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Visibility

Dr. Ernesto Bersusky
Executive Editor of the Journal of the Asociación Argentina de Ortopedia y Traumatología

Dear readers:

Recently, the article "Sacrectomía parcial por abordaje posterior único. [Partial sacrectomy by single posterior approach.]" by doctors Pedro L. Bazán, Sergio Terraza, Álvaro E. Borri and Martín Medina,[1] carried out at the Hospital Interzonal General de Agudos "General San Martín" in La Plata, and published in our Journal in 2017, has reached 2,500 readings.

This is due to a series of factors and conditions that somehow add up to the success of scientific work:

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2) Authors known by peers.

3) A title that summarizes the hypothesis in a complete and attractive sentence for the reader.

4) Academic prestige.

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1) Quality of published work

Without a doubt, this factor is determined by the authors. However, there is an interaction between the AUTHOR-EDITOR-REVIEWER, who are in charge of making corrections and suggestions to improve the article's quality.

The RAAOT policy is that the manuscript that is submitted for review is not qualified, but rather improved as much as possible. As a result, the author must understand that the reviewers' comments are intended to improve the article to the superlative level and that there is no animosity toward the authors, but rather the opposite.

Our Journal has Section Editors and Reviewers according to the subspecialties of Orthopedics and Traumatology, who work hard and ad honorem to achieve the quality objectives of the Journal.

2) Authors known by peers

When an author or a group publishes and their works are of high quality, their name and surname are sufficient to entice readers to read a particular manuscript.

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The title is paramount. It should summarize the most outstanding fact of the research carried out and be written in an attractive way to arouse the curiosity of the reader.

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4) Academic prestige

With the advent of the Internet and, later, the policy of open access to research, multiple research journals have emerged, some of questionable quality or completely non-scientific, without indexing or with false indexing, all under the guise of "Open Access." (This has been developed by us in another Editorial[2]).

RAAOT complies with all the ethical rules of the *Committee of Publication Ethics* (COPE), as well as other institutions: *Council of Science Editors* (CSE), *International Committee of Medical Journal Editors* (ICMJE), adopting all the resolutions and recommendations of said institutions.

This optimizes the quality of what is published. Readers are familiar with the journals and know which ones can be trusted.

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The visibility depends on the databases in which the Journal is indexed and the repositories where the articles are deposited, safeguarding them over time.

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Our journal is available in Google Scholar within 24-48 hours of publication, regardless of indexing in SciELO, DOAJ, or other indexers. At the moment, Google Scholar is the most frequently used because it has access to all original articles that are available in Open Access.

All of this requires a massive effort on the part of the Journal's entire Editorial Board, which includes a remarkable team of professionals whose sole goal is to show the world the production of Argentine and Latin American knowledge. We are proud of the Journal's visibility and congratulate the authors of the most-read article.

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2. Bersusky E. Las editoriales predadoras. [Predatory publishers.]. *Rev Asoc Argent Ortop Traumatol* 2017; 82(2): 89-90. https://doi.org/10.15417/696

Case Presentation

Rodrigo Re,[*] Santiago L. Iglesias,[**] Bartolomé L. Allende[**]
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Case Resolution on page 257.

The patient was a 28-year-old woman from La Rioja who worked as an Intensive Care Unit nurse. She sought treatment for one year of progressive right coxalgia. She had limitations when walking and had recently been forced to rest. She was diagnosed with acetabular friction syndrome, and analgesic treatment had little effect on her. She came to our facility after being advised to undergo an arthroscopy.

During the consultation, she described intense progressive pain and difficulty walking. Pain was detected during the physical examination during both active and passive movements. There were no palpable tumors, and she had no previous trauma history.

Panoramic radiographs of the pelvis (Figure 1) and right hip (Figure 2) were requested.

Figure 1. Panoramic pelvic radiograph. Incipient arthritic changes with acetabular overcoverage are observed (arrow).

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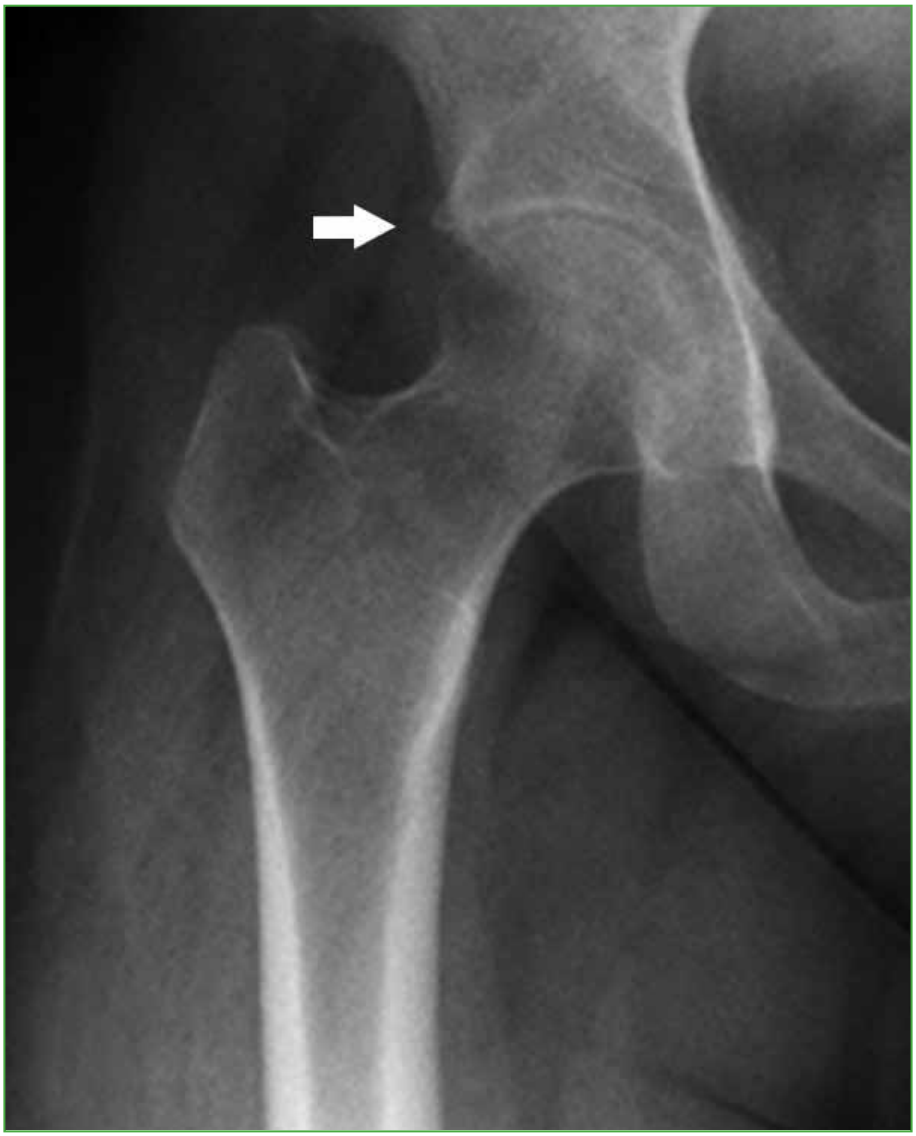

Figure 2. Right hip radiograph. Incipient arthritic changes with acetabular overcoverage are visualized. No soft tissue lesions are observed.

FINDINGS AND INTERPRETATION OF IMAGING STUDIES

Panoramic radiographs of the pelvis and right hip showed incipient arthritic changes with minimal acetabular overcoverage. No lytic or blastic lesions were visible.

Due to the persistence of pain, the imaging studies were completed with an MRI of the right hip.

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Usefulness of the Measurement of the Psoas and Paraspinal Muscles by Computed Tomography and Magnetic Resonance

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ABSTRACT

Background: Sarcopenia is becoming increasingly significant in the research of various diseases to predict morbidity and mortality in the perioperative period. **Objectives:** The objectives of this study were to evaluate the efficacy of computed tomography and magnetic resonance imaging in measuring the psoas and paraspinal muscles and to compare these indexes with age, sex, and pathology. **Materials and Methods:** Computed tomography and magnetic resonance imaging of outpatients were used. Muscle measurements were taken at the L3 and L4 pedicles. **Results:** The study included 18 CT and 34 MRI scans. The patients were divided into groups based on their age range, which was 15 to 80 years. In the overall averages, males were above the global average in both studies. Regarding age ranges, it was observed that the first group (15–29 years) had a higher muscle volume and Hounsfield units in the psoas compared to the >60 age group. Patients consulting for spondylolisthesis had less muscle mass than those with discopathy. **Conclusions:** There is no difference between magnetic resonance imaging and computed tomography in measuring the paraspinal and psoas muscles. It is evident that the decrease in muscle volume is common in older patients and those with diseases that affect spinal balance.

Keywords: Sarcopenia; Hounsfield units; spine; psoas; multifidus; fat infiltration.

Level of Evidence: IV

Utilidad de la medición de los músculos psoas y paraespinales mediante tomografía computarizada y resonancia magnética

RESUMEN

Introducción: La sarcopenia está revistiendo importancia en el estudio de diferentes enfermedades para predecir la morbimortalidad en el perioperatorio. Los objetivos de este estudio fueron evaluar la eficacia de la tomografía y la resonancia en la medición de la musculatura del psoas y los paraespinales, y comparar estos índices con la edad, el sexo y la enfermedad. **Materiales y Métodos:** Se utilizaron las tomografías computarizadas y las resonancias magnéticas de pacientes ambulatorios. La medición de los músculos se realizó en los pedículos de L3 y L4. **Resultados:** El estudio incluyó 18 tomografías y 34 resonancias. El rango de edad de los pacientes era de 15 a 80 años, divididos en grupos etarios. En los promedios globales, en ambos estudios, el sexo masculino estaba por encima del promedio global. Con respecto a los rangos etarios, se observó que el primer grupo (15-29 años) tenía un mayor volumen muscular y de unidades Hounsfield en el psoas comparado con el grupo >60 años. Los pacientes que consultaron por espondilolistesis tenían menos masa muscular que aquellos con discopatías. **Conclusiones:** No existe diferencia entre la resonancia magnética y la tomografía computarizada en cuanto a la medición de los músculos paraespinales y psoas. Queda en evidencia que la disminución del volumen muscular es común en pacientes de mayor edad y con enfermedades que afectan el balance espinal.

Palabras clave: Sarcopenia; unidades Hounsfield; columna; psoas; multífidos; infiltración grasa.

Nivel de Evidencia: IV

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INTRODUCTION

Sarcopenia is defined as the progressive and generalized loss of skeletal muscle mass and strength as a consequence of a sedentary lifestyle, poor diet and various diseases that force a reduction in physical activity.[1]

The size of the psoas muscle is used as a sarcopenia parameter rather than that of the paravertebral musculature, which does not appear to decrease in size but is replaced by fatty tissue in what is known as "fatty degeneration".[1]

Muscle mass indexes are described in numerous articles as a predictor of morbidity and recovery in patients undergoing various types of treatments or surgical interventions, not only spinal. Likewise, the results of other scientific studies are not conclusive regarding whether sarcopenia can influence the prognosis of each individual in particular.[1-8]

The objectives of this study were: to assess the efficacy of computed tomography and magnetic resonance imaging in measuring the psoas and paraspinal muscles, and to compare these indexes with age, sex, and disease.

MATERIALS AND METHODS

A prospective study was conducted using computed tomography and magnetic resonance imaging images of patients who attend daily consultations for various spinal conditions. 52 imaging studies were loaded into the Excel program. The computer programs used for data collection were KPACKS and DICOM. The volume of the psoas muscle and paraspinal muscles was measured in millimeters and Hounsfield units (HU). Measurements were made at L3 and L4, the level of the vertebral pedicles. A transverse line was drawn in the widest area of both muscles and a perpendicular line was drawn at the widest level of the psoas and at the base of the transverse process in the paravertebral gutter (Figure 1).

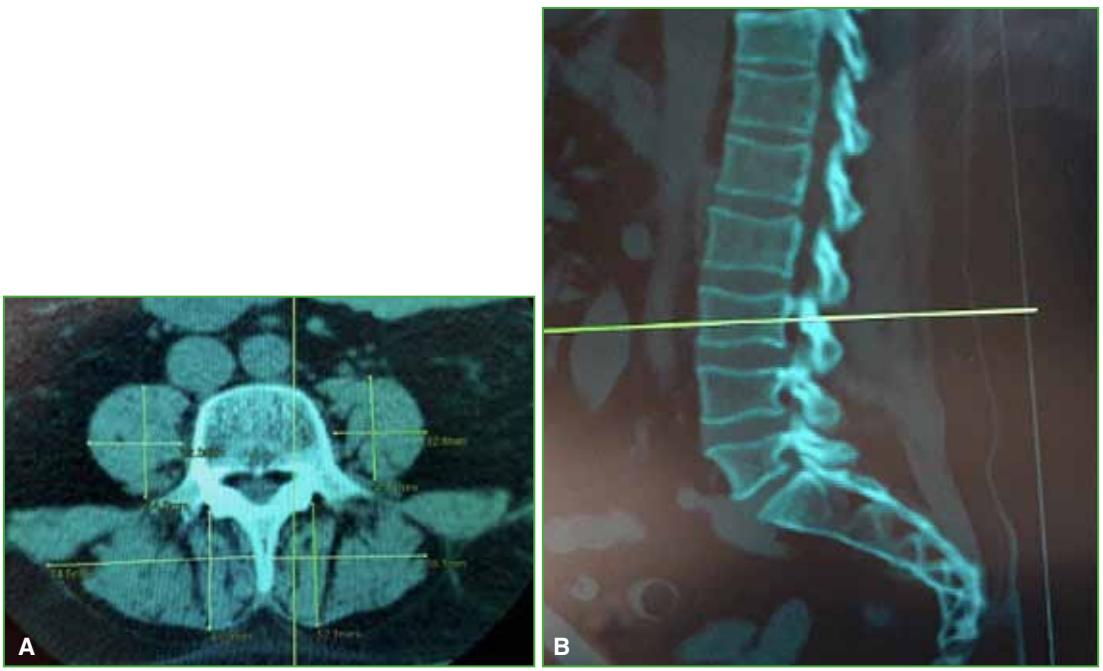

Figure 1. CT scan showing measurement of psoas muscles and paravertebral gutter muscles. **A.** Axial section. **B.** Sagittal section. Level where the measurements are made (height of the pedicles).

Muscle volume was obtained by multiplying these two parameters in both muscle groups, adding them and dividing by the squared height (right psoas + left psoas/height^2); and the HUs at the intersection of both lines. The data was discriminated by sex, age range, disease and type of complementary study used. Patients with deformities (scoliosis) or previous spinal surgeries were excluded.

RESULTS

Measurements were taken in 18 CT and 34 MRI scans of male and female patients. The participants ranged in age from 15 to 80 years. In terms of muscle volumes and density using the HU, the group of male patients was above the global average in both MRIs and CTs, while the group of female patients was below (Figures 2, 3 and 4).

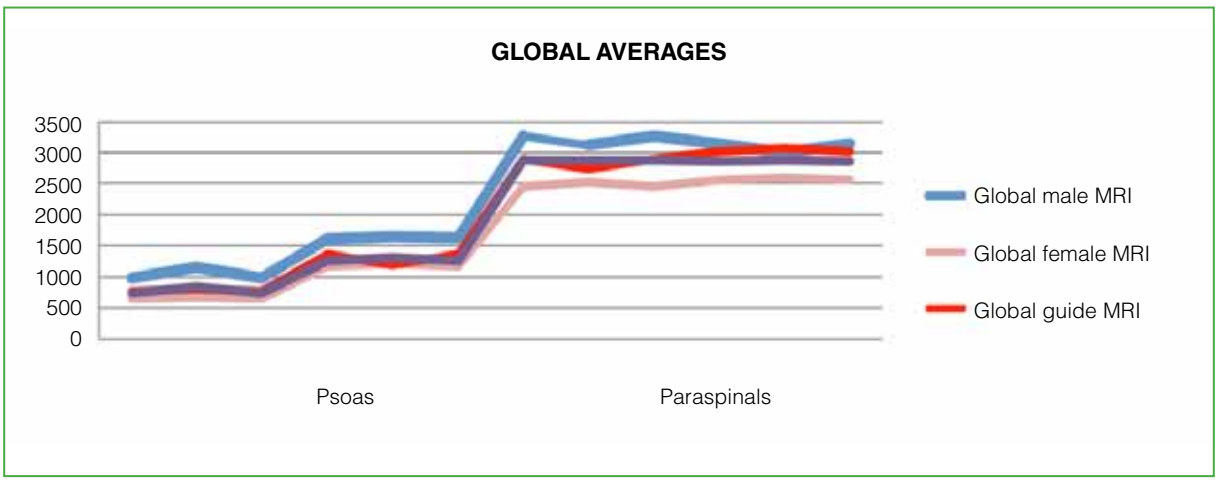

Figure 2. Difference in the volume of the psoas and paraspinal muscles in magnetic resonance imaging, comparing males and females.

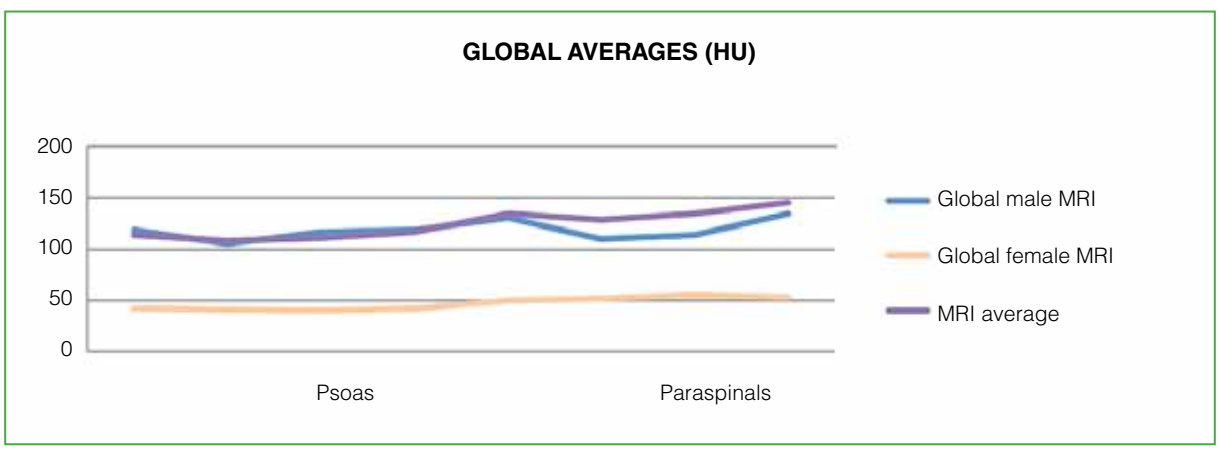

Figure 3. Comparison of Hounsfield unit measurement between psoas muscle and paraspinal muscles.

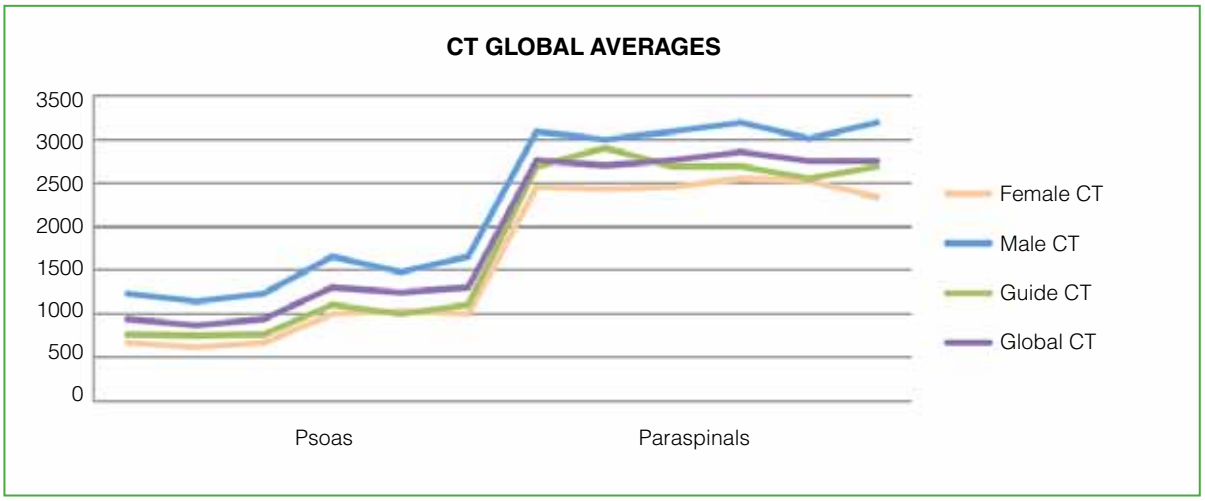

Figure 4. Comparison of muscle volumes measured by computed tomography, comparing males and females.

Three patients who had both complementary studies were taken as reference, and their layout on the graphs was similar to that of the overall group. Regarding the age ranges, it was observed that the first group (15-29 years) had a greater muscle volume and HU in the psoas compared to the group >60 years, the two remaining groups of 30-44 years and ages 45-59 remained close to the global averages (Figure 5).

Likewise, the patients in the younger age range had a greater volume of the psoas than of the paravertebral muscles with respect to the last age group. Patients who consulted for spondylolisthesis had less muscle mass than those with disc disease (Figure 6).

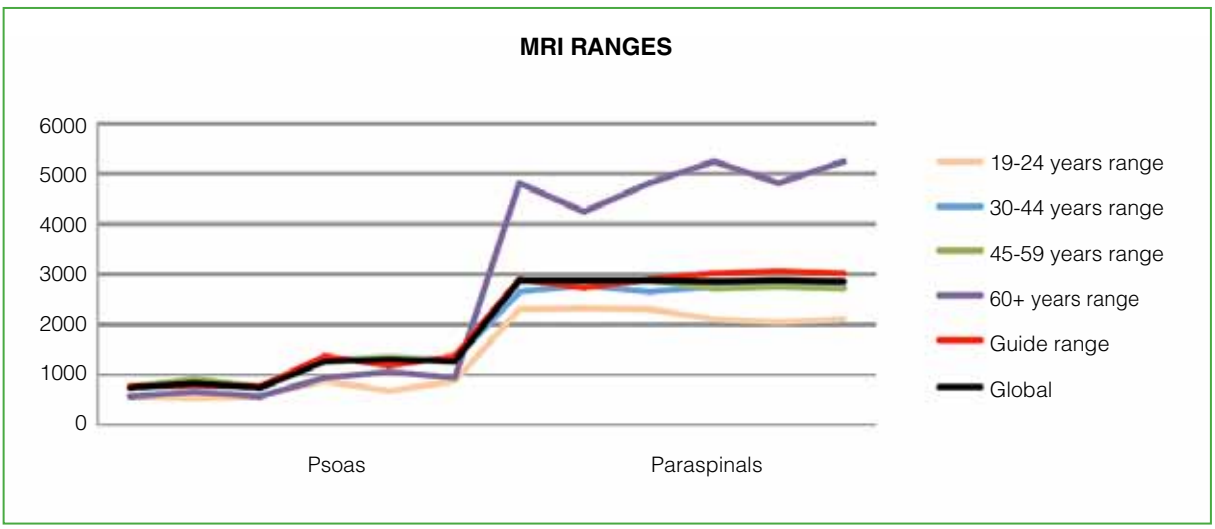

Figure 5. Comparison of muscle volumes measured by magnetic resonance imaging and divided by age range.

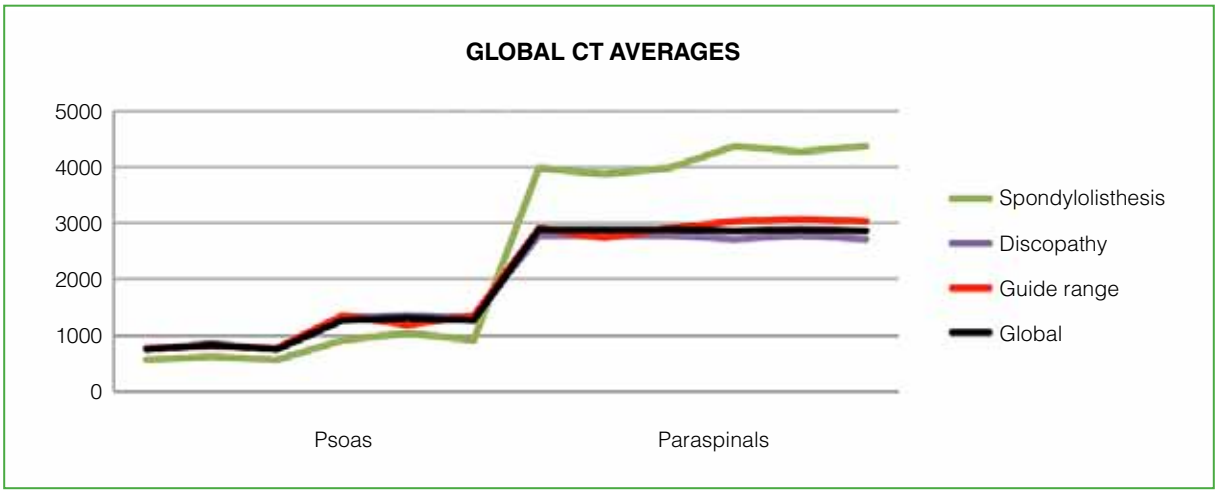

Figure 6. Measurement of muscle volumes comparing spondylolisthesis and disc disease.

DISCUSSION

It is common to detect atrophy of the psoas muscle and fatty degeneration of the paraspinal muscles in elderly patients. These conditions cause alterations in posture and walking, because they modify, to a great extent, the extensor function of the lower spinal part.[3]

Measurement of lumbar muscle density (psoas) could be used as a predictor of poor postoperative outcomes in cardiovascular surgeries[2] and colorectal resection surgery.[4]

Shahidi et al. studied 97 patients who underwent one-level spinal fusion, with a 90-day follow-up, but did not obtain conclusive results regarding the influence of psoas volume in the perioperative period.[6]

Instead, Yoo et al. evaluated 151 patients admitted for trauma to a hospital in Ohio, United States. Psoas muscle density is a significant predictor of poor outcomes after traumatic injury. It is an objective, quick, and easy measure of sarcopenia, and can identify patients who require nutritional and physical therapy to improve prognosis.[1]

In a literature review, Fortin and Gazzi Macedo found a decrease in multifidus and paraspinal volume in patients with chronic low back pain compared with a control group without low back pain or with acute pain.[8]

Moskven et al. carried out a systematic review and did not observe that sarcopenia and frailty could have a significant impact on the postoperative period of spinal surgeries.[9]

Magnetic resonance imaging provides higher image resolution than ultrasound and tomography. In this way, it allows better detection of soft tissues and muscles. Atrophied muscle usually has irregular margins and fatty infiltration.[10,11]

CONCLUSIONS

No differences were found between measurements of the paraspinal muscles and the psoas taken with magnetic resonance or computed tomography; therefore, both studies are effective for such measurements.

The paraspinal muscles do not decrease in size with age, but fatty infiltration is observed, and is generally greater at the lower lumbar levels, such as L4 and L5. MRI has better image resolution.

It is evident that the decrease in muscle volume is frequent in older patients and those with diseases that affect spinal balance, such as spondylolisthesis.

Regarding sex, although the size of the musculature is greater in men than in women, the measurements decrease in both sexes when compared with age and disease.

Conflict of interest: The authors declare no conflicts of interest.

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Post-Traumatic Vertebral Injuries

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ABSTRACT

Introduction: Spinal injuries are common among young adult men. Recognizing kinematics can help reduce the number of late diagnoses, especially if there are consciousness disorders. Vertebral fractures can be single or multiple, and they are often associated with extravertebral injuries. **Objectives:** To examine the distribution of the lesion based on the mechanism of production, to characterize the neurological condition, to evaluate the lesion pattern and its relationship with extravertebral lesions, and to analyze the treatment. **Materials and Methods:** This was a multicenter, prospective study of patients admitted with post-trauma vertebral injuries between July 1, 2018 and June 30, 2020. Age, gender, kinematics, neurological condition, affected sector, pattern of injury, and associated extravertebral injuries were all examined. **Results:** There were 281 patients (60% men) evaluated, with 400 vertebral and 118 extravertebral lesions. The causes were as follows: polytrauma in 62 cases, falls from great heights in 147 patients, and traffic accidents in 98. ASIA E was the most frequently observed neurological picture (8 cases), which was not determined at admission. The T2-L5 sector was the most affected, mostly by compression injuries. Head and chest trauma were the most common extravertebral injuries; there was one case of SCIWORA and one early death. **Conclusions:** The most commonly affected spinal sectors were thoracolumbar, thoracic, and lumbar; the injuries are typically caused by falls from great heights and, in general, are isolated, with no neurological injuries. The treatment is determined by the stability and neurological condition.

Keywords: Spine; trauma; fracture; kinematics; vertebral fracture; spinal injury.

Level of Evidence: IV

Lesiones vertebrales postraumáticas

RESUMEN

Introducción: Las lesiones raquídeas son frecuentes en hombres adultos jóvenes. Reconocer la cinemática ayuda a disminuir la tasa de diagnósticos tardíos, principalmente si hay trastornos de la conciencia. Las fracturas vertebrales pueden ser únicas o múltiples, y asociarse con lesiones extravertebrales. Los objetivos de este estudio fueron analizar la distribución de la lesión según el mecanismo de producción, caracterizar el cuadro neurológico, evaluar el patrón de lesión y la asociación con lesiones extravertebrales, y analizar el tratamiento. **Materiales y Métodos:** Estudio multicéntrico, prospectivo de pacientes con lesiones vertebrales postrauma, que ingresaron entre el 1 de julio de 2018 y el 30 de junio de 2020. Se analizaron los siguientes parámetros: edad, sexo, cinemática, cuadro neurológico, sector afectado, patrón de lesión, lesiones extravertebrales asociadas. **Resultados:** Se evaluó a 281 pacientes (60% hombres) con 400 lesiones vertebrales y 118 extravertebrales que, en 62 casos, conformaban un cuadro de politraumatismo; 147 con trauma por caída de altura y 98, por accidente de tránsito. El cuadro neurológico más observado fue ASIA E (8 casos), no determinado al ingreso. El sector T2-L5 fue el más afectado, en su mayoría, por lesiones por compresión. Las lesiones extravertebrales más frecuentes fueron el trauma de cráneo y de tórax; hubo un caso de SCIWORA y un

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óbito temprano. **Conclusiones:** Los sectores raquídeos más afectados fueron: el toracolumbar, el torácico y lumbar; las lesiones suelen deberse a caídas de altura y suelen ser únicas, sin un cuadro neurológico. El tratamiento se decide según la estabilidad y el cuadro neurológico.
Palabras clave: Columna; trauma; fractura; cinemática; fractura vertebral; lesión vertebral.
Nivel de Evidencia: IV

INTRODUCTION

Spinal cord injuries are a major cause of morbidity and mortality among young people, accounting for 60% of injuries in people <40 years of age. The risk of suffering from this type of injury is higher in the male sex.[1,2]

The reported incidence of spinal cord injuries in the general population is 64 people per 100,000 inhabitants. However, it is distributed disproportionately throughout the world, and the incidence is higher in developing countries than in more developed nations, due to changes in the automotive industry. Severe injuries to the spine, particularly to the upper cervical region, are often fatal, while those involving the spinal cord often result in permanent disability.[3,4]

Recognizing the kinematics of a spinal trauma can help determine the type of injury suffered by the patient upon admission. The first lumbar vertebra (L1) is the most frequently injured vertebral level, followed by the adjacent thoracic vertebra (T12), in motorcycle accidents.[3] In addition, motorcyclists are more likely to sustain a serious spinal injury when they hit an object directly than if they hit the ground directly during an accident.[3]

In epidemiologic studies, accidental falls have been shown to be the most common cause of spinal fractures, while motor vehicle injuries rank second.[2]

Accurate evaluation and classification of spinal fractures are very important for making appropriate treatment decisions. To facilitate this, in addition to the AOSpine thoracolumbar classification system, Verheyden et al. took into account morphological modifiers such as vertebral alignment, spinal canal stenosis, vertebral body comminution, and intervertebral disc injury.[5]

Associated injuries, such as head trauma or thoracic injuries, can significantly influence the prognosis of spinal cord injuries.[1]

The objectives of this study were to analyze the distribution of the injuries according to the mechanism of production, to characterize the neurological condition, to evaluate the injury pattern and the association with extravertebral injuries, and to analyze the treatment guidelines.

MATERIALS AND METHODS

A multicenter, prospective case series study involving patients admitted with traumatic spinal injuries between July 1, 2018, and June 30, 2020, was carried out. The study was approved by the ethics committee of the main hospital.

The following variables were analyzed: age, sex, seasonal variability, neurological condition on admission, kinematics, affected sector, vertebral injuries and initial treatment, and extravertebral injuries.

The exclusion criteria were: age <15 years, pathological or low-energy vertebral fracture, history of spinal surgery.

The ASIA (American Spinal Injury Association) scale was used to assess the neurological condition, and the AOSpine system was used to classify the injury's morphology and neurological status.[6-8]

In order to analyze the kinematics, four general groups were determined: 1) traffic accident, 2) fall from height, 3) sports trauma and 4) direct trauma.

Initially, injuries were grouped by sector: 1, high cervical (C0-C2); 2, low cervical (C3-C7); 3, cervicothoracic (C7-T1); 4, thoracic (T2-T9); 5, thoracolumbar (T10-L2); 6, lumbar (L3-L5) and 7, sacrum. In addition, cases of a single or multiple vertebral injury pattern were analyzed.

Extravertebral injuries were grouped into: 1, head trauma; 2, facial trauma; 3, thoracic trauma; 4, upper limb; 5, abdomen; 6, pelvis and 7, lower limb. Tables such as SCIWORA (*Spinal Cord Injury without Radiologic Abnormality*) and deaths in the first 72 hours were recorded.

The aforementioned variables were analyzed with the EpiInfo® V7 program.

RESULTS

In this study, 17 Latin American centers participated: 10 from Argentina, four from Paraguay, one from Chile, one from the Dominican Republic and one from Uruguay.

281 patients were included, 113 women and 168 men, with an average age of 45.63 years (range 15-90), who had 400 spinal injuries. 54.8% were Argentines, 35.2% were Chileans, 8.54% were Paraguayans, 1.07% were Dominicans, and 0.36% were Uruguayans. In the variables examined, no statistically significant differences were discovered.

The age group 45 to 60 years was the most affected (86 cases), but this was not statistically significant (Figure 1). The highest amount of admissions was recorded between November and February of both years of the study (Figure 2).

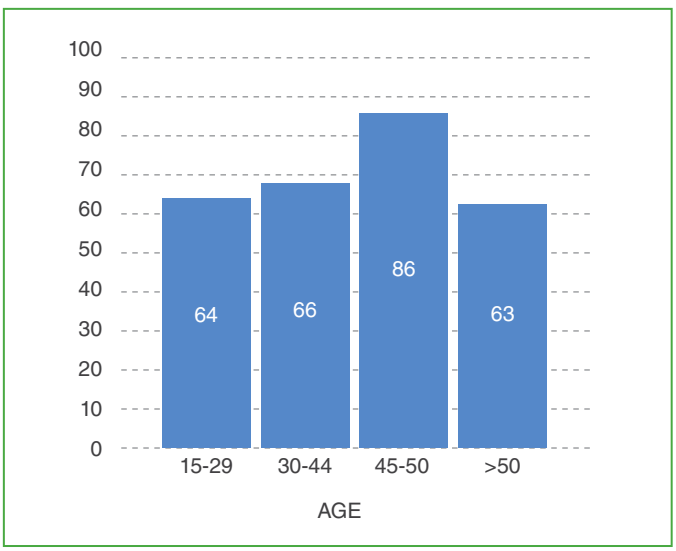

Figure 1. Distribution by age of trauma patients.

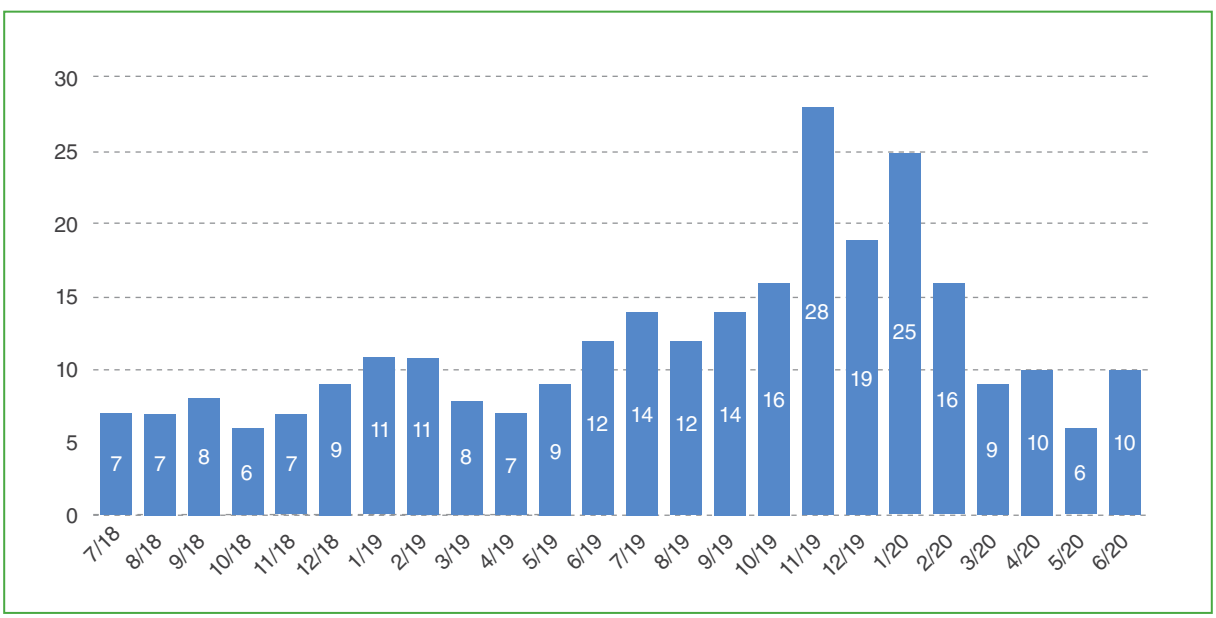

Figure 2. Number of admissions per month from July 2018 to June 2020.

The most frequent neurological condition was ASIA E in 244 patients, followed by a complete injury (12 cases); in eight patients, baseline neurological status could not be determined due to disturbances of consciousness or hemodynamic compromise (Figure 3).

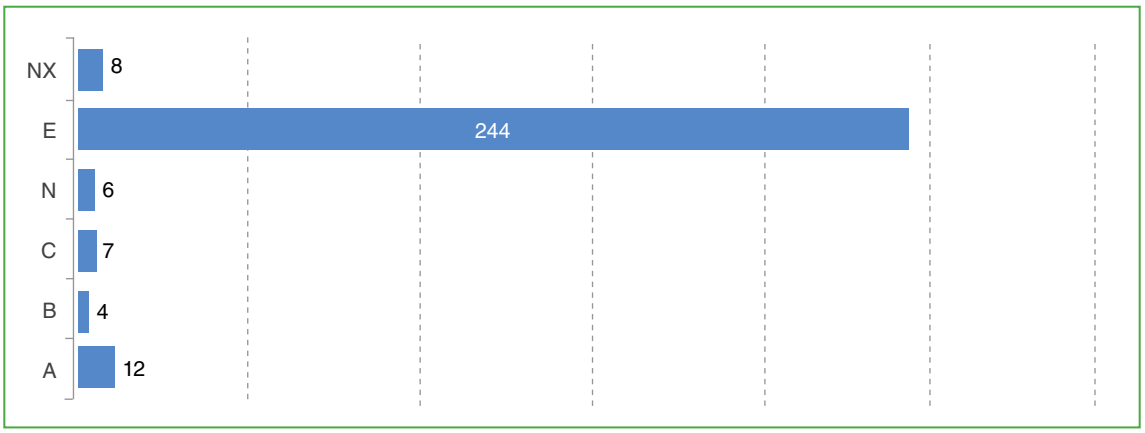

Figure 3. Neurological chart of 281 patients upon admission.

The most frequent kinematic causes were falls from a height (147 injuries) and traffic accidents (98 injuries); and both compromised, to a large extent, the thoracolumbar sector (Figure 4), which was the most affected (266 lesions), followed by the thoracic (76 cases) and lumbar (40 cases), which made up a global sector of 372 injuries (Figure 5).

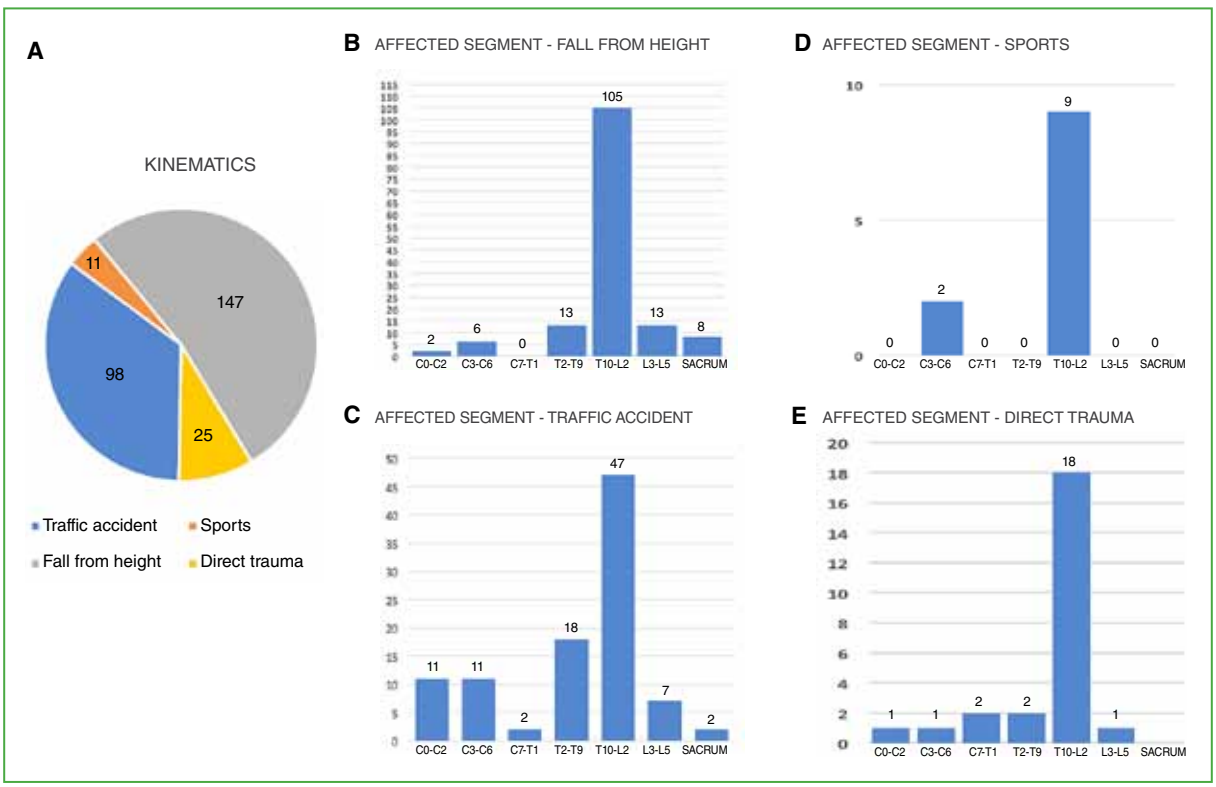

Figure 4. Relationship between the mechanism of action and vertebral lesions. **A.** Kinematic distribution. Distribution of injuries caused by traffic accidents (**B**), falls from a height (**C**), sports trauma (**D**) and direct trauma (**E**).

