni SS, Kim YH. Long-term clinical outcomes and survivorship of press-fit condylar sigma fixed-bearing and mobile-bearing total knee prostheses in the same patients. J Bone Joint Surg Am 2014;96(19):e168

7 Fransen BL, van Duijvenbode DC, Hoozemans MJM, Burger BJ. No differences between fixed- and mobile-bearing total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2017;25(06):1757–1777

8 Cobra H, Palma IM. Polietileno tibial móvel na artroplastia total do joelho. Rev Bras Ortop 2009;44(06):475–478

9 ISO 14243–1:2009 Implants for surgery - Wear of total knee-joint prostheses–Part 1: Loading and displacement parameters for wear-testing machines with load control and corresponding environmental conditions for test. Disponível em: https://www.iso.org/standard/44262.html

10 ISO 14243–2:2009 Implants for surgery–Wear of total knee-joint prostheses–Part 2: Methods of measurement. Disponível em: https://www.iso.org/standard/44263.html

11 Guglielmetti LG, Couto RC, Camargo OP, et al. Artroplastia total do joelho com o apoio tibial móvel. Avaliação dos resultados a médio prazo. Acta Ortop Bras 2010;18(06):310–314

12 Jorgensen NB, McAuliffe M, Orschulok T, Lorimer MF, de Steiger R. Major Aseptic Revision Following Total Knee Replacement: A Study of 478,081 Total Knee Replacements from the Australian Orthopaedic Association National Joint Replacement Registry. J Bone Joint Surg Am 2019;101(04):302–310

13 Ranawat CS, Flynn WF Jr, Saddler S, Hansraj KK, Maynard MJ. Long-term results of the total condylar knee arthroplasty. A 15-year survivorship study. Clin Orthop Relat Res 1993;(286):94–102

14 McEwen HM, McNulty DE, Auger DD, et al. Wearanalysis of mobile bearing knee. In: Hamelynck KJ, Stiehl JB, editors. LCS mobile bearing knee arthroplasty: a 25 years worldwide review. Heidelberg, Germany: Springer Verlag; 2002:67–73

15 Scmidt R, Jinnah R, Green J, Moseley J, Brownhill J. In vitro assessment of a cruciate retaining and cruciate sacrificing medially pivoting knee replacement. In: Annual Meeting of the Orthopaedic Research Society 2011, Long Beach, CA, 2011. (Poster n° 1150. ORS 2011).

Analysis of Posterior Tibial Slope as Risk Factor to Anterior Cruciate Ligament Tear

Análise da inclinação tibial posterior como fator de risco para lesão do ligamento cruzado anterior

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Abstract

Objective The objective of the present study was to evaluate the relationship between patients with anterior cruciate ligament (ACL) injury by indirect trauma and increased posterior tibial inclination.

Methods Retrospective study, performed by analysis of medical records and digital radiographs of patients, present in a database of a tertiary orthopedic hospital. The sample consisted of two groups, the first group consisting of patients diagnosed with ACL injury by indirect trauma, and a control group matched by age.

Results Each group consisted of 275 patients, whose measurements of posterior tibial inclination were measured by three specialists. It was observed that the group of patients with ACL lesion presented a significantly higher tibial slope (in degrees) than the control group in the total sample and in the subsamples stratified by gender. The best cutoff point for the first group was identified as a posterior tibial inclination $\geq 8°$, achieving a sensitivity of 63.3% and a specificity of 62.5%. The first group also had a tibial slope ratio $\geq 8°$ (63.3%), significantly higher than the control group (37.5%), with an odds ratio of 2.8.

Conclusion It was concluded that the increase of the posterior tibial inclination is associated with an increased risk for injury of the ACL by indirect trauma, mainly for values $\geq 8°$.

Keywords
- anterior cruciate ligament
- ligaments
- knee injuries
- tibia

Resumo

Objetivo O objetivo do presente estudo foi avaliar a relação entre pacientes com lesão do ligamento cruzado anterior (LCA) por trauma indireto e o aumento da inclinação posterior da tíbia.

Métodos Estudo retrospectivo, realizado por análise de prontuários e radiografias digitais de pacientes, presentes em banco de dados de um hospital terciário de

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ortopedia e traumatologia. A amostra foi composta por dois grupos, sendo o primeiro formado por pacientes com diagnóstico de lesão do LCA, por trauma indireto, e um grupo controle pareado por idade.

Resultados Cada grupo foi formado por 275 pacientes, cujas medidas de inclinação tibial posterior foram aferidas por 3 especialistas. Observou-se que o grupo dos pacientes com lesão do LCA apresentou slope tibial (em graus) significativamente maior que o grupo controle na amostra total e nas subamostras estratificadas por gênero. Identificou-se como o melhor ponto de corte (*cutoff*) para o primeiro grupo uma inclinação tibial posterior $\geq 8°$, atingindo uma sensibilidade de 63,3% e uma especificidade de 62,5%. O primeiro grupo também apresentou proporção de slope tibial $\geq 8°$ (63,3%), significativamente maior que o grupo controle (37,5%), com razão de chances de 2,8.

Conclusão Concluiu-se que o aumento da inclinação tibial posterior está associado com um maior risco para lesão do LCA por trauma indireto, principalmente para valores $\geq 8°$,

Palavras-chave
- ligamento cruzado anterior
- ligamentos
- traumatismos do joelho
- tíbia

Introduction

The anterior cruciate ligament (ACL) is the main restrictor of the anterior translation of the tibia over the femur, being responsible for 85% of the anterior knee stabilization.[1,2] It also acts by limiting internal rotation and secondarily restricting valgus and varus stresses.[2–4]

Anterior cruciate ligament injury is one of the most common ligament injuries of the knee, with increasing incidence due to the rising number of individuals involved with the practice of sports activities.[2,4] It occurs predominantly secondary to indirect trauma, with an association between knee valgus stress and internal tibial rotation.[2,4,5] Failure to properly treat previous instability can lead to injuries to other structures or long-term degenerative changes. Its surgical treatment has good results, although the patient is not always able to return to sports activities with the same performance as before the injury.[5–7]

The identification of risk factors for ACL injuries during physical and sports activities has become a focus of musculoskeletal research. Understanding the mechanisms that produce this instability allows the identification of people at increased risk so that preventive interventions can be applied.[6,7]

The posterior tibial slope has been increasingly studied as a potential risk factor for ACL injury, showing quite varied results between its increase and ligament injury.[6,8,9]

Some biomechanical studies of the knee joint verify that, during an axial compression load, the posterior tibial slope acts producing a force component that leads to the anteriorization of the tibia in relation to the femur.[8–12] It is known that the ACL is the primary retention system against this type of knee movement, that is, an increase in the posterior tibial slope will generate a stress increase in this ligament.[1,11,12] Although some studies suggest the relationship between the posterior slope of the tibial plateau and the ACL injury, the level of risk presented by this intrinsic factor remains unclear.[6,8,9]

Reducing the occurrence of ACL injuries in young active individuals remains an important goal in sports medicine. The objective of the present study is to evaluate, in the Brazilian population, the relationship between patients with ACL injury due to indirect trauma and the increase in posterior tibial slope.

Material and Methods

This is a retrospective study, conducted through the analysis of medical records and digital radiographs of patients present in the database of a tertiary hospital for orthopedics and traumatology in Brazil, from January 2014 to January 2016.

The sample consisted of two groups, with Group I formed by patients diagnosed with ACL injuries due to indirect trauma. During the study period, 643 patients with ACL injury were identified. To form group I, patients who did not have medical records clearly showing the trauma mechanism as indirect were excluded. Other exclusion criteria were radiographs of the knee that prevented reliable measurement of posterior tibial slope (poor quality, radiological changes due to previous surgery or osteoarthritis).

A control group (Group II) was formed from a database of knee radiographs, paired by age with Group I. Any patient with evolution of the medical record showing knee ligament injury was excluded. Research subjects with images that prevented reliable measurement of the tibial slope were also excluded, as described for group I. After analyzing the exclusion criteria, each group was composed of 275 patients. The sample age ranged from 16 to 55 years old. ►**Table 1** provides data on age and gender distribution.

All of the patients underwent a radiographic study according to the routine recommended by the institution. The 500 mA Shimadzu (RADspeed MF, Shimadzu, Kyoto, Japão) X-ray machine was used with a 50 KV and 25 mA technique. A 30×40 cm film was placed at one meter from the ampoule of the digital radiographic apparatus. Then, images in lateral view (profile) with a 30° semiflexion were obtained.

The patients had their knee profile radiographs analyzed, and their posterior tibial slope measured by three orthopedics specialists who were unaware of which group each patient belonged to. This measurement was performed by

Table 1 Sample characterization regarding age and gender

Variable	ACL injury due to indirect trauma ($n = 275$)	Control group ($n = 275$)	Total ($n = 550$)
Age (years)			
Mean (SD)	33.0 (8.8)	38.4 (9.7)	35.7 (9.7)
Sex (N)			
Male	241 (87.6%)	212 (77.1%)	453 (82.4%)
Female	34 (12.4%)	63 (22.9%)	97 (17.6%)

Abbreviation: ACL, anterior cruciate ligament; SD, standard deviation.

drawing a line on the posterior tibial cortical and another on the proximal articular surface of the tibia. The angle formed between the perpendicular to the posterior cortical line and the line of the articular surface corresponded to the measurement of the posterior tibial slope, as described in ►**Figure 1** and determined by the technique of Hohmann et al.[13]

The statistical analysis was composed by the Student t test for independent samples in the comparison of continuous data between the group with ACL injury by indirect mechanism and the control group, and by the chi-squared test ($\chi 2$) when comparing categorical data. In the association between continuous variables, the Pearson correlation coefficient was used.

A Receiver Operating Characteristic (ROC) curve was built to identify the best cutoff point for posterior tibial slope for indirect trauma. The strength of the association between elevated posterior tibial slope and indirect trauma was measured by odds ratio (OR) and its respective 95% confidence interval (CI).

The normality of data distribution was assessed using the Kolmogorov-Smirnov test and graphical analysis of the histogram. The significance determination criterion adopted was the level of 5%. The statistical analysis was processed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). The study was previously approved by the research ethics committee of the hospital where the study was carried out under the number CAAE 79853617.0.0000.5273.

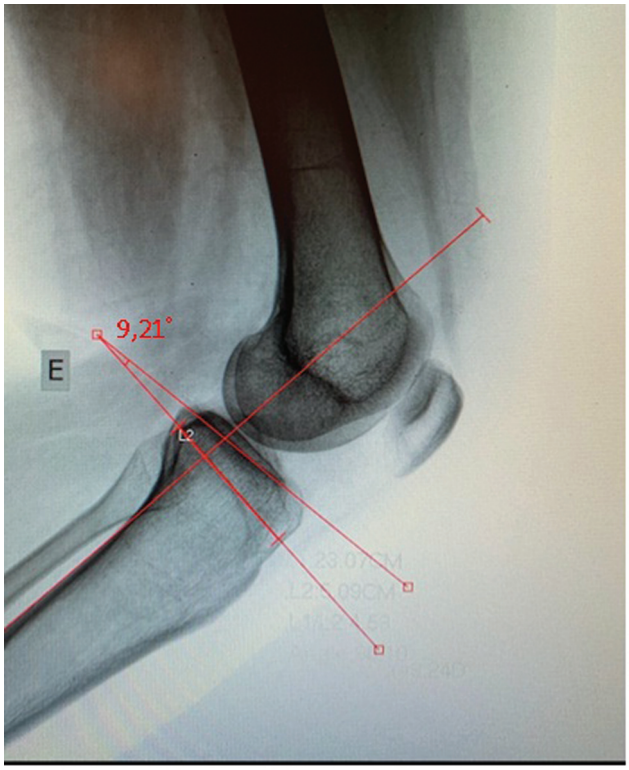

Fig. 1 Demonstration of measurement of posterior tibial inclination.

Results

The values of the posterior tibial slope ranged from 2.6° to 18.1° in the first group, with an average of 9.1°, and from 0 to 17.6° in the second, with an average value of 7.3°. Evaluating the variables posterior tibial slope and gender as a whole, according to the Student's *t* test, we verified that there was no significant association ($p = 0.66$), that is, men did not present a medium tibial slope (8.2 ± 2.9 degrees) significantly different from women (8.1 ± 2.8 degrees).

When we performed the association between tibial slope and the two groups under study, we observed that the group of patients with ACL injury due to indirect trauma presented a tibial slope (in degrees) significantly greater than the control group in the total sample and in the subsamples stratified by gender. ►**Table 2** provides the descriptive of the tibial slope (mean, standard deviation [SD], minimum and maximum, in degrees) according to the groups and the corresponding descriptive level (*p-value*) of the Student *t* test for independent samples, in the total sample and stratified by gender (men and women).

►**Figure 2** illustrates the ROC curve of posterior tibial slope for the group with ACL injury due to indirect trauma in the total sample. The overall accuracy of a test can be

Table 2 Tibial slope (in degrees) according to groups and stratified by gender. Student *t* test for independent samples

Sample	ACL injury due to indirect trauma	Control group	*p-value*
All ($n = 275 \times 275$)			
Mean (SD)	9.1 (2.9)	7.3 (2.6)	< 0.0001
Minimum–maximum	2.6–18.1	0–17.6	
Men ($n = 241 \times 212$)			
Mean (SD)	9.0 (2.9)	7.3 (2.6)	< 0.0001
Minimum–maximum	2.6–18.1	0.10–17.6	
Women ($n = 34 \times 63$)			
Mean (SD)	9.3 (3.0)	7.4 (2.5)	0.001
Minimum–maximum	3.1–14.6	0–12.5	

Abbreviation: ACL, anterior cruciate ligament; SD, standard deviation.

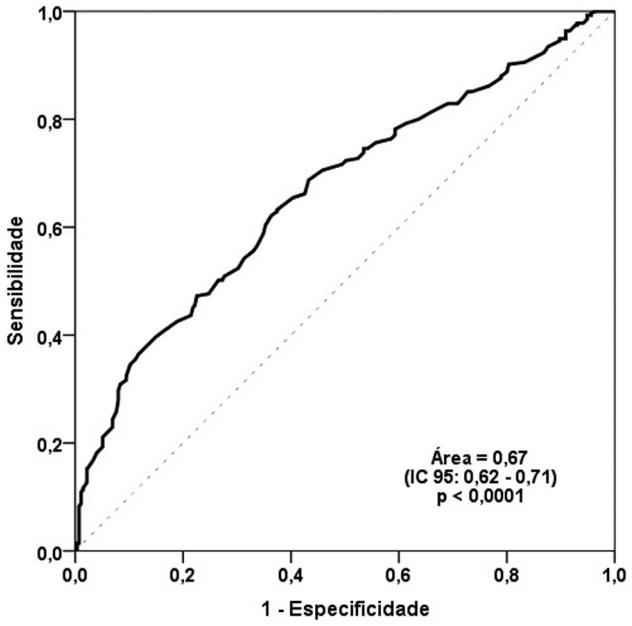

Fig. 2 ROC curve of the tibial slope (in degrees) for patients with ACL injury from indirect trauma.

described as the area under the ROC curve, and the larger the area, that is, the closer to 1, the better the test.

An area of 0.67 was observed with a 95%CI of 0.62 to 0.71, expressing a "moderate/regular" discriminatory power with a significant value ($p < 0.0001$). In addition, considering the control group as a reference category, the best cutoff point for the first group can be identified, which was, according to the ROC curve in the present study sample, a posterior tibial slope $\geq 8°$, reaching a sensitivity of 63.3% and a specificity of 62.5%.

►**Table 3** provides the frequency (n) and percentage (%) of the tibial slope $\geq 8°$ according to the groups under analysis, the corresponding descriptive level (*p-value*) and the odds ratio (OR) for ACL injury due to indirect trauma with the respective 95%CI in the total sample. It was observed, in the total sample, that the group with ACL injury due to indirect trauma presented a proportion of tibial slope $\geq 8°$ (63.3%) significantly higher than the control group (37.5%), with an OR of 2.8 (95%CI: 2.04–4.07) (►**Figure 3**).

However, in ►**Table 4**, it was observed that group I presented a proportion of posterior tibial slope $\geq 8°$ significantly higher than the control group by stratifying into subsamples according to gender, with an OR of ~ 3 for ACL injury from indirect trauma.

Discussion

The association between ACL injury and posterior tibial slope is well-documented in the literature, even though there is still not a consolidated consensus on the level of risk that such an association may have. The present study specifically sought to assess the importance of the degree of posterior tibial slope in patients with ACL injuries originating from indirect trauma. In view of the results found, there is no association between the gender of the patient and the intensity of the posterior tibial slope, differently from what was found by Hohmann et al.,[13] who found greater angulations among females. In the face of equal exposure conditions, it is known that females have a greater risk of ACL injury than males;[7,14] however, the posterior tibial slope could not be considered, according to the results found, one of the reasons for this increased risk.

The relationship between posterior tibial slope and patients with ACL injury due to indirect trauma showed that an increase in angulation would represent an increased risk to the ACL structure when compared to a control group, proving an important interference of the anatomy and biomechanics of the knee in the stability of the joint.

This relationship has been previously described by some authors[9,15–18] who demonstrated that posterior tibial slope has an adverse effect on knee kinematics. On a cadaveric model, Dejour et al.[15] showed a 6 mm increase in anterior tibial translocation for each 10° increase in posterior tibial slope. Similarly, Giffin et al.[16] demonstrated a significant increase in anterior tibial translocation if the posterior slope was increased by 4.4° after a high tibial osteotomy in the opening wedge. Fening et al.[9] performed high tibial osteotomies in the opening wedge and reported an increase in anterior tibial translocation with an increase in tibial slope.

McLean et al.[19] suggested that axial compression of a knee with a greater slope of the lateral tibial plateau, compared to that of the medial tibial plateau, may cause greater anterior movement of the lateral tibial compartment, compared to the other, generating stress in internal rotation of the tibia in relation to the femur, further increasing the load on the ACL.

The statistical analysis of the present study found that patients with an angle $\geq 8°$ are 3 times more likely to damage the ACL through indirect trauma than patients with an angle $< 8°$, regardless of gender.

Some authors advocate the performance of deflection osteotomy as a surgical treatment for patients with excessive posterior tibial slope associated with ACL rupture.[20,21] Dejour et al.[20] evaluated retrospectively a series of patients with tibial slope $> 12°$ who underwent a second ACL

Table 3 Distribution of patients with posterior tibial slope $\geq 8°$ according to groups

Tibial slope	ACL injury due to indirect trauma	Control group	*p value*	OR	CI 95%
$\geq 8°$	174 (63.3%)	103 (37.5%)	< 0.0001	2.87	2.04–4.07
$< 8°$	101 (36.7%)	172 (62.5%)			

Abbreviations: ACL, anterior cruciate ligament; CI, confidence interval; OR, odds ratio.
χ^2 test.

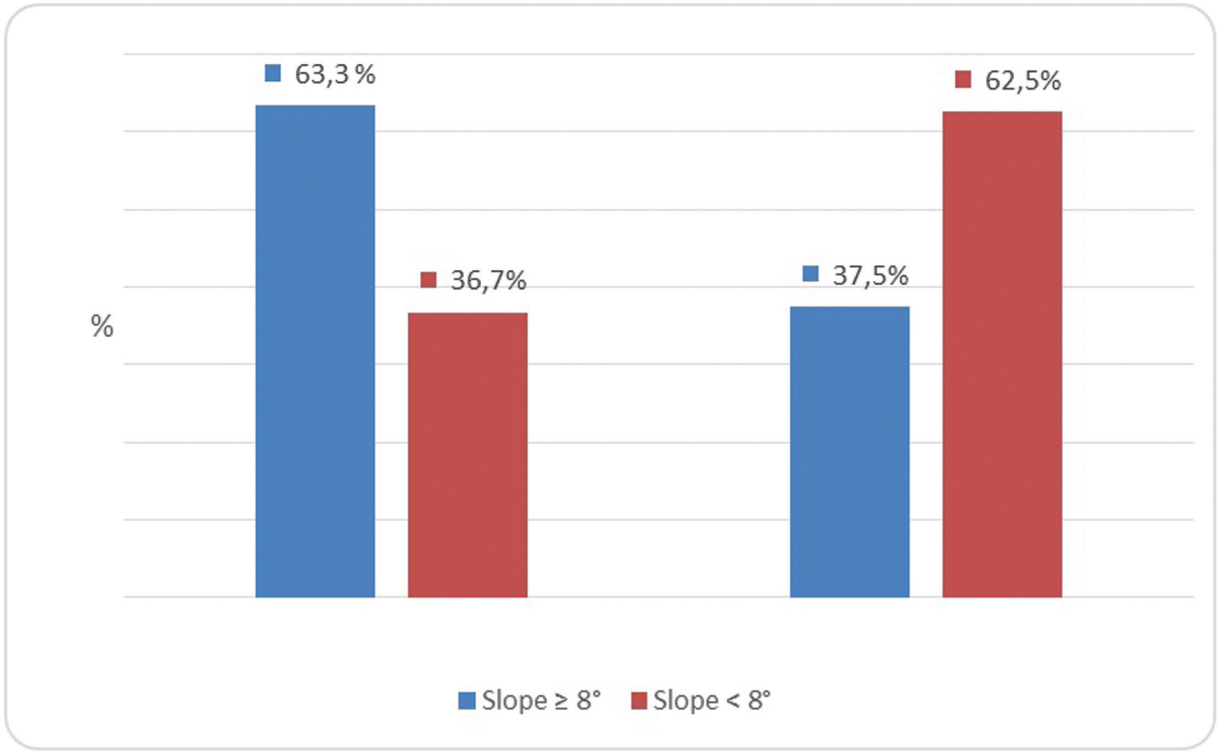

Fig. 3 Tibial slope ≥ 8° according to the groups under study.

Table 4 Tibial slope ≥ 8 degrees according to the type of trauma in the total sample and stratified by gender and age group

Tibial slope	ACL injury due to indirect trauma	Control group	*p-value*	OR	CI 95%
All *(n = 275 × 275)*					
≥ 8 degrees	174 (63.3%)	103 (37.5%)	< 0.0001	2.87	2.04–4.07
< 8 degrees	101 (36.7%)	172 (62.5%)			
Men *(n = 241 × 212)*					
≥ 8 degrees	149 (61.8%)	74 (34.9%)	0.011	3.02	2.05–4.43
< 8 degrees	92 (38.2%)	138 (65.1%)			
Women *(n = 34 × 63)*					
≥ 8 degrees	25 (73.5%)	29 (46.0%)	< 0.0001	3.25	1.31–8.08
< 8 degrees	9 (26.5%)	34 (54.0%)			

Abbreviations: ACL, anterior cruciate ligament; CI, confidence interval; OR, odds ratio.
χ^2 test.

reconstruction review associated with deflection osteotomy. After a minimum follow-up of 2 years, the 9 patients in the study, who met the adopted criteria, were free of complications and with satisfactory functional scores, justifying the procedure for selected cases.

The present study had limitations because it was retrospective. This led to the exclusion of research subjects, due to incomplete information in the medical records, in addition to making it difficult to match the groups on other important criteria, such as the level of sports activity performed or on other associated risk factors for ACL injuries, such as angular deformities.

Conclusion

It is concluded that the increase in posterior tibial slope is associated with a greater risk of ACL injury due to indirect trauma, regardless of gender. Thus, corrective measures should be considered, particularly for those who present excessive tibial slope associated with anterior knee instability.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Butler DL, Noyes FR, Grood ES. Ligamentous restraints to anterior-posterior drawer in the human knee. A biomechanical study. J Bone Joint Surg Am 1980;62(02):259–270

2 Dargel J, Gotter M, Mader K, Pennig D, Koebke J, Schmidt-Wiethoff R. Biomechanics of the anterior cruciate ligament and implications for surgical reconstruction. Strateg Trauma Limb Reconstr 2007;2(01):1–12

3 Dennis DA, Mahfouz MR, Komistek RD, Hoff W. In vivo determination of normal and anterior cruciate ligament-deficient knee kinematics. J Biomech 2005;38(02):241–253

4 Logan M, Dunstan E, Robinson J, Williams A, Gedroyc W, Freeman M. Tibiofemoral kinematics of the anterior cruciate ligament (ACL)-deficient weightbearing, living knee employing vertical access open "interventional" multiple resonance imaging. Am J Sports Med 2004;32(03):720–726

5 Domnick C, Raschke MJ, Herbort M. Biomechanics of the anterior cruciate ligament: Physiology, rupture and reconstruction techniques. World J Orthop 2016;7(02):82–93

6 Wordeman SC, Quatman CE, Kaeding CC, Hewett TE. In vivo evidence for tibial plateau slope as a risk factor for anterior cruciate ligament injury: a systematic review and meta-analysis. Am J Sports Med 2012;40(07):1673–1681

7 Smith HC, Vacek P, Johnson RJ, et al. Risk factors for anterior cruciate ligament injury: a review of the literature - part 1: neuromuscular and anatomic risk. Sports Health 2012;4(01): 69–78

8 Zeng C, Cheng L, Wei J, et al. The influence of the tibial plateau slopes on injury of the anterior cruciate ligament: a meta-analysis. Knee Surg Sports Traumatol Arthrosc 2014;22(01):53–65

9 Fening SD, Kovacic J, Kambic H, McLean S, Scott J, Miniaci A. The effects of modified posterior tibial slope on anterior cruciate ligament strain and knee kinematics: a human cadaveric study. J Knee Surg 2008;21(03):205–211

10 Dejour H, Bonnin M. Tibial translation after anterior cruciate ligament rupture. Two radiological tests compared. J Bone Joint Surg Br 1994;76(05):745–749

11 Torzilli PA, Deng X, Warren RF. The effect of joint-compressive load and quadriceps muscle force on knee motion in the intact and anterior cruciate ligament-sectioned knee. Am J Sports Med 1994;22(01):105–112

12 Voos JE, Suero EM, Citak M, et al. Effect of tibial slope on the stability of the anterior cruciate ligament-deficient knee. Knee Surg Sports Traumatol Arthrosc 2012;20(08):1626–1631

13 Hohmann E, Bryant A, Reaburn P, Tetsworth K. Is there a correlation between posterior tibial slope and non-contact anterior cruciate ligament injuries? Knee Surg Sports Traumatol Arthrosc 2011;19(Suppl 1):S109–S114

14 Alentorn-Geli E, Mendiguchía J, Samuelsson K, et al. Prevention of anterior cruciate ligament injuries in sports. Part I: systematic review of risk factors in male athletes. Knee Surg Sports Traumatol Arthrosc 2014;22(01):3–15

15 Dejour H, Walch G, Chambat P, Ranger P. Active sub- luxation in extension: a new concept of study of the ACL-defi- cient knee. Am J Knee Surg 1988;1:204–211

16 Giffin JR, Vogrin TM, Zantop T, Woo SL, Harner CD. Effects of increasing tibial slope on the biomechanics of the knee. Am J Sports Med 2004;32(02):376–382

17 Hohmann E, Bryant AL. Closing or opening wedge high tibial osteotomy: watch out for the slope. Oper Tech Orthop 2007;17(01):17–38

18 Liu W, Maitland ME. Influence of anthropometric and mechanical variations on functional instability in the ACL-deficient knee. Ann Biomed Eng 2003;31(10):1153–1161

19 McLean SG, Lucey SM, Rohrer S, Brandon C. Knee joint anatomy predicts high-risk in vivo dynamic landing knee biomechanics. Clin Biomech (Bristol, Avon) 2010;25(08):781–788

20 Dejour D, Saffarini M, Demey G, Baverel L. Tibial slope correction combined with second revision ACL produces good knee stability and prevents graft rupture. Knee Surg Sports Traumatol Arthrosc 2015;23(10):2846–2852

21 Sonnery-Cottet B, Archbold P, Cucurulo T, et al. The influence of the tibial slope and the size of the intercondylar notch on rupture of the anterior cruciate ligament. J Bone Joint Surg Br 2011;93 (11):1475–1478

Comparative Study of the Function and Quality of Life of Patients Submitted to Total Knee Arthroplasty with Fixed and Mobile Tibial Platforms

Estudo comparativo da função e qualidade de vida de pacientes submetidos à artroplastia total do joelho com plataformas tibiais fixa e móvel

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Abstract

Objective To compare the function and quality of life of patients undergoing total knee arthroplasty (TKA) with fixed tibial platform and mobile tibial platform.

Methods We evaluated 240 patients with knee osteoarthritis, randomized into two groups - Group A consisted of 120 patients who underwent TKA with fixed tibial platform, and the B group, consisting of 120 patients who underwent mobile platform arthroplasty. Patients were accessed according to the function and quality of life by the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the Short Form Health Survey (SF-36), and pain scores by visual analog scale (VAS) of pain, preoperatively and at 6 months, 1 year, 2 years, 4 years and 8 years of surgery.

Results Regarding the various domains of the SF-36, we observed that the average behavior of functional capacity scores, physical aspects, pain and emotional aspects in the patient groups were statistically different during follow-up. The other domains of quality of life showed no mean differences. Regarding the pain assessed by VAS and WOMAC pain scores, we can see that it showed a mean change in follow-up in both patient groups. However, at 2 years of follow-up, they were statistically worse in group A, equaling group B in the other moments.

Conclusion After 2 years of follow-up, we observed that pain scores and VAS were lower in the fixed platform group. However, these differences did not remain in the mid-term, suggesting that the mobile tibial platform arthroplasty has a short-term advantage, and may help in the rehabilitation process.

Keywords
- arthroplasty, replacement, knee
- quality of life
- osteoarthrosis

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Resumo

Objetivo Comparar a função e qualidade de vida dos pacientes submetidos a artroplastia total de joelho (ATJ) com plataforma tibial fixa e plataforma tibial móvel.
Métodos Foram avaliados 240 pacientes com diagnóstico de osteoartrose de joelho, em um ensaio clínico, randomizados em dois grupos: grupo A, composto por 120 pacientes submetidos a ATJ com plataforma tibial fixa, e grupo B, formado por 120 pacientes com plataforma móvel. Todos foram avaliados de acordo com a função e qualidade de vida pelos questionários de Western Ontario andMcMasterUniversitiesArthritis Index (WOMAC) e Short Form Health Survey(SF-36), e escores de dor, por meio da escala visual analógica (EVA) de dor, no pré-operatório e com 6 meses, 1 ano, 2 anos, 4 anos e 8 anos de cirurgia.
Resultados Com relação aos diversos domínios do SF-36, o comportamento médio dos escores de capacidade funcional, aspectos físicos, dor e aspectos emocionais foram estatisticamente diferentes ao longo do seguimento, em ambos os grupos. Os demais domínios de qualidade de vida não apresentaram diferenças. Assim como na EVA de dor, o escore médio do WOMAC de dor apresentou melhora ao longo do seguimento em ambos os grupos. Entretanto, com dois anos de seguimento, foram estaticamente piores no grupo A, se igualando ao grupo B nos outros momentos de acompanhamento.
Conclusão Com 2 anos de pós-operatório, os escores de dor do WOMAC e daEVA foram piores no grupo submetido aATJ com plataforma tibial fixa. Porém, as diferenças não permaneceram no médioprazo, sugerindo que a artroplastia com plataforma tibial móvel tem uma vantagem no curto prazo, podendo auxiliar no processo de reabilitação.

Palavras-chave
- artroplastia do joelho
- qualidade de vida
- osteoartrose

Introduction

In the last decades, with the ageing of the general population and the changes in the musculoskeletal system resulting from this process, osteoarthritis has become an important health problem.[1–3] The symptoms of this degenerative joint cartilage disease lead to functional disability and loss of quality of life for the elderly.[4–9] These have been elements of evaluation of treatments, including total knee arthroplasty (TKA).[10,11]

The methods for evaluating the results of TKA are mortality rates, morbidity, complications, and durability. However, with the rapid growth of improvements in procedures, these rates no longer reflect the real benefit in the quality of life of the individual.[12–14] Thus, evaluations with generic or specific questionnaires regarding treatment have provided valuable information. Among them, the Western Ontario and McMaster Universities Arthritis Index (WOMAC) for TKA, and the Short Form Health Survey (SF-36) to assess quality of life, stand out.[10,15] These questionnaires have shown the good results of TKA in improving the function and quality of life of elderly patients.

Total knee arthroplasty can be divided according to the tibial component into two types: TKA with fixed platform and with mobile platform. According to Wylde and Potter,[16] the standard TKA - with fixed platform - can lead to an excessive load in the posterior region of the tibial component, increasing polyethylene wear, leading to a higher risk of failure, and the need for revision. Thus, TKA with a mobile platform, as it allows greater rotational mobility and better congruence of the polyethylene component, has the theoretical advantage of self-aligning, reducing the incidence of anterior knee pain, producing better function.

In view of this, the theoretical advantages of TKA with a mobile platform must be confirmed clinically, since until now, there is no consensus regarding the best results, and previous studies were considered of low quality.[17]

The objective of the present study is to compare the function and quality of life of patients who underwent TKA with fixed and mobile platforms.

Methods

All procedures were approved by the research ethics committee of our university.

This is a randomized, double-blind clinical trial, conducted from January 2004 to January 2007. Inclusion criteria were: 1– age between 55 and 70 years old, 2–clinical signs and symptoms compatible with knee osteoarthritis, 3–radiographic signs of three-compartment osteoarthritis grades III, IV and V according to the Ahlbäck classification modified by Keyes and Goodfellow, 4–absence of associated diseases affecting the lower limbs, 5–absence of neurological disorder, 6–absence of nerve injuries or previous fractures in the lower limbs. The non inclusion criteria were: 1–infection, 2–flexion deformity $> 10°$, 3–angular deviations in varus and

valgus > 25°, 4–focal tumor defect, 5–physical conditions that would eliminate adequate implant support, 6–coexisting life-threatening disease in the year following the procedure. Patients who said that they were unable or unsure of returning for follow-up were excluded from the study.

After a complete clinical and radiological evaluation, patients with indication for TKA who met the criteria were invited to participate in the study. Those who confirmed their participation signed the free and informed consent form. The randomization method used was block exchange, with the aim of maintaining a similar distribution of the number of patients in each studied group. Eight patient blocks were created, with different combinations. Sealed, opaque envelopes numbered from 1 to 240 contained the group to which each patient belonged. The first group (group A), submitted to TKA with fixed tibial platform (Depuy Synthes, Warsaw, IN, USA), and the second group (group B), submitted to TKA with a mobile tibial platform (LCS, Depuy Synthes, Warsaw, IN, USA).

All of the patients were assessed with questionnaires in the preoperative and postoperative periods at 6, 24, 48 and 96 months regarding function (WOMAC), quality of life (SF-36) and subjective pain perception (visual analogue scale [VAS] for pain).

Sample Size

To accept an alpha risk of 0.05 and aβ risk of 0.20, 98 patients were needed for each group to detect a $\geq$ 08 points difference between the average of pre- and postoperative scores for the dimensions of pain and function using the WOMAC questionnaire, deemed a clinically important difference.[18] A common standard deviation (SD) of 20 was assumed. The sample was overestimated by 20% to allow for possible losses, so that each group should contain 120 patients.

Surgical Technique

All prostheses were implanted by the same surgeon. In all patients, spinal anesthetic block was performed. For 48 hours, prophylactic antibiotic therapy with sodium cefazolin was used. Pneumatic tourniquet was used routinely. The access route was the anterior one with medial parapatellar arthrotomy. The patella was everted and replaced in all cases. Both prostheses had a similar femoral component, and all were later stabilized. Both cruciate ligaments were extracted. Horizontal tibial bone cutting was performed first, using an extramedullary guide for the tibia and intramedullary for the femur. All of the components were cemented. A suction drain was used for 24 hours as a routine. For thromboembolic prophylaxis, for 14 days, patients received low molecular weight heparin.

Rehabilitation

Rapid mobilization was recommended, in which, on the first postoperative day, metabolic ankle exercises and isometric exercises for the quadriceps were performed. On the second postoperative day, after the suction drain was removed, gait training with a walker and weight unloading in both limbs began. Gait training was performed according to the tolerance of each patient (pain and clinical conditions). All of them underwent one-hour sessions of continuous passive movement (CPM), twice a day (morning and afternoon), and the angle of movement varied according to the pain tolerance by each patient. Hospital discharge was given on average 5 days after the surgery, when the patient reached close to 90° of knee flexion and was able to walk independently with crutches or a walker. The outpatient physiotherapy sessions started 1 week after hospital discharge. The outpatient rehabilitation program lasted an average of 2 months, being similar for both groups.

Clinical Evaluation

The function was evaluated using the WOMAC, being composed of three domains: function, pain and stiffness. The sum of the points of each domain forms the result, varying from 0 to 68. To assess quality of life, the SF-36 was used, ranging from 0 to 100, presenting 36 response items, involving 8 concepts: functional capacity, physical aspect, pain, general health, vitality, social aspects, emotional aspects and mental health. The EVA was also applied, varying from 0 to 10.

Statistical Analysis

There was an association between the types of prosthesis and the characteristics using chi-squared tests.[19] The quantitative characteristics of the patients were described according to the types of prosthesis using summary measures (mean, SD, median and quartiles, P25 and P75) and compared between the groups using the analysis of t-Studenttests.[19] The scores of the evaluated scales were described according to the types of prosthesis at each evaluation moment and compared between the types of prosthesis and moments using generalized estimation equation analyses with normal marginal distribution and logarithmic link function, due to the asymmetric distribution of scores, assuming a first-order autoregressive correlation between the moments of assessment.[20] The analyses were followed by multiple comparisons of Bonferroni[21] to compare groups and times, when differences in scores were significant. The analyses were performed with the data evaluated in the patients, even considering losses during the follow-up. The results were illustrated with graphs of average profiles, with the respective standard errors, and the tests were performed with a significance level of 5%.

Results

Patients were recruited consecutively from November 2011 until December 2012. In total, 1,268 patients were evaluated and 1,028 were excluded, resulting in a final sample of 240 patients. Patients were randomized into 2 groups: 120 in the TKA with fixed platform and 120 in the TKA with mobile platform. From the fixed platform group, five patients died, and six did not adhere. From the mobile platform group, six died, four did not adhere, one had a cerebral vascular accident (CVA) and one had a rupture of the patellar ligament. All deaths occurred after >2 years of follow-up (►**Figure 1**).

Of the 240 randomized patients, 6 from the fixed platform group and 5 from the mobile platform group experienced

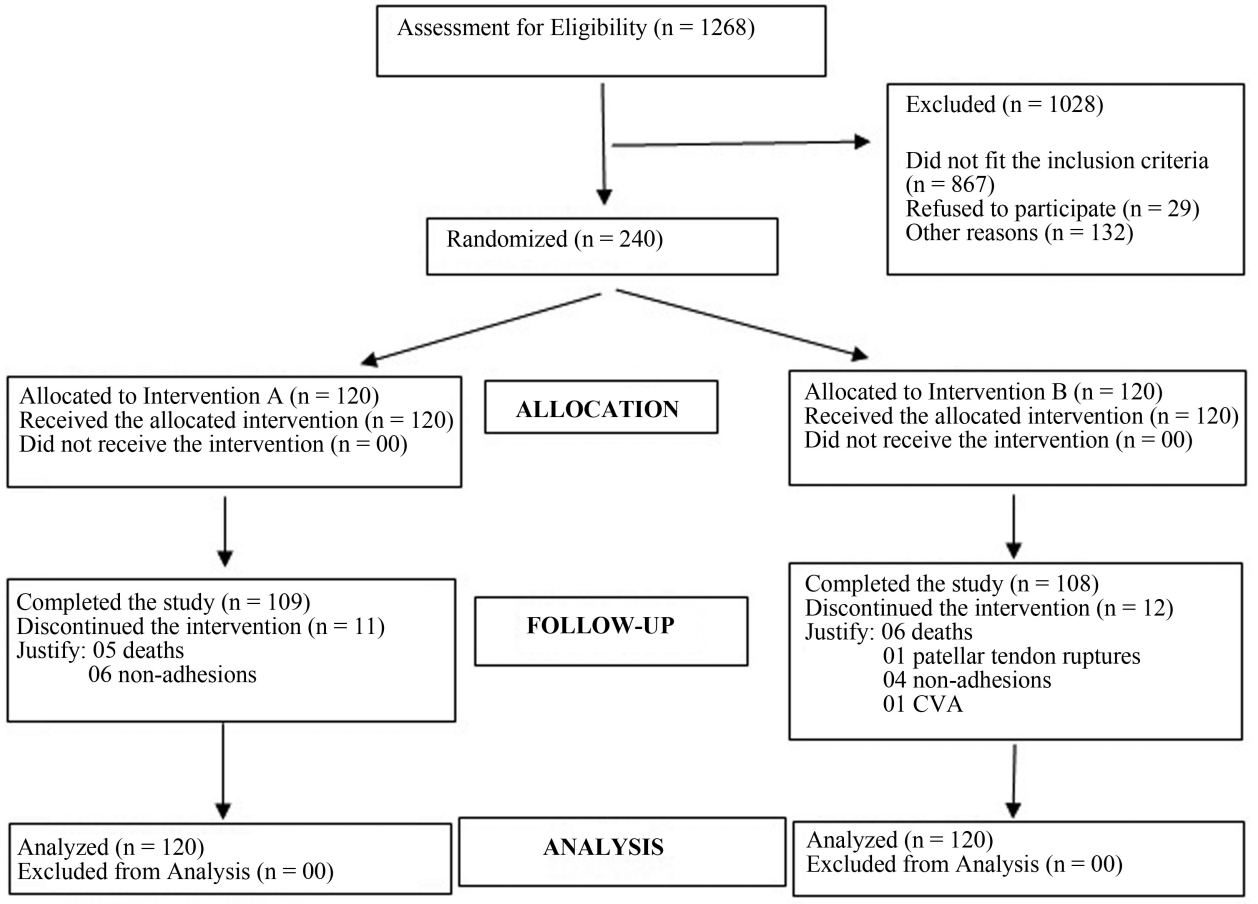

Fig. 1 Flowchart of Phases.

complications. In the fixed platform group, we had three cases of infection, two with embolism and one with deep venous thrombosis. In the mobile platform group, we had two cases of infection, one with deep venous thrombosis, one with CVA, and one with rupture of the patellar ligament.

The ages of the individuals in the sample were between 59 and 70 years old, with an average of 65.7 years old (SD= 3.7). A total of 81% were female, with a body mass index (BMI) of 30 (SD = 4.7). The personal characteristics evaluated did not show any association or statistically significant differences; therefore, the groups were homogeneous, as shown in ►**Table 1**.

Regarding the various domains of the SF-36 quality of life questionnaire, no difference was shown between groups regarding quality of life at the end of the follow-up. Only in some domains there is a difference between groups at certain times. An example is in the pain score in 1 and 2 years of follow-up, but they seem to equal each other in other moments.

►**Table 2** shows that the average behavior of the scores of functional capacity, pain and emotional aspects, were statistically different during the follow-up, in the groups of patients, according to the values highlighted in the table. The other domains of quality of life showed mean differences only during the follow-up, at different times of assessment, but with no difference between groups.

In ►**Table 3**, VAS for pain and WOMAC scores showed, on average, statistically different behavior between groups during follow-up ($p< 0.001$). In the WOMAC function and stiffness score, there was a statistically significant mean difference only during the follow-up, at different times of assessment, with no difference between groups ($p< 0.001$).

Discussion

The present prospective, randomized and controlled study found that, 8 years after the surgery, there were no significant differences in the clinical outcome of pain in the SF-36 and WOMAC quality of life questionnaires, as well as in the VAS scores, after knee prosthesis surgery with fixed tibial platform in relation to mobile platform implants. Recent prospective randomized studies[16,22,23] also failed to find a difference in clinical evolution, radiological analysis or survival between fixed and mobile prostheses. These same authors compared the clinical results of the two types of implants in the same patient and found no differences in pain and range of motion (ROM) scores over 5 years of follow-up. Aglietti et al,[24] in their study of patients undergoing unilateral knee arthroplasty comparing the two types of prostheses, they also did not observe significant differences with 3 years of follow-up in pain scores, although greater flexion was pointed out in knees with fixed tibial platform. It is

Table 1 Description of personal characteristics of the patients according to types of prosthesis and results of statistical tests

Variable	Prosthesis type		Total ($N = 240$)	*p* Value
	Fixed ($N = 120$)	Mobile ($N = 120$)		
Gender, n (%)				
Female	96 (80)	100 (83.3)	196 (81.7)	0.505*
Male	24 (20)	20 (16.7)	44 (18.3)	
Operated side, n (%)				
Right	64 (53.3)	57 (47.5)	121 (50.4)	0.366*
Left	56 (46.7)	63 (52.5)	119 (49.6)	
Age (years)				
mean (SD)	65.9 (3.9)	65.4 (3.4)	65.7 (3.7)	0.369
median (P25; P75)	66 (63; 70)	65 (63; 68)	65 (63; 69)	
Weight (Kg)				
Mean (SD)	78.4 (12.1)	80.3 (13.5)	79.4 (12.8)	0.276
median (P25; P75)	78.5 (73; 85)	78.5 (71; 87)	78.5 (72; 86)	
Height (m)				
mean (SD)	1.62 (0.06)	1.62 (0.14)	1.62 (0.10)	0.320
median (P25; P75)	1.63 (1.6; 1.66)	1.63 (1.57; 1.67)	1.63 (1.59; 1,67)	
BMI (Kg/m2)				
mean (DP)	29.7 (4.2)	30.2 (5.1)	30 (4.7)	0.426
median (P25; P75)	29.5 (27.2; 32.3)	30.1 (27.2; 33.1)	29.7 (27.2; 32,9)	

Abbreviations: BMI, body mass index; SD, standard deviation.
t-Student test; * Chi-squared test.

Table 2 Description of quality of life scores according to types of prosthesis and moments of evaluation and statistical results

Variable	Moment	Prosthesis type						*p* Value Prosthesis type	*p* Value Moment	*p* Value Interaction
		Fixed			Mobile					
		Mean	SD	N	Mean	SD	N			
Functional capacity	Preoperative	20.22	18.10	120	17.17	14.79	120	0.219	<0.001	0.019
	6 months	57.54	19.47	120	62.79	19.39	120			
	1 year	65.46	15.38	120	74.42	17.32	120			
	2 years	68.37	16.76	120	73.88	16.71	120			
	4 years	61.63	15.46	120	63.88	15.14	120			
	8 years	51.46	16.72	120	55.46	16.09	120			
Physical aspects	Preoperative	13.48	26.58	120	17.23	25.76	120	0.910	<0.001	0.536
	6 months	71.68	28.24	120	67.86	37.68	120			
	1 year	77.08	24.38	120	73.96	31.49	120			
	2 years	88.27	65.30	120	82.75	29.13	120			
	4 years	84.77	23.00	120	75.43	35.65	120			
	8 years	78.93	25.52	120	78.34	28.06	120			
Pain	Preoperative	41.89	26.12	120	35.34	22.69	120	0.053	<0.001	0.004
	6 months	80.19	26.03	120	79.39	23.79	120			
	1 year	75.41	30.97	120	86.20	18.29	120			
	2 years	69.63	34.84	120	92.49	86.12	120			
	4 years	76.72	28.09	120	81.05	19.50	120			
	8 years	74.07	27.78	120	85.28	62.49	120			

(*Continued*)

Table 2 (*Continued*)

Variable	Moment	Prosthesis type						*p* Value Prosthesis type	*p* Value Moment	*p* Value Interaction
		Fixed			Mobile					
		Mean	SD	N	Mean	SD	N			
General Health Status	Preoperative	69.58	18.19	120	71.60	16.32	120	0.512	<0.001	0.167
	6 months	77.96	13.10	120	80.53	12.77	120			
	1 year	78.10	12.54	120	76.38	15.23	120			
	2 years	76.18	12.89	120	72.29	18.29	120			
	4 years	77.21	14.26	120	75.18	15.45	120			
	8 years	74.88	14.10	120	73.51	14.69	120			
Vitality	Preoperative	68.03	18.79	120	68.45	19.16	120	0.366	<0.001	0.779
	6 months	78.64	14.60	120	78.14	15.10	120			
	1 year	79.49	13.16	120	77.23	16.89	120			
	2 years	78.36	14.18	120	75.43	17.09	120			
	4 years	78.85	14.14	120	77.98	15.59	120			
	8 years	79.56	16.12	120	77.98	15.93	120			
Social Aspects	Preoperative	45.90	26.75	120	50.80	27.66	120	0.062	<0.001	0.080
	6 months	81.65	23.33	120	86.17	20.40	120			
	1 year	84.28	23.08	120	87.68	20.49	120			
	2 years	85.06	21.43	120	84.22	23.49	120			
	4 years	83.60	22.30	120	84.38	24.01	120			
	8 years	78.95	25.64	120	87.13	20.68	120			
Emotional Aspects	Preoperative	52.68	45.09	120	40.26	45.11	120	0.771	<0.001	0.036
	6 months	73.54	36.84	120	81.40	35.59	120			
	1 year	79.74	34.68	120	86.65	29.79	120			
	2 years	92.98	109.76	120	86.61	30.13	120			
	4 years	86.88	90.35	120	86.08	29.47	120			
	8 years	81.36	30.33	120	87.21	27.42	120			
Mental health	Preoperative	71.04	20.07	120	73.81	18.15	120	0.317	<0.001	0.484
	6 months	77.27	17.25	120	76.85	16.31	120			
	1 year	76.87	17.04	120	77.20	13.12	120			
	2 years	75.05	19.15	120	75.99	14.34	120			
	4 years	75.09	19.65	120	78.43	14.58	120			
	8 years	73.58	19.55	120	75.90	16.25	120			

Abbreviation: SD, standard deviation.

possible that the lack of difference in clinical results after 8 years of follow-up found in the present study, between implants with fixed platform and mobile platform, was due to the characteristics of the participants, especially regarding the age group.

In addition, the generic instrument for evaluating the SF-36 quality of life of patients in this age group contributes to confirm these results, but it seems insufficient when used separately to establish conclusions from the clinical point of view. When pain is analyzed, some patients are confused, because the issue is related to "pain in the body." All of the questions regarding pain, such as emotional aspects, disposition, and vitality, were often answered positively, but in almost all cases it was difficult to relate the response directly to the knee, as they are questions of greater scope.

The average age of the participants in the present study was 65.7 (SD = 3.7) years old, and the majority did not perform recreational or sports physical activities that required a higher degree of joint movement. According to Wylde et al,[16] the mobile tibial support prosthesis was designed to provide a greater range of joint movement and to allow participation in activities that require greater knee mobility in all planes. Therefore, it can be argued that the implantation of mobile tibial knee support did not reach its full potential in this group of patients because it is a study of an older population. A randomized clinical trial involving

Table 3 Visual analogue scale description of pain and functionality scores according to the types of prosthesis and moments of evaluation and statistical results

Variable	Moment	Prosthesis type						*p* Value Prosthesis type	*p* Value Moment	*p* Value Interaction
		Fixed			Mobile					
		Mean	SD	N	Mean	SD	N			
VAS for Pain	Preoperative	84.69	17.04	120	85.40	17.49	120	0.016	<0.001	<0.001
	6 months	26.43	22.13	120	24.70	22.43	120			
	1 year	25.63	15.08	120	20.53	20.85	120			
	2 years	28.83	19.40	120	16.57	18.97	120			
	4 years	14.06	17.39	120	13.04	18.07	120			
	8 years	13.78	16.37	120	10.56	16.59	120			
WOMAC for Pain	Preoperative	13.60	3.86	120	14.04	3.42	120	0.032	<0.001	<0.001
	6 months	3.46	3.53	120	3.42	3.82	120			
	1 year	3.86	3.30	120	2.67	3.91	120			
	2 years	5.11	3.97	120	2.86	4.01	120			
	4 years	2.91	3.06	120	2.24	3.92	120			
	8 years	2.31	3.21	120	1.77	3.72	120			
WOMAC function	Preoperative	43.64	13.91	120	45.36	12.60	120	0.037	<0.001	0.001
	6 months	14.11	11.78	120	10.94	9.45	120			
	1 year	9.62	9.81	120	8.53	7.79	120			
	2 years	8.83	9.81	120	7.11	7.39	120			
	4 years	13.12	9.81	120	10.13	7.96	120			
	8 years	21.37	10.90	120	18.31	8.47	120			
WOMAC stiffness	Preoperative	4.40	2.43	120	5.01	2.34	120	0.198	<0.001	0.203
	6 months	1.38	1.66	120	1.31	1.40	120			
	1 year	0.98	1.49	120	0.99	1.25	120			
	2 years	0.88	1.49	120	0.58	1.00	120			
	4 years	0.94	1.43	120	0.63	1.02	120			
	8 years	0.93	1.49	120	0.68	1.04	120			

Abbreviations: SD, standard deviation; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

younger, more active patients, could reveal some functional advantage of one design over another.

An important finding of the present study that must be highlighted is the fact that, in a short period of time – 2 years after surgery – the VAS and WOMAC pain scores were significantly worse in the group with fixed tibial platform ($p< 0.05$ and $p< 0.001$, respectively). At that time, the worst pain scores had a negative influence on quality of life in patients undergoing TKA with a fixed tibial platform.

Concurrently, it is noted paradoxically that, exactly in this period with 2 years of follow-up, the groups had the best functional capacity scores, both in the SF-36 quality of life questionnaire assessments and in the WOMAC questionnaire functional assessments, with no statistically significant differences between the fixed and mobile groups.

Although TKA has already been shown to be a successful procedure for treating patients with osteoarthritis, a significant percentage can still experience pain after surgery.[25] Although the results of randomized controlled trials are not yet conclusive to determine whether the type of implant can influence postoperative knee pain, the data obtained in the present study suggest that, in 2 years of follow-up, the SF-36 pain domain had less influence on quality of life in the group of patients submitted to TKA with a mobile tibial platform when compared to the group submitted to total prosthesis with fixed platform.

Aglietti et al[24] suggested that the advantages of a project with mobile tibial support may diminish over time. This is also observed in the present study, in which, after 2 years of surgery, it seems that the pain scores align again, with no statistically significant differences between the groups with 4 and 8 years in terms of pain levels. However, as anterior knee pain is relevant for patients even in the short term, it is not believed that this constitutes a limitation for the use of TKA with a mobile platform.

The highlight of the present study is the fact that all surgeries were performed by the same surgeon, with experience in both types of TKA, minimizing bias factors. In

addition, follow-up is medium to long term, with a larger sample size than most previous studies. In order to reduce the application bias, the questionnaires were completed by the patients themselves, with the help of the evaluator. Assessments were always performed by a physical therapist who did not know which group the patients had been randomized to.

As a limitation of this analysis, we can mention the nondivision of patients according to the ROM prior to the surgical and final procedure. Also, no radiological analysis was carried out in order to assess the advantages of one implant over the other in relation to the loosening aspect, which was not an objective of the present research.

When idealizing the present study, the focus was to find out if there were functional and quality of life differences in a group of elderly people with knee osteoarthritis who underwent both types of TKA. However, during its realization, some questions arose and remain unanswered, needing to be investigated.

Conclusion

The data from the present study demonstrate that 2 years after the surgery, pain scores in the questionnaires (SF-36, VAS and WOMAC) were worse in the fixed platform TKA group. However, individuals who underwent TKA with a fixed tibial platform did not present any functional and quality of life differences compared with those who underwent arthroplasty with a mobile tibial platform, with a medium-term follow-up.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Lanza IR, Towse TF, Caldwell GE, Wigmore DM, Kent-Braun JA. Effects of age on human muscle torque, velocity, and power in two muscle groups. J Appl Physiol (1985) 2003;95(06):2361–2369
2 Narici MV, Maganaris C, Reeves N. Myotendinous alterations and effects of resistive loading in old age. Scand J Med Sci Sports 2005; 15(06):392–401
3 Herzog W, Longino D. The role of muscles in joint degeneration and osteoarthritis. J Biomech 2007;40(Suppl 1):S54–S63
4 Laborde JM, Powers MJ. Life satisfaction, health control orientation, and illness-related factors in persons with osteoarthritis. Res Nurs Health 1985;8(02):183–190
5 Downe-Wamboldt B. Coping and life satisfaction in elderly women with osteoarthritis. J Adv Nurs 1991;16(11):1328–1335
6 Dickstein R, Heffes Y, Shabtai EI, Markowitz E. Total knee arthroplasty in the elderly: patients' self-appraisal 6 and 12 months postoperatively. Gerontology 1998;44(04):204–210
7 Heck DA, Robinson RL, Partridge CM, Lubitz RM, Freund DA. Patient outcomes after knee replacement. Clin Orthop Relat Res 1998;(356):93–110
8 Bachmeier CJ, March LM, Cross MJ, et al. Arthritis Cost and Outcome Project Group. A comparison of outcomes in osteoarthritis patients undergoing total hip and knee replacement surgery. Osteoarthritis Cartilage 2001;9(02):137–146
9 Hartley RC, Barton-Hanson NG, Finley R, Parkinson RW. Early patient outcomes after primary and revision total knee arthroplasty. A prospective study. J Bone Joint Surg Br 2002;84(07): 994–999
10 Mäntyselkä P, Kumpusalo E, Ahonen R, Takala J. Patients' versus general practitioners' assessments of pain intensity in primary care patients with non-cancer pain. Br J Gen Pract 2001;51(473): 995–997
11 Janse AJ, Gemke RJ, Uiterwaal CS, van der Tweel I, Kimpen JL, Sinnema G. Quality of life: patients and doctors don't always agree: a meta-analysis. J Clin Epidemiol 2004;57(07):653–661
12 O'Boyle CA. Assessment of quality of life in surgery. Br J Surg 1992; 79(05):395–398
13 Givon U, Ginsberg GM, Horoszowski H, Shemer J. Cost-utility analysis of total hip arthroplasties. Technology assessment of surgical procedures by mailed questionnaires. Int J Technol Assess Health Care 1998;14(04):735–742
14 Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. J Bone Joint Surg Am 2004;86(05):963–974
15 Ware J Jr, Kosinski M, Keller SDAA. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. Med Care 1996;34(03):220–233
16 Wylde V, Learmonth I, Potter A, Bettinson K, Lingard E. Patient-reported outcomes after fixed- versus mobile-bearing total knee replacement: a multi-centre randomised controlled trial using the Kinemax total knee replacement. J Bone Joint Surg Br 2008;90 (09):1172–1179
17 Jacobs W, Anderson P, Limbeek J, Wymenga A. Mobile bearing vs fixed bearing prostheses for total knee arthroplasty for post-operative functional status in patients with osteoarthritis and rheumatoid arthritis. Cochrane Database Syst Rev 2004;(02): CD003130
18 Núñez M, Núñez E, del Val JL, et al. Health-related quality of life in patients with osteoarthritis after total knee replacement: factors influencing outcomes at 36 months of follow-up. Osteoarthritis Cartilage 2007;15(09):1001–1007
19 Kirkwood BR, Sterne JA. Essential medical statistics. 2nd ed. Massachusetts, USA: Blackwell; 2006
20 McCullagh P, Nelder JA. Generalized linear models. 2nd ed. New York, USA: Chapman and Hall; 1989
21 Neter J, Kutner MH, Nachtsheim CJ, Wasserman W. Applied Linear Statistical Models. 4th ed. Ilinois: Richard D. Irwing; 1996
22 Bhan S, Malhotra R, Kiran EK, Shukla S, Bijjawara M. A comparison of fixed-bearing and mobile-bearing total knee arthroplasty at a minimum follow-up of 4.5 years. J Bone Joint Surg Am 2005;87 (10):2290–2296
23 Matsuda S, Mizu-uchi H, Fukagawa S, et al. Mobile-bearing prosthesis did not improve mid-term clinical results of total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2010; 18(10):1311–1316
24 Aglietti P, Baldini A, Buzzi R, Lup D, De Luca L. Comparison of mobile-bearing and fixed-bearing total knee arthroplasty: a prospective randomized study. J Arthroplasty 2005;20(02): 145–153
25 Hofmann S, Seitlinger G, Djahani O, Pietsch M. The painful knee after TKA: a diagnostic algorithm for failure analysis. Knee Surg Sports Traumatol Arthrosc 2011;19(09):1442–1452

Analysis of the Clinical and Radiological Results of Bridge Plate Versus External Fixation in Comminuted Distal Radius Fractures*

Análise clínica e radiológica do resultado placa ponte versus fixador externo na fratura cominutiva do rádio distal

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Abstract

Objective To evaluate and compare the clinical and radiological outcomes of patients with comminuted distal radius fractures treated with an external fixator or a dorsal bridge plate.

Methods In total, 45 patients were analyzed 1 year after surgery; 18 were treated with an external fixator, and 25 received a dorsal bridge plate. An analog pain scale and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire were applied, in addition to radiographic, strength and range of motion assessments. Statistical analyzes were performed using the chi-squared test and the Mann-Whitney non-parametric test.

Results Fractures were more common in women over 60 years old who suffered falls from their own height. Both methods demonstrated similar functional and radiological results. Infections were more prevalent in patients receiving external fixators, but their residual grip strength was better. Reflex sympathetic neuropathy was more common in subjects treated with a dorsal bridge plate.

Conclusion Our analysis showed no consensus on the superiority of one method over the other. Each method had advantages and disadvantages, but both led to good, similar outcomes. The treatment must be chosen according to the profile of the trauma, the patient's clinical conditions, the surgeon's experience, and the availability of materials.

Keywords
- distal radius
- bone plates
- external fixators

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Resumo

Objetivo Avaliar e comparar os resultados clínicos e radiológicos de pacientes com fraturas cominutivas distais do rádio tratados com fixador externo ou placa ponte dorsal.

Métodos Foram analisados 45 pacientes, sendo 18 tratados com fixador externo, e 25, com placa ponte dorsal, após 1 ano de pós-operatório. Aplicou-se uma escala analógica de dor e o questionário Disabilities of the Arm, Shouder and Hand (DASH), além de análise radiográfica, da avaliação de força, e da amplitude de movimento. As análises estatísticas foram realizadas utilizando o teste qui-quadrado e o teste não paramétrico de Mann-Whitney.

Resultados A fratura foi mais comum em mulheres acima de 60 anos por queda do mesmo nível. Ambos os métodos demonstraram resultados funcional e radiológico similares. A infecção foi mais prevalente com o uso do fixador externo, mas a força de preensão residual foi melhor. Neuropatia simpático-reflexa foi mais comum com o uso da placa ponte dorsal.

Conclusão Não houve consenso da superioridade de um método em relação ao outro em nossa análise. Cada um dos métodos apresenta vantagens e desvantagens, mas ambos mostraram resultados bons e semelhantes. A escolha do tratamento deve ser atribuída ao perfil do trauma, às condições clínicas do paciente, à experiência do profissional, e à disponibilidade de materiais.

Palavras-chave

- rádio distal
- placas ósseas
- fixadores externos

Introduction

Distal radius fractures correspond to 12% of fractures in adults, constituting a major cause of morbidity.[1] In younger populations, these injuries are severe comminuted fractures resulting from high-energy trauma; in the elderly population, they are caused by low-energy trauma.[2] If not properly treated, these fractures result in chronic pain, motion limitation and functional impairment,[3] with a great impact on the patient's quality of life and burdening the public healthcare system, since most of these subjects are young patients who are unable to work.[2]

Despite the great prevalence and social consequences of these injuries, there is still no consensus as to the best treatment due to the great possibility of distal radial fracture profiles.[4] The best therapeutic method must consider the fracture pattern (classification, bone quality), patient profile (age, daily activities), additional injuries (ligament or bone lesions) and the surgeon's experience with the materials.[5]

Distal radius fractures can be conservatively or surgically treated depending on the aforementioned factors.[6] No treatment is exempt from complications, and they must be customized for each individual patient. The surgical treatment can be beneficial in fractures meeting the Lafontaine criteria after closed reduction.[7] The options of surgical treatment include percutaneous fixation with Kirschner wires, volar or dorsal plates, and external fixators[8] The most widespread methods are Kirschner wires and volar plates due to the easy access to these materials. However, in highly-comminuted fractures from high-energy trauma or those affecting osteoporotic bones, these methods may be unsuccessful.[1,3] Since these joint fractures are difficult to stabilize, new fixation forms are required. Other options include external fixators and bridge plates associated with Kirschner wires[9] External fixators are promptly placed, with lower cutaneous aggression, but they are esthetically worse for patients and related to a higher risk of infection at their path.[10] Bridge plates are more aggressive to the soft tissues due to the incision, but they can result in an improved fracture reduction.[11]

The present study compared the postoperative outcomes of comminuted distal radius fractures classified as 23C2 or 23C3 according to AO Classification System surgically treated with an external fixator and Kirschner wires or with a dorsal bridge plate.

Materials and Methods

Ethics

The present was an observational, analytical study approved by the Ethics in Research Committee of Hospital Municipal São José (Joinville, Santa Catarina, Brazil) under opinion number 2.439.743.

Participants

In total, 43 patients presenting intra-articular distal radius fracture with AO classification 23C2 or C3 and followed-up for at least 1 year after surgery in an outpatient facility were selected. Among them, 18 patients were treated with an external fixator, and 25 received a bridge plate, associated with Kirschner wires if required. The sample size was based on previously-published studies comparing surgical techniques for distal radius fractures using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[12,13]

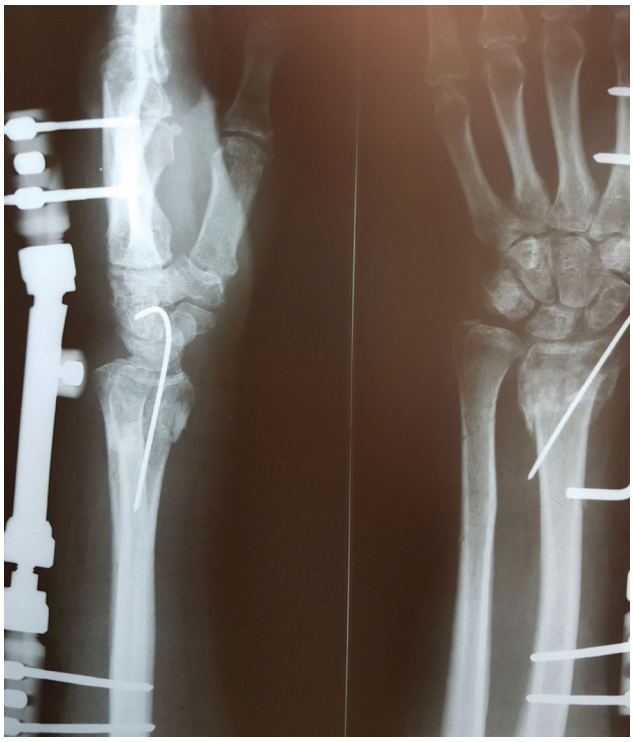

Fig. 1 Postoperative radiograph of a patient with an external fixator.

The patients were recruited from December 2017 to May 2018 during outpatient return visits at Hospital Municipal São José, in which the surgical treatment was performed, always by the same hand surgeon, who is the chief physician. Patients with associated fractures in the same limb, open distal radial fractures, previous deformities and/or those requiring care at an intensive care unit were excluded from the study.

Surgical Techniques

In patients treated with an external fixator, Schanz pins were placed under fluoroscopy at the second metacarpal bone diaphysis and the radial diaphysis; the fracture was reduced and fixed using the Colles external wrist fixator. If required, Kirschner wires were associated to maintain the reduction and add stability (►**Figure 1**). At the postoperative follow-up of six to eight weeks, the external fixator and the Kirschner wires were removed under local anesthesia at the Schanz pins, according to the radiographic evaluation. Subsequently, the patient was referred for physical therapy and rehabilitation.

The dorsal bridge plate technique was initially described as a form of distraction for more complex type-C3 fractures; here, however, it was used as an alternative in type-C2 fractures, which are more common in hospital care.

In patients treated with dorsal bridge plate and screws, 3 incisions were made: an incision of approximately 2 cm at the region of the third metacarpal diaphysis, an incision at the third extensor tunnel, at the level of the Lister tubercle, to isolate the long extensor tendon of the thumb, and 1 incision at the radial diaphysis (►**Figure 2**). Then, the plate was placed retrogradely.

A dynamic compression plate (DCP) was placed juxta-osseously, moving the long extensor tendon of the thumb at the third tunnel through an access of approximately 3 cm in the Lister tubercle. The plate was passed below the extensor tunnels, and an access was made to isolate the long extensor tendon of the thumb and to make sure that the plate was below the tendons. Fixation was performed with two distal screws, followed by fracture reduction and fixation with two proximal screws. A synthesis with Kirschner wires was also performed if required (►**Figure 3**).

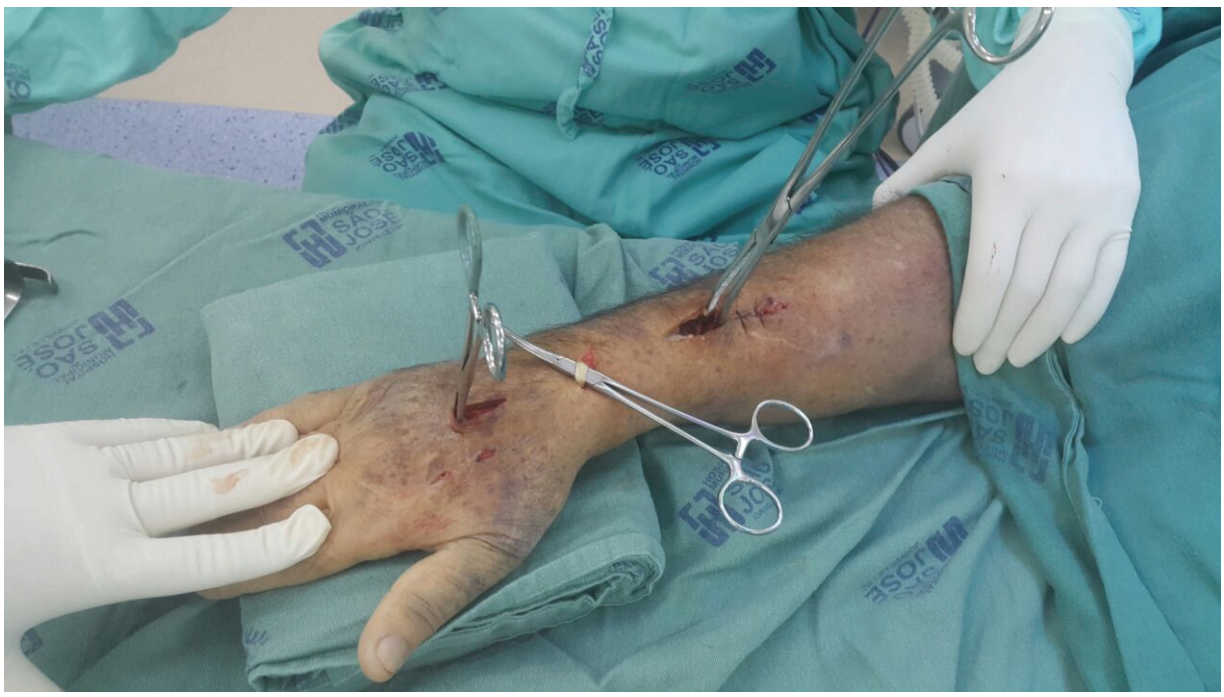

Fig. 2 Intraoperative image of the bridge plate technique.

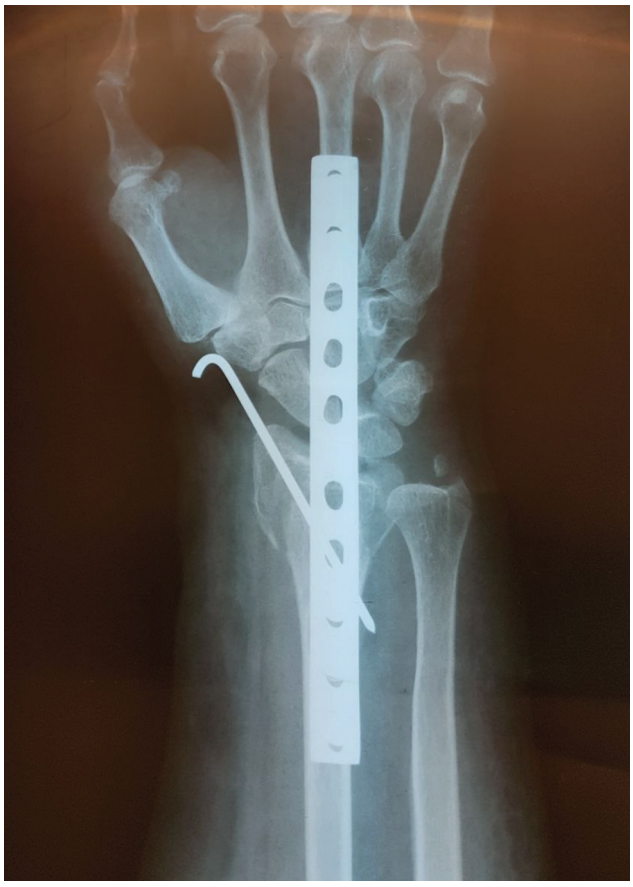

Fig. 3 Postoperative radiograph of a patient with a dorsal bridge plate.

All patients received an intraoperative antibiotic agent (cefazolin), in addition to an oral prophylactic antibiotic agent (cephalexin) for 10 days.

The first return visit was standardized for two weeks after surgery for suture removal and general education. Six weeks after the procedure, finger mobility was accessed, and the external fixator and Kirschner wires were removed. Twelve weeks after surgery, finger mobility after the removal of the external fixator was accessed; in addition, the synthesis material was removed at the operating room under anesthesia, and the joint was manipulated. After the removal of the synthesis material, patients from both groups were referred to physical therapy and rehabilitation, returning for visits every 12 weeks to assess mobility until completing 1 year of outpatient follow-up.

Evaluated Variables

Outcome variables were collected up to one year after surgery during the outpatient follow-up. The presence of superficial or deep infections and the incidence of reflex sympathetic neuropathy were determined through the analysis of the medical records, as the diagnosis is clinical in both situations.

The visual analog scale (VAS) was used to assess the postoperative pain.

The DASH questionnaire was used for the functional assessment of the patients, and it consists of 30 questions related to limitations in daily living activities.[14] The questionnaire was always applied by the same evaluator. The questions were read and explained before they were answered by the patient.

Radiographic measurements of distal radial angles were performed with a goniometer on anteroposterior (AP) and lateral radiographs using the appropriate technique.

Ranges of motion were determined at a physical examination using a goniometer in flexion (normal: 70° to 80°), extension (normal: 60° to 70°), maximum pronation (normal: 0° to 80°), maximum supination (normal: 0° to 90°), radial deviation (normal: 20°) and ulnar deviation (normal: 45°).[15]

Grip strength was evaluated using a calibrated digital dynamometer, always by the same operator; values from both hands were determined and considered normal, decreased, or increased compared to the contralateral side.

Statistical Analysis

Data were tabulated in an Excel (Microsoft Corp. Redmond, WA, US) spreadsheet and submitted to statistical analysis using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, EUA), version 20.0. The frequency and distribution of the variables were determined. Nominal variables were related to surgical techniques using the chi-squared test. Numerical variables were related to surgical techniques through a non-parametric Mann-Whitney test.

Results

From the 43 patients evaluated, the mean age was 54.4 years old, and 25 patients (58.1%) of them were female. The most prevalent trauma mechanism was a fall from the own height (51.2%). In 22 patients (51.2%), the fracture occurred on the right side; 34 patients (79.1%) were right-handed (►**Table 1**).

Regarding postoperative infection, there was one case in the bridge plate group and two cases in the external fixator group, with no significant difference in incidences from both techniques ($p = 0.379$). Reflex sympathetic neuropathy occurred in two patients treated with bridge plates and in one patient receiving an external fixator; once again, there was also no statistically significant difference between both groups ($p = 0.738$). In total, 15 patients operated with bridge plate and 6 treated with an external fixator showed decreased grip strength, with a statistically significant difference between the 2 surgical techniques ($p = 0.041$) (►**Table 2**).

According to the VAS, both techniques were associated with the same level of pain, with no statistically significant difference between them. The mean DASH score for the patients operated with a bridge plate was 39.05, and it was 36.36 for those operated with an external fixator, with no statistically significant difference between them ($p = 0.569$). At the radiographic assessment, there were no statistically significant differences between the two surgical techniques in any of the measurements performed. Similarly, there were no statistically significant differences in the ranges of motion for extension, flexion, pronation, and radial deviation. In supination, the mean values were 41.82 and 59.29 for the bridge plate and the external fixator respectively, with a statistically significant difference between them ($p = 0.012$).

Table 1 Descriptive analysis of the demographic characteristics, surgeries, and fracture causes

Characteristics		N (%)
Gender		
	Male	18 (41.9)
	Female	25 (58.1)
Age		
	20–35	9 (20.9)
	36–45	5 (11.6)
	46–60	9 (20.9)
	> 61	20 (46.5)
Surgical technique		
	Bridge plate	25 (58.2)
	External fixator	18 (41.8)
Trauma mechanism		
	Fall at the own height	22 (51.2)
	Fall from height	14 (31.7)
	Traffic accident	7 (17.1)
Fractured side		
	Right	22 (51.2)
	Left	21 (48.8)
Dominant side		
	Right	34 (79.1)
	Left	9 (20.9)

Table 2 Comparative analysis of the two surgical techniques

Surgical techniques				
		Bridge plate	**External fixator**	***p*-value**
Postoperative infection	Yes	1	2	0.379
	No	24	16	
Reflex sympathetic neuropathy	Yes	2	1	0.738
	No	23	17	
Grip strength	Normal	10	12	**0.041**
	Decreased	15	6	

Ulnar deviation presented a statistically significant difference between both surgical techniques ($p = 0.0049$), with 7.73 for the bridge plate, and 13.57 for the external fixator (►**Table 3**).

Table 3 Mean and standard deviation values for the two surgical techniques considering the numerical variables

	Bridge plate	**External fixator**	***p*-value**
Pain scale	3.68 ± 2.61	4.64 ± 2.43	0.172
DASH	39.05 ± 13.75	36.36 ± 12.03	0.569
Radiographic measurements			
Radial height	8.14 ± 2.27	9.29 ± 2.19	0.069
Radial angle	15.91 ± 4.45	17.86 ± 3.18	0.217
Volar deviation	3.55 ± 4.00	4.21 ± 3.66	0.329
Range of motion (ROM)			
ROM – extension	40.45 ± 16.75	45.71 ± 14.39	0.667
ROM – flexion	51.14 ± 16.68	52.14 ± 18.47	0.438
ROM – pronation	43.18 ± 18.09	58.21 ± 17.71	0.062
ROM – supination	41.82 ± 18.67	59.29 ± 20.17	**0.012**
ROM – ulnar deviation	7.73 ± 7.02	13.57 ± 8.41	**0.0049**
ROM – radial deviation	7.73 ± 6.31	12.86 ± 6.41	0.066

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire.

Discussion

To our current knowledge, few studies compared the treatment of comminuted fractures with external fixators and bridge plates. These fractures are very prevalent and difficult to manage, and there is no consensus on the best surgical technique to treat them. As such, the present study was carried out to show the outcomes with the use of materials that are easily accessible through the Brazilian Unified Health System (Sistema Único de Saúde, SUS, in Portuguese) and may improve the lives of the patients.

The dorsal bridge plate technique is indicated for deviated comminuted joint fractures with diminutive fragments that cannot be fixed using a volar plate.[16] Some authors advocate dorsal plates due to ligamentotaxis, which helps reduce fractures and spares soft tissues. Since there is no friction between tendons of the extensors and the plate, this technique favors finger mobility, and it is indicated in osteopenic bones, comminuted fractures, and polytraumas.[17] However, the dorsal plate may result in loss of wrist mobility, and it requires removal and reduces the fracture in only one plane.[17] In addition to the 3.5-mm DCP plate, there are semi-tubular plates in a single column for the radius or double column. When the fracture line is more proximal, 2.4-mm and 3.5-mm reconstruction plates may be used, which are more available at the SUS. Other plate types have been developed for this surgical technique, such as low-profile interlocked plates, which can be used in the second or third metacarpal bones. Wrist arthrodesis plates can also be employed to fix distal radius fractures, enabling the placement of larger screws to add stability. Similar to arthrodesis plates, more specific devices have recently emerged to treat these fractures through distraction; these are the spanning plates, which are shaped to facilitate the passage through extensor tendons and have fewer central holes, providing increased stiffness.[16,18]

Wrist transarticular external fixators were introduced in 1970,[17] and are increasingly used. As an advantage, these

fixators are minimally-invasive, sparing the retinaculum and the tendons. In addition, this is an easy and quick technique for polytrauma patients.[19]

When comparing the two surgical techniques, in general terms, we did not observe statistically significant differences, similarly to Saving et al.,[20] who evaluated the postoperative outcomes of external fixators and volar plates in a three-year follow-up period.

As complications, there were three cases of postoperative infection, two in patients treated with external fixators and one in a subject receiving a bridge plate. One of the cases of infection with an external fixator was superficial, and it was treated with an oral antibiotic agent, whereas the other required surgical debridement and fixator realignment. The bridge plate infection required surgical debridement and intravenous antibiotic therapy. Cui et al.[21] compared the use of internal versus external synthesis in patients with AOC3 distal radial fracture, and they observed a higher rate of infection when the external synthesis was performed. Abramo et al.[22] evaluated 50 patients with unstable distal radius fractures submitted to open reduction and internal fixation or closed reduction and external fixation, and they observed equivalent rates of superficial and deep infections in both techniques, corroborating our findings. In that study,[22] the main postoperative complication was hyperesthesia at the sensitive path of the radial nerve. Kreder et al.[23] assessed 179 patients with distal radial fractures treated with percutaneous fixation or internal fixation, using external fixators and plates. Infection was the most common postoperative complication; superficial infections were more common in indirect reduction with percutaneous fixation, but the incidence of deep infections was similar in both groups. In a meta-analysis study[18] comparing external fixators and bridge plates, the incidence of infection and reflex sympathetic dystrophy was lower in patients treated with bridge plates, but the cases of dystrophy did not require additional surgical treatment.

Reflex sympathetic neuropathy occurred in 2 patients treated with plates and 1 patient receiving an external fixator, corresponding to almost 7% of the total of patients; all of these subjects were female. Xu et al.[24] compared the treatment of type-C fractures according to the AO classification with external fixation and plates and did not observe any case of reflex sympathetic dystrophy. Arora et al.[25] evaluated the incidence of reflex sympathetic neuropathy in patients older than 65 years of age with distal radial fractures, including 36 subjects who underwent surgery and 37 individuals who were conservatively treated. Two surgical patients and five who were treated conservatively developed the syndrome. All patients improved their condition with analgesia and physical therapy. Xavier et al.[26] evaluated patients treated with blocked volar plates for distal radius fractures, and they observed an incidence of 1.5% of reflex sympathetic dystrophy, illustrating that even more modern materials may cause this complication.

Grip strength increased when external fixators were used. This is probably due to the earlier finger mobility provided by the lack of plastered immobilization, with sustained moving during the immediate postoperative period; in addition, the placement of the dorsal plate requires lesser muscle manipulation during surgery. This finding is in line with the observation by Schønnemann et al.[27] that internal synthesis materials have better outcomes when external fixation is compared with intramedullary fixation. Aita et al.[28] compared the distal radial fixation with plates, nails and external fixators, and they observed that, at the third postoperative week, the grip strength was lower in the subjects treated with external fixators compared to other techniques; however, after one year, the grip strength was similar in the patients from the three groups.

McQueen and Caspers[29] described the main complications of distal radius fractures, such as pain, stiffness, deformity, and loss of grip strength. These findings remain true today, despite the major advances in surgical techniques.

In the present study, we observed that, regardless of the treatment, postoperative pain after the removal of the synthesis material and physical therapy was similar in both groups. This outcome may be attributed to the reduction in fractures with similar radiographic features, because a better reduction of the fracture results in improved range of motion and less pain.[30] Aita et al.[28] compared locked volar plates, intramedullary nails and external fixators for the treatment of distal radius fractures, and they found a lower rate of pain in patients with internal synthesis material compared to those receiving external fixators after the third week.

The DASH scores were similar for both surgical techniques. These data were also obtained by Zenke et al.,[31] who found no significant difference when comparing these techniques. Xavier et al.[26] observed a correlation between reduced extension, flexion and grip strength with worse DASH scores, with an average DASH score of 10 for young people and of 21 for elderly patients.

The radiographic evaluation showed that we achieved a similarly acceptable fracture reduction with both techniques. A meta-analysis by Cui et al.[21] showed that several papers comparing different techniques also managed to reduce fractures within the recommended parameters. The only difference found by Xu et al.[24] was regarding radial inclination throughout years of evaluation, with no alterations in the range of motion of the patients.

In the present study, the ranges of motion resulting from both techniques were similar, except for supination and ulnar deviation, which were improved with the use of external fixators. Despite this difference, both techniques reached functional ranges of motion. Xavier et al.[26] also found no difference the range of motion of the patients. Kreder et al.[23] did not observe differences between different groups regarding postoperative mobility. Evaluating 33 patients older than 60 years of age with osteoporotic bones and C2 or C3 fractures who were treated using the dorsal bridge plate technique, Richard et al.[32] obtained good results for consolidation and range of motion.

Lewis et al.[33] assessed the incidence of complications in the fixation of second or third metacarpal bones in cadavers. The authors concluded that the fixation of the third

metacarpal bone had a greater chance of injury to the long extensor tendon of the thumb and, that the flexion-extension of the wrist was a bad indicator.

Our findings are particularly important for the progression of the fixation of distal radius fractures in patients with severe injuries who need to return to their daily and professional activities as soon as possible. Both operative techniques are easy to perform for orthopedic surgeons, and they require cheap materials that are promptly available at public services.

The reduced number of patients evaluated and their highly variable age, indicating different bone qualities, can be considered limitations for this study. We suggest that future studies include a higher number of subjects, stratified by age, and the inclusion of other fixation methods available, such as radial intramedullary nail and distal radial locked plate.