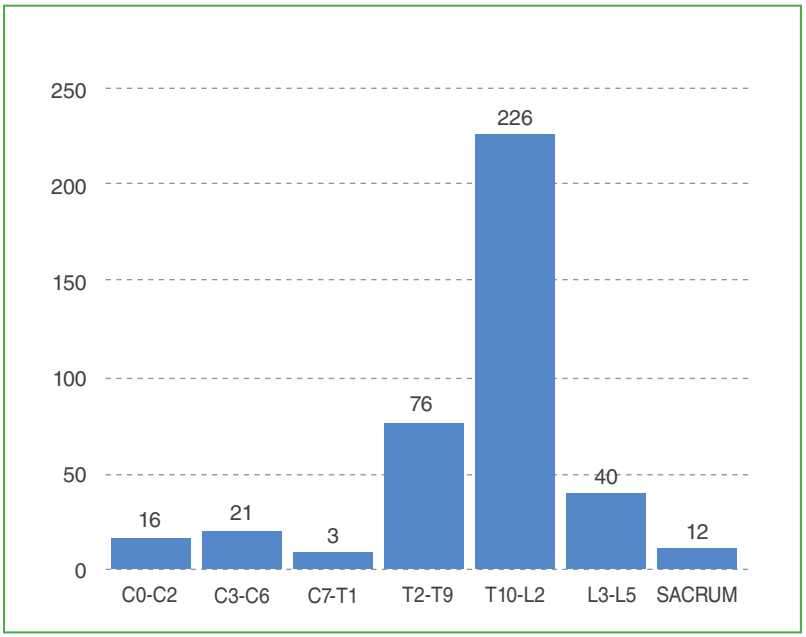

Figure 5. Distribution of vertebral lesions.

A total of 217 patients had single spinal injuries, 56.74% due to falls from a height. Sixty-four had multiple spinal injuries (p 0.0576) and the most frequent association was thoracolumbar-thoracolumbar (16 cases) and thoracic-thoracic (8 cases) (Figure 6); 48.48% occurred due to traffic accidents and 40.91% due to falls from a height.

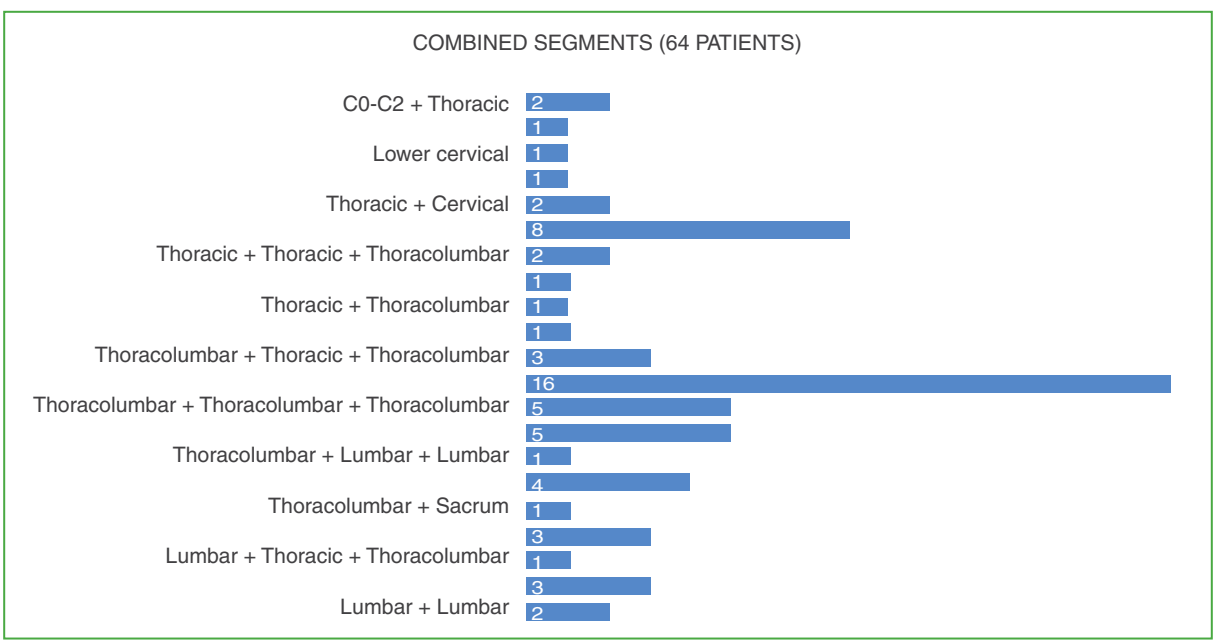

Figure 6. Association pattern of multiple vertebral lesions.

When analyzing the thoracic, thoracolumbar, and lumbar regions grouped together (T2-L5), type A1 injuries were the most frequent, followed by burst fractures. In patients with type B fractures and compression fractures of the vertebral body, the most frequent type of secondary injury was also the A1 fracture.

Conservative treatment was prescribed for 129 patients with stable injuries, while 122 underwent surgery due to unstable injuries or neurological deficits (Figure 7).

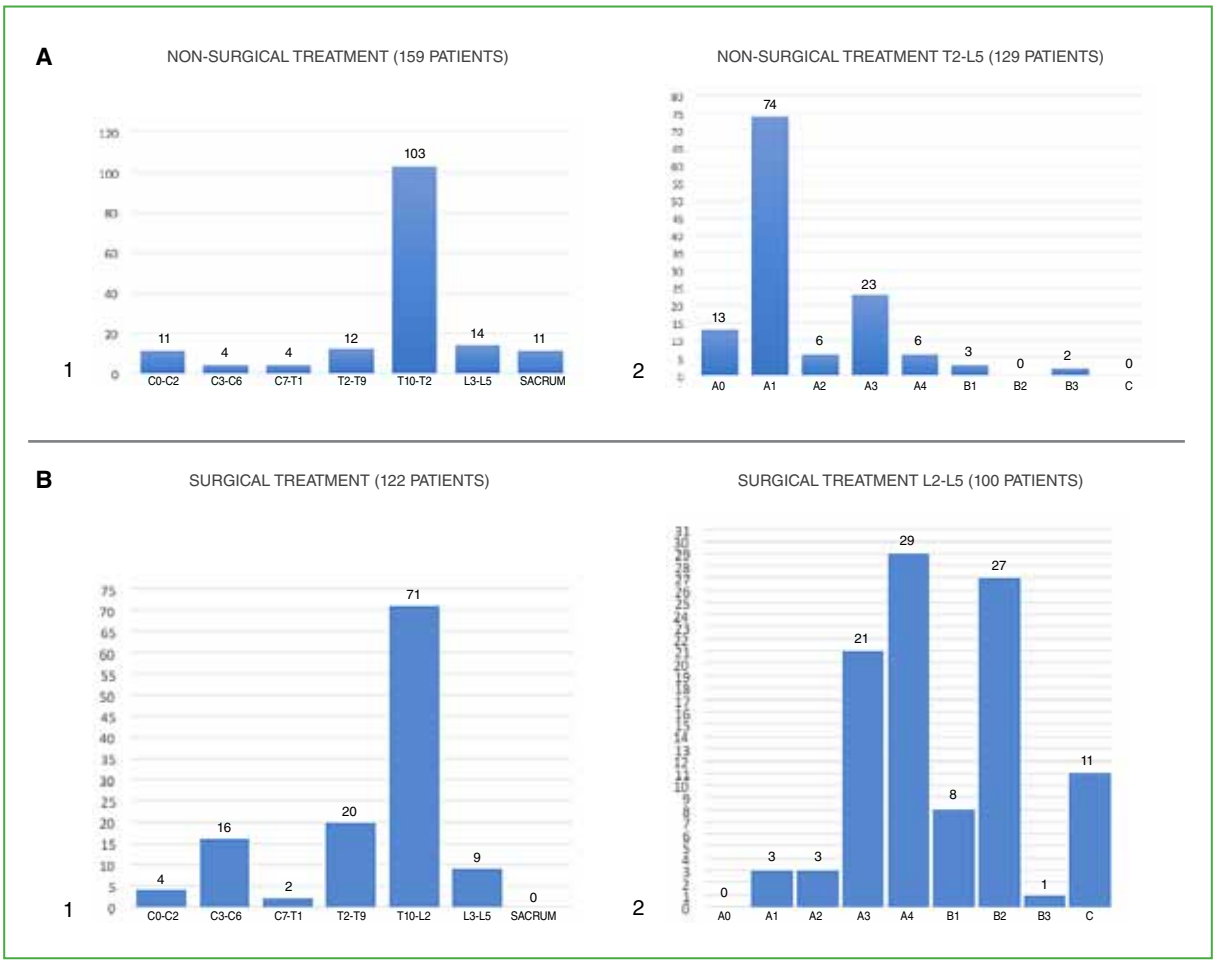

Figure 7. Therapeutic decision and type of injury. **A.** Non-surgical treatment. **B.** Surgical treatment **1.** Distribution of lesions in both treatments. **2.** Type of lesion in the T2-L5 region.

Eighty-two patients presented with 118 extravertebral injuries associated with vertebral injuries, with 61 exhibiting polytrauma symptoms. The most common injuries were head trauma (26 cases) and thorax (22 cases); once again, T2 to L5 trauma was associated with the highest percentage of these injuries (Figure 8).

44.19% of patients who suffered associated injuries were involved in traffic accidents, and 41.86% were involved in a fall from a height (p 0.06), but if only cases with a polytrauma diagnosis are considered, 50.82% were involved in traffic accidents (p 0.016).

Having two or more simultaneous spinal injuries was associated with the presence of associated injuries. However, this relationship was not statistically significant (Fisher 2-tailed p = 0.3; OR = 1.8).

One case of SCIWORA was detected and one death occurred in the first 72 hours.

Short-term adverse events were: increased kyphosis in one patient after the first radiographic control, which led to changing the therapeutic decision, and two cases of surgical site infection.

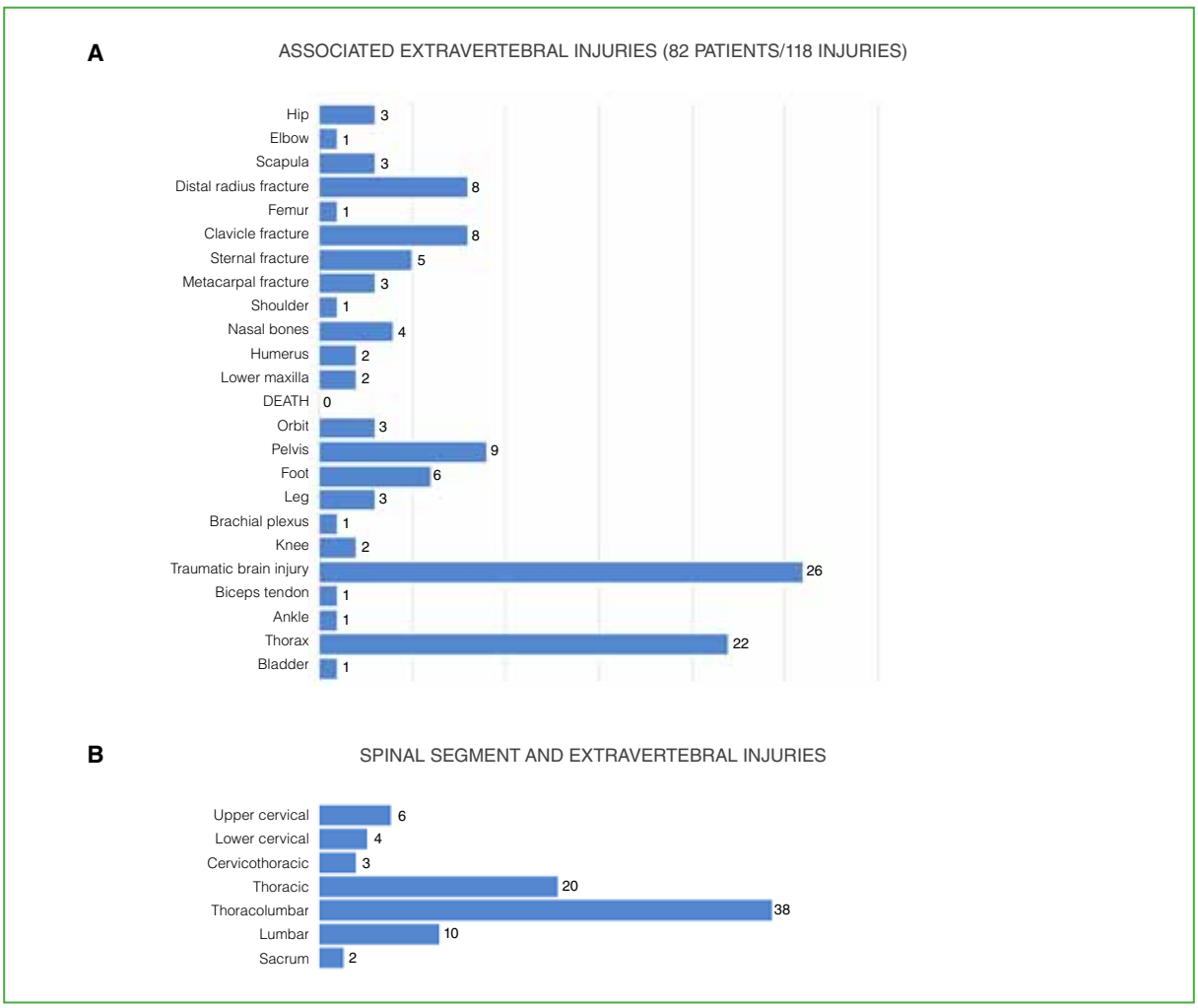

Figure 8. Relationship between vertebral and extravertebral lesions. **A.** Distribution of extravertebral lesions. **B.** Vertebral sector associated with extravertebral injuries.

DISCUSSION

Traumatic injury is the leading cause of death and morbidity in the adult population. 60% of spinal cord injuries occur in people <40 years of age, and they are more frequent in men.[9-11]

These injuries can be aggravated by the risk of neurological deficit in the short and long term.[12] In our study, 49% had no associated injuries on admission, and 32% of them had a mild or moderate neurological status (Frankel D and E). It is important to recognize spinal cord injuries, including SCIWORA, in adults, as they can result from high- or low-energy trauma and be missed on radiographs.

Magnetic resonance imaging is the diagnostic study of choice. In these patients, the probability of neurological recovery is related, in the first instance, to the initial injury, the diameter of the canal, the age, the extension of the lesion and the severity of the neurological symptoms.[13] Therefore, surgery is not the gold standard treatment.[14]

Understanding the factors that contribute to spinal injuries is critical to preventing them.[1] In this series, 13 patients rode motorcycles or quadricycles of different displacements, and none wore a helmet. Kuo et al. highlight the protective effect of helmets, the mortality rate is significantly lower among motorcyclists who wear a helmet.[15]

The injuries that caused the most neurological compromise (Frankel A) occurred in the cervical sector (90%), with only the thoracolumbar and lumbar sectors being compromised in 10% of the cases. When describing the

topography of vertebral injuries based on the mechanism of injury, the cervical spine was the most common location in patients involved in traffic accidents. The thoracolumbar spine was the predominant topography of those who had a fall from a great height. This agrees with the study by Zileli et al. who described that the most frequent mechanism of cervical spine trauma is traffic accidents (39.5%), followed by falls (38%). However, there are differences between the various regions, for example, falls are the most common mechanism in low-income countries (54%) and sports-related injuries are rare in these countries (2.1%).[16]

Seat belts and airbags reduce thoracic and lumbar injuries, but they are frequently associated with cervical injuries.[17] Only 29% of patients who suffered cervical spine trauma as a result of a traffic accident wore a seat belt.

When treating these patients, it is important to evaluate the entire spine and look for associated injuries.[18] In our study, patients with vertebral fractures in the presence of associated non-vertebral injuries were classified as polytraumatized. This is consistent with the findings of Driessen et al., who report that a percentage of spinal trauma is associated with polytrauma.[19] The current definition of polytrauma refers to patients who have multiple injuries and are at high risk of death. The definition includes lesions with an AIS score ≥3 in two or more body regions combined with the presence of one or more physiologic risk factors, such as age, Glasgow Coma Scale, hypotension, acidosis, and coagulopathy.[19] One of the diseases that should be suspected when a patient with polytrauma is admitted is ankylosing spondylitis, as it is a risk factor for spinal fractures. In a retrospective multicenter study of a case series with six patients who suffered a fall from a height, it was observed that these types of patients have a higher risk of suffering a thoracolumbar fracture due to low-energy trauma.[20]

Other injuries that were associated with spinal cord trauma in this study were chest and head injuries. This coincides with what has been published in the current literature, an incidence between 20% and 57%.[12] 25-50% of patients with traumatic spinal cord injuries have an associated brain injury. It is extremely important to recognize associated injuries during the primary review of patients with spinal trauma, since associated non-vertebral injuries can significantly influence the prognosis of these patients.[1,21,22] According to recent studies, the mechanism of injury is an independent determinant of death after trauma. In other series, the mortality rate was higher in patients who suffered traffic accidents than falls from height.[2]

There is a relationship between spinal injuries and sports.[23,24] In our series, the percentage of patients with a history of sports trauma as a mechanism of spinal cord injury was lower compared to those who suffered falls from a height, traffic accidents, and direct trauma. These injuries usually occur due to inexperience and poor knowledge of the inherent dangers of the sport, inadequate training and practice facilities, and lack of supervision, protective equipment and strict refereeing.[20,23] Cantu et al. reported that teaching game skills and improving medical care both on and off the field of play reduced permanent spinal cord injuries in American football by 270%.[25]

The use of safety elements, such as a belt, a helmet, and a harness when working at heights, is a fundamental measure for the prevention of spinal injuries.[1] Traffic accidents caused the majority of spinal injuries in a study by Bazán et al.[10] Road accidents have a multifactorial etiology; however, driver behavior is one of the most important factors. Other influencing factors are: vehicle safety and improvements in road infrastructure. Minimum vehicle safety standards and the implementation of breathalyzer tests for drivers have reduced the number of fatalities from traffic accidents.[1]

The correct assessment of the morphology of a spinal fracture depends on an accurate diagnosis[14] based on the new AOSpine Thoracolumbar Classification System and morphological modifiers implemented by the German Orthopedics and Trauma Society in 2017.[5] This classification helps to understand the degree of instability and to determine the various therapeutic alternatives.[5] Although these modifiers were not exposed in our study, they are taken into account when deciding on treatment in clinical practice.

CONCLUSIONS

In general, the thoracolumbar sector is the most affected by a traumatic injury, followed by the thoracic and lumbar. The most frequent mechanism of action is a fall from height, followed by traffic accidents; the thoracolumbar sector is the most compromised regardless of the kinematics.

The majority of vertebral injuries are isolated compression injuries; cases of multiple vertebral injuries are frequently associated with extravertebral injuries and, in a large percentage of cases, comprise a picture of polytrauma.

The prevalent neurological condition is the pattern without neurological injury; there are cases that cannot be classified when the patient is admitted and this increases the risk of diagnostic error.

Conservative treatments were indicated for patients with stable bone lesions and surgery was reserved for those with bone or osteoligamentary lesions or neurological deficits.

Conflict of interest: The authors declare no conflicts of interest.

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Morphological Aspects of Pyogenic Spinal Epidural Abscess

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ABSTRACT

Introduction: A pyogenic spinal epidural abscess is an infectious collection inside the spinal canal, outside the dural sac. The diagnosis is difficult and the consequences are devastating due to compression or vascular compromise. MRI has a high diagnostic sensitivity and specificity, which improves when a contrast medium is used. **Objectives:** To determine the inter- and intra-observer reproducibility, and to discriminate the different parameters and differences between specialties. **Materials and Methods:** Twenty-seven independent observers evaluated 5 parameters: region, location, involvement, association, and perivertebral, anterior, lateral, or posterior extravertebral abscess. The kappa coefficient was used to analyze 35 cases on three occasions. **Results:** The overall intra- and inter-observer global agreement level is kappa 0.76, with the following values obtained: region 0.94; location 0.88; involvement 0.55; association 0.67 and perivertebral abscess 0.77. The first three parameters indicate volume, while the final two indicate the presence of vertebral infectious foci outside the canal. **Conclusions:** The proposed morphological classification is simple to use and has high intra- and inter-observer reproducibility. The most reproducible parameters are region and location (>0.87).

Keywords: Infection; epidural; abscess; osteomyelitis; spondylodiscitis; classification; magnetic resonance.

Level of Evidence: III

Aspectos morfológicos del absceso epidural espinal piógeno

RESUMEN

Introducción: El absceso epidural espinal piógeno es la localización de una colección infecciosa dentro del canal raquídeo, por fuera del saco dural. El diagnóstico es difícil y las consecuencias son devastadoras a causa de la compresión o el compromiso vascular. La resonancia magnética tiene una alta sensibilidad y especificidad diagnósticas que aumentan si se administra un medio de contraste. Los objetivos de este estudio fueron: determinar la reproducibilidad inter- e intraobservador, y discriminar los distintos parámetros y diferencias entre especialidades. **Materiales y Métodos:** Veintisiete observadores independientes evaluaron 5 parámetros: región, ubicación, compromiso, asociación y perivertebral, absceso extravertebral anterior, lateral o posterior. Se analizaron 35 casos en tres oportunidades, se utilizó el coeficiente kappa. **Resultados:** El nivel de acuerdo global intra- e interobservador global es kappa 0,76; los valores obtenidos fueron: región 0,94; ubicación 0,88; compromiso 0,55; asociación 0,67 y perivertebral 0,77. Los tres primeros parámetros dan noción de volumen y los dos últimos reflejan la presencia de focos infecciosos vertebrales por fuera del conducto. **Conclusiones:** La clasificación morfológica propuesta es de uso simple y tiene una muy buena tasa de reproducibilidad intra- e interobservador. Los parámetros con mayor reproducibilidad son: región y ubicación (>0,87).

Palabras clave: Infección; absceso epidural; osteomielitis; espondilodiscitis; clasificación; resonancia magnética.

Nivel de Evidencia: III

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INTRODUCTION

Infectious processes that affect the spine can appear in a variety of locations (disc, vertebral body, spinal canal, perivertebral space), either in isolation or in association. A pyogenic spinal epidural abscess is an infectious collection inside the spinal canal,[1] between the dura mater and the osteoligamentous structures. Depending on its dimensions and location, it causes a variety of symptoms that are closely related to the compression of neural structures and have a direct impact on the content of the canal. The therapeutic indication and surgery pose a great challenge for the spinal surgeon.[2]

Despite its low incidence,[3] it is nine times more frequent than its intracranial variant,[1] and it can be a devastating disease[2,4] from the neurological point of view, and even fatal. It is almost always considered a consequence of spondylodiscitis, osteomyelitis, or a psoas muscle abscess, but in other cases, it is detected as a primary expression of an infectious process, the location of which may vary depending on its origin.[5] Neurological deficit is the most feared complication, and it may be due to a mass effect[2,3,6,7] or to vascular disorders, such as thrombosis or infarction.[2,8]

The diagnostic imaging study of choice is magnetic resonance imaging (MRI) due to its high sensitivity and specificity, mainly in the T2-weighted sequence;[2,3,7,9-11] gadolinium administration increases sensitivity.[4,9,12]

In the international literature, it is classified as a variant or accessory of an infection located in the disc or the body;[13,14] using tumor compression classifications,[15] in addition to imaging and neurological compromise,[16,17] but none of these classifications are specific to pyogenic spinal epidural abscess, as they do not consider its length, location, or size.

In order to improve or even facilitate the diagnosis, it is necessary to have a high index of suspicion.[5,9,11]

Our research group presented these morphological parameters of pyogenic spinal epidural abscesses[18] as the first step in a research process that will end with a clinical classification using images.

The objectives of this study were: to determine the inter- and intra-observer reproducibility, discriminate the different parameters and differentiate between the specialties of the independent observers.

MATERIALS AND METHODS

After approval by the Hospital Research Service (HSMLP2021/0054), the second phase of a project was carried out to implement a classification of pyogenic epidural abscess, with the ultimate goal of providing therapeutic suggestions based on images and clinical manifestations, in a complementary and final future.

A morphological classification of different epidural abscesses was carried out in magnetic resonance images extracted from a database. The length, location within the spinal canal, and involvement of its content were recorded, which confers an idea of volume; and the association with intra- and extravertebral foci was analyzed.

The morphological parameters were: region (R), location (L), involvement (I), association (A) and perivertebral (P) (RLIAP).

Region: it is determined by taking the upper and lower limits of the image corresponding to the epidural abscess and excluding the supernatant inflammatory process. If one of the limits coincides with the vertebral body, it receives the name of the vertebral body; if it coincides with the disc, it receives the name of the upper or lower adjacent vertebra, depending on whether it is the upper or lower limit. Therefore, the first data is the location and spatial length of the process.

Location within the canal: it can be anterior or posterior to the dural content (Figure 1); in this way, we can evaluate if there is involvement of the anterior or posterior cord of the spinal cord at the cervical or thoracic level.

Involvement: M, affects the meningeal space without displacing or compressing intradural content, which can be medullary or radicular depending on the sector; C1, displaces the content without compressing it; and C2, deforms the meningeal content. (Figure 2).

Association: The abscess may or may not be associated with vertebral infections, such as disc (O0), body (O1), or both (O2). A single variant must be selected or (-) if there is no combination.

Perivertebral: the association with perivertebral abscesses in the anterior (prevertebral), lateral (includes the psoas) or posterior (vertebral gutter) space is taken into account (Figure 3). It is marked with (+) if there are any of them or with (-) if they are not observed.

There were 27 independent observers: three spinal orthopedists, one subspecialty trainee orthopedist, 20 orthopedic residents, one spinal neurosurgeon, and two imaging residents.

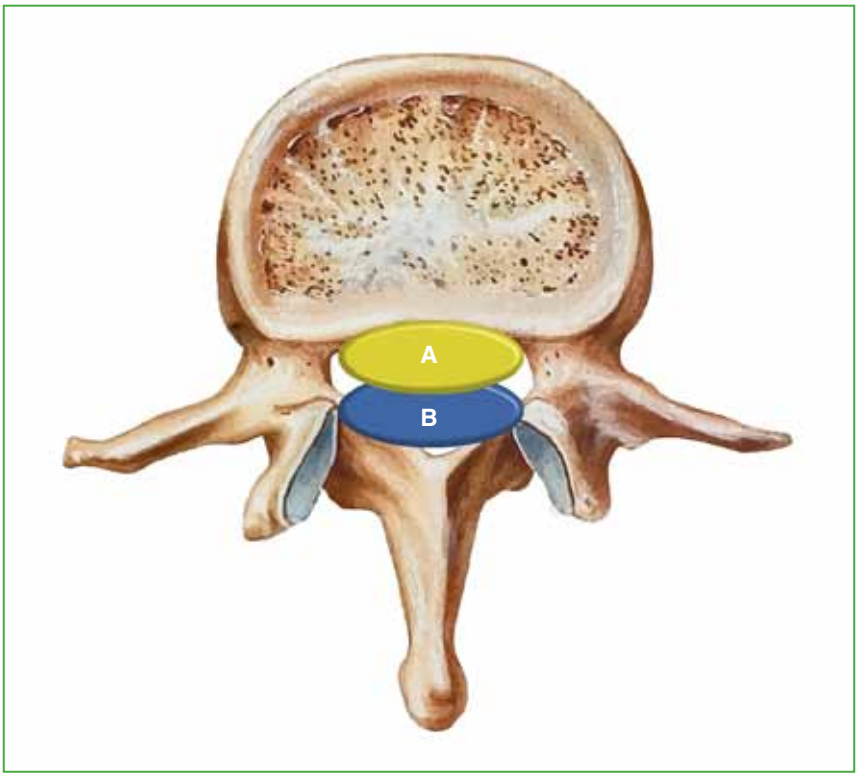

Figure 1. Diagram showing the location of the epidural abscess within the canal (considered the largest occupation). A = anterior, occupies from the posterior wall up to 50% of the diameter. B = posterior, occupies from the posterior osteoligamentous margin forwards to 50% of the diameter of the canal.

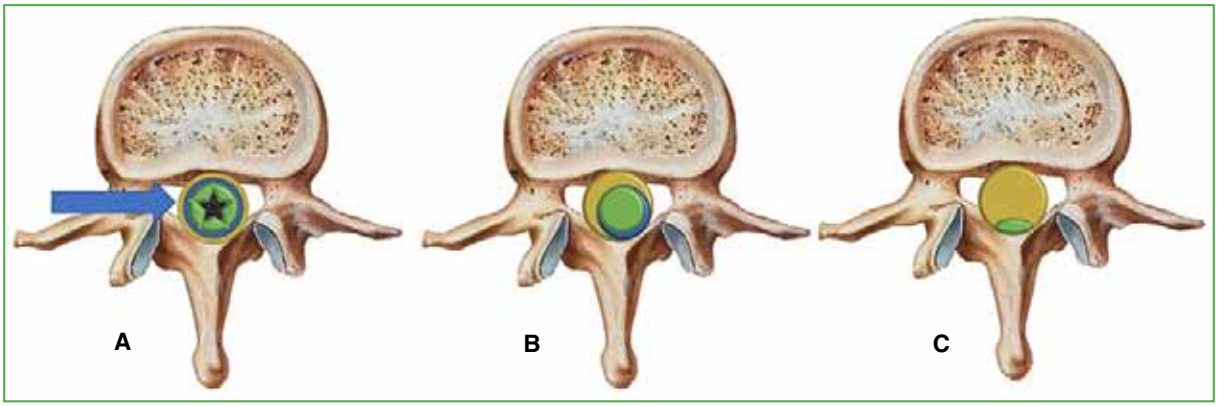

Figure 2. Diagram showing canal content involvement. The canal is depicted with three circumferential rings, the central one with a star and showing the content (medulla or roots) in green, with its enclosure in blue. **A.** The superficial ring marked with the arrow and colored orange represents the epidural space occupied by the pyogenic spinal epidural abscess (classified as M). **B.** The abscess displaces the contents (C1). **C.** The abscess compresses the content (C2).

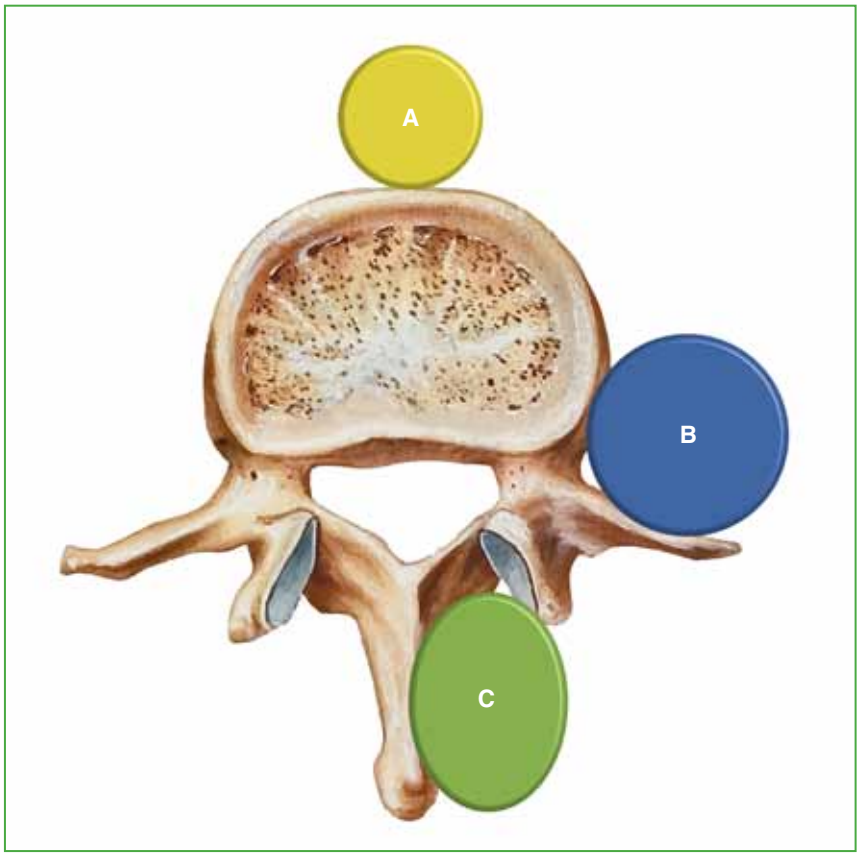

Figure 3. Diagram showing the location of perivertebral abscesses. A = anterior, B = lateral, C = posterior.

Evaluation methodology

Thirty-five cases with magnetic resonance imaging were included in different windows that were organized by the main author of the study who was not part of the evaluation. A PowerPoint presentation of each case was created, which was recorded in .mp4 video, with automatic replay every 30 seconds. Three rounds of evaluation were carried out separated by five weeks, the evaluator had to deliver them in 24 hours.

For the second evaluation, the position of the cases was modified, taking a random number and modifying the location of all of them. Based on the location of the second assessment, the same procedure was performed for the third assessment.

A response grid of the different evaluations was prepared and sent with the video by email. After answering the first evaluation and, after a few days, the same procedure was carried out for the second and third evaluation.

The results were entered into a spreadsheet of the IBM SPSS Static® 20.0 program and analyzed with Cohen's kappa coefficient separated by parameter and overall by case to determine intra- and inter-observer reproducibility.

RESULTS

Cohen's kappa coefficient on overall intra- and inter-observer agreement was 0.76, which is considered a very good reproducibility agreement. The values of each particular parameter were: R 0.94; L 0.88; I 0.55, depending on the resonance window and the use of contrast medium; A 0.67 and P 0.77. The first three parameters give a notion of volume that, in a future process, could be related to making a therapeutic decision and the last two indicate the presence of vertebral infectious foci outside the canal (Figures 4-6).

The gadolinium T2-weighted window was the image with the highest inter-rater agreement (kappa >0.87) in all sections, followed by T2 without contrast, STIR, and finally T1-weighted without contrast.

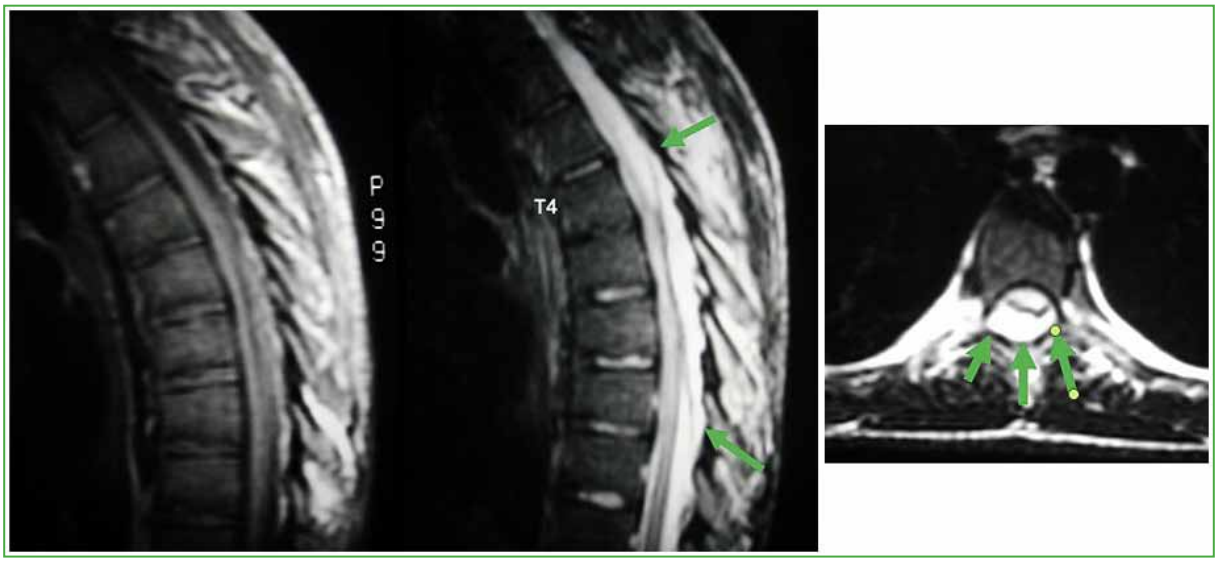

Figure 4. Case 10. MRI, T1- and T2-weighted sagittal sections, and T2-weighted axial section. Defined as T4-T8, P, C2 (Region: T4-T8, Location: posterior; Involvement: compresses the content). In cases of posterior pyogenic spinal epidural abscess, there may not have association; therefore, it is association and perivertebral negative.

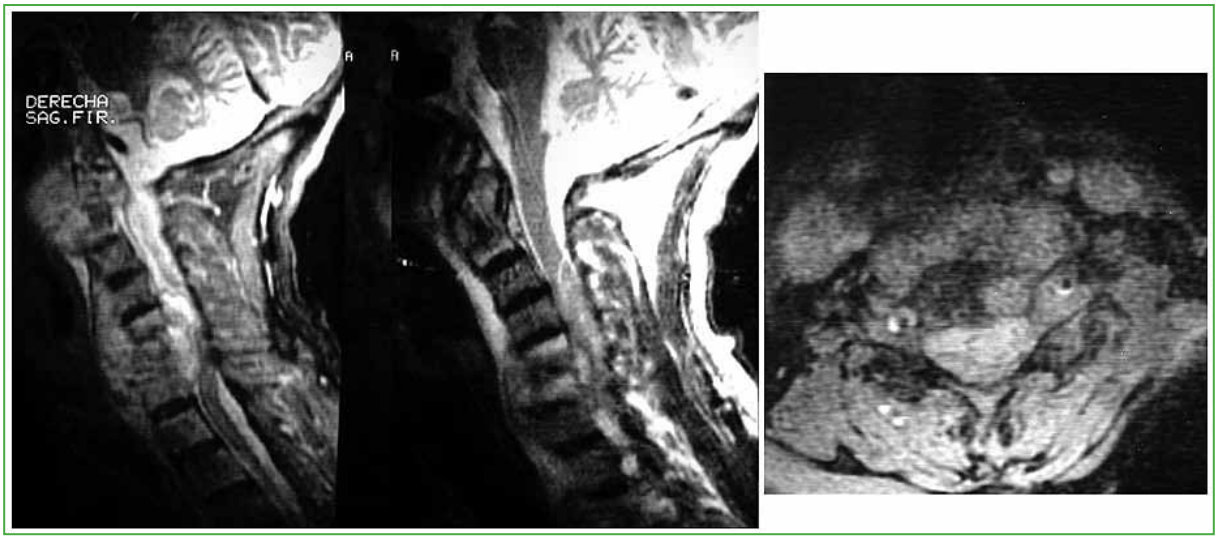

Figure 5. Case 17. MRI, T2-weighted sagittal sections without contrast and with contrast, and axial T2-weighted with contrast. Defined as C5-C7, A, C2, O2, + (Region: C5-C7, Location: anterior, Involvement: compresses the content, Association: disc and bone involvement, Perivertebral: positive - Anterior).

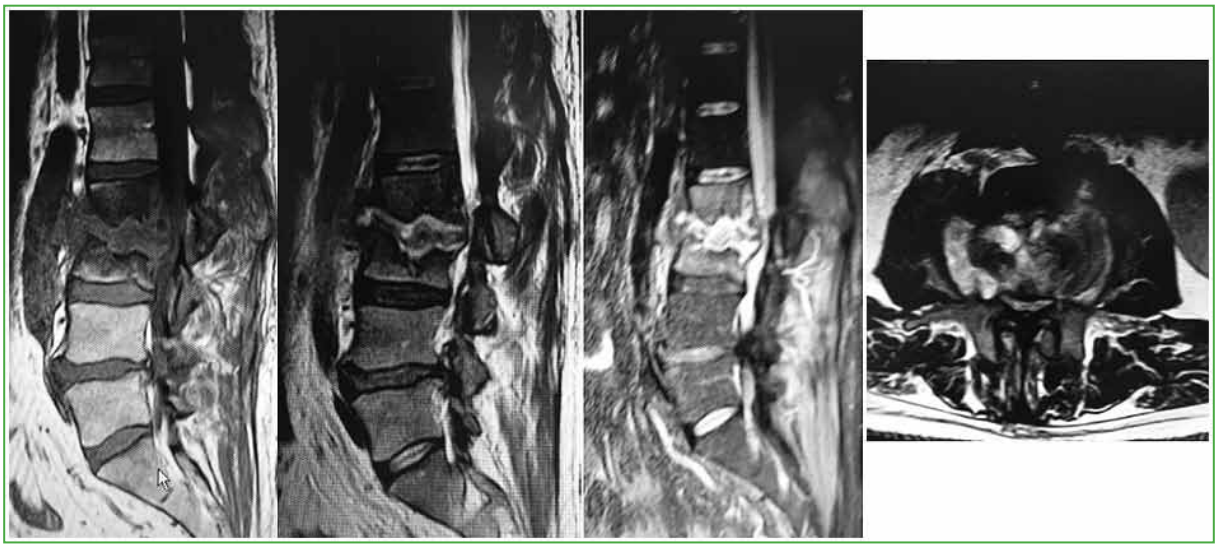

Figure 6. Case 35. MRI, T1- and T2-weighted sagittal sections, T2-weighted with contrast medium, and axial T2-weighted. Defined as L2-L3, A, C2, O2, + (Region: L2-L3, Location: anterior, Involvement: compresses the content, Association: disc and bone infection, Perivertebral: lateral/psoas).

DISCUSSION

There are studies in the current literature that emphasize lesions that compromise bone and disc indemnity without describing the epidural abscess, the region in which it is found (cervical, dorsal, lumbosacral), its extension, the involvement of intracanal structures, or the presence of extraosseous or distant lesions.

Pola et al.[13] proposed the most widespread and currently used classification, classifying their cases according to whether the infection causes bone destruction or instability, whether there is an epidural abscess, whether there is a neurological condition or involvement of the paravertebral space. In this way, three main types can be highlighted: A, discitis; B, osteomyelitis, and C, epidural abscess, and the authors provided global treatment guidelines without extensive rationale. Type A, depending on whether there is involvement of the paravertebral space, is divided into five subtypes; type B, into four subtypes, according to the combination of instability and paravertebral space, and type C, the subject matter of our work, is differentiated into four subtypes according to the combination of bone destruction, instability, and the neurological condition. The length is not identified, which is not applicable to epidural abscesses of more than one level. Recently, Camino Willlhuber et al.[19] analyzed the reproducibility of this classification, giving it a moderate inter- and intra-observer reproducibility index.

Almansour et al.[14] developed a clinical-radiological classification that includes, in one of its points, epidural abscess, together with neurological deficit, instability, laboratory analyses, pain, and magnetic resonance lesions. They described treatment guidelines and one of the main indications for a surgical approach is deficit due to epidural abscess.

At present, other classifications and scores for the management of epidural abscess developed for other purposes are used, such as the study by Bilsky et al.[15] We believe that they have weaknesses, because they lack a division by regions, they do not analyze the length of the pyogenic epidural abscess, nor the association with other infectious foci.

On the other hand, Shah et al.[16] and Uchida et al.[17] formulated a hypothesis for the treatment of lumbar epidural abscesses using magnetic resonance imaging with contrast medium and neurological correlation based on the Frankel score, and it was reproducible in the cervical and thoracic spine.

In the first part of this process,[18] Cohen's kappa coefficient on global intra- and inter-observer reproducibility was 0.81, an excellent reproducibility value; the remaining values were: R 0.95; L 0.92; I 0.66 according to the resonance window and the use of contrast medium; A 0.70 and P 0.80, significantly higher than the result of this evaluation, we believe that it is due to the fact that, in the first experience, the participating specialists were orthopedists dedicated exclusively to spinal pathology.

Our morphological classification proposal describes and incorporates aspects related to length, location, type of compression and its association with the vertebral body, intervertebral and paravertebral discs, and distant infections, with excellent inter- and intra-observer reproducibility.

The strength of our study is the lack of international studies that describe the morphological characteristics covering the different regions, their pathology, and their extension. The weakness is the display of images of few cases, because they correspond to the initial parts of the planned project. The sample will be increased in the final stage of the investigation, and clinical evaluation, laboratory studies, and treatment will be included to provide therapeutic projections. Finally, independent evaluators will be sought for validation.

CONCLUSIONS

The proposed morphological classification is simple to use and has an excellent intra- and interobserver reproducibility rate. The parameters with the highest reproducibility were: R and L (>0.87) and the rest yielded figures between 0.55 and 0.77.

On average, the difference between professionals specializing in spinal pathology and those who are not is 0.10 point. It is estimated that the two diagnostic imaging professionals in training are related to the first group.

Conflict of interest: The authors declare no conflicts of interest.

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Results of Neurolysis for the Treatment of Neuropathic Pain in Patients with Sciatic Nerve Injury. Case Report

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ABSTRACT

Introduction: Sciatic nerve injury may cause paresthesias and hypoesthesias, severe neuropathic pain, and paralysis. Neurolysis can improve function, pain, and quality of life for these patients. The objective of this paper is to evaluate the clinical-functional outcomes of a series of patients with neuropathic pain due to sciatic nerve injury that was refractory to conservative treatment in whom neurolysis was performed. **Materials and Methods:** A retrospective case series of patients operated on for neurolysis of the greater sciatic nerve between March 2009 and June 2018 was analyzed. Preoperative and postoperative pain were evaluated using the visual analog scale (VAS) and the Likert scale. The type of postoperative pain was evaluated using the DN4 questionnaire, and the health-related quality of life was measured with the SF-36 questionnaire. **Results:** Eight patients were included. All patients evolved with a notable improvement in pain, with an average of 3 and 1.88 points on the VAS and Likert scales, respectively. The mean follow-up was 32 months (range 14–66). The DN4 questionnaire showed an average of 3.75 points (range 2–7). According to the SF-36, "Physical Health" was the variable with the worst results, with an average of 30.15. **Conclusions:** Sciatic nerve neurolysis in patients with neuropathic pain due to sciatic nerve injury and poor response to conservative treatment may improve pain and quality of life.

Keywords: sciatic neurolysis; neuropathic pain; SF-36 questionnaire; sciatic nerve injury.

Level of Evidence: IV

Resultados de la neurólisis como tratamiento del dolor neuropático en pacientes con lesión del nervio ciático. Reporte de casos

RESUMEN

Introducción: La lesión del nervio ciático puede ocasionar desde parestesias e hipoestesias, hasta dolor neuropático severo y parálisis. La neurólisis suele mejorar la función, el dolor y la calidad de vida de los pacientes. El objetivo de este estudio fue evaluar los resultados clínico-funcionales de una serie de pacientes con dolor neuropático por lesión del nervio ciático que no respondieron al tratamiento conservador y fueron sometidos a neurólisis. **Materiales y Métodos:** Se analizó retrospectivamente una serie de pacientes sometidos a neurólisis del nervio ciático mayor entre marzo de 2009 y junio de 2018. El dolor pre- y posoperatorio se evaluó mediante la escala analógica visual y la escala de Likert. El tipo de dolor posoperatorio se evaluó con el cuestionario DN4 y la calidad de vida relacionada con la salud, con el cuestionario SF-36. **Resultados:** Se incluyó a 8 pacientes. A los 32 meses de seguimiento promedio (rango 14-66), el dolor había mejorado notablemente (promedio de 3 y 1,88 puntos en las escalas analógica visual y de Likert, respectivamente). El cuestionario DN4 arrojó un promedio de 3,75 puntos (rango 2-7). Según el SF-36, la "salud física" fue la variable con peores resultados (promedio 30,15). **Conclusiones:** La neurólisis, cuando se indica a pacientes con mala respuesta al tratamiento conservador, es un método que alivia el dolor y mejora la calidad de vida de los pacientes con dolor neuropático secundario a una lesión del nervio ciático.

Palabras clave: Neurólisis del ciático; dolor neuropático; cuestionario SF-36; lesión del nervio ciático.

Nivel de Evidencia: IV

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INTRODUCTION

Sciatic nerve injury is a rare but potentially devastating complication.[1] The most common etiologies are: traumatic, compressive, ischemic, neoplastic and idiopathic.[2] Total hip arthroplasty (THA) represents the main cause of sciatic nerve neuropathy.[3] Its incidence varies from 0.08% to 3.7% in primary replacements and up to 7.6% in revision surgeries.[3-5]

Neuropathy secondary to THA can result from compression of the nerve by bruising or osteosynthesis material, excessive traction from inappropriately placed retractors, tension generated due to excessive lengthening of the lower limb, and thermal injury from extrusion of surgical cement.[6] The consequences of such an injury can range from paresthesia and hypoesthesia in the nerve distribution zone, to severe neuropathic pain and paralysis.[7] Initial management of sciatic nerve neuropathy usually consists of conservative treatment with physiotherapy and orthosis to avoid equinus deformity, hoping that function will be restored over time.[8,9] The first-line drugs to treat neuropathic pain are tricyclic antidepressants (particularly amitriptyline), dual antidepressants (duloxetine) and antiepileptics, such as gabapentin and pregabalin, the latter being the only drug that is indicated to treat central neuropathic pain.[8,9] In all cases, psychological counseling is suggested, since neuropathic pain is often associated with sleep disorders, anxiety, and depression.[8,9]

If conservative treatment fails and the pain persists, neurolysis of the sciatic nerve can be performed to free it from adhesions and retractable scar areas along its path.[1] Timely neurolysis can improve function, pain, and quality of life for patients.[1]

The objective of this study was to evaluate the clinical-functional outcomes of a series of patients with neuropathic pain due to sciatic nerve injury, who had not responded to conservative treatment and underwent sciatic nerve neurolysis.

MATERIALS AND METHODS

A consecutive case series of eight patients who had failed conservative treatment and underwent neurolysis of the greater sciatic nerve between March 2009 and June 2018 was retrospectively analyzed. Conservative treatment had consisted mainly of physiotherapy, with muscle strengthening and transcutaneous electrical nerve stimulation for pain relief for 8-12 weeks along with first-line medication, such as pregabalin, in doses ranging from 150 to 300 mg/day.

All were operated on by the same surgeon. The data was extracted from the electronic medical record of our hospital. The study protocol was approved by the Ethics Committee for Research Protocols of our Institution (IRB 00010193).

Patients >18 years of age were included, with neuropathic pain due to sciatic nerve injury without response to medical-pharmacological treatment and with a minimum follow-up of 12 months.

At the most recent consultation, pre- and postoperative pain was assessed using a 10-point visual analogue scale (VAS), with 0 representing no pain and 10 representing the worst possible pain perceived by the patient. In turn, postoperative pain was evaluated using the 5-point Likert scale, where 1 represents "no pain"; 2, "little pain"; 3, "moderate pain"; 4, "severe pain" and 5, "extreme pain". The amount of time that had passed until the change in pain type or absence of pain was assessed.

The DN4 questionnaire (Douleur Neuropathique 4)[10,11] was also used to assess the type of postoperative pain, and a value ≥4 was considered positive for neuropathic pain. Although it is not part of the questionnaire, it was asked if the pain was identified or became more severe during the night. Physical activity and the subjective question "Is your current pain similar to what you were experiencing before the operation?" were used to assess postoperative pain.

The subjective degree of postoperative satisfaction was evaluated using the Likert scale (1 "very dissatisfied", 2 "dissatisfied", 3 "indifferent", 4 "satisfied" and 5 "very satisfied") and the 10-point VAS.

Health-related quality of life was analyzed using the SF-36 subjective sensation of well-being questionnaire (*Short Form-36 Health Survey*). In this study, the Spanish version of the Ware and Sherbourne SF-36 was used, adequately translated and validated under the name of *Cuestionario de Salud SF-36 estándar.*[12,13] This survey evaluates eight dimensions of health status: physical functioning, limitation due to physical problems, bodily pain, social role, mental health, limitation due to emotional problems, vitality, energy or fatigue, and general perception of health.

Scores for each of these dimensions on the SF-36 range from 0 to 100. Values greater than 50 are considered positive health states, and a value of 100 indicates optimal health. Although the questionnaire is not designed for a

global index, cumulative scores can be obtained that describe health-related quality of life. These scores are analyzed by combining the following dimensions: cumulative measure of physical health (physical function, physical role, bodily pain, general health) and cumulative measure of mental health (emotional role, social function, mental health and vitality). Table 1 summarizes the eight dimensions of the questionnaire.

Table 1. Content of the dimensions of the SF-36 questionnaire

Meaning of scores from 0 to 100			
Assessment	**No. of Items**	**Worst Score (0)**	**Best Score (100)**
Physical function	10	Very limited to carry out all physical activities, including bathing or showering, due to health	Carries out all kinds of physical activities including the most vigorous without any limitation due to health
Limitations due to physical problems	4	Problems with work or other daily activities due to physical health	No problem with work or other daily activities due to physical health
Limitations due to emotional problems	3	Problems with work and other daily activities due to emotional problems	No problem with work and other daily activities
Body ache	2	Very intense and extremely limiting pain	No pain or limitations due to it
General health	5	Evaluates own health as poor and believes that it may worsen	Evaluates own health as excellent
Vitality	4	Feels tired and exhausted all the time	Feels very dynamic and full of energy all the time
Social function	2	Extreme and very frequent interference with normal social activities, due to physical or emotional problems	Carries out normal social activities without any interference due to physical or emotional problems
Mental health	5	Feels anxious and depressed all the time	Feels happy, calm and peaceful all of the time

Taken from Vilagut G, et al. El Cuestionario de Salud SF-36 español: una década de experiencia y nuevos desarrollos (8,9,19)

Surgical technique

The patient was placed in the lateral or prone position, and general and spinal anesthesia was administered. In patients who had already undergone THA, the posterolateral approach was used for prosthesis replacement, extending proximally and distally. If the patient had not undergone a THA, a posterior approach was made following the gluteal fold from lateral to medial to the midpoint of the thigh where the approach was continued distally. At the proximal level, the intermuscular plane between the iliotibial band and the gluteus maximus was used to access the external rotators. The incision was continued distally over the posterior region of the thigh. The sciatic nerve was identified proximal, immediately distal to the quadratus femoris muscle insertion, and running between the gluteus maximus and the biceps femoris. The nerve was freed from surrounding scars and adhesions using microscopic binocular magnifying glasses at 3.5 magnification. When neuromas were visualized, a longitudinal epineurotomy was performed in order to perform fascicular decompression. Careful hemostasis was performed and the wound was closed in layers.

RESULTS

Eight patients were included in the study (2 men and 6 women; mean age at injury: 49 years [range 19-73]). Three died from causes unrelated to treatment and one was lost to follow up. The demographic variables evaluated are summarized in Table 2.

Table 2. Demographic data.

Patient	Sex	Age at injury (years)	Age at time of surgery (years)	Time from injury to surgery (months)	Comorbidities	Cause of neurological injury
1	M	50	51	14	Smoking	Total hip replacement
2	M	19	19	1	-	Gunshot wound
3	F	53	59	78	Obesity	Total hip replacement
4	F	54	55	17	Smoking	Revision of total hip replacement
5	F	33	39	66	Smoking, diabetes	Acetabular fracture
6	F	54	58	46	Liver-kidney transplantation, chronic renal failure	Hip fracture
7	F	73	74	13	Obesity	Total hip replacement
8	F	64	64	8	-	Total hip replacement

M = male; F = female

50% of the patients suffered a sciatic injury due to elongation in a THA. One had a partial laceration secondary to a displaced acetabular fracture and another a compression injury secondary to a hematoma from a hip fracture. Three of the four patients included in the final evaluation were smokers. After an average of 32 months (range 14-66), pain had improved by more than 5 points in all patients: mean VAS score of 9.63 before surgery and 3 postoperatively. The score on the Likert scale for postoperative pain at the last follow-up was, on average, 1.88 (0-7/10). In the immediate postoperative period, pain had improved in 50% of patients (Table 3).

The DN4 questionnaire, the degree of postoperative satisfaction, and health-related quality of life were determined only in those patients included in the final evaluation. The DN4 questionnaire revealed neuropathic pain in only one patient (total mean 3.75 points; range 2-7). The four patients under follow-up reported preoperative nocturnal pain and continued to have pain during physical activity in the postoperative period. Only one patient remained with postoperative nocturnal pain. However, when compared to the preoperative period, all reported pain of lesser intensity and with different characteristics (Table 3).

The degree of postoperative satisfaction was, on average, 4.75 points according to the Likert scale and 9 points on the VAS (Table 3).

Table 3. Pre- and postoperative pain outcomes

Patient	VAS Pre-op pain	VAS Post-op pain	Likert scale - Post-op pain	Time until pain change	DN4 Question-naire	Night pain Pre-op	Night Pain Post-op.	VAS Post-op satis-faction	Likert scale Post-op satis-faction	Activity post-op pain
1	10/10	3/10	2	Immediate post-op period	3/10	Yes	No	10/10	5	Yes
2	10/10	6/10	3	Immediate post-op period	-	-	-	-	-	-
3	10/10	0/10	1	9 months	-	Yes	-	-	-	-
4	10/10	2/10	1	Immediate post-op period	2/10	Yes	No	10/10	5	Yes
5	9/10	7/10	3	3 months	7/10	Yes	Yes	6/10	4	Yes
6	9/10	0/10	1	1 month	-	-	-	-	-	-
7	10/10	6/10	3	3 months	-	-	-	-	-	-
8	9/10	0/10	1	Immediate post-op period	3/10	Yes	No	10/10	5	Yes

VAS = visual analog scale; pre-op. = preoperative; post-op. = postoperative; DN4 = Douleur Neuropathique 4 Questionnaire

The results of the SF-36 are summarized in Table 4. 75% of the patients had severe limitations in work activities and daily life activities due to physical problems; the results in these dimensions were 0%. With an average percentage of 31.25% (range 25-40%), all demonstrated physical function below the positive state of health. One patient had severe limitations due to emotional problems, two achieved a positive state of health and another reached an optimal level. In the "vitality" dimension, one patient reported being exhausted and tired most of the time. Regarding the "mental health" field, none qualified it as bad and all maintained that it could possibly improve. The item "body pain" failed to reach a positive state of health in any of the three patients; however, all considered themselves to have acceptable "general health" (Table 4).

Table 4. Results of the SF-36 questionnaire

Assessment	SF-36 questionnaire (%)			
	Patient 1	Patient 4	Patient 5	Patient 8
Cumulative measure of physical health				
Physical function	35	25	40	25
Limitations due to physical problems	0	25	0	0
Body ache	12.5	45	35	35
General health	40	65	60	40
Cumulative measure of mental health				
Limitations due to emotional problems	0	100	66.7	55
Vitality	20	60	50	50
Mental health	60	76	60	60
Social function	25	25	75	25

In terms of cumulative measures, "physical health" had the lowest average of 30.15 points, compared to the cumulative measure of mental health (50.48); a positive global health status was obtained (Table 4).

DISCUSSION

Sciatic nerve palsy has an uncertain prognosis.[14] The nature of the original nerve injury, as well as the duration of the aggression, are critical factors in determining prognosis.[14] This prognosis is also influenced by the patient's age, the duration of denervation, the anatomical level of the injury, and the associated injuries.[15] Favorable results have been described in patients <64 years of age.[3] Younger people have better nerve recovery because they have more neuronal growth and plasticity.[15] In our study, the youngest patient had the worst recovery and the oldest had the best recovery. However, this could be due to the nature of the injury and the time evolution from the original injury to the procedure. The patient who had the greatest postoperative pain had sustained sciatic nerve injury from a displaced acetabular fracture secondary to high-energy multiple trauma. Azcuénaga et al. published a series of patients with acetabular fracture in the context of high-energy trauma.[16] Two of these patients had sciatic nerve neuropraxia that completely reversed in an average of three months, but clinical outcomes were unfavorable.[16]

Although sciatic nerve injuries are often treated conservatively in the first instance, it is important to consider whether early intervention may benefit the patient.[16] Following a maximum of four months of follow-up, surgical treatment should be considered.[7] However, most authors agree that positive outcomes can be obtained up to 12 months after injury.[3] The time from injury to neurolysis in our series varied greatly, with patients treated within 14 months of injury showing marked improvement compared to those treated later.

Neuropathic pain is caused by a somatosensory system injury, such as structural damage to the nociceptive pathways, peripheral receptors, or conduction pathways. This determines that a stimulus is not necessary for the pain to manifest.[17] Complex regional syndrome, especially type II with an identifiable nerve injury (causalgia), is one of the differential diagnoses to consider with neuropathic pain.[18] Its diagnosis is primarily clinical and is based on the Budapest Diagnostic Criteria, which the patients in this study did not meet.[18]

Pritchett et al. concluded that both sympathectomy and neurolysis could be beneficial in reducing dysesthetic pain by producing marked improvement in properly selected patients in whom conservative treatment has failed.[19]

Regardless of the time of evolution, 88% of the patients evaluated had a notable change in both the intensity and the characteristics of the pain after surgery. Only one continued to have moderate postoperative pain, with a VAS score of 7/10. This is consistent with the results obtained in the DN4 questionnaire, in which 75% obtained values below 4, absence of postoperative nocturnal pain and exacerbation during physical activity, which was interpreted as absence of neuropathic pain.

As previously reported in other series,[2,19] the degree of postoperative satisfaction assessed using the Likert scale and the VAS reached a high level, indicating that the patients were satisfied with the surgical treatment regardless of the results obtained.

In terms of functional outcomes, the SF-36 revealed a significant decrease in the four patients' cumulative measure of "physical health." This implies a limitation in carrying out work and other daily activities, either due to pain or physical disability, in which the patient perceives a lower performance, greater difficulty, or even impossibility. Although one patient reported severe interference of emotional problems in the usual socio-professional life, acceptable scores in the areas of general health, vitality, and mental health can be observed in the other three patients; this implies that, after the surgery, they did not see their perspective of health or their feeling of energy diminished, reaching a cumulative measure of positive "mental health". It is important to note that the SF-36 measures the general health perceived by the patient and is not disease specific; thus, the comorbidities or associated conditions of patients undergoing sciatic neurolysis can be seen reflected in the questionnaire results.

The limitations of this study are those inherent to its retrospective nature. Likewise, and despite being a low-prevalence complication, we have a low number of patients, so it is not possible to perform a statistical significance analysis. On the other hand, we do not have a control group with conservative treatment.

However, we believe that patients treated with sciatic nerve neurolysis will perceive a relief of neuropathic pain even in late stages of the condition.

CONCLUSION

Neurolysis for those who do not respond to conservative treatment is a method that improves pain and quality of life in patients with neuropathic pain secondary to sciatic nerve injury.

Conflict of interest: The authors declare no conflicts of interest.

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Bilateral Simultaneous Unicompartmental Knee Arthroplasty. Medium-term Outcomes in 86 Arthroplasties with an Average Follow-up of 6.2 Years

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ABSTRACT

Objective: The purpose of this article is to examine the functional outcomes, complications, and medium-term survivorship of medial or lateral bilateral simultaneous unicompartmental knee arthroplasty (bUKA) for the treatment of bilateral knee osteoarthritis. **Materials and Methods:** Retrospective report of patients who underwent a medial or lateral bUKA for treatment of bilateral knee osteoarthritis between April 2004 and April 2020, with a minimum follow-up of 1 year. The KSS 2011 was used for the clinical-functional evaluation of each patient. The duration of surgery, length of hospital stay, and transfusion requirements were determined. The short-term and medium-term complications were analyzed, as well as the revision rate and the prosthesis survivorship. **Results:** We evaluated 86 bUKAs in 43 patients with a mean follow-up of 6.1 years. The clinical and functional KSS improved from 46.1 ± 10.2 to 80.9 ± 15.9 and 22.8 ± 11.9 to 89.8 ± 18.9 respectively. Postoperative maximal flexion improved from 106.3º ± 5.2º to 125.1º ± 4.2º and flexion contracture improved from 7.5º ± 2.2º to 2.3º ± 1.6º. The mean surgical time was 178.6 minutes and the hospital stay was 39.8 hours. Two patients required transfusions. The complication rate was 6.9%. Three knees required revision surgery for aseptic loosening after 12, 8.5 and 7 years. The survivorship rate was 96.5%. **Conclusion:** Simultaneous medial or lateral bUKA provides excellent clinical-functional outcomes with a low rate of complications in patients with bilateral knee osteoarthritis.

Keywords: unicompartmental knee arthroplasty; bilateral UKA (bUKA); bilateral knee osteoarthritis; bilateral knee arthroplasty; simultaneous unicompartmental arthroplasty.
Level of Evidence: IV

Reemplazo unicompartimental bilateral de rodilla en un tiempo quirúrgico. Resultados a mediano plazo de 86 prótesis con un seguimiento promedio de 6.2 años

RESUMEN

Objetivo: Evaluar los resultados funcionales, las complicaciones y la supervivencia a mediano plazo de la prótesis unicompartimental bilateral medial o lateral de rodilla en un tiempo quirúrgico. **Materiales y Métodos:** Estudio retrospectivo de pacientes con prótesis unicompartimental bilateral medial o lateral de rodilla colocada en un tiempo quirúrgico por gonartrosis entre abril de 2004 y abril de 2020, seguimiento mínimo 1 año. Se evaluaron los resultados clínico-funcionales con el KSS 2011. Se determinaron los tiempos quirúrgico total y de internación, y el requerimiento de transfusiones. Se analizaron las complicaciones a corto y mediano plazo, y las tasas de revisión y de supervivencia de la prótesis. **Resultados:** Se evaluaron 86 prótesis unicompartimentales en 43 pacientes (seguimiento promedio 6.1 años). El KSS clínico y funcional aumentó de 46,1 ± 10,2 a 80,9 ± 15,9 y de 22,8 ± 11,9 a 89,8 ± 18,9, respectivamente. La flexión máxima mejoró de 106,3° ± 5,2° a 125,1° ± 4,2° y la contractura en flexión, de 7,5° ± 2,2° a 2,3° ± 1,6°. La cirugía duró 178.6 min y la internación, 39.8 h. Dos pacientes requirieron transfusión**.** La tasa de complicaciones fue del 6,9%, todas menores. Tres rodillas tuvieron un aflojamiento mecánico aséptico y requirieron revisión a prótesis total de rodilla o nueva prótesis unicompartimental tras 12, 8.6 y 7 años. La supervivencia de la prótesis fue del 96,5%. **Conclusión:** La prótesis unicompartimental bilateral medial o lateral en un tiempo quirúrgico para la gonartrosis unicompartimental de rodilla proporciona excelentes resultados clínico-funcionales, con bajas tasas de complicaciones.

Palabras clave: Prótesis unicompartimental; gonartrosis bilateral; reemplazo unicompartimental bilateral; prótesis unicompartimental bilateral simultánea.
Nivel de Evidencia: IV

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INTRODUCTION

Knee osteoarthritis predominantly affects one of the two tibiofemoral compartments in more than a third of patients (35%).[1] In these cases, unicompartmental knee arthroplasty (UKA) relieves symptoms and improves functional values, with outcomes comparable to or better than those of total knee arthroplasty (TKA).[2,3] Recent research suggests that UKA is indicated in approximately 50% of knee arthroplasties.[4] UKA surgery is less invasive than TKA and has several advantages, including less bleeding, a shorter surgical time and hospital stay, faster rehabilitation times, better functional outcomes, and lower infection rates.[2,3,5,6] UKA has a 10-year survival rate of 97%, a 20-year survival rate of 85.9%, and a 25-year survival rate of 80%.[2,7]

Knee osteoarthritis is bilateral in 66-85% of patients, and a quarter of them have symptoms.[1,8,9] After knee arthroplasty, 36-70% will require replacement surgery on the contralateral knee over the next 10 years.[9] The most common pattern of presentation of bilateral knee osteoarthritis is that which involves the internal compartment of both knees.[1] In these cases, medial or lateral bilateral UKA represents an attractive therapeutic alternative. Patients who require bilateral knee arthroplasty have the operation performed in the same surgical procedure and anesthesia time, or it can be done in two separate procedures separated by a time interval.

In well-chosen patients, the potential benefits of single-stage medial or lateral bilateral UKA include shorter hospitalization, surgical, and recovery times, lower costs, and comparable clinical and functional outcomes to two-stage UKA.[10,11] Despite this, there is concern that single-stage bilateral UKA is associated with higher rates of complications, revisions, morbidity, and mortality than the two-stage procedure.[12]

The purpose of this research was to assess the clinical and imaging outcomes, complications, and medium-term survival of the prosthesis of medial or lateral unicompartmental knee replacements performed bilaterally during the same surgical procedure. The secondary objective was to determine the surgical and hospitalization times, the need for transfusion, and the revision rate. Our hypothesis was that bilateral UKA performed in a single stage is associated with low complication rates and functional outcomes and survival rates comparable to those reported in the international literature.

MATERIALS AND METHODS

Retrospective observational study to evaluate the functional outcomes, complications and medium-term survival of simultaneous bilateral medial or lateral UKA in patients with bilateral unicompartmental knee osteoarthritis. Cases operated on consecutively by the same surgeon and with the same technique between April 2004 and April 2020, with a minimum follow-up of one year, were analyzed.

The inclusion criteria were: patients with bilateral medial or lateral unicompartmental knee osteoarthritis treated with simultaneous bilateral UKA, age >18 years and follow-up >12 months. The exclusion criteria were: patients with bilateral unicompartmental knee osteoarthritis treated with sequential UKA in two stages, patients with knee osteoarthritis treated with TKA, loss to follow-up.

Clinical evaluation

Preoperative data was gathered retrospectively from the medical records of patients who met the inclusion criteria. Clinical assessment was made before surgery and at the last control using the *Knee Society Score* 2011 (KSS). Joint stability was verified using the varus-valgus stress test, the Lachman test, the pivot-shift test, and the anteroposterior drawer test, and joint range of motion was determined with a goniometer. During surgery, patellofemoral chondropathy, according to the modified Outerbridge classification, and the integrity of the anterior and posterior cruciate ligaments were evaluated.

Surgical time (from the start of anesthesia to the end of surgery), hospital stay, and the need for transfusions were determined. A red blood cell transfusion was indicated if the patient had a hemoglobin value <7 mg/dL or symptomatic anemia (paleness, palpitations, or tachypnea). During the postoperative controls, the presence of both acute (before three months) and late complications was determined. Revision was defined as any new surgical intervention in the operated knee that included the removal or replacement of any of the prosthesis components, as well as reoperation with these preserved.

Radiographic evaluation

Before surgery, anteroposterior and lateral radiographs of both knees were taken, with bipodal standing, axial of the patella at 30º flexion (Merchant), anteroposterior in 45º semiflexion (Schuss), and varus and forced valgus radiographs to assess collateral ligament sufficiency, misalignment correction, and contralateral compartment impingement. In the postoperative period, anteroposterior, lateral, and axial radiographs of the patella were taken (Figure 1).

The pre- and postoperative tibiofemoral axis was measured with a goniometer. The degree of osteoarthritis in the affected compartment was quantified according to the Ahlback classification for genu varus, and the Kellgren-Lawrence classification for genu valgus. The evaluations were carried out by one of the authors who was not involved in the surgery.

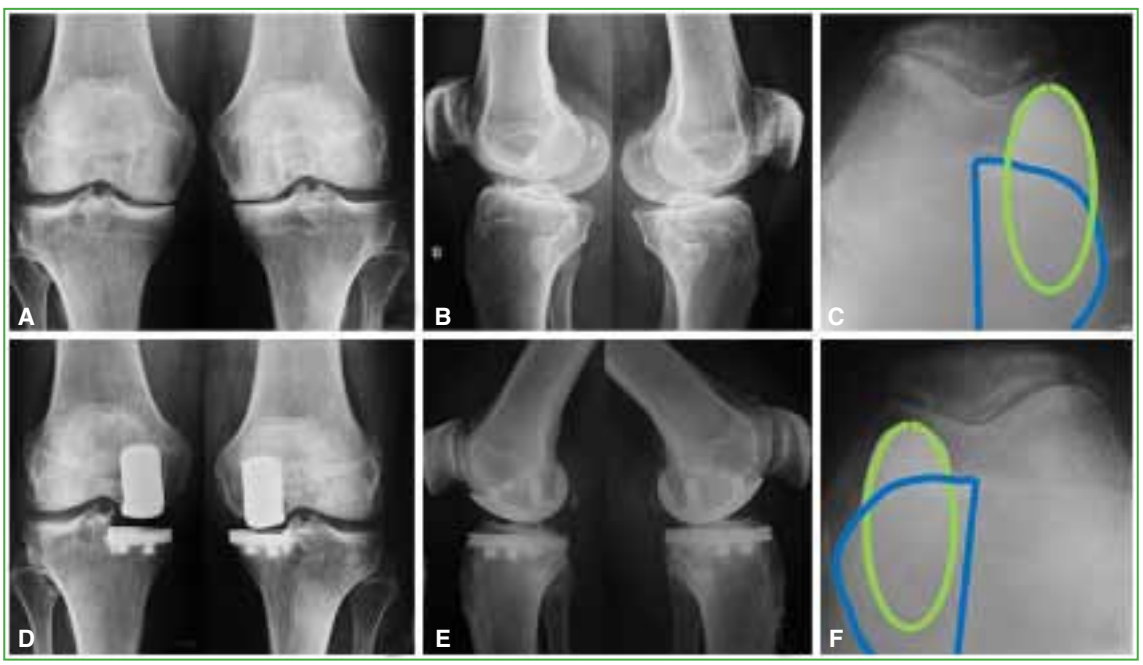

Figure 1. Patient with bilateral internal unicompartmental prosthesis and 6.3 years of follow-up.
A and B. Anteroposterior and lateral preoperative radiographs of both knees. Bilateral osteoarthritic genu varus is observed. **C-F.** Postoperative anteroposterior and lateral radiographs of both knees, and axial radiograph of the patella. The correct alignment of the components can be visualized in all projections.

Indications

Bilateral UKA was proposed if the patient had symptomatic bilateral tibiofemoral unicompartmental knee osteoarthritis, either internal or external; correctable deformity on varus or valgus stress radiographs; preservation of joint space in the contralateral tibiofemoral compartment; valgus or varus deviation of up to 20º, preoperative flexion ≥90º, preoperative extension deficit ≤15º, clinical ligament sufficiency in the coronal and sagittal planes, and body mass index ≤40. The extended indications were: symptomatic or asymptomatic patellofemoral osteoarthritic changes, osteophytes or incipient tibiofemoral osteoarthritis without clinical repercussions in the contralateral compartment, degenerative lesion of the anterior cruciate ligament without clinical instability secondary to osteoarthritic progression, were not considered contraindications, as well as age at the time of surgery.

Contraindications were: knee osteoarthritis with bicompartmental tibiofemoral involvement, impingement of the contralateral compartment on knee radiographs with varus or valgus stress, fixed or severe imbalance >20º, preoperative flexion <90º, preoperative flexion >15º, anteroposterior or mediolateral clinical instability, body mass index >40 and active systemic arthropathies (such as rheumatoid arthritis).

The selection of patients for the simultaneous bilateral procedure was based on:

- an ASA (*American Society of Anesthesiology*) score ≤3 (1 = healthy patient, 2 = moderate systemic disease, 3 = severe systemic disease, 4 = severe systemic disease that constantly threatens life, 5 = person dying person not expected to survive without operation, 6 = person with brain death).

- the level of activity of the patient. People with an active, non-sedentary lifestyle.

- The proactive psychological disposition and conviction of the benefits of performing the procedure simultaneously, which is assessed during questioning and the doctor-patient relationship.

Surgical protocol

All surgeries were carried out by the same surgeon and surgical team, according to the same protocol. Each surgery was performed at the same surgical stage, with the drapes of each one placed independently. The surgeries were carried out in medium-complexity operating rooms, without laminar flow and under spinal anesthesia. The irrigation system or pulsatile lavage gun was systematically used as an intra-surgical antiseptic protocol. Because of the administration of tranexamic acid, no hemostatic tourniquets have been placed in the last seven years.

From patient installation to the rigorous surgical technique, the surgical protocol was always similar or standardized. For genu varus, a midline skin incision was made, followed by an internal parapatellar arthrotomy or mid-vastus approach, and for genu valgus, a lateral transretinacular approach. After the tibial resection in knee flexion, the femoral resection was performed with the knee in extension, ensuring strict parallelism between the tibial and femoral cuts. The polyethylene with a thickness that ensured a safety laxity of 2 mm at 20° flexion was chosen (Figure 2). In all cases, a fixed-bearing UKA was used. Image intensifier was not used.

On the patellofemoral joint, the following surgical procedures were performed on demand: resection of osteophytes, cartilage shaving, microfractures, and lateral patellar facetectomy. Finally, the lateral retinaculum was partially or completely released to reduce lateral patellofemoral hypertension and achieve proper patellar tracking.

A tight capsular and superficial tissue closure was performed in the cases of medial UKA and a partial subsynovial closure for lateral UKA, which facilitates active mobilization of the knee with no limits other than pain in the immediate postoperative period. An aspirator was placed in all patients, which was removed 12 and 24 hours after surgery, before discharge. Dabigatran 150 mg per day was administered for 30 days as antithrombotic prophylaxis.

Rehabilitation protocol

Patients were trained and instructed to perform and achieve effective isometric quadriceps contractions prior to surgery in order to facilitate a quick recovery. The early rehabilitation protocol included quadriceps, hamstrings, gastrocnemius, and soleus strengthening exercises, and ambulation with full weight-bearing allowed from the first day after surgery. Physical therapy began after 3-4 weeks and return to normal activities occurred at 6-8 weeks.

Statistical Analysis

An observational cross-sectional study was carried out. The results are expressed in frequency tables or graphs depending on the nature of the variables. For quantitative variables, measures of central tendency (mean and median) and measures of dispersion (standard deviation and interquartile range) were calculated. The 95% confidence intervals were calculated for the estimates of the means of the variables of interest.

For statistical inference, the nonparametric Wilcoxon signed-rank test was used to compare the pre- and postoperative KSS distributions and also the pre- and postoperative distributions of the variables of interest. The means of two independent populations were compared using the Mann-Whitney-Wilcoxon non-parametric statistical test. To study whether the correlation between two quantitative variables was statistically significant, Spearman's correlation test was used. All hypothesis tests are performed considering a significance level of 5%.

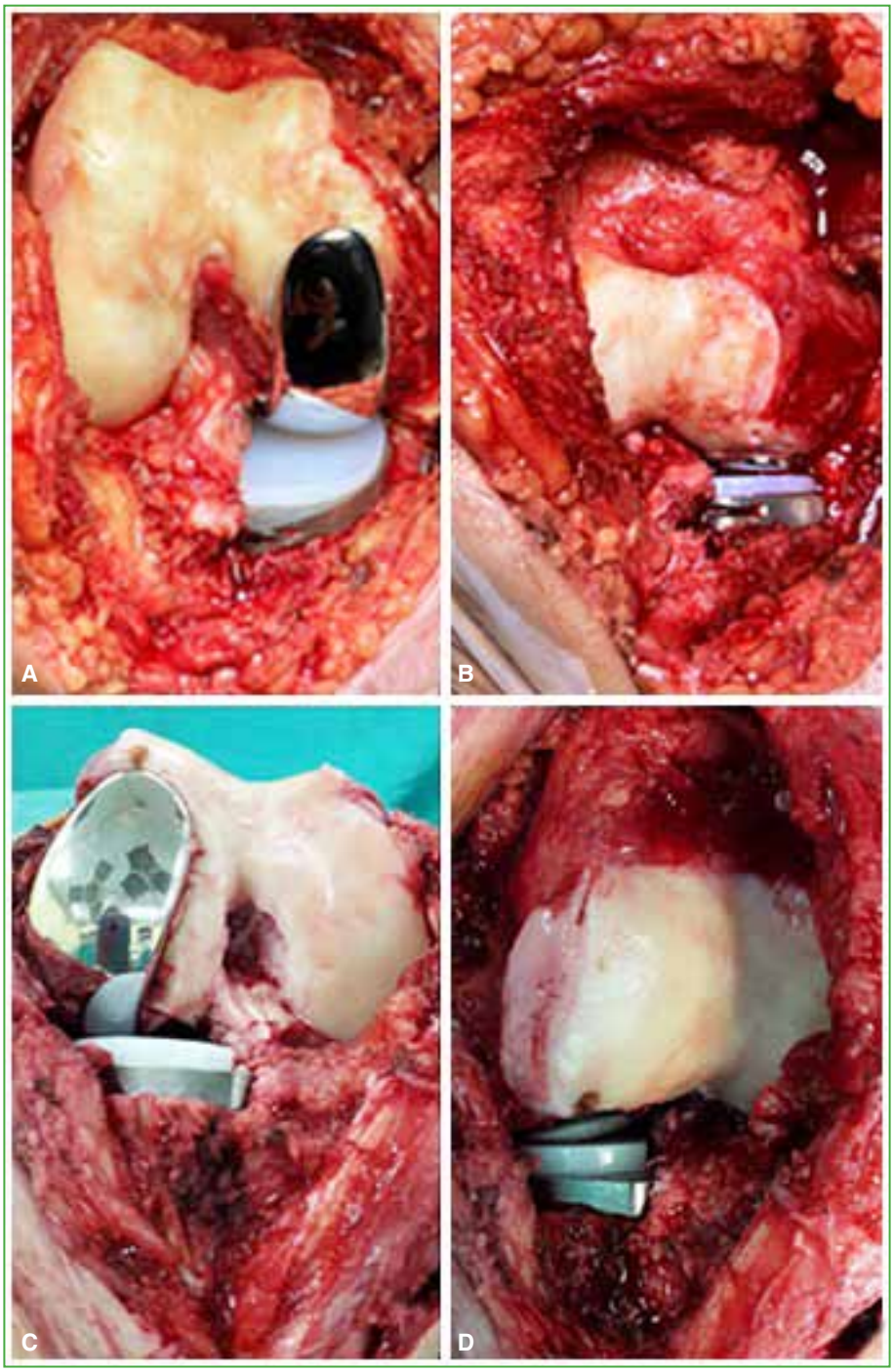

Figure 2. A and B. Intraoperative images of the medial unicompartmental prosthesis with the knee in flexion and extension. The alignment of the tibial and femoral component in flexion and extension can be observed. **C and D.** Intraoperative images of the lateral unicompartmental prosthesis with the knee in flexion and extension. The divergent orientation of the femoral and tibial components is observed with the knee in flexion, due to the femorotibial screwing mechanism (**C**) and the correct alignment in extension (**D**).

RESULTS

284 UKAs were performed between April 2004 and April 2020. Six patients were excluded: four due to loss of follow-up and two due to follow-up <1 year. The sample was made up of 86 UKAs in 43 patients who met the inclusion criteria. 72.1% (n = 31) were women (mean age 66.3 years [range 50-83]), body mass index was 29.3 (range 18.6-39.6), and mean follow-up was 6.1 years (range 1.1-17). In 40 patients (93%), a bilateral medial UKA was performed, two (4.7%) had a bilateral lateral UKA, and one (2.3%) had a medial UKA in one knee and a lateral UKA in the other. Thus, 81 UKA were medial (94.2%) and five UKA were lateral (5.8%). 23.3% of the patients had undergone a previous arthroscopy (n = 10), four of them in both knees (Table 1).

Table 1. Demographic characteristics of the sample

Total patients **Total number of bilateral unicompartmental prostheses**	**43** **86**
Age (years)	66.3 (range 50-83)
Body mass index	29.3 (range 18.6-39.6)
Follow-up (years)	6.1 (range 1.1-17)
Sex Female Male	 31 (72.1%) 12 (27.9%)
Unicompartmental prosthesis Bilateral medial Bilateral lateral Medial and Lateral	 40 (93%) 2 (4.7%) 1 (2.3%)

The implants used were: 76 ZUK (Zimmer®, Warsaw, IN, USA), six Allegretto (Sulzer, Winterthur, Switzerland) and four MG (Zimmer®, Warsaw, IN, USA) prostheses.

A statistically significant increase was observed in the KSS values with respect to the preoperative scores. The clinical KSS increased from 46.1 ± 10.2 to 80.9 ± 15.9 in the postoperative period, and the functional KSS, from 22.8 ± 11.9 to 89.8 ± 18.9 ($p < 0.05$). The KSS of satisfaction improved from 9.1 ± 3.2 to 38.2 ± 7.4, and that of expectations from 10.7 ± 2.3 to 14.5 ± 2.8 ($p < 0.05$). An increase in the range of motion was observed, which went from a maximum preoperative flexion of 106.3° ± 5.2° to 125.1° ± 4.2° postoperatively, while the flexion contracture was 7. 5° ± 2.2° to 2.3° ± 1.6°, respectively ($p < 0.05$) (Figure 3).

The radiographs revealed genu varus osteoarthritis in 81 knees, 9.9% (n = 8) corresponded to grade 3 of the Ahlback classification; 43.2% (n = 35) to grade 4 and 46.9% (n = 38) to grade 5. Of the latter, 22 (57.9%) had subluxation in the coronal plane reducible on radiographs with forced valgus. In all cases of genu valgus osteoarthritis, grade 4 degeneration was found according to the Kellgren-Lawrence classification. The preoperative tibiofemoral axis was 9° ± 2.3° of varus for genu varus osteoarthritis (range 4-15) and 14.6° ± 4.2° of valgus for genu valgus osteoarthritis (range 10-20). The postoperative tibiofemoral axis was corrected to 3.6° ± 1.4° varus (range 1-9) and 7.4° ± 2.8° valgus (range 4-10), respectively ($p < 0.05$) (Table 2 and Figure 4).

The total surgical time was 178.6 min (range 150-195). During surgery, it was discovered that 18.6% of the knees (n = 16) had grade 2 patellofemoral chondropathy, 53.5% (n = 46) had grade 3, and 27.9% (n = 24) had grade 4. Three of the latter required lateral patellar facetectomy, all with lateral UKA. The mean hospitalization time was 39.8 h (range 27-48). Two patients (4.7%) required a transfusion of red blood cells, both had undergone surgery 17 years before when tranexamic acid was not administered.