Conclusion

Both techniques proved to be effective in the treatment of complex distal radius fractures, with a low rate of postoperative complications, satisfactory functional outcomes, and no superiority of one over the other.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Alffram PA, Bauer GC. Epidemiology of fractures of the forearm. A biomechanical investigation of bone strength. J Bone Joint Surg Am 1962;44-A:105–114

2 Arora R, Gabl M, Gschwentner M, Deml C, Krappinger D, Lutz M. A comparative study of clinical and radiologic outcomes of unstable colles type distal radius fractures in patients older than 70 years: nonoperative treatment versus volar locking plating. J Orthop Trauma 2009;23(04):237–242

3 Tumia N, Wardlaw D, Hallett J, Deutman R, Mattsson SA, Sandén B. Aberdeen Colles' fracture brace as a treatment for Colles' fracture. A multicentre, prospective, randomised, controlled trial. J Bone Joint Surg Br 2003;85(01):78–82

4 Glickel SZ, Catalano LW, Raia FJ, Barron OA, Grabow R, Chia B. Long-term outcomes of closed reduction and percutaneous pinning for the treatment of distal radius fractures. J Hand Surg Am 2008;33(10):1700–1705

5 Lee DY, Park YJ, Park JS. A Meta-analysis of studies of volar locking plate fixation of distal radius fractures: conventional versus minimally invasive plate osteosynthesis. Clin Orthop Surg 2019;11(02):208–219

6 Handoll HHG, Madhok R. Closed reduction methods for treating distal radial fractures in adults. Cochrane Database Syst Rev 2003; (01):CD003763

7 LaMartina J, Jawa A, Stucken C, Merlin G, Tornetta P III. Predicting alignment after closed reduction and casting of distal radius fractures. J Hand Surg Am 2015;40(05):934–939

8 Piva Neto A, Lhamby FC. Fixação das fraturas da extremidade do rádio distal pela técnica de Kapandji: avaliação dos resultados radiológicos. Rev Bras Ortop 2011;46(04):368–373

9 Snow M, Kelly M, Jeyam M, Fahmy N. Functional versus position: a randomized controlled trial of interfocal Kirschner wiring of unstable distal radial fractures. Eur J Trauma Emerg Surg 2007; 33(01):81–86

10 Benson LS, Minihane KP, Stern LD, Eller E, Seshadri R. The outcome of intra-articular distal radius fractures treated with fragment-specific fixation. J Hand Surg Am 2006;31(08):1333–1339

11 Azad A, Intravia JM, Hill JR, et al. Carpal translocation following dorsal bridge plate fixation of distal radius fractures: a cadaveric study. J Wrist Surg 2019;8(03):234–239

12 Harley BJ, Scharfenberger A, Beaupre LA, Jomha N, Weber DW. Augmented external fixation versus percutaneous pinning and casting for unstable fractures of the distal radius–a prospective randomized trial. J Hand Surg Am 2004;29(05):815–824

13 Atroshi I, Brogren E, Larsson GU, Kloow J, Hofer M, Berggren AM. Wrist-bridging versus non-bridging external fixation for displaced distal radius fractures: a randomized assessor-blind clinical trial of 38 patients followed for 1 year. Acta Orthop 2006;77 (03):445–453

14 Hudak PL, Amadio PC, Bombardier C; The Upper Extremity Collaborative Group (UECG). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. Am J Ind Med 1996;29(06):602–608

15 Barros Filho TEP, Lech O. Exame físico em ortopedia. 3ª. Ed. São Paulo: Editora Sarvier; 2017

16 Vakhshori V, Alluri RK, Stevanovic M, Ghiassi A. Review of internal radiocarpal distraction plating for distal radius fracture fixation. Hand (N Y) 2018:1558944718787877

17 Hyatt BT, Hanel DP, Saucedo JM. Bridge plating for distal radius fractures in low-demand patients with assist devices. J Hand Surg Am 2019;44(06):507–513

18 Tinsley BA, Ilyas AM. Distal radius fractures in a functional quadruped: spanning bridge plate fixation of the wrist. Hand Clin 2018;34(01):113–120

19 Mishra AK, Sud AD, Prasad M, Kaul R, Singh CM. A comparative study of functional outcome of external fixation and volar plating in unstable distal radius fractures. Int J Res Orthop 2019;5(02):326–334

20 Saving J, Enocson A, Ponzer S, Mellstrand Navarro C. External Fixation Versus Volar Locking Plate for Unstable Dorsally Displaced Distal Radius Fractures-A 3-Year Follow-Up of a Randomized Controlled Study. J Hand Surg Am 2019;44(01):18–26

21 Cui Z, Pan J, Yu B, Zhang K, Xiong X. Internal versus external fixation for unstable distal radius fractures: an up-to-date meta-analysis. Int Orthop 2011;35(09):1333–1341

22 Abramo A, Kopylov P, Geijer M, Tägil M. Open reduction and internal fixation compared to closed reduction and external fixation in distal radial fractures: a randomized study of 50 patients. Acta Orthop 2009;80(04):478–485

23 Kreder HJ, Hanel DP, Agel J, et al. Indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular fractures of the distal radius: a randomised, controlled trial. J Bone Joint Surg Br 2005;87(06): 829–836

24 Xu GG, Chan SP, Puhaindran ME, Chew WY. Prospective randomised study of intra-articular fractures of the distal radius: comparison between external fixation and plate fixation. Ann Acad Med Singapore 2009;38(07):600–606

25 Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients sixty-five years of age and older. J Bone Joint Surg Am 2011;93(23):2146–2153

26 Xavier CR, Molin DC, Santos RM, Santos RD, Ferreira Neto JC. Tratamento cirúrgico das fraturas do radio distal com placa volar bloqueada: correlação dos resultados clínicos e radiográficos. Rev Bras Ortop 2011;46(05):505–523

27 Schønnemann JO, Hansen TB, Søballe K. Randomised study of non-bridging external fixation compared with intramedullary fixation of unstable distal radial fractures. J Plast Surg Hand Surg 2011;45(4-5):232–237

28 Aita MA, Ferreira CH, Ibanez DS, et al. Ensaio clínico randomizado de osteossíntese percutânea e minimamente invasiva das fraturas

da extremidade distal do rádio. Rev Bras Ortop 2014;49(03): 218–226
29 McQueen M, Caspers J. Colles fracture: does the anatomical result affect the final function? J Bone Joint Surg Br 1988;70(04):649–651
30 Andrade LE, Oliveira D, Barros JW. Tratamento das fraturas instáveis da extremidade distal do rádio com desvio volar utilizando-se placa de apoio. Acta Ortop Bras 2002;10(04):5–9
31 Zenke Y, Sakai A, Oshige T, et al. Clinical results of volar locking plate for distal radius fractures: conventional versus minimally invasive plate osteosynthesis. J Orthop Trauma 2011;25(07): 425–431
32 Richard MJ, Katolik LI, Hanel DP, Wartinbee DA, Ruch DS. Distraction plating for the treatment of highly comminuted distal radius fractures in elderly patients. J Hand Surg Am 2012;37(05): 948–956
33 Lewis S, Mostofi A, Stevanovic M, Ghiassi A. Risk of tendon entrapment under a dorsal bridge plate in a distal radius fracture model. J Hand Surg Am 2015;40(03):500–504

Is there an association between electroneuromyography and ultrasound in the diagnosis of carpal tunnel syndrome?*

Existe associação entre a eletroneuromiografia e a ultrassonografia no diagnóstico da Síndrome do Túnel do Carpo?

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Abstract

Objective To verify whether there is an association between the results of the severity in electroneuromyography and the positivity in ultrasound in the diagnosis of carpal tunnel syndrome.

Methods Sixty-eight patients were included in the study, 61 women and 7 men, with a mean age of 54.4 years. The ultrasound results (positive or negative) were crossed with the results of electroneuromyography (mild, moderate or severe), and the existence of association was verified.

Results One hundred and thirty-six hands with suspicion or symptoms of carpal tunnel syndrome were evaluated. Positive ultrasound diagnosis was observed in 72 hands and negative in 64; 123 hands presented positive electroneuromyography for carpal tunnel syndrome, and there were 13 negative results. The severe degree in electroneuromyography was prevalent.

Conclusion There was a statistically significant association between electroneuromyography and ultrasonography ($p < 0.05$), and ultrasound positivity was higher for more severe levels of carpal tunnel syndrome given by electroneuromyography.

Keywords
- electroneuromyography
- compressive neuropathy
- carpal tunnel syndrome
- ultrasonography

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Resumo

Objetivo Verificar se existe associação entre os resultados da gravidade da eletroneuromiografia e a positividade da ultrassonografia no diagnóstico da síndrome do túnel do carpo.

Métodos Sessenta e oito pacientes foram incluídos no estudo, sendo 61 mulheres e 7 homens, com média de idade de 54,4 anos. Os resultados da ultrassonografia (positivo ou negativo) foram cruzados com os resultados da eletroneuromiografia (leve, moderado ou grave) e verificada a existência de associação.

Resultados Cento e trinta e seis mãos com suspeita ou sintomas de síndrome do túnel do carpo foram avaliadas. O diagnóstico ultrassonográfico positivo foi observado em 72 mãos e negativo em 64; 123 mãos apresentaram eletroneuromiografia positiva para síndrome do túnel do carpo e 13 apresentaram resultado negativo. O grau grave da eletroneuromiografia foi prevalente.

Conclusão Houve associação estatisticamente significativa entre eletroneuromiografia e ultrassonografia ($p < 0,05$), sendo que a positividade da ultrassonografia foi maior para níveis mais graves de síndrome do túnel do carpo dados pela eletroneuromiografia.

Palavras-chave

- eletroneuromiografia
- neuropatia compressiva
- síndrome do túnel do carpo
- ultrassonografia

Introduction

Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy due to compression of the median nerve in the carpal tunnel.[1] Diagnosis is usually made through clinical history and physical examination,[2] while electroneuromyography (ENMG) assists in the diagnostic confirmation of dubious cases and in the establishment of severity.[3]

Ultrasonography (US) was introduced as a diagnostic tool for CTS in the early 1990s[4] and was also used to diagnose some musculoskeletal disorders, such as ulnar nerve and fibular nerve neuropathy.[5–7] One of the typical findings related to CTS is the increase in the cross-sectional area of the median nerve proximal or distal to the compression site.[8] Other findings that can be identified by this examination are decreased echogenicity and nerve mobility, increased vascularization and anatomical variations of the median nerve, which may contribute to the compressive clinical picture. Electroneuromyography, in turn, is considered the diagnostic method of choice for people suspected of having peripheral neuropathies, providing additional information on myelin dysfunction and axonal loss.[9]

Studies directly comparing the classification of ENMG and US positivity for the diagnosis of CTS are scarce. Moreover, we observed in our clinical practice a large number of people with clinical picture compatible with CTS and results of divergent tests. Our study aims to verify whether there is an association between the results of the ENMG and the positivity of US in the diagnosis of CTS.

Casuistry and Methods

An observational, cross-sectional, quali-quantitative study was conducted with evaluation of 68 patients scheduled consecutively in a 4-month period in a regional reference hand surgery outpatient clinic. All procedures were performed according to ethical standards determined by the Research Ethics Committee for research in human beings, and by the Helsinki Declaration of 1964. The free and informed consent form was obtained from all participants by signing a specific term.

The inclusion criteria were people of both genders, over 18 years of age, who presented, at the initial consultation, ENMG of upper limbs and US of wrist, both with diagnostic hypothesis of CTS. We excluded people with other neuropathies, previous wrist injuries, pregnant women, people with reports of tenosynovitis or tumors in the wrist, those with a known history of uncontrolled systemic comorbidities, and people with reports of current work activities with repetitive movements or hand vibration.

In relation to US, in our service, the medical team specialized in radiology and imaging diagnosis defines the sectional cutoff point of the median nerve suggestive of abnormality at 10 mm or more. The ENMG, in turn, is performed by the same neurologist specialized in electroneuromyographic studies, belonging to the clinical staff of the institution. The classification of ENMG is thus standardized: mild degree (alteration only of sensory conduction), moderate degree (alteration of sensory and motor conduction) and severe degree (altered sensory and motor conduction and signs of denervation to needle electromyography).

The qualitative characteristics were evaluated in all patients and described using absolute and relative frequencies. The quantitative variable age was described using summary measures (mean, standard deviation, median, minimum and maximum).

Seventy-six people were attended and 8 were excluded (1 with previous wrist trauma, 2 with uncontrolled diabetes, and 5 with previous wrist surgeries), totaling 68 participants included in this study.

►**Table 1** shows the clinical characteristics of the 68 people who constituted our sample. Regarding gender, there

Table 1 Description of sample characteristics

Variable	Description (N = 68)
Age (years)	
mean ± SD	54.4 ± 10.1
median (min.; max.)	53.5 (35; 76)
Gender, n (%)	
Female	61 (89.7)
Male	7 (10.3)
Profession, n (%)	
Housewife/retired	24 (35.3)
In work	44 (64.7)
Dominance, n (%)	
Right	65 (95.6)
Lefty	3 (4.4)
Affected side, n (%)	
Right	14 (20.6)
Left	6 (8.8)
Both	48 (70.6)
Comorbidities, n (%)	
One systemic disease	24 (35.3)
Two or more systemic diseases	16 (23.5)
No reported disease	28 (41.2)

Abbreviations: n, number; SD, standard deviation.

were 61 women (89.7%) and 7 men (10.3%). The mean and standard deviation of age was 54.4 years ± 10.1. Regarding the employment situation, 24 people (35.3%) reported being retired or housewives, while 44 (64.7%) were in current work activity. Sixty-five people (95.6%) reported being right-handed and 3 (4.4%) left-handed. Regarding the side affected by symptoms,14 people reported symptoms only on the right (20.6%), 6 (8.8%) only on the left, and 48 (70.6%) reported bilateral symptomatology. When asked about comorbidities, 28 people (41.2%) denied having any comorbidities, while 24 (35.3%) reported having a systemic disease, and 16 (23.5%) 2 or more.

The US results (positive or negative) were crossed with the results of the ENMG (mild, moderate, or severe) and the existence of association with the use of the Chi-squared test was verified. [10] Kappa [11] coefficients of agreement were calculated to verify the degree of agreement between US and ENMG, as well as diagnostic measures sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), to evaluate the prediction of CTS using US.

The SPSS for Windows version 20.0 software (IBM Corp., Armonk, NY, USA) was used to perform the analyses, and Microsoft Excel 2003 software (Microsoft Corp., Redmond, WA, USA) was used to tabulate the data. The tests were performed with a significance level of 5%.

Results

Using the hand as a sampling unit, ►**Table 2** shows the crossing between US and ENMG, and the result of statistical

Table 2 Results of the crossing between US and ENMG

Variable	US for CTS		Total	*p*	Kappa	Sensitivity	Specificity	PPV	NPV
	Negative (N = 64)	Positive (N = 72)	N = 136		95% CI	95% CI	95% CI	95% CI	95% CI
ENMG				**0.036**					
Normal	8 (61.5)	5 (38.5)	13						
Mild	12 (63.2)	7 (36.8)	19						
Moderate	19 (57.6)	14 (42.4)	33						
Serious	25 (35.2)	46 (64.8)	71						
ENMG				0.271	0.058	54.5	61.5	93.1	12.5
Normal	8 (61.5)	5 (38.5)	13		(-0.046; 0.162)	(45.2; 63.5)	(31.6; 86.1)	(84.5; 97.7)	(5.6; 23.2)
Altered	56 (45.5)	67 (54.5)	123						
ENMG				**0.045**	0.150	57.7	62.5	83.3	31.3
Normal/mild	20 (62.5)	12 (37.5)	32		(0.003; 0.297)	(47.6; 67.3)	(43.7; 78.9)	(72.7; 91.1)	(20.2; 44.1)
Moderate/ severe	44 (42.3)	60 (57.7)	104						
ENMG				**0.004**	0.248	64.8	60.0	63.9	60.9
Normal/mild/ moderate	39 (60)	26 (40)	65		(0.085; 0.411)	(52.5; 75.8)	(47.1; 72.0)	(51.7; 74.9)	(47.9; 72.9)
Serious	25 (35.2)	46 (64.8)	71						

Abbreviations: 95% CI, 95% confidence interval; CTS, carpal tunnel syndrome; ENMG, electroneuromyography; N, number; NPV, negative predictive value; PPV, positive predictive value; US, ultrasound.
Chi-square test.

tests and diagnostic measures. From the 136 hands evaluated, 123 presented positive ENMG for CTS and 13 presented a negative result. Regarding the classification of the ENMG, there were 19 mild (15.5%), 33 (26.8%) moderate, and 71 (57.7%) severe cases. From the 19 hands with mild degree ENMG, 12 (63.2%) had negative US for CTS and 7 (36.8%) had a positive result. In relation to the 33 hands with moderate degree ENMG, 19 (57.6%) had negative US for CTS and 14 (42.4%) positive. From the 71 hands with severe degree ENMG, 25 (35.2%) had negative US for CTS and 46 (64.8%) positive. Finally, from the 13 hands with negative ENMG (normal ENMG), 8 (61.5%) had negative US for CTS and 5 (38.5%) positive.

Discussion

In population-based studies, the prevalence of CTS is higher in women and increases with aging,[10] with an estimated involvement up to three times more than men.[11] This can be explained by the fact that women have a lower size cuff [12] and lower carpal tunnel elasticity, which can contribute to lower compliance and accommodation of structures.[13,14] It is possible that women are predisposed to more rectified tunnels, which may also contribute to the development of CTS.[15] Based on these publications, our work is in agreement with the literature, with a high prevalence of CTS involvement in women.

In the United States, CTS is the third cause of work leave.[16] In our study, 35.3% of people with CTS reported being retired or housewives, while the majority reported being in current work activity.

Some risk factors for CTS include personal and family history, diabetes, obesity, hypothyroidism, pregnancy, and rheumatoid arthritis.[17] In our series, more than half of the people had at least one systemic comorbidity, and the most common among them were hypertension, diabetes and hypothyroidism.

The definition of the sectional cutoff point of the median nerve by US, suggestive of CTS, is controversial. Most articles set the value between 8 and 14 mm.[18] In our institution, the medical team stipulates the value equal to or greater than 10 mm as suggestive of abnormality. According to Özçakar et al.,[19] US has the advantage of being low-cost, user-friendly, noninvasive, portable, available in most health services and well tolerated by patients, an opinion also shared by Horng et al.[20] however, these authors indicate the examination as a complement to the ENMG. In contrast, Mhoon et al.[21] do not find a significant correlation between ultrasound parameters and electrophysiological severity, and conclude that US is not able to determine the severity of CTS. For Abrishamchi et al.,[22] US may be complementary, but not conclusive, in relation to the classification of CTS severity. According to Fowler et al.,[8] US and ENMG have diagnostic accuracy similar to clinical tests, but ENMG can diagnose other etiologies of paresthesia in the hands besides CTS, such as cervical radiculopathy, cubital tunnel syndrome and prone syndrome.[23,24]

Our study demonstrated that there was a statistically significant association between ENMG and US ($p < 0.05$), and US positivity was higher for more severe levels of CTS given by ENMG. Certainly, this fact is related to the sensitivity and scope of the US method. Median nerve changes secondary to more advanced compression are detected, while the more subtle or initial ones are not. It is worth to discuss whether the decision of surgical indication can be made based only on US, since only severe cases were associated with ENMG.

Despite this association, US presented low agreement with ENMG (Kappa < 0.25) and diagnostic measures were mostly low for any groupings used in the severity of ten ENMG.

We agree with Fowler et al.[8] when they state that the comparison between US and ENMG cannot be considered reliable because there is no accepted reference standard. We also emphasize that both are tests that may be influenced by the examiner's experience in what is intended to be investigated.

We believe that decisions regarding the diagnosis of CTS can be made, initially, based on clinical history and thorough physical examination, directed at what is intended to be investigated.

Conclusion

We conclude that, despite the association with statistical significance between US and more severe levels of ENMG, the two tests did not present significant agreements for the diagnosis of CTS.

Conflict of Interests

The authors declare that there is no conflict of interests.

References

1 Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosén I. Prevalence of carpal tunnel syndrome in a general population. JAMA 1999;282(02):153–158
2 Wang WL, Buterbaugh K, Kadow TR, Goitz RJ, Fowler JR. A Prospective Comparison of Diagnostic Tools for the Diagnosis of Carpal Tunnel Syndrome. J Hand Surg Am 2018;43(09):833–836.e2
3 Sears ED, Swiatek PR, Hou H, Chung KC. Utilization of Preoperative Electrodiagnostic Studies for Carpal Tunnel Syndrome: An Analysis of National Practice Patterns. J Hand Surg Am 2016;41(06):665–672.e1
4 Buchberger W, Schön G, Strasser K, Jungwirth W. High-resolution ultrasonography of the carpal tunnel. J Ultrasound Med 1991;10(10):531–537
5 Kerasnoudis A, Tsivgoulis G. Nerve Ultrasound in Peripheral Neuropathies: A Review. J Neuroimaging 2015;25(04):528–538
6 Simon NG, Talbott J, Chin CT, Kliot M. Peripheral nerve imaging. Handb Clin Neurol 2016;136:811–826
7 Hobson-Webb LD, Padua L. Ultrasound of Focal Neuropathies. J Clin Neurophysiol 2016;33(02):94–102
8 Fowler JR, Cipolli W, Hanson T. A Comparison of Three Diagnostic Tests for Carpal Tunnel Syndrome Using Latent Class Analysis. J Bone Joint Surg Am 2015;97(23):1958–1961
9 Wee TC, Simon NG. Ultrasound elastography for the evaluation of peripheral nerves: A systematic review. Muscle Nerve 2019;60(05):501–512
10 Kirkwood BR, Sterne JA. Essential medical statistics. 2nd ed. Massachusetts, USA: Blackwell Science; 2006

11 Fleiss JL. The design and analysis of clinical experiments. New York: Wiley; 1986
12 Mondelli M, Giannini F, Giacchi M. Carpal tunnel syndrome incidence in a general population. Neurology 2002;58(02):289–294
13 Sassi SA, Giddins G. Gender differences in carpal tunnel relative cross-sectional area: a possible causative factor in idiopathic carpal tunnel syndrome. J Hand Surg Eur Vol 2016;41(06): 638–642
14 Lakshminarayanan K, Shah R, Li ZM. Sex-related differences in carpal arch morphology. PLoS One 2019;14(05):e0217425
15 Bower JA, Stanisz GJ, Keir PJ. An MRI evaluation of carpal tunnel dimensions in healthy wrists: Implications for carpal tunnel syndrome. Clin Biomech (Bristol, Avon) 2006;21(08):816–825
16 Brett AW, Oliver ML, Agur AM, Edwards AM, Gordon KD. Quantification of the transverse carpal ligament elastic properties by sex and region. Clin Biomech (Bristol, Avon) 2014;29(06): 601–606
17 Cobb TK, Dalley BK, Posteraro RH, Lewis RC. Anatomy of the flexor retinaculum. J Hand Surg Am 1993;18(01):91–99
18 Barcenilla A, March LM, Chen JS, Sambrook PN. Carpal tunnel syndrome and its relationship to occupation: a meta-analysis. Rheumatology (Oxford) 2012;51(02):250–261
19 Harris-Adamson C, Eisen EA, Kapellusch J, et al. Biomechanical risk factors for carpal tunnel syndrome: a pooled study of 2474 workers. Occup Environ Med 2015;72(01):33–41
20 Tai TW, Wu CY, Su FC, Chern TC, Jou IM. Ultrasonography for diagnosing carpal tunnel syndrome: a meta-analysis of diagnostic test accuracy. Ultrasound Med Biol 2012;38(07):1121–1128
21 Özçakar L, Kara M, Chang KV, et al. Nineteen reasons why physiatrists should do musculoskeletal ultrasound: EURO-MUSCULUS/USPRM recommendations. Am J Phys Med Rehabil 2015; 94(06):e45–e49
22 Horng YS, Chang HC, Lin KE, Guo YL, Liu DH, Wang JD. Accuracy of ultrasonography and magnetic resonance imaging in diagnosing carpal tunnel syndrome using rest and grasp positions of the hands. J Hand Surg Am 2012;37(08):1591–1598
23 Mhoon JT, Juel VC, Hobson-Webb LD. Median nerve ultrasound as a screening tool in carpal tunnel syndrome: correlation of cross-sectional area measures with electrodiagnostic abnormality. Muscle Nerve 2012;46(06):871–878
24 Abrishamchi F, Zaki B, Basiri K, Ghasemi M, Mohaghegh M. A comparison of the ultrasonographic median nerve cross-sectional area at the wrist and the wrist-to-forearm ratio in carpal tunnel syndrome. J Res Med Sci 2014;19(12):1113–1117

Is there an association between the Hand Diagram and Electrodiagnostic Testing for Carpal Tunnel Syndrome?

Existe associação entre o diagrama da parestesia da mão e a eletroneuromiografia no diagnóstico da Síndrome do Túnel do Carpo?

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Abstract

Objective Verify if there is an association between the hand diagram of paresthesia (HDP) and the results of electroneuromyography (ENMG) in the diagnosis of carpal tunnel syndrome.

Methods A total of 92 people filled in a schematic drawing of the hand with the exact location of the paresthesia (167 hands). The main author classified the diagrams according to the criteria of Katz et al.[5] The results of the HDP were crossed with the positive results of ENMG for the diagnosis of carpal tunnel syndrome.

Results The possible pattern of the HDP was prevalent both in isolation and after crossing with the degrees of ENMG.

Conclusion There was no association between the HDP and ENMG in the diagnosis of carpal tunnel syndrome.

Keywords
- electromyography
- median neuropathy
- carpal tunnel syndrome

Resumo

Objetivo Verificar se existe associação entre o diagrama da parestesia da mão (DPM) e os resultados da eletroneuromiografia (ENMG) no diagnóstico da síndrome do túnel do carpo.

Métodos Um total de 92 pessoas preencheram um desenho esquemático da mão com o local exato da parestesia (167 mãos). O autor principal classificou os diagramas de acordo com os critérios de Katz et al. Os resultados do DPM foram cruzados com os resultados positivos da ENMG para o diagnóstico da síndrome do túnel do carpo.

Resultados O padrão possível do DPM foi prevalente tanto isoladamente quanto após o cruzamento com os graus da ENMG.

Conclusão Não houve associação entre o DPM e a ENMG no diagnóstico da síndrome do túnel do carpo.

Palavras-chave
- eletromiografia
- neuropatia mediana
- síndrome do túnel do carpo

* Work developed at the Hand Surgery Service of the Santa Casa de São Paulo, São Paulo, SP, and at the Universidade Federal do Triângulo Mineiro, Uberaba, MG, Brazil.

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Introduction

Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy of the upper limbs due to compression of the median nerve at the level of the carpal tunnel.[1] The diagnosis is usually made through clinical history and physical examination,[2] while electroneuromyography (ENMG) assists in the diagnostic confirmation of doubtful cases and in establishing the severity.[3,4] In 1990, Katz et al.[5] popularized hand diagrams, which are schematic drawings in which the patient marks the exact location of the numbness symptoms in the hands. These hand diagrams of paresthesia (HDPs) were considered, at the time, as a screening method in people with suspected CTS.[5,6]

In our clinical practice and in the field of occupational medicine, we have observed an increase in the number of work leaves caused by CTS due to some doctors prioritizing positive ENMG for this condition to the detriment of a well-performed clinical examination, generating consequences for the employer, from negative company image to production delay, and to the employee, with unnecessary surgery and prolonged leave. We justify the performance of the present work, too, due to the scarcity of publications in the literature that directly compare the classification of HDP with ENMG.

The aim of our study was to verify whether there is an association between HDP and ENMG in the diagnosis of CTS.

Casuistry and Methods

A cross-sectional, qualitative, and quantitative study was carried out, with the evaluation of 107 consecutively scheduled patients over a 4-month period. All procedures were performed in accordance with the ethical standards determined by the Research Ethics Committee for research on human beings, and with the Helsinki Declaration of 1964. The Free and Informed Consent Form was obtained from all study participants, by signing a specific term.

The inclusion criteria were people of both genders, >18 years old, who presented, in the initial consultation, upper limb ENMG positive for CTS. The exclusion criteria were people who had neuropathy of the cervical spine, of the median nerve in the proximal region or associated with the ulnar nerve, anatomical variations identified by ENMG, history of polyneuropathies, trauma or previous surgery on the wrist, uncontrolled comorbidities (diabetes, hypothyroidism, rheumatoid arthritis, systemic lupus erythematosus, gout, amyloidosis, chronic renal failure), tenosynovitis or tumors in the wrist, pregnant women, and people with reports of labor activities with repetitive movements of flexion-extension of the wrists, vibration of hands and arms or exposure to cold working conditions.

On the scheduled day and time of the medical consultation, all patients underwent screening by a single nurse with a specialization in orthopedics and belonging to the clinical staff of the university who, for the present study, referred people who presented positive upper limb ENMG for CTS to our team.

Then, as soon as the patients entered the doctor's office, before the consultation, they were instructed on how to complete the schematic drawing of the hands. This guidance was performed by a single team member physician who was unaware of any participant data. Filling consisted of marking with a pen the region corresponding to the exact location of the paresthesia. Our study addressed only the location of the marked area in the HDP, and not the intensity of the symptoms. After the completion of the filling, the main author of the present work classified the diagram according to the criteria of Katz et al.,[5] without knowledge of any clinical data of the studied patient.

Katz et al.,[5] in 1990, proposed a hand diagram, in which the location of the paresthesia is marked by means of schematic drawings. The results were classified as classic, probable, possible, or unlikely.

After completing the HDP, the drawing was kept in a proper file for later statistical analysis and, then, the participant was submitted to medical care according to the outpatient routine, at which time the information on the qualitative and quantitative variables was obtained.

Electroneuromyography was performed by the same neurologist specialized in electroneuromyographic studies, belonging to the institutional clinical staff, blind to clinical data and with no specific link with the present work. The exam is performed bilaterally, according to local institutional regulations. The Neuropack EMG electroneuromyograph model S1, MEB-9400K (Nihon Kohden Corporation, Tokyo, Japan) was used, at room temperature of 28°C, available at our institution. The classification of ENMG is standardized as follows: mild degree (alteration of sensory conduction only), moderate degree (alteration of sensory and motor conduction) and severe degree (altered sensory and motor conduction and signs of denervation on needle electromyography).

The information obtained from the participants was organized in a database, according to the criteria of Katz et al.[5] (classic, probable, possible, or unlikely) for CTS, and according to the severity of the ENMG (mild, moderate, or severe).

The HDP results were crossed with the positive result of the ENMG for CTS, using the hand as a sample unit, using the likelihood ratio test.[7]

A total of 107 people were assisted and 15 were excluded (1 pregnant woman, 2 with previous trauma to the wrist, 5 with uncontrolled diabetes and/or hypothyroidism, and 7 with previous wrist surgery), totaling 92 participants included in the present study. Regarding gender, our sample included 14 men (15.2%) and 78 women (84.8%). The mean and standard deviation (SD) of age was 55.2 ± 10.5 years old.

Of the 92 patients with ENMG positive for CTS and, using the hand as a sample unit, we obtained 75 people with positive ENMG bilaterally (150 hands) and 17 unilaterally (17 hands), totaling 167 hands with a positive result of ENMG for CTS.

To perform the analyzes, IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA) was used, and Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA,

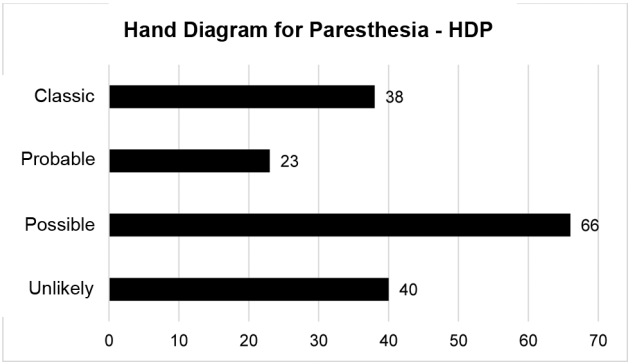

Fig. 1 Distribution of the number of hands according to the HDP.

USA) software was used to tabulate the data. The tests were performed with a significance level of 5%.

Results

►**Figure 1** shows the distribution of the 167 hands that presented positive ENMG for CTS, classified according to the criteria of Katz et al.[5] In our study, we obtained 38 hands (22.7%) with a classic pattern, 23 (13.8%) probable, 66 (39.5%) possible and 40 (24.0%) unlikely.

►**Table 1** presents the crossing between HDP and ENMG, with the statistical results. In decreasing order of involvement, we observed that of the 22 hands with mild grade ENMG, 10 cases (45.5%) presented possible standard HDP, followed by improbable in 6 cases (27.2%), classic in 4 cases (18.2 %) and probable in 2 cases (9.1%). In decreasing order of involvement, we observed that of the 67 hands with moderate degree ENMG, 26 cases (38.8%) presented possible standard MPD, followed by classic in 18 cases (26.9%), unlikely in 16 cases (23.9 %) and probable in 7 cases (10.4%). Finally, in decreasing order of involvement, we observed that of the 78 hands with severe grade ENMG, 30 cases (38.5%) presented possible standard HDP, followed by improbable in 18 cases (23.1%), classic in 16 cases (20.5%) and probable in 14 cases (17.9%).

Discussion

We currently have several clinical instruments for the diagnosis of CTS, but it is essential that they are validated.[8] We agree with Moradi et al.[9] when considering HDP as a screening method for the diagnosis of CTS, which was even used by our team in the initial approach. Of the 167 hands assessed in our study, we identified in the HDP that the possible pattern was the most prevalent, in 66 cases (39.5%), while the least prevalent was the likely pattern, in 23 cases (13.8%).

We observed that there are divergences of opinion on the need for ENMG to confirm the diagnosis of CTS, and the literature is controversial when it demonstrates which is the best diagnostic method. Agreement between symptoms, physical examination and ENMG is low, and Stevens has found a 5% agreement between the three parameters.[10] These authors believe that the person with ENMG positive for CTS in the absence of symptoms cannot be considered as having CTS.

When evaluating the crossing between HDP and ENMG, we observed that both cases with mild, moderate, or severe ENMG had a predominance of possible standard HDP. In contrast, the probable pattern was the least prevalent in all degrees of ENMG involvement. In our results, we found that there was no statistically significant association ($p = 0.797$) between HDP and ENMG results.

As positive points of our study, we had a sample of 92 patients, totaling 167 hands. Studies by Sharma et al.[11] include 40 patients and 71 hands; Nelson et al.,[12] 26 patients and 34 hands; and Katz and Stirrat,[5] 63 patients and 85 hands. In addition, ENMG was performed only by a specialized neurologist, using a single ENMG device available at our institution. As a negative point, it is possible that there was a bias regarding the classification of HDP, which, in our study, was performed by a single doctor on the team. As it is a subjective assessment tool, one of the measures to reduce this bias would be the classification of diagrams by two or more doctors.

At the time of the present study, we did not find in the literature sufficient recommendations, guidelines or criteria validated at national level indicating when ENMG should be requested for investigation of CTS, which makes the diagnosis of this condition a challenging task.

We understand that it is unwise to exclude the diagnosis of CTS in people with typical symptoms and normal ENMG, not least because there is no way to predict whether the person is experiencing transient ischemia, in which case, ENMG may be normal. We believe that ENMG is a useful exam in doubtful cases that are refractory to the initial treatment, and should be requested carefully and based on what is intended to be

Table 1 Crossing between hand diagram for paresthesia and electroneuromyography

HDP	ENMG			Total	*p-value*
	Mild	Moderate	Severe		
Classic	4 (18.2)	18 (26.9)	16 (20.5)	38 (22.8)	0.797
Probable	2 (9.1)	7 (10.4)	14 (17.9)	23 (13.8)	
Possible	10 (45.5)	26 (38.8)	30 (38.5)	66 (39.5)	
Unlikely	6 (27.2)	16 (23.9)	18 (23.1)	40 (24.0)	
Total	**22 (100)**	**67 (100)**	**78 (100)**	**167 (100)**	

Abbreviations: HDP, Hand Diagram for Paresthesia; ENMG, Electroneuromyography.
Likelihood ratio test.

investigated, avoiding the discomfort of the exam and the anxiety of the patient. Regarding HDP, we believe that more studies are needed to prove the effectiveness and precision of this method for the diagnosis of CTS; however, we believe that this clinical tool can be used for screening this condition.

In our opinion, neither HDP nor ENMG should be used alone or in place of a detailed clinical history and thorough physical examination for the diagnosis of CTS.

We conclude that there is no association between the HDP and ENMG in the diagnosis of CTS.

Conflict of interests

The authors have no conflict of interests to declare.

References

1 Spahn G, Wollny J, Hartmann B, Schiele R, Hofmann GO. [Meta-analysis for the evaluation of risk factors for carpal tunnel syndrome (CTS) Part I. General factors]. Z Orthop Unfall 2012; 150(05):503–515

2 Wang WL, Buterbaugh K, Kadow TR, Goitz RJ, Fowler JR. A prospective comparison of diagnostic tools for the diagnosis of carpal tunnel syndrome. J Hand Surg Am 2018;43(09):833–836.e2

3 Rempel D, Evanoff B, Amadio PC, et al. Consensus criteria for the classification of carpal tunnel syndrome in epidemiologic studies. Am J Public Health 1998;88(10):1447–1451

4 Sears ED, Swiatek PR, Hou H, Chung KC. Utilization of preoperative electrodiagnostic studies for carpal tunnel syndrome: an analysis of National Practice Patterns. J Hand Surg Am 2016;41(06): 665–672.e1

5 Katz JN, Stirrat CR. A self-administered hand diagram for the diagnosis of carpal tunnel syndrome. J Hand Surg Am 1990;15 (02):360–363

6 Calfee RP, Dale AM, Ryan D, Descatha A, Franzblau A, Evanoff B. Performance of simplified scoring systems for hand diagrams in carpal tunnel syndrome screening. J Hand Surg Am 2012;37(01): 10–17

7 Kirkwood BR, Sterne JA. Essential medical statistics. 2nd ed. Blackwell ScienceMassachusetts, USA2006:502

8 Goulart BNG, Chiari BM. [Screening versus diagnostic tests: an update in the speech, language and hearing pathology practice]. Pro Fono 2007;19(02):223–232

9 Moradi A, Mellema JJ, Oflazoglu K, Isakov A, Ring D, Vranceanu AM. The relationship between catastrophic thinking and hand diagram areas. J Hand Surg Am 2015;40(12):2440–6.e5

10 de Krom MC, Kester AD, Knipschild PG, Spaans F. Risk factors for carpal tunnel syndrome. Am J Epidemiol 1990;132(06): 1102–1110

11 Sharma V, Wilder-Smith EP. Self-administered hand symptom diagram for carpal tunnel syndrome diagnosis. J Hand Surg [Br] 2004;29(06):571–574

12 Nelson JT, Gauger MR, Whaley JD, Zinberg EM. Patient-reported symptom-mapping in carpal tunnel syndrome. Muscle Nerve 2019;59(03):321–325

Double-Blinded Randomized Study of the Correlation between Simple Radiography and Magnetic Resonance Imaging in the Evaluation of the Critical Shoulder Angle: Reproducibility and Learning Curve*

Estudo duplo-cego randomizado da correlação entre radiografia simples e ressonância magnética na avaliação do ângulo crítico do ombro: Reprodutibilidade e curva de aprendizado

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Abstract

Objective To evaluate the feasibility of magnetic resonance imaging (MRI) to obtain the critical shoulder angle (CSA) comparing the results obtained through radiography and MRI, and assess the learning curves.

Methods In total, 15 patients were evaluated in a blinded and randomized way. The CSA was measured and compared among groups and subgroups.

Results The mean angles measured through the radiographic images were of 34.61 ± 0.67 and the mean angles obtained through the MRI scans were of 33.85 ± 0.53 ($p = 0.29$). No significant differences have been found among the groups. The linear regression presented a progressive learning curve among the subgroups, from fellow in shoulder surgery to shoulder specialist and radiologist.

Conclusion There was no statistically significant difference in the X-rays and MRI assessments. The MRI seems to have its efficacy associated with more experienced evaluators. Data dispersion was smaller for the MRI data regardless of the experience of the evaluator.

Keywords
- rotator cuff
- shoulder joint
- radiography
- magnetic resonance imaging
- reproducibility of results

Resumo

Objetivo Avaliar a confiabilidade da obtenção do ângulo crítico do ombro (ACO) na ressonância magnética (RM) comparada com esse mesmo ângulo obtido por meio de radiografias, e avaliar a curva de aprendizado do método.

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Palavras-chave
- manguito rotador
- articulação do ombro
- radiografia
- ressonância nuclear magnética
- reprodutibilidde dos testes

Métodos As imagens de radiografias e RMs de 15 pacientes foram avaliadas prospectivamente de forma cega e randômica. O ACO foi medido e comparado entre os grupos e subgrupos.

Resultados A média dos ACOs nas imagens de radiografia foi de $34{,}61^\circ \pm 0{,}67$, e na RM, $33{,}85^\circ \pm 0{,}53$ ($p = 0{,}29$). Não houve diferença estatisticamente significativa. Houve curva de aprendizado progressiva na regressão linear entre os subgrupos, de especializando em ombro a especialista e radiologista.

Conclusão Não houve diferença estatisticamente significativa entre o ACO por imagens de radiografia e RM. O método da RM parece ter sua eficiência associada a avaliadores mais experientes. Independente da experiência do avaliador, a variabilidade dos dados foi menor nas avaliações por RM.

Introduction

The etiology of rotator cuff tendinopathy is not yet fully known, but mechanical overload is one of the most suggested causes for tendon degeneration, and it may be influenced by the constitutional factors of the affected individuals.[1–3] The critical shoulder angle (CSA), which is obtained through radiographic evaluations, has been considered an important predictive factor for mechanical overload.[4,5] A biomechanical assay analysis has also corroborated the establishment of this correlation.[6]

The CSA is criticized by some authors, who did not find this same correlation; however, inadequate positioning on the radiographs may have been a limiting factor in these studies.[7] Based on the possible source of patient positioning bias, tests showing images with better quality would be the logical way to improve the reproducibility in the evaluation of the CSA.

Some authors suggested the use of computed tomography, and found a high degree of agreement with the radiographic study.[8] However, tomography exposes the patient to higher doses of radiation than radiography, and its indication should be more carefully evaluated.[9] The use of nuclear magnetic resonance (NMR) does not use ionizing radiation, being widely requested for the evaluation of various orthopedic conditions, and it also has less dependence on positional factors that may skew the traditionally used radiographic image.

In a recent CSA study using magnetic resonance imaging (MRI), it was suggested that there was higher data variability of the MRI when compared to radiography, which was more evident in patients with osteoarthritis, and that the method would not be adequate.[10]

The present study aims to evaluate the viability of the MRI to obtain the CSA, and the correlation between the results obtained in radiographic and MR images by a new MR evaluation methodology.

Materials and Methods

The present prospective, randomized, double-blinded comparative study for radiographic and MRI evaluation of the CSA was approved by the institutional ethics committee under number 2.706.960, CAAE: 87182318.2.0000.8054.

The examinations of 15 patients were randomly evaluated and blinded to the evaluator. Only examinations of patients who were to undergo both radiography and MRI on the same day, and with positioning standardization, were used.

Inclusion Criteria

Patients over 18 years of age of both sexes who agreed to participate in the study and had any of the following symptoms: shoulder strength loss, instability, range of motion limitation, and pain.

Exclusion Criteria

Patients with shoulder deformities, with shoulder fracture sequelae, previous shoulder surgeries, radiographic positioning error, and indigenous individuals, those mentally handicapped, or those from other populations who have any ethical conflict.