There was no statistically significant relationship between age, BMI, degree of patellofemoral chondropathy, and degree of preoperative misalignment and postoperative KSS values ($p>0.05$). There was no difference in surgical time between patients who received a tourniquet and those who did not, with 44 receiving a tourniquet and a surgical time of 177.3 ± 17.5 compared to 42 without a tourniquet and a surgical time of 180 ± 15 ($p = 0.25$).

Figure 3. A 60-year-old patient treated for right genu valgus and left genu varus osteoarthritis with a bilateral unicompartmental prosthesis. **A and B.** Anteroposterior and lateral radiographs of both knees in the postoperative period. The correct alignment of the prosthetic components is observed. **C.** Recovery of the primitive axis and full range of motion after 7.6 years of follow-up.

Table 2. Comparative pre- and postoperative outcomes.

	Preoperative	Postoperative	P
Clinical KSS	46.1 ± 10.2	80.9 ± 15.9	<0.005
Functional KSS	22.8 ± 11.9	89.8 ± 18.9	<0.005
KSS satisfaction	9.1 ± 3.2	38.2 ± 7.4	<0.005
KSS expectations	10.7 ± 2.3	14.5 ± 2.8	<0.005
Maximum flexion	106.3° ± 5.2°	125.1° ± 4.2°	<0.005
Flexion contracture	7.5° ± 2.2°	2.3° ± 1.6°	<0.005
Tibiofemoral axis Varus Valgus	 9° ± 2.3° 14.6° ± 4.2°	 3.6° ± 1.4° 7.4° ± 2.8°	 <0.005 <0.005

KSS = *Knee Society Score*.

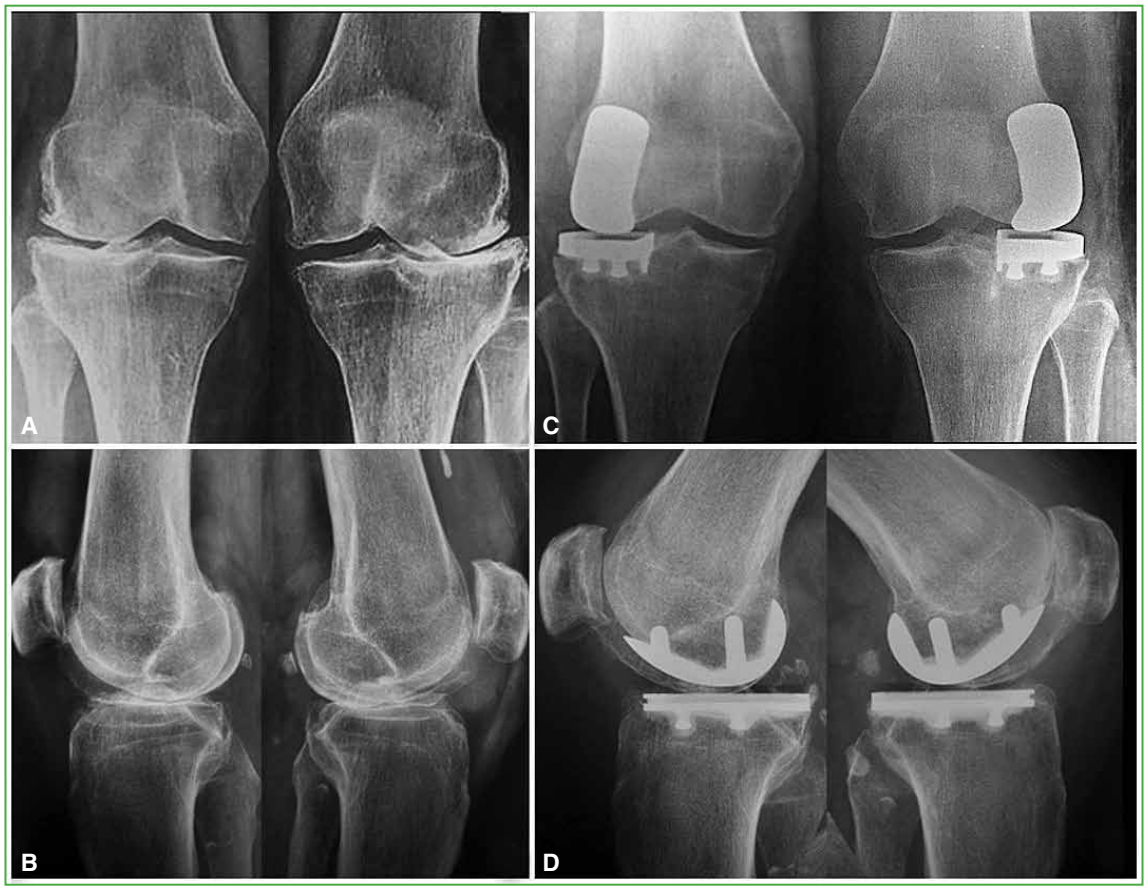

Figure 4. Preoperative (**A and B**) and postoperative (**C and D**) anteroposterior and lateral radiographs of both knees. Patient with bilateral lateral unicompartmental prosthesis and 7.2 years of follow-up.

The complication rate was 6.9% (n = 6), all of which were minor: one mobilization under bilateral anesthesia in the same patient six weeks after the initial surgery, with complete recovery of the range of motion; 2 wound dermatitis, 1 dehiscence and 1 superficial necrosis, all with good evolution by outpatient treatment. Three knees in three patients (3.5%) evolved to aseptic mechanical loosening, one of them traumatic, for which we proceeded to revision and conversion to TKA in two cases, and revision of the unicompartmental tibial component to a new *all poly* tibial plateau UKA in the remainder, after 12, 8.6 and 7 years, respectively. The survival of the prosthesis was 96.5% at 6.1 years (1.1-17) (Figures 5 and 6).

DISCUSSION

Bilateral medial or lateral UKA at the same surgical stage is recommended for appropriately selected patients. The findings of this retrospective study indicate that a simultaneous bilateral medial or lateral UKA as a treatment for bilateral unicompartmental knee osteoarthritis is a safe procedure with low complication rates and long-term favorable outcomes.

There is a wealth of literature highlighting the advantages of simultaneous bilateral UKA over two-stage UKA.[10,11,13-17] Marullo et al. observed a statistically significant improvement in gait pattern after simultaneous bilateral UKA, in contrast to cases with bilateral knee osteoarthritis treated with unilateral UKA, where the gait pattern did not change from the preoperative period.[18] In this series, there was a statistically significant increase in clinical and functional parameters in the postoperative period, determined by the KSS and range of motion. Similarly, studies comparing bilateral UKA in one and two stages found that patients operated on in a single surgical stage had similar, if not superior, clinical and functional outcomes, with shorter recovery times.[10,14-17]

Figure 5. Revision of unicompartmental prosthesis to total knee prosthesis with posterior stabilized primary prosthesis and tibial stem after 12 years, due to mechanical prosthetic loosening of the tibial component. **A.** Anteroposterior and lateral radiographs of the right knee in the preoperative period. Polyethylene wear and loosening of the tibial component. **B.** Anteroposterior and lateral radiographs of the right knee in the postoperative period. Revision with primary total knee arthroplasty associated with a tibial stem.

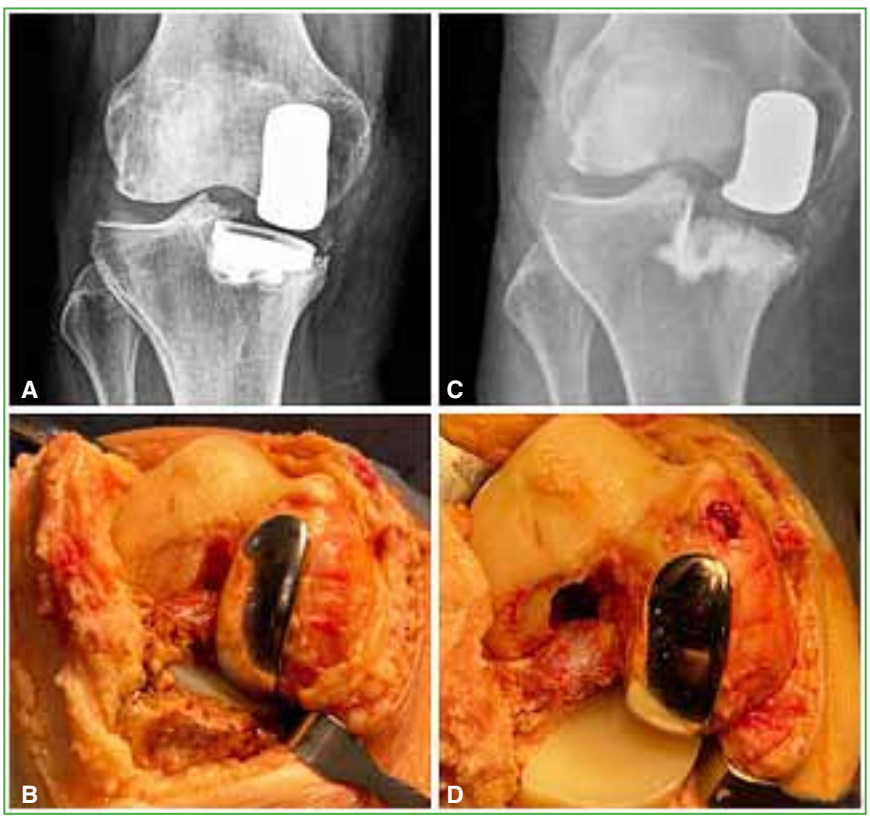

Figure 6. Revision of the UKA tibial component to a new UKA tibial plateau due to mechanical prosthetic loosening of the tibial component after 7 years. **A.** Anteroposterior radiograph of the right knee. Loosening and subsidence of the tibial component. **B.** Intraoperative image. The loosening of the metallic tibial plateau and the indemnity of the remaining joint structures were confirmed. **C.** Anteroposterior right knee radiograph after revision to an internal unicompartmental prosthesis with an *all-poly* tibial component. **D.** Intraoperative image of the revision of the unicompartmental tibial component.

Undercorrection of the axis is the gold standard to avoid deterioration of the contralateral compartment due to overload during the static and dynamic phase of gait, with the aim of restoring the primitive axis of the limb.[2,19] In our series, the postoperative tibiofemoral axis was 3.6° ± 1.4° varus (range 1-9) and 7.4° ± 2.8° valgus (range 4-10), respectively. This prevents the progression of osteoarthritic deterioration in the contralateral compartment, which is uncommon but one of the leading causes of prosthesis revision.[2,19]

Patients who undergo bilateral UKA in the same surgery benefit from significantly shorter anesthesia and hospitalization times than those who undergo two operations.[10,11,13-17] An average anesthesia time of 178 min was recorded, slightly higher than that published for bilateral procedures in one surgery (between 61.3 and 147 min).[8,10-12,14,15,17,20] However, it should be noted that most of the patients in the series had advanced degrees of osteoarthritis (90.1% of genu varus corresponded to the Ahlback classification 4 or 5, 100% of genu valgus, to the Kellgren-Lawrence classification 4 and 81.4%, to the Outerbridge classification 3 or 4) justifying the longer duration of the intervention. Surgery for bilateral UKA has the advantage that two different surgical teams can perform both procedures simultaneously, as reported by Siedlecki et al.[15] In all cases, the hospitalization time was <48 hours, which is lower than most published reports and even comparable to the Sekka and Berend outpatient procedures, in which patients were discharged with bilateral UKA implanted at a single stage 1.1 and 1.7 days after the operation, respectively.[3,8,10-12,14,15,20,21]

One of the limitations when indicating single-stage bilateral UKA is the possible increase in the volume of bleeding and the need for transfusions. Many publications report bleeding rates after bilateral UKA that are comparable to those of two-stage procedures without the need for transfusions.[10,11,14,17,20-22] On the other hand, in the study by Rogmagnoli et al., the transfusion rate was 11% in patients with bilateral procedures and 4% in those with unilateral UKA.[8] However, they did not use a tourniquet or tranexamic acid.[8] Biazzo et al.[13] published similar results. In this series, only two patients required red blood cell transfusion (4.7%), all of whom had undergone surgery before the use of tranexamic acid.

Despite concerns about an increase in complications following bilateral UKA at the same surgical stage, a complication rate of 6.9% was observed in this series, all minor and with good evolution, values similar to those published in the international literature.[3,8,10,11,13-15,17,20-23] Likewise, according to multiple publications, the incidence of postoperative complications is similar between procedures in one and two surgical stages.[10,11,13-17] The only study that reported higher complication rates for the bilateral UKA group at one stage was that of Chan et al., with a major complication rate of 4.1% (n = 13 in 318 bilateral UKA), of which 76.9% (n = 10) were thromboembolic events and one death due to pulmonary thromboembolism.[12] However, it is important to highlight that the procedures were carried out by 10 different surgeons and that postoperative thromboembolic prophylaxis was not administered, so these complications could be prevented and do not represent an increase in the real risk of the procedure (Table 3).[12]

Two patients required revision to TKA and one required revision of the UKA tibial component for a new *all-poly* tibial plateau UKA due to aseptic loosening, after 12, 8.6, and 7 years, respectively. According to the literature and our experience, most conversions to TKA can be performed relatively easily, with only one-third of cases requiring the use of revision stems and implants.[24] If the remaining joint structures are intact, there is evidence of good outcomes after revision to a new UKA.[19,25] Similarly, Romagnoli et al. published the largest cohort to date with 220 bilateral UKAs, reporting revision rates of 3.5% for single-stage bilateral UKA, with no difference from the unilateral UKA group.[8] Survival of the prosthesis was 96.5% after 6.1 years of follow-up.

The proper selection of patients is essential in this type of procedure. The ASA score is one of the most important parameters to consider; in most studies, it is a key selection criterion, usually with values ≤3.[11,13,15,17,21] In their study, Siedleki et al. reported 18% of patients >80 years of age with similar complication rates as younger patients.[15] On the other hand, Akhtar et al. performed the bilateral procedure considering only the ASA score (≤3), regardless of the body mass index, with complication rates of 3.9%, similar to those of the two-stage procedures.[21]

Despite the fact that it was not assessed in this study, it has been reported in the international literature that single-stage bilateral UKA is associated with lower hospital costs due to shorter hospitalization, surgery, and rehabilitation times, with functional outcomes and complications comparable to those of two-stage procedures.[11,14,15] Feng et al. noted that the hospital cost decreased by 12.1% in bilateral procedures in one stage.[14]

Table 3. Comparative results with the published international literature.

	Bilateral UKAs	KSS-OKS	Surgery time (min)	Hospitalization time (days)	Transfusion	Complications
Chan et al.[12] (2009)	318 Oxford	-	114	5	-	13 major (4.1%), 10 (3.1%) thromboembolic. No prophylaxis
Berend et al.[10] (2011)	70 Oxford	Functional KSS 88	109	1.7	0	4 minor (5.7%)
Chen et al.[11] (2013)	248	KSS clinical 88 and functional 80 OKS 17	130	5	1 (0.8%)	5 (2%), 3 thromboembolic
Akhtar et al.[21] (2014)	76 Oxford	modified OKS 34	83	3.5	0	1 major (1.3%) and 2 minor (2.6%)
Romagnoli et al.[8] (2014)	440	-	61.3	4	24 (10.9%)	9 major (2%)
Ma et al.[17] (2015)	72 Oxford	OKS 18.3	113.5	-	0	1 (1.4%) major, 2 minor (2.8%)
Ahn et al.[3] (2017)	104	Clinical KKS 89.2 and functional 84.2	-	8.4	9 (17.3%)	1 minor (0.9%)
Siedlecki et al.[15] (2018)	88	-	75.1	6.7	1 (2.3%)	4 major (4.5%) and 2 minor (2.3%)
Clavé et al.[22] (2018)	100 Oxford	Modified OKS 44.5 KSS 192.6	-	-	3 (6%)	5 (5%) 60% thromboembolic
Yildiz et al.[23] (2018)	88 Oxford	OKS 39.6	-	2	-	3 (3.4%)
Feng et al.[14] (2019)	78 Oxford	Clinical KSS 88.9 and functional 80.9	120.2	4.2	1 (2.6%)	4 minor (5.1%)
Biazzo et al.[13] (2019)	102	-	93.2		4 (7.8%)	1 major (1%) and 3 minor (2.9%)
Sakka et al.[20] (2020)	238 Oxford	-	147.1	1.1 (6.7% ambulatory)	0	2 readmissions (0.8%) at 90 days
Gaggiotti (2021)	86	Clinical KSS 80.9 and functional 89.8	178.6	1.6	2 (4.7%)	6 minor (6.9%)

KSS = *Knee Society Score*; OKS = Oxford Knee Score.

In their comparative study of paired patients, Ahn et al. discovered that single-stage bilateral UKA caused fewer postoperative complications, blood loss, transfusions, and had better functional outcomes at six months than unilateral TKA.[3] Sakka et al. carried out a comparative study between single-stage bilateral UKA and unilateral UKA, and found that the incidence of complications was similar between both procedures.[20] In this way, not only the results of single-stage bilateral UKA are comparable to those of sequential bilateral UKA, but they are also comparable with respect to those obtained after unilateral UKA.[8,20,22,23]

This study presents the limitations inherent to the non-comparative observational and retrospective methodology. Low complication rates may be due to patient selection bias when performing the procedure (ASA ≤3). However, we did not find similar national publications, so we believe that our analysis can contribute to the literature of our field. Among the strengths, it is important to note that the study population was homogeneous. In addition, all patients were operated on by the same surgical team, with the same type of implant, and an identical rehabilitation protocol was indicated. Studies with a larger sample, longer follow-up, and a control group are needed.

CONCLUSIONS

Simultaneous bilateral UKA in a single surgical stage as a treatment for medial or lateral unicompartmental knee osteoarthritis is a conservative procedure that is associated with excellent clinical-functional outcomes with low rates of transfusions, complications, and revisions. Proper evaluation and selection of the patient, a rigorous surgical technique, and trained personnel are essential to achieve reproducible results.

Conflict of interest: The authors declare no conflicts of interest.

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Nonunion After Chevron Osteotomy: Incidence, Treatment, Follow-up, and Outcomes

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ABSTRACT

Introduction: Hallux valgus is the most common disorder of the first toe. It causes pain, functional impairment, and alters gait patterns. Mild to moderate deformities are typically corrected with distal osteotomies of the first metatarsal, such as the chevron osteotomy, a safe procedure, but not without complications. The objectives of this study were to determine the incidence of pseudarthrosis following this osteotomy and report our therapeutic method, follow-up, and outcomes. **Materials and Methods:** A retrospective multicenter study was carried out, which included patients operated on between 2009 and 2018. A total of 1156 chevron osteotomies were evaluated as a treatment for mild to moderate hallux valgus in 1017 patients (age range 16–83 years; average 57.5 years) performed by 4 experienced surgeons. The inclusion criterion was that the patient had imaging studies compatible with pseudarthrosis six months after surgery. **Results:** We evaluated five patients who met our criterion. The average AOFAS (American Orthopedic Foot and Ankle Society) scores were 51 before hallux valgus treatment and 87.8 after pseudarthrosis treatment. **Conclusion:** The incidence of pseudarthrosis was 0.4% in the distant postoperative period. Our approach and treatment of pseudarthrosis achieved excellent clinical and functional improvements in all operated patients.
Keywords: Hallux valgus; Chevron osteotomy; nonunion.
Level of Evidence: III

Seudoartrosis después de una osteotomía en chevron: incidencia, tratamiento, seguimiento y evolución

RESUMEN

Introducción: El hallux valgus es el trastorno más común del primer dedo del pie. Provoca dolor, discapacidad funcional y altera los patrones de la marcha. Las deformidades leves o moderadas se han corregido con osteotomías distales del primer metatarsiano, como la osteotomía en chevron, un procedimiento seguro, pero no exento de complicaciones. Los objetivos de este estudio fueron determinar la incidencia de seudoartrosis por dicha osteotomía y comunicar nuestro método terapéutico, el seguimiento y la evolución. **Materiales y Métodos:** Se realizó un estudio multicéntrico, retrospectivo que incluyó a pacientes operados entre 2009 y 2018. Se evaluaron 1156 osteotomías en chevron como tratamiento del hallux valgus leve o moderado en 1017 pacientes (rango etario 16-83 años; promedio 57.5) realizadas por 4 cirujanos experimentados. El criterio de inclusión fue que el paciente contara con estudios por imágenes compatibles con seudoartrosis a los 6 meses de la cirugía. **Resultados:** Se evaluó a 5 pacientes con diagnóstico de seudoartrosis después de una osteotomía en chevron para tratar el hallux valgus. Los puntajes promedio de la AOFAS fueron 51 antes del tratamiento del hallux valgus y 87,8 después del tratamiento de la seudoartrosis. **Conclusiones:** La incidencia de seudoartrosis fue del 0,4% en el posoperatorio alejado. Nuestro abordaje y el tratamiento de la seudoartrosis lograron una excelente mejoría clínica y funcional en todos los pacientes operados.
Palabras clave: Hallux valgus; osteotomía en chevron; seudoartrosis.
Nivel de Evidencia: III

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INTRODUCTION

Hallux valgus is the most clinically relevant foot deformity, with a prevalence of 2-4%,[1] and it predominates in the female sex.[2] It can be due to extrinsic (footwear) and intrinsic (heredity) causes.[3] It often causes pain, functional disability, and alterations in gait patterns.[4,5]

Traditionally, mild and moderate deformities have been treated with a distal osteotomy procedure.[7] The first reports of this type of technique in the area of the first metatarsal for the correction of hallux valgus can be attributed to Reverdin (1881), who described a subcapital closing wedge osteotomy. Other reports appear in the context of a horizontally directed "V" displacement osteotomy of the first metatarsal, described by Austin and Leventen.[8] Good primary stability was obtained with this procedure due to the type of osteotomy and it was Johnson who coined the term *chevron osteotomy* in 1979.[9] This technique provides stability, allows rapid recovery, and achieves minimal shortening of the first metatarsal.[10] A low rate of complications has been reported, such as avascular necrosis of the metatarsal head, one of the most feared complications, with a frequency of 0.8%; restricted range of motion (12.1%), recurrence of hallux valgus (6.9%), hallux varus (4.8%), transfer metatarsalgia (3.2%), nonunion (3.1%), wound healing disorders (1.8%) and infections (1.5%).[11]

As nonunion is a rare complication and there are few published cases, our objective was to determine the incidence of nonunion after chevron osteotomy and to report our therapeutic method, follow-up, and outcome.

MATERIALS AND METHODS

A retrospective, multicenter study was conducted that included patients who underwent chevron and Akin osteotomy (Figure 1) for the treatment of mild or moderate hallux valgus, between 2009 and 2018. A total of 1156 chevron osteotomies were evaluated in 1017 patients (355 bilateral). 95% were women and 5% men, the age ranged from 16 to 83 years (average 57.5). The procedure was carried out by four experienced surgeons. Johnson's modified V-shaped osteotomy was performed. The osteotomy was stabilized with a 3.0 mm screw directed from proximal to distal and from medial to lateral. Radiographs of all patients were taken in the immediate postoperative period, at one month, and at three and six months. Patients with radiographic signs of osteotomy consolidation were discharged six months after surgery.

Figure 1. Anteroposterior and lateral foot radiographs in the immediate postoperative period. Chevron osteotomy, Akin osteotomy, and distal interphalangeal arthrodesis of the second toe.

The inclusion criteria were patients with clinical and radiographic alterations compatible with signs of pseudarthrosis.

Thus, the series was made up of five patients (4 female and 1 male) who had imaging studies compatible with pseudarthrosis six months after the operation (Figures 2 and 3). The AOFAS (*American Orthopaedic Foot and Ankle Society*) score was used before and after both procedures (initial hallux valgus surgery and nonunion surgery).

Figure 2. Anteroposterior and lateral radiographs of the foot, three months after the operation. A nonunion focus is observed at the level of the chevron osteotomy.

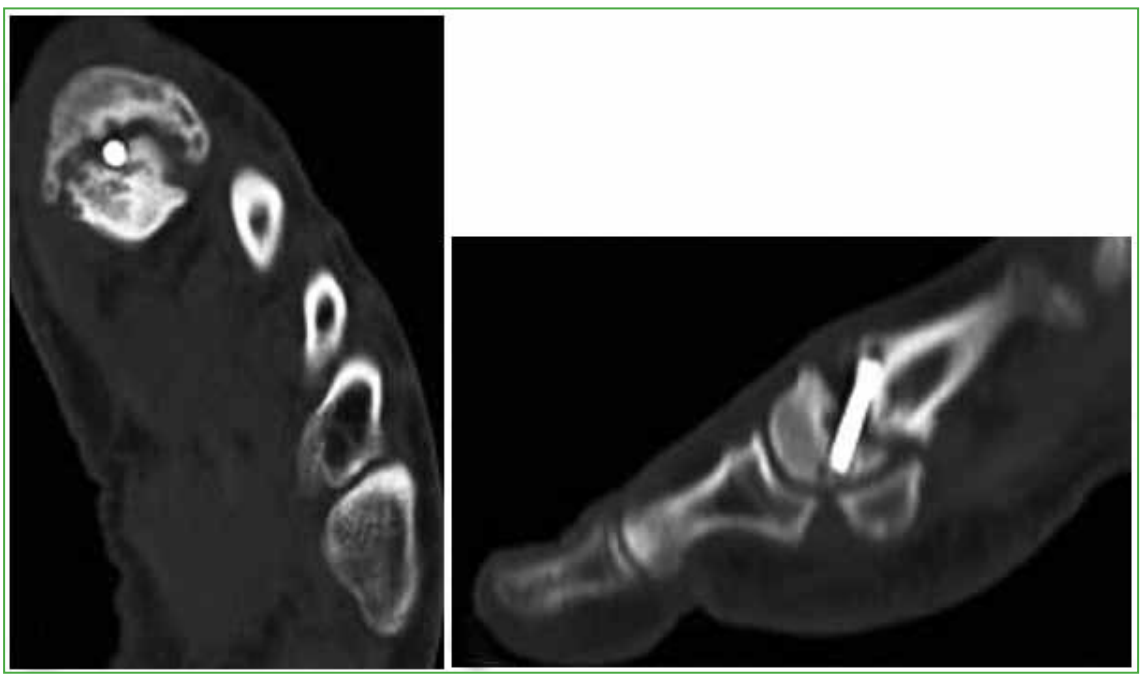

Figure 3. Computed tomography of the foot, axial and sagittal slices. The nonunion focus is observed at the level of the chevron osteotomy.

All patients were treated with surgery (Figures 4 and 5). Follow-up for this treatment was >24 months.

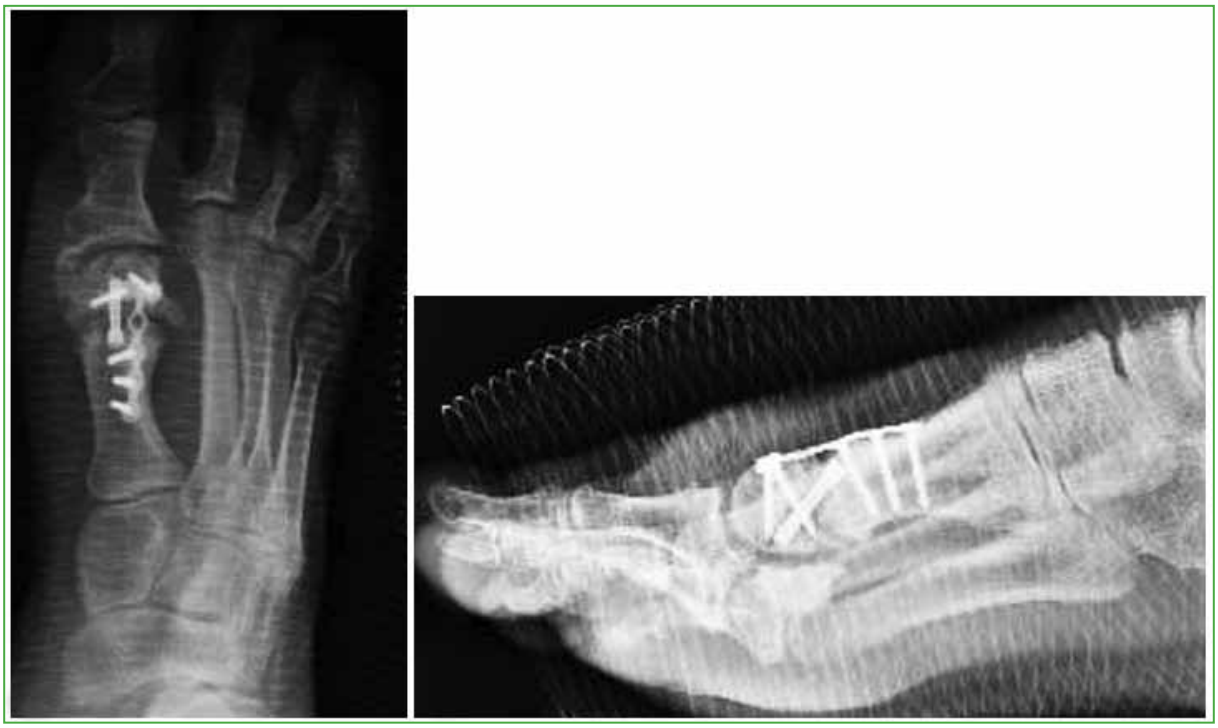

Figure 4. Anteroposterior and lateral foot radiographs in the immediate postoperative period. Plate and screw osteosynthesis is shown for the treatment of nonunion.

Figure 5. Radiographic control 2 months after surgery. Consolidation of the nonunion focus is visualized.

Surgical technique and postoperative period.

The patient is placed in dorsal decubitus position on the general surgery table. Antibiotic prophylaxis is administered at anesthetic induction, after decontamination with 2% chlorhexidine gluconate mixed with 70% isopropyl alcohol. Double fields are placed according to technique and an Esmarch bandage is applied to the ankle. A lateral incision is made over the calcaneus to harvest the autologous bone graft (Figure 6).

Figure 6. Lateral incision on the calcaneus to harvest the autologous bone graft.

A medial longitudinal approach to the hallux is made over the anterior incision, the capsulotomy is carried out, and the focus of nonunion is identified (Figure 7).

Figure 7. Medial longitudinal approach to the hallux over the previous incision, capsulotomy, and identification of the nonunion focus.

The osteosynthesis material is removed and bone curettage is performed (Figure 8).

Figure 8. Removal of osteosynthesis material and subsequent bone curettage.

An autologous calcaneal graft is placed over the nonunion focus and secured with a pin before being reduced and stabilized with an anatomical plate and screws (Figure 9). We then perform capsulorrhaphy, Esmarch bandage removal, careful hemostasis, skin closure, and flat dressing. An elastic bandage is applied, and the limb is placed in a walker boot.

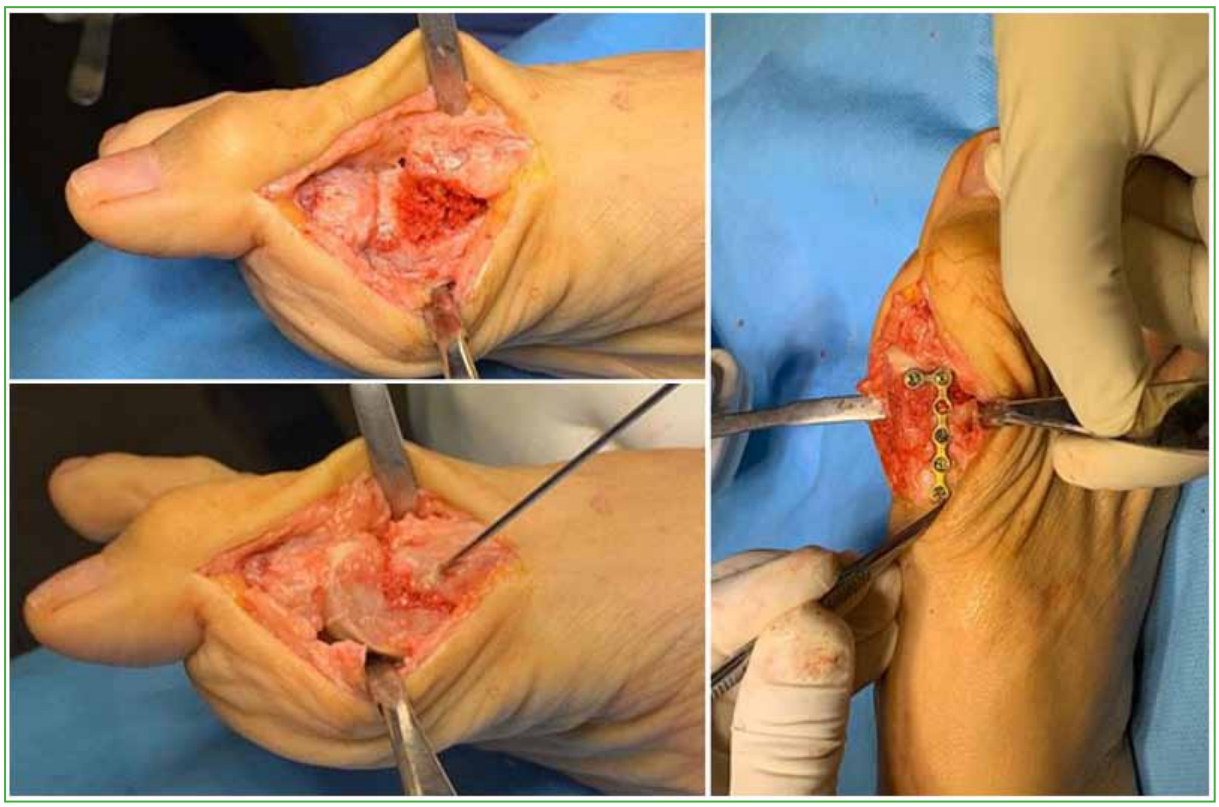

Figure 9. Placement of an autologous calcaneal graft over the nonunion focus, temporary fixation with a pin, reduction and stabilization with an anatomical plate and screws.

Post-surgical control is performed for healing during the first week. In the third week, the sutures are removed, and in the fourth week, control radiographs are taken and the Walker boot is removed. From then on, the patients wear a rigid-soled sandal for four more weeks, and a clinical and radiographic control is carried out in the third and sixth months to verify the consolidation of the nonunion focus.

RESULTS

The AOFAS scale (Table) was used before treatment for hallux valgus and after treatment for nonunion. This scale values the operated hallux, in percentage, with respect to the function of a normal hallux (100%). By applying this score, an absolute numerical value is obtained, which is nothing more than the recovery percentage of the operated foot with respect to a normal foot.

The AOFAS scale assesses pain (40 points) and function (60 points). This last item is subdivided into: activity limitation, insole requirements, metatarsophalangeal and interphalangeal range of motion, metatarsophalangeal stability, calluses, and final alignment.

Of the five patients evaluated for the nonunion complication (Table), four were women and one was a man (age range 55-75 years).

An average of 51 points was obtained before treatment for hallux valgus and 87.8 after treatment for pseudarthrosis.

Regarding pain, one patient reported that it had completely subsided, three continued with mild pain and one with moderate pain.

Regarding the function of the operated hallux, four patients had no limitation of activity and one patient, limitation of recreational sports activity. One patient could wear fashionable footwear and four, comfort footwear.

Metatarsophalangeal range of motion was preserved in three of the patients, one presented a mild restriction and the other evolved with severe metatarsophalangeal osteoarthritis that required arthrodesis. The same results were obtained when analyzing the interphalangeal joint. The joint was stable in 100% of the cases.

It should be noted that none of the patients operated on for hallux valgus presented pseudarthrosis of the Akin osteotomy.

Table. Series of patients with pseudarthrosis

	Age	Sex	Initial treatment	AOFAS score (Preoperative)	AOFAS score (Postoperative)	Comorbidities	Smoking
1	73	Female	Chevron + Akin	63	90	Hypothyroidism, arterial hypertension	No
2	61	Female	Chevron + Akin	58	88	Arterial hypertension	No
3	55	Female	Chevron + Akin	57	89	Diabetes	No
4	75	Female	Chevron + Akin	10	87	Asthma, gout, high blood pressure	No
5	73	Male	Chevron + Akin	70	85	High blood pressure, diabetes	No

AOFAS = *American Orthopaedic Foot and Ankle Society*.

DISCUSSION

Joint stiffness, recurrence of hallux valgus, hallux varus, transfer metatarsalgia, avascular necrosis of the metatarsal head, impaired wound healing, and infection are some of the documented complications after chevron osteotomy for the treatment of hallux valgus.[8] Pseudarthrosis is a rare complication with few reports in the literature. It is defined as the absence of definitive bone consolidation of a fracture or arthrodesis, whose pathological

process corresponds to the formation of a scar through non-ossified fibrous tissue, the pathological alteration appears when there is no osteoblastic integration that confers fibrous scar tissue the characteristics of bone tissue. This occurs due to a lack of perfect and uninterrupted immobilization, excessive separation of bone fragments, interposition of soft tissue, insufficient vascularization or pathological bone fracture.[11]

There are other factors that have been classified as mechanical and biological. The latter include the clinical and pharmacological antecedents that present with alterations of bone metabolism and, consequently, of the normal consolidation process.[11] Therefore, their identification and consideration are relevant, both due to the added cost and the additional number of surgical interventions required by patients with pseudarthrosis, without leaving aside the associated complications that interfere with both personal and work daily activities.[12,13]

Smoking has been associated with delayed fracture union in numerous studies. One of the mechanisms causing this effect is the decrease in bone mineralization.[14] Smokers, who commonly require more time to heal a fracture or osteotomy, suffer a greater number of complications during recovery (2.5 to 3 times those of nonsmokers) and need more healing time, according to studies made in different joints and bones.[14] However, there are studies that do not show this association; W-Dahl and Toksvig-Larsen published that they did not observe a direct relationship between smoking and the genesis of nonunion.[15]

The precise location of the distal osteotomy of the first metatarsal, as well as the effects of the temperature increase during bone cutting with the microsaw, could be linked to the appearance of this complication.[16-20]

The location of the osteotomy is an important determining factor in the incidence of nonunion. Distal osteotomies receive minimal weight-bearing forces that favor a low incidence of nonunion secondary to biomechanical displacement. However, one of the disadvantages of these osteotomies is that the proximity to the metatarsophalangeal joint limits its ability to rotate. On the other hand, proximal osteotomies receive greater weight-bearing force, and this leads to a significantly higher incidence of pseudarthrosis.[21,22]

It is known that exposure of bone to excessive temperature increases during drilling or cutting can cause thermal necrosis of bone. Temperatures above 50º C for 60 seconds cause irreversible changes in the structure and physical properties of bone, such as osteocyte degeneration, increased osteoclastic activity, the appearance of fibrosis and bone necrosis.[18] The use of cutting blades in poor condition or at inappropriate revolutions generates an increase in temperature for a prolonged time that causes local alterations and can lead to delayed consolidation and pseudarthrosis.[18-20]

Metatarsal nonunions after hallux valgus surgery are often symptomatic and can cause pain and insufficiency in the first ray leading to transfer metatarsalgia. Treatment of this can restore a mechanically healthy first ray. In most cases, removal of the osteosynthesis material, debridement of the nonunion site, bone grafting, realignment, and stable fixation help promote healing.[20,21]

One of the strengths of this study is its multicenter design and that it is the first national series of cases on the subject, with a large patient sample. However, this is a retrospective study, surgeries were performed by four different foot surgeons, and a single functional score was used to assess patients.

CONCLUSIONS

Given the low specific prevalence of this condition, there are very few national literature reports on its incidence, diagnosis, and surgical management. In this paper, we discuss how important it is to consider pseudarthrosis as a real complication following a chevron osteotomy for the treatment of hallux valgus and the importance of diagnosis for its appropriate surgical treatment.

Given this, it is easy to see that, in order to have a casuistry that allows us to know the true cause of this complication, all patients must be registered and retrospectively analyzed, allowing us to increase the number of cases evaluated.

From the epidemiological point of view, there are estimators that predispose to pseudarthrosis, such as smoking, the anatomical site of the osteotomy, increased temperature, and the condition of the saw. However, it is only an approximation, so the prediction may fail and it is more difficult to study given the low incidence.

Our experience shows us that chevron osteotomy for the treatment of hallux valgus is a safe technique with a low rate of complications and an incidence of pseudarthrosis of 0.4% in a sample of 1017 patients, compared

to the 3.1 % published. We believe that our therapeutic method, which consists of removing the osteosynthesis material, curettage of the nonunion focus, decortication, and the use of autologous calcaneal graft with adequate fixation with a plate and screw, is a safe and effective procedure that requires a relatively short surgical time.

The patients who underwent this procedure had a good evolution beyond 24 months after surgery, and favorable radiographic images, with consolidation of the nonunion focus.

Conflict of interest: The authors declare no conflicts of interest.

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Mucopolysaccharidosis Type VI: Case Report

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ABSTRACT

Mucopolysaccharidosis type VI, also known as Maroteaux-Lamy syndrome, is caused by a deficiency of the arylsulfatase B enzyme, which causes intracellular accumulation of dermatan sulfate. The risk of spinal cord compression is particularly high and frequent at the occipitocervical junction. Enzyme replacement therapy has been essential for patients with this disease; however, it has no effect on skeletal abnormalities, and its impact on spinal stability is still under study. An annual examination (neurological evaluation, radiography, magnetic resonance imaging, and somatosensory evoked potentials) is recommended. In case of anomalies, it should be repeated every 6 months. Despite the high anesthetic risk, myelopathy and progressive symptoms indicate the need for surgical decompression. We present the case of a 12-year-old girl with mucopolysaccharidosis type VI treated with enzyme replacement therapy since the age of 7, who came to the consultation with symptoms compatible with progressive high cervical myelopathy. She underwent occipitocervical decompression and fusion with enlargement of the foramen magnum. This disease is rare; therefore, multidisciplinary patient follow-up is imperative, as well as knowing the risk of spinal cord compression and its timely surgical treatment by spinal surgeons.

Keywords: Mucopolysaccharidosis; Maroteaux-Lamy syndrome; spinal cord compression; myelopathy.
Level of Evidence: IV

Mucopolisacaridosis tipo VI: a propósito de un caso

RESUMEN

La mucopolisacaridosis tipo VI o síndrome de Maroteaux-Lamy se produce por la deficiencia de la enzima arilsulfatasa B que ocasiona la acumulación intracelular de dermatán sulfato. El riesgo de compresión medular es particularmente elevado y muy frecuente en la unión occipito-cervical. La terapia de reemplazo enzimático ha sido esencial para los pacientes con esta enfermedad; sin embargo, no tiene efecto sobre las alteraciones esqueléticas, y su impacto sobre la estabilidad espinal está aún en estudio. Se sugiere un examen anual (evaluación neurológica, radiografías, resonancia magnética y potenciales provocados somatosensitivos) y, en caso de anomalías, cada 6 meses. Pese al alto riesgo anestésico, la mielopatía y los síntomas progresivos indican la necesidad de una descompresión quirúrgica. Presentamos a una niña de 12 años con mucopolisacaridosis tipoVI tratada con terapia de reemplazo enzimático desde los 7 años, que acude a la consulta con síntomas compatibles con mielopatía cervical alta progresiva. Fue sometida a una descompresión y artrodesis occipito-cervical con ampliación del foramen magno. Esta enfermedad es infrecuente; por lo tanto, es imperativo el seguimiento multidisciplinario del paciente, así como conocer el riesgo de compresión medular y su oportuno tratamiento quirúrgico a cargo de cirujanos espinales.

Palabras clave: Mucopolisacaridosis; síndrome de Maroteaux-Lamy; compresión medular; mielopatía.
Nivel de Evidencia: IV

INTRODUCTION

Mucopolysaccharidoses (MPS) are a group of hereditary diseases, mostly autosomal recessive, characterized by the accumulation of glycosaminoglycans caused by the deficiency of lysosomal enzymes. The intracellular accumulation of metabolites in different tissues leads to systemic compromise, which reduces life expectancy and quality of life. The clinical and skeletal manifestations depend on the deficient enzyme. Systemic involve-

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ment includes: liver, cardiac, visual, cardiovascular, central nervous system, and airway disorders. It affects both the formation and growth of the skeletal system.[1-3] Typical spinal manifestations are: atlantoaxial instability (with or without odontoid hypoplasia), thoracolumbar kyphosis, scoliosis, canal stenosis, and spinal cord compression.[23]

MPS VI or "Maroteaux-Lamy syndrome" was first described in 1963 by Maroteaux and Lamy, and is caused by an autosomal recessive hereditary deficiency of the enzyme arylsulfatase B (also called N-acetylgalactosamine-4 -sulfatase), which causes intracellular accumulation of dermatan sulfate. It is characterized by organomegaly, hearing disorders, bone dysplasia, cardiorespiratory and neurological problems. There are more than 100 types of mutations of this enzyme that cause different phenotypes categorized as slowly or rapidly progressive. Patients with a slowly progressive phenotype often present late; however, they are at risk of serious and sometimes fatal neurologic complications as a result of spinal cord compressions.[1,4-10]

Some manifestations of osteoarticular compromise are: short stature, joint stiffness, vertebral anomalies, coxa valga, and lack of ossification of the femoral head.[11] The risk of spinal cord compression is particularly high and, although it can occur at any spinal level, it is very frequent at the occipito-cervical junction. Compression is produced by retro- or periodontoid tissue that is thickened by deposition of glycosaminoglycans, ligament hypertrophy, and bone stenosis.[8-11]

The advantages of new enzyme replacement therapies and stem cell transplantation for the management of this disease have been demonstrated, especially at the visceral level; however, it is ineffective in bone deformities, including the spine.

The objective of this study is to present this disease, its main manifestations and treatment, through the presentation of a case and a literature review.

CLINICAL CASE

In March 2021, a 12-year-old girl presented to our office with non-specific neck pain associated with claudication when walking at 200 m, diffuse and progressive paresthesias in all four limbs, of approximately two years of evolution, which had increased in the last six months, and a delay in consultation due to the COVID-19 pandemic.

She suffered from type VI MPS (monitoring and enzyme replacement treatment at another institution) and minor heart disease (mild involvement of the mitral and aortic valves).

Physical examination revealed a short overall height, a short neck, overweight, no observable distal weakness, symmetrical hyporeflexia, Babinsky and Lhermitte signs, and negative clonus. The Japanese Orthopedic Association scale score was 15. Laboratory parameters, including those related to inflammation but excluding those related to the underlying disease, were all normal.

Initial radiographs showed a decrease in height of the C3-4-5 vertebral bodies. In addition, there was an impressive hypoplasia of the odontoid process, with no signs of instability on dynamic radiographs (Figures 1 and 2).

Computed tomography and magnetic resonance imaging (MRI), performed in the supine position, showed morphological varieties from C1 to C5, with decreased height of the vertebral bodies (hypoplasia), mainly in C3-4-5, hypoplasia of odontoids and periodontoid tissue that caused a decrease in the diameter of the cervical canal at that level; and myelomalacia in C0-1-2 (Figures 3-5).

Furthermore, a posterior displacement of the nucleus pulposus of the thoracic discs was observed, as well as an anatomical variation of the vertebral foramen in C2 that placed it slightly medial. No other congenital abnormalities were detected. The electromyogram was normal; however, she had abnormal conduction of the posterior cord in the upper cervical sector suggestive of high cervical myelopathy on somatosensory evoked potentials.

Given her progressive condition and irreversible spinal cord damage, as well as the underlying disease, the case was presented to a specialized surgical center, and surgery for decompression and posterior occipito-cervical fixation was proposed.

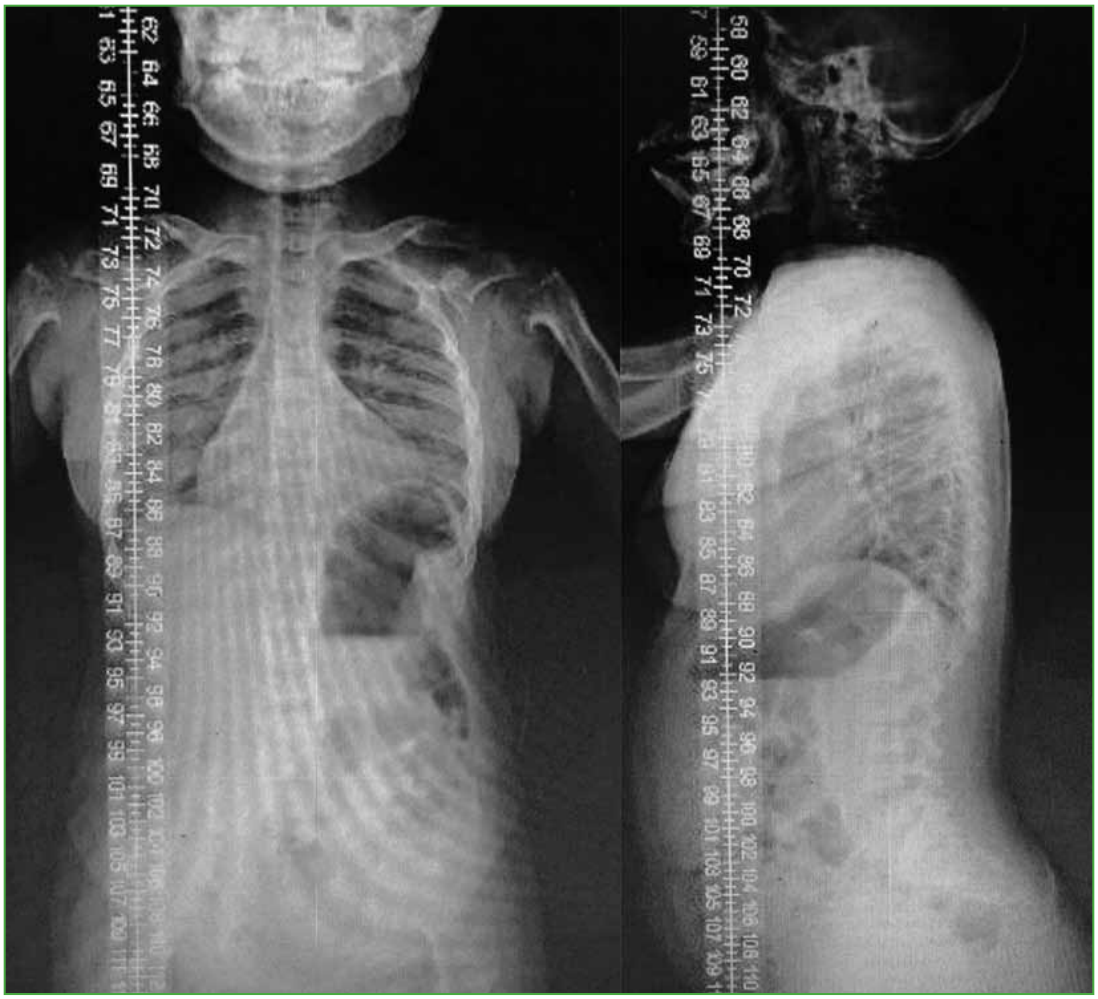

Figure 1. Anteroposterior and lateral spinogram. Note the overweight and short stature, the flat back, and the decreased height of the C3-4-5 vertebral bodies.

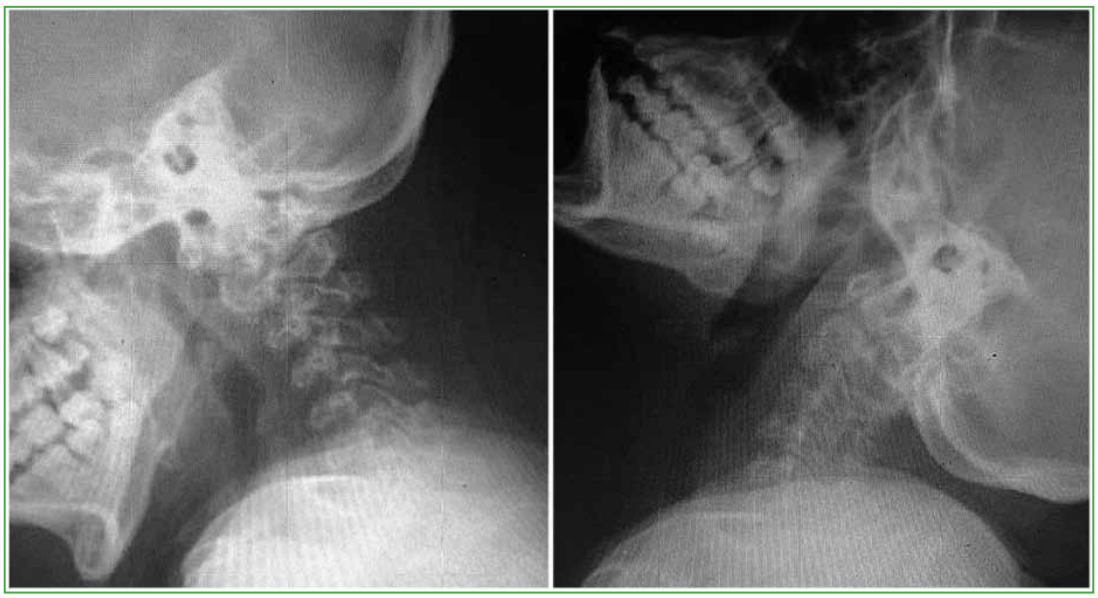

Figure 2. Dynamic cervical radiographs (flexion/extension). Decreased height of the C3-4-5 vertebral bodies, with apparent hypoplasia of the odontoid process, without signs of instability.

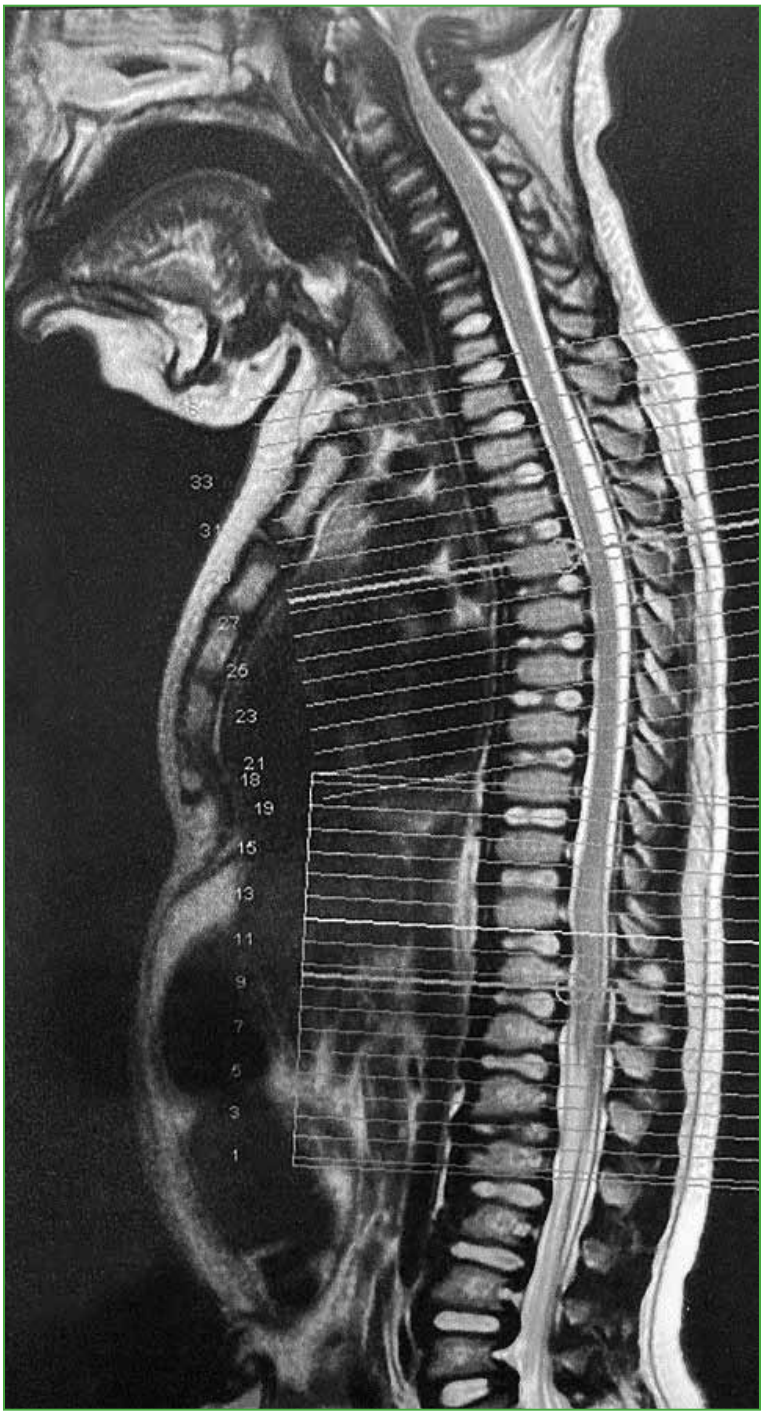

Figure 3. Magnetic resonance imaging of the complete spine, sagittal section. Posterior displacement of the nucleus pulposus, dysplasia of the vertebral bodies, and a decrease in spinal diameter at C0-2 are observed.

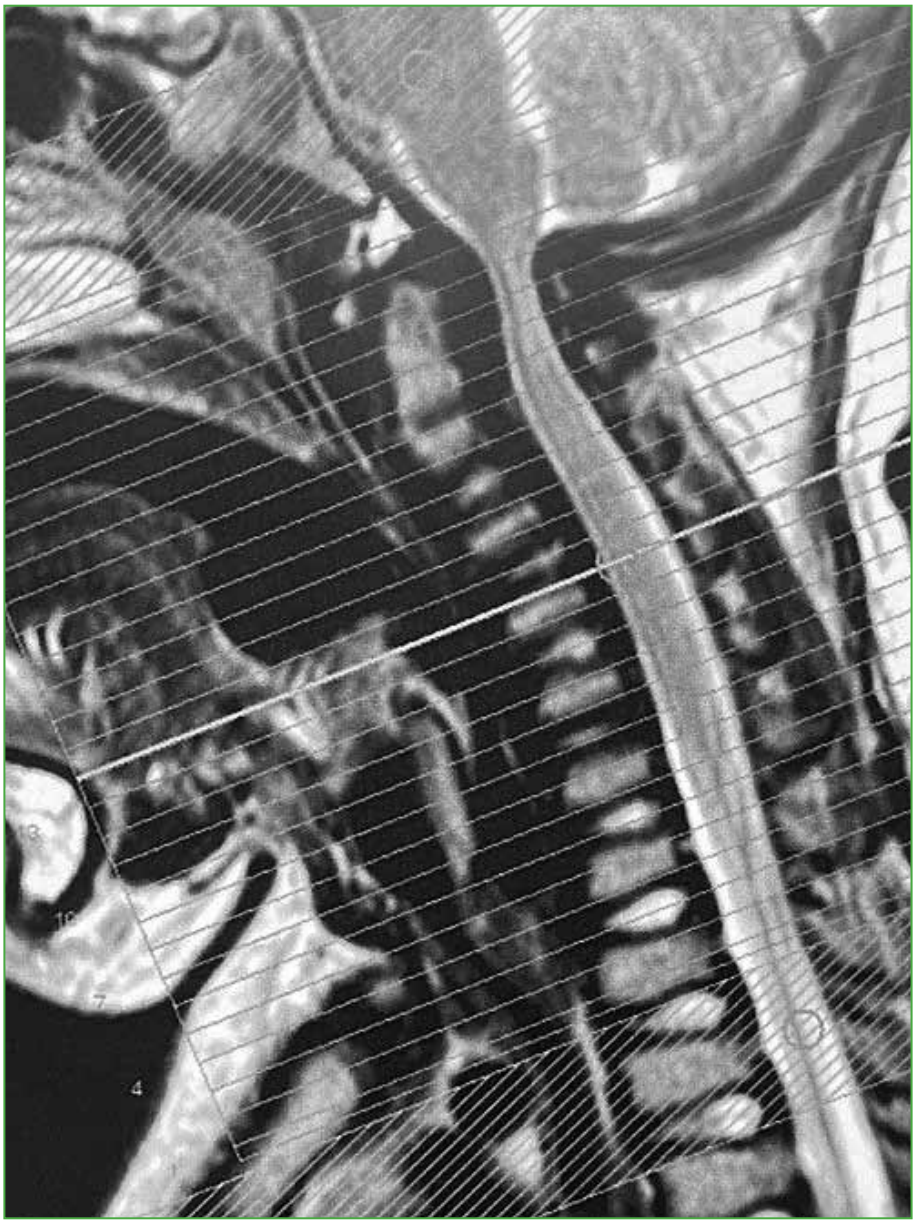

Figure 4. Cervical magnetic resonance, sagittal section. There is dysplasia of the vertebral bodies, hypoplasia of the odontoid process, and periodontoid tissue that causes a decrease in the diameter of the spinal canal, as well as myelomalacia in C0-1-2.

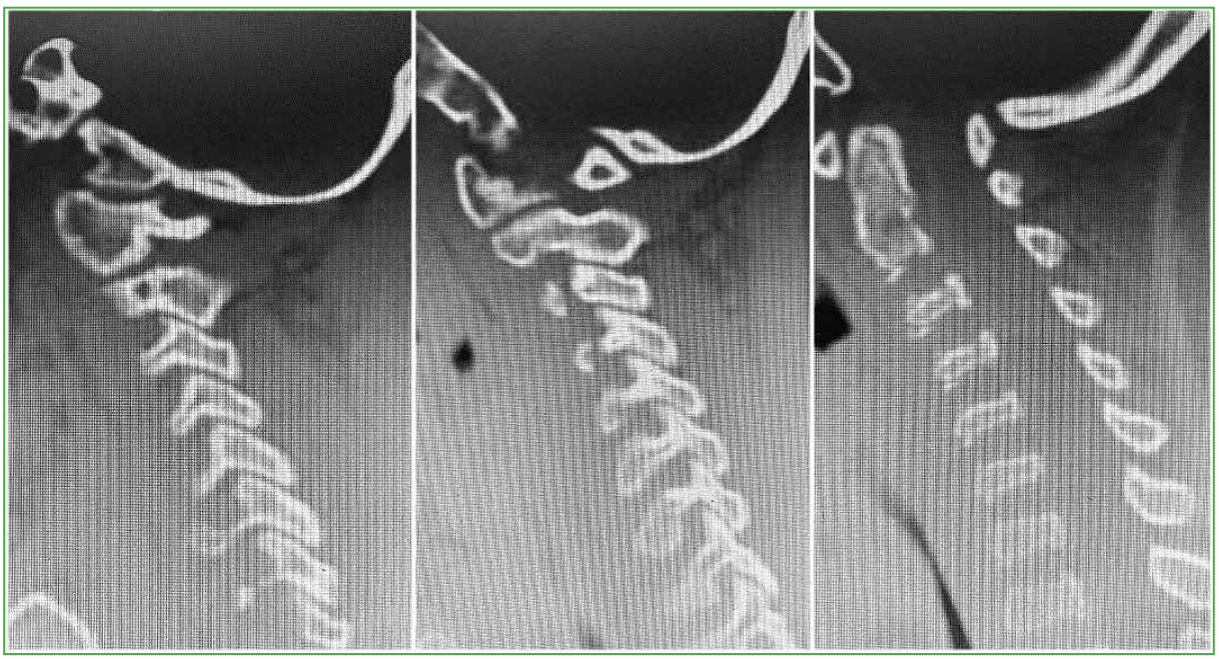

Figure 5. Cervical computed tomography, sagittal section. A decrease in the height of the C3-4-5 vertebral bodies is visualized, with no other bone anomalies.

Our center does not have an established protocol for this type of patient, but based on previous publications, preoperative check-ups were requested with the cardiology, neurology, pediatrics, anesthesiology, and pulmonology services, and the pediatric intensive care unit.

In June 2021, an arthrodesis of C0-C4 was performed with laminectomy of C1 and C2, and enlargement of the foramen magnum (in charge of the neurosurgery service). A protective halo brace was placed (Figure 6).

In this type of patients, intubation is a challenge, because they have a short neck, with a difficult airway associated with tracheal anatomical variations, so they must be evaluated by a specific team to define the need for a preoperative tracheotomy. In our case, it was not initially considered necessary.

Another concern is surgical positioning. Neuromonitoring should begin with the sedated patient in the supine position to avoid injury during intubation (controlling hyperextension of the neck) and rotation (it must be performed en bloc with head protection). The surgical position must be prone, with the head in a neutral position. If possible, it is preferred to place the halo brace for correct positioning.

The approach must be performed without any sudden movements and with careful bleeding control, because the pressure applied to the vertebral bodies to release or place the screws increases intracanal pressure and can cause neurological disorders. During the procedure, we found hypoplastic C1 and C2 posterior arches. During the decompression maneuvers (both at the level of C1 and the foramen magnum), the patient had episodes of extreme bradycardia with a drop in potentials and partial recovery at the end of the decompression. After the procedure, the patient was admitted intubated to the pediatric intensive care unit.

She was kept intubated and sedated for a month due to the difficult airway, short neck, and neutral position of the neck maintained by the halo brace, until it was decided to perform a tracheotomy. The patient suffered a lung infection associated with mechanical ventilation and a urinary infection, both conditions were treated with intravenous antibiotics, without complications at the surgical site.

Postoperatively, a control CT scan was performed and decompression was observed with the material in the correct position (Figures 7 and 8).

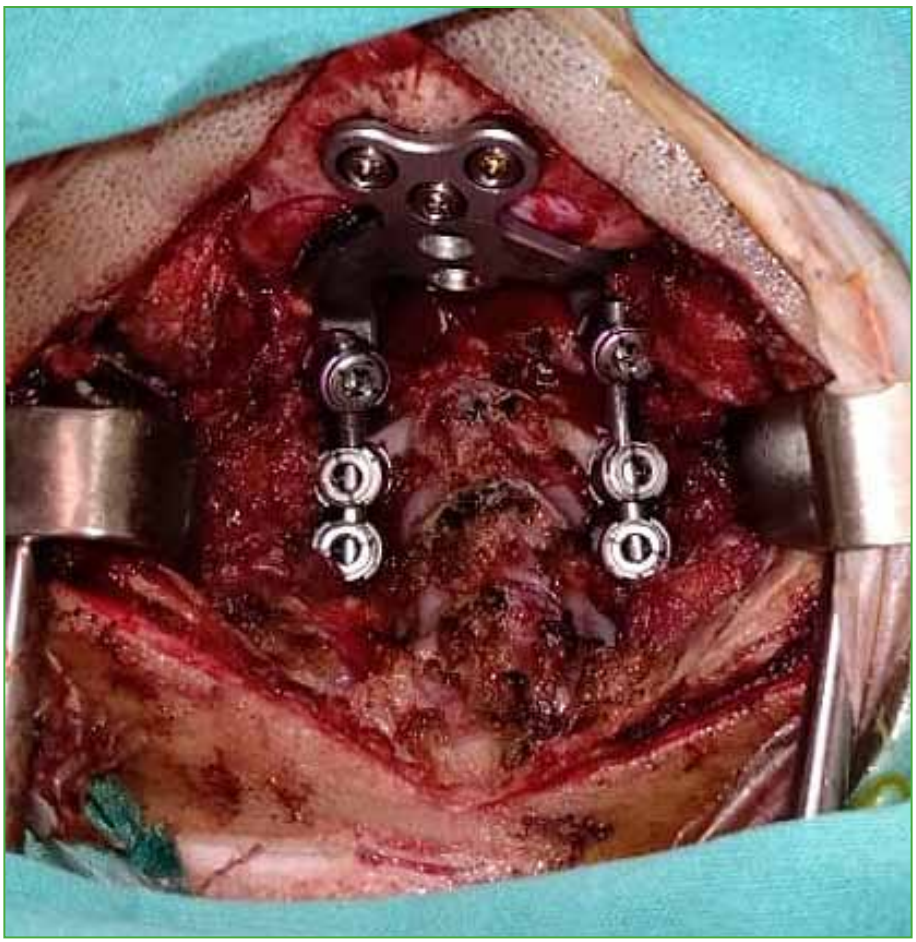

Figure 6. Intraoperative image. Decompression of C1-2. Occipito-cervical instrumentation.

Figure 7. Postoperative cervical computed tomography, sagittal section. Instrumentation is appreciated, with occipital plate and cervical screws.

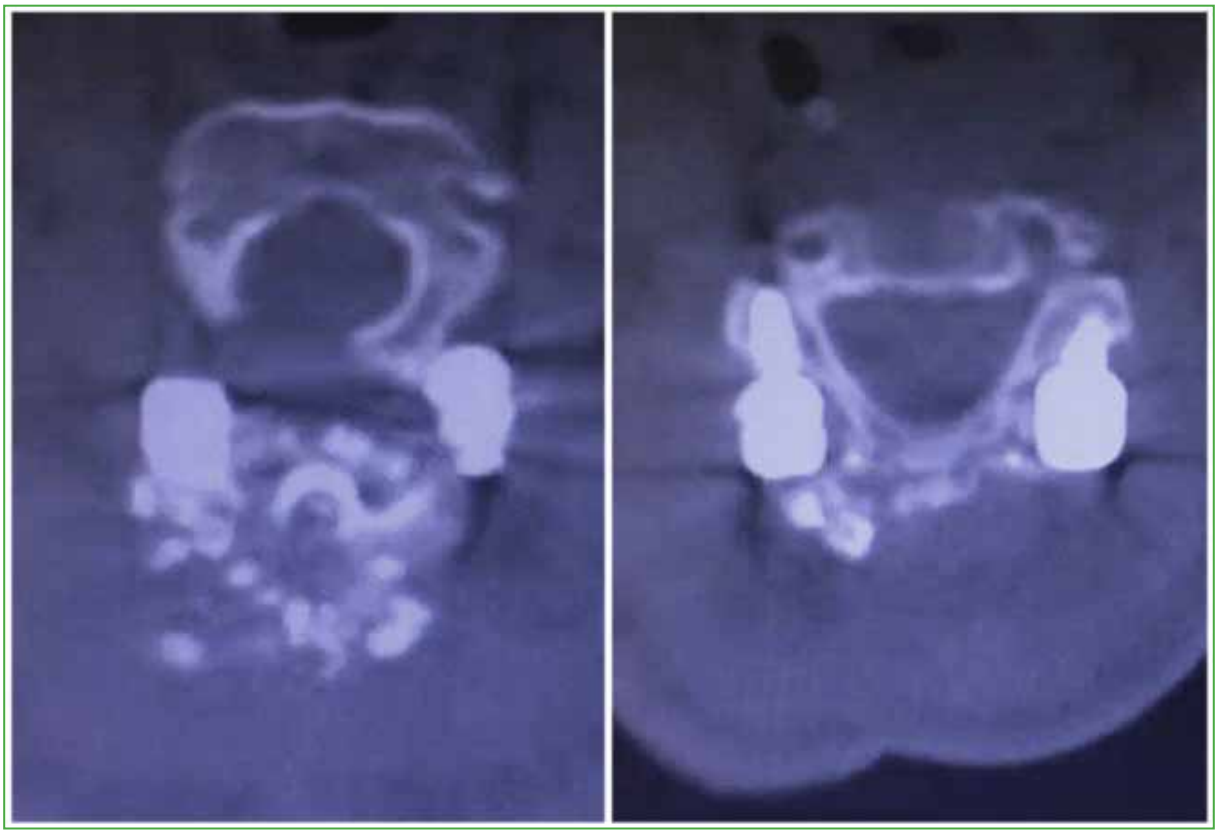

Figure 8. Postoperative cervical computed tomography, axial section. Note the decompression and the position of the screws.

When this article was written (18 months after surgery), the patient still had a tracheotomy, was walking unaided at home and with assistance outside the home, her paresthesias and neck pain had improved (Figure 9), and her preclaudication walking distance had increased. No signs of loosening were observed on the last radiographs (Figure 10).

DISCUSSION

The international literature on this disease mainly includes case reports or series of few patients. The preparation of treatment guidelines is complex.

In 2016, Solanki et al. published the findings of the Clinical Surveillance Program for MPS VI where 75% of patients with MRI had signs of spinal cord compression, demonstrating its high prevalence.[6] In agreement with the observations of Horovitz et al., they observed that spinal cord involvement can occur at very early ages, even in children <2 years of age.[4,6] They highlight an association between the severity of the baseline condition and abnormal findings of the cervical spine on MRI (dysmorphic vertebrae, stenosis, odontoid hypoplasia, periodontoid tissue) and conclude that it is essential to perform an MRI of the entire spine since the diagnosis of MPS VI.

Spinal cord compression can occur in both phenotypes (rapidly and slowly progressive forms) of patients with MPS VI. When the phenotype is rapidly progressive, compression occurs as early as 2 years of age, and patients typically require surgical decompression at a median age of 12 years, compared to those with the slowly progressive forms, which may require the procedure in the second or third decades of life. Despite the fact that there are no specific guidelines and given the high incidence of spinal cord compression, some follow-up rules have been established:[6,8-12]

Figure 9. Clinical image 17 months after surgery.

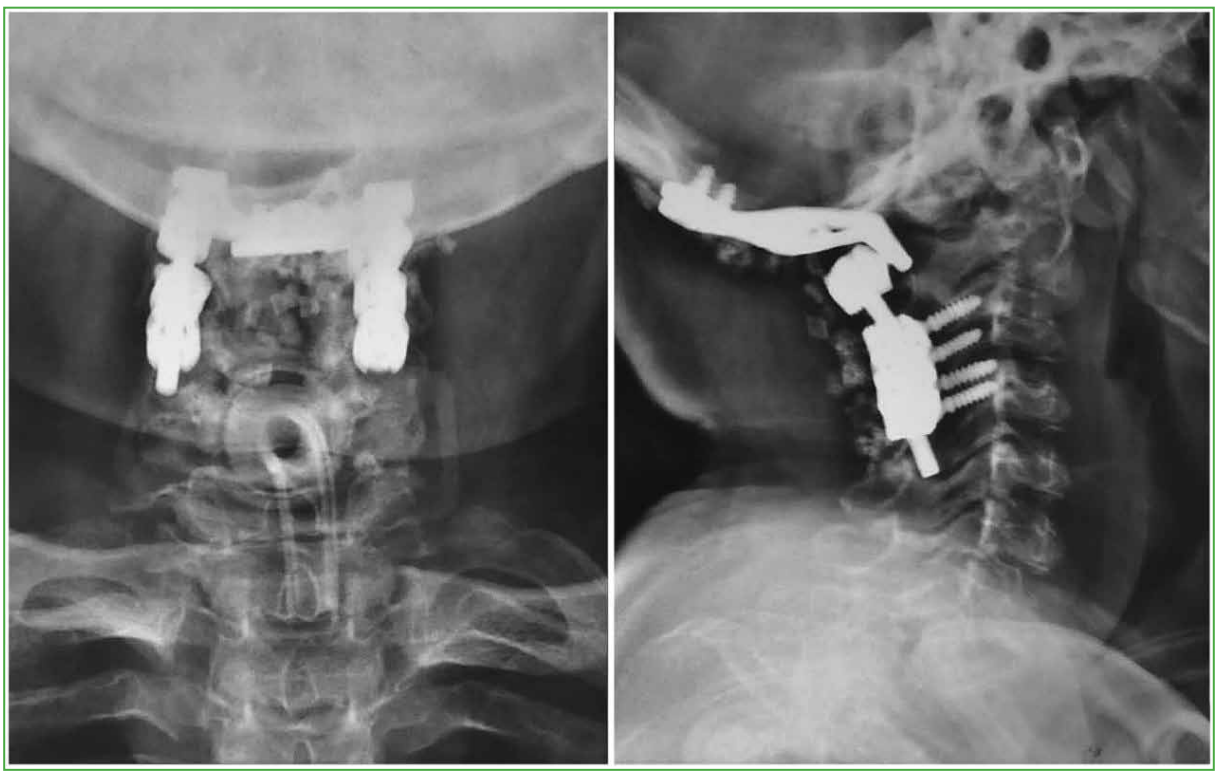

Figure 10. Anteroposterior and lateral cervical radiographs, after 9 months. Occipito-cervical instruments (C0-4) without signs of loosening.

- MRI of the entire spine, with sedation, before starting the enzymatic treatment. Despite the anesthetic risks posed by young patients, different groups suggest this study to establish a baseline risk and guide potential risks.[4,6]

- Routine neurological evaluation every 6 months to look for upper motor neuron signs, impaired proprioception, gait disturbances, reduced gait tolerance, bladder or rectal dysfunction. The search for impaired deep tendon reflexes, clonus, Babinsky, and Hoffman signs is especially important.

- Somatosensory evoked potentials every six months or yearly.[5,8]

- Cervical spine radiographs (static and dynamic), MRI or, if necessary, cervical computed tomography at least once a year, or every six months if the findings are abnormal.

MRI is considered the reference study in these patients, it is important to include the entire spine and the cerebellar fossa. It should be noted that, in specialized centers, flexion-extension MRIs are being performed to assess instability; however, to date, the risk of spinal cord injury in sedated patients is unknown.[6,9,11]

Since 2005, galsulfase enzyme replacement therapy has been available to treat patients with MPS VI, which has proven beneficial effects on some of the conditions of this disease, such as visceromegaly, respiratory infections, and quality of life. However, it has no effect on skeletal abnormalities and its effect on spinal stability is controversial. According to various studies,[4,5,9,11] enzyme replacement therapy can promote spinal cord damage by improving cervical mobility, and in cases of instability, even a few millimeters of movement can be clinically problematic, because the canal stenosis prevents any movement. As a result, regular neurological examinations and MRI follow-up are advised.

Lins et al.[11] analyzed the MRI findings of 12 patients and correlated them with the clinical manifestations. They evaluated the presence of odontoid process dysplasia, periodontoid tissue thickening, the space available for the medullary cord, the presence or absence of myelopathy, the presence of basilar intussusception and flattened vertebral bodies, disc signal alterations or disc disease, and nasopharyngeal airway narrowing. They found that all patients had cervical stenosis and periodontoid tissue. 50% had spinal cord compression, which was severe in 33%. Solanki et al.[6] reported a prevalence of spinal cord compression of 75% with 10% myelopathy. These authors emphasize that even asymptomatic patients with a normal neurological examination can have spinal cord compression.

Bullut et al.[9] analyzed the role of MRI and their findings were similar. They pointed out that age has a statistically significant relationship with the presence of periodontoid tissue, and reported a prevalence of myelopathy of 79% (the age range was higher than that of the Lins group). The authors concluded that MRI changes may precede the appearance of neurological examination abnormalities, so it is essential to perform neuroimaging studies before the changes become irreversible.

Not only was our patient symptomatic, but she also had unusual imaging findings: myelopathy, occipitocervical junction compression, vertebral body dysplasia, thoracic disc changes, and odontoid hypoplasia.

Regarding treatment, although there are no defined guidelines that guide when to operate and whether to opt for decompression or arthrodesis, there is consensus that surgery is indicated when symptoms or myelomalacia appear.[9-13]

When deciding on a treatment, the high anesthetic risk and potential benefit of decompressive surgery must be carefully considered. Multidisciplinary management of these patients is essential, as is preparation for the treatment of intraoperative (emergency tracheostomy, paraplegia) and postoperative complications (complex extubation, respiratory or urinary infections, cardiac complications). It would be useful to establish pre-surgical protocols for these patients in order to reduce complications, for example, tracheotomy planning could reduce complications associated with prolonged ventilation, as in this case.[2,6,12]

In 2013, Lampe et al.[13] developed a scale to indicate surgical treatment and predict outcomes, analyzing data from 31 patients. It contains three areas: the clinical-neurological examination, the somatosensory evoked potentials, and the MRI findings. Each is scored from 0 to 3 based on the findings. They recommend surgery in patients with a score of 4 or more; score 3 represents a relative indication for surgery and requires close monitoring of these patients. Our patient had 7 points on this scale (myelomalacia, increased latency in somatosensory evoked potentials, and weakness of the lower limbs); according to Lampe, surgery was imperative.

Although there are no specific recommendations, we opted for C0-1-2 decompression and C0-4 arthrodesis, due to the instability generated by the large release.

CONCLUSIONS

We present a patient with a rare disease who underwent surgery and discuss the factors to consider when making a therapeutic decision as well as the precautions to take during the operation.

It is critical to understand this disease in order to provide adequate follow-up, a multidisciplinary evaluation for proper management, and the appropriate choice of surgery.

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Endoscopic Treatment of Lumbar Spondylodiscitis. Case Report and Literature Review

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ABSTRACT

We describe the case of a 62-year-old male patient with multiple comorbidities who attended the outpatient clinic due to severe low back pain compatible with T12-L1-L2 spondylodiscitis. Endoscopy was performed with a left posterolateral approach and an all-inside technique for diagnostic and therapeutic purposes. A germ was isolated and treated with specific antibiotics. Due to the good clinical evolution, the patient was discharged 7 days after surgery with good pain management and home intravenous antibiotic therapy. A brief literature review is presented.

Keywords: endoscopic surgery, lumbar spondylodiscitis
Level of Evidence: IV

Tratamiento endoscópico de la espondilodiscitis lumbar. Reporte de caso y revisión bibliográfica

RESUMEN

Se describe el caso de un hombre de 62 años de edad, con múltiples comorbilidades que concurre a la consulta por dolor lumbar severo compatible con espondilodiscitis de T12-L1-L2. Se realizó una endoscopia con abordaje posterolateral izquierdo con técnica adentro-adentro para fines diagnóstico y terapéutico. Se aisló un germen y se administró un tratamiento antibiótico específico. Dada la buena evolución clínica del paciente, fue dado de alta a los 7 días de la cirugía, con buen manejo del dolor y antibióticos intravenosos en el domicilio. Se presenta una breve revisión bibliográfica.

Palabras clave: Endoscopia; espondilodiscitis lumbar.
Nivel de Evidencia: IV

INTRODUCTION

Spondylodiscitis is an infection that affects the spine, more specifically the vertebral end plate (osteomyelitis) and the intervertebral disc (discitis). It is the main manifestation of hematogenous osteomyelitis in patients >50 years of age. At present, its prevalence is increasing due to the prolongation of life expectancy and immunosuppressive drugs.[1,2]

Some of the conditions that increase the risk of suffering from this infection are: infectious focus or bacteremia, chronic renal failure, diabetes, immunosuppression, oncological disease, previous surgery, kidney transplant, human immunodeficiency virus infection/AIDS, advanced age, hemodialysis, addiction to intravenous drugs, catheters, corticosteroids, alcoholism, liver cirrhosis, pulmonary fibrosis, obesity, tuberculosis disease, rheumatological diseases, iatrogenesis.[2-7]

The infection is usually treated with antibiotics without the need for surgery. Surgery is considered if the response to conservative treatment is poor, there is progressive spinal deformity, instability, and neurologic deficit.[8]

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Various surgical treatments are available that depend on the clinical conditions of each patient and the characteristics of the disease. In 2007, Ito et al. described a series of 15 patients with lumbar spondylodiscitis who underwent surgical debridement using an endoscopic posterolateral approach with excellent outcomes.[9]

Endoscopic spinal surgery was described by Kambin in 1973 and, since then, the indications and available technology have evolved.[10] Today, several companies manufacture and distribute various endoscopy equipment, facilitating access and encouraging the use of these techniques.

Endoscopic techniques have been shown to achieve at least the same results for the treatment of lumbar disc conditions when compared to conventional techniques.[11-13] In addition, the incision for the uniportal technique usually measures between 6 and 8 mm, depending on the type of cannula used, which reduces the iatrogenic damage caused in conventional surgery.

In accordance with the international consensus for the publication of case reports of the SCARE guidelines,[14] we report the case of a patient with multiple comorbidities who suffers severe low back pain compatible with spondylodiscitis, and we present a brief literature review.

CLINICAL CASE

The patient was a 62-year-old man with a history of smoking, prostate cancer, chronic kidney disease (left nephrectomy) receiving renal replacement therapy with intermittent hemodialysis three times a week. He had right pyelonephritis with exacerbated chronic renal failure for the previous three months, which had progressed to septic shock caused by *Candida tropicalis* and *Pseudomonas aeruginosa* the previous month. He consulted for intense low back pain that had been evolving for a month. The patient gave his written informed consent for the publication of this information.

Clinical findings

Acute low back pain was detected (9/10 visual analogue scale) associated with paresthesias in the lower limbs. The patient reported that the symptoms worsened with activity and also at rest. When the thoracolumbar spinous bones were palpated, there was no pain, and the cervical and lumbar ranges of motion were complete. Right L4 and S1 hyporeflexia were observed, with the rest being unremarkable. In dermatomes from L1 to S1, sensitivity was preserved and symmetric.

Diagnostic evaluation

Due to the oncological history, a positron emission tomography scan was performed, which showed increased uptake in the vertebral bodies of T12, L1 and L2 and in the intervertebral disc of L1-L2 (Figure 1).

Due to severe kidney disease, an MRI without contrast was performed, which revealed hyperintensity of L1-L2 and ruled out compression (Figure 2).

Laboratory analysis revealed high values of acute phase reactants (erythrocyte sedimentation rate 110 mm/h and C-reactive protein 6.66 mg/dl).

Therapeutic intervention

Given the patient's comorbidities, the lack of a certain diagnosis and the poor evolution, an endoscopy was indicated for diagnostic and therapeutic purposes. The procedure was performed under anesthetic sedation, with a uniportal left posterolateral approach 10 cm from the midline at the level of L1-L2 (Figure 3).

The all-inside technique was used (Figure 4), which consists of working inside the disc by placing an intradiscal cannula. We proceeded to take samples of the intervertebral disc of L1-L2, the lower endplate of L1, and the upper endplate of L2 (Figures 5 and 6). Samples were sent to the laboratory for culture and pathological study. An endoscopy system from the company RIWOspine® was used, which has a continuous irrigation-aspiration system. The procedure lasted 17 minutes.

Meropenem and daptomycin were administered to the patient as an empirical treatment. The patient had good tolerance 12 hours after surgery with the use of a thoracolumbar corset, so rehabilitation began with standing position.