An Espree 1.5 tesla (Siemens, Munich, Germany) MRI machine was used, as well as an MS–18S® (General Electric, Boston MA, US) digital radiography equipment.

The pattern of analysis for the position of the radiograph was true anteroposterior, with the patient in the orthostatic position, and rays penetrating at 90° in the glenoid joint. The MRI was performed with the patient in supine position.

The coronal MRI was established and standardized during the study, and we evaluated the best visualization of the target structures, and compared it with the radiographic results.

The CSA was calculated with the help of the Carestream (Carestream Health, Onex Corporation, Toronto, Ontario, Canada) software. After standardization, the values obtained were analyzed using the STATA (StataCorp, College Station, TX, US) software, version 15.0.

The MRI measurements used T1-weighted images for better bone visualization in the axial and coronal planes (►**Figure 1**).

In the axial plane, the section with the largest lateral projection of the acromion was identified and marked as the lateral point.

The central point of the glenoid cavity was also found in the axial plane, and marked in the software to use this point to establish the most central section in the coronal plane.

The lateral point was superimposed on all coronal plane images; the most central section of this plane was used to

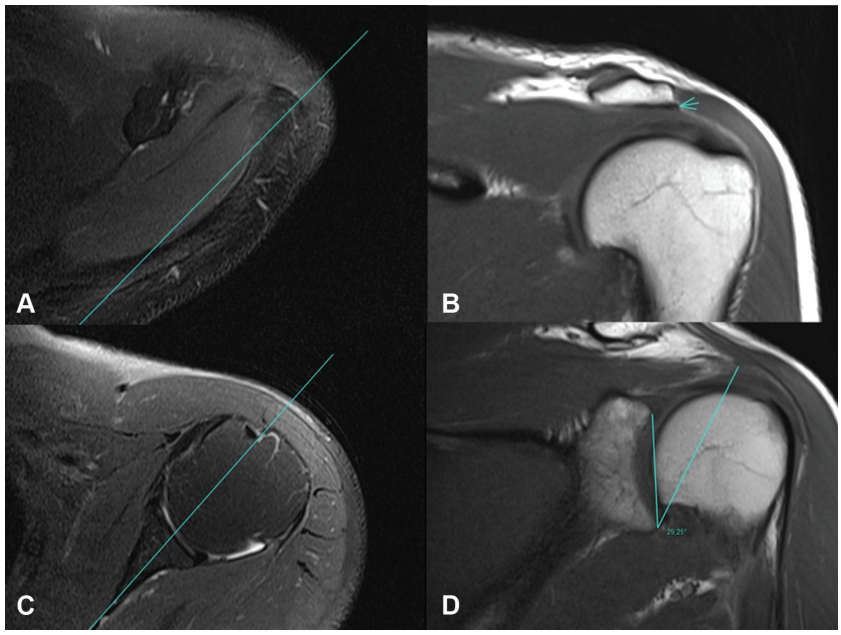

Fig. 1 (A) Marking of the most lateral point of the acromion;T2 image, axial plane. (B) Marking of the most lateral point of the acromion; T1 image, coronal plane. (C) Marking of the center of the glenoid; T2 image, axial plane. (D) Critical shoulder angle (CSA) measurement; coronal image at the central section of the glenoid. Line between the glenoid border and the projection for this section of the most lateral point of the acromion, obtained in sections A and B.

mark the line of the superoinferior axis of the glenoid cavity, and the line between the lowest point of the glenoid and the lateral point was artificially inserted into the image by the software. The angle between these two straight lines was considered the CSA measured by MRI.

The measurement of the angle on the radiographs followed the patterns described by Moor et al[4] (►**Figure 2**).

The data were blindly and randomly evaluated by three evaluators, one fellow in shoulder surgery, a shoulder specialist with three years of experience, and a musculoskeletal radiology specialist with three years of experience, to establish a learning curve.

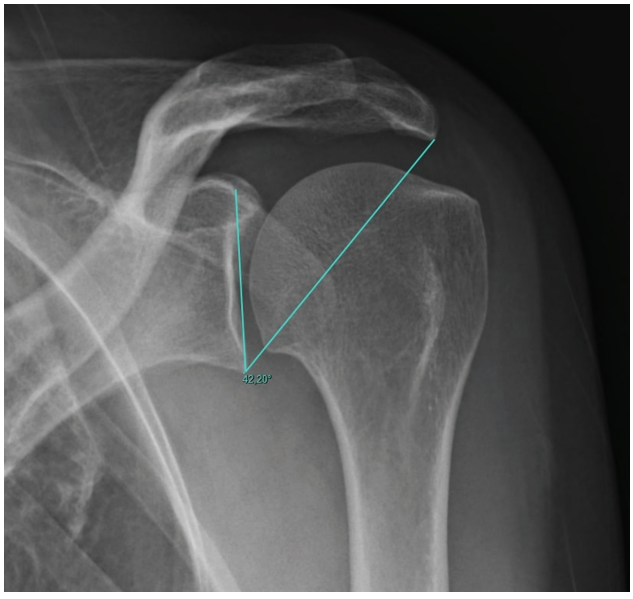

Fig. 2 Measurement of the CSA by radiography.

The statistical evaluation was performed respecting the nature of the data. The results were presented in the format of mean ± standard error (standard deviation, SD). Data were considered significant with $p < 0.05$ in a two-tailed curve. The patient examinations were blindly and randomly evaluated. In the parametric data, comparisons were made using paired *t* tests, analysis of variance (ANOVA) and the Tukey test.

A comparison was also made between the means obtained by the evaluators and the linear regression in order to establish the differences in the learning curves of the evaluation of the radiographs and the MRI between the fellow in shoulder surgery and the specialist with 3 years of experience in shoulder surgery.

Results

The mean of the angles measured by the radiographs was of 34.61 ± 0.67(SD: 4.54) and the mean of the MRI exams was of 33.85 ± 0.53 (SD: 3.54); $p = 0.29$. The mean difference between the radiographic and MRI angles was of 0.76° ± 0.72(SD: 4.81).

Separate data and comparisons in the subgroups fellow in shoulder surgery, shoulder specialist, and radiologist are summarized in ►**Table 1**. The comparisons between groups by the Tukey method are summarized in the ►**Table 2**.

In the linear regression, the difference in degrees of the evaluation between radiographs and the MRI showed a constant of 3.07° with coefficient of -1.15°, which is multiplied by 1 for the fellow group, by 2 for the specialist group, and by 3 for the radiologist group.

Table 1 Means with standard errors of the angles by subgroup

	X-Ray	Magnetic resonance imaging (MRI)	Mean difference (X-Ray versus MRI)	*p*-value (X-Ray versus MRI)
Fellow in shoulder surgery	35.21° ± 1.32	33.19° ± 0.87	2.02°	0.15
Shoulderspecialist	34.43° ± 1.09	33.86° ± 0.92	0.57°	0.57
Radiologist	34.19° ± 1.15	34.49° ± 0.98	0.30°	0.84
Analysis of variance among groups	0.82	0.62	0.42	

Table 2 Tukey assessment among groups and significance of the differences

Tukey	*p*-value of the X-Ray among groups	*p*-value of the magnetic resonance imaging (MRI) among groups	Difference in *p*-value (X-Ray versus MRI) among groups
Radiologist versus fellow in shoulder surgery	0.82	0.59	0.40
Fellow in shoulder surgery versus specialist	0.89	0.87	0.69
Radiologist versus specialist	0.99	0.88	0.87

Discussion

The CSA has been used to evaluate patients with various degenerative and inflammatory processes of the shoulder. Its data provide an expectation that relates this angle to some types of injuries.[4]

This angular evaluation, however, does not take into account the forces of other muscles such as the pectoralis major, the latissimus dorsi and the biceps, which may also contribute to a more accurate predictability of mechanical shoulder overloads,[4–6,11,12] since muscle recruitment simplifications are used even in its theorizing.[11–13] Passive structures are also not taken into account this evaluation, as in the current models only at the extremes of movement they would have some influence on the forces acting on the shoulder.[14]

The assessment of the critical shoulder angle is made by radiographic examination; however, in patients already undergoing MRI, the use of this ionizing radiation may be unnecessary. The present study shows a tendency adverse to that of the literature to compare CSA evaluations by radiography and MRI.[10] This divergence may have its origin in the following methodological errors of the literature: the most lateral point of the clavicle did not have a properly standardized marking, the sample was insufficient, it was not validated in internal validation tests, and the MRI and radiography tests were not performed at the same time.

The radiographic examination may present greater difficulty in standardization, being more dependent on human variables to be performed. This fact becomes clear when we evaluate the differences between dispersion data in all groups: data dispersion was greater in the radiographic evaluation groups than in the MRI groups, regardless of the type of evaluator.

There was greater agreement and proximity of data among more experienced examiners, with the musculoskeletal radiology specialist presenting the closest data, demonstrating that there is a clear learning curve, which is more important in the MRI assessment. In the ANOVA, there is greater agreement in the radiographic evaluation among the groups and, considering the results demonstrated by the Tukey technique, data dispersion and linear regression, there is a clear learning curve, possibly linked to the greater familiarity with imaging tests, especially the MRI.

The learning curve of the MRI assessment seems to be more dependent on specific training than the radiographic assessment curve. However, this fact may also be related to the higher exposure of the fellow in shoulder surgery to the radiographic exam during his training in general orthopedics, so this professional was more familiarized with radiographic evaluations than MRI images.

These mechanical effects do not seem to influence image extraction.

Conclusion

There were no statistically significant differences in MRI data and CSA radiographs, with a mean divergence between the methods of only 0.76°.

The MRI seems to have its efficiency associated with more experienced evaluators.

Regardless of the evaluator's experience, data variability was lower in the MRI assessments.

Conflict of interests

The authors have no conflict of interests to declare.

References

1 Fukuda H, Hamada K, Yamanaka K. Pathology and pathogenesis of bursal-side rotator cuff tears viewed from en bloc histologic sections. Clin Orthop Relat Res 1990;(254):75–80
2 Bedi A, Maak T, Walsh C, et al. Cytokines in rotator cuff degeneration and repair. J Shoulder Elbow Surg 2012;21(02):218–227
3 Hashimoto T, Nobuhara K, Hamada T. Pathologic evidence of degeneration as a primary cause of rotator cuff tear. Clin Orthop Relat Res 2003;(415):111–120

4 Moor BK, Bouaicha S, Rothenfluh DA, Sukthankar A, Gerber C. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?: A radiological study of the critical shoulder angle Bone Joint J 2013;95-B(07):935–941
5 Gomide LC, Carmo TC, Bergo GHM, Oliveira GA, Macedo IS. Associação entre o ângulo crítico do ombro e lesão do manguito rotador: um estudo epidemiológico retrospectivo. Rev Bras Ortop 2017;52(04):423–427
6 Gerber C, Snedeker JG, Baumgartner D, Viehöfer AF. Supraspinatus tendon load during abduction is dependent on the size of the critical shoulder angle: A biomechanical analysis. J Orthop Res 2014;32(07):952–957
7 Chalmers PN, Salazar D, Steger-May K, Chamberlain AM, Yamaguchi K, Keener JD. Does the critical shoulder angle correlate with rotator cuff tear progression? Clin Orthop Relat Res 2017;475 (06):1608–1617
8 Bouaicha S, Ehrmann C, Slankamenac K, Regan WD, Moor BK. Comparison of the critical shoulder angle in radiographs and computed tomography. Skeletal Radiol 2014;43(08):1053–1056
9 Smith-Bindman R, Lipson J, Marcus R, et al. Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. Arch Intern Med 2009;169(22):2078–2086
10 Spiegl UJ, Horan MP, Smith SW, Ho CP, Millett PJ. The critical shoulder angle is associated with rotator cuff tears and shoulder osteoarthritis and is better assessed with radiographs over MRI. Knee Surg Sports Traumatol Arthrosc 2016;24(07):2244–2251
11 Nikooyan AA, Veeger HE, Westerhoff P, Graichen F, Bergmann G, van der Helm FC. Validation of the Delft Shoulder and Elbow Model using in-vivo glenohumeral joint contact forces. J Biomech 2010;43(15):3007–3014
12 Favre P, Snedeker JG, Gerber C. Numerical modelling of the shoulder for clinical applications. Philos Transact A Math Phys. Eng Sci 2009;367(1895):2095–2118
13 Oizumi N, Tadano S, Narita Y, Suenaga N, Iwasaki N, Minami A. Numerical analysis of cooperative abduction muscle forces in a human shoulder joint. J Shoulder Elbow Surg 2006;15(03):331–338
14 Lippitt S, Matsen F. Mechanisms of glenohumeral joint stability. Clin Orthop Relat Res 1993;(291):20–28

Captured Rotator Cuff: A Poor Prognostic Factor in Rotator Cuff Repair

Manguito capturado: Um fator de mau prognóstico no reparo do manguito rotador

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Abstract

Objective To describe a new presentation of tears and retears of the rotator cuff, which we denominate captured rotator cuff (CRC). We also aim to evaluate it clinically and through images.

Methods We assessed retrospectively 16 patients with intraoperative diagnosis of CRC between March 2005 and September 2017; by means of imaging (radiography and magnetic resonance imaging [MRI]) and functional scores (UCLA and Constant & Murley). In images we analyzed the evolution for rotator cuff arthropathy and presence of retears. Functionally, we compared the affected side with the contralateral side and extensive lesions with nonextensive.

Results Five (31.25%) patients presented with rotator cuff arthropathy, and 10 (62.5%) with retears. Three (75%) patients with nonextensive lesions had good/excellent UCLA and Constant & Murley scores. In patients with extensive lesions, when the Constant & Murley score was evaluated, 6 (50%) presented good/excellent results, and in the UCLA score, 7 (58.3%). Comparing the affected side (Constant 74.72 points; UCLA 20 points) with the contralateral side (Constant 96.96 points; UCLA 25.63 points), there were worse functional results with statistical significance.

Conclusion The diagnosis of CRC is suspected by characteristic findings on MRI and confirmed in arthroscopy. The affected shoulders present worse functional postoperative scores.

Keywords
- rotator cuff
- shoulder
- rupture
- subacromial adhesions

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Resumo

Objetivo Descrever uma nova apresentação de ruptura e rerruptura do manguito rotador (MR), a qual denominamos manguito capturado (MC). Objetivamos também avaliá-la clinicamente e por meio de imagens.

Métodos Foram avaliados retrospectivamente 16 pacientes com diagnóstico intraoperatório de MC no período de março de 2005 a setembro de 2017; por meio de exames de imagem (radiografia e ressonância magnética [RM]) e escores funcionais (UCLA e Constant & Murley). Nas imagens, analisamos a evolução para artropatia do manguito rotador e presença de rerrupturas. Funcionalmente, comparamos o lado afetado com o contralateral e as lesões extensas com nãoextensas.

Resultados Cinco (31,25%) pacientes evoluíram com artropatia do manguito rotador e 10 (62,5%) tiveram rerrupturas. Três (75%) pacientes com lesões não extensas tiveram UCLA e Constant & Murley bons/excelentes. Nos pacientes com lesões extensas, quando avaliado Constant & Murley, 6 (50%) apresentaram resultados bons/excelentes, e no escore UCLA, 7 (58,3%). Comparando o lado acometido (Constant 74,72 pontos; UCLA 20 pontos) com o contralateral (Constant 96,96 pontos; UCLA 25,63 pontos), houve pior resultado funcional com significância estatística.

Conclusão O diagnóstico de MC é suspeitado por achados característicos na RM e confirmado na artroscopia. Os ombros acometidos apresentam piores escores funcionais pós-operatórios.

Palavras-chave

- manguito rotador
- ombro
- ruptura
- aderências subacromiais

Introduction

Rotator cuff (RC) injuries are among the most common upper limb orthopedic conditions.[1] The repair of these lesions was first described by Codman in 1911.[2] With the advancement and popularization of arthroscopic techniques, and improvement in the quality of imaging, postoperative complications have been more diagnosed and studied. Shoulder stiffness is one of the most common postoperative complications and is present in 4.8 to 8.7% of patients in some series.[3,4] Retear is the most common and can reach 94%, as described by Paxton et al.[5] Some factors are related to an increased risk of retear, including: lesion size, fat infiltration, muscle atrophy, age and work activity.[6,7] The clinical outcome after repair of a retear remains inconclusive. While some studies indicate poor results, others state that there is no clinically negative impact.[8,9]

In 1996, Mormino et al[10] described a form of complication of open and arthroscopic repair of total and partial ruptures of the RC, calling it the "captured shoulder" (CS). The criteria for confirming the diagnosis were defined as subdeltoid adhesions of the RC, healed tendon repair and associated osteochondral lesions.

Among the patients who underwent arthroscopic surgery due to rupture of the RC, in our group, subacromial adhesions of the previously repaired tendons were verified. This feature was also identified in shoulders without previous surgery.

The purpose of the present study is to describe a new presentation of tear and retear of the RC, which we call captured rotator cuff (CRC). We also aim to evaluate it clinically and by means of images.

Materials and Methods

From March 2005 to September 2017, 16 patients had intraoperative diagnosis of CRC. These lesions were defined by the presence of complete rupture of one or more tendons of the RC associated with their adherence to the acromion. All of the cases were operated arthroscopically by the same team.

The present study included patients with a minimum follow-up of 12 months (maximum of 101 months) and surgical findings as mentioned above. Following the exclusion criteria, those with incomplete data, previous surgeries unrelated to arthroscopic repair of the RC, and with poor quality imaging, were not part of the study.

After selecting the inclusion and exclusion criteria, from a total of 4038 shoulders undergoing arthroscopic RC rupture repair, we obtained 16 patients, with a total of 16 shoulders, equivalent to 0.39%.

In the clinical evaluation, the Constant & Murley score was considered,[11] as well as the University of California at Los Angeles (UCLA) score [12] and the visual analogue scale (VAS).[13]

The patients underwent on-site clinical evaluation with at least 1 year of follow-up. In those patients who were diagnosed with CRC, the radiographic study evaluated the Hamada[14] and Seebauer[15] classifications for those with RC arthropathy. On magnetic resonance imaging (MRI), postoperative healing was evaluated by the Sugaya classification[16] as: type 1) sufficient tendon thickness with low intensity homogeneous tendon; type 2) sufficient tendon thickness with high intensity area; type 3) insufficient tendon thickness with no discontinuity; type 4)

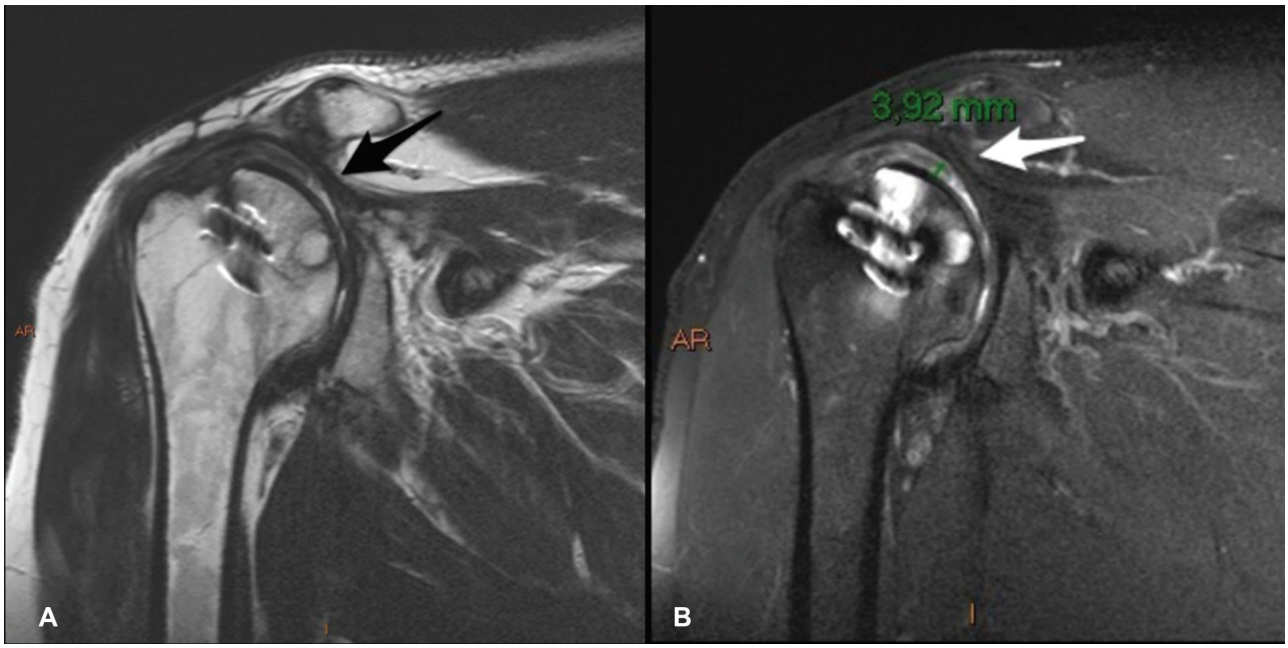

Fig. 1 (A) Continuity between the tendon stump and the subacromial bursa (black arrow). (**B**) Orientation/superior dislocation of the tendon stump (white arrow) and fluid sheet between it and the superomedial surface of the humeral head (3.92mm).

presence of minor discontinuity; type 5) presence of major discontinuity.

Radiographic examinations were performed on a Siemens DR digital device (Siemens Healthcare GmbH, Erlangen, Bavaria, Germany), in true anteroposterior position, in neutral, medial rotation, lateral rotation, outlet view and simple axillary profile. The magnetic resonance exams were performed in a GE 1.5 T Signa device (General Electric Medical Systems, Milwaukee, WI, USA). The evaluation of the examinations and measurements were made by three fellows of the shoulder surgery service, with the help of a radiologist specialized in musculoskeletal radiology with more than 10 years of experience.

In five patients, we observed specific characteristics on preoperative MRI (►**Figure 1**). There is a continuity between the tendon stump and the subacromial/subdeltoid bursa to which it is thickened. The tendon stump is displaced/oriented superiorly with a liquid sheet between it and the superomedial surface of the humeral head, in this case with a maximum distance of 3.9 mm.

Lesions were classified as nonextensive lesion, affecting one single tendon of the RC, and extensive lesion, affecting two or more tendons[17] according to intraoperative findings. We compared the mean value of functional scores in patients with extensive and nonextensive lesions, and the affected side with the contralateral side.

The Constant & Murley score was grouped according to Boehm:[18] excellent ($\geq$ 91), good (81–90), satisfactory (71–80), regular (61–70), or poor ($\leq$ 60). According to Amstutz et al,[12] results found using the UCLA method can be excellent ($\geq$ 25 points), good (18–24 points), regular (9–17 points) or poor ($\leq$ 8 points). For the VAS measurement, numerical values between 0 and 10 were used, where 0 represents no pain, and 10 as the maximum pain felt by the patient.[13]

Data were compared by statistical analysis using the chi-squared test, the Fisher exact test and paired t-test using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp, Armonk, NY, USA). The study was approved by the Ethics Committee of the responsible institution under the number CAAE 97060718.4.0000.5126.

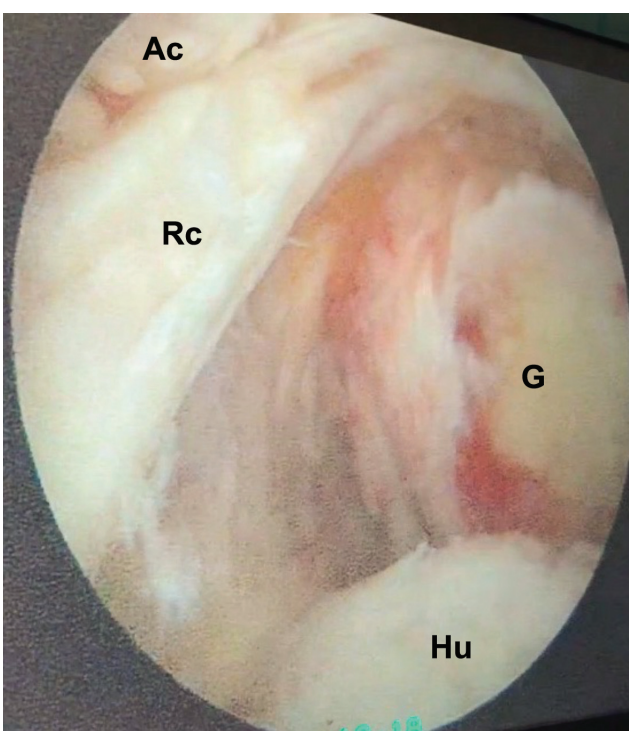

Fig. 2 "Empty shoulder" sign. G: glenoid. Ac: acromion; RC: rotator cuff; Hu: humerus.

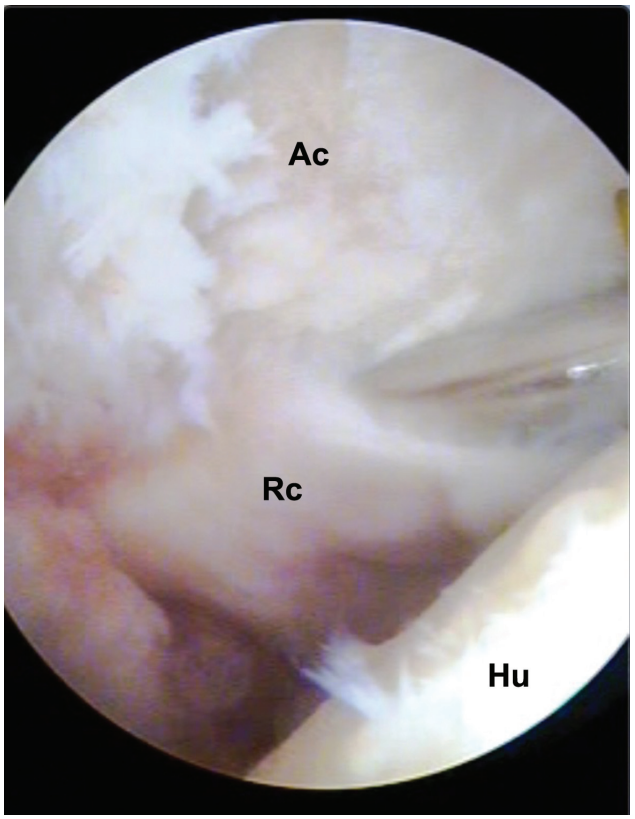

Fig. 3 Adhesions between tendons of the RC and the acromion. Ac: acromion; RC: rotator cuff; Hu: humerus.

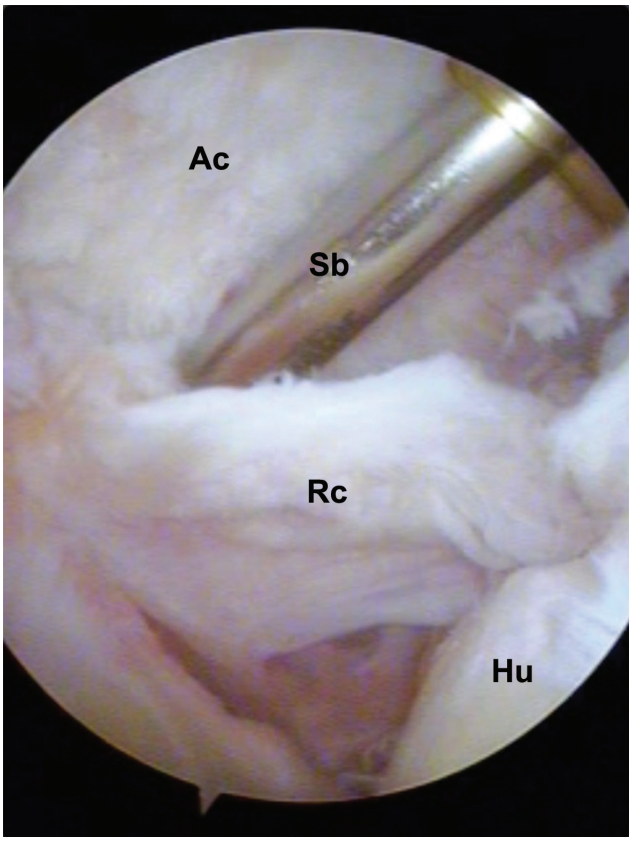

Fig. 4 Creating cleavage plane between the acromion (Ac) and the rotator cuff (RC). Hu: humerus; SB: synovial shaver blade.

Surgical Technique

Patient under general anesthesia and brachial plexus block, in lateral decubitus with 15° dorsal inclination, and upper limb traction affected with 30° abduction and 15° flexion. The surgical procedure begins with glenohumeral inspection through the standard posterior portal. In cases where there are lesions or signs of subluxation/dislocation of the biceps long head tendon, tenotomy with or without tenodesis is performed. The bursal space is accessed using posterior portal for visualization, lateral for instrumentation and anterior for irrigation and instrumentation. Attention should be taken at this time, because in these cases of CRC, unlike normal subacromial vision, we find the sign of "empty shoulder" (►**Figure 2**), characterized by the nonvisualization of the RC, and the impression that the optic is still positioned in the articular space. At this time, the surgeon should look for the acromial RC adhesions (►**Figure 3**). After their identification, a cleavage plane is created with the aid of a synovial shaver blade or of a periosteum detachment (►**Figure 4**). With proper release, tendon flexibility is verified (►**Figure 5**) and repair is performed with as little tension as possible (►**Figure 6**), using metal anchors and high strength synthetic wires. Acromioplasty is performed at the discretion of the shoulder based on the presence of subacromial friction signal. One of the group surgeons does not perform the procedure (13 acromioplasties). Postoperatively, the patient is placed in a sling with abduction cushion for a period between 3 weeks (lesions $\leq$

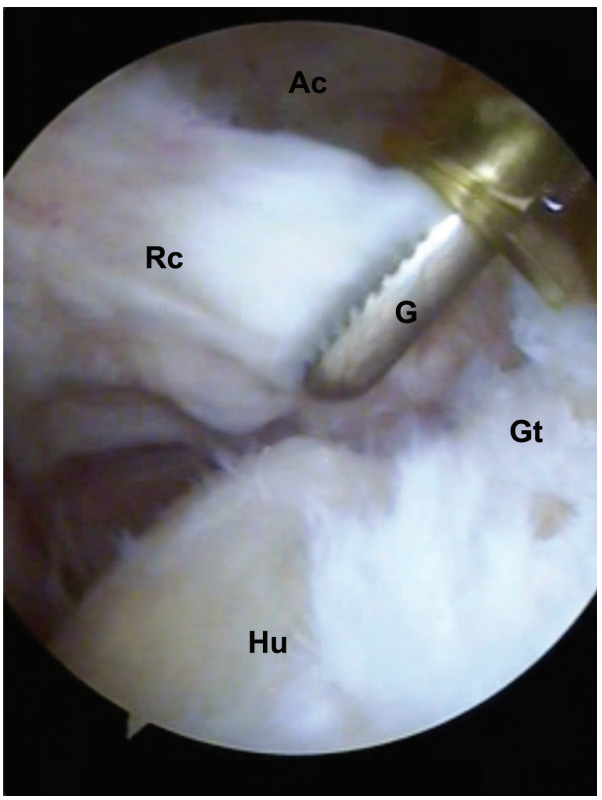

Fig. 5 Rotator cuff released from the acromion and evaluation of tendon flexibility with Grasper instruments (G). Hu: humerus; GT: Greater tubercle.

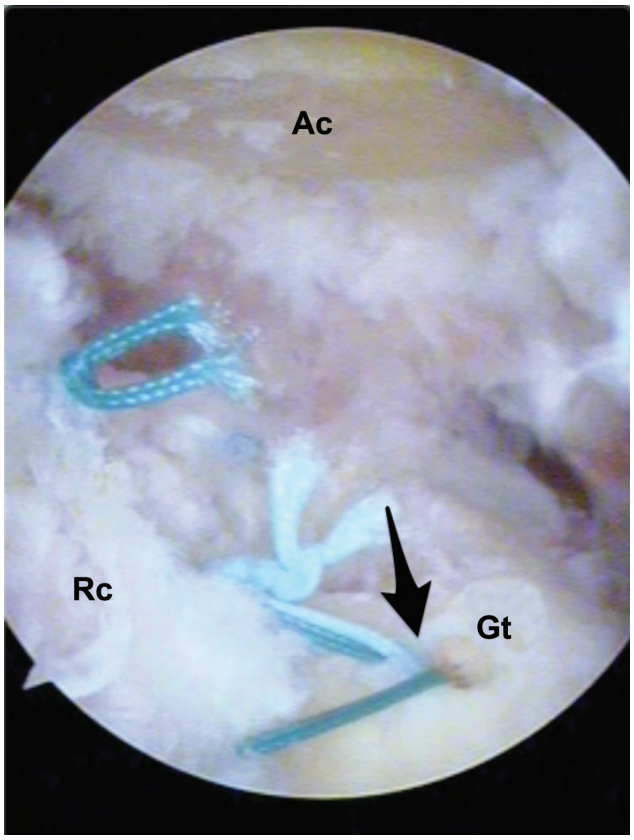

Fig. 6 Tendon sutured in its footprint using metal anchors (black arrows). Ac: acromion; RC: rotator cuff; GT: Greater tuber.

Table 1 Epidemiological and intraoperative data

Mean age at surgery	58.18 years old	Minimum: 42 Maximum: 69
Gender (male/female)	9/7	56,25%/43,75%
Affected side (right/left)	13/3	81,25%/18,75%
Dominance (right-handed/ left-handed)	15/1	93,75%/6,25%
Type of repair	Complete	14 (87,5%)
	Partial	2 (12,5%)
Complementary Findings and/or Complementary Procedures	Acromioplasty	14 (87,5%)
	Tenotomy of LHBT	8 (50%)
	Tenodesis of LHBT	1 (6,25%)
	Previous tear of LHBT	2 (12,5%)
Ruptured tendons	SS	4 (25%)
	SS + IS	8 (50%)
	SS + IS + Tm	2 (12,5%)
	SS + SC	2 (12,5%)

Abbreviations: IS, infraspinatus; LHBT, long head biceps tendon; SC, subscapularis; SS, supraspinatus; Tm, teres minor.

2 cm) and six weeks (lesions > 2 cm). The patient is oriented to actively mobilize the elbow, wrist and fingers from the first day after surgery. The physiotherapy program with passive and self-passive exercises for range of motion gain and analgesia (ultrasound, transcutaneous electrical neurostimulation, cryotherapy) begins after removal of the sling. Isometric strengthening starts from 8 to 12 weeks and isotonic strengthening from 12 to 16 weeks depending on the size of the lesion.

Results

Epidemiological and intraoperative data are presented in ►**Table 1**.

Patients with extensive lesions (mean 73.4 points; 36.1 to 97.8) had a worse Constant & Murley score compared with those with nonextensive lesions (mean 78.2 points; 30.1 to 103.1); without statistical significance (►**Table 2**). Both patients undergoing partial repair had regular functional scores. Neither evolved with rotator cuff arthropathy. The 14 (87.5%) patients with total repair had good and excellent functional scores.

Patients with extensive lesions (mean 19.3 points; 8 to 30) had worse UCLA scores compared with those with nonextensive lesions (mean 23.5 points, ranging from 10 to 30) but without statistical significance (►**Table 3**).

Table 2 Lesion extension *versus* Constant & Murley (Postoperative)

			Constant				Total	*p-value*: 0.384
			Poor	Regular	Good	Excellent		
Lesion	Nonextensive	*n*	1	0	2	1	4	
		%	25.0%	0.0%	50.0%	25.0%	100.0%	
	Extensive	*n*	1	5	5	1	12	
		%	8.3%	41.7%	41.7%	8.3%	100.0%	
Total		*n*	2	5	7	2	16	
		%	12.5%	31.3%	43.8%	12.5%	100.0%	

Chi-square test.

Table 3 Postoperative UCLA versus lesion extension

			UCLA				Total	*p-value* 0.572
			Poor	Regular	Good	Excellent		
Lesion	Nonextensive	*n*	0	1	0	3	4	
		%	0.0%	25.0%	0.0%	75.0%	100.0%	
	Extensive	*n*	2	3	2	5	12	
		%	16.7%	25.0%	16.7%	41.7%	100.0%	
Total		*n*	2	4	2	8	16	
		%	12.5%	25.0%	12.5%	50.0%	100.0%	

Chi-square test.

Table 4 Constant and Murley mean score of affected side versus contralateral side

Comparation	Mean	Standard Deviation	Mean difference	95% CI for mean difference		*p-value*
Affected side	74.72	20.82	−22.24	−32.87	−11.62	<0.001
Contralateral side	96.96	12.95				

Paired T test.

Table 5 Mean UCLA score of affected side versus contralateral side

Comparation	Mean	Standard Deviation	Mean difference	95% CI for mean difference		*p-value*
Affected side	20.00	8.48	−5.63	−9.96	−1.29	**0.014**
Contralateral side	25.63	6.35				

Paired T test.

Patients with nonextensive lesions had a higher proportion of good and excellent Constant & Murley and UCLA scores (75% in both), compared with those with extensive injury (50% and 58.3%, respectively); without statistical significance ($p = 0.585$ Constant & Murley score; $p = 1.000$ UCLA; Fisher exact test).

When comparing the mean Constant & Murley and UCLA scores of the affected side (74.72 and 20 points, respectively) with the contralateral side (96.96 and 25.63 points) there was worse result on the operated side, with statistical significance (►**Table 4** and **5**).

Five (31.25%) patients were diagnosed with rotator cuff arthropathy, presenting decreased acromion-humeral distance with or without acetabularization of the coracoacromial arch and glenohumeral arthrosis. (►**Table 6**).

At the review consultation, there was a decrease in VAS from 6.8 (3 to 10) to 2.7 (0 to 9).

By the Sugaya classification, we found 1 patient (6.25%) type 1, 2 (12.5%) type 2, 3 (18.7%) type 3 and 10 (62.5%) type 5. There were no patients with Sugaya type 4. Patients with extensive lesions had a higher proportion of retears when compared to those with nonextensive lesions (67 versus 50%).

Of the three patients diagnosed with primary CRC, two (one with nonextensive lesion and one with extensive lesion) had good and excellent functional scores with healed tendon (Sugaya 1 and 2). The third patient had an extensive lesion, complete repair was performed, but he presented low functional scores, evolving with RC arthropathy (Hamada 4 A).

Table 6 Radiographic classifications

	Types	Quantity
Hamada	1	8 (50%)
	2	3 (18.75%)
	3	0
	4A	3 (18.75%)
	4B	2 (12.5%)
	5	0
Seebauer	IA	0
	IB	2 (12.5%)
	IIA	3 (18.75%)
	IIB	0

Discussion

In the present study, evaluating 16 patients with clinical and arthroscopic CRC, we found significant differences in relation to the article described by Mormino et al,[10] in which they analyzed that all patients underwent a previous procedure of acromioplasty with repair of rotator cuff injury or partial lesion debridement. These patients presented stiffness and pain after this first procedure and were therefore submitted to a new arthroscopic approach in which the findings of the so-called CS were identified. In contrast, no patient in our sample had postoperative stiffness, and in three cases we observed CRC in patients with complete RC tear and without previous surgery.

Mormino established three diagnostic criteria for intraoperative findings: 1) healed tendon lesions; 2) subdeltoid adhesions of the RC; 3) chondral lesion in the glenoid. In our patients, we observed: 1) tendon ruptures of the RC (relapses or primary), 2) RC adhered to the acromion, and 3) sign of "empty shoulder." We did not find subdeltoid adhesions or chondral lesions associated. Due to these differences, our findings describe a pathology to which the name of CS is not reliable, so we chose to name it CRC.

It is noteworthy that certain factors may have contributed to the differences in diagnostic criteria between CS and CRC. In addition to the association between open and video surgery, the arthroscopic technique in the 1990s was still in its early stages of improvement. Contrary to what happens today, when there is more experience in arthroscopy.

Two (12.5%) patients presented preoperatively with pseudoparalysis (anterior active elevation $< 90°$, complete passive elevation, and absence of causative neurological or osteoarticular injury) and none had joint stiffness. Captured rotator cuff developed primarily in 3 (18.75%); of these, 1 progressed poorly, with regular UCLA and progression to RC arthropathy.

Choi et al,[6] evaluating 147 patients who underwent arthroscopic repair of medium, large and extensive RC injuries, found a mean Constant & Murley score, after repair, of 84.3 points. Kim et al,[19] in 221 RC repair arthroscopies, achieved a mean Constant & Murley score of 89.3 points and 33% of rupture. Agout et al,[20] after 10 years of follow-up, noted that among 965 shoulders with RC tears arthroscopically repaired, the mean Constant & Murley score was 77.8 points, as well as 19% of retear in nonextensive lesions, and 29.3% in extensive lesions. Collin et al,[21] in a sample of 234 patients with arthroscopic repair of extensive posterosuperior lesions, at 10 years of follow-up, found a mean Constant & Murley score of 78.5 points, 34% of retear, and 47% of new rupture after secondary repair. Miyazaki et al,[22] evaluating 163 arthroscopically operated shoulders in patients ≥ 65 years old, using the UCLA score, obtained 96.4% of good and excellent results, as well as 2.45% of retear. Godinho et al,[23] analyzing 86 shoulders after RC repair for nontraumatic (51 shoulders) and traumatic (35 shoulders) injuries, the mean modified UCLA was 33.7 points in the first group, and 32.8 points in the second. In the present study, we obtained a mean Constant & Murley score of 74.7 points, a mean UCLA of 20 points, and a retear ratio (Sugaya 5) of 62.5%. One patient (33.3%) with primary CRC, and 9 (69.27%) with secondary CRC had retear. Comparing with the literature, we believe that patients with CRC have a worse functional score, and greater likelihood of retear in both primary and secondary patients.

In a previous article of the group,[24] evaluating 100 patients (110 shoulders), the clinical outcome of the complete RC rupture repair showed a high percentage of functional recovery (Constant & Murley 83.96) when compared to the contralateral side (Constant & Murley 85.3). In contrast, in the present study, there was a worse functional result of the affected shoulders (Constant & Murley 74.71) when compared to the contralateral side (Constant & Murley 96.95), with statistical significance.

In 5 of the 16 patients diagnosed with CRC, we found the following MRI findings: 1) thickening of the subacromial/subdeltoid bursa; 2) continuity between the tendon stump and these bursa; 3) superior orientation of the tendon stump and 4) presence of a sheet of fluid between the tendon stump and the superomedial surface of the humeral head. These characteristics described above may suggest the diagnosis of CRC.

We did not find any definite cause that explains CRC; however, we think some factors may be associated with this condition. One of the functions of the biceps is to be a secondary humeral head depressant;[25,26] two patients (one of them primary) had previous rupture of the biceps. It is also known that one of the advantages of performing acromioplasty is the increase in local concentration of growth and angiogenic factors, influencing the tendon healing of the RC.[27,28] On the other hand, during acromioplasty, a bleeding bone bed is formed, conducive to possible adhesions. Fourteen patients underwent previous acromioplasty. Further studies are needed to establish and confirm the causal factors of this entity.

In the literature, we find several articles citing CS as a cause of stiffness; these authors describe that its prevention requires early rehabilitation.[3,29,30] However, to our knowledge, this is the only article describing this presentation of a lesion of the RC, the CRC.

As limitations, we had a small sample (16 patients) and did not have a control group to compare functional results.

Conclusion

Captured rotator cuff diagnosis is confirmed by arthroscopy with the following criteria: 1) empty shoulder sign; 2) rupture or retear of one or more tendons of the RC; and 3) adherence of the ruptured tendons to the acromion.

The affected shoulders have worse postoperative functional scores with statistical significance compared to the contralateral shoulder.

Magnetic resonance imaging may show superior displacement of the tendon stump, continuity of the tendon with the subacromial bursa, and a fluid sheet separating the tendon of the RC from the humeral head.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Chen AL, Mears SC, Hawkins RJ. Orthopaedic care of the aging athlete. J Am Acad Orthop Surg 2005;13(06):407–416
2 Codman EA. Rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa. The shoulder. Boston: Thomas Todd; 1934
3 Brislin KJ, Field LD, Savoie FH 3rd. Complications after arthroscopic rotator cuff repair. Arthroscopy 2007;23(02):124–128
4 Huberty DP, Schoolfield JD, Brady PC, Vadala AP, Arrigoni P, Burkhart SS. Incidence and treatment of postoperative stiffness following arthroscopic rotator cuff repair. Arthroscopy 2009;25 (08):880–890
5 Paxton ES, Teefey SA, Dahiya N, Keener JD, Yamaguchi K, Galatz LM. Clinical and radiographic outcomes of failed repairs of large or massive rotator cuff tears: minimum ten-year follow-up. J Bone Joint Surg Am 2013;95(07):627–632
6 Choi S, Kim MK, Kim GM, Roh YH, Hwang IK, Kang H. Factors associated with clinical and structural outcomes after arthroscopic rotator cuff repair with a suture bridge technique in medium, large, and massive tears. J Shoulder Elbow Surg 2014;23(11):1675–1681
7 Cho NS, Lee BG, Rhee YG. Arthroscopic rotator cuff repair using a suture bridge technique: is the repair integrity actually maintained? Am J Sports Med 2011;39(10):2108–2116
8 Godinho GG, França FO, Freitas JM, et al. Resultado do tratamento cirúrgico artroscópico das re-rupturas do manguito rotador do ombro. Rev Bras Ortop 2015;50(01):89–93
9 Miyazaki AN, Fregoneze M, Santos PD, et al. Evaluation of the results from reoperations on patients with rotator cuff lesions. Rev Bras Ortop 2011;46(01):45–50
10 Mormino MA, Gross RM, McCarthy JA. Captured shoulder: a complication of rotator cuff surgery. Arthroscopy 1996;12(04):457–461
11 Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987;(214):160–164
12 Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. Clin Orthop Relat Res 1981;(155):7–20
13 Huskisson EC. Measurement of pain. Lancet 1974;2(7889): 1127–1131
14 Hamada K, Fukuda H, Mikasa M, Kobayashi Y. Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop Relat Res 1990;(254):92–96
15 Seebauer L. Biomecanical classification of cuff tear arthropaty [abstract]. In: Global Shoulder Society Meeting; 2003 July 17-19 Salt Lake City, UT-USA
16 Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: single-row versus dual-row fixation. Arthroscopy 2005;21 (11):1307–1316
17 Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Joint Surg Am 2000;82(04):505–515
18 Boehm D. Valuation of the Constant score. In: Habermeyer P, Magosch P, Lichtenberg S, editors. Classifications and scores of the shoulder. Heidelberg: Springer; 2006:20–21
19 Kim JH, Hong IT, Ryu KJ, Bong ST, Lee YS, Kim JH. Retear rate in the late postoperative period after arthroscopic rotator cuff repair. Am J Sports Med 2014;42(11):2606–2613
20 Agout C, Berhouet J, Bouju Y, et al. Clinical and anatomic results of rotator cuff repair at 10 years depend on tear type. Knee Surg Sports Traumatol Arthrosc 2018;26(08):2490–2497
21 Collin P, Colmar M, Thomazeau H, et al. Clinical and MRI Outcomes 10 Years After Repair of Massive Posterosuperior Rotator Cuff Tears. J Bone Joint Surg Am 2018;100(21):1854–1863
22 Miyazaki AN, da Silva LA, Santos PD, Checchia SL, Cohen C, Giora TS. Evaluation of the results from arthroscopic surgical treatment of rotator cuff injuries in patients aged 65 years and over. Rev Bras Ortop 2015;50(03):305–311
23 Godinho GG, França FdeO, Alves FJ, et al. Evaluation of anatomical integrity using ultrasound exanination and functional integrity using the Constant & Murley score, of the rotator cuff following arthroscopic repair. Rev Bras Ortop 2015;45(02):174–180
24 Abechain JJK, Godinho GG, Matsunaga FT, Netto NA, Daou JP, Tamaoki MJS. Functional outcomes of traumatic and non-traumatic rotator cuff tears after arthroscopic repair. World J Orthop 2017;8(08):631–637
25 Kido T, Itoi E, Konno N, Sano A, Urayama M, Sato K. The depressor function of biceps on the head of the humerus in shoulders with tears of the rotator cuff. J Bone Joint Surg Br 2000;82(03): 416–419
26 Ikemoto RY, Pileggi PE, Murachovsky J, et al. Tenotomy with or without tenodesis of the long head of the biceps using repair of the rotator cuff. Rev Bras Ortop 2012;47(06):736–740
27 Frank JM, Chahal J, Frank RM, Cole BJ, Verma NN, Romeo AA. The role of acromioplasty for rotator cuff problems. Orthop Clin North Am 2014;45(02):219–224
28 Galliera E, Randelli P, Dogliotti G, et al. Matrix metalloproteases MMP-2 and MMP-9: are they early biomarkers of bone remodelling and healing after arthroscopic acromioplasty? Injury 2010; 41(11):1204–1207
29 Millett PJ, Horan MP, Maland KE, Hawkins RJ. Long-term survivorship and outcomes after surgical repair of full-thickness rotator cuff tears. J Shoulder Elbow Surg 2011;20(04):591–597
30 Parada SA, Dilisio MF, Kennedy CD. Management of complications after rotator cuff surgery. Current Reviews in Musculoskeletal Medicine, 2015;8(01):40–52

Humeral Head Osteonecrosis: Outcomes of Hemiarthroplasty After Minimum 10-Year Follow-Up*

Osteonecrose da cabeça do úmero: Avaliação dos resultados da artroplastia parcial com seguimento mínimo de 10 anos

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Abstract

Objective To analyze long-term functional and radiographic results of partial shoulder replacement for humeral head osteonecrosis.

Methods Retrospective review of thirteen cases, with a mean postoperative follow-up of 17 years (range 10 to 26 years). The findings from the last follow-up were compared to those in which the patients had one year of postoperative follow-up. Functional assessment consisted of shoulder movement measurements and application of the University of California, Los Angeles (UCLA) shoulder score. All patients underwent radiographic examination to measure glenoid erosion, proximal humeral migration and lateral glenohumeral dislocation.

Results Glenoid erosion increased over time significantly ($p < 0.05$). Paradoxically, all active shoulder movements also improved ($p < 0.05$), while UCLA scores remained the same. Radiographic deterioration was not correlated with clinical function. We had an 84.7% survival rate for arthroplasties after a mean time of 16 years.

Conclusions Early functional outcomes were maintained in the long run and do not correlate with radiographic deterioration (increased erosion of the glenoid).

Keywords
- osteonecrosis
- humeral head
- follow-up studies

Resumo

Objetivo Analisar os resultados funcionais e radiográficos de longo prazo da artroplastia parcial do ombro para estosteonecrose da cabeça do úmero.

Métodos Revisão retrospectiva de 13 casos, com seguimento pós-operatório médio de 17 anos (variação de 10 a 26 anos). Os achados do último seguimento foram

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comparados àqueles em que os pacientes tinham com 1 ano de acompanhamento pós-operatório. A avaliação funcional consistiu em medidas do movimento do ombro e aplicação do escore do ombro da Universidade da Califórnia, Los Angeles (UCLA). Todos os pacientes foram submetidos a exame radiografico para medir a erosão glenoidal, a migração umeral proximal, e o deslocamento glenoumeral lateral.

Resultados A erosão da glenoide aumentou com o tempo significativamente ($p < 0,05$). Paradoxalmente, todos os movimentos ativos do ombro também melhoraram ($p < 0,05$), enquanto os escores da UCLA permaneceram os mesmos. A deterioração radiográfica não teve correlação com a função clínica. Tivemos uma taxa de sobrevida de 84,7% das artroplastias após tempo médio de 16 anos.

Conclusões Os resultados funcionais precoces mantiveram-se a longo prazo e não se correlacionem com a deterioração radiográfica (aumento da erosão glenoidal).

Palavras-chave
- osteonecrose
- cabeça do úmero
- seguimentos

Introduction

Humeral head osteonecrosis is a rare condition, but a significant cause of shoulder joint pain, which in many cases responds poorly to non-surgical treatment.[1–3] It corresponds to approximately 5% of the preoperative diagnosis of all shoulder arthroplasties performed.[4]

When opting for surgical treatment of osteonecrosis, depending on the degree of involvement of the joint surface, the most common indication is arthroplasty.[2,5,6] The decision on the choice between partial and total arthroplasty is generally based on the state of the cartilage of the glenoid cavity during surgery. Neer classified the disease into 4 stages: in stage 3 of Neer, there is collapse of the subchondral bone of an area of the humeral head; the cartilage in this region is irregular and may come loose. The use of partial shoulder arthroplasty is recommended at this stage. In stage 4, in which there is also involvement of the articular surface of the glenoid cavity, total arthroplasty is usually indicated. However, if there is rotator cuff tendon injury, concentric arthrosis, and/or if the surgeon deems that the glenoid cavity bone stock is very poor, a partial arthroplasty is always an option[6] (►**Fig. 1**).

The literature shows that the use of partial arthroplasty for the surgical treatment of osteonecrosis is effective for pain relief, for increased shoulder mobility, and patient satisfaction, even when compared to total arthroplasty results.[2,4,6,7]

Pollock et al,[8] in 1996, in a clinical evaluation study, obtained good results with the use of partial arthroplasty in concentric arthroses (when the humeral head remains centered in the glenoid cavity), as well as total arthroplasty in eccentric arthroses (in which there is incongruity of the humeral head, leading to uneven glenoid deterioration, and, eventually, the posterior subluxation of the humeral head) (►**Fig. 2**). In 2001, our group evaluated 21 patients with humeral head osteonecrosis who underwent total and partial arthroplasty performed at our medical service, with a mean follow-up of 37 months. In this study, it was concluded that total or partial arthroplasty is a good procedure for pain relief and joint function recovery of these patients.[9]

However, few studies have compared the long-term results of total arthroplasty with hemiarthroplasty in osteonecrosis cases. Gadea et al,[10] in 2012, showed a 94% survival rate of arthroplasty over a 10-year follow-up. The authors concluded that partial shoulder arthroplasty is a reliable indication in cases of humeral head osteonecrosis, regardless of etiology. However, in the same study, the authors highlighted the fact that, despite similar functional results, it was observed that the "survival" rate was higher when total prosthesis was performed.[10]

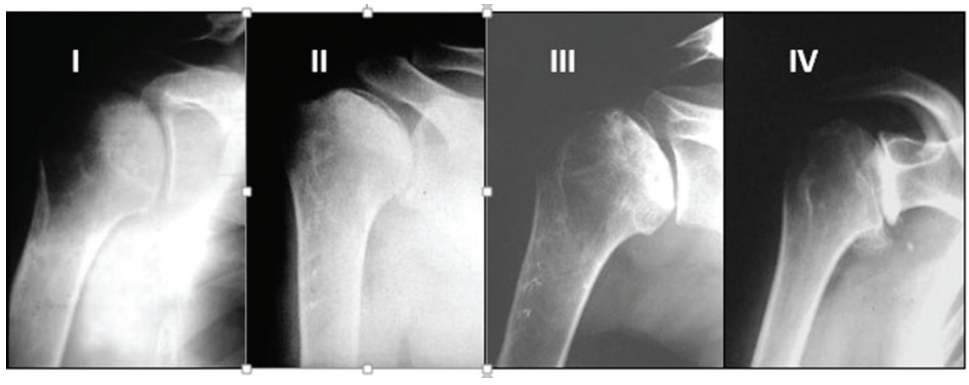

Fig. 1 Radiographic aspect of the different stages of humeral head osteonecrosis, according to the Neer classification.[6]

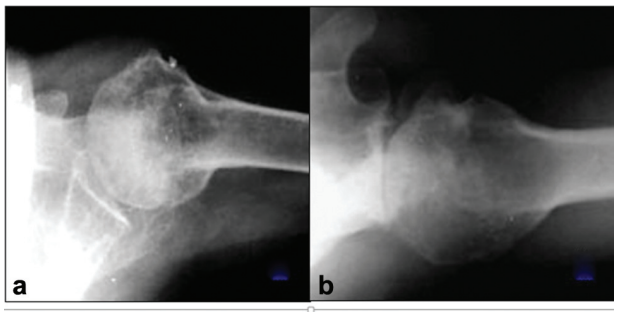

Fig. 2 Concentric-type (**a**) and eccentric (**b**) humeral head osteonecrosis, according to Pollock et al.[8]

The development of erosion of the glenoid cavity is a known complication of partial shoulder arthroplasty, being the main cause of unfavorable evolution in the medium and long term, resulting in pain, progressive loss of range of motion, decreased shoulder function and consequently increased patient dissatisfaction rates.[4,11–14] Herschel et al[11] showed that the glenoid cavity developed some degree of visible erosion on radiographic examination in 89% of the operated patients, after a mean follow-up of 51 months.

The aim of this study is to verify if, over 10 years, the functional results of our patients who underwent partial arthroplasty due to osteonecrosis were maintained, if they had erosion progression, and if their clinical results correlate with the radiographic findings found in the current exams.

Casuistry and Methods

Between December 1988 and February 2008, 27 partial arthroplasties were performed on 27 shoulders of 25 patients to treat osteonecrosis.

All patients with humeral head osteonecrosis were included in our study, regardless of etiology or degree of involvement, who underwent partial arthroplasty and completed a minimum follow-up of 10 years postoperatively. Patients who did not meet the above criteria were excluded from the study.

From the 27 shoulders, we could reevaluate 13, with follow-up ranging from 10 to 26 years (average 16.8 years). Twelve patients (14 shoulders, 2 had bilateral partial arthroplasty) were excluded: 5 because they could not be located and 7 because they died, not completing a 10-year follow-up (►**Table 1**).

The age of the patients at the last assessment ranged from 42 to 92 years (mean: 71 years). Six (46.15%) patients were male and 7 (53.85%) female. In 8 (61.54%) situations, the dominant side was affected.

Regarding the etiology, we had 8 (61%) shoulders with posttraumatic necrosis, 3 (23%) shoulders with idiopathic necrosis, 1 shoulder (7.7%) due to sickle cell anemia, and 1 shoulder (7.7%) due to dysbarism.

The degree of joint involvement was assessed by staging of Ficat and Enneking,[15] modified by Neer,[6] consisting of 10 (77%) cases of stage III necrosis, and 3 (23%) in stage IV. (►**Fig. 1**) All cases in stage IV were considered as concentric arthrosis.[8]

All patients underwent partial deltopectoral access arthroplasty. All arthroplasties had a cemented humeral shaft, and the models used were, in seven cases, the Neer II model (Memphis, Tennessee, US), and in six cases, the Eccentra model (São Paulo, SP, Brazil).

Postoperatively, the patients were immobilized for 6 weeks in a sling of the "Velpeau" type. Physiotherapy started with pendular and external to neutral rotation exercises, passively, from the 1st postoperative day. The active movements are introduced from the 6th week.

To measure the degree of joint mobility, we used the method of the American Academy of Orthopedic Surgeons (AAOS).[16]

Table 1 Clinical data of patients

Case	Age (y)	Gender	Dom	Etiology	Neer (stage)	Prosthesis type	Follow-up (y)
1	59	F	–	Posttraumatic	III	Neer II	27
2	73	F	–	Idiopathic	III	Neer II	24
3	74	M	+	Dysbarism	III	Neer II	23
4	57	M	–	Idiopathic	III	Eccentra	20
5	92	F	+	Posttraumatic	IV	Neer II	19
6	68	M	+	Posttraumatic	III	Eccentra	18
7	74	M	–	Posttraumatic	III	Neer II	15
8	62	M	+	Posttraumatic	III	Eccentra	13
9	72	M	–	Posttraumatic	III	Eccentra	13
10	79	F	+	Posttraumatic	IV	Neer II	12
11	42	F	+	Sickle cell anemia	III	Eccentra	12
12	88	F	+	Idiopathic	IV	Neer II	10
13	85	F	+	Posttraumatic	III	Eccentra	10

Source: Institution Medical Archives.
Abbreviations: DOM, dominance; F, female; M, male; y, year.

For the functional evaluation of the patients, we used the University of California, Los Angeles (UCLA) method.[17]

All patients underwent imaging reevaluation. Shoulder radiographs were performed in the corrected frontal, axillary and supraspinatus tunnel positions. In corrected frontal radiography, we measured some parameters based on the method published by Ohl et al[18]:

- **lateral glenohumeral offset:** defined as the distance between the lateral margin of the greater tubercle and the base of the coracoid process;
- **glenohumeral joint space:** defined as the region where the joint space is narrower between the prosthesis and the glenoid;
- **glenoid cavity depth**: measured between the center of the glenoid and a line passing between the apex and the lower margin of the glenoid;
- **proximal humerus migration:** defined as the distance between a horizontal line passing through the lower margin of the glenoid and a horizontal line through the humeral head implant;
- **subacromial space:** determined by the distance separating the upper limit of the greater tubercle and the lower margin of the acromion (►**Fig. 3**).

The degree of erosion of the glenoid cavity was evaluated on the shoulder radiograph, frontal corrected incidence, using the method proposed by Sperling et al[19] and Herschel et al,[11] in 2007, being graduated as follows:

- **Absent (grade I);**
- **Mild (grade II),** erosion in the subchondral bone;
- **Moderate (grade III),** medialization of subchondral bone with hemispheric deformation of the glenoid;
- **Severe (grade IV),** complete hemispheric deformation of the glenoid with superior bone loss at the base of the coracoid process.

For the sample of 13 patients, frequency distributions were initially calculated, some descriptive statistical tests and Boxplot graphs were constructed to illustrate the comparison between the initial situations (1 PO year) and the follow-up (10 PO years), as well as to identify possible discrepant observations.

As the sample was considered homogeneous, it allowed the use of the Student t-test and the nonparametric Mann-Whitney test.[20]

A significance level of 5% was adopted, and hypotheses with descriptive levels (*p*-values) lower than this value were rejected. The analyzes were performed using the Minitab, v.17 statistical program (Minitab LLC., State College, PA, USA).[20]

The study protocol was approved by the institutional ethics committee.

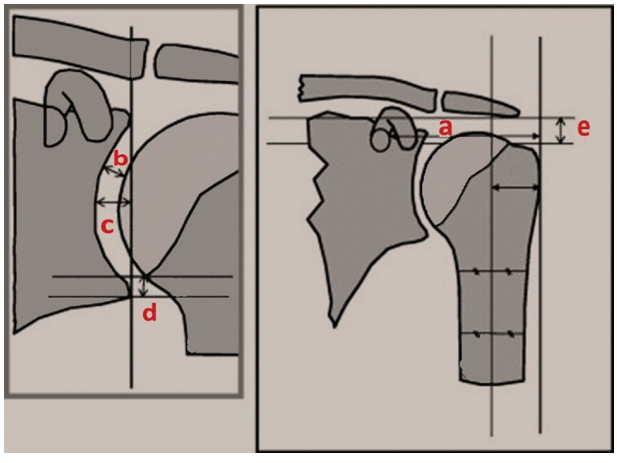

Fig. 3 Illustration showing the different radiographic parameters used: (**a**) lateral glenohumeral offset, (**b**) joint space, (**c**) glenoid cavity depth (GC), (**d**) proximal migration (pM), (**e**) subacromial space.

Results

After evaluating the 13 operated patients, we compared the range of motion at 1 year postoperatively (PO1y) with that found in the evaluation after 10 years (PO10y). The values are illustrated in ►**Table 2**, which shows us that there was gain in all directions of movement, with an average increase of 5° elevation, 2° lateral rotation and two medial vertebral levels. The values obtained presented a significance level of 5%.

The UCLA scale mean [17] in PO1y was 24 (17-30) and in PO10y was 24.5 points (ranged from 14 to 34), showing that UCLA[17] did not change after 10 years of postoperative follow-up.

In the follow-up of PO1y patients, we had 4 good results (30.8%), 6 reasonable or fair results (46.2%), and 3 (23.1%) patients with poor results. When we compared these results with hose of PO10y patients, we found excellent results in 1 case (7.7%), good in 5 (38.5%), reasonable or fair in 3 (23.1%) and poor in 4 patients (30.8%). Regarding the degree of satisfaction, 4 (30.8%) patients were dissatisfied at PO1y, whereas only 2 (15,4%) were dissatisfied at PO10y.

Regarding the radiographic evaluation of the degree of erosion evaluated by the method proposed by Sperling et al[19] and Herschel et al,[11] there was a mean increase of one stage in the wear of the glenoid cavity, during the follow-up, that is, in the mean of PO1y, the patients had an erosion classified as stage II, and, now, in the PO10y, the erosion found was classified as stage III. The full evaluation is in the ►**Table 3**.

In corrected frontal radiography, using the method proposed by Ohl et al,[18] we obtained the following results: decreased lateral glenohumeral offset, glenohumeral joint space and subacromial space. There was increased glenohumeral cavity depth and proximal humeral head migration, illustrated in ►**Table 4**. All with statistical significance ($p > 0.1$).

Table 2 Mobilidade articular média dos pacientes

Mean	PO 1 y	PO 10 y	*p*-value
Elevation	100°	105°	$p > 0.100$
External rotation	34°	36°	$p > 0.100$
Internal rotation	L3	L1	$p > 0.100$

Source: Institution Medical Archives.
Abbreviations: PO, postoperative, y, years.

Table 3 Radiographic measurement of the degree of erosion of the glenoid cavity at 1 year and at 1o years postoperatively evaluated by the method proposed by Sperling et al[19]

Grade	PO 1 y n (%)	PO 10 y n (%)
I	01 (08)	–
II	10 (77)	01 (08)
III	01 (08)	09 (69)
IV	01 (08)	03 (23)

Source: Institution Medical Archives.
Abbreviations: PO, postoperative, y, years; n, number.

Table 4 Evaluation of the radiographic parameters of the shoulder found by the method proposed by Ohl et al[18]

	PO 1 y (mm)	PO 10 y (mm)	PO 1 y–PO 10 y (mm)
Lateral glenohumeral offset	67.3	63.6	3.7
Glenohumeral joint space	2.07	1.15	0.92
Glenoid cavity depth	4.1	8.53	-4.38
Proximal migration	4.42	6.31	-1.88
Subacromial space	8.07	5.38	2.69

Source: Institution Medical Archives.
Abbreviations: PO 1 y, values found one year after surgery; PO 10 y, values found at follow-up after a minimum of 10 years; PO 1 y—PO 10 y, difference between both.

Discussion

With a minimum follow-up of 10 years, we obtained increased shoulder mobility in all directions and a mean UCLA[17] of 24.5 (regular), that is, a half-point gain compared to the PO1y evaluation. By analyzing separately the increase in glenoid cavity depth (4.3 mm on average), and the decrease in glenohumeral joint space (average 0.9 mm), which were the most evident radiographic alterations, we observed that there was no correlation directly proportional to the UCLA result,[17] which remained around 24.

According to Gadea et al[10] and Smith et al,[21] it is recognized that partial arthroplasty may result in erosion of the glenoid cavity, which is the main cause of clinical deterioration and revision for total arthroplasty. In a study by Herschel et al,[11] 89% of patients developed some degree of erosion of the glenoid cavity, visible on radiographic examination, within a median follow-up of 31 months, but only 10% had indication for surgical revision. The same can be observed in the study by Sperling et al,[19] in which, with 7 years of mean follow-up, only 24% of patients underwent a reoperation, erosion of the glenoid cavity being the most common cause of surgery (90%).

In the present study, we found that all patients had some degree of visible erosion on radiographic examination after a minimum PO10y follow-up. Despite the radiographic evolution found, we obtained satisfactory functional results, with a survival rate of 84.7% of arthroplasties after an average time of 16 years. Cerciello et al [22] found a 72% incidence of glenoid cavity erosion, associated with symptomatology in 6 to 72% of the cases, which supports the results found in our work that erosion is not always associated with symptoms, and, when they exist, they may not be disabling (►**Fig. 4**).

When asked about satisfaction with the surgical outcome, 11 (84.7%) patients were satisfied with the result at the last evaluation (at PO10y), despite the degree of alteration found on radiographic examinations. We believe this is due to a clinical and functional adaptation of patients when performing their daily activities, and, therefore, despite radiographic deterioration, patients no longer feel more incapacitated than before. And as satisfaction is one of the parameters evaluated in the UCLA criteria,[17] this directly affects its result.

Only 2 (15.4%) patients were really dissatisfied with their results. These 2 presented, in the radiographic examination of PO10y follow-up, a severe erosion of the glenoid cavity, classified as grade IV of Sperling et al.[19]

In the first case, the patient presented idiopathic osteonecrosis, affecting the dominant limb. She had grade IV osteonecrosis and concentric arthrosis in the preoperative evaluation. A partial Neer arthroplasty was performed. At PO10y, the patient had 15 points on the UCLA scale,[17] with the range of motion of 80°, 20°, gluteus with pain, and functional disability. Hemiarthroplasty revision procedure for total arthroplasty was indicated. Currently, the patient is in the 5th year after revision, with controlled pain, and range of motion of 80°, 40°, sacrum (20° lateral rotation gain).

The other case is the youngest patient in our series (45 years old). The etiology of necrosis is secondary to sickle cell anemia. The patient is at 12 years postoperatively, with a 14-point UCLA score,[17] range of motion 90°, 0°, L4. At 1 year postoperatively, the patient had a UCLA[17] of 24, with 80°, 20°, gluteus. The operated limb is the dominant limb, but in the contralateral limb the patient also has osteonecrosis of the humeral head, classified as grade II, a fact that is making it very difficult to perform activities of daily living. Therefore, despite the small loss of range of motion during follow-up, we believe that contralateral involvement is contributing to its dissatisfaction and difficulty in adapting. She is in outpatient follow-up in our group, with referral for surgical treatment on the contralateral side, but due to private problems she does not want to have surgery at the moment.

Of the 7 patients who presented unsatisfactory results in the PO10y follow-up, we could observe that prosthesis type Neer II was used in 5 of them; however, from a statistical point of view ($p > 5\%$), there was no difference when using the prosthesis Eccentra and Neer II considering UCLA[17] and the range of motion between the PO1y and PO10y follow-ups.

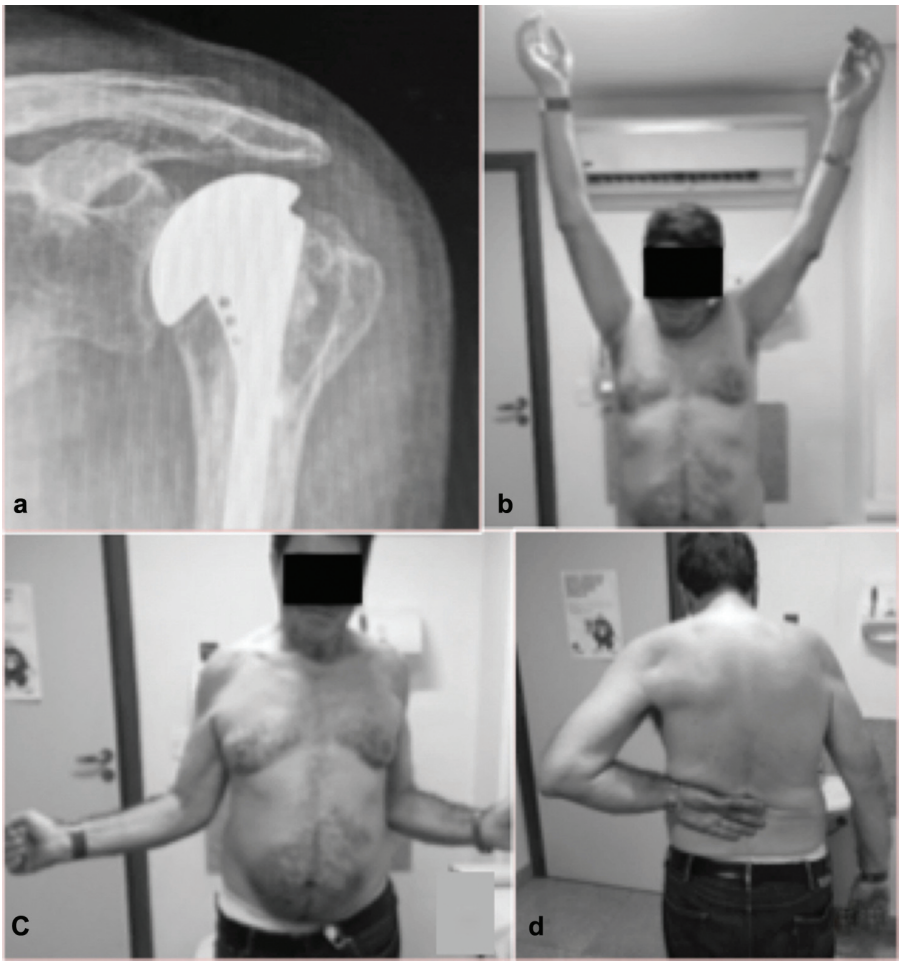

Fig. 4 Patient at 13 postoperative years of partial arthroplasty for posttraumatic osteonecrosis. (**a**) radiographic examination shows decreased glenohumeral joint space and erosion of glenoid cavity. Patient with 34points in the University of California, Los Angeles (UCLA) classification, with good joint mobility: (**b**) elevation, (**c**) lateral rotation and (**d**) medial.

Conclusion

The study shows us that the functional results of our patients who underwent partial arthroplasty due to humeral head osteonecrosis were maintained over 10 years. Progression of glenoid cavity erosion was observed; however, the clinical results in 85% of the patients did not correlate with the deterioration of the radiographic aspects found in the current exams.

Conflict of Interests

The authors declare that there are no conflict of interests.

References

1 Loebenberg MI, Plate AM, Zuckerman JD. Osteonecrosis of the humeral head. Instr Course Lect 1999;48:349–357
2 Feeley BT, Fealy S, Dines DM, Warren RF, Craig EV. Hemiarthroplasty and total shoulder arthroplasty for avascular necrosis of the humeral head. J Shoulder Elbow Surg 2008; 17(05):689–694
3 Hernigou P, Flouzat-Lachaniette CH, Roussignol X, Poignard A. The natural progression of shoulder osteonecrosis related to corticosteroid treatment. Clin Orthop Relat Res 2010;468(07):1809–1816
4 Schoch BS, Barlow JD, Schleck C, Cofield RH, Sperling JW. Shoulder arthroplasty for post-traumatic osteonecrosis of the humeral head. J Shoulder Elbow Surg 2016;25(03):406–412
5 Parsch D, Lehner B, Loew M. Shoulder arthroplasty in nontraumatic osteonecrosis of the humeral head. J Shoulder Elbow Surg 2003;12(03):226–230
6 Neer CS. Glenohumeral arthroplasty. In: Shoulder reconstruction. Philadelphia: W.B. Saunders; 1990:143–227
7 Orfaly RM, Rockwood CA Jr, Esenyel CZ, Wirth MA. Shoulder arthroplasty in cases with avascular necrosis of the humeral head. J Shoulder Elbow Surg 2007;16(3, Suppl)S27–S32
8 Pollock R, Glasson JM, Djurasovic M, et al. Hemiarthroplasty for glenohumeral osteoarthrits in pacients with an intact rotador cuff: results correlated to degree of glenoid wear. In: AAOS Twelvth Open Meeting, Atlanta GA, February 25, 1996
9 Checchia SL, Santos PD, Miyazaki AN, et al. Osteonecrose da cabeça do úmero: resultados das artroplastias. Rev Bras Ortop 2001;36(12):29–36
10 Gadea F, Alami G, Pape G, Boileau P, Favard L. Shoulder hemiarthroplasty: outcomes and long-term survival analysis according to etiology. Orthop Traumatol Surg Res 2012;98(06): 659–665
11 Herschel R, Wieser K, Morrey ME, Ramos CH, Gerber C, Meyer DC. Risk factors for glenoid erosion in patients with shoulder hemiarthroplasty: an analysis of 118 cases. J Shoulder Elbow Surg 2017;26(02):246–252

12 Schoch BS, Barlow JD, Schleck C, Cofield RH, Sperling JW. Shoulder arthroplasty for atraumatic osteonecrosis of the humeral head. J Shoulder Elbow Surg 2016;25(02): 238–245
13 Mansat P, Huser L, Mansat M, Bellumore Y, Rongières M, Bonnevialle P. Shoulder arthroplasty for atraumatic avascular necrosis of the humeral head: nineteen shoulders followed up for a mean of seven years. J Shoulder Elbow Surg 2005;14(02): 114–120
14 Cofield RH. Total shoulder arthroplasty with the Neer prosthesis. J Bone Joint Surg Am 1984;66(06):899–906
15 Satterlee CC. Osteonecrosis and other non-inflammatory degenerative diseases of the glenohumeral joint including Gaucher's diseases, sickle cell diseases, hemochromatosis and synovial osteochondromatosis. In: AAOS Instructional Course Lectures. RosemontIL1997: 233–240
16 Hawkins JR, Bokor DJ. Clinical evaluation of shoulder problems. In: Rockwood CA, Matsen FA, editors. The shoulder. Philadelphia: Saunders; 1990:149–177
17 Ellman H, Kay SP. Arthroscopic subacromial decompression for chronic impingement. Two- to five-year results. J Bone Joint Surg Br 1991;73(03):395–398
18 Ohl X, Nérot C, Saddiki R, Dehoux E. Shoulder hemi arthroplasty radiological and clinical outcomes at more than two years follow-up. Orthop Traumatol Surg Res 2010;96(03):208–215
19 Sperling JW, Cofield RH, Schleck CD, Harmsen WS. Total shoulder arthroplasty versus hemiarthroplasty for rheumatoid arthritis of the shoulder: results of 303 consecutive cases. J Shoulder Elbow Surg 2007;16(06):683–690
20 Montgomery DC, Runger GC. Estatística aplicada e probabilidade para engenheiros. 6a. ed. Rio de Janeiro: LTC; 2016
21 Smith RG, Sperling JW, Cofield RH, Hattrup SJ, Schleck CD. Shoulder hemiarthroplasty for steroid-associated osteonecrosis. J Shoulder Elbow Surg 2008;17(05):685–688
22 Cerciello S, Morris BJ, Visonà E, et al. No relationship between critical shoulder angle and glenoid erosion after shoulder hemiarthroplasty: a comparative radiographic study. Arch Orthop Trauma Surg 2017;137(07):919–923

Postoperative Comparative Evaluation of Patients Undergoing Surgical Treatment for Acute Versus Chronic Acromioclavicular Dislocations*

Avaliação pós-operatória comparativa dos pacientes submetidos ao tratamento cirúrgico das luxações acromioclaviculares aguda versus crônica

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Abstract

Objectives The present study evaluates and compares the surgical treatment of acute and chronic acromioclavicular dislocations (ACDs) to define the most effective therapeutic plan.

Methods A retrospective study consisting of 30 patients submitted to the surgical treatment of types III and V ACDs between 2011 and 2018; the subjects were separated according to a temporal classification in acute (< 3 weeks; subgroup I) and chronic (> 3 weeks; subgroup II) subgroups. All patients underwent a postsurgical evaluation with a standardized protocol containing epidemiological, functional, and radiological data.

Results Subgroup I presented a visual analog scale (VAS) score of 1.10, a Constant-Murley score of 92.3, and a University of California at Los Angeles (UCLA) Shoulder Rating score of 33.5. The coracoclavicular (CC) distance was of 11.0 mm, and the average increase in CC space was lower than 8.9% compared to the contralateral shoulder. In subgroup II, the VAS score was of 1.11, the Constant-Murley score was of 94.2, and the UCLA score was of 32.4. The CC distance was of 13.8 mm, with a 22.9% increase in CC space compared to the contralateral side.

Conclusion Although there was no significant difference between the evaluated items, subgroup I tended to present a lower CC distance ($p = 0.098$) and a lower

Keywords
- acromioclavicular joint/injuries
- acromioclavicular joint/surgery
- joint dislocations
- ligaments, articular

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percentage increase in CC distance ($p = 0.095$) compared to subgroup II. Thus, the surgical treatment must be performed within three weeks after the trauma to try to avoid such trend. If the acute treatment is not possible, the modified Weaver Dunn technique has good clinical and functional outcomes.

Resumo

Objetivos Avaliar e comparar os resultados do tratamento cirúrgico das luxações acromioclaviculares (LACs) aguda e crônica, definindo o plano terapêutico mais eficaz.
Métodos Estudo retrospectivo realizado com 30 pacientes operados entre 2011 e 2018 para LAC tipos III e V, separados de acordo com a classificação temporal em subgrupo agudo (< 3 semanas; subgrupo I) e subgrupo crônico (> 3 semanas; subgrupo II). Todos os pacientes foram submetidos a avaliação pós-cirúrgica com protocolo padronizado composto por dados epidemiológicos, funcionais e radiográficos.
Resultados No subgrupo I, a pontuação na escala visual analógica (EVA) foi de 1,10, o escore de Constant-Murley foi de 92,3, e o escore da University of California at Los Angeles (UCLA) foi de 33,5. A distância coracoclavicular (CC) foi de 11,0 mm, e o aumento do espaço CC foi em média menor do que 8,9% em relação ao ombro contralateral. No subgrupo II, a EVA foi de 1,11, o escore de Constant-Murley foi de 94,2, e o da UCLA, 32,4. A distância CC foi de 13,8 mm, sendo o aumento do espaço CC de 22,9% em relação ao contralateral.
Conclusão Apesar de não ter havido diferença significativa entre os quesitos avaliados, houve uma tendência de o subgrupo agudo apresentar distância CC ($p = 0,098$) e percentual de aumento da distância CC ($p = 0,095$) menor do que o subgrupo crônico. Assim, é interessante que o tratamento cirúrgico seja realizado nas primeiras três semanas após o trauma, para tentar evitar essa tendência. Nos casos em que não for possível realizar o tratamento na fase aguda, a técnica de Weaver Dunn modificada apresenta bons resultados clínicos e funcionais.

Palavras-chave
- articulação acromioclavicular/lesões
- articulação acromioclavicular/cirurgia
- luxações articulares
- ligamentos articulares

Introduction

The diarthrodial joint between the medial acromial aspect and the side of the clavicle is called acromioclavicular (AC) joint. Its anteroposterior stability is provided by the AC ligaments, which consist of thickening portions of the joint capsule, in which the upper one is the strongest. Superoinferior stability is maintained by the coracoclavicular (CC), trapezoid and conoid ligaments.[1]

Fukuda et al.,[2] identified that the AC ligaments were the main limiting factors for posterior and superior translation in minor dislocations. In larger dislocations, the conoid ligament is the primary limiting factor for upper translation, while the trapezoidal ligament provides tensile strength to the AC joint.[2]

Injuries to the AC joint typically result from direct trauma to the shoulder caused by falls and contact sports with the arm in an adducted position. Force deflects the acromion inferiorly, while the clavicle remains in its anatomical position. This results in varying degrees of damage to both the AC and CC ligaments.[3]

Williams et al.,[4] based on a study by Tossy et al.,[5] developed a widely-accepted classification system according to anatomical severity, dividing the injuries into six types. In addition, AC injuries can be divided into acute (< 3 weeks) and chronic (> 3 weeks) lesions.[6,7]

Most authors recommend the non-surgical treatment for type-I and type-II injuries.[1,8,9] The treatment for type-III lesions is controversial, since several authors have presented conservatively-treated case series with good to excellent outcomes.[10,11] However, other authors have reported cases with pain and other residual symptoms.[12,13] In an attempt to maximize the positive outcomes, many authors have advocated the surgical repair in young, active patients.[14,15]

For type-IV, type-V and type-VI lesions, the surgical treatment is established.[1,3,9,14] Multiple techniques for the surgical treatment have been described, but there is no evidence of the superiority of one when compared to the others. The only consensus is that, regardless of the approach, five key elements must be reached: anatomical reduction, CC ligament reconstruction or direct repair, CC ligament protection, deltotrapezoid fascia repair, and, in chronic lesions, distal resection of the clavicle.[3]

The present study aims to analyze the outcomes of the treatment of acute and chronic AC dislocations (ACDs) to identify the best time for surgical therapy and to define a more effective therapeutic plan.

Table 1 Clinical variables in each group

Clinical ariable	Acute subgroup (n = 21)		Chronic subgroup (n = 9)	
	Mean	Standard deviation	Mean	Standard deviation
Age (years)	40.7	13.1	42.1	14.6
Time until surgery (days)	4.5	4.0	424	462
Time until the return to work (days)[a]	73.0	49.8	78.1	49.1
Time until the return to sports (months)[b]	5.3	2.8	7.50	5.01
Laterality				
Right	15 (71.4%)		6 (66.7%)	
Left	6 (28.6%)		3 (33.3%)	

Notes: The numerical data were expressed as means and standard deviations.
[a]The time until the return to work showed loss of registration or did not apply to both acute and chronic subgroups (n = 19 *versus* n = 7).
[b]The time until the return to sports showed loss of registration or did not apply to both acute and chronic subgroups (n = 17 *versus* n = 8).

Material and Methods

A retrospective cross-sectional study was conducted with 39 cases of ACD treated surgically between 2011 and 2018 in 2 private hospitals. Due to the long follow-up and patient profile, only 30 subjects returned for evaluation. **All patients were evaluated radiographically using the anteroposterior (AP) and Zanca views, including both shoulders, as well as axillary views.** Of these patients, 28 were diagnosed at the time of surgery as ACD grade V, while 2 patients were diagnosed as ACD grade III.

Of the 30 patients, 21 had acute injuries (subgroup I) and 9 presented chronic injuries (subgroup II). The subjects in subgroup I were operated on average 4.5 days after the trauma, while the patients in subgroup II were operated on average 424 days after the trauma. Most patients (96.6%) were male. The mean age was 40.7 years in subgroup I, and 42.1 years in subgroup II. The right side was the most affected, accounting for 71.4% of the injuries in subgroup I , and for 66.7% of the lesions in subgroup II (►**Table 1**).

All patients were reevaluated by the same examiner using a postsurgical standardized protocol consisting of the University of California at Los Angeles (UCLA) Shoulder Rating score, the Constant-Murley score, the visual analog scale (VAS) score, as well as of epidemiological data and comparative, contralateral force assessment with a digital dynamometer. **After the evaluation, AP, Zanca and axillary radiographs were performed to determine the residual displacement of the operated shoulder by comparing its coracoclavicular distance with the contralateral shoulder.**

The experimental design was submitted to and approved by the local ethics committee under CAAE 95443218.4.0000.0023.

Statistical Methodology

Tables were developed to present the results of the descriptive analysis, with numerical data expressed as means and standard deviations, and the categorical data expressed as frequencies and percentages.

In inferential analysis, we compared the subgroups (acute and chronic) using the *Mann-Whitney test* for the numerical data and the *Fisher exact test* for the categorical data. Paired data were compared using the *Wilcoxon signed-rank test*. The *Spearman correlation coefficient* was used to analyze the association between the numerical variables.