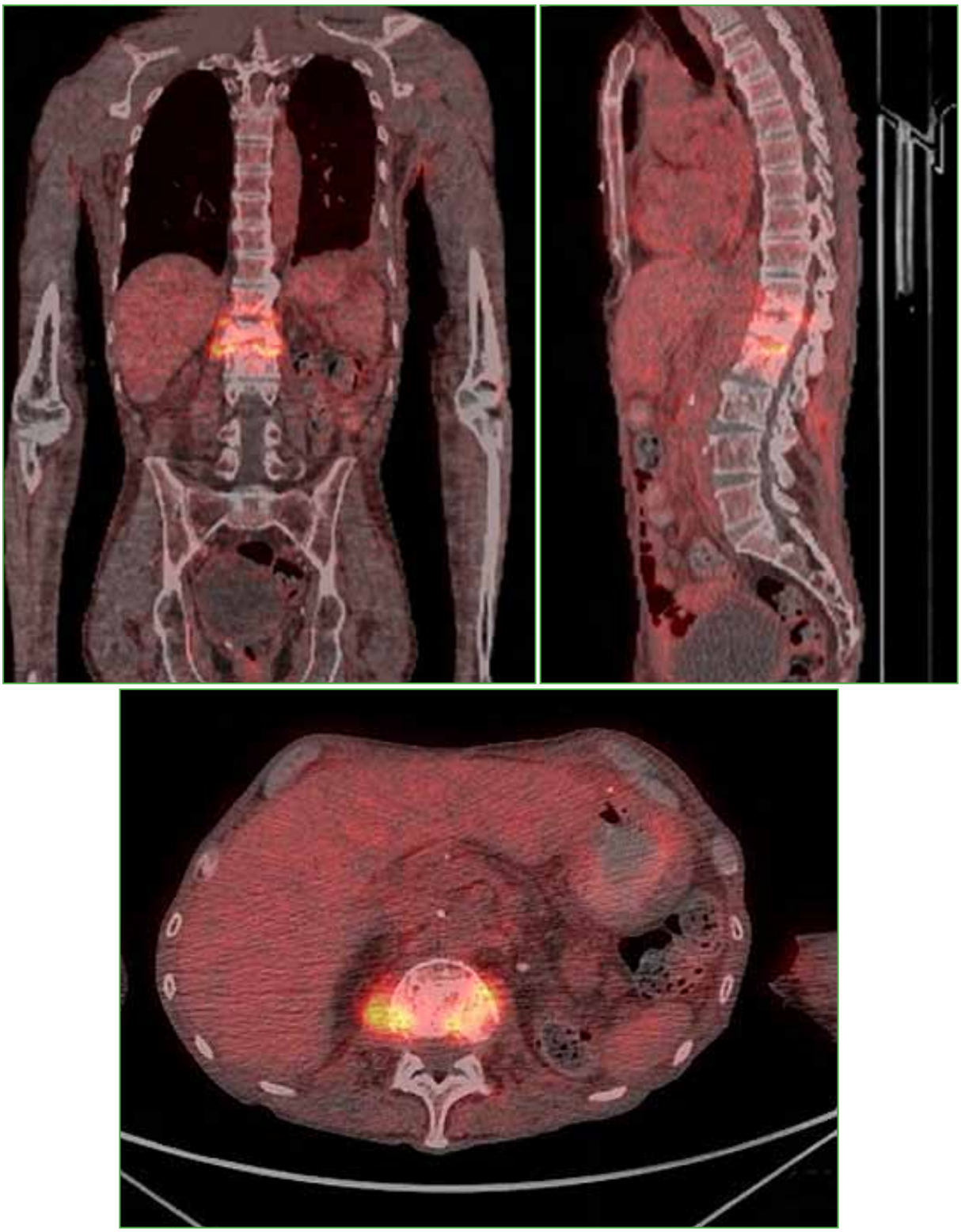

Figure 1. Positron emission tomography of the thoracolumbar spine, coronal, sagittal and axial slices. Hyperintensity of the intervertebral space of L1-L2 and of the vertebral bodies of T12, L1 and L2 is observed.

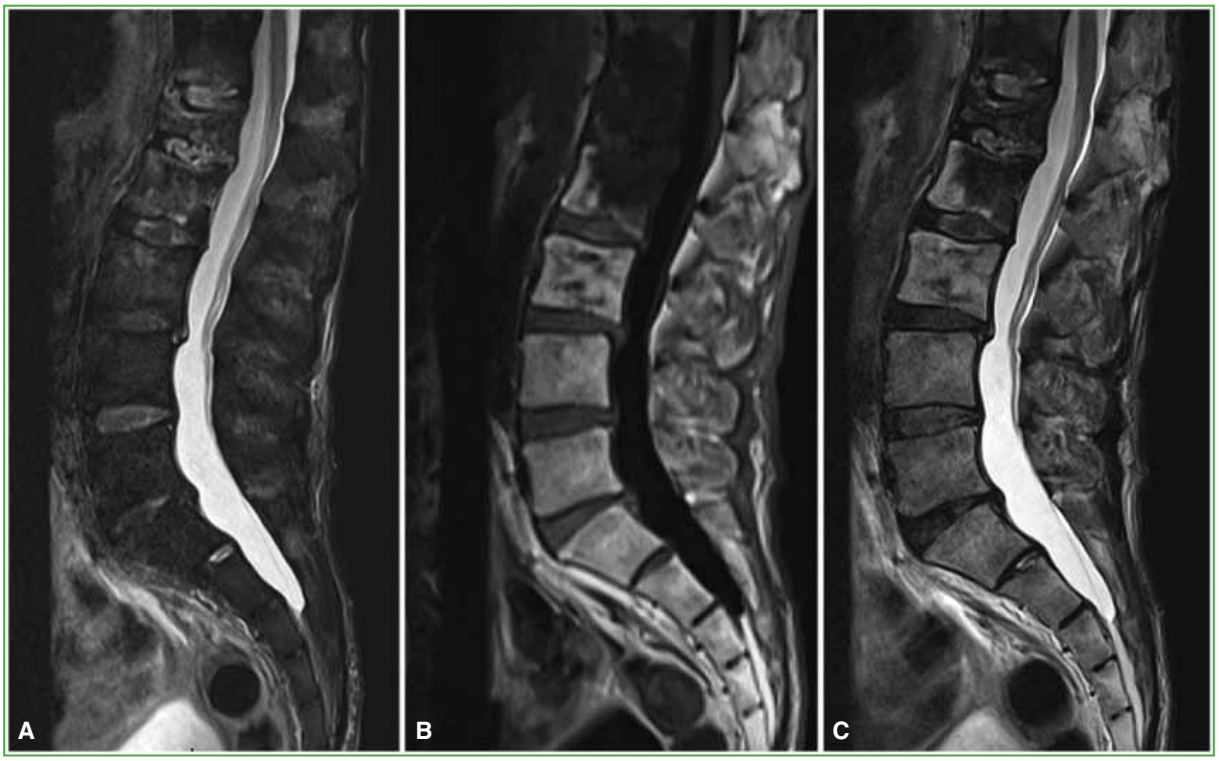

Figure 2. Magnetic resonance imaging of the lumbosacral spine, sagittal section. **A.** STIR sequence. **B.** T1-weighted sequence. **C.** T2-weighted sequence. Images compatible with spondylodiscitis of T12, L1 and L2 are observed.

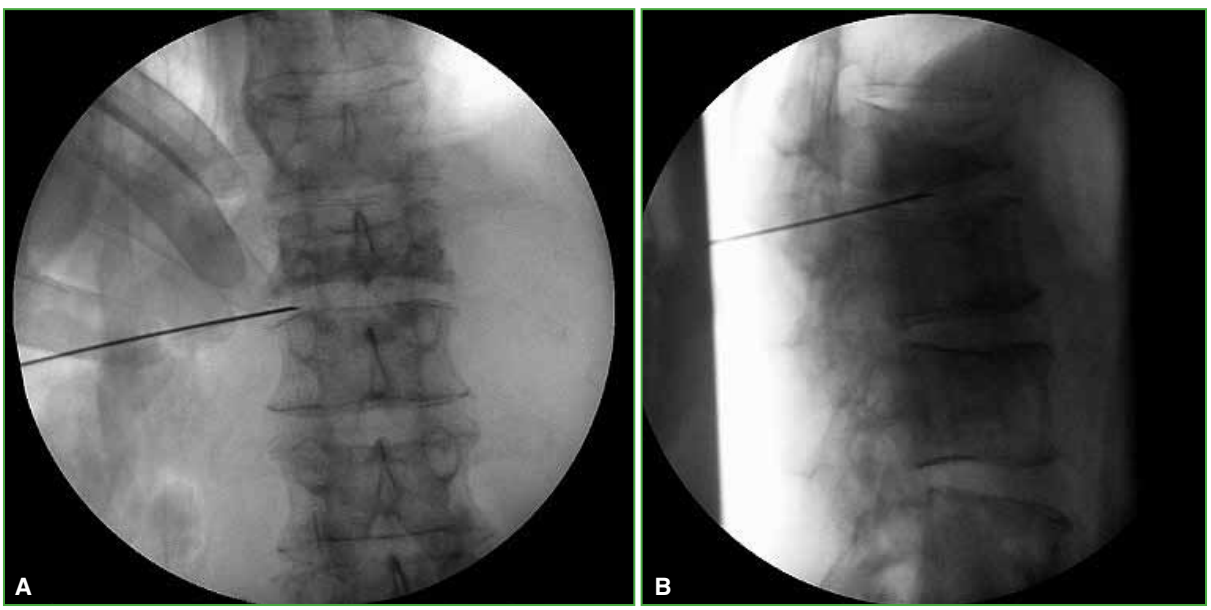

Figure 3. Intraoperative anteroposterior (**A**) and lateral (**B**) radiographic projections. The posterolateral entry point is visualized.

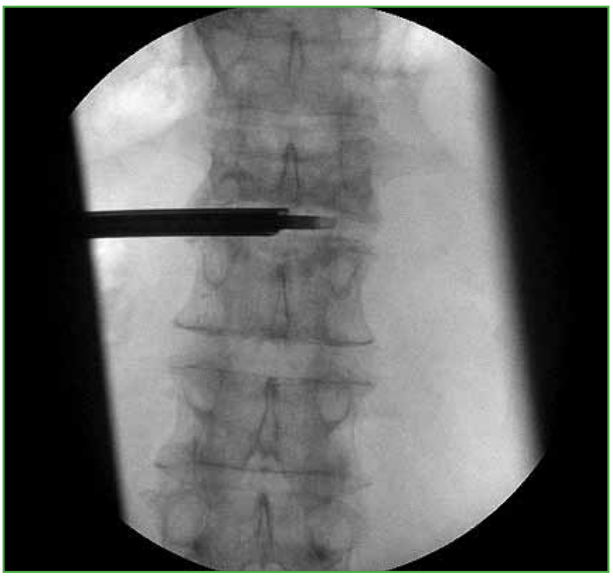

Figure 4. Anteroposterior radiographic projection. The placement of the endoscope according to the all-inside technique is observed.

Figure 5. Sample of the L1-L2 intervertebral disc that was sent for studies.

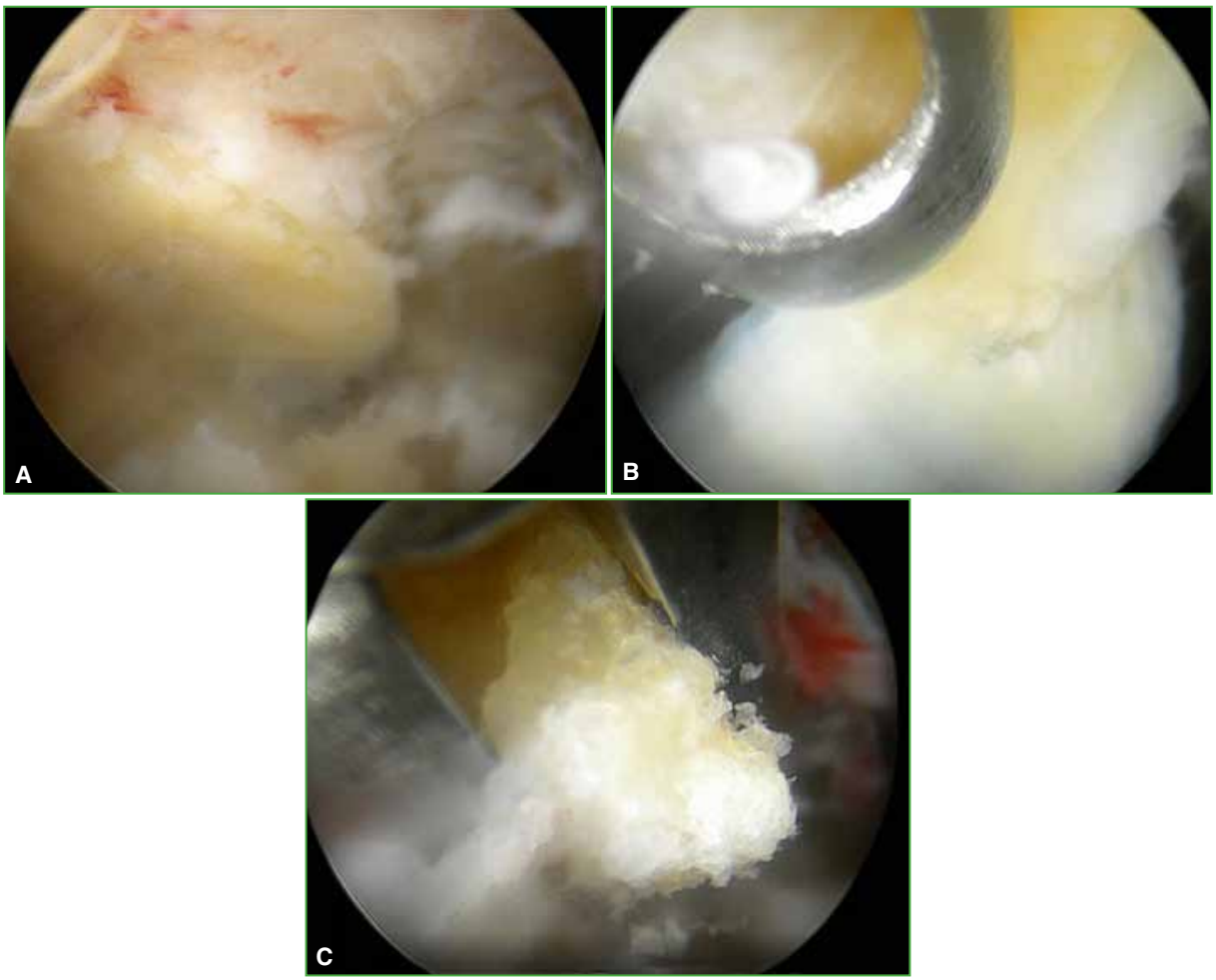

Figure 6. Endoscopic vision. **A and B.** The L1-L2 intervertebral disc is visualized and the infected tissue is excised. **C.** Resection of a bone fragment corresponding to the inferior end plate of L1.

Evolution and results

The patient evolved favorably. After 48 h, he reported significant pain relief (2/10 visual analogue scale). In all the samples, *Pseudomonas aeruginosa* was isolated at 48 h and the antibiotic treatment was adjusted with intravenous meropenem. Acute phase reactant values had improved significantly after surgery.

Due to the good clinical evolution, the patient was discharged seven days after the procedure, with an indication of intravenous antibiotics for three weeks and oral antibiotics for three months.

The patient was monitored with clinical and laboratory tests (complete blood count, erythrocyte sedimentation rate, and C-reactive protein) by the infectious disease and spinal surgery teams. Three months later, he came back to the clinic and reported back pain (visual analog scale 2/10); laboratory tests were normal (erythrocyte sedimentation rate 11 mm/h and C-reactive protein 0.32 mg/dl).

DISCUSSION

This patient had multiple comorbidities and a delicate clinical state that made him vulnerable to larger-scale surgeries. The absence of germ isolation could have been resolved with a guided puncture. In the center where he was treated, we opted for endoscopic lavage and sample collection, since access to the endoscopic method is easy

and allows us not only to obtain a quality sample, but also gives us the possibility of performing the lavage with physiological solution and, at the same time, resecting the devitalized tissue using the same endoscope.

In patients with spinal infection, bacterial identification using CT-guided puncture techniques has a variable range of 36% to 91%.[15-21] Yang et al. reported a 90% positivity for the endoscopic technique used to take samples from infected patients.[15] Germs were isolated in all of our patient's samples, which is consistent with the investigations described by these authors.

Currently, there are few literature reports on the endoscopic treatment of spondylodiscitis. Abreu et al. carried out a systematic review that included 14 studies with a total of 342 patients. They pointed out that it is a safe and effective procedure, although there is no clear consensus regarding the surgical indication.[22]

Spinal surgery is exponentially migrating to less and less invasive procedures. Endoscopic surgery has great potential to become the new gold standard for treating lumbar disc herniations.[23] Much remains to be investigated on its use for spinal infections.

One of the main difficulties for its routine use is the high economic costs of the instruments. Another difficulty in applying this technique is the learning curve. Within the spectrum of diseases that can be treated with the endoscopic technique, the all-inside technique used in the described case is one of the simplest in terms of technical aspects and the risk of complications is low. At the beginning of the learning curve, training with surgeons with experience in this type of technique, attending courses on simulated models or cadavers, and having a mentor surgeon who provides pre-surgical advice is recommended.[24]

The fact that there is little tissue damage is not the only reason why this technique is recommended. Currently, they can be used to treat almost all diseases of the spine, leaving out deformity surgeries. Endoscopic surgery minimizes iatrogenic damage and preserves the integrity of the articular facets; in turn, the vision achieved with the probe is greater than that achieved with a microscope. The overall risk of infections is 4.4% for spinal surgeries,[25] but there are few cases reported with endoscopic techniques. In terms of economics, these procedures shorten hospital stays and return to work times. Choy et al. published a cost-effective comparison of microdiscectomy and endoscopy, and the results were better with endoscopy.[26]

Regarding the complications caused by these techniques, increased intracranial pressure, epidural hematoma, and incidental dural injury have been reported. Intracranial hypertension can lead the patient to develop headaches and, in some cases, seizures. It is recommended to finish the procedure as quickly as possible if dural injury occurs. Regarding epidural hematoma, if bleeding is excessive when irrigation is interrupted, it is advisable to place an epidural drainage catheter. Dural injuries <1 cm can be treated without the need to suture the sac, while for those >1 cm, conversion to conventional/tubular surgery is recommended.[27]

In conclusion, the results in this patient were satisfactory and recovery was faster than when opting for conservative treatment. Taking into account the low post-surgical morbidity caused by this type of procedure, it is a safe and effective option in trained hands.

Given the advantages of endoscopic surgery over conventional surgeries, we believe it is important for spine surgeons to develop skills in this type of procedure, whether it is for the treatment of infections or other types of spinal conditions.

Conflict of interest: Dr. José-Carlos Sauri-Barraza is a spokesperson for RIWOspine®. Dr. Enrique Gobbi is a spokesperson for Nuvasive ®. The rest of the authors do not report conflicts of interest.

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Vascularized Ulnar Periosteal Graft for the Treatment of Recalcitrant Nonunion of the Radius. Case Report

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ABSTRACT
There are many techniques described to achieve consolidation in the nonunion of long bones, including morselized cancellous or structural non-vascularized bone graft, vascularized bone graft, or the induced-membrane technique. In 2018, Barrera-Ochoa described the anatomy of a vascularized ulnar periosteal flap based on the posterior interosseous vascular axis and showed his initial experience using it on children to treat a radius atrophic nonunion and bone defect secondary to the exeresis of an Ewing Sarcoma. We present our experience with a vascularized ulnar periosteal graft for the treatment of a recalcitrant nonunion of the radius shaft in an adult patient.
Keywords: radius; nonunion; periosteal vascularized graft; induced-membrane technique.
Level of Evidence: IV

Injerto perióstico vascularizado de cúbito para el tratamiento de la seudoartrosis recalcitrante de radio: A propósito de un caso

RESUMEN
Se han desarrollado distintas técnicas para estimular la consolidación ósea en las seudoartrosis de huesos largos, como el uso de injerto óseo molido o estructural, injertos vascularizados o la técnica de membrana inducida. En 2018, Barrera-Ochoa describió la anatomía de un injerto perióstico vascularizado del cúbito con eje vascular interóseo posterior, y mostró su experiencia clínica inicial en niños utilizándolo en una seudoartrosis atrófica de radio y un defecto óseo después de la exéresis de un tumor de Ewing. Presentamos nuestra experiencia con el injerto perióstico vascularizado de cúbito para el tratamiento de una seudoartrosis recalcitrante en la diáfisis de radio de un paciente adulto.
Palabras clave: Radio; falta de consolidación; injerto perióstico vascularizado; técnica de membrana inducida.
Nivel de Evidencia: IV

CLINICAL CASE

The patient was a 39-year-old man, who was admitted to the Emergency Service after suffering multiple injuries from a motorcycle traffic accident. He was diagnosed with an exposed Galeazzi fracture-dislocation in the right forearm, and a Gustilo II fracture (comminuted radial diaphyseal fracture and irreducible distal radioulnar dislocation) (Figures 1 and 2), for which antibiotics and emergency surgery were indicated according to the protocol for open fractures. Seven days later, definitive open reduction and internal fixation of the right radius plus stabilization of the distal radioulnar joint were carried out, with good initial clinical-radiological results (Figure 3).

Six weeks after surgery, the patient consulted due to pain and seropurulent discharge from the previously healed surgical wound. On radiographs, signs of bone resorption were seen at the focus, with no signs of implant loosening (Figure 4); acute-phase reactant values (erythrocyte sedimentation rate, white blood cells, and C-reactive protein) were normal.

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Figure 1. Galeazzi exposed fracture-dislocation in the right forearm, Gustilo II.

Figure 2. Anteroposterior and lateral forearm radiographs. Galeazzi exposed fracture-dislocation in the right forearm, Gustilo II.

Figure 3. Anteroposterior and lateral forearm radiographs. Initial radiographic result. Reduction and osteosynthesis.

Figure 4. Clinical-radiological findings 6 weeks after surgery. **A.** Active fistula. **B.** Radiological osteolysis at the fracture site.

With the clinical suspicion of late post-osteosynthesis infection, extensive surgical debridement of the focus was performed, with sampling for bacteriological study. When a 3 cm bone defect was discovered in the same surgical procedure, the induced membrane technique, described by Masquelet, was used, using orthopedic cement with antibiotics (vancomycin 2 g/cement dose) and stained with methylene blue to recognize it when extracted.[1] The decision was made to preserve the implant due to the solidity of the fixation, the time since surgery, the low virulence and the good condition of the patient.

Empirical antibiotic treatment was initiated and then directed against *S. epidermidis* and *P. acnes* (germs isolated in cultures from surgery).

The second stage of the Masquelet technique was performed eight weeks after the procedure; there was no infection in the tissues and the laboratory parameters were normal. An iliac crest bone graft was used to fill the bone defect. (Figure 5).

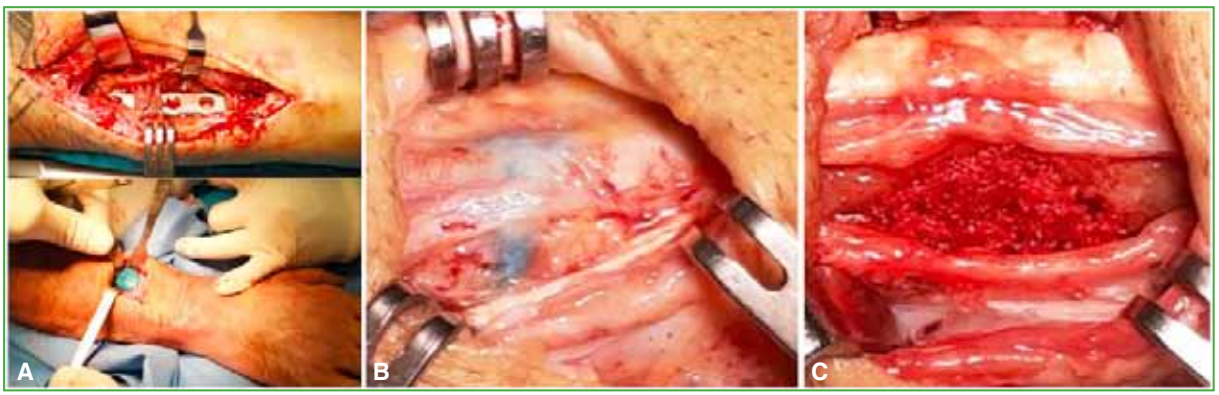

Figure 5. Induced membrane technique. **A.** First stage: debridement and filling of the bone defect. **B.** Second stage: neoformed pseudomembrane. **C.** Bone filling of the defect.

The patient's evolution was satisfactory, with correct healing, pain relief, and normal laboratory parameters. Serial clinical and radiographic controls revealed that the bone defect was progressively filling, allowing the patient to gradually resume his activities.

Eight months after surgery, he referred pain during weight-bearing. Filling of the bone defect was seen on radiographs, but with persistence of the focus of linear pseudarthrosis and implant failure due to fatigue (Figure 6).

Figure 6. Anteroposterior and lateral forearm radiographs. Filling of the bone defect, with linear pseudarthrosis. Fatigue and rupture of the implant.

As a result, a new intervention was performed to remove the implant, explore the focus, collect bacteriological samples, and provide external stabilization with plaster (Figure 7).

Figure 7. Anteroposterior and lateral forearm radiographs. Removal of the implant. Linear recalcitrant pseudarthrosis (with filling of the previous bone defect).

Given the negative results of the tissue samples sent to bacteriology analysis and the recalcitrant pseudarthrosis of the radius, it was decided to perform a new intervention with revision and fibrous debridement of the bone focus, stabilization with a 3.5-mm diameter straight plate and filling with allogeneic ground bone graft from the tissue bank (Figure 8).

Figure 8. Anteroposterior and lateral forearm radiographs. Internal fixation with plate and 3.5 mm straight screws.

To improve the biological contribution in the nonunion focus, the vascularized periosteal flap of the ulna described by Barrera-Ochoa was performed during the same surgical procedure (Figure 9).

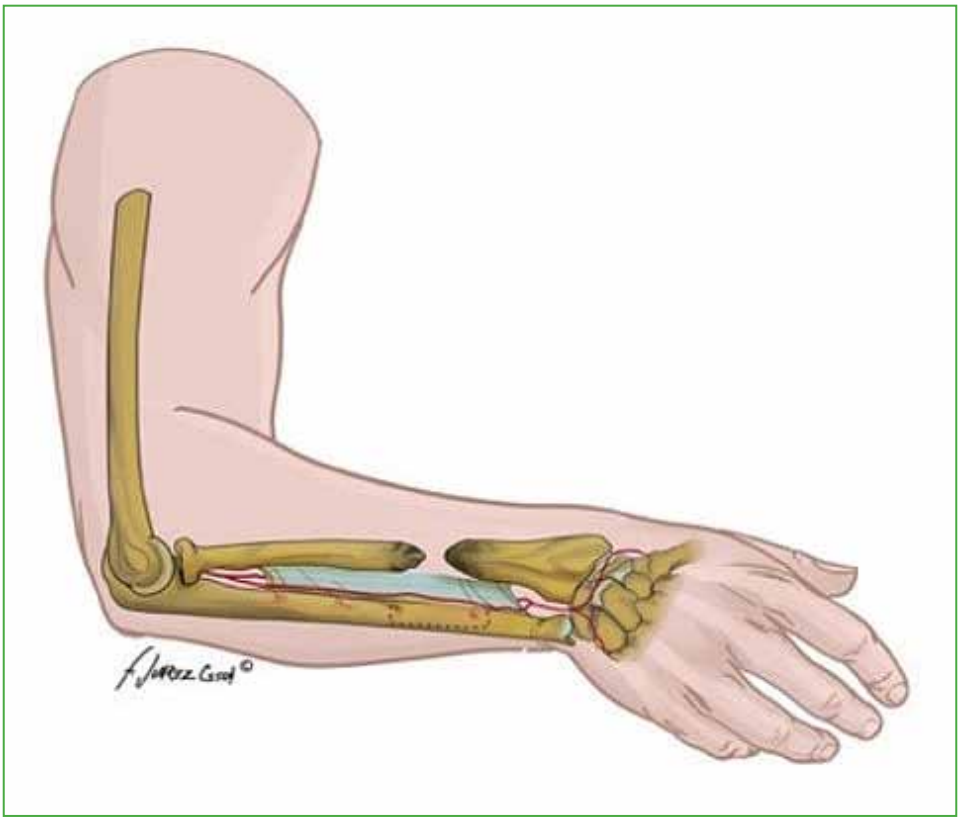

Figure 9. Barrera-Ochoa vascularized periosteal graft.

Summary of the technique

1) Cutaneous marking of the flap along the axis of the posterior interosseous artery, drawing a line connecting the epicondyle to the distal radioulnar joint while keeping the elbow flexed.

2) Initial distal wrist dissection with opening of the extensor retinaculum over the 6th compartment, from a point 2 cm proximal to the distal radioulnar joint (anastomosis level of the recurrent branch of the anterior interosseous artery and the posterior interosseous artery) . In this compartment, the extensor carpi ulnaris tendon is easy to identify, but the vascular axis is not recognizable.

3) Opening of the 5th extensor compartment containing the extensor digiti minimi with recognition of the posterior interosseous artery on the radial side of the intercompartmental septum between the 5th and 6th compartments (Cavadas modification).[2]

4) Initial carving of the pedicle.

5) Ligation of the pedicle's cutaneous and muscular branches; release from a plane immediately superficial to the ulna's periosteum.

6) Once the pedicle has been cut long enough for transposition, the periosteal graft is designed to be large enough to cover the nonunion.

7) Taking the periosteal graft with a thin layer of muscle to preserve its irrigation and respecting the posterior interosseous pedicle.

8) Tunneling of the graft in the subcutaneous plane without tension to cover the largest possible area of the nonunion site. Fixation with non-absorbable suture.

9) Temporary removal of the hemostatic cuff to confirm the vitality of the graft (Figure 10).

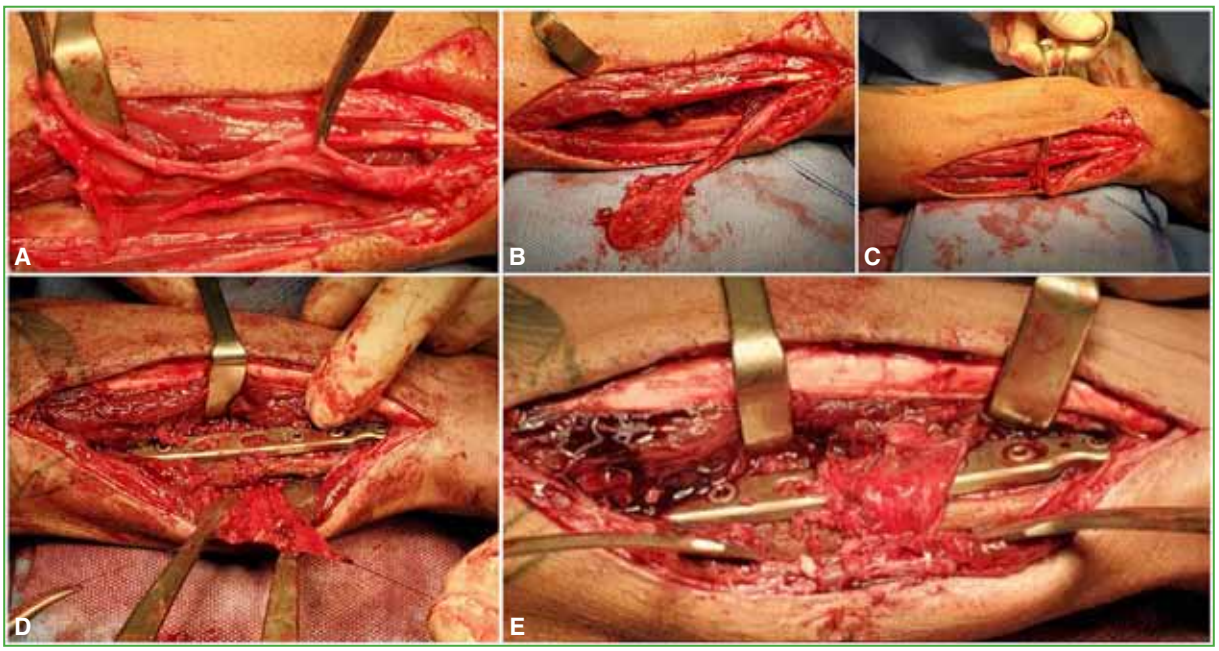

Figure 10. **A.** Sculpting of the vascularized periosteal graft with visualization of the periosteal perforator. **B.** Carved graft. **C.** Tunneling and passage of the vascularized graft. **D.** Graft placement with coverage around the entire circumference of the radius. **E.** Graft placed.

The patient evolved to complete radiological consolidation (by radiography and computed tomography) in all the cortices 2 months after surgery; with complete subjective recovery of the strength and range of motion of the limb, and return to his professional and sporting activity four months after surgery (Figure 11).

Figure 11. Clinical and radiographic results 4 months after surgery.

DISCUSSION

The treatment of pseudarthrosis continues to be a difficult problem to solve, which requires stability and biological support. Vascularized grafts provide both resources; however, they entail technical difficulties.

In 1978, Finley et al. described the osteogenic and angiogenic potential of vascularized periosteum taken from ribs in tibial bone defects of dogs.[3] In 1990, Penteado et al. experimentally showed the anatomical bases for the carving of different vascularized periosteal grafts.[4] In 1991, Sakai et al. reported excellent outcomes from the treatment of upper limb nonunion with a corticoperiosteal flap from the medial femoral condyle.[5] Qi et al. described the use of periosteal grafting of the greater trochanter to treat nonunion of the femoral neck in children,[6] and Soldado et al. published the use of a vascularized periosteal flap from the fibula for the treatment of pseudarthrosis of the tibia in children, and achieved union rates close to 100%.[7]

In 2018, Barrera-Ochoa et al. described the anatomical basis for the use of a vascularized ulna graft, based on the axis of the posterior interosseous artery. In addition, they reported its use in an atrophic radial nonunion and in a radial bone defect after excision of an Ewing tumor (both in children).[8,9]

Based on the good results, promising case series have been published for the treatment of nonunion of the scaphoid,[10] humerus,[11] and forearm[12] in children or adolescents. The biological superiority is evident, as well as the greater thickness of the periosteum in the pediatric population,[12] which limited the development of this technique in adults. When carving this type of graft, there is also concern about potential injury to the osteoperiosteal cambium, the home of periosteal stem cells.

However, in 1994, Camilli and Penteado confirmed the efficacy of periosteal and osteoperiosteal grafts in rats.[13]

In 2021, Barrera-Ochoa et al. extended the indication for periosteal grafts to adults in a series of 11 radius nonunions treated with vascularized periosteal grafting of the ulna, with 100% consolidation and good functional outcomes.[14]

Due to their osteogenic properties, vascularized periosteal grafts, like vascularized bone grafts, may provide the necessary biologic support.

Our report cannot validate the use of this technique, but it does allow us to explore this new option for the management of recalcitrant pseudarthrosis (a term introduced by Zaidenberg in 2008 in the national literature),[15] especially of the radius.

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Current Concepts on Bracing in the Ponseti Method

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ABSTRACT
The Ponseti method has become the gold standard for the treatment of clubfoot, with excellent long-term functional outcomes. Adherence to the bracing protocol is essential for the long-term success of the treatment. Currently, there are multiple braces that can be used to prevent relapse. In this article, we provide a review of clubfoot braces, discussing their advantages and disadvantages, as well as the current evidence on each of them.
Keywords: clubfoot; Ponseti; brace; relapse.
Level of Evidence: V

Conceptos actuales sobre el tratamiento ortésico en el método Ponseti

RESUMEN
El método Ponseti se ha convertido en el patrón de referencia para el tratamiento del pie bot, con excelentes resultados funcionales en el seguimiento a largo plazo. El cumplimiento del protocolo de férula es fundamental para mantener la corrección obtenida y el éxito terapéutico a largo plazo. Existen múltiples férulas para mantener la corrección y prevenir la recurrencia. En este artículo, proporcionamos una revisión de las férulas utilizadas para el pie bot, y analizamos sus ventajas y desventajas, así como la evidencia sobre cada una.
Palabras clave: Pie bot; Ponseti; ortesis; recurrencia.
Nivel de Evidencia: V

INTRODUCTION

The Ponseti method has become the gold standard for the treatment of clubfoot, with excellent functional outcomes in long-term follow-up.[1] It consists of a series of manipulations and casting every 5-7 days, using a specific technique, generally combined with a percutaneous Achilles tendon tenotomy.[2,3] After removing the last cast, an abduction orthosis is indicated to maintain the correction. Proper orthotic protocol generally requires the child to wear the brace 23 hours per day for the first 3 months after cast removal and then during the night and naps (approximately 12-14 hours) until 4 or 5 years old. Compliance with the orthotic protocol is essential for the long-term success of treatment, and is a better predictor of recurrence than the severity of the deformity at birth.[4-7]

In this article, we provide a review of braces used for clubfoot, and discuss their advantages and disadvantages, as well as the evidence on each.

RECOMMENDATIONS

According to the recommendations of the Ponseti method, once the foot has been corrected, it should be kept in a brace that places it in an abduction and dorsiflexion position to prevent recurrence of the deformity. Ideally, the bar connecting the shoes should be bent to allow 10° of dorsiflexion and allow for progressive heel width adjustment as the child grows. The splint must also allow movement of the hip, knee, and ankle. These movements are necessary for the development of the muscles of the lower limbs and to prevent recurrence.[2]

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TYPES OF BRACES

There are three main categories of brace designs used for clubfoot: 1) ankle-foot orthoses, 2) Wheaton-type orthoses, and 3) abduction braces.

1) Ankle-Foot Orthosis

This orthosis fully covers the foot and ankle, thereby providing only dorsiflexion which is typically set to neutral (0° dorsiflexion). Notably, it does not provide abduction, which is important for the elongation of medial structures. Also, the lack of movement in the ankle contributes to calf muscle atrophy which is already abnormal in clubfoot patients. The results of using a unilateral ankle-foot brace after treatment with the Ponseti method have been disappointing, with a high recurrence rate.[8] However, this brace may be useful in combination with an abduction bar in specific circumstances, particularly when the child has limited dorsiflexion and minimal muscle support (myelomeningocele, arthrogryposis, fibular nerve dysfunction, etc.). In cases where full-time orthotic use is necessary to provide the necessary support, ankle and foot braces may be an option.

2) Wheaton brace

This orthosis and other devices based on a similar design can provide some abduction of the foot. It has multiple disadvantages: it is expensive because it is custom-made, it requires fairly frequent adjustments, and because it reaches up to the thigh, it can promote atrophy of the calf and thigh muscle. To the best of our knowledge, there is no evidence to support its efficacy, so it is not recommended for the treatment of clubfoot.

3) Abduction braces

These orthoses are an evolution and adaptation of the orthosis described by Denis Browne in 1931.[9] Several designs are marketed (Figure 1):

Figure 1. Abduction braces for the treatment of clubfoot.

- Denis Browne – It has a dorsiflexed foot brace attached to leather boots. The toe and heels can be opened to check if the foot is plantigrade.

- Markell Shoes (C-Pro Direct, Kent, UK) – These are symmetrical shape shoes and are designed to work with the Denis Browne bar.

- Steenbeek – This brace was developed in Uganda and is made using local tools. It is quite affordable and meets all the requirements for braces after the Ponseti cast. It is used in many clubfoot programs that take place in developing countries in Africa and Asia. Bouchoucha et al.,[10] and Gupta et al.[11] reported excellent outcomes with this brace in Tunisia and India.

Horton Click (MJ Markell Shoe Co, New York, USA) – This system uses a shoe that can be easily clicked into the bar and allows for internal and external rotation of the foot.

Mitchell – This brace, also known as the Ponseti™ FAB, was developed to provide a more comfortable shoe alternative to improve treatment compliance. The shoes are sandal-type leather footwear with a molded soft thermoplastic elastomer lining that prevents slipping of the foot. They have a quick release mechanism to make it easy to remove the shoes from the bar, making them easy to put on and take off. These shoes are relatively expensive. Zionts et al.[12] evaluated 57 patients (84 feet) who used this device after correction. 60% complied with the protocol. Eight (14%) had skin problems; in six of them, it was a superficial abrasion of the dorsal skin. At last follow-up, all feet were plantigrade and at least 10° dorsiflexed. None required surgical releases. Of the 31 patients monitored for at least three years, 26 (84%) used the brace for at least three years. Recently, the manufacturer (MD Orthopaedics - Orthopediatrics) introduced a dynamic bar called MP-Move that allows independent movement between limbs and potentially improves comfort (Figure 2). The boots have a wedge incorporated in the heel area with the 10° dorsiflexion required to prevent recurrence.

Figure 2. MP-Move dynamic bar (Md Orthopaedics - Orthopediatrics).

- Iowa – Designed by a team of specialists, directed by Dr. José Morcuende from the University of Iowa. It has a fixed 60° abduction angle for the affected ankle. The bar is not adjustable, but it comes in three lengths: 8, 10 and 12 inches. The connecting bar is called the Flex Bar because it provides some limited movement when the child moves the lower limbs, but always returns to the desired position when the patient relaxes.

- Kessler – The bar is flexible to allow the child some plantarflexion during kicking and then returns to the original dorsiflexed position once the child stops kicking.

- Dobbs (D-Bar Enterprises, LLC, St. Louis, USA) – The bar allows the child to move both legs independently, but dorsiflexion can be difficult to achieve. These bars are compatible with Mitchell Ponseti or Markell shoes, or a custom molded solid AFO. The bar is relatively expensive. Chen et al.[13] evaluated 28 patients (49 feet) treated with

a dynamic abduction brace. They reported a lower non-compliance rate than with the traditional Denis Browne brace (7.1% vs. 41%). Seven percent of the patients who used the dynamic orthosis suffered skin lesions, in contrast to the 23.5% observed with the traditional abduction brace. Garg and Porter[14] published similar results with higher compliance, fewer recurrences, and fewer skin complications when using the dynamic brace.

- 3D-printed braces – Recently, 3D-printed braces have been developed using open source technology. These braces have similar features to others available on the market, but their cost is significantly lower. This would make them particularly suitable for use in developing countries.[15]

- Unilateral Designs: Some authors have attempted to use unilateral orthoses due to compliance issues. Published results are limited, but have generally been inferior to standard bilateral splints as they do not provide abduction.[8,16,17] Recently, a unilateral brace called the ADM brace from C-Pro Direct (7A Enterprise Way, Edenbridge, Kent, UK) has been launched on the market. This brace has a dynamic mechanism that provides active dorsiflexion and abduction without the need to use a bar that joins both feet. It can be worn on one foot or both feet, so it would have the potential advantage of providing more comfort. However, Mahan et al.[18] published their initial experience with this orthosis, reporting that almost half of the patients did not tolerate it for the prescribed time.

All available abduction braces that meet Ponseti's recommendations can be used to prevent recurrence of the deformity. The type of brace and the brand are not important as long as they follow the principles and recommendations of the method.

Compliance monitoring

Some authors have described the use of pressure or temperature sensors to monitor how long the braces were worn. This information could improve our practice as has occurred in the treatment of idiopathic scoliosis.[19-21] Morgenstein et al.[22] used pressure sensors and observed a rapid decrease in the time of wear in the first months and a significant discrepancy between the time of wear reported by the parents and the actual time of wear. Sangiorgio et al.[23] used wireless temperature sensors and observed that parents applied the brace only 62% of the prescribed time. In addition, they reported that patients who wore it for at least 8 hours per day had a lower risk of recurrence than those who wore it <5 hours per day. Richards et al.[24] confirmed these findings in a recently published case series. The potential advantages of monitoring the time of wear could be related to better compliance and better control in those patients with a higher risk of recurrence, which would lead to better outcomes.