Nonparametric methods were used since the data did not show a normal (Gaussian) distribution, due to the rejection of the null hypothesis of normality according to the Shapiro-Wilk test in at least one group and/or time point. Significance was defined at a level of 5%. The statistical analysis was processed using the SAS System statistical software (SAS Institute, Inc., Cary, North Carolina, US), version 6.11.

Surgical Technique

The treatment for acute injuries recommended by the authors uses suture anchors and transarticular fixed Kirschner wires as described by Phemister.[16] The advantages include the small incision and limited dissection above the coracoid region, with no need for any instrumentation below it, minimizing the risk of neurovascular injury.

With the patient in the beach chair position, anesthetized with an interscalene block, the arm and shoulder are prepared. A 5-cm incision is made below the clavicle, at the level of the coracoid process. The subcutaneous tissue is dissected until the deltotrapezoid fascia is exposed. A medial to lateral incision is then made following the curvature of the clavicle until bone exposure.

A blunt dissection is performed until the dorsal base of the coracoid process is exposed. After satisfactory exposure, two #5 suture anchors are used with two #2 Fiberwire (Arthrex, Naples, Florida, US) non-absorbable sutures. A 3.2-mm drill is used to make 2 holes in the collarbone, one more posterior, 3.5 cm from the AC joint, and the other more anterior, 2.5 cm from the AC joint.[17,18]

The dislocation is hyper-reduced, and a 2.0-mm Kirschner wire is transfixed by the AC joint. Its position is confirmed by arthroscopy. After the reduction, each suture is tied

separately. The deltotrapezoid fascia is repaired, and the subcutaneous tissue and skin are sutured. **The Kirschner wires are bent and kept under the skin.**

Chronic dislocations are treated using the modified Weaver-Dunn technique. The patient is positioned and prepared as in the previous procedure. Two suture anchors are placed at the coracoid process. A medial, 5 cm to 7 cm in length, incision is made at the AC joint towards the coracoid process. The deltotrapezoid fascia is identified and incised. The periosteal detachment of the trapezius and deltoid is then performed. Through blunt dissection, the coracoacromial ligament is identified and detached at its anteroinferior acromial insertion. The lateral end of the clavicle is excised about 1.0 cm to 1.5 cm from the lateral edge.

The clavicle is then reduced, and one or two Kirschner wires are passed, transfixing the AC joint. Two holes are made in the upper cortical layer of the clavicle, and the end of the coracoacromial ligament is repaired and tied through the clavicular holes, projecting the ligament into the medullary canal. Suture anchors are tied to the clavicle, the deltotrapezoid fascia is repaired, and the subcutaneous tissue and skin are closed. **As in acute cases, the Kirschner wires are bent and remain under the skin.**

Postoperative Period

In both subgroups, the arm was kept in a three-point American sling for six weeks. At the end of the sixth week, the Kirschner wire was surgically removed, and mobilization was allowed. Then, motor physical therapy was started for range of motion and stretching. Muscle strengthening was allowed after the third postoperative month, and return to sports was allowed after the fifth month.

Results

Regarding the functional scores, the mean VAS was of 1.10 (standard deviation [SD]: 1.61) in subgroup I, and of 1.11 (SD: 2.09) in subgroup II. The mean Constant-Murley score was of 92.3 (SD: 7.1) in subgroup I, and of 94.2 (SD: 6.9) in subgroup II. The mean UCLA score was of 33.5 (SD: 2.2) in subgroup I, and of 32.4 (SD: 4.9) in subgroup II. There were no significant differences in the functional score at the level of 5% (►**Table 2**).

As for force, in subgroup I, the average abduction in the operated arm was of 11.1 kgf (SD: 5.4), with a delta value for the relative variation comparing the operated and the contralateral shoulder of -2.94%. In subgroup II, the average abduction in the operated arm was of 11.5 kgf (SD: 3.4), with a delta value of -7.54%.

In subgroup I, the mean medial rotation force in the operated arm was of 15.9 kgf (SD: 8.9), with a delta value of -3.23%. In subgroup II, the mean medial rotation force in the operated arm was of 14.2 kgf (SD: 3.8), with a delta value of -1.37%.

Subgroup I presented an average lateral rotation force of 11.2 kgf (SD: 5.1) in the operated arm, with a delta value of -7.21%. In subgroup II, the average lateral rotation force was of 10.5 kgf (SD: 2.9) in the operated arm, with a delta value of

Table 2 Functional and force variables in each group

Variables	Acute subgroup (n = 21)		Chronic subgroup (n = 9)	
Functional	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
VAS score	1.10	1.61	1.11	2.09
Constant-Murley score	92.3	7.1	94.2	6.9
UCLA score	33.5	2.2	32.4	4.9
CC distance (mm)	11.0	4.0	13.8	4.1
Increase in distance (%)	8.9	14.2	22.9	24.1
Force at operated shoulder	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Abduction force (kg)	11.1	5.4	11.5	3.4
Medial rotation force (kg)	15.9	8.9	14.2	3.8
Lateral rotation force (kg)	11.2	5.1	10.5	2.9
Force at the contralateral shoulder	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Abduction force (kg)	11.7	5.4	12.5	3.8
Medial rotation force (kg)	15.6	9.1	14.6	4.5
Lateral rotation force (kg)	12.2	5.7	11.4	4.4
Delta value for force (%)				
Delta value for abduction force (%)	-2.94		-7.54	
Delta value for medial rotation force (%)	3.23		-1.37	
Delta value for lateral rotation force (%)	-7.21		-4.68	

Abbreviations: CC, coracoclavicular; VAS, visual analog scale; UCLA, University of California at Los Angeles (UCLA) Shoulder Rating score.
Notes: The numerical data were expressed as means and standard deviations. The delta value for force corresponds to the relative variation comparing the operated and contralateral shoulders: (operated – contralateral shoulder) / contralateral shoulder x 100.

-4.68%. The force-related variables showed no significant difference at the level of 5% (►**Table 2**).

The mean CC distance was of 11.0 mm (SD: 4.0) in subgroup I, and of 13.8 mm (SD: 4.1 mm) in subgroup II. In subgroup I, 38.09% of the patients presented AC-joint subdisclocation, with an average increase in CC space compared to the contralateral shoulder of 8.9% (SD: 14.2); in subgroup II, 66.66% of the patients presented said subdislocation, with an average increase of 22.9% (SD: 24.1). The subjects in subgroup I tended to present a lower CC distance ($p = 0.098$) and a lower percentage increase in CC distance ($p = 0.095$) compared to subgroup II. In addition, there was no significant correlation, at the level of 5% between the percentage of increased distance with functional and force parameters, both in the total sample and in subgroups I and II.

The average time until the return to work was of 73 days for subgroup I, and of 78.1 days for subgroup II. The average time until the return to sports was of 5.3 months (SD: 2.8) in subgroup I, and of 7.5 months (SD: 5.01) in subgroup II.

Functional and force results are shown in ►**Table 2**.

Discussion

There is no consensus in the current literature on which is the best surgical technique to treat chronic and acute ACDs. Scientific publications have presented outcomes from several therapeutic modalities for these injuries, but few compare the techniques used in each of these cases. We evaluated the outcomes of the surgical treatment of acute and chronic dislocations and compared them.

Both groups were submitted to surgical techniques following the five key elements of surgery recommended by Li et al.[3]: anatomical reduction, CC ligament reconstruction or direct repair, CC ligament protection, deltotrapezoid fascia repair, and, in chronic injuries, distal resection of the clavicle.

Unlike Von Heideken et al.,[19] who found a statistically significant difference in the Constant-Murley score (91 for the acute group *versus* 85 for the chronic group), and Rolf et al.,[20] who also reported inferior clinical and functional outcomes in the late reconstruction group (87.17 *versus* 78.10), in the present study, there were no statistical differences between subgroup I and subgroup II regarding the Constant-Murley and UCLA scores.

Tauber et al.[21] observed a mean VAS score of 2.3 points, which is similar to that found by Hegazy et al.[22] in their series (average score: 1); these findings are in line with our VAS assessment, with an average of 1.10 points in subgroup I, and 1.11 points in subgroup II, with no statistical significance.

The mean UCLA score was of 33.5 points (SD: 2.2) in subgroup I, with good/excellent values (> 27 points) in 95.23% of the subjects. In subgroup 2, the mean UCLA score was pf 32.4 points (SD: 4.9), with good/excellent values in 88.8% of the cases. There was no statistically significant difference between the groups. These results are similar to those reported in the Brazilian literature, with 92.8% of good/excellent cases according to Molin et al.[23] and 95.2% according to Scandiuzzi et al.[24]

Complications were present in 43.3% of our patients, in a rate that is in line with that of other studies, such as those by Ferreira Neto et al.[25] (40.9%) and Neviaser[26] (39%). Superficial infection occurred in 14.21% of the cases on subgroup I, and in 11.11% of the subjects in subgroup II. All cases were treated with oral antibiotic therapy and daily dressings, with no cutaneous suture dehiscence or clinical repercussions. Another complication observed was the lateral migration of the AC Kirschner wire in a group-I patient (4.76%), which was treated with the removal of the synthesis material and no further intercurrence. Residual pain was reported by 14.28% of the subjects in subgroup I and 11.11% of the patients in subgroup II.

Clavicular prominence was reported by 4.76% of the patients in subgroup I, and by 22.2% of the subjects in subgroup 2. A radiologically-assessed increase in CC space higher than 12 mm was observed in 8.9% (SD: 14.2) of the subjects in subgroup I, and in 22.9% (SD: 24.1) of the patients in subgroup II. Although there was no significant difference at the level of 5%, the subgroup-I patients tended to present lower CC distance ($p = 0.098$) and lower percentual increase in CC distance compared to the contralateral side ($p = 0.095$) than the subgroup-II patients.

Despite the high incidence of this deviation as a complication, it had no final impact on level of satisfaction of the patients. In addition, no patient presented scapular dyskinesia, which corroborates literature reports that anatomical reduction is not always required to restore adequate shoulder function, and that the loss in reduction does not seem to significantly influence the outcomes.[12,27,28]

In total, 28 patients (93.3%) were satisfied with the treatment, with no statistically significant difference between the subgroups. This is in line with the literature,[13] suggesting that there is no relationship between the clinical and radiographic findings.

The main limitations of the present study are its retrospective nature, the relatively low number of patients, and the discrepancy between the subgroups.

Conclusion

We conclude that the surgical treatment of ACDs presents satisfactory outcomes both in acute and chronic cases. However, due to the greater trend for residual dislocation with the increased CC space in chronic cases, we should seek to treat these injuries immediately after the trauma.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Arliani GG, Utino AY, Nishimura EM, Terra BB, Belangero PS, Astur DC. Luxação acromioclavicular: tratamento e reabilitação. Perspectivas e tendências atuais do ortopedista brasileiro. Rev Bras Ortop 2015;50(05):515–522

2 Fukuda K, Craig EV, An KN, Cofield RH, Chao EY. Biomechanical study of the ligamentous system of the acromioclavicular joint. J Bone Joint Surg Am 1986;68(03):434–440

3 Li X, Ma R, Bedi A, Dines DM, Altchek DW, Dines JS. Management of acromioclavicular joint injuries. J Bone Joint Surg Am 2014;96 (01):73–84
4 Williams GR, Nguyen VD, Rockwood CA Jr. Classification and radiographic analysis of acromioclavicular dislocations. Appl Radiol 1989;18(02):29–34
5 Tossy JD, Mead NC, Sigmond HM. Acromioclavicular separations: useful and practical classification for treatment. Clin Orthop Relat Res 1963;28(28):111–119
6 Veado MA, Paiva AA, Pinto MS. Tratamento cirúrgico da luxação acromioclavicular completa. Rev Bras Ortop 2000;35(08): 309–313
7 Domos P, Sim F, Dunne M, White A. Current practice in the management of Rockwood type III acromioclavicular joint dislocations-National survey. J Orthop Surg (Hong Kong) 2017;25 (02):2309499017717868
8 Riand N, Sadowski C, Hoffmeyer P. [Acute acromioclavicular dislocations]. Acta Orthop Belg 1999;65(04):393–403
9 Rockwood CA Jr, Williams GR, Young DC. Injuries to the Acromioclavicular Joint. In: Rockwood CA Jr, Green DP, Buchholz RW, Heckman JD, eds. Fractures in adults. Philadelphia: Lippincott Raven; 1996:1341–1413
10 Galpin RD, Hawkins RJ, Grainger RW. A comparative analysis of operative versus nonoperative treatment of grade III acromioclavicular separations. Clin Orthop Relat Res 1985;(193):150–155
11 Dias JJ, Steingold RF, Richardson RA, Tesfayohannes B, Gregg PJ. The conservative treatment of acromioclavicular dislocation. Review after five years. J Bone Joint Surg Br 1987;69(05):719–722
12 Murena L, Canton G, Vulcano E, Cherubino P. Scapular dyskinesis and SICK scapula syndrome following surgical treatment of type III acute acromioclavicular dislocations. Knee Surg Sports Traumatol Arthrosc 2013;21(05):1146–1150
13 Larsen E, Bjerg-Nielsen A, Christensen P. Conservative or surgical treatment of acromioclavicular dislocation. A prospective, controlled, randomized study. J Bone Joint Surg Am 1986;68(04): 552–555
14 Gallay SH, Hupel TM, Beaton DE, Schemitsch EH, McKee MD. Functional outcome of acromioclavicular joint injury in polytrauma patients. J Orthop Trauma 1998;12(03):159–163
15 Lemos MJ. The evaluation and treatment of the injured acromioclavicular joint in athletes. Am J Sports Med 1998;26(01):137–144
16 Phemister DB. The treatment of dislocation of the acromioclavicular joint by open reduction and threaded-wire fixation. J Bone Joint Surg Am 1942;24(01):166–168
17 Salzmann GM, Paul J, Sandmann GH, Imhoff AB, Schöttle PB. The coracoidal insertion of the coracoclavicular ligaments: an anatomic study. Am J Sports Med 2008;36(12):2392–2397
18 Grutter PW, Petersen SA. Anatomical acromioclavicular ligament reconstruction: a biomechanical comparison of reconstructive techniques of the acromioclavicular joint. Am J Sports Med 2005; 33(11):1723–1728
19 von Heideken J, Boström Windhamre H, Une-Larsson V, Ekelund A. Acute surgical treatment of acromioclavicular dislocation type V with a hook plate: superiority to late reconstruction. J Shoulder Elbow Surg 2013;22(01):9–17
20 Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohlke F. Acromioclavicular dislocation Rockwood III-V: results of early versus delayed surgical treatment. Arch Orthop Trauma Surg 2008;128(10):1153–1157
21 Tauber M, Eppel M, Resch H. Acromioclavicular reconstruction using autogenous semitendinosus tendon graft: results of revision surgery in chronic cases. J Shoulder Elbow Surg 2007;16(04): 429–433
22 Hegazy G, Safwat H, Seddik M, Al-Shal EA, Al-Sebai I, Negm M. Modified Weaver-Dunn Procedure Versus The Use of Semitendinosus Autogenous Tendon Graft for Acromioclavicular Joint Reconstruction. Open Orthop J 2016;10:166–178
23 Molin DC, Ribeiro FR, Brasil Filho R, et al. Via de acesso cirúrgico póstero-superior para o tratamento das luxações acromioclaviculares: resultados de 84 casos operados. Rev Bras Ortop 2012;47 (05):563–567
24 Scandiuzzi F, Torquato MT, Mizobuchi RR, Moraes Filho DC, Durigan A Junior. Tratamento cirúrgico da luxação acromioclavicular pela transferência do ligamento coracoacromial. Rev Bras Ortop 1999;34(05):305–312
25 Ferreira Neto AA, Camargo OP, Ferreira Filho AA, et al. Tratamento cirúrgico da luxação acromioclavicular aguda pela técnica de Vukov. Rev Bras Ortop 1996;31:719–726
26 Neviaser JS. Acromioclavicular dislocation treated by transference of the coraco-acromial ligament. A long-term follow-up in a series of 112 cases. Clin Orthop Relat Res 1968;58(58):57–68
27 Horn JS. The traumatic anatomy and treatment of acute acromioclavicular dislocation. J Bone Joint Surg Br 1954;36-B(02): 194–201
28 Bjerneld H, Hovelius L, Thorling J. Acromio-clavicular separations treated conservatively. A 5-year follow-up study. Acta Orthop Scand 1983;54(05):743–745

Evaluation of Nutritional Status and Correlation with Postoperative Complications in Elderly Patients Submitted to Surgical Treatment of Proximal Femoral Fractures*

Avaliação do estado nutricional e correlação com complicações cirúrgicas em pacientes idosos submetidos a tratamento cirúrgico de fratura do fêmur proximal

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Abstract

Objective This study aims to evaluate and correlate the nutritional status with potential complications during the immediate postoperative period of elderly patients surgically treated for proximal femoral fractures.

Methods A prospective, cross-sectional analytical study with a quantitative approach, targeting patients aged 60 years old or more who were admitted to a hospital in Amazonas, Brazil, for surgical treatment of proximal femoral fractures. Surgical complications during the immediate postoperative period and their relationship with the nutritional status of the patient were determined using the mini nutritional assessment (MNA); in addition, the lymphocyte numbers and serum albumin levels were determined and correlated with the length of hospital stay.

Results The sample consisted of 19 elderly patients, of both genders, with a mean age of 70.8 years. Most of the subjects (68.4%) were female. Malnutrition was diagnosed in 15.8% of the subjects using the body mass index (BMI) as, an anthropometric variable, and the MNA identified 31.6% of the subjects with malnutrition. Regarding total lymphocyte count, 100% of the sample showed a positive association with malnutrition in varying degrees; using serum albumin level as a parameter, malnutrition was identified in 89.4% of the subjects. Malnourished patients had the highest average

Keywords
- postoperative complications
- malnutrition
- femoral fractures

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length of stay. Surgical complications as surgical site infections occurred in 10.5% of the patients at risk of malnutrition.

Conclusion This study revealed a higher rate of postoperative complications in elderly patients diagnosed with malnutrition.

Resumo

Objetivo Avaliar e correlacionar o estado nutricional com possíveis complicações no pós-operatório imediato de pacientes submetidos a tratamento cirúrgico de fraturas de fêmur proximal.

Métodos Estudo transversal prospectivo analítico e de abordagem quantitativa, tendo como população-alvo pacientes com idade igual ou superior a 60 anos, internados em uma instituição hospitalar no Amazonas, submetidos a tratamento cirúrgico de fraturas de fêmur proximal. Foram avaliadas as complicações cirúrgicas no pós-operatório imediato e sua relação com o estado nutricional através da mini avaliação nutricional (MAN), assim como a mensuração da contagem de linfócitos e albumina e a sua correlação com o tempo de internação.

Resultados A amostra foi composta por 19 pacientes idosos, de ambos os sexos, com média de idade de 70,8 anos. A maioria dos pacientes (68,4%) eram do sexo feminino. Por meio da variável antropométrica índice de massa corporal (IMC), identificou-se a presença de desnutrição em 15,8% dos pacientes e, por meio da MAN, de 31,6%. Na avaliação do cálculo da contagem total de linfócitos, 100% da amostra apresentou associação positiva com desnutrição em graus variáveis e, fazendo-se uso da albumina sérica como parâmetro, a desnutrição foi identificada em 89,4%. Os pacientes desnutridos apresentaram a maior média de tempo de internação. As complicações cirúrgicas, como infecções do sítio cirúrgico, ocorreram em 10,5% dos pacientes em risco nutricional.

Conclusão Neste estudo, observou-se maior índice de complicações no pós-operatório em idosos diagnosticados com desnutrição.

Palavras-chave
- complicações pós-operatórias
- desnutrição
- fraturas do fêmur

Introduction

Nutritional status is a critical health concern in elderly subjects. Aging is related to physiological, metabolic, and functional capacity changes that impact caloric requirements. Among elderly subjects, the most important of these conditions is malnutrition, which is associated with increased mortality and susceptibility to infections and reduced quality of life. Malnutrition is often misdiagnosed because it frequently accompanies other aging-related organic changes.[1]

Malnutrition increases the risk of developing a variety of conditions, including anemia, pressure sores, bone fractures, frailty, cognitive impairment, dehydration, orthostatic hypotension, and immune dysfunction.[2] The main indicators of malnutrition in elderly subjects include an involuntary weight loss of 5% in 1 month, 7.5% in 3 months and/or 10% in 6 months; low weight for height, that is, less than 20% of ideal body weight; a body mass index (BMI) lower than 22 kg/m^2; a serum albumin level below 3.5 mg/dL; a serum total cholesterol level below 160 mg/dL; a functional status change from independent to dependent; an inadequate food intake; an arm muscle circumference below the 10th percentile; and a tricipital skinfold below the 10th percentile or greater the than 95th percentile.[3]

Most authors believe that anthropometric measurements and laboratory tests are good parameters to assess the nutritional status of elderly subjects.[4] Although anthropometry is a simple method, it is good at predicting future diseases, functional disability, and mortality.[5] Hemoglobin levels, hematocrit and total lymphocyte counts usually reflect the nutritional status; in addition, lymphocyte counts are associated with immunosenescence.[4]

The mini nutritional assessment (MNA), a validated score to classify the nutritional status of elderly subjects,[1] is considered an easy-to-use, simple, fast, and reliable tool. It allows the identification of malnutrition risk even before the onset of clinical changes.[6] This score adopts the following reference parameters: a total score lower than 17 points indicates malnutrition; a score ranging from 17 to 23.5 points indicates risk of malnutrition; and a total score above 23.5 points indicates good nourishment.[1] The MNA uses the sum of two scores; one refers to changes in food intake, weight, mobility, psychological status, clinical status and BMI, while the other refers to the global assessment.[1]

Proximal femoral fracture is a common and important cause of mortality and functional loss in elderly subjects.[2] Its incidence increases with age due to the higher number of falls and increased osteoporosis prevalence.[7] Proximal femoral

fractures can be intracapsular or extracapsular. Intracapsular fractures include femoral neck and head injuries, whereas extracapsular fractures include transtrochanteric injuries. Both result from low energy trauma.[8] Protein-calorie malnutrition is an important determinant of the clinical outcome of elderly subjects with hip fracture, but the effectiveness of nutritional support programs in routine clinical practice is controversial.[9] Nevertheless, elderly patients with hip fractures rarely receive nutritional assessments and adequate interventions.[10]

Methods

This is a prospective, analytical cross-sectional study with a quantitative approach approved by the Ethics and Research Committee under CAAE number 68313817.5.0000.5020. The population consisted of elderly patients with proximal femoral fractures who were admitted to the orthopedic clinic for surgical treatment. The sample size was calculated based on the estimated average number of patients submitted to surgery in the last 3 years using the formula for finite populations (prevalence, 0.5; margin of error, 5%; confidence coefficient, 95%). The patients were selected according to the following inclusion criteria: informed consent form signature; elderly subjects over 60 years old; and diagnosis of proximal femoral fracture with surgical indication up to 5 days after trauma and up to 48 hours after hospitalization. Patients with neurological conditions and those from native populations were excluded. Patients were evaluated using the MNA score and biochemical tests. Postoperative complications were recorded on a specific form.

Results

Twenty patients were selected per the inclusion criteria and evaluated from July 2017 to July 2018. A questionnaire was applied for data collection and laboratory tests assessment. The subjects were cataloged and characterized according to age, gender, nutritional status, and surgical complications. One patient was excluded from the study due to loss to follow-up.

The final sample consisted of 19 elderly subjects, from both genders, with a mean age of 70.8 years old (minimum, 62; maximum; 84 years) with a standard deviation value of 7.12; in addition, 68.4% of the patients were female (n = 13) and 31.6% were male (n = 6).

The anthropometric variable BMI led to a malnutrition diagnosis in 15.8% (n = 3) of the subjects (►**Table 1**).

The MNA questionnaire revealed malnutrition in 31.6% (n = 6) of the subjects and a risk of malnutrition in 42.1% (n = 8) of them (►**Table 2**).

All subjects presented abnormal variations in total lymphocyte counts. Using serum albumin level as a parameter, malnutrition was identified in 89.4% of the patients (►**Table 3**).

The relative risk of complications was considered higher for albumin levels (9.39), MNA scores (3.56), and BMI (3.48), compared to the other variables analyzed (►**Figure 1**).

Table 1 Nutritional status classification according to the body mass inde

	n	%
Underweight	3	15.8
Eutrophic	11	57.9
Overweight/obesity	5	26.3
Total	*19*	*100*

In elderly subjects (Lipschitz continuity); n = 19.

Table 2 Nutritional status classification aFccording to the mini nutritional assessment score

	n	%
Normal nutrition	5	26.3
Malnutrition risk	8	42.1
Malnourishment	6	31.6
Total	*19*	*100*

In elderly subjects; n = 19.

Table 3 Nutritional status classification according to biochemical parameters: total lymphocyte count and serum albumin levels

	TLC		Albumin	
	n	%	n	%
Severe malnutrition	–	–	–	–
Moderate malnutrition	10	52.6	7	36.8
Mild malnutrition	9	47.4	10	52.6
Normal nutrition			2	10.5
Total	19	100	19	100

Abbreviation: TLC, total lymphocyte count.
TLC (cells/mm^3): severe depletion, < 800; moderate depletion, 800 to 1,199; mild depletion, 1,200 to 2,000; normal values, > 2,000; Albumin levels (g/dL): normal values, > 3.5; mild depletion, 3.0 to 3.5; moderate depletion, 2.4 to 2.9; severe depletion, < 2.4.

The average hospitalization period of the study population was 9.1 days, with a minimum of 5 days and a maximum of 23 days; the highest average hospitalization time was 13 days, in malnourished patients according to the MNA score (►**Table 4**).

Postoperative complications included surgical site infections in 10.5% (n = 2) of the patients; these subjects were in malnutrition risk according to the MNA score and had moderate malnutrition according to total lymphocyte counts and serum albumin levels. Bruises were detected in 26.2% (n = 5) of the patients; of these, 5.2% (n = 1) were classified as well-nourished; 10.5% (n = 2) as in malnutrition risk, and 10.5% (n = 2) as malnourished, according to the MNA score. Sacral ulcers were observed in 5.2% (n = 1) of the patients classified as well-nourished and in 5.2% of those under malnutrition risk according to the MNA score. No suture dehiscence or necrosis were observed (►**Table 5**).

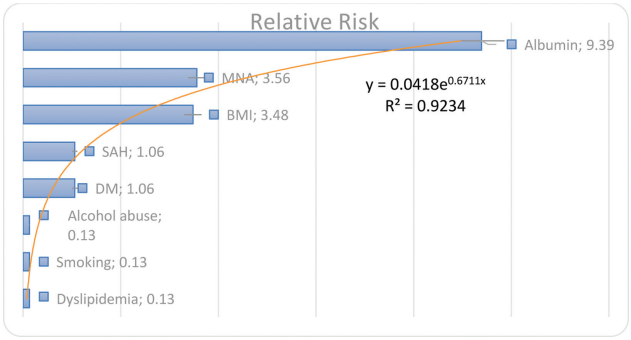

Fig. 1 Relative risk of the major comorbidities related to surgical complications in the analyzed population. Abbreviations: MNA, mini nutritional assessment; BMI, body mass index; SAH, systemic arterial hypertension; DM, diabetes mellitus.

Table 4 Comparison between nutritional status according to the mini nutritional assessment classification and the average length of stay in days

MNA classification	n	%	Average length of stay (days)
Normal nutrition	5	26.3	5.8
Malnutrition risk	8	42.1	9
Malnourishment	6	31.6	13
Total	*19*	*100*	*9.1*

Abbreviation: MNA, mini nutritional assessment.

Discussion

The current data indicate that the prevalence of malnutrition in elderly subjects living in households ranges from 1 to 15%; in elderly people admitted to hospitals, these figures range from 35 to 65%. Compared to other countries, the risk of death secondary to malnutrition in Brazilian elderly subjects is 71% higher than in the USA and 32.13% higher than in Costa Rica.[8]

The present study revealed that adding malnutrition rates to the risk of malnutrition resulted in a prevalence rate of 73.7% (*p*-value of 0.00036 and an increased relative risk of 3.56, with minimum and maximum values of 1.55 and 8.06, respectively). All subjects presented abnormal total lymphocyte counts, and 89.4% of them had abnormal serum albumin levels.[6]

At a randomized controlled trial to determine whether nutritional supplementation reduces fracture-related complication rates in a selected group of healthy patients with hip fractures, the risk of complications was greater in the control group (70%) compared to the experimental group (15%). The authors concluded that balanced nutritional supplements result in lower complications and mortality rates 120 days after surgery.[9]

Another study revealed a greater risk of death in patients with hypoalbuminemia (albumin level < 3.5g/dL) during hospitalization, and higher mortality rates 1 year after fracture in subjects with lymphopenia (total lymphocyte count $< 1{,}500$ cells/μL).[7] Other authors reported that preoperative serum albumin levels are a strong predictor of complications in the first 30 postoperative days and that this parameter is associated with greater morbidity and mortality, longer hospitalization, and a higher number of readmissions.[8]

Our study showed that changes in albumin levels, malnutrition risk, and BMI scores were statistically representative, due to the high *p*-value and the increased relative risk.

For Nourissat et al.,[11] malnourished patients are more likely to present complications compared to their well-nourished counterparts. Such complications include wound healing issues, fistula formation, infection, increased hospital stay, decreased survival time, and reduced quality of life.

Cruz and Marimoto[12] stated that an adequate nutritional monitoring ensures surgical success, and reduces complication, morbidity, and mortality rates, as well as the length of hospital stay and surgical site infections.

Malnourished patients had a longer average hospital stay (13 days) and a higher number of complications during the postoperative period.

Conclusion

In the present study, elderly people, either malnourished or at risk of malnutrition, and proximal femoral fracture presented a higher rate of surgical site infection and longer length of hospital stay when compared to eutrophic patients. The parameters used in the current study (MNA score,

Table 5 Correlation between nutritional status according to the mini nutritional assessment classification and postoperative complications

MNA Classification	n	Complications	% per classification	% from total
Normal nutrition	5	Hematomas (n = 1)	20	5.2
Malnutrition risk	8	Surgical site infections (n = 2) Hematomas (n = 2) Sacral ulcers (n = 1)	62.5	26.2
Malnourishment	6	Hematomas (n = 2) Sacral ulcers (n = 1)	50	15.8
Total	19			47.2

Abbreviation: MNA, mini nutritional assessment.

albumin levels, and total lymphocyte count) are good for nutritional status assessment.

Conflict of Interests

The authors declare no conflict of interests.

References

1 Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev 1996;54(1 Pt 2):S59–S65

2 Alarcón T, González-Montalvo JI, Bárcena A, Saez P. Further experience of nonagenarians with hip fractures. Injury 2001;32 (07):555–558

3 Riobó Serván P, Sánchez-Vilar O, González de Villar N. [Geriatric nutrition]. Nutr Hosp 1999;14(Suppl 2):32S–42S

4 Fonseca ACE. Estado nutricional - relação com a atividade física e doenças crônicas em idosos institucionalizados [dissertação]. Covilhã: Universidade da Beira Interior; 2009

5 Maciel A. Avaliação multidisciplinar do paciente geriátrico. Rio de Janeiro: Revinter; 2008

6 Faulkner KG, Wacker WK, Barden HS, et al. Femur strength index predicts hip fracture independent of bone density and hip axis length. Osteoporos Int 2006;17(04):593–599

7 Koval KJ, Maurer SG, Su ET, Aharonoff GB, Zuckerman JD. The effects of nutritional status on outcome after hip fracture. J Orthop Trauma 1999;13(03):164–169

8 Abel RM. Nutrição e coração. . In: Fisher JE, ed. Nutrição em cirurgia. São Paulo: Editora Médica Científica; 2009:546

9 Avenell A, Handoll HH. A systematic review of protein and energy supplementation for hip fracture aftercare in older people. Eur J Clin Nutr 2003;57(08):895–903

10 Sousa VMC, Guariento ME. Avaliação do idoso desnutrido. Rev Bras Clin Med 2009;7(01):46–49

11 Nourissat A, Mille D, Delaroche G, et al. Estimation of the risk for nutritional state degradation in patients with cancer: development of a screening tool based on results from a cross-sectional survey. Ann Oncol 2007;18(11):1882–1886

12 Cruz MRR, Marimoto IMI. Intervenção nutricional no paciente cirúrgico: resultado de um protocolo diferenciado. Rev Nutr 2004; 17(02):263–272

Minimally Invasive Osteosynthesis of Transtrochanteric Fractures with Dynamic Hip Screw (DHS)*

Osteossíntese minimamente invasiva de fraturas transtrocantéricas com Dynamic Hip Screw (DHS)

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Abstract

The method presented here consists of a minimally invasive surgical technique for osteosynthesis of transtrochanteric fractures with *Dynamic Hip Screw* (DHS) 135°. It is indicated in the treatment of 31-A1 and 31-A2 fractures (Arbeitsgemeinschaft für Osteosynthesefragen Classification - AO) that meet the prerequisites required for using DHS. The surgery is performed, preferably, before 48 hours after the fracture. With the use of the same instruments as the traditional surgical technique and the aid of the C-arm, a closed reduction of the fracture and implantation of the DHS is performed by a 2-cm surgical incision, through dissection of the underlying tissues, with minimal bleeding and damage to the soft parts. In the immediate postoperative period, the patient is encouraged to orthostatism and walk with full load, which anticipates hospital discharge and favors early functional rehabilitation. Outpatient return is scheduled at 2, 6, 12 and 24 weeks postoperatively, with radiographic evaluation to assess fracture healing.

Keywords
- femoral fractures
- hip fractures
- minimally invasive surgical procedures

Resumo

O método aqui apresentado consiste em técnica cirúrgica minimamente invasiva para osteossíntese de fraturas transtrocantéricas com *Dynamic Hip Screw* (DHS) 135°. Esta técnica é indicada no tratamento de fraturas 31-A1 e 31-A2 (Classificação Arbeitsgemeinschaft für Osteosynthesefragen - AO) que cumpram os pré-requisitos exigidos para o uso do DHS. A cirurgia é realizada, preferencialmente, antes de 48 horas após o acometimento da fratura. Com a utilização do mesmo instrumental da técnica cirúrgica tradicional e auxílio do arco-C, realiza-se redução incruenta da fratura e implantação do DHS por incisão cirúrgica com 2 cm, através de dissecção dos tecidos subjacentes, com mínimo sangramento e agressão às partes moles. No pós-operatório imediato, o paciente é estimulado ao ortostatismo e à deambulação com carga total, o que antecipa a alta hospitalar e favorece a reabilitação funcional precoce. O retorno ambulatorial é agendado com 2, 6, 12 e 24 semanas de pós-operatório, com avaliação radiográfica, a fim de avaliar a consolidação da fratura.

Palavras-chave
- fraturas do fêmur
- fraturas do quadril
- procedimentos cirúrgicos minimamente invasivos

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Introduction

Transtrochanteric fracture is a type of injury that occurs in the proximal region of the femur, mainly affects the elderly, and has high rates of morbidity and mortality. Its treatment is surgical in most cases and must be performed within 48 hours after the trauma to reduce the risk of secondary injuries. Otherwise, there is a considerable increase in the risk of mortality.[1]

Three aspects call attention in the management of the elderly with this diagnosis: the aging of the Brazilian population, the traditional technique widely used (since it does not allow immediate functional recovery, causing many complications in an already fragile organism) and the high costs for the public and private health systems in the treatment of such conditions.[2–4]

The main argument of those who advocate the use of locked intramedullary nailing in the treatment of transtrochanteric fractures is the size of the surgical incision, which would decrease surgical trauma and postoperative pain, with better functional recovery for elderly patients. In this sense, this treatment has assumed a leading role given the aggressiveness of more traditional surgical approaches.[4]

A great surgical trauma is harmful to the target population of these fractures, since large incisions and great tissue damage are the cause of infections, delayed consolidation and long periods of immobility.[4,5] It should also be considered that in the elderly population there is a high prevalence of comorbidities and significant functional deficit,[1] and that a less traumatic technique is required for osteosynthesis of these fractures. The method presented here is a minimally invasive technique for implanting of the *Dynamic Hip Screw* (DHS) in transtrochanteric osteosynthesis.

Surgical Technique

The indications of the technique presented here coincide with the techniques proper to the DHS-135°, that is, transtrochanteric fractures classified as 31-A1 and 31-A2 (Arbeitsgemeinschaft für Osteosynthesefragen Classification - AO) that respect the criteria for the use of DHS: lateral cortex $\geq$ 20.5mm.[6] The technique is contraindicated in unstable fractures, classified as 31-A3 (AO), with an oblique-reverse line, and with an affected lateral wall.[2,4] In conventional DHS instruments, the large size guide requires large incisions. They were abandoned and replaced by a transparency (template) that, when placed over the image of the C-arm, determines the angle of 135° required by the implant. Tube plates of three holes are used, fixed only in 4 cortices, through the first and third holes of the plate. Other items used in osteosynthesis are part of the standard instruments, not being modified or adapted for the application of this technique (►**Figure 1**).

In the operating room, after isobaric spinal anesthesia, the patient is placed on the orthopedic table with the affected limb extended and the contralateral limb flexed, giving access to the surgical arch in the lateral view (►**Figure 2A**). Satisfactory fracture reduction should be required in both the frontal and sagittal planes, and this search for the best reduction is considered the most important point of the procedure (►**Figures 2B** and **2C**).

Initially, the skin incision is located on the lateral side of the proximal thigh, achieved by positioning a Kirschner wire over the skin of the anterior hip (►**Figure 3A**), verifying its position in the anteroposterior (AP) view, which should be centralized in the femoral neck (►**Figure 3B**). The projection of this wire on the side of the thigh determines the position of the incision to be made. At this point, the wire is introduced into the skin until contact with the lateral cortex of the femur, in order to determine the height of the incision, in the sagittal plane, which must be in the center of the diaphysis.

A 2-cm incision is made, using a scalpel, and involving the skin, subcutaneous tissue, and the fascia lata. The vastus lateralis muscle of the thigh will be divulsed with scissors, opening a submuscular space, both towards the greater trochanter and towards the femoral diaphysis.

Subsequently, the guidewire is introduced through the lateral cortex towards the neck of the femur. When the guidewire touches the lateral cortex, an AP image is made, and a

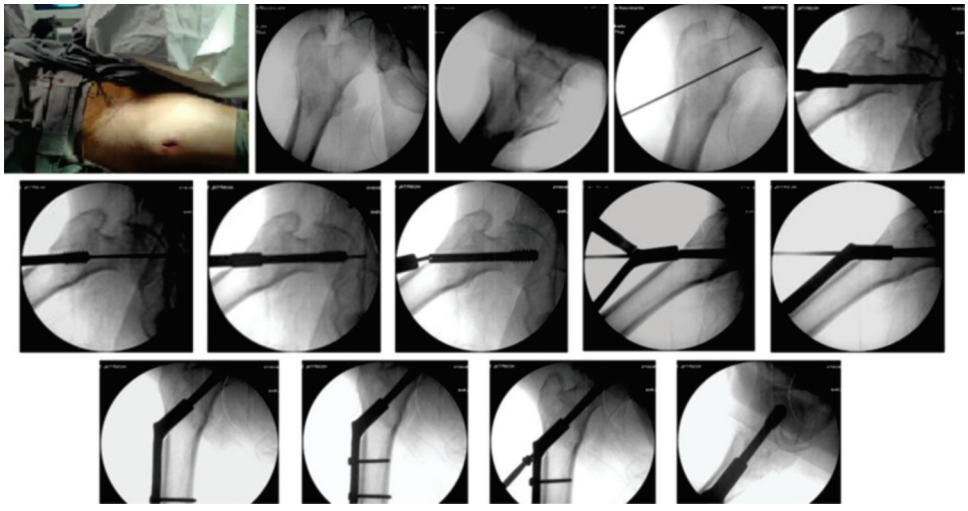

Fig. 1 Radioscopic sequence of transtrochanteric osteosynthesis. It draws attention to the size of the necessary incision.

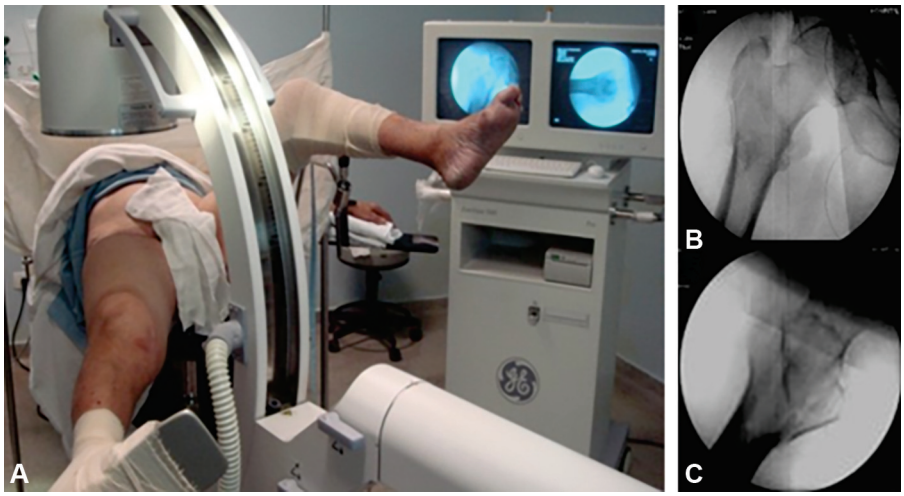

Fig. 2 Positioning the patient on an orthopedic table. Anteroposterior and profile views of the fracture reduction.

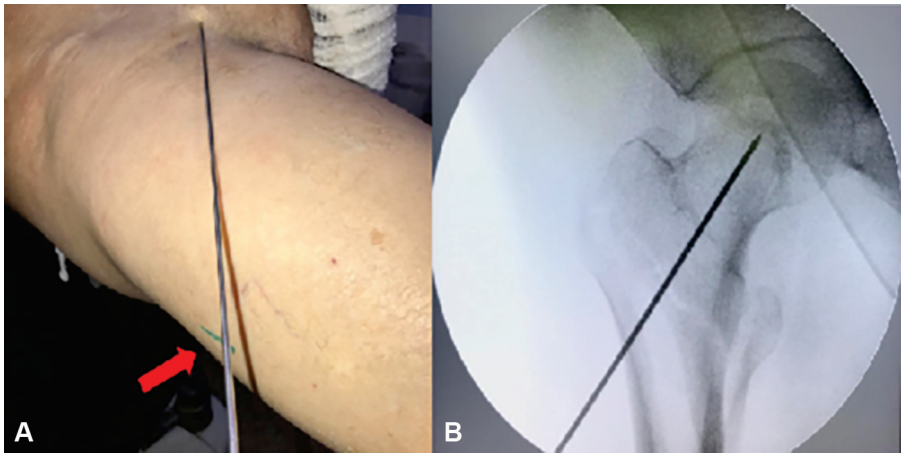

Fig. 3 In A, projection of the anterior wire on the lateral face determines the location of the incision (red arrow). In B, radioscopic view of the centralized position of this wire in the femoral neck.

transparency applied to the surgical arch monitor will determine a cervico-diaphyseal angle of 135° (►**Figures 4A** and **4B**). When the wire and the template's marking are coincident, the wire is introduced to the subchondral bone of the femoral head. To assess the position of this guidewire introduced in the sagittal plane, the lateral view should be performed. The guidewire should be centered on the neck and femoral head in the AP (►**Figure 4C**) and profile views (►**Figure 4D**). This will determine the quality of osteosynthesis.

The size of the sliding screw is determined using another wire, of the same length, subtracting with the extra bony part of the inserted wire. Next, the chosen sliding screw is milled and placed, which must reach 10 mm from the hip joint space. After that, remove the guidewire. In sequence, the tube-plate is placed in the skin incision in an inverted manner, that is, with the tube pointing outwards from the patient (►**Figure 5A**) and the plaque sliding into the submuscular space opened at the beginning of the surgery (►**Figure 5B**). With the help of the sliding screw extender, it is easily made a 180° turn on the plate, in the longitudinal axis, leaving it in the position of adaptation to the sliding screw, which will be completed with the aid of the plate impactor (►**Figure 5C**). The holes in the femur are made to place the cortical screws and the fracture is compressed with the introduction of the compression screw. The incision is closed with a mononylon 2-0 thread, with a stitch on the fascia lata and two on the skin (►**Figure 5D**).

In the immediate postoperative period, 12 hours, orthostatism and walking at full load are encouraged, with assistance. Hospital discharge occurs on the first day after surgery and outpatient visits are scheduled at 2, 6, 12 and 24 weeks postoperatively. The consolidation criteria are radiological and consist of trabecular reform or bridged bone callus around the trochanteric region. Consolidation delay was defined as no radiological signs of consolidation at 6 months postoperatively and pseudarthrosis is diagnosed at 9 months postoperatively.

Final Comments

Osteosynthesis of the transtrochanteric fracture using the conventional technique (open reduction and internal fixation with DHS-135°) uses an incision that varies from 10 to 14 cm,

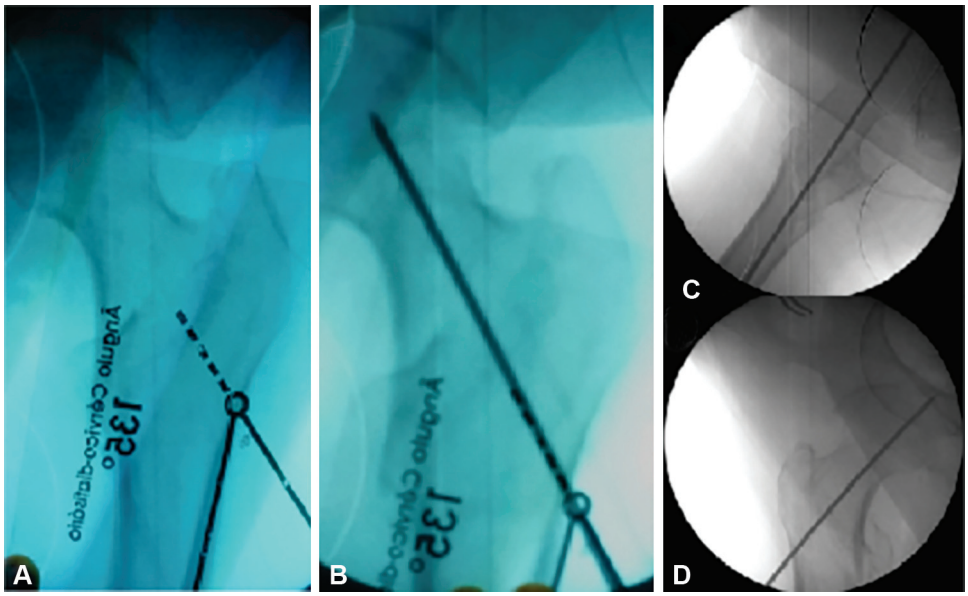

Fig. 4 In A, note the apposition of the template on the C-arm monitor; In B, guidewire introduced respecting the template's marking; In C and D, final position of the guidewire in profile and anteroposterior views, respectively.

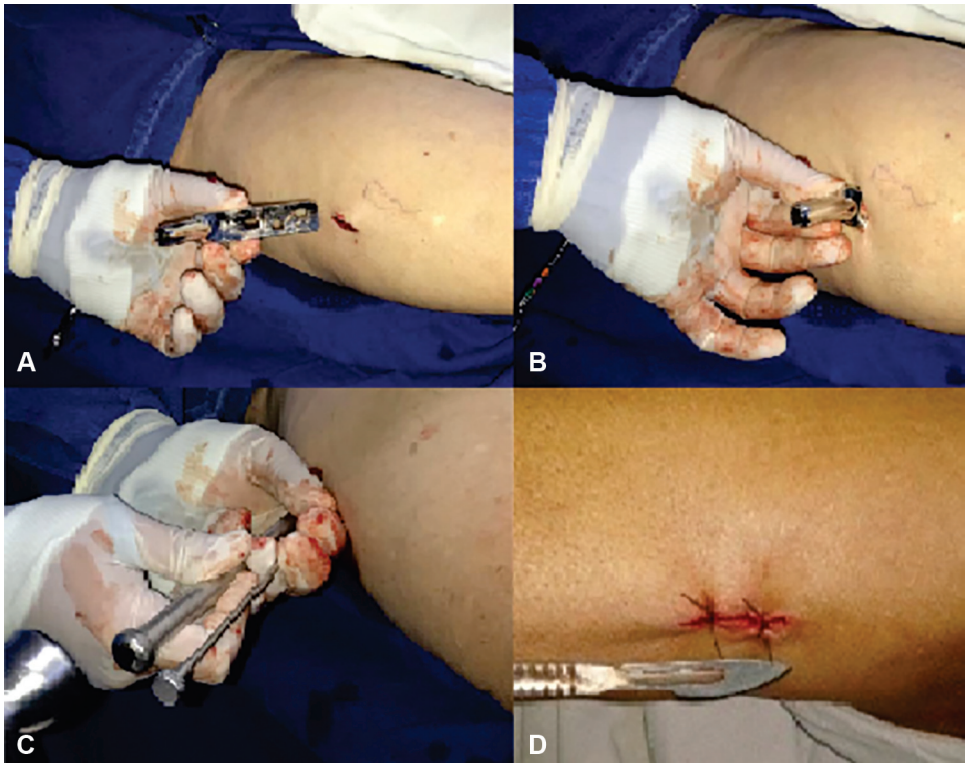

Fig. 5 In A and B, the plate is inserted in the inverted position; in C, on the sliding screw extension, the plate is impactioned; in D, surgical wound suture.

which determines the long duration of the surgery, high aggression to the soft tissues and massive blood loss.[3,7,8] Minimally invasive techniques, in turn, bring several benefits to orthopedics, such as: less soft tissue injury and blood loss, as well as reduced risk of infections and duration of surgery. In addition, they allow early rehabilitation, with a consequent decrease in the risk of postoperative complications.[5]

The patient operated by the technique described evolves with less pain in the immediate postoperative period, with orthotastism and gait at full load being stimulated 12 hours after the procedure. It is a technique with easy execution and high reproducibility that can contribute to help in the epidemic of fractures of the proximal femur expected in the coming decades, due to the aging of the population.

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

References

1 Bottle A, Aylin P. Mortality associated with delay in operation after hip fracture: observational study. BMJ 2006;332(7547):947–951
2 Matre K, Havelin LI, Gjertsen JE, Vinje T, Espehaug B, Fevang JM. Sliding hip screw versus IM nail in reverse oblique trochanteric and subtrochanteric fractures. A study of 2716 patients in the Norwegian Hip Fracture Register. Injury 2013;44(06):735–742
3 Kellam JF. Tratamento cirúrgico de fraturas intertrocantéricas. In: Sledge CB. Quadril. Rio de Janeiro: Revinter; 2005:109–128
4 Shen J, Hu C, Yu S, Huang K, Xie Z. A meta-analysis of percutenous compression plate versus intramedullary nail for treatment of intertrochanteric HIP fractures. Int J Surg 2016;29:151–158
5 Thaeter M, Kobbe P, Verhaven E, Pape HC. Minimally Invasive Techniques in Orthopedic Trauma. Curr Trauma Rep 2016;2(04):232–237
6 Hsu CE, Shih CM, Wang CC, Huang KC. Lateral femoral wall thickness. A reliable predictor of post-operative lateral wall fracture in intertrochanteric fractures. Bone Joint J 2013;95-B(08):1134–1138
7 Sledge CB. Quadril – Master Techniques in Orthopaedic Surgery. Rio de Janeiro: Revinter; 2005
8 Sawaia RN, Belangero WD. Sistema MINUS® - Técnica Minimamente Invasiva para o tratamento das FraturasTranstrocanterianas do Fêmur. Rev Bras Ortop 2012;47(01):113–117

Posttraumatic Arachnoid Cyst in the Thoracic Spine with Medullary Compression: Case Report

Cisto aracnóide após trauma na coluna torácica com compressão medular: Relato de caso

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Abstract

Arachnoid cysts are rare; they can occur at all levels of the dural sac, and can have a congenital, traumatic, iatrogenic or inflammatory origin. In the present article, we report a patient presenting a compressive thoracic myelopathy due to an unusual intradural arachnoid cyst with posttraumatic manifestation and its resolution, in addition to a literature review on the subject. These cysts mainly occur at the thoracic spine, followed by the lumbar, lumbosacral and thoracolumbar spines. Traumatic cysts are caused by an injury to the inner dural layer. These lesions produce neurological deficits through a mass effect on the spinal cord. Concomitant compressive myelopathy is even rarer. In case of myelopathy, cyst resection or drainage is the treatment of choice, and it must be performed immediately. Although rare, arachnoid cysts can be a complication of spine fractures; as such, orthopedists and neurosurgeons, who commonly see these injuries, must be prepared for this unusual situation.

Keywords
- arachnoid cysts
- spinal cord injuries
- spinal cord compression

Resumo

Cistos aracnóides são raros, podem ocorrer em todos os níveis do saco dural, e sua origem pode ser congênita, traumática, iatrogênica ou inflamatória. Neste artigo, relatamos o caso de uma paciente com mielopatia torácica compressiva decorrente de um cisto aracnoide intradural incomum, de manifestação pós-traumática, assim como sua resolução, além de realizar revisão da literatura sobre o tema. A principal localização é na coluna torácica, seguida das colunas lombar, lombossacra e toracolombar. O cisto com origem traumática é causado por lesão da camada interna da

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Palavras-chave
- cistos aracnóideos
- traumatismos da medula espinhal
- compressão da medula espinal

dura-máter. Essas lesões produzem déficit neurológico por meio de efeito de massa sobre a medula espinhal. A existência de mielopatia compressiva associada é mais rara ainda. A ressecção ou drenagem dos cistos na vigência de mielopatia deve ser imediata, sendo o tratamento de escolha. Apesar de raros, podem ser uma complicação de fraturas da coluna vertebral que são muito comuns na prática de ortopedistas e neurocirurgiões, que devem estar preparados para essa situação incomum.

Introduction

Arachnoid cysts are rare; these injuries can occur at all levels of the dural sac, and can have congenital, traumatic, iatrogenic or inflammatory origin.[1,2] Cysts are believed to form due to herniation of the arachnoid membrane through a dura-mater defect. Traumatic cysts are even rarer, and are caused by penetrating trauma, spinal fractures associated with dural lesions by bone fragments, and intraoperative iatrogenic dural injuries.[3] The most common sites for the cyst ostium are the entry point of the dorsal root into the dural sac and the dural midline.[1] The clinical presentation ranges from asymptomatic cases to pain, weakness, paresthesia and paralysis due to neural compression. The imaging evaluation includes computed tomography (CT), myelography and magnetic resonance imaging (MRI). The surgical intervention, when required, consists of primary closure of the dural defect through a posterior approach, accompanied by laminectomy and/or costotransversectomy.[1]

Although rare, arachnoid cysts can be a complication of spinal fractures, which are commonly seen by orthopedists and neurosurgeons; as such, all physicians must be aware of these lesions.

In the present article, we report a case of a patient presenting compressive thoracic myelopathy due to an unusual intradural arachnoid cyst with posttraumatic manifestation, its resolution, and a literature review on the subject.

Case Report

A 46-year-old female patient had been in a car accident in the previous 7 months, and suffered a compressive fracture of the tenth thoracic vertebra, type B (A1) according to the Arbeitsgemainchaft für Osteosynthesefragen (Working Community for Osteosynthesis Issues, AO) group classification.[4] Back then, emergency care was performed at another hospital, with conservative treatment of the fracture using a thoracolumbar orthosis. After three months, the patient was walking with increasing difficulty and developed severe spastic paraparesis and an inability to walk in the last month. When the patient came to our outpatient service, she had grade-III motor strength in the left lower limb and hypoesthesia distal to the L1 dermatome. In addition, she presented exacerbation of the deep-tendon reflexes, a positive Babinski sign, and inexhaustible clonus. The results of the routine laboratory tests were within normal range. Thoracic spine radiographs showed no acute osteoarticular changes or fracture sequelae. The MRI showed: an old fracture of the T10 vertebral body sparing the anatomy; widening of the space between the T9 and T10 spinous processes, suggesting chronic ligament rupture; alteration of the spinal cord signal at the T9, T10 and T11 levels, consistent with myelomalacia; and posterior adhesion of the spinal cord at the T7-T9 level and anterior adhesion at the T9-T12 level, associated with adhesive arachnoiditis and a ventral arachnoid cyst at the vertebral canal in these levels, posteriorly dislocating the cord (►**Figure 1**). In the same week, the patient underwent a surgical decompressive treatment through a posterior approach, accompanied by laminectomy and left costotransversectomy in T9 and T10 for the anterior approach to the vertebral canal. An anterolateral durotomy was then performed with a direct approach to the arachnoid cyst for drainage and repair with 5-0 nylon suture, followed by stabilization and arthrodesis with pedicle screws and pins from T8 to T11 (►**Figures 2**, **3** and **4**). No orthosis was required, and rehabilitation began on the first postoperative day. The neurological deficit gradually improved in about a week, with recovery of the strength of the lower limbs and sensitivity. Six months later, there was residual ataxia, but the patient walked with no assistance or orthosis. There were no complications related to the surgical site. The follow-up tests showed adequate position and alignment of the fused segment, as well as bone healing (►**Figure 5**).

Discussion

While arachnoid cysts are rare, concomitant compressive myelopathy is even rarer.[2,5,6] The frequent use of MRI scans increased the reports of these injuries.[6] Most cases have an idiopathic origin and are asymptomatic.[5] Among the potential causes, posttraumatic injuries, as presented here, are rare. Their prevalence is not yet available in the literature, probably due to the fact that asymptomatic cases are not interesting enough to be published, and only cases with concomitant myelopathy are reported.[7] Most arachnoid cysts are located in the thoracic spine, followed by the lumbar, lumbosacral and thoracolumbar spines.[8] Posttraumatic cysts are caused by a defect in the inner dural layer.[5] Ventral cysts can cause weakness and myelopathy, while dorsal cysts present with neuropathic pain and paresthesia.[7] The symptomatology differs because ventral lesions can compress the territory of the anterior spinal artery, leading to weakness or myelopathy, while dorsal lesions locally compress the spinal tracts, resulting in radiculopathy and pain.[9] Failure in treating the cause of the cyst can lead to recurrences, whose frequency is still unknown.[3] Myelography and CT scans reveal compression of

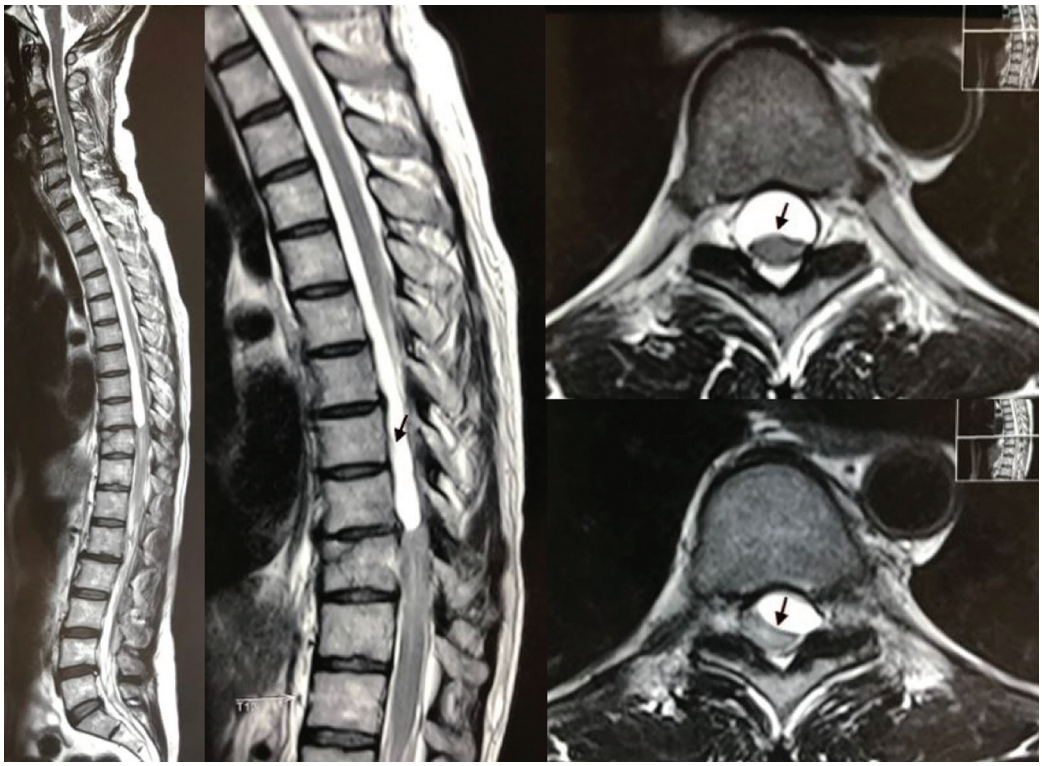

Fig. 1 Sagittal T2-weighted magnetic resonance imaging showing an old fracture at the T10 vertebral body; space widening between the T9-T10 spinous processes, suggesting chronic ligament rupture; alteration of the spinal-cord signal at the T9, T10 and T11 levels, consistent with myelomalacia; posterior adhesion of the spinal cord at the T7-T9 level, and anterior adhesion at the T9-T12 level, associated with adhesive arachnoiditis and an arachnoid cyst at these levels. The white arrows show the boundaries of the cyst and posterior spinal adherence.

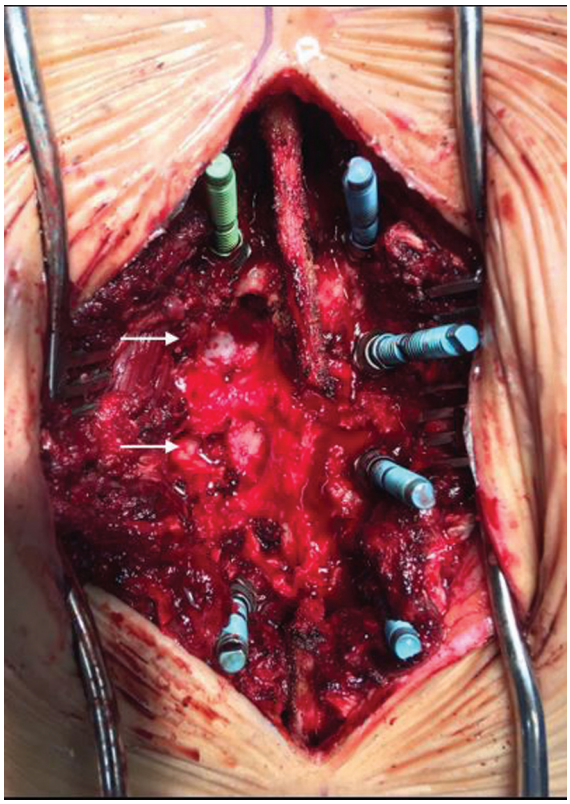

Fig. 2 Laminectomy and costotransversectomy (white arrows) after the insertion of the pedicle screws at the T8 and T11 levels to approach the arachnoid cyst and perform the subsequent stabilization.

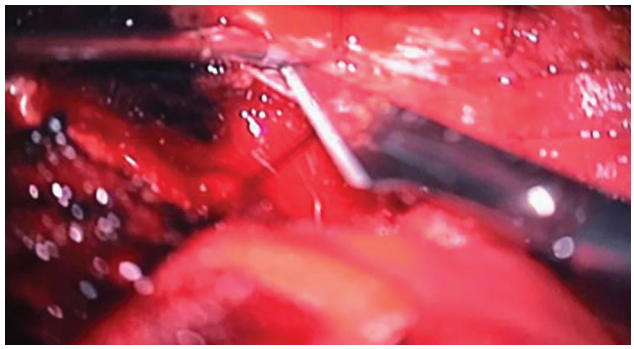

Fig. 3 Microscope image showing durotomy and cyst drainage at the T9 and T10 levels.

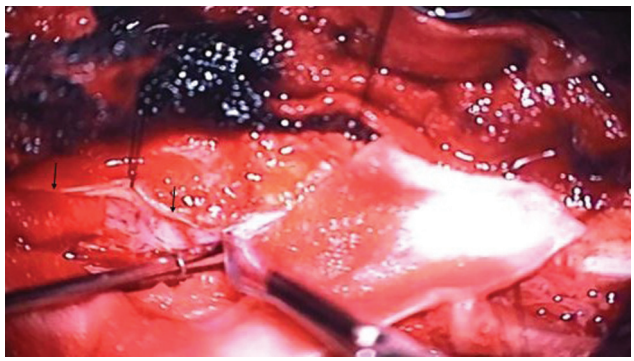

Fig. 4 Repair of arachnoid cyst using primary, 5-0 non-absorbable nylon suture. The arrows highlight the edge of the durotomy to approach the cyst.

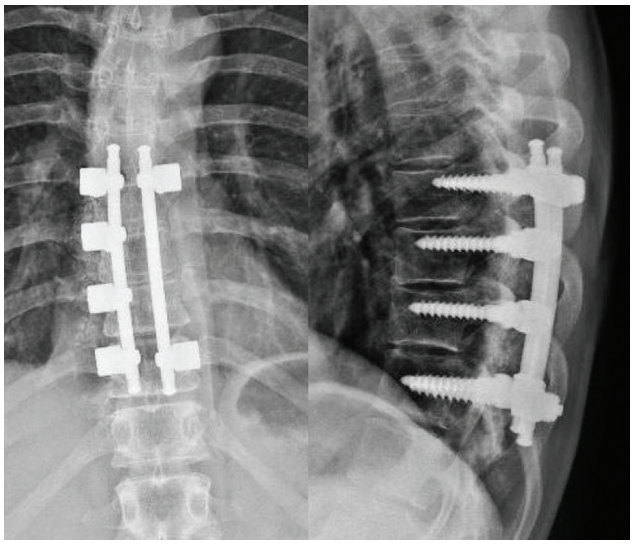

Fig. 5 Posterolateral and lateral radiographs of the thoracic spine at the end of the procedure, showing adequate position and alignment of the pedicle screws.

the structures adjacent to the cyst and the site of communication between the lesion and the dural sac. The MRI shows a mass effect on the adjacent structures, revealing a hypersignal on the cerebrospinal fluid in T2-weighted images.[1] Radical cyst removal is the treatment of choice; if not feasible due to technical limitations, the cyst must be drained.[4,6–10] Hemilaminectomy sparing the posterior-ligament complex was performed in most cases reported in the literature; it is sufficient to approach the cyst, avoiding complications such as deformity and instability, as well as the need for additional stabilization. In this case, laminectomy was associated with a two-level costotransversectomy due to the ventral location of the cyst and the need to approach it without dislocating the spinal cord. Non-absorbable wires can be used, and, in cases of major failures, complemented by covering with fat tissue, fascia, dural substitute or fibrin sealant.[1,2,5] In most published reports, the patients evolved with total improvement in the neurological deficit and the myelopathy after surgery.[1,3,7,9] Since this is a rare condition, with few publications and a low level of evidence, the reproducibility in the clinical practice and the discussion regarding treatment options are limited.

Arachnoid cysts are rare lesions that can produce neurological deficit through a mass effect on the spinal cord. In case of myelopathy, the treatment of choice is cyst resection or drainage, which must be performed immediately.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Yanni DS, Mammis A, Thaker NG, Goldstein IM. Traumatic fracture of thin pedicles secondary to extradural meningeal cyst. J Surg Tech Case Rep 2011;3(01):40–43
2 Shibata T, Nakamura H, Yamano Y. Intradural arachnoid cyst associated with thoracic spinal compression fracture: 7-year follow up after surgery. Spinal Cord 2001;39(11):599–601
3 Hernández-León O, Pérez-Nogueira FR, Corrales N. [Postraumatic epidural arachnoid spinal cyst: case report]. Neurocirugia (Astur) 2011;22(03):267–270
4 Vaccaro AR, Oner C, Kepler CK, et al. AOSpine Spinal Cord Injury & Trauma Knowledge Forum. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. Spine 2013;38(23):2028–2037
5 Chen HJ, Chen L. Traumatic interdural arachnoid cyst in the upper cervical spine. Case report. J Neurosurg 1996;85(02):351–353
6 Alvisi C, Cerisoli M, Giulioni M, Guerra L. Long-term results of surgically treated congenital intradural spinal arachnoid cysts. J Neurosurg 1987;67(03):333–335
7 Levin TL, Zimmerman RD, Lieberman H. Intradural spinal arachnoid cyst. Case report. Clin Imaging 1990;14(03):245–247
8 Kong WK, Cho KT, Hong SK. Spinal extradural arachnoid cyst: a case report. Korean J Spine 2013;10(01):32–34
9 Wang MY, Levi AD, Green BA. Intradural spinal arachnoid cysts in adults. Surg Neurol 2003;60(01):49–55, discussion 55–56
10 Kendall BE, Valentine AR, Keis B. Spinal arachnoid cysts: clinical and radiological correlation with prognosis. Neuroradiology 1982;22(05):225–234

Rare Presentation of Schwannoma in the Ankle: A Case Report*

Apresentação rara de schwannoma no tornozelo: Um relato de caso

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Abstract

Schwannomas are benign slow-growing tumors that constitute 8% of all soft-tissue tumors. The clinical signs and symptoms are often misinterpreted because of the low incidence, and these tumors are often misdiagnosed. A 39-year-old male patient presented with non-traumatic solitary swelling in the posteromedial aspect of the right ankle that gradually increased in size and was associated with pain. Clinically, the swelling was firm, non-fluctuant, and was not associated with sensorimotor impairment. Surgical excision of the swelling was performed without damaging the surrounding vessels and nerves. The histopathological examination of the excised tumor revealed a schwannoma.

Keywords
- ankle
- schwannoma
- rare location
- case report

Resumo

Schwannomas são tumores benignos de crescimento lento, e constituem 8% de todos os tumores de tecido mole. Os sinais clínicos e sintomas são muitas vezes mal interpretados por causa da baixa incidência, e, muitas vezes, esses tumores são mal diagnosticados. Um paciente do sexo masculino de 39 anos apresentou um inchaço solitário não traumático sobre o aspecto posteromedial do tornozelo direito, que aumentou gradualmente de tamanho e estava associado a dor. O inchaço era clinicamente firme, não flutuante, e não associado a qualquer comprometimento sensório-motor. A excisão cirúrgica do inchaço foi feita sem danificar os vasos e os nervos circundantes. O exame histopatológico do tumor excisado revelou schwannoma.

Palavras-chave
- tornozelo
- schwannoma
- localização rara
- relato de caso

Introduction

Schwannomas are benign slow-growing soft-tissue tumors that arise from Schwann cells of the peripheral nerve sheaths. They constitute 8% of all soft-tissue tumors.[1] Of all the reported cases, between 12% and 19% are located in the upper extremity, and between 10% to 13%, in the lower extremity. Its common locations are the flexor surface of the extremities, the neck, the mediastinum, the retroperitoneum, the posterior spinal roots, and the cerebellopontine angle.[2] The clinical signs and symptoms are often misinterpreted because of the low incidence, and schwannomas are often misdiagnosed as other soft-tissue tumors, such as neurofibroma.

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Case Presentation

A 39-year-old male patient presented to the outpatient department with complaints of a non-traumatic solitary swelling over the posteromedial aspect of the right ankle associated with mild pain. He had noticed the swelling 15 years before, and it gradually increased in size and was associated with pain that was mild to moderate in intensity and intermittent in nature. There was no significant family history.

The clinical findings showed firm swelling over the posteromedial aspect of the ankle measuring $3 \times 2 \times 2$ cm approximately, and it was non-fluctuant, non-pedunculated, non-compressive, and with no transillumination present. There was no sensorimotor impairment in the right leg and foot.

A magnetic resonance imaging (MRI) scan of the leg (►**Fig. 1a,b,c**) revealed a well-circumscribed lesion in the subcutaneous plane in the posteromedial aspect of the distal third of the leg abutting underlying soleus and tAchilles tendon with no definitive evidence of infiltration likely benign lesion? neurogenic.

We proceeded with the surgical excision of the swelling after we obtained consent and the complications were explained. The skin overlying the swelling was incised in a curved fashion, and a dissection was performed to demarcate the capsule of the tumor that was incised. Further fine blunt dissection was performed circumferentially along the branch of the posterior tibial nerve, with the perineural sheath attached. The tumor was retracted and removed without damaging the surrounding vessels and nerves (►**Fig. 2a,b**).

The nerve was fully preserved and examined before closure. The excised tumor was sent for a histological study (►**Fig. 2c**). The postoperative period was uneventful, with good skin healing and well-preserved nerves.

The histopathological examination revealed a Schwannoma (►**Fig. 3**) consisting of Antoni type A tissue, which is composed of highly cellular spindle-shaped cells

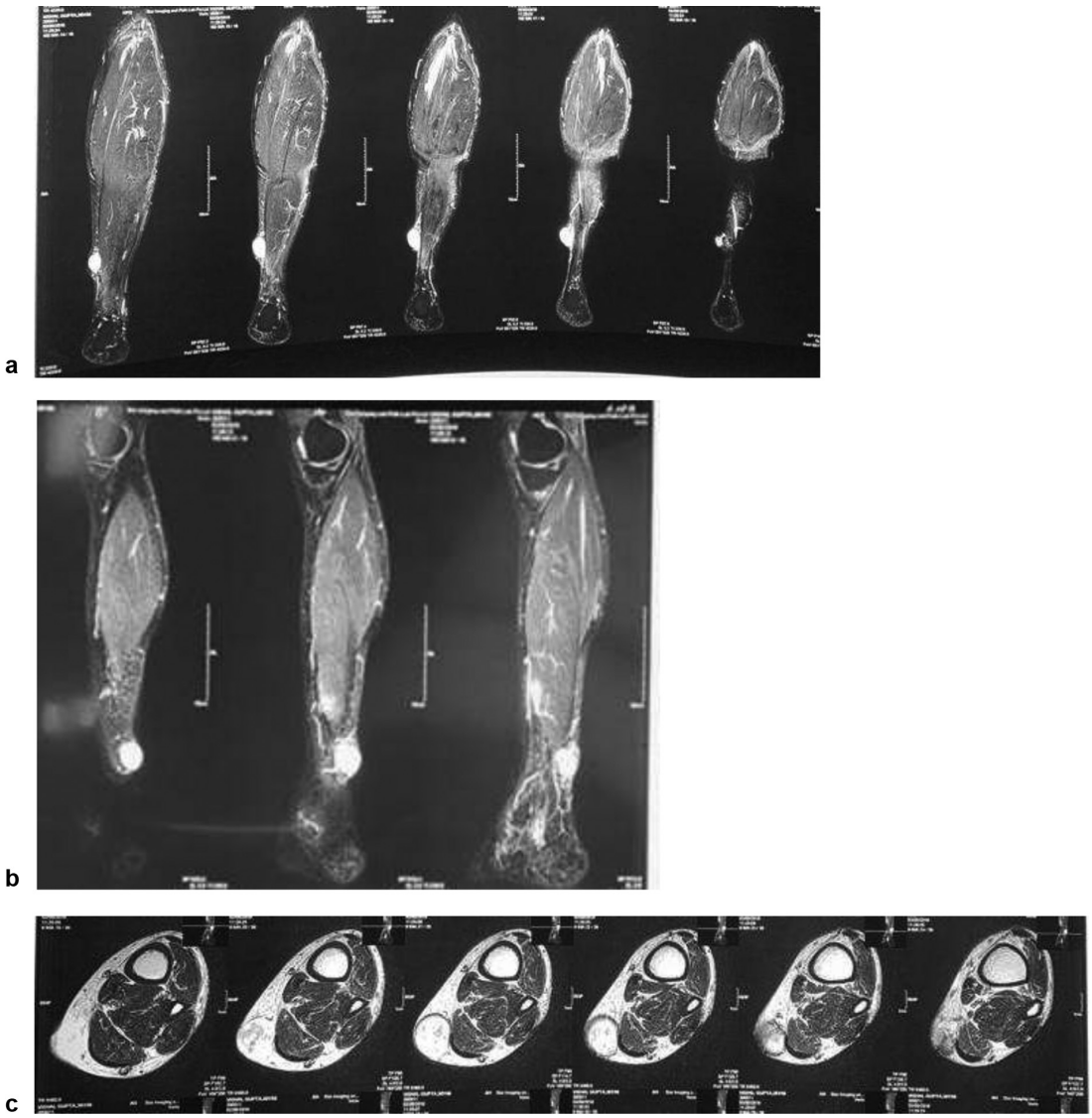

Fig. 1 (a) Magnetic resonance imaging scan (MRI) showing posteromedial swelling over the distal third of the leg in coronal view. (b) MRI showing posteromedial swelling over the distal third of the leg in sagittal view. (c) MRI showing posteromedial swelling over the distal third of the leg in axial view.

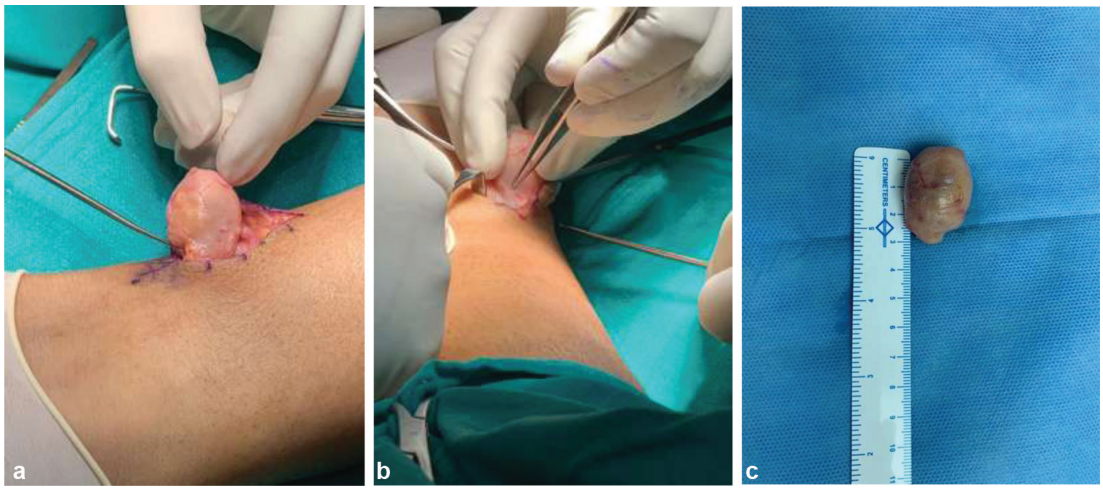

Fig. 2 (a) Intraoperative image showing the tumor attached to the underlying neurovascular tissue, as well as other soft tissues. (b) Fine dissection of the neurovascular structures from the tumor. (c) Measurement of the dimension of the excised tumor.

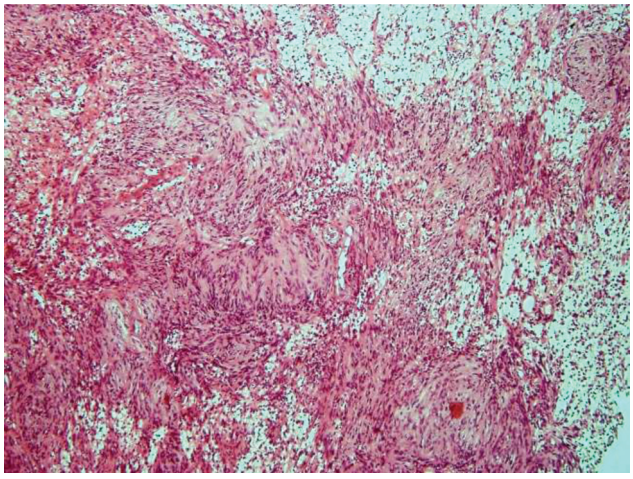

Fig. 3 Histopathological slide showing a tumor composed of cellular areas of oval to spindly cells with thin oval nuclei and formation of Verocay bodies (Antoni type A tissue) and loose paucicellular area of Antoni type B tissue.

surrounding the Verocay bodies and Antoni type B tissue, which consists Schwann cells.

Discussion

Schwanommas in the lower extremities are limited to less than 10% of all cases, according to a study by Albert et al.[3] Our case is rare, as the literature search results show very few case reports of schwannomas affecting the posterior tibial nerve.

Delay in the diagnosis is often peculiar in cases of tibial-nerve schwanomma; our patient was operated after 15 years of the onset of symptoms. A similar delay in diagnosis, of up to 10 years, was reported by Ghaly.[4] Smith and Amis[5] reported pain in the foot for 8 years before the recognition of a schwannoma, while Nawabi and Sinisi[6] suggested that the mean time to diagnose the schwannoma was of 86.5 months (more than 7 years).

Extracapsular excision is a commonly-used technique[7] that may be associated with the risk of developing postoperative neurological deficits. During tumor dissection, to reduce the risk of damage to the nerve fascicles, Hussain et al.[8] proposed tumor release by incising the capsule far laterally to the path of the nerve and dissecting circumferentially, with the epineural capsule behind to act as a protective covering; in our case, we incised the capsule in the dorsal aspect, as we knew that the nerve was in the ventral aspect. This was followed by dissection until the nerve and further fine dissection separating it from the parent nerve.

The present is a report of a rare location of a schwannoma of the posterior tibial nerve in the posteromedial aspect of the ankle, which was managed by excision, with no neurovascular damage.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Adani R, Baccarani A, Guidi E, Tarallo L. Schwannomas of the upper extremity: diagnosis and treatment. Chir Organi Mov 2008; 92(02):85–88
2 Fletcher CD. Peripheral nerve sheath tumors. A clinicopathologic update. Pathol Annu 1990;25(Pt 1):53–74
3 Albert P, Patel J, Badawy K, et al. Peripheral Nerve Schwannoma: A Review of Varying Clinical Presentations and Imaging Findings. J Foot Ankle Surg 2017;56(03):632–637
4 Ghaly RF. A posterior tibial nerve neurilemoma unrecognized for 10 years: case report. Neurosurgery 2001;48(03):668–672
5 Smith W, Amis JA. Neurilemoma of the tibial nerve. A case report. J Bone Joint Surg Am 1992;74(03):443–444
6 Nawabi DH, Sinisi M. Schwannoma of the posterior tibial nerve: the problem of delay in diagnosis. The Journal of bone and joint surgery 2007;89-B(06):814–816
7 Rockwell GM, Thoma A, Salama S. Schwannoma of the hand and wrist. Plast Reconstr Surg 2003;111(03):1227–1232
8 Hussain M, Jhattu H, Pandya A, et al. A precise excision technique for schwanommas. Eur J Plast Surg 2012;36(02):111–114

Arthroscopic Treatment of Femoroacetabular Impingement in Slipped Capital Femoral Epiphysiolysis: A Case Report*

Tratamento artroscópico do impacto femoroacetabular na epifisiólise capital femoral proximal: Relato de caso

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Abstract

Slipped capital femoral epiphysiolysis (SCFE) may result in femoroacetabular impingement (FAI) of the hip in up to one third of the cases. Residual deformity of the cam-type, or "pistol-grip", is associated with chondrolabral injury, resulting in pain, functional disability, and early osteoarthritis. The arthroscopic treatment with osteochondroplasty proved to be beneficial in a selected case of FAI secondary to SCFE.

Keywords
- arthroscopy
- hip
- epiphyses, slipped
- femoroacetabular impingement

Resumo

A epifisiólise capital femoral proximal (ECFP) pode resultar em impacto femoroacetabular (IFA) do quadril em até um terço dos casos. A deformidade residual em came ou "cabo de pistola" está associada a lesão condrolabral, resultando em dor, incapacidade funcional, e osteoartrose precoce. O tratamento artroscópico com osteocondroplastia mostrou-se benéfico em um caso selecionado de IFA secundário a ECFP.

Palavras-chave
- artroscopia
- quadril
- epífise deslocada
- impacto femoroacetabular

Introduction

Slipped capital femoral epiphysiolysis (SCFE) is the most common adolescent hip disorder, with a reported incidence

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of 10.8 for every 100 thousand inhabitants. Bilaterality can occur in up to 20% of the cases.[1] Mechanical factors such as obesity, femoral retroversion, and relative vertical orientation of the proximal femoral physis have been associated with this etiology.[2]

The proximal femoral neck moves anterolaterally at the level of the physis over the femoral head, which remains inside the acetabulum. This deformity leads to a prominence in the anterolateral aspect of the cephalocervical junction and an attitude in external rotation of the proximal femur. The patients may subsequently develop a "pistol-grip" deformity close to the femoral head, also called "queilo" by some authors.[3] This deformity can be improved by remodeling; however, such potential is limited by the fixation in situ, which compromises physeal growth. In addition, SCFE occurs in an age group in which the ability to compensate for residual deformities by remodeling is no longer possible.

Up to one third of the patients diagnosed with SCFE have persistent pain and/or femoroacetabular impingement (FAI) resulting from the deformity.[4] Residual prominence ("pistol-grip" deformity) and relative retroversion of the femoral head were defined as the cause of cam-type FAI, with worse long-term clinical and radiographic results. An important mark of this deformity is the reduced or absent offset between the femoral head and the neck, which can be radiographically graded.

Residual prominence at the head-neck junction protrudes into the acetabular ridge, generating stress at the chondrolabral junction, resulting in the separation of the labrum from the articular cartilage, which is a precursor of irreversible chondral injury. This lesion begins shortly after sliding in the SCFE and usually progresses over time, leading to deterioration of the hip at an early age.[5]

There is evidence in the literature to support arthroscopic osteochondroplasty of the femoral neck in the treatment of symptomatic FAI secondary to SCFE, with encouraging results,[6,7] and an early approach is suggested right after the slide in order to prevent irreversible progression with worse long-term results.[7]

Case Report

Female patient, 15 years old, without comorbidities, in the 2nd postoperative year of bilateral in situ fixation of the femoral head by SCFE. She reported pain and limited movement of the left hip that worsened with support.

During the inspection, an attitude of external rotation of the left lower limb was observed, most evident during walking. The patient presented a slight limp in the left lower limb during gait, which was associated with pain in the hip. There was no sign of Trendelenburg.

Upon physical examination, she had an important limitation of internal rotation of the left hip associated with pain during the maneuver. The Drennan sign was observed on the left during the examination. The patient had no neurovascular changes in the lower limbs. Preserved muscle strength was verified in both lower limbs.