How to improve compliance?

There are multiple strategies that can be applied. It is important to achieve complete correction of the deformity, ensure optimal brace comfort, and educate parents on the importance of this stage. Parents need to understand the mechanism by which the orthosis decreases the risk of recurrence and how to use it. The treating physician must continually reinforce the concept that the brace is essential to the child's recovery and that, without it, the chances of requiring a new series of casts or surgery are high. There are obstacles that exceed the doctor or families, such as financial difficulties or the distance to the treatment center. It is important to recognize these limitations, discuss them with the family, and try to resolve them.

CONCLUSIONS

The use of the abduction brace is essential to prevent relapse in patients treated with the Ponseti method. The type and brand of the brace are not important as long as they comply with the recommendations suggested by Ponseti. Future research should focus on increasing patient comfort and satisfaction to improve compliance, and on reducing the cost of orthoses to make them accessible. Likewise, the development of more advanced technology to monitor the use of the brace could allow us to make observations that modify our current practice.

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Short Femoral Stems for Primary Total Hip Arthroplasty in Young Patients: Clinical and Biomechanical Outcomes*

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ABSTRACT

Total hip arthroplasty is an effective surgery to treat osteoarthritis. Given the rising demand for a higher quality of life, this procedure is being performed on increasingly younger patients. However, a longer life expectancy is also tied to a higher demand for multiple revision surgeries for the same patient. This poses technical challenges due to bone loss. There is a growing need to identify durable and highly functional implants that are suitable for future revision. Although cemented femoral stems were the main option in the past, uncemented femoral stems have demonstrated long-term fixation and excellent results. However, some issues related to fixation can still be improved. Short femoral stems have been developed to address some of these challenges while maintaining the good results obtained with conventional stems. This study analyzes the experience after 10 years of using short femoral stems in hip surgeries on young patients. Biomechanical outcomes and femoral bone preservation are compared, postoperative outcomes regarding return to sports are reported, and complications related to their use are evaluated. Short stems have multiple advantages when used in primary hip surgery.. The indication for this type of implant is justified in young and active patients, to reproduce the results of conventional implants with less bone consumption and the possibility of future revision.

Keywords: total hip arthroplasty; short stem; hip osteoarthritis.
Level of Evidence: IV

Vástagos femorales cortos para el reemplazo total de cadera primario en pacientes jóvenes. Resultados clínicos y biomecánicos*

RESUMEN

La artroplastia total de cadera es una cirugía eficaz para tratar la artrosis. Con el aumento de la necesidad de una mejor calidad de vida, este procedimiento se está realizando en pacientes más jóvenes. Pero, con la mayor expectativa de vida, también crece la demanda de múltiples cirugías de revisión para el mismo paciente. Esto plantea desafíos técnicos debido a la pérdida de hueso. Existe una necesidad creciente de identificar implantes duraderos y altamente funcionales que sean adecuados para la revisión futura. Aunque los vástagos femorales cementados eran la opción principal en el pasado, los vástagos femorales no cementados han logrado una fijación a largo plazo y excelentes resultados. Sin embargo, aún se pueden mejorar algunos problemas relacionados con la fijación. Los vástagos femorales cortos han sido desarrollados para abordar algunos de estos desafíos, mientras se mantienen los buenos resultados obtenidos con los vástagos convencionales. En este artículo, se analiza la experiencia tras 10 años de uso de vástagos femorales cortos en cirugías de cadera en pacientes jóvenes. Se comparan los resultados biomecánicos y la preservación ósea femoral, se reportan los resultados posoperatorios en relación con el regreso al deporte, y se evalúan las complicaciones relacionadas con su uso. El empleo de vástagos cortos en cirugía primaria de cadera brinda múltiples ventajas. La indicación de este tipo de implante está justificada en pacientes jóvenes y activos, con el objetivo de reproducir los resultados de los implantes convencionales con un menor consumo de hueso y la posibilidad de una revisión futura.

Palabras clave: Artroplastia total de cadera; tallo corto; artrosis de cadera.
Nivel de Evidencia: IV

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INTRODUCTION

Total hip arthroplasty (THA) is a clinically, functionally, and radiologically successful procedure for the treatment of degenerative hip disease.[1,2] Over the last three decades, the number of patients undergoing THA has increased significantly, as has life expectancy and activity level,[3] implying an increase in revision surgery in the future.[4] This has sparked interest in bone-sparing prosthesis designs that enable a minimally invasive, tissue-sparing surgical approach in order to facilitate future THA revisions without compromising surgical outcomes or primary surgery survival.

Cementless THA has become the standard fixation option in the United States, Canada, and many European countries, and is used in more than 90% of all primary THAs.[5,6] However, despite the success of these components and the scope of their indication, a number of particular challenges for cementless fixation technologies in younger patients have emerged. These challenges include:

1. Preservation of the proximal femoral bone stock.
2. Potential need for an effective revision of the femoral component.
3. Femoral anatomomorphological mismatch due to proximal-distal mismatch.
4. Ability to insert implants safely and reproducibly.

Short stem cementless femoral implants have been developed to address some of these issues, as long as they do not hinder the current level of success achieved by conventional length cementless implants. Wear caused by metal and polyethylene microparticle debris, early and late periprosthetic fracture, aseptic loosening, and dysfunction-induced bone loss of the proximal femur all increase the risk of revision THA in young patients. Some of these complications are caused by nonphysiological femoral stresses. Responding to the demands of an increasingly young and active patient population, recent advances in hip arthroplasty aim to minimize tissue damage and spare bone without compromising implant stability. This has resulted in the introduction of innovative femoral bone-preserving implants, such as short-stem THAs,[7] with the aim of preserving bone for future revisions.

DEFINITION AND CHARACTERISTICS OF SHORT STEMS

THA success is based on both initial rotational and axial stability (fixation by interference),[8] which are responsible for promoting long-term implant fixation (definitive fixation). There are various types of uncemented fixation that influence the femoral preparation. On the one hand, there are stems that are exclusively metaphyseal (they are 'reamed' only in their femoral preparation), wedge-shaped, and typically have a proximal porous titanium cover (coated or uncoated), while their distal surface is typically rough (in very few cases, the distal surface is polished). Second, there are stems with anatomical fixation (they are 'scaled and reamed' for femoral preparation), and they typically have a completely porous surface to occupy the entire metaphyseal and diaphyseal cavity in both anteroposterior and lateral radiographs. Finally, there are stems with distal fixation, which are solely diaphyseal (they are only 'reamed' for their femoral preparation). They are commonly used in primary hip surgeries for dysplasia to 'bridge' very anteverse femoral necks or metaphyses with significant extra-articular deformity. The metaphyseal wedge-shaped conventional-length stems (i.e., those that are only scraped for placement), which have been associated with less long-term osteolysis of the proximal femur, have historically been the modern implants that best promote physiological weight-bearing.

All stems designed to be less invasive than conventional uncemented stems are commonly referred to as "short stems" (except for surface replacements which, despite preserving bone stock, do not have a stem *per se*). Short-stem implants have been defined as those measuring <120 mm in length, which normally coincides with the metaphyseal-shaft junction. According to a recent study, reducing the stem length to less than 105 mm does not reduce the interference stability of cementless fixation implants.[9] However, this term is misleading, because it refers to a heterogeneous group of stems that differ in terms of design, biomechanics, and fixation principles. For this reason, various classification systems have been developed taking into account characteristics such as stem length, weight-bearing location, osteotomy level for neck resection, and implant fixation principles.[10,11] McTighe et al.[10] have proposed a classification based on the three main types of short-stem implant fixation:

1. Stabilized metaphyseal (standard neck resection).

2. Stabilized neck (preservation of the femoral neck).

3. Stabilized head (surface prosthesis).

Standard neck resection short-stem implants can be further classified into anatomical and wedge-fixation implants. These implants also tend to be shortened versions of conventional cementless implants. On the other hand, the implants that preserve the femoral neck adapt to the anteversion of the remaining femoral neck depending on the level of the osteotomy performed.[12]

In 2014, Khanuja et al.[13] tried to answer this question. Given the existence of various types of proximal fixation, the authors classify short stems into four large groups, each of which contains subgroups: type 1A, prosthesis with exclusive support in the trapezoidal section neck; type 1B, exclusive neck support prosthesis with rounded geometry and ridges for rotational stability; type 1C, exclusive neck support prosthesis with ridged geometry for rotational stability; type 2A, calcar-loading prosthesis with trapezoidal section and wedge design; type 2B, calcar-loading prosthesis with rounded section and partial femoral neck preservation; type 2C, neck preservation stem with fixation in the lateral metaphyseal cortex; type 2D, or screw-plate design that compresses the calcar against the outer metaphyseal cortex; type 3, stems with lateral trochanteric extension, and type 4, stem of conventional design but shorter in length, seeking only metaphyseal fixation. (Figure 1).

Periprosthetic bone remodeling of the proximal femur is an important factor in achieving long-term stability of an implant. This depends on its geometry and the femoral canal, and on the ratio of load transfers from the implant to the bone. The stability of these shorter stems depends on their metaphyseal fixation, which is a requirement for optimal proximal load transfer.[14,15] Biomechanical studies have shown that the optimization of proximal load transfer has a positive impact on the preservation of bone stock. Chen et al.[16] analyzed the bone stock in patients who had undergone THA with a short Mayo stem (Zimmer International, Warsaw, IN, USA). Through dual-energy X-ray absorptiometry (DEXA), a mean bone loss of only 3.3% has been demonstrated in patients with short stems, compared to the literature standard of 20% with conventional implants.[17] However, it should be noted that a randomized controlled study[18] compared bone remodeling between a shortened stem and a conventional-length stem using dual-energy X-ray absorptiometry region-free analysis (DEXA-RFA). The authors identified a consumption of periprosthetic bone stock in the calcar, and the lateral and proximal femoral aspect in both groups ($p < 0.05$). In other words, femoral bone remodeling appears to be multifactorial, conditioned by the anatomy of the proximal femur, previous osteopenia, intraoperative femoral preparation, and the degree of interference fixation achieved in the primary surgery. However, it is not a minor fact that the geometry of the stem and its length (short vs. conventional) could have a significant long-term influence on bone remodeling and this remains to be clarified with new randomized studies; hence the current interest in short stems.

Short neck-preserving stems are a promising alternative to conventional uncemented stems. This is mainly due to their bone-preserving nature that would allow for easier revision surgery, as well as biomechanical advantages such as a potential improvement in axial load transmission. On the other hand, osseointegration could be more favorable due to the reduction of cyclical movement after implantation. The effects of stress shielding are reduced by a higher physiological load on the femur due to the lower flexural stiffness of the new stem. In this sense, it has been proposed that the use of a short femoral stem could have various advantages:

1. Preservation of bone stock and soft tissues, in the greater trochanteric and subtrochanteric regions, at the time of implantation for future revisions.[19]

2. Reduction of stress shielding, caused by the resorption of the metaphyseal bone and the diaphyseal cortical hypertrophy.[20]

3. Decreased stress concentration at the tip of the stem, which has been shown in a traditional component to be the cause of thigh pain.[20,21]

4. The tension band effect of the IT band provides compressive forces both medially and laterally on the proximal femur.[22] The lateral cortex provides strong support as a second column of compression.[22,23]

5. The transfer of load to the metaphysis from a superior to an inferior direction in a physiological way.[22-24]

6. Versatility in revision surgery due to the minimally invasive approach, less soft tissue damage, and intact bone stock below the lesser trochanter.[22,23]

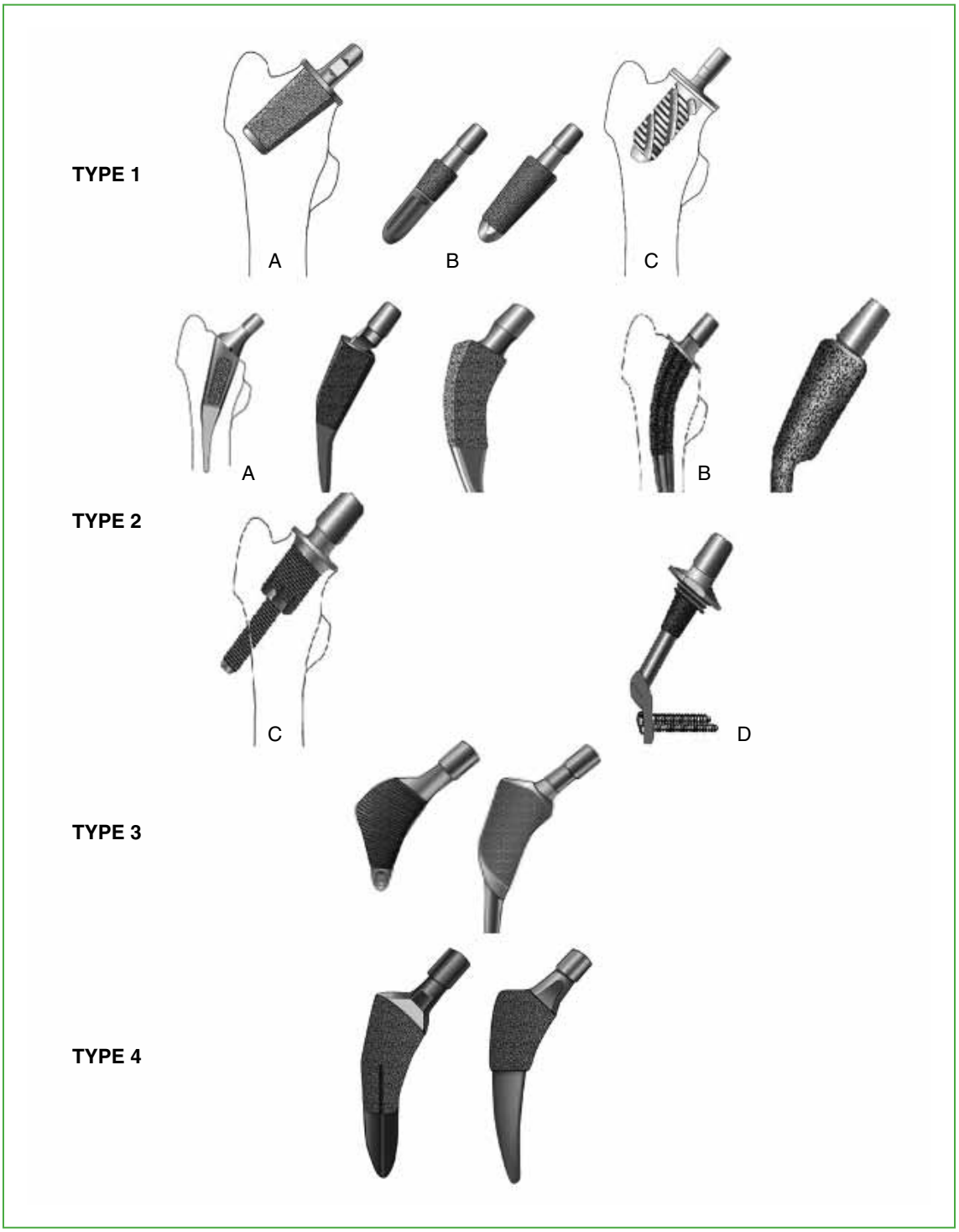

Figure 1. Classification of short stems. Type 1A, prosthesis with exclusive neck support, trapezoidal section; type 1B, prosthesis with exclusive neck support, with rounded geometry and grooves for rotational stability; type 1C, prosthesis with exclusive neck support, with ridged geometry for rotational stability; type 2A, prosthesis with calcar support, with trapezoidal section and wedge design; type 2B,prosthesis with calcar support, with a rounded section and preservation of the femoral neck; type 2C, neck preservation stem with fixation in the lateral metaphyseal cortex; type 2D, or screw-plate design that compresses the calcar against the outer metaphyseal cortex; type 3, stem with lateral trochanteric expansion; type 4, stem of conventional design, but shortened in length, seeking only metaphyseal fixation in the proximal femur.

From the demographic point of view, its implantation in young patients (≤55 years) is preferable, although in a lower proportion (15%), they can be used in patients between 55 and 60 years of age who practice sports recreationally (Figure 2A and B). It is a requirement that this group of patients have adequate metaphyseal bone stock together with an intact femoral neck, a morphologically normal calcar and a sufficient distal lateral femoral cortex to achieve correct fixation and anatomical restoration.

Figure 2. A. Preoperative anteroposterior radiograph of both hips. 52-year-old patient with primary osteoarthritis of the left hip. **B.** Anteroposterior radiograph of both hips. A total left hip replacement with a MiniHip™ stem, 4 years after surgery.

Contraindications to the use of short stems in primary hip surgery include age >60 years, severe metaphyseal translational deformity of the femur, severe osteoporosis, or pathologies in which there is a significant mismatch between the size of the neck and the femoral metaphysis, for example, in a multiple osteochondromatosis (Figure 3).

Figure 3. Anteroposterior radiograph of both hips. Bilateral aggressive multiple osteochondromatosis, contraindicating implantation of a short femoral stem.

During surgery, it must be confirmed that the bone quality is suitable for implantation and that the femoral neck area is strong enough to support the load transmission of a short stem. For this reason, if this requirement is not met, the authors always recommend having an uncemented stem of conventional length.

Our interest in short stems began in 2010, when the results of resurfacing arthroplasty began to be poor due to the release of metal particles derived from the friction surface, causing adverse reactions such as metallosis, pseudotumors, and short-term failure, with complications associated with revision surgeries in these patients.[25] After a detailed analysis of the short stems available in our country, we decided on a coated system similar to the one we used for conventional uncemented stems, with excellent outcomes after 20 years of follow-up.[26] The hydroxyapatite, as well as the loading surface, were exactly the same as what we were using at the time. This chosen design was approved by the *Food and Drug Administration* and quickly became popular in Germany and the United Kingdom, and it was not only shorter than a conventional uncemented stem, but it also preserved part of the femoral neck, according to various publications.[25,27] There are nine size options with a 130° cervicometaphyseal angle, and their longitudinal serrations are designed to resist torsional forces.

Objective:

The objective of this work was to analyze the following points after 10 years of experience with the use of short femoral stems in hip surgery in young patients:

1. Femoral bone preservation.
2. Biomechanical reconstruction.
3. Medium-term outcomes of the first 100 cases.
4. Comparative functional outcomes in a young athlete population.
5. Medium-term comparison with uncemented stems of conventional length.
6. Comparative rate of intraoperative complications between two designs that partially preserve the femoral neck.
7. Medium-term outcomes in patients with developmental dysplasia of the hip.
8. Complex situations: medium-term outcomes in proximal femoral deformities.

1. FEMORAL BONE PRESERVATION

Material and methods

The first 50 short stems (MiniHip™, Corin, Cirencester, United Kingdom) were analyzed in a comparative retrospective study with the objective of radiographically determining the preservation of femoral bone stock when a short stem for cervicometaphyseal fixation was used.[27] Anteroposterior radiographs were used to assess the level of cervical resection and the length of the stem. These were compared with filmstrips from a conventional metaphyseal-shaft fixation stem (MetaFix™, Corin, Cirencester, UK).

The average age of the patients was 46.7 years (range 21-62); 38 patients were male and 12 were female. The main diagnoses were degenerative osteoarthritis (42 cases), developmental dysplasia of the hip (5 cases), osteonecrosis (2 cases) and idiopathic chondrolysis (1 case). All implants were placed by the same surgeon through a posterolateral approach under spinal anesthesia.

The preoperative planning of the short stems was performed according to the method described by Salvati et al.,[28] and was carried out by a surgeon with more than 10 years of experience in the use of this method. Postoperative digital radiographs of patients in whom a cervicometaphyseal fixation stem was implanted were analyzed by two independent observers, overlaying films from a hydroxyapatite-coated metaphyseal fixation stem (MetaFix™). The length of the conventional stem and the cut level of the femoral neck necessary to implant this stem were drawn. The difference in longitudinal bone preservation between the two implants was then quantified at the femoral neck and diaphyseal levels, with the total resulting from the sum of both measurements and implant lengths (Figure 4A and B).

Results

The short cervicometaphyseal fixation stems radiographically preserved an average of 77 mm when compared to those of conventional length. The neck cut on the conventional stems was between 3 and 15 mm more distal than with the short stems. (average 10mm). Conventional implants occupied 66 mm more shaft (range 41-81) than short stems ($p < 0.001$). The average length of the implanted short stems was 82 mm (range 68-102). The average length of conventional metaphyseal-shaft fixation stems was 142 mm (range 132-151) ($p < 0.001$) (Table 1). According to these results, the short stems allowed radiographic preservation of 42% of bone length compared with the metaphyseal-diaphyseal fixation stems (Figure 4 C).

2. BIOMECHANICAL RECONSTRUCTION

Material and methods

A retrospective descriptive study[29] was carried out that included 124 patients with a mean age of 52 years (range 26-65). Three groups of patients were analyzed: the first group consisted of 36 patients who were implanted with a MiniHip™ short-stem prosthesis, the second group included 46 patients with a conventional cementless Corail® total hip prosthesis (DePuy-Synthes , Warsaw, IN, USA), and the third included 42 patients treated with a resurfacing prosthesis (Durom, Zimmer, Warwae, IN, USA).

Figure 4. **A.** Measurement procedure with a postoperative anteroposterior radiograph of the hip. The neck cut level and the length of the implant that would have been placed in the case of using a metaphyseal-diaphyseal fixation stem are drawn. **B.** The two measured implants are shown: the cervicometaphyseal fixation stem (on the right) and the metaphyseal-diaphyseal fixation stem (on the left). **C.** Patient with a cervicodiaphyseal fixation stem in the right hip and a metaphysodiaphyseal fixation stem in the left hip. Note the difference in length at the level of the neck cut and in the invasion of the femoral canal.

Table 1. Comparative analysis of femoral preservation between a short stem and a conventional length stem

Case	Prox*	Distal	Sum	MiniHip™	MetaFix™	p
Average	10.04	66.44	77	82.72	141.88	<0.001
Highest	15	81	94	102	151	<0.001
Lowest	3	41	47	68	132	<0.001

*Distance measured at the femoral neck.
MiniHip™ = MiniHip TM stem length; MetaFix™ = MetaFix™ stem length.
Nally FJ, Rossi LA, Diaz F, Stagnaro J, Isodoro Slullitel PA, Buttaro MA. Which prosthetic system restores hip biomechanics more effectively? Comparison among three systems. *Current Orthopaedic Practice* 2015;26:382-6.

After the Institutional Ethics Committee approval, the study included patients <65 years of age who had osteoarthritis of the hip and a contralateral healthy or early osteoarthritis hip (Tönnis 0 or 1),[30] which was used as a control for biomechanical parameters. All surgeries were performed through a posterolateral approach. Simultaneous bilateral arthroplasties were excluded, as well as fractures or other diagnoses or any surgical history of the affected hip.

Radiographic measurements were performed by three independent observers using a digital imaging system (RAIMViewer, USA) previously calibrated to the size of the femoral head implant. The three observers analyzed three different subgroups of patients. The same observer measured the postoperative period and the healthy contralateral hip to avoid interobserver bias.

Lower limb length discrepancy was measured on radiographs using the distal endpoint of the teardrop sign and the lesser trochanter as references. Once the discrepancy value was obtained, the discrepancy of the center of rotation was subtracted to exclude the acetabular factor and obtain discrepancy data only for the femur. Femoral offset was evaluated by measuring the distance between the axis of the femoral shaft and the center of rotation of the femoral head.

The horizontal center of rotation was defined as the distance between the center of hip rotation and the center of the distal end of the teardrop sign. The vertical center of rotation was measured from the center of rotation of the femoral head to a line passing through the two vertices of the distal end of the teardrop sign.

Acetabular tilt was calculated using the angle between a line passing through the two vertices of the distal end of the teardrop sign and the axis of the acetabular component. The Lewinnek[31] method was used to assess acetabular anteversion (arcsine of the width of the ellipse over the external diameter of the implant). It was determined if the position of the cup was within the Lewinnek safe zone (40 ± 10° of inclination and 15 ± 10° of anteversion).

Results

Horizontal center of rotation

The average discrepancies in the horizontal center of rotation were not statistically significant when comparing the three prostheses (p = 0.275). The horizontal center of rotation was slightly medialized in the short stem group (-0.09 mm; p = 0.189) and in the conventional stem group (-0.58; p = 0.39), while it was slightly lateralized in the group with resurfacing prosthesis (0.51 mm; p = 0.45). In 16 cases with a short stem (44.4%), 29 cases with a conventional stem (63%), and 28 cases with a surface prosthesis (66.6%), the horizontal center of rotation was restored within ± 3 mm (p = 0.85).

Vertical center of rotation

The differences in the vertical center of rotation between the three groups were not statistically significant (p = 0.425). The vertical center of rotation was more proximal with the three prostheses: 1.75 mm (p = 0.021) in the short stem group, 1.32 mm (p = 0.021) in the conventional stem group, and 2.34 mm (p = 0.001) in the resurfacing group. In 17 short-stem cases (52.7%), 34 conventional-stem cases (73.9%), and 23 resurfacing cases (54.7%), the center of vertical rotation was recovered by 3 mm (p = 0.08).

Lower limb length discrepancy

The average leg length discrepancy was 1.19 mm in the short stem group; 2.31 mm in the group with a conventional stem and 2.11 mm in the group with a resurfacing prosthesis (p <0.001). In 67.3% of those with surface prosthesis, the restoration remained in a range of less than ± 5 mm (p = 0.103). Femoral length discrepancy averaged -0.87 mm in the short stem group, 0.34 mm in the conventional stem group, and -4.44 mm in the resurfacing group (p = 0.003).

Femoral lateralization

The mean femoral offset difference between the three groups was statistically significant (p = 0.0001). When compared to the contralateral healthy side, mean postoperative lateral offset increased by 3.51 mm in the short stem group (p = 0.001) and 1.71 mm in the conventional stem group (p = 0.081), while it was reduced 3.95 mm in the resurfacing group (p = 0.001). Femoral displacement was within ± 5 mm in 23 cases of short stem (63.8%); 33 cases of conventional stem (71.7%) and 27 cases of surface prosthesis (64.2%) (p = 0.683) (Table 2).

Table 2. Biomechanical parameters of the different prostheses compared with those of the normal contralateral hip

	SS (p)	CLS (p)	SP (p)
Horizontal center of rotation	-0.9 (0.189)	-0.58 (0.392)	0.51 (0.45)
Vertical center of rotation	1.75 (0.021)	1.32 (0.021)	2.34 (0.001)
Femoral lateralization	3.51 (0.001)	1.71 (0.081)	-3.95 (0.001)
Length discrepancy up to ± 5 mm	94.4%	86.9%	67.3%
Safe zone	88.9%	93.5%	83.3%

SS = short stem; CLS = conventional length stem; SP = surface prosthesis.
Nally FJ, Rossi LA, Diaz F, Stagnaro J, Isodoro Slullitel PA, Buttaro MA. Which prosthetic system restores hip biomechanics more effectively? Comparison among three systems. *Current Orthopaedic Practice* 2015;26:382-6.

3. MEDIUM-TERM RESULTS OF THE FIRST 100 CASES

Material and methods

In a retrospective study,[32] the first 84 patients (100 hips) treated with a THA with a type 2B short stem were prospectively analyzed.[13,33] The surgeon's learning curve was included in these cases. Sixteen patients were operated sequentially, on both sides, on the same day. The average age was 47 years (range 17-58). In this series, the indications for a short stem were: young patients with a maximum age of 55 years (85 cases) and patients between 56 and 60 years of age who had practiced impact sports in the past (15 cases). The sports or activities defined as having an impact were: running, soccer, taekwondo, *squash*, and aerobic gymnastics training. The average body mass index (BMI) of the group was 27 kg/m^2 (range 22-37). The primary diagnosis was primary osteoarthritis (82 cases), developmental dysplasia (6 cases), osteonecrosis (8 cases), idiopathic chondrolysis (2 cases), sequelae of Perthes disease (1 case) and pigmented villonodular synovitis (1 case).

Surgical technique

Preoperative planning is a fundamental and mandatory step that can be performed according to analog or conventional methods.[34] Depending on the surgical technique, the cut of the femoral neck is precisely planned to avoid excessive elongation of the operated leg and to calculate the lateralization of the femur. In cases with increased lateralization, a more vertical neck cut is performed and, in cases of decreased lateralization, a more horizontal neck cut, as described by Teoh et al.[35] The entry point on the femur is calculated 4 mm lateral to the

center of the femoral neck. In order to avoid cortical perforation, a step can be added to the original surgical technique using a curved vascular clamp in the direction of the femoral canal. After confirming the correct location of the starter instrument in the intramedullary canal, the first starter rasp is placed. The proximal femoral bone is then compacted with rasps of progressive size until rotational stability and lateral cortical contact are achieved.

Results

Stem survival free of aseptic failure was 99% (95%CI 93.1-99.8%) at a mean follow-up of 42 months (range 24-64) and 98% when infection was included. No patient was lost to follow-up. The main complication occurred in case 6 (listed in chronological order of inclusion in the study according to the date of surgery): a perforation of the lateral cortex (Figure 5A) that was treated the same day, during surgery, with conversion of the short stem to one of conventional length with metaphyseal shaft fixation coated with hydroxyapatite (Figure 5B). Likewise, three incomplete intraoperative calcar fractures (3%) were recorded, of which only one required wire cerclage and partial offloading during the first 30 postoperative days.

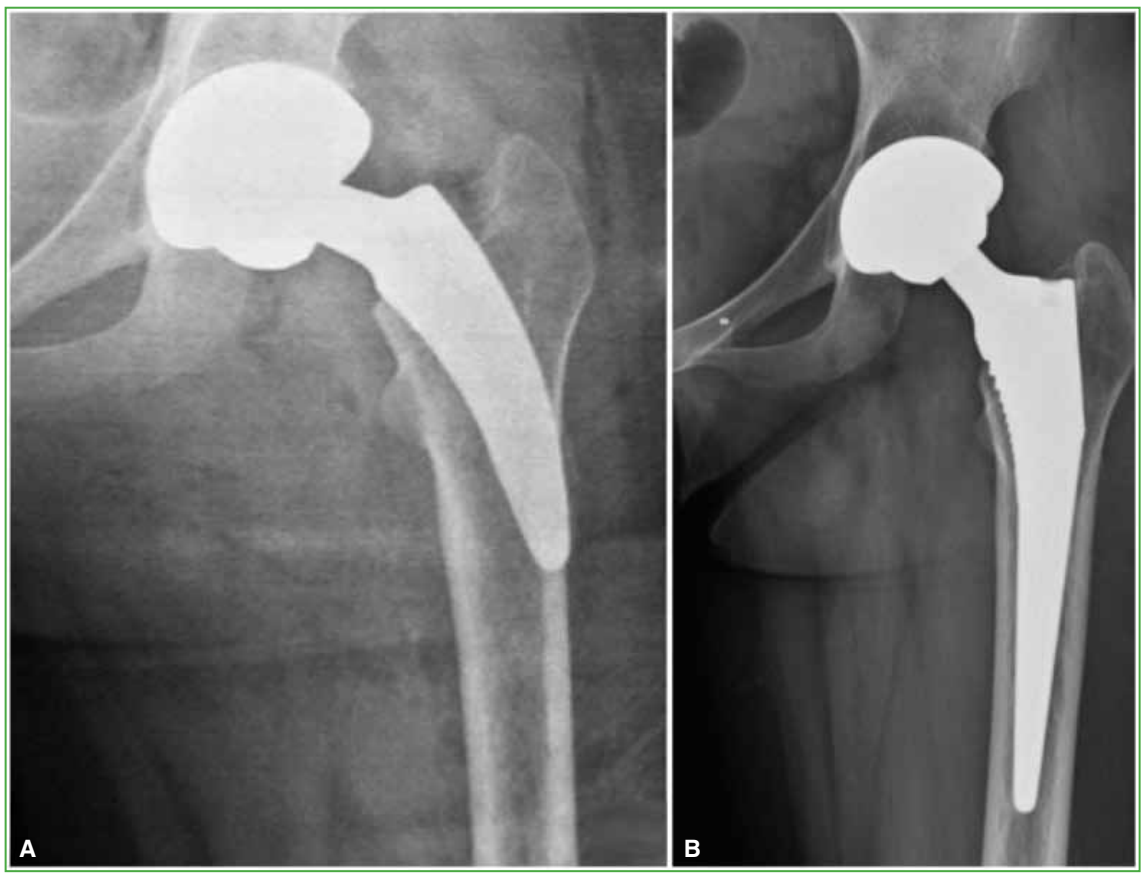

Figure 5. A. Anteroposterior radiograph of the left hip in the immediate postoperative period. A 21-year-old patient with idiopathic chondrolysis presented with cortical perforation after bilateral sequential total hip replacement, which was treated with a conventional uncemented stem revision. **B.** Anteroposterior radiograph of both hips 5 years after the revision. The modified Harris score was 95 for each hip.

There was one case of 4 mm subsidence that was stabilized 45 days after the operation and weight-bearing, with no need for additional surgical treatment due to the absence of symptoms.

There were no cases of thigh pain or dislocations. The mean Harris Functional Score (HHS) improved significantly from 55 before surgery to 96 (range 82-100) at the last follow-up ($p < 0.05$). At the last control, 24 patients ran more than 5 km/week, 18 swam 1 or 2 times/week, 12 of them rode a bicycle for more than 2 hours/week, eight played unrestricted golf, six played non-competitive soccer, six practiced martial arts, two of them played basketball and one took up squash. The average weekly sports activity was 6 hours, and 20 patients practiced more than one sport discipline in the last follow-up. The return to sports activity occurred, on average, at 4.4 months (range 3-7).

In all cases, bone incorporation was verified according to the Engh classification.[36]

No stem showed radiolucent lines. The average limb discrepancy was 1.7 mm (range -4.7 to +7). Mean femoral lateralization increased 4.6 mm (range 4 to +7). Six patients had bone remodeling of the femoral neck and three, hypertrophy of the lateral cortex. One suffered a deep acute infection that was successfully treated with debridement, component retention, and antibiotics.

4. COMPARATIVE FUNCTIONAL OUTCOMES IN A YOUNG SPORTS POPULATION

Material and methods

55 patients operated on by the same surgical team were evaluated to describe and quantify the type and intensity of physical activity performed in young patients undergoing resurfacing arthroplasty and those receiving a short cervicometaphyseal fixation stem. This was a comparative study[37] with two temporally associated cohort groups, given the change in the indication in relation to the complications reported with the metal-on-metal friction pair. A comparison was made between the last 31 resurfacing prostheses and the first 31 short-stem prostheses.

In the first group of patients, 31 consecutive resurfacing prostheses (Durom) were implanted, one of them bilateral, and in the second group, 31 consecutive cervicometaphyseal fixation prostheses were implanted, six of them bilateral. The mean age for resurfacing prostheses was 44.6 years (range 34-57) and 51.5 years (range 36-66) for the cervicometaphyseal fixation prosthesis group. All patients were active with advanced primary hip osteoarthritis.

All were operated under spinal anesthesia in a laminar flow operating room through a posterolateral approach. The rehabilitation protocol included early range of motion exercises at 24 hours with full weight-bearing according to pain tolerance. For the first three weeks, they used two Canadian canes and then a walking cane for one to two more weeks according to progress.

A descriptive study was carried out using the score from the University of Los Angeles in California (UCLA), determining the physical activity achieved (type and number of weekly hours) at the end of the follow-up, degree of personal satisfaction during sports practice through a visual analog scale and the need for analgesics before and after physical activity.

Results

The median duration of follow-up was 24 months (range 12-66). The guidelines given to the patients were consistent, allowing them to resume normal activities six months after surgery. Contact sports activity was recorded in 15 patients with surface prostheses and 10 patients with short-stem prostheses. Soccer and basketball were the most common sports, and cycling, a non-contact sport, was the best tolerated, and high performance was achieved in the series.

The mean UCLA score was 9.5 for the resurfacing group and 8.5 for the metaphyseal fixation group. The degree of personal satisfaction corresponded to the results obtained in the UCLA score. Both groups did, on average, 6 weekly hours of physical activity. The average time from surgery to physical activity for the surface prosthesis group was 6.3 months versus 4.4 months for the short-stem prostheses ($p = 0.0031$).

In this series of patients, both implants allowed contact physical activity to be carried out with a comparable regularity in both groups. However, patients with a short stem, although they required a higher consumption of postoperative analgesics when performing physical activity, returned to sports earlier than those who underwent resurfacing arthroplasty (Figure 6).

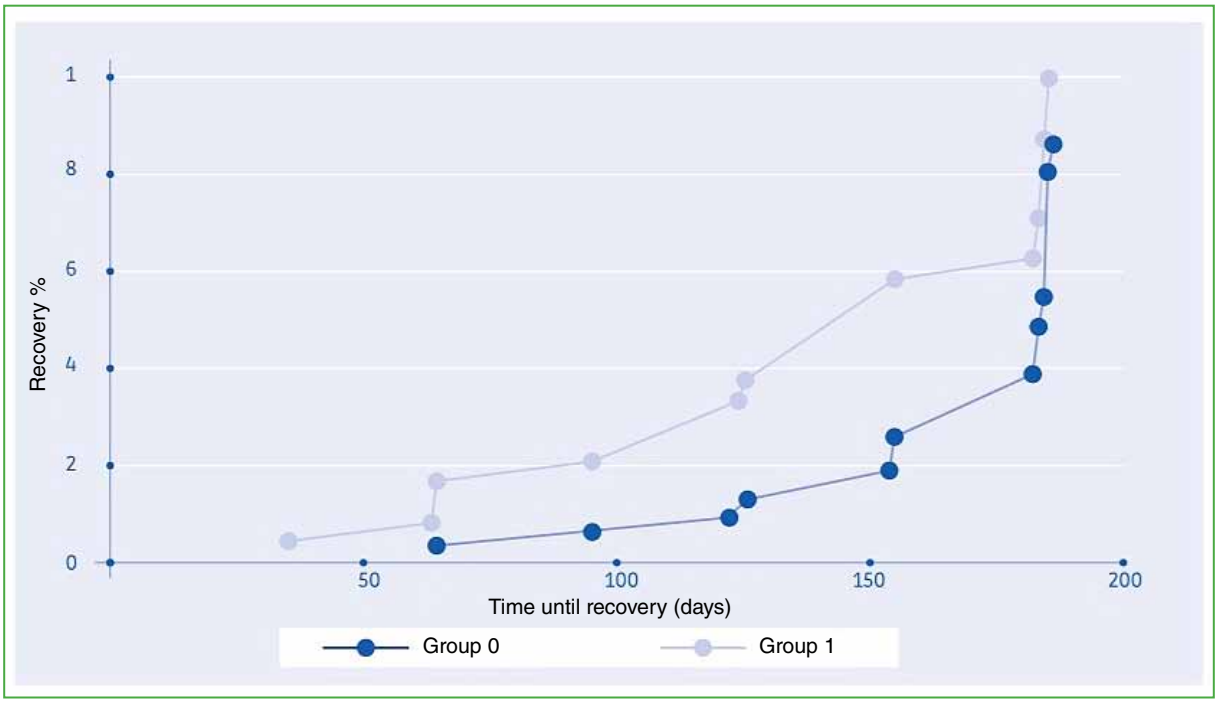

Figure 6. Survival curve of the short stem group (group 1) vs. the resurfacing group (group 0): recovery time in the short-stem prosthesis group was significantly less than that in the resurfacing group (p = 0.0031).

5. MEDIUM TERM COMPARISON WITH UNCEMENTED STEMS OF CONVENTIONAL LENGTH

Material and methods

A total of 1100 consecutive primary THAs were studied prospectively, with 20 cemented, 247 hybrid, and 833 uncemented. The latter group received 506 fully hydroxyapatite-coated Corail® tapered stems and 117 MiniHip™ short cervicometaphyseal stems, respectively. The choice of implant was based on patient expectations, proximal femoral morphology, preoperative digital planning, and surgeon choice.

All adult patients <55 years of age were consecutively included; therefore, 300 and 14 were excluded in the Corail® and MiniHip™groups, respectively. Sixty cases operated on with the Corail® stem and two cases with the MiniHip™ stem were lost to follow-up and therefore excluded, leaving 247 uncemented THAs in 220 patients for analysis. In the conventional and short stem groups, 11 and 16 patients underwent bilateral THA in the same procedure, respectively. The mean age of the series was 46 years (range 17-55) (p = 0.16). There were 87 and 62 men in the Corail® and MiniHip™ group, respectively (p = 0.11). Median follow-up was 7.7 years (range 5-10) for the conventional stem group and 7.3 years (range 5-9) for the short stem cohort (p = 0.07).

Results

There was no difference in mean surgical time and mean hospitalization time between the two groups. None of the patients required a blood transfusion. There was a significant improvement in the HHS when comparing the preoperative and postoperative values in both groups (p < 0.001).

Mean femoral neck length preservation was double in patients treated with a short stem [13.6 mm for the conventional stem vs. 25.9 mm in the short stem (p = 0.001)] (Figure 7), while the mean diaphyseal invasion was three times less in the short stem group [114.5 mm vs. 39.7 (p = 0.001)].

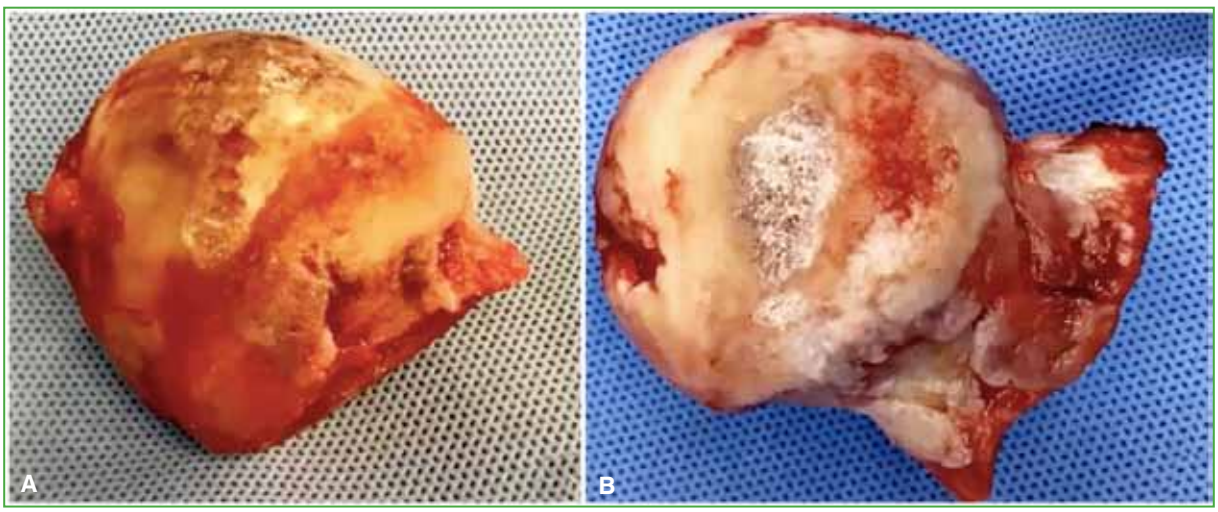

Figure 7. A. Anatomical specimen of the femoral head with the subcapital osteotomy of the neck in a short-stem arthroplasty. **B.** Anatomical piece with a basicervical osteotomy, in an arthroplasty with a conventional femoral stem.