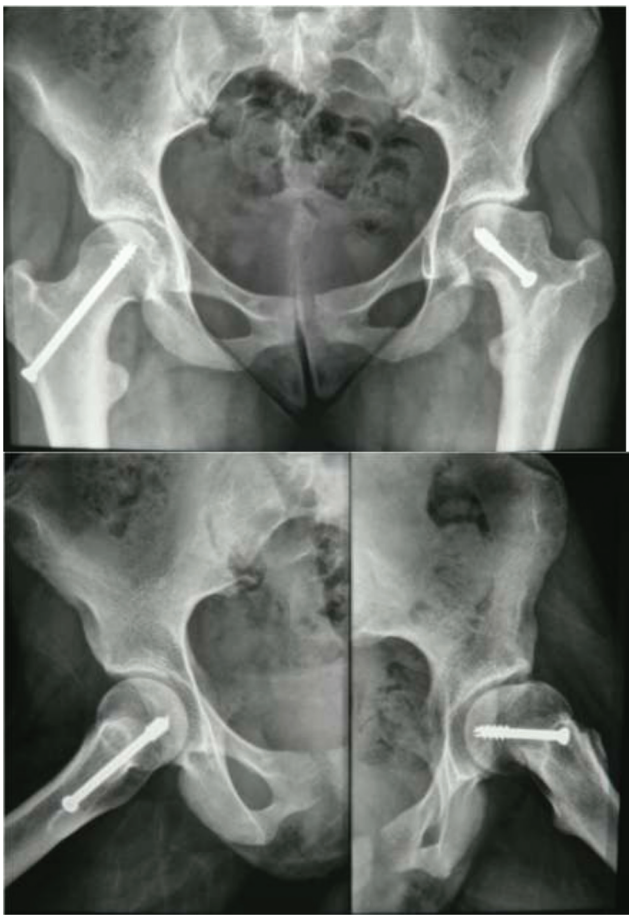

Fig. 1 Anteroposterior radiographs of the pelvis (above) and in Dunn profile of the hips (below) showing deformity in the anterolateral region of the left femoral neck compatible with cam-type impingement.

On anteroposterior (AP) radiographs of the pelvis and profile radiographs of the hip (►**Figure 1**), epiphysiolysis of the left hip was observed, with significant anterolateral prominence in the head-neck transition associated with

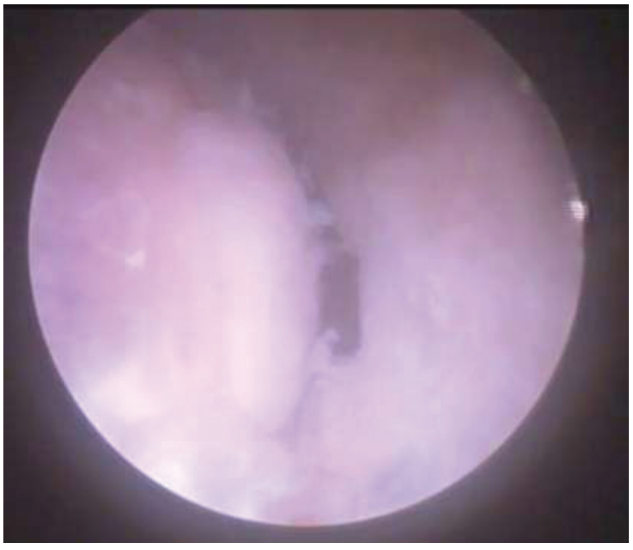

Fig. 2 Chondrolabral lesion observed during arthroscopy.

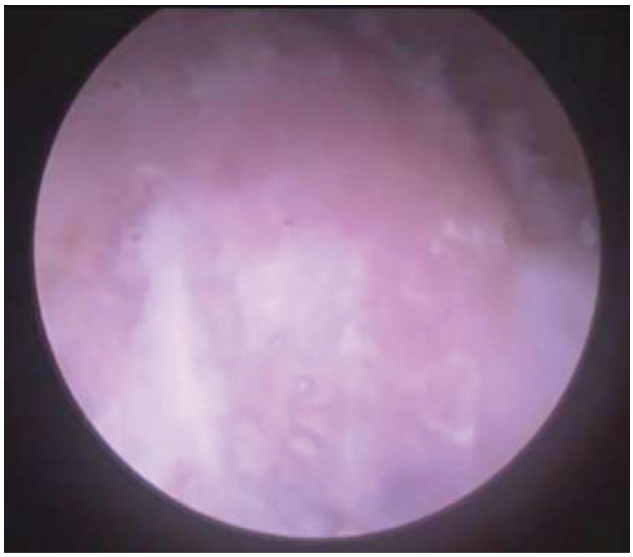

Fig. 3 Cam-type deformity in the head-neck transition.

reduced offset. The Trethowan signal was present. The growth of the physis was already closed.

The anamnesis, the physical examination, and the radiographs were compatible with cam-type FAI secondary to epiphysiolysis. Due to the symptomatic pain associated with joint blockage, the recommended treatment was osteochondroplasty via arthroscopy.

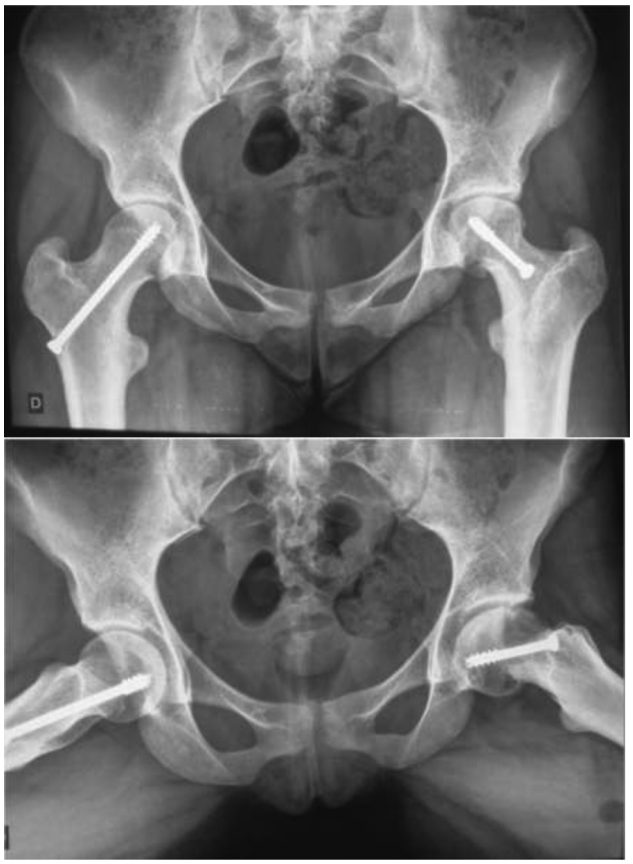

Fig. 4 Anteroposterior radiograph (above) and in Lauenstein profile (below) of the pelvis in the postoperative period showing the correction of the deformity.

During the arthroscopy, a chondrolabral lesion was found in the anterolateral ridge of the acetabulum (►**Figure 2**), compatible with cam-type FAI (►**Figure 3**), which was confirmed during the dynamic evaluation in the intraoperative period. Labrum debridement and osteochondroplasty of the femoral neck and acetabular ridge were performed, with the aid of fluoroscopy to control the head-neck offset. After the procedure, the dynamic assessment no longer showed any impingement. Postoperative radiographs showed correction of the prominence responsible for the impingement (►**Figure 4**).

Rehabilitation was started on the first postoperative day with assisted passive movement, active movement and walking with load restriction on the operated limb for two weeks.

In the first postoperative month, the patient already had significant improvement in pain and gait. There was an important gain in the internal rotation of the left hip and in the overall range of motion. At the third month, she walked without complaints of pain. At the sixth month, she returned to sports activities, being totally asymptomatic.

Discussion

The association between SCFE, symptomatic FAI and chondrolabral injury is currently well-established.[8] Even after epiphyseal stabilization, specific cases of SCFE may be suitable for arthroscopic treatment, which consists of an emerging technique with few long-term follow-ups.[9] Some studies suggest that arthroscopy can be applied even in severe epiphysiolysis deformities.[10]

Cheilectomy of the hip is a well-suited procedure for patients aged between10 and 14 years with a feeling of joint blockage secondary to pathologies of the hip in childhood and adolescence, consisting of a relatively simple technique, and free from major complications, which can delay the degenerative process of the joint for up to 10 to 15 years.[3]

The selection of patients who can benefit from arthroscopy depends on femoral morphology. The precise indication has not yet been established, but osteochondroplasty may be beneficial in cases of SCFE associated with a cam-type impingement. If the areas of impingement of the deformity are accessible to an arthroscopic approach, the surgeon should consider it instead of an open approach. However, the mechanical effect of different degrees of retroversion of the femoral neck, acetabular depth and orientation, and epiphyseal displacement must be considered before indicating an arthroscopic approach.[11]

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Lehmann CL, Arons RR, Loder RT, Vitale MG. The epidemiology of slipped capital femoral epiphysis: an update. J Pediatr Orthop 2006;26(03):286–290
2 Pritchett JW, Perdue KD. Mechanical factors in slipped capital femoral epiphysis. J Pediatr Orthop 1988;8(04):385–388
3 Guarnieiro R, Luzo CAM, Grigoletto Júnior W, et al. A queilectomia como operação de salvamento na patologia do quadril: resultados preliminares. Rev Bras Ortop 1995;30(1/2):42–44

4 Dodds MK, McCormack D, Mulhall KJ. Femoroacetabular impingement after slipped capital femoral epiphysis: does slip severity predict clinical symptoms? J Pediatr Orthop 2009;29(06): 535–539
5 Leunig M, Casillas MM, Hamlet M, et al. Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. Acta Orthop Scand 2000;71 (04):370–375
6 Basheer SZ, Cooper AP, Maheshwari R, Balakumar B, Madan S. Arthroscopic treatment of femoroacetabular impingement following slipped capital femoral epiphysis. Bone Joint J 2016;98-B(01):21–27
7 Mahran MA, Baraka MM, Hefny HM. Slipped capital femoral epiphysis: a review of management in the hip impingement era. SICOT J 2017;3:35
8 Abraham E, Gonzalez MH, Pratap S, Amirouche F, Atluri P, Simon P. Clinical implications of anatomical wear characteristics in slipped capital femoral epiphysis and primary osteoarthritis. J Pediatr Orthop 2007;27(07):788–795
9 Leunig M, Horowitz K, Manner H, Ganz R. In situ pinning with arthroscopic osteoplasty for mild SCFE: A preliminary technical report. Clin Orthop Relat Res 2010;468(12):3160–3167
10 Akkari M, Santili C, Braga SR, Polesello GC. Trapezoidal bony correction of the femoral neck in the treatment of severe acute-on-chronic slipped capital femoral epiphysis. Arthroscopy 2010; 26(11):1489–1495
11 Zaltz I, Kelly BT, Larson CM, Leunig M, Bedi A. Surgical treatment of femoroacetabular impingement: what are the limits of hip arthroscopy? Arthroscopy 2014;30(01):99–110

Comments on the Article 'Radiological Evaluation of the Femoral Tunnel Positioning in Anterior Cruciate Ligament Reconstruction'

Comentários sobre o artigo "Avaliação radiológica do posicionamento do túnel femoral na reconstrução do ligamento cruzado anterior"

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Dear Editor,

The debate on the ideal positioning of femoral tunnels is an important topic of research in recent times. In this regard, the article by Peres et al is very important, because it evaluates and compares the inclination angles and femoral tunnel lengths between two commonly used techniques of anterior cruciate ligament (ACL) reconstruction.[1] We found that they have made a very good comparison between the transtibial and the transportal techniques. They have used the coronal plane inclination angle and the femoral tunnel length as variables for comparison between the two techniques.

In this study, the authors have compared the femoral tunnel lengths in the coronal plane using a computed tomography (CT) based evaluation. This method of estimation of femoral length has serious flaws, as they are measuring the length in the coronal plane, while the tunnel is drilled at an angle starting posteriorly and ending anteriorly. This has been explained by providing examples from cases performed in our institute.

►**Fig. 1** shows two coronal images of the same patient, in whom the femoral tunnel has been drilled using transportal technique. The CT scan was performed 1 week after the surgery. The coronal cuts are taken at different depths from the anterior femoral articular surface. As can be clearly seen, there can be a significant difference in the measurement of femoral tunnel lengths at different positions from the anterior surface. The reason for this difference is that the tunnel is not drilled parallel to the coronal axis. Rather, it is drilled at an anteroposterior angle, with the entry point being more posterior than the exit point.

We recommend that the femoral tunnel length can be best measured in axial plane CT scans using curved reformats, as shown in ►**Fig. 2**. Curved reformatting allows us to visualize the entire tunnel in its length and provides accurate length. A similar method of calculating the femoral tunnel length has been used by Sim et al in their article comparing two techniques of femoral tunnel preparation.[2]

Excluding this error, we find that the article provides valuable information about the femoral tunnel placement in both techniques.

Conflicts of Interests

The authors have no conflicts of interests to declare.

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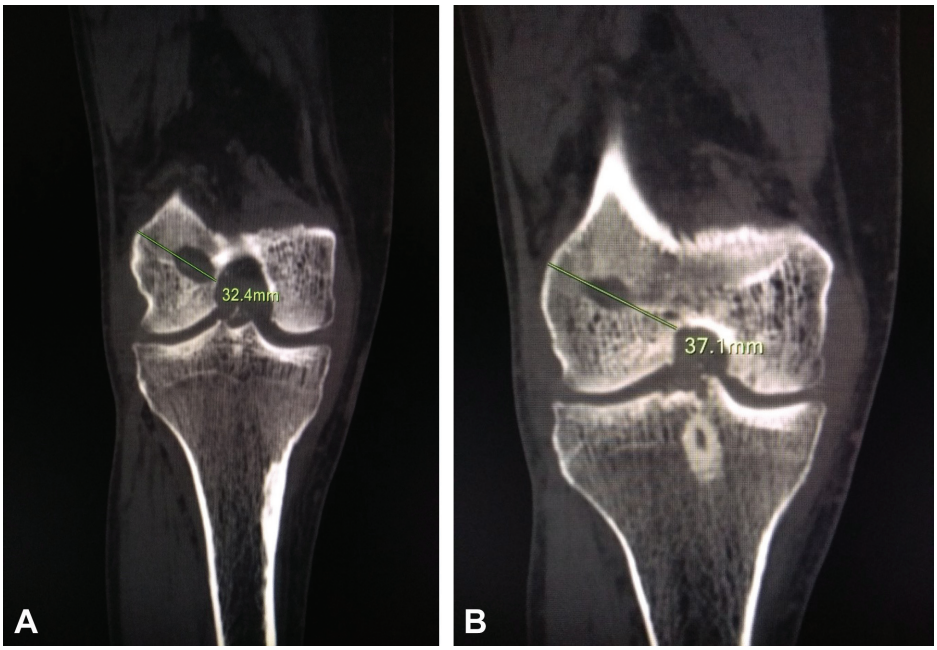

Fig. 1 Coronal computed tomography images of the same patient showing two different femoral tunnel lengths at two different positions.

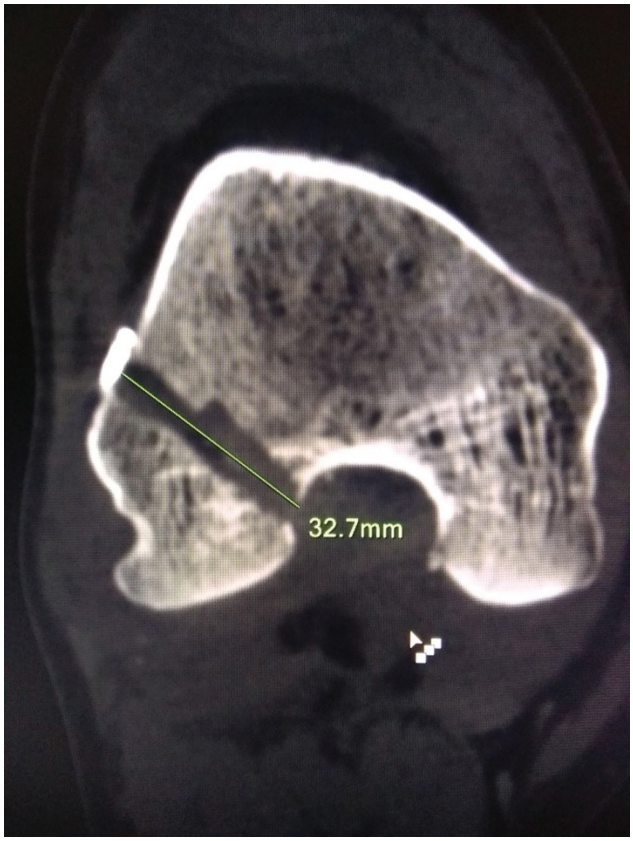

Fig. 2 Axial curved reformatted computed tomography image visualizing the entire femoral tunnel and measuring the exact femoral tunnel length.

References

1 Peres LR, Teixeira MS, Scalizi Júnior C, Akl Filho W. Radiological evaluation of the femoral tunnel positioning in anterior cruciate ligament reconstruction. Rev Bras Ortop 2018;53(04):397–403
2 Sim JA, Kim JM, Lee S, Song EK, Seon JK. No difference in graft healing or clinical outcome between trans-portal and outside-in techniques after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2018;26(08):2338–2344

Answer to the Letter to the Editor Regarding the Comments on the Article "Radiological Evaluation of the Femoral Tunnel Positioning in Anterior Cruciate Ligament Reconstruction"

Resposta à carta ao editor referente aos comentários sobre o artigo "Radiological Evaluation of the femoral Tunnel Positioning in Anterior Cruciate Ligament Reconstruction"

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Dear editor,

First of all, we would like to thank you for your interest in our article. We appreciate your references regarding our study.

The main objective of our study was to evaluate the inclination and length of femoral tunnels and to compare the measurements obtained through computed tomography (CT) and anteroposterior (AP) radiography. Since the femoral tunnel is oblique, there is no supplementary test nor gold standard method to measure its length. Length assessment in an axial CT or CT with three-dimensional (3D) reconstruction seems more reliable. However, as described in our study and reported by the cited authors, the difficulty in comparing different tests is evident, mainly because radiography is subject to a bias regarding knee positioning in addition to the overlap and magnification of anatomical bone landmarks.

The radiological measurements in AP view were based on a line that inferiorly touches the image formed by the overlap of the entire femoral condyle, not considering femoral rotation. Since the femoral tunnel is oblique, a CT standard axial section does not consider a more proximal position of the anatomical curvature of the condyle. Therefore, any comparison is unfeasible, since these reference lines may not be parallel.

Therefore, we decided to measure the inclination and length of the femoral tunnel at the same tomographic position, considering the lower portion of the femoral condyles. A perfect comparison between tests would require the knowledge of the real anatomical inclination and length of the femoral tunnel, either in a cadaveric evaluation or using an anatomical model made with a 3D printer.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Hensler D, Working ZM, Illingworth KD, Tashman S, Fu FH. Correlation between femoral tunnel length and tunnel position in ACL reconstruction. J Bone Joint Surg Am 2013;95(22): 2029–2034

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In Memoriam

Arnaldo Amado Ferreira Filho (1930–2020)

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Fig. 1 Arnaldo Amado Ferreira Filho.

Arnaldo Amado Ferreira Filho (►**Fig.1**), one of the fathers of shoulder surgery in Brazil, passed away from natural causes in his home on November 10, 2020, at the age of 90.

A graduate of The School of Medicine of Universidade de São Paulo (Faculdade de Medicina da Universidade Federal de São Paulo, FMUSP, in Portuguese) in 1955, Dr. Ferreira Filho spent his entire professional life at this institution. He was in charge of the hemophilia outpatient facility, in which he gathered data for his master's degree thesis in 1978. His interest in shoulder surgery began in the 1970s, when he started to treat recurrent shoulder dislocation with bone block with what was then called the Bristow-Latarjet technique, the subject of his doctoral thesis from 1984.

The teaching of shoulder surgery in Brazil started with the first specialized outpatient clinic at the Teaching Hospital at FMUSP, in 1983, coordinated by Dr. Ferreira Filho. There, he trained dozens of specialists, and many of them continue to form new generations. In the 1980s and 1990s, shoulder pathology dominated his professional activities, and Dr. Ferreira Filho traveled throughout Brazil and neighboring countries to disseminate his specialty at a time when little was known about it and the surgical arsenal was still rudimentary. Its first arthroscopic material did not have a monitor, and the limited visual field was obtained through "vision"!

Dr. Ferreira Filho actively participated in the creation of the Shoulder and Elbow Committee of the Brazilian Society of Orthopedics and Traumatology (Comitê de Ombro e Cotovelo da Sociedade Brasileira de Ortopedia e Traumatologia, COC-SBOT, currently called Sociedade Brasileira de Cirurgia do Ombro e Cotovelo, SBCOC, in Portuguese) in Brasília, Brazil, at the 1988 Brazilian Congress on Orthopedics and Traumatology (Congresso Brasileiro de Ortopedia e Traumatiologia, CBOT, in Portuguese). When nominated as the first president of the new institution, Dr. Ferreira Filho renounced the distinction and indicated his friend Donato D'Ângelo, from Rio de Janeiro. This is why the next generation started to call them the "Fathers of Shoulder Surgery in Brazil."

Dr. Ferreira Filho made several international contributions to shoulder surgery, paving the way for future endeavors. In 1992, Charles Neer invited him to be an editor at the new *Journal of Shoulder and Elbow Surgery*, a unique honor. Back then, Dr. Ferreira Filho indicated Sérgio Checchia, Sérgio Nicoletti, Paulo Sérgio dos Santos, Donato D'Ângelo, Américo Zoppi Fo, and Osvandré Lech as associate editors. In a handwritten letter, Neer thanked Dr. Ferreira Filho: "The Founding Trustees are delighted the South Americans have appointed such an outstanding staff and adopt our Journal as their official Journal […]."

The South American Shoulder and Elbow Society (currently called Latin American Shoulder and Elbow Society, Sociedad Latinoamericana de Hombro y Codo, SLAHOC, in Spanish) was founded at the 1994 CBOT in the city of Salvador, Brazil, with Charles Neer as the "inaugural lecturer". On the occasion, Dr. Ferreira Filho was appointed as the first president. In addition, since 1994 Dr. Ferreira Filho was an international correspondent member of the American Shoulder and Elbow Surgeons (ASES).

Dr. Ferreira Filho ended his activities at USP in 1998, but remained active in his private practice until recently. He participated in several international congresses on shoulder and elbow (initially at the International Congress of Shoulder and Elbow Surgeons [ICSS], then at the International Congress on Shoulder and Elbow Surgery [ICSES]). Dr. Ferreira Filho was honored as a "Pioneer" in 2001, in Cape Town, South Africa, when Brazil was nominated as host of the 2007 ICSS.

Known to all by his vast general culture, Dr. Ferreira Filho would talk about art, music, literature, history etc. with a notable volume of information.

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In the early 1990s, the notable Hiroaki Fukuda, during his only visit to Brazil to speak at the International Update Congress on Orthopedics (Congresso Internacional de Atualização em Ortopedia e Traumatologia, ORTRA, in Portuguese), and after talking at length with Dr. Ferreira Filho, asked him: "Where did you learn so much about shoulder surgery?". The answer was simple: "During my residency training and studying by myself." Fukuda had before him a self-taught shoulder surgeon, something rare at the time and nonexistent today... He was impressed by the fact and repeated the story many times. Self-education along with a rigid process of learning from experience, carefully following the bibliography and keeping an open mind for innovations, is the best way to define Dr. Ferreira Filho's impressive scientific trajectory. He used to say that "The scientific spirit does not come from institutions, but from people who think freely."

Dr. Ferreira Filho leaves his wife Vera, children Fernando and Arnaldo, daughter-in-law Christina, grandchildren Sylvia, Vitória and Gustavo, and great-granddaughter Ava, family members and a legion of admirers.

Attributed to Leonardo da Vinci, the quote "As a well-spent day brings happy sleep, so a life well spent brings happy death" reflects the life and work of the brilliant Professor Arnaldo Amado Ferreira Filho.

Rest in Peace.

In Memoriam

Arnaldo Amado Ferreira Filho: A pioneer in shoulder and elbow surgery in Brazil

Arnaldo Amado Ferreira Filho: Pioneirismo na cirurgia de ombro e cotovelo do Brasil

Arnaldo Amado Ferreira Neto[1]

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Dr. Arnaldo Amado Ferreira Filho was born on November 1, 1930, in São Paulo, Brazil. He graduated from the Faculdade de Medicina da Universidade de São Paulo (FMUSP) in 1955, in the 38th class. He completed his training in orthopedics at the Instituto de Ortopedia e Traumatologia (IOT) from the Hospital das Clínicas, FMUSP, Brazil, in 1956, and soon joined the institution as an assistant in 1957.

A general orthopedic surgeon, Dr. Ferreira Filho worked in outpatient and surgical care in several orthopedics areas, including hand surgery, spine conditions, pediatric orthopedics, treatment of poliomyelitis sequelae, obstetric paralysis, and hemophilia. Dr. Ferreira Filho held a Master's degree and a PhD in orthopedics and traumatology from the FMUSP in 1978 and 1984, respectively.

As an assistant at the Instituto de Ortopedia and Traumatologia (IOT) from HC-FMUSP, Dr. Ferreira Filho carried out numerous associate, administrative and research activities as founder and Head of the Hemophilia Group, Head of the Emergency Department and Orthopedic Clinic, Head of the Clinical Staff, and the first Scientific Committee from the Orthopedics and Traumatology Department.

However, Dr. Ferreira Filho really stood out in shoulder and elbow surgery. Together with Professor Manlio Marco Mario Napoli, Dr. Ferreira Filho was the founder of the first Shoulder and Elbow Group in Brazil and Latin America in 1983. Soon after, he took over as head until 1998. His interest in shoulder and elbow surgery dates back to the early 1960s, when caring for children with obstetric paralysis sequelae and working in the first surgeries to treat shoulder instability. Dr. Ferreira Filho performed the first Bristow-Latarjet procedure in 1972, culminating in his doctoral thesis – Treatment of Recurrent Anterior Dislocation of the Shoulder by the Bristow-Latarjet Technique – a study with 45 cases, defended in 1984. His thesis was a landmark and a reference in shoulder instability treatment, followed by numerous Brazilian services. His passion for teaching and the pursuit of knowledge comes from his self-taught drive and constant monitoring of the medical literature. An interesting passage from his teaching life was during the International Congress on Orthopedics (ORTRA), in the 1990s. After a long, informal conversation, Professor Hiroaki Fukuda, lecturer and international guest, asked Dr. Ferreira Filho: *"where did you learn so much about shoulder surgery?"*. The answer was simple: *"during my residency training and studying by myself"*. Dr. Ferreira Filho was always open to innovations and encouraged those looking for the most recent developments. In countless surgeries, he used to say that "*the scientific spirit does not come from institutions, but from people who think freely*".

Shoulder and elbow surgery projected Dr. Ferreira Filho both nationally and internationally. He was a founder of the Shoulder and Elbow Committee of the Brazilian Society of Orthopedics and Traumatology (SBOT) in 1988, and the second chairman of this committee in the 1990-1992 board of the now called Brazilian Society of Shoulder and Elbow Surgery (SBCOC). Dr. Ferreira Filho was the founder and first president of the South American Shoulder and Elbow Society, now Latin American Shoulder and Elbow Society (SLAHOC).

When the Journal of Shoulder and Elbow Surgery (JSES) was introduced, in 1993, Dr. Ferreira Filho was invited by Prof. Charles Neer to be part of this prestigious magazine as a SBCOC representative, working as the editor for South

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America until 1996. In 1994, he was elected International Correspondent Member of American Shoulder and Elbow Surgeons (ASES), and later became a Senior Member.

In 1998, Dr. Ferreira Filho retired from his institutional activities but remained working at his private office and participating in numerous congresses in Brazil and abroad, standing out as a delegate at the International Congresses on Shoulder and Elbow Surgery (ICSES). Dr. Ferreira Filho was a true independent thinker, choosing the best ideas from various authors to develop his own concepts. His passion and thoroughness for teaching were endless. His dedication is recognized unconditionally by his peers. He trained countless colleagues throughout Brazil and abroad, and always called them friends.

He was an avid reader, learning to love books and the history of humanity with his father, Prof. Arnaldo Amado Ferreira, Associated Professor at Forensic Medicine Department at FMUSP.

Family man, exemplary husband, demanding father, father-in-law, grandfather and, recently, great-grandfather. Righteous citizen, man of the world, admired by many.

Here is his legacy…Applause…

Revista Brasileira de Ortopedia

Instruções aos Autores

Muito obrigado por contribuir com a *Revista Brasileira de Ortopedia*. Por favor, leia cuidadosamente as instruções a seguir. A falta de concordância com essas instruções pode causar atrasos desnecessários na publicação de seu artigo.

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- Todos os autores: nome completo, departamento, afiliação.
- Autor correspondente: nome complete, maior título, departamento, afiliação, endereço de correspondência, telefone e e-mail.

☐ MANUSCRITO
- Deve ser um arquivo digital – cópias impressas não serão aceitas.

☐ RESUMO E PALAVRAS-CHAVE
- Veja a seção Tipo de Artigo.

☐ REFERÊNCIAS
- Citadas sequencialmente em estilo AMA.

☐ FIGURAS E TABELAS
- Citadas sequencialmente no manuscrito, salvas em arquivos separados do manuscrito.

☐ ARTES
- Devem ser salvas a parte do manuscrito.

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SUMÁRIO

A Revista Brasileira de Ortopedia (RBO) é a publicação oficial da Sociedade Brasileira de Ortopedia e Traumatologia (SBOT) com o objetivo de divulgar artigos que contribuam positivamente com a prática, a pesquisa e o ensino de Ortopedia e áreas correlatas. A RBO é publicada bimestralmente em fevereiro, abril, junho, agosto, outubro e dezembro, e tem sido publicada regularmente desde sua 1ª edição em 1965. A revista é dedicada aos ortopedistas associados à SBOT, profissionais da saúde dedicados a atividades similares e ortopedistas em outros países.

FORMATO DO MANUSCRITO

Tipos de Artigo

A tabela a seguir mostra os tipos de artigos aceitos para publicação e seus requisitos.

Tipos de Artigo	Limite para Resumo	Limite de Palavras chave	Limite para Títulos	Figuras/Tabelas	Referências
Artigo Original (Até 2,500 palavras)	Até 250 palavras	6	não aplicável	10 Figuras e 6 Tabelas	Até 30 referências
Artigo de Atualização (Até 4,000 palavras)	Até 250 palavras	6	não aplicável	3 Figuras e 2 Tabelas	Até 60 referências
Artigos de Revisão Sistemática e Meta-análise (Até 4,000 palavras)	Até 250 palavras	6	não aplicável	3 Figuras e 2 Tabelas	Até 60 referências
Relato de Caso (Até 1.000 palavras)	Até 250 palavras	6	não aplicável	5 Figuras	Até 10 referências
Nota Técnica (Até 1.500 palavras)	Até 250 palavras	6	não aplicável	5 Figuras e 2 Tabelas	Até 8 referências
Carta ao Editor (Até 500 palavras)	N/A	N/A	não aplicável	2 Figuras	Até 4 referências
Editorial (Até 500 palavras)	N/A	N/A	não aplicável	N/A	N/A

- **Artigo Original**: Descreve pesquisa experimental ou investigação clínica - prospectiva ou retrospectiva, randomizada ou duplo cego. Deve ter: Título, Resumo estruturado (Objetivo, Métodos, Resultado e Conclusão), Palavras-chave, Introdução, Materiais e Métodos, Resultados, Discussão, Conclusões e Referências. Máximo de 2.500 palavras, 30 referências, 10 figuras e 6 tabelas.
- **Artigo de Atualização**: Revisões do estado da arte sobre determinado tema, escrito por especialista a convite do editor-chefe. Deve ter: Título, Resumo (não estruturado), Palavras-chave e Referências. Máximo de 4.000 palavras, 60 referências, 3 figuras e 2 tabelas.
- **Artigos de Revisão Sistemática e Meta-análise**: Tem como finalidade examinar a bibliografia publicada sobre determinado assunto fazendo avaliação crítica e sistematizada da literatura sobre certo tema específico, além de apresentar conclusões importantes baseadas nessa literatura. Deve ter: Título, Resumo (não estruturado), Palavras-chave, Introdução, Materiais e Métodos, Resultados, Discussão, Considerações Finais e Referências. Máximo de 4.000 palavras, 60 referências, 3 figuras e 2 tabelas.
- **Relato de Caso:** Deve ser informativo e não deve conter detalhes irrelevantes. Só serão aceitos os relatos de casos clínicos de interesse, quer pela raridade como entidade nosológica, ou ainda pela forma não usual de apresentação. Deve ter: Título, Resumo (não estruturado), Palavras-chave, e Referências. Máximo de 1.000 palavras, 10 referências e 5 figuras.
- **Nota Técnica:** Destina-se à divulgação de método de diagnóstico ou técnica cirúrgica experimental, novo instrumental cirúrgico, implante ortopédico, etc. Deve ter: Título, Resumo (não estruturado), Palavras-chave, Introdução Explicativa, Descrição do Método, do Material ou da Técnica, Comentários Finais e Referências. Máximo de 1.500 palavras, 8 referências, 5 figuras e 2 tabelas.
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- **Editorial**: Escritos a convite do editor-chefe, apresentando comentários de trabalhos relevantes da própria revista, pesquisas importantes publicadas ou comunicações dos editores de interesse para a especialidade. Máximo de 500 palavras.

Guia Geral

- A submissão deve ser em formato digital. Cópias impressas não serão aceitas.
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- O Manuscrito, incluindo a Folha de Rosto, o Resumo e as palavras-chave, o texto, as referências, títulos e legendas de figuras e tabelas devem ser digitadas em espaço duplo, fonte em tamanho 12 com 2,5 cm para todas as margens salvas em um arquivo.
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- Use nomes genéricos de drogas. Você pode citar nomes registrados entre parênteses seguidos do fabricante e local de origem.
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Checklist de Arquivos e Informação:

- Um dos autores deve ser designado como correspondente. O e-mail e endereço de correspondência devem ser incluídos na Folha de Rosto. Para maiores detalhes, veja a seção Folha de Rosto.
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  - Incluir palavras-chave
  - Todos os títulos e legendas de Figuras
  - Todas as Tabelas (incluindo título, descrição, legendas e notas)
  - Assegurar que todas as Figuras e Tabelas citadas no texto combinem com os arquivos fornecidos
  - Indicar com clareza como as cores devem ser usadas nas Figuras
  - Arquivos complementares (supplemental files)
- Considerações adicionais
  - O manuscrito deve ser submetido a algum corretor ortográfico
  - Todas as referências devem ser citadas no texto e listadas ao final
  - Concessões devem ser obtidas se for usado material protegido por copyright (incluindo da internet)
  - Quaisquer conflitos de interesse devem ser declarados, mesmo que não haja nenhum a declarar
  - As instruções da revista devem ser revistas e consideradas

Idioma

Os artigos devem ser escritos em Português ou Inglês.

Folha de Rosto

- A RBO adota a revisão duplo-cego (double-blinded peer-review policy). A Folha de Rosto **n**ã**o** deve fazer parte do manuscrito e deve ser fornecida separadamente.
- Título: Conciso e informativo. Títulos são normalmente usados em sistemas de busca de informação. Evite abreviações e fórmulas sempre que possível.
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Veja a seção Tipo de Artigo para limite de palavras.

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Um resumo estruturado pode demonstrar o contexto e a base do estudo, assim como apresentar seu objetivo, método, resultados e principais conclusões. Deve ressaltar os aspectos novos e relevantes do estudo ou observações.

Os resumos podem ter no máximo 250 palavras e estruturados no seguinte formato: Objetivo: Uma ou duas frases que afirmem de forma simples o propósito do estudo. Métodos: Fornecer detalhes sobre o método do estudo, incluindo análise de dados. Resultados: Apresentar os achados mais importantes do estudo. Por favor, forneça números (médias com desvios-padrão ou medianas com amplitude) para fundamentar seus achados e resultados. Conclusões: Uma ou duas frases com o que seu estudo identificou e de fato demonstrou. Por favor não inclua comentários ou afirmações sem o suporte de dados do seu estudo. Nível de evidência (para estudo envolvendo pessoas) ou Relevância Clínica (ciências básicas *in vitro* ou *in vivo*).

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- Artigos Originais, Revisões Sistemáticas e Meta-análises devem trazer textos estruturados (Introdução, Métodos, Resultados e Discussão).
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- Usar nomes genéricos de drogas ou aparelhos. Se uma marca em particular for usada no estudo, informar junto ao nome registrado o fabricante e a cidade entre parênteses.
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Reúna agradecimentos em uma seção a parte ao final do artigo, antes das referências e não as inclua na Folha de Rosto. Cite aqui aqueles que ajudaram na pesquisa (e.g. revisando o idioma, ajudando na redação ou revisando o texto, etc.).

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Referências devem ser as mais recentes possíveis e pertinentes à literatura disponível. É essencial que estejam completas e checadas. Se a referência informada estiver incompleta, boas opções para busca são a National Library of Medicine: www.nlm.nih.gov; Books in Print: www.booksinprint.com; PubMed: www.ncbi.nlm.nih.gov/PubMed/; ou o website da editora.

- Referências devem ser listadas no estilo AMA, usando o Index Medical *journal title abbreviation*.
- Referências devem vir ao final do texto. Abra uma linha antes de relacionar as referências.
- Referências devem ser citadas de forma sequencial no texto em ordem numérica (não alfabética).
- Cita todos os autores até o sexto autor. Se mais de 6 autores, citar os 3 primeiros seguidos de et al.
- Referências devem seguir estilo conforme os exemplos a seguir:

1. Artigo de revista:
   Borges JLP, Milani C, Kuwajima SS, Laredo Filho J. Tratamento da luxação congênita de quadril com suspensório de Pavlik e monitorização ultra-sonográfica. Rev Bras Ortop 2002;37(1/2):5-12
2. Capítulo de livro:
   Johnson KA. Posterior tibial tendon. In: Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995. p. 43-51
3. Livro:
   Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995
4. Tese:
   Laredo Filho J. Contribuição ao estudo clínico-estatístico e genealógico-estatístico do pé torto congênito equinovaro [tese]. São Paulo: Universidade Federal de São Paulo colocar virgula Escola Paulista de Medicina; 1968
5. Publicação governamental:
   Food and Drug Administration. Jin Bu Huan Herbal Tablets. Rockville, MD: National Press Office; April 15, 1994. Talk Paper T94-22
6. Artigo online:
   Lino Junior W, Belangero WD. Efeito do Hólmio YAG laser (Ho: YAG) sobre o tendão patelar de ratos após 12 e 24 semanas de seguimento. Acta Ortop Bras [periodical on the Internet] 2005 [cited 2005, Aug 27];13(2):[about 5 p.] Available from: http://www.scielo.br/ scielo
7. Artigo de simpósio:
   Eisenberg J. Market forces and physician workforce reform: why they may not work. Paper presented at: Annual Meeting of the Association of American Medical Colleges; October 28, 1995; Washington, DC

Título e legenda de Figura

- Figuras vão de fotografias ou radiografias, ilustrações, gráficos, quadros, fluxogramas e organogramas, mas NÃO tabelas.
- Figuras devem ser citadas em ordem numérica. Enumere todas as figuras (e títulos correspondentes) de forma sequencial em ordem numérica no texto.
- Títulos de Figuras devem ser escritos após as referências. Abra uma linha antes de inserir os títulos das Figuras.
- Títulos de Figuras devem incluir uma descrição da figura e/ou subparte (A, B, etc.), assim como quaisquer símbolos, setas, asteriscos etc.
- Para Figuras emprestadas ou adaptadas de outra publicação (com a devida permissão), o crédito da fonte deve ser informado ao final de cada legenda entre parênteses. Este crédito deve ser completo com a referência bibliográfica da fonte ou o copyright.

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- Dados em tabelas devem ser comentados, mas sem repetição no texto. Assegure-se de ter colunas e linhas compostas por um programa de texto adequado.
- Não intercale tabelas em meio ao texto. Tabelas devem vir ao final com seus respectivos títulos e legendas.
- Tabelas devem ter espaço duplo e numeração na sequência em que são citadas no texto. Um curto título descritivo deve ser fornecido.
- Se uma tabela contém imagem ou arte, forneça a arte em arquivo à parte.

- Para tabelas emprestadas ou adaptadas (com a devida permissão), o crédito da fonte deve ser informado ao final de cada legenda entre parênteses. Este crédito deve ser completo com a referência bibliográfica da fonte ou o copyright.
- Outras notas de referência da tabela devem ser indicadas com letras sobrescritas em ordem alfabética.
- Qualquer abreviação usada na tabela deve ser descrita na legenda.

Vídeos

- São aceitos os seguintes formatos: *.avi, *.mov and *.mpg.
- Para vídeos complementares, a extensão não pode exceeder 4 minutos e a legenda não pode ter mais de 40 palavras por video ou sequência.
- Se houver som sobre o video, deve ser em inglês e com clareza. Ser preciso, informativo e claro em sua fala.

Material Complementar

Material complementar como aplicações, imagens e podcasts podem ser publicados em seu artigo para aprimorá-lo. O material complementar submetido é publicado tal como fornecido. Por favor, envie seu material junto ao artigo e forneça uma descrição concisa para cada item. Se desejar alterar o material complementar, por favor forneça o arquivo atualizado.

PREPARAÇÃO DE ARTE DIGITAL

Guia Geral

- O ideal é usar o Adobe Photoshop para criar e salvar imagens, e Adobe Illustrator para dísticos e textos.
- Evite criar arte em Microsoft Excel, Word ou PowerPoint.
- Salve cada figura em um arquivo separado.
- Não compactar os arquivos.
- Todas as artes em preto & branco e em cores devem ter o menos resolução de 300 dpi (*dots per inch*) em formato TIFF. Arquivos desenhados devem ter 1.200 dpi em formato EPS ou TIFF. Contate o editor de produção da Thieme se estiver inseguro quanto ao tamanho final.
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  Nota: Resoluções menores (inferiores a 300 dpi) e formato JPEG (.jpg) para escalas de cinza e em cor não são ideais devido à baixa qualidade. O formato JPEG, por definição, é uma resolução menor (compactada) destinadas a rápidos uploads em telas de computador.

Arte em preto & branco (PB)

- Artes em PB podem ser fotografias, radiografias, ilustrações, gráficos ou fluxogramas. A Thieme aceita somente arte em formato digital.
- Se possível, não envie arte em cores para conversão em PB. Faça a conversão antes de enviar para que você possa verificar o resultado antes, evitando perda de detalhes importantes.
- Para melhores resultados, desenhos devem ser em PM em um fundo branco.

Arte em cores

- Toda arte em cores deve ser salva em CMYK, não em RGB.

Dísticos

- Setas, asteriscos e outros símbolos devem ser escuros sobre fundos claros e em formatos maiores. Caso contrário, estes marcadores podem ser difíceis de ver após redução da resolução.
- Use iniciais maiúsculas em cada item de texto. Considere usar todas as maiúsculas se precisar de maior destaque.
- Assegure-se de usar textos e símbolos consistentes a todas as figuras.
- Evite usar fontes ou tamanhos diferentes no texto.

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