Twenty (8.1%) THAs presented symptomatic metaphyseal radiolucencies around the stem in the Corail® group (p = 0.001), all in Gruen's zones[31] 1, 7, 8 and 14 and were detected after the first postoperative year, with radiographic progression and clinical relevance during follow-up. There was no evidence of osteolysis of the prosthesis around the femoral component. Six (4%) and five (5%) patients in the Corail® and MiniHip™ groups respectively presented initial femoral subsidence <3 mm, with no further progression, and no symptoms until the last follow-up (p = 0.75).

In the conventional stem group, five cases had aseptic loosening of the femoral component due to metaphyseal debonding,[39] treated with a single-stage revision (p = 0.06), and one case had septic failure that was treated surgically with a two-stage revision (p = 0.41).

Five hips (3.4%) in the Corail® group and three (3%) in the MiniHip™ group suffered an intraoperative periprosthetic femoral fracture (p = 0.84). All but one were undisplaced calcar fractures without involvement beyond the lesser trochanter (Vancouver A2) and therefore treated with wire cerclage and partial load without sequelae. The remaining patient in the MiniHip™ group was revised to a conventional hydroxyapatite-coated stem (MetaFix™) due to intraoperative perforation of the lateral cortex (Vancouver A1).

Symptomatic metaphyseal femoral radiolucency[39] was evidenced in 13.7% of the patients in the Corail® group (20 vs. 0, p = 0.001). This phenomenon was related to increased BMI, Dorr B morphology, and a hard-hard friction surface (metal-metal or ceramic-ceramic). All patients reported tolerable thigh pain during impact sports activities and 10 of them during activities of daily living. Five were lost to follow up. Six refused revision surgery because they found their symptoms tolerable. The remaining nine cases are under follow-up, either awaiting surgery or uncertain whether to undergo the procedure.

Aseptic stem loosening was more frequent in the Corail® group than in the MiniHip™ group [5 (3.4%) vs. 0, p = 0.06)]: Four patients were revised to a modular uncemented fluted stem (ZMR®, Zimmer, Warsaw, IN, USA), and one to a long cemented stem (VerSys®, Zimmer Biomet, Warsaw, IN, USA).

At a mean follow-up of 7.6 years, taking stem revision for any reason as the end point, survival was 95.9% and 99% for the Corail® and MiniHip™ groups, respectively (p = 0.15).

6. COMPARISON OF THE INTRA-OPERATIVE COMPLICATION RATE BETWEEN TWO DESIGNS THAT PARTIALLY PRESERVE THE FEMORAL NECK

Material and methods

A prospective analysis of a consecutive series of 190 cases who underwent primary THA was performed, 89 of whom were treated with a collum femoris preserving short stem (CFP™, LINK, Germany) and 101 with a MiniHip TM short stem.[40] Both were classified as "partial column" designs with neck-preserving osteotomy, as described by Falez et al.[41] The main objective of this study was to compare the clinical and radiological outcomes of both stems, with special interest in intraoperative periprosthetic fracture (IPPF).

The series consisted of 151 men and 39 women, the distribution was similar between the two groups (p = 0.12). The mean age was 47 years (SD ± 8.92), with no statistical difference between the two groups (p = 0.93). The mean BMI was 28 kg/m^2 (SD ± 4.06). The diagnoses that led to surgery were as follows: primary osteoarthritis in 151 cases, avascular necrosis in 18 cases, dysplasia in 16 cases, post-traumatic degenerative changes after acetabular fracture in four cases, and idiopathic chondrolysis in one case. There were no statistical differences regarding the distribution of diagnoses between both groups (p = 0.816). The median follow-up was 72 months (interquartile range [IQR]: 66-81), with no differences between both groups (p = 0.43).

Radiological evaluation was performed using an anteroposterior radiograph of the pelvis, a modified Dunn's lateral axial view, and a false profile view. Postoperative radiographs were analyzed to detect osteolysis and eventual progressive radiolucency and subsidence. All intraoperative and postoperative complications, whether related or unrelated to the surgical procedure, were documented.

Patients were prospectively followed up at 2 weeks, 6 weeks, and 3 and 6 months after surgery, and annually thereafter. The patients were evaluated before and after the operation with the modified HHS (mHHS).

Results

Mean mHHS improved from 54.39 (SD ± 10.53) to 95.93 (SD ± 2.73) in the MiniHip™ group (p <0.001) and from 64.07 (SD ± 10.39) to 98 .21 (SD ± 2.86) in the CFP™ group (p <0.001). Four patients showed initial subsidence (<2mm) in the MiniHip™ group, all of them asymptomatic. There were no cases of subsidence in the CFP™ cohort and there were no differences between the two groups (p = 0.643). There were 0 and 2 (2.25%) cases of proximal femoral osteolysis around the MiniHip™ and CFP™ stems, respectively (p = 0.834). Femoral radiolucencies <2 mm wide were observed around two MiniHip™ stems (1.98%) and six CFP™ stems (6.74%) (p = 0.15), without clinical relevance. The median resorption of the femoral neck was 1 mm in the MiniHip™ group (IQR 1-2) and 0 mm in the CFP™ group (IQR 0-1) (p = 0.06). The median hypertrophy of the lateral cortex was 0 mm for both groups (p = 0.306), while cervical hypertrophy was observed in three cases of the MiniHip™ stem and four of the CFP™ group (p = 0.708).

No significant differences were observed in terms of loosening, infection and instability. In total, there were five postoperative complications (2.63%), four in the MiniHip™ group and one in the CFP™ group. There were two aseptic loosening of the acetabular component (treated with revision single-stage THA) and one acute surgical site infection in the MiniHip™ group, which was successfully treated with implant-preserving irrigation and debridement. In addition, there was one case of Vancouver B2 postoperative periprosthetic fracture after an accidental fall 45 days after surgery. The patient underwent revision surgery with an uncemented modular ZMR® stem. In the CFP™ group, only one septic loosening was evidenced which was treated with a revision single-stage THA with an uncemented primary porous cover cup and a distally fixed uncemented modular ZMR® stem. There were no cases of instability or residual pain in the thigh in any of the cohorts.

Regarding intraoperative complications, in total, six IPPF were observed.

(7/190 = 3.68%), three in the MiniHip™ group (1 Vancouver type A1 and 2 type A2) and three in the CFP™ group (3 Vancouver type B2 and 1 type C3). In the MiniHip™ group, there was one lateral cortical perforation categorized as Vancouver A1, which was immediately revised to a conventional hydroxyapatite-coated uncemented stem (MetaFix™) on the same day of surgery. In addition, there were two (2%) intraoperative incomplete calcar fractures (Vancouver A2) of which only one required wire cerclage and partial offloading for 30 days. These two cases occurred at the time of stem insertion and neither of them required a subsequent surgical procedure.

In the CFP™ group, three cases of IPPF occurred. One case with incomplete calcar fracture occurred during definitive stem insertion, and was treated with multiple cerclage.

The second case was diagnosed on the immediate postoperative radiograph, in which a non-displaced femoral shaft fracture was diagnosed, which did not require surgical treatment other than unloading of body weight. The third case occurred during progressive curettage and was classified as Vancouver C3, thus ultimately the CFP™ stem could not be inserted. Therefore, a fully porous coated uncemented conventional stem (LCU, Waldemar Link GmbH & Co, Hamburg, Germany) associated with a 4.5 mm locked compression plate was revised. None of the cases required a new surgical procedure or revision of the femoral stem.

7. MEDIUM-TERM RESULTS IN PATIENTS WITH DEVELOPMENTAL DYSPLASIA OF THE HIP

Material and methods

A consecutive series of 116 patients diagnosed with hip dysplasia and treated with type 2B cervicometaphyseal preservation stem was prospectively studied to analyze the technical problems encountered when reconstructing the proximal femur of patients with osteoarthritis secondary to congenital hip dysplasia treated with a THA using a short stem.[42]

The patient population consisted of 11 women and 6 men with a mean age of 43 years (SD ± 9.97). In five of the cases, the hip dysplasia was bilateral; in one case, bilateral THA was performed in a single procedure, and in four of these hips, sequential surgical treatment was performed at different stages due to the potential complications of complex single-stage bilateral surgeries that require significant reconstructions. The mean BMI was 27 kg/m^2 (SD ± 4.50). Four cases presented a history of pelvic osteotomy during childhood (2 Salter osteotomies and 2 Chiari osteotomies), while four cases had undergone a derotation osteotomy and a varus osteotomy of the femoral neck. The mean follow-up was 41.22 months (range 24-61).

Imaging evaluation was performed using an anteroposterior radiograph of the pelvis, a modified Dunn's lateral axial view (45° hip flexion, foot in neutral rotation), and a false profile view. The degree of hip dysplasia was classified as described by Hartofilakidis,[43] Wiberg's lateral center-edge angle, and Crowe's classification.[44,45] The degree of preoperative osteoarthritis degeneration was characterized with the Tönnis classification.[30] The average lateral center-edge angle was 5.37° (SD ± 6.97). Eight cases were scored as Crowe 1, four as Crowe 2, and 10 as Crowe 3. Similarly, 10 hips were classified as Hartofilakidis A, 10 as B, and two as C. The preoperative mean lower limb length discrepancy, which was assessed by measuring the distance between the line between the tear-drop images and the center of the femoral head, was 17.33 mm

(SD ± 10.87).[20] The overall preoperative anteroposterior cervicodiaphyseal angle was 140.6° (SD ± 6.32), while the mean preoperative offset difference between the contralateral and affected sides was 5.3 mm (SD ± 8.44).[21]

Intraoperative and postoperative complications related to the surgical procedure were recorded. Loosening of the acetabular and femoral components was assessed according to the methods described by De Lee and Charnley,[46] and by Gruen et al.,[47] respectively, comparing the immediate postoperative radiograph with that obtained at the last follow-up. Radiographic assessment of stem fixation was assessed in accordance with Engh et al.[36] Any reoperation performed to correct the undesirable sequelae of the previous surgery, with or without the addition, removal, or replacement of components, was considered therapeutic failure.

Results

All patients showed a statistically significant improvement when comparing the preoperative and postoperative mHHS values (54.19 vs. 94.57; p = 0.0001) and visual analogue pain scale (8.71 vs. 0.71; p = 0.0003). No cases of thigh pain, instability or infection were found. One case of loosening of the cup and one case of periprosthetic fracture of the femur were diagnosed at 8 months and 45 days, respectively. Overall survival was 84.7% at 5 years (95% CI 64.4-105.3) considering revision for any reason as therapeutic failure. When stem performance was evaluated considering reoperation failure due to loosening of the stem only, the survival rate was 100% at 5 years (Figure 8).

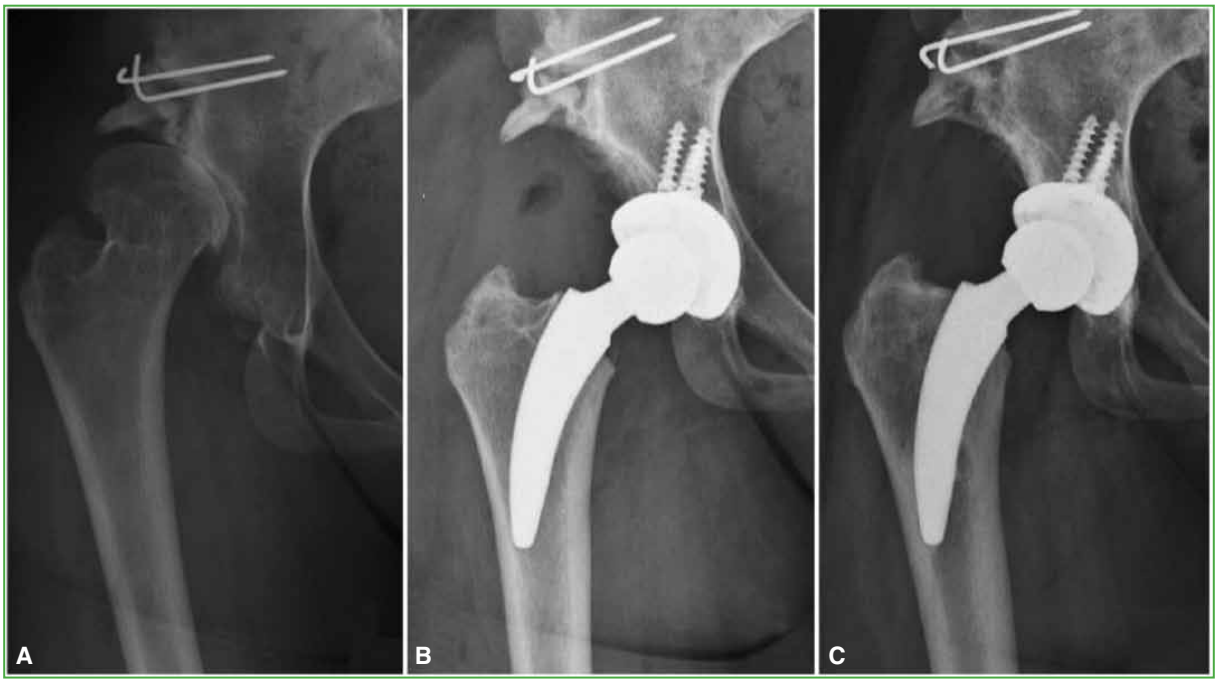

Figure 8. A. Anteroposterior radiograph of the right hip. A 25-year-old woman with dysplastic coxarthrosis Hartofilakidis grade B and coxa valga, and a history of pelvic osteotomy during childhood. **B.** Immediate postoperative anteroposterior radiograph of the patient's hip after femoral reconstruction with a partially neck-preserving MiniHip™ uncemented short stem. **C.** Anteroposterior radiograph of the patient's hip at 5-year follow-up showing stable stem fixation with no signs of implant loosening or subsidence.

8. COMPLEX SITUATIONS
MEDIUM TERM RESULTS IN PROXIMAL DEFORMITIES OF THE FEMUR

Proximal femoral deformities are generally a consequence of developmental diseases of the hip during childhood, previous osteotomy failures, or fracture sequelae (Figure 9).

Anatomic abnormalities of the proximal femur can make biomechanical reconstruction challenging. This surgical procedure has been associated with technical difficulties, prolonged surgical time and approach, high complication rates, the need for more than one surgery, and poor functional outcomes.

Material and methods

Thirty-one patients (35 hips) with proximal femoral deformities treated with uncemented primary THA using a short stem with cervicometaphyseal fixation (MiniHip™) were prospectively analyzed. There were 19 male (23 hips) and 12 female (12 hips) patients, with a mean BMI of 26.7 ± 4.1 kg/m^2. Twelve cases (38.7%) had a history of surgical procedure, and six of them were failed childhood osteotomies. The mean age of the series was 44 ± 12 years, the mean follow-up was 81 ± 27 months, and there were no patients lost to follow-up. Proximal femoral deformities were categorized according to a modified Berry classification.[48] The preoperative femoral cervicodiaphyseal angle varied between 90° and 157°. The average preoperative discrepancy in lower limb length was -16.3 mm (range -50 to 2). Compared with the contralateral hip, preoperative femoral lateralization averaged -7.6 mm (range -28 to 8).

Clinical outcomes and pain were assessed using the mHHS[49,50] and the visual analog scale, respectively. Postoperative radiographs were analyzed to determine the presence of osteolysis, radiolucencies, subsidence and loosening of the stems according to the Engh method.[36] Postoperative complications and survival rate were also recorded.

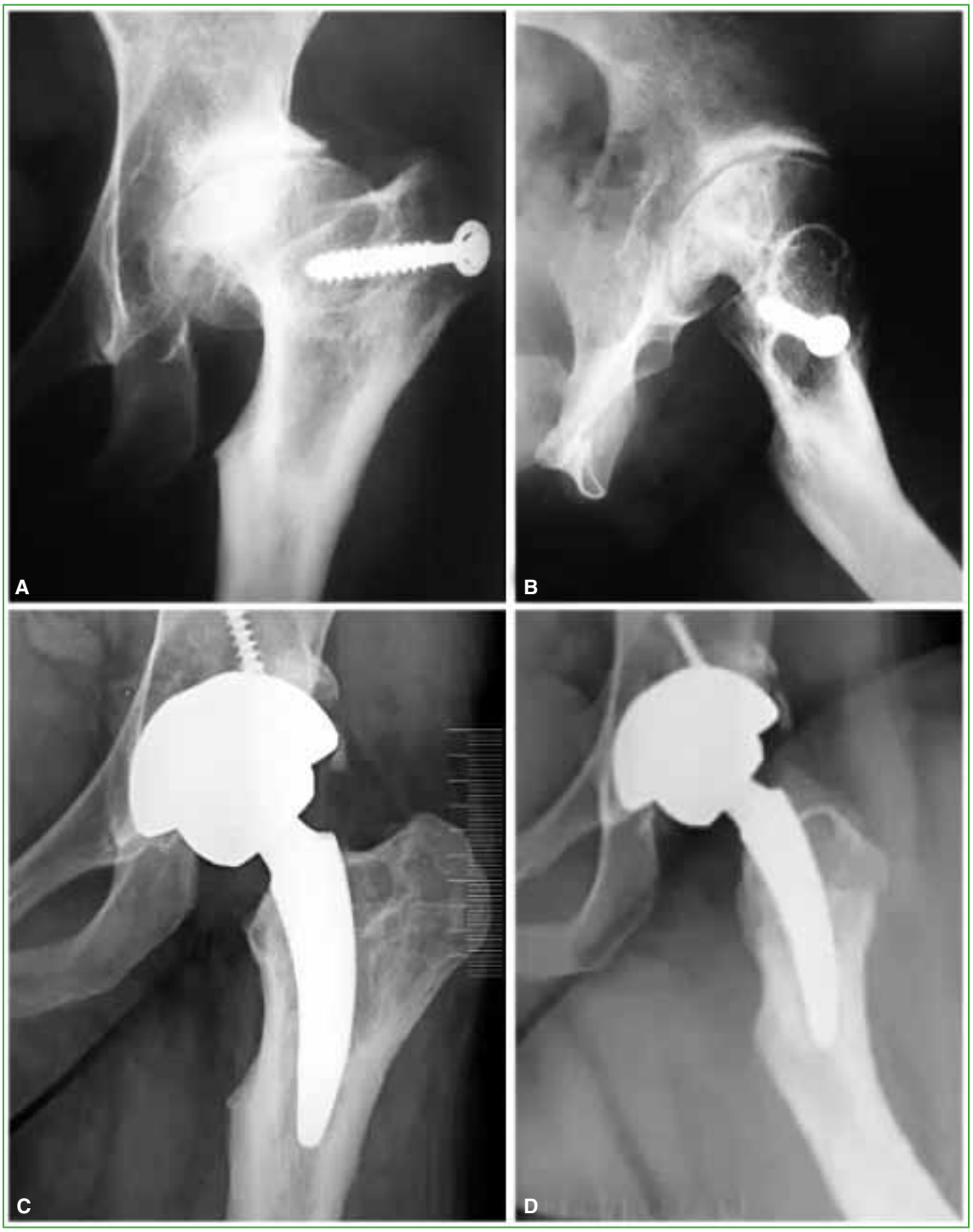

Figure 9. Preoperative anteroposterior (**A**) and lateral (**B**) radiographs of the left hip, showing the proximal deformity of the femur and the osteosynthesis material. Anteroposterior (**C**) and lateral (**D**) radiographs in the immediate postoperative period. The total hip replacement is shown with a short stem and proper alignment in the femoral canal.

Results

At a mean follow-up of 81 months, the survival rate was 97.1% taking revision of the stem for any reason as therapeutic failure and 100% taking aseptic loosening of the femoral component exclusively. An additional femoral osteotomy was not required in any case. The average surgical time was 66 minutes (range 45-100). There was a significant improvement in mHHS when comparing preoperative and postoperative values (47.3 ± 10.6 vs. 92.3 ± 3.7, p = 0.0001).

Regarding pain assessment, the mean preoperative value was 8.6 ± 1 and the mean postoperative value was 1.1 ± 1.1 (p = 0.0001). The postoperative length discrepancy was, on average, 1 mm (range -9 to 18) (p = 0.0001). Postoperative femoral lateralization differed, on average, 29 mm (range -16 to 20) compared to the contralateral side (p = 0.0001). No cases of IPPF were registered. There was no evidence of periprosthetic osteolysis around the femoral stems. A uniform, <2 mm wide, radiolucency of the femoral stem was observed in Gruen's area 1, without clinical relevance.

Four patients presented initial femoral collapse (<3 mm), without further progression and without symptoms until the last control. According to Engh's criteria,[36] all stems were classified as stable with no signs of loosening at the end of follow-up. Postoperative complications included one pulmonary thromboembolism, one neurogenic sciatic pain without paresis (complex regional pain syndrome), one transient sciatic nerve palsy that fully recovered after six months, and two acute periprosthetic joint infections that were successfully treated with debridement, antibiotics and retention of the implant. One patient sustained a postoperative Vancouver B2 periprosthetic femoral fracture 45 days after surgery and was revised with a distal fixation modular uncemented fluted stem.

DISCUSSION

In this multi-objective study, we found that short cervicometaphyseal fixation stems can radiographically preserve up to 42% of the femoral bone stock, adequately reconstruct the biomechanics of the hip in relation to the contralateral hip, allow a return to sport in the same way as a surface replacement (and often earlier), have a 97% medium-term survival rate, and have a failure rate no less than that of a partial neck-preserving stem and even no less than that of a conventional one established with 25 years on the market, making them very useful in cases of hip dysplasia and proximal femur deformity.

Despite advances in prosthesis design and surgical technique, anatomical reconstruction of the hip remains a considerable challenge. When an anatomic reconstruction of the hip is not achieved, the results are often unsatisfactory.[50] Discrepancies in femoral length and lateralization are responsible for generating alterations in contiguous joints, such as the knee or the lumbosacral spine, and represent one of the greatest causes of medical litigation in the United States.[34,50-52] Regardless of the prosthetic system used, all stems have the ability to radiographically restore the biomechanics of the hip.[29] However, the short stem appears to be superior to other systems in restoring length to the lower limbs.

It has been shown[29] that the average limb discrepancy is only 1.76 mm (range -4.7 to +7 mm), while the average femoral lateralization difference is 4.56 mm (range -4 to +7) with short stems, which is acceptable if compared with those of other series in which the control of these parameters has been less predictable.[53] Unlike surface arthroplasty, we believe that the learning curve for the short stem can be quickly overcome, allowing the patient to preserve femoral bone stock, especially in young and active people, with less risk of intraoperative complications, as described for surface replacement.

Today's hip surgeon is increasingly confronted with an active patient with high functional demands that must be met through implant selection and periodic follow-up, warning about potential risks directly related to physical activity intensity. Physical activity benefits both operated and non-operated patients, according to the literature. According to current recommendations, patients who participate in sports with high demand for the joint such as individual tennis, soccer, squash, basketball, running, karate, or volleyball after surgery have a higher risk of complications.[54] The remarkable long-term results obtained with hydroxyapatite-coated stems, including 95% fixation at a 25-year follow-up and a zero rate of wear with the ceramic-ceramic friction pair,

encourage the use of an implant with these coating conditions and a surface that preserves periprosthetic bone tissue.[26] Complications regarding the level of ions in the blood and ALVAL (acute lymphocytic vasculitis and associated lesions) have currently limited the use of metal-on-metal prostheses (that is, surface prostheses) to selected male patients.

There is strong evidence that conventional femoral stems provide excellent short, medium, and long-term outcomes.[1,55,56] With the growing interest in cementless short femoral stems, a comparative analysis was performed between a time-honored conventional stem and a type 2B short stem that partially preserves the femoral neck.[38] In this study, although the latter showed excellent survival and similar functional results, it preserved twice the femoral neck length and had three times less diaphyseal invasion than the conventional length stem. Symptomatic metaphyseal femoral radiolucency was evidenced in 13.7% of the patients in the conventional stem group (20 vs. 0, p = 0.001); however, no significant differences were found in terms of the overall rate of IPPF, infection, or instability. On the other hand, the rate of aseptic loosening was greater in the conventional stem group than in the short stem group [5 (3.4%) vs. 0, p = 0.06)]. Steinbrück et al.[57] used propensity score matching to harmonize confounding factors related to patient demographics (such as age and sex), volume of surgeries, and joint friction surface in order to examine the potential patient selection bias between short-stem and conventional THA. Using the Kaplan-Meier survival method to estimate the cumulative probability of revision, the authors showed that, when using raw data, the short stem group had a lower cumulative probability of revision than the conventional stem group by up to four years after surgery (p = 0.0001). The authors concluded that the short-stem THA did not present any discernible disadvantages compared with the conventional stem in terms of surgical revision in the short and medium term.

The association between a THA with a short stem and a higher incidence of periprosthetic fracture is dissimilar in the literature. Li et al.[58] reported an IPPF rate of 7% using the CFP™ prosthesis, which were treated conservatively, in all cases, without the need for revision at a mean follow-up of 4.7 years. We believe that technical errors, such as an incorrect cervical osteotomy level (too close to the lesser trochanter) and an inappropriate entry point during femoral canal preparation, are crucial in short, curved stems to avoid calcar cracking or a fracture with diaphyseal extension. Likewise, stems with great curvature ("banana" type), such as the CFP™ design, can increase the risk of intraoperative fracture. A very low neck osteotomy may result in the stem being placed in extreme valgus alignment, which could fracture the femur at the diaphyseal level upon contact with the lateral cortex.[40] However, this finding requires further investigation because the available literature fails to determine whether optimal alignment of short stems should account for various femoral morphologies to prevent IPPF.[59] However, any short varus stem should be inserted lightly to bring the tip of the implant into contact with the lateral cortex for a third fulcrum.[60]

THA with a short-stem prosthesis has already shown excellent clinical

and radiological outcomes in the medium and long term,[61,62] with a variable survival between 92.2% and 100%.[63-66] However, not all designs are similar in size and shape;[13] therefore, different load distributions towards the proximal femur can trigger different patterns of bone remodeling, generating different clinical and radiological outcomes.[13,33] When postoperative thigh pain is diagnosed, understanding its potential etiologies is critical to selecting the appropriate treatment modality. Initially, attempts were made to reduce structural stiffness with modern uncemented stem designs;[67] however, excessive stress transfer from a flexion stiffness mismatch has been a concern in terms of mechanical alterations in the proximal femur's modulus of elasticity, and pain production is a potential consequence.[67,68] With the advent of short stems, much research has focused on thigh pain, and many more recent theories have emerged to explain its genesis.[13,33] In some situations, postoperative radiographs may show cortical hypertrophy as a consequence of bone remodeling that is almost always an asymptomatic event. Maier et al. have analyzed the clinical and radiological outcomes of their first 100 consecutive THAs with the Fitmore® stem (Zimmer, Warsaw, IN, USA).[69] After a mean follow-up of 3.3 years (range 2-4.4), survival was 100% considering revision for any reason as failure, without reporting loosening of the femoral component. However, cortical hypertrophy was observed in 50 hips, predominantly in Gruen's zones 3 and 5.[47,69] Of these, two patients reported moderate pain in the thigh that worsened during physical exercise.

That said, in Argentina, a case of unusual stress fracture has been reported in a 43-year-old man, a professional golfer, at the lateral distal tip of a short uncemented stem with metaphyseal fixation[70] (Figure 10).

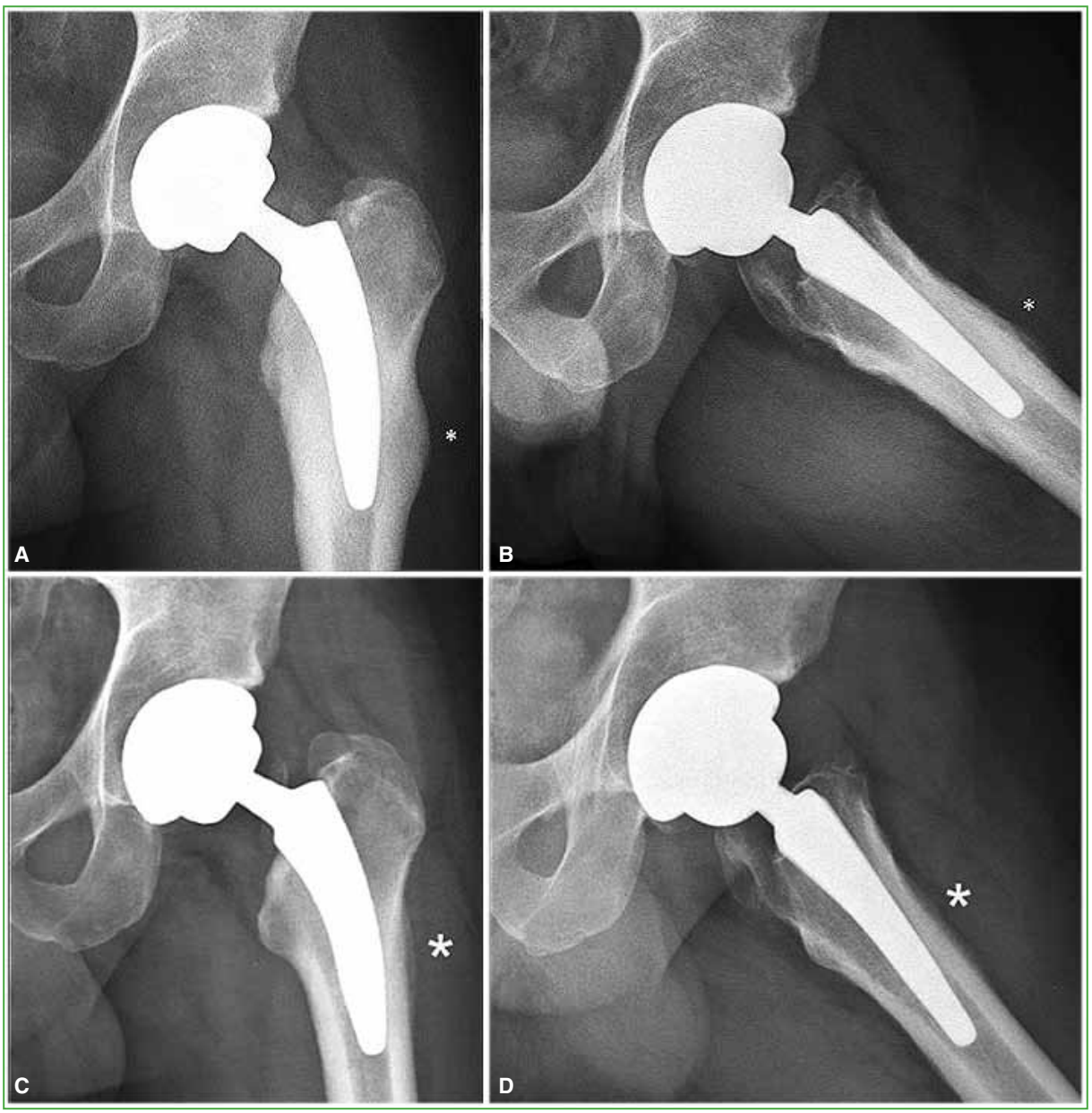

Figure 10. Anteroposterior (**A**) and lateral (**B**) radiographs of the hip of the same patient at the 8-month follow-up. Bone remodeling and periosteal reaction located in the lateral and anterior femoral cortex (*), which correlated with incessant pain exacerbated with axial load. There are no signs of sinking or loosening of the prosthesis. Anteroposterior (**C**) and lateral (**D**) radiographs of the left hip at 2.5 years of follow-up. The hypertrophic callus (*) is visualized, without signs of loosening of the stem. Completely asymptomatic patient.

After ruling out infection and loosening, the authors recommend that reconstructive surgeons be aware of periprosthetic stress fractures as a source of (sometimes overlooked) thigh pain, and that, while rare, these cases should always be considered, given that these cases can be managed conservatively with rest and partial offloading. As previously stated, the stem should be slightly in varus to distribute loads evenly in the medial calcar and lateral femoral cortex.[42,71]

Historically, many prosthetic systems have been used for the treatment of dysplastic coxarthrosis. However, the reference pattern for its treatment is still a matter of debate, since anatomical alterations of the proximal femur (coxa valga extrema, coxa vara due to previous osteotomy, previous osteosynthesis, increased femoral anteversion, marked lower limb length discrepancy, etc.) make implant selection complex.[72] The proximal-distal femoral anatomic mismatch found in dysplastic hips often poses a challenge when deciding on the stem to reconstruct the femur (Figure 11).

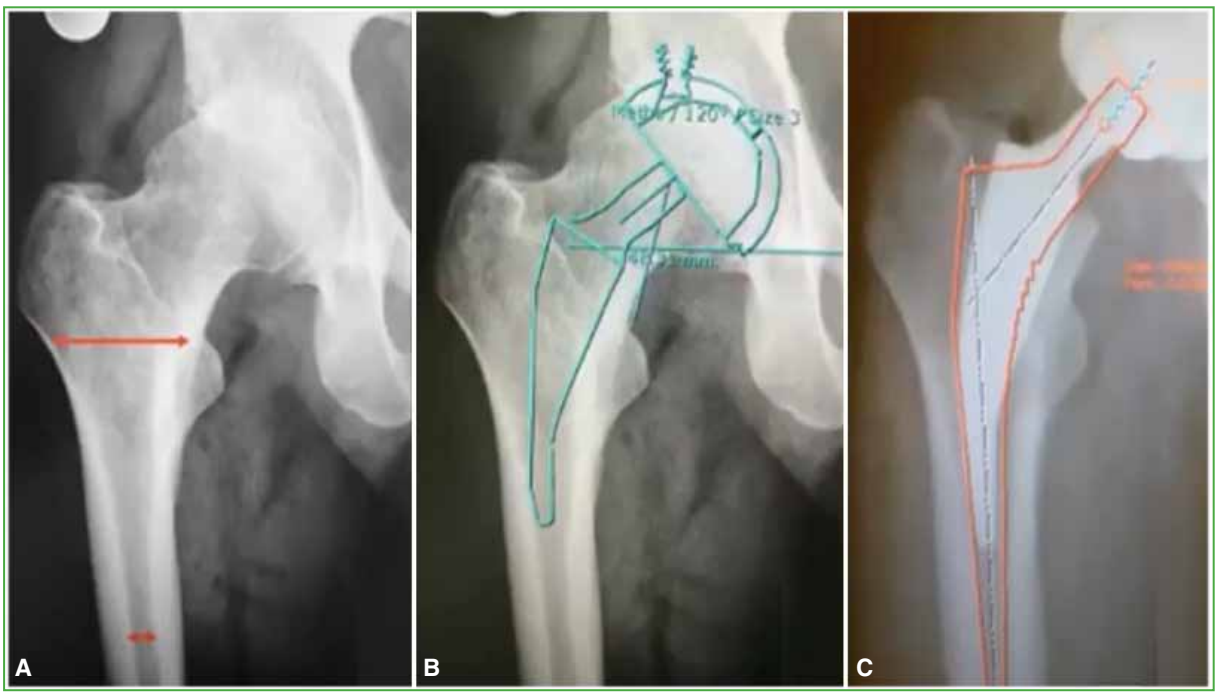

Figure 11. Anteroposterior radiograph of the right hip. The discrepancy between the proximal metaphysis and the diaphysis is observed, in a Dorr A femur (**A**). **B.** Preoperative digital planning with a short stem. The correct filling of the proximal metaphysis is visualized. **C.** Digital preoperative planning with a conventional uncemented stem. Engagement of the distal segment of the stem in the femoral diaphysis is observed.

Conventional length uncemented femoral components rely on proper proximal bone-host contact, which requires excellent fit and filling with resistance to rotational torque to restore hip biomechanics. However, the potential stress shielding remains latent and could cause a massive deficiency of femoral bone stock, making revision surgery a new challenge in the future.[73,74] In this regard, alternative modular femoral components with proximal coating and metaphyseal fixation have been designed, such as the S-ROM (DePuy). Although this implant allows an adequate reconstruction by combining the distal proximal anatomy, it has the problem of modularity. Since most patients with dysplastic osteoarthritis are very young, long-term revision surgery is likely to be necessary, and ideally there are no metallic interfaces that can generate extra debris and wear to the polyethylene wear. In this scenario, preserving bone by using short stems that preserve the femoral neck would allow for an easier final

reconstruction.[75] Short stems have shown their usefulness to reconstruct the biomechanics of the hip in cases of dysplasia with a low prevalence of bone alterations and a low rate of revision surgery.[76]

Deformities of the proximal femur can occur at any level. Likewise, they increase the technical difficulty and present a high risk of intraoperative complications, such as fractures or cortical perforation, especially when there are long-standing previous osteosynthesis elements (Figure 12).

Figure 12. A. Preoperative anteroposterior radiograph. Post-traumatic osteoarthritis in a hip treated with plate and screw osteosynthesis. **B.** Immediate postoperative lateral radiograph and immediate postoperative anteroposterior radiographic image (**C**). The joint replacement with a short stem is shown, with removal of the cervical screw and retention of the internal fixation plate.

Treatment of a proximal femoral deformity requires clinical judgment. Anatomy restoration efforts are critical because residual uncorrected deformities can have negative biomechanical consequences. Throughout our experience with short stem implants, we have found that they are advantageous in cases of proximal femoral deformities, because they can avoid concomitant femoral osteotomies, and because they can be inserted while avoiding the total or partial removal of previous implants.[45,77,78] Additionally, they can compensate for extra-articular deformities at the diaphyseal level (more distal).

CONCLUSIONS

1. Bone preservation associated with the use of short stems could bring long-term benefits in young patients with high functional demand.

2. Similar to conventional length stems and resurfacing prostheses, the use of a short stem effectively restores the biomechanics of the hip.

3. A type 2B short stem has achieved excellent survival outcomes at 2-5 years of follow-up, with 1% failure.

4. Like resurfacing prostheses, the short stems allow an early return to the physical activity sought by young patients with advanced hip osteoarthritis.

5. At medium-term follow-up, a short stem with partial femoral neck preservation demonstrated excellent survival rates and functional outcomes comparable to a well-established conventional stem; however, it demonstrated a lower rate of complications.

6. THA with a short type 2B stem for the treatment of dysplastic osteoarthritis would pose very few intraoperative technical problems, it is a useful alternative for femoral reconstruction.

7. In complex scenarios with deformities of the proximal femur, the use of short stems shows advantages, avoiding the need for preoperative and intraoperative corrective osteotomies.

After analyzing the institutional experience with short stems over a 10-year period, the authors of this study believe that the indication of this type of femoral implant is justified in young and active patients, not to outperform the proven results with reliable conventional implants, but to reproduce them with less femoral bone stock consumption.

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Scores VII

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ABSTRACT
The Editorial Committee wants to provide its readers with an update on the commonly used scales. The use of tables and scales is a widespread practice in Orthopedics and Traumatology. The measurement and quantification of clinical, functional, and radiographic aspects has become an essential tool for decision-making in different aspects of healthcare activity. We carry out a review of the most used scales, defining their use and including original and updated literature.
Keywords: Scales; scores; tables; update.
Level of Evidence: V

Puntajes VII

RESUMEN
El Comité Editorial quiere brindar a sus lectores una actualización de las escalas de uso corriente. El empleo de tablas y escalas es una práctica muy extendida en la Ortopedia y Traumatología. La medición y la cuantificación de los aspectos clínicos, funcionales y radiográficos se convirtieron en una herramienta imprescindible para la toma de decisiones en diferentes aspectos de la actividad asistencial. Llevamos a cabo una revisión de las escalas más utilizadas, definiendo su uso e incluyendo bibliografía original y actualizada.
Palabras clave: Escalas; puntajes; tablas; actualización.
Nivel de Evidencia: V

INTRODUCTION

The Editorial Committee wants to provide its readers with an update on the most commonly used scales. The use of tables and scales is a widespread practice in Orthopedics and Traumatology. The measurement and quantification of clinical, functional, and radiographic aspects have become essential tools for decision-making in different aspects of healthcare activity.

We carried out a review of the most used scales, defining their use and including original and updated literature. In this opportunity, we dealt with the section of pediatric pathology scores. Although assessment scales are commonly used in publications about orthopedic problems in children and adolescents, instruments that have not been designed or validated for a pediatric population are frequently used. Some of the most commonly used validated or designed instruments for children are listed below.

Pediatric Outcomes Data Collection Instrument (PODCI)

The *Pediatric Orthopaedic Society of North America* (POSNA) developed the PODCI questionnaire in the late 1990s. This instrument evaluates four variables: 1) the upper extremity function scale, 2) mobility (reflecting the patient's ability to move independently), 3) function in sports and physical activity, and 4) pain/comfort and a

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global function value (representing the mean of the four specific function values). It consists of three parts: 1) the pediatric questionnaire (to be answered by parents of children between 2 and 11 years old), 2) the questionnaire for parents of adolescents (11-18 years old) and 3) the questionnaire for adolescents (between 11 and 18 years old). The PODCI has been validated in Spanish.

The scale can be downloaded at: https://www.gillettechildrens.org/assets/uploads/general/Forms/Gait_Lab_Forms/9990-151_Pediatric_Outcomes_Questionnaire_Spanish.pdf

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PROMIS® Pediatric and Parent Proxy Profile

The *PROMIS® Pediatric and Parent Proxy Profile* instruments are a collection of short forms containing a fixed number of items from six PROMIS domains (Depressive Symptoms, Anxiety, Mobility, Pain Interference, Fatigue, and Peer Relations) together with a single item on the intensity of the pain. There are three profiles: PROMIS-25 includes four items per domain; PROMIS-37, six items per domain and PROMIS-49, eight items per domain. As with other PROMIS instruments, the profiles are universal rather than disease-specific. They evaluate all domains over the past seven days.

The PROMIS® Pediatric Profile instrument is designed for pediatric self-reporting (8-17 years). The PROMIS® Parent Proxy Profile is intended for parents acting as proxy reporters for their children (ages 5-17).

The scales can be downloaded at: https://www.promishealth.org/57461-2/.

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Oxford Ankle Foot Questionnaire for Children (OxAFQ-C)

This is a questionnaire to measure the state of health self-reported by the child or reported by the parent (representative). The OxAFQ-C is used with patients ages 5 to 16 who have foot and ankle conditions. It has a total of 15 items: the first 14 items are used to calculate the scores for the three domains: Physical (6 items, 1-6), School and Play (4 items, 7-10), Emotional (4 items, 11- 14). Scores for the three domains are reported separately, there is no total score. The response options for each item are on a 5-point scale: never (4), rarely (3), sometimes (2), very often (1), always (0), where the number in parentheses represents the value that should be applied by the annotator to each answer. Domain scores are calculated as the total of the scale item scores divided by the maximum for each domain. Domain scores can be transformed to a percentage scale (0-100) for ease of interpretation. A higher score for a domain represents better performance.

The final item (item 15: Has your foot or ankle stopped you wearing any shoes you wanted to wear?) was added to reflect the concern many children have about being able to wear the shoes they prefer. This topic is important to children and therefore adds validity, but psychometrically it does not fit into any of the domains. Therefore, this final item 15 is reported as a single item.

The scales can be downloaded at:
https://innovation.ox.ac.uk/outcome-measures/the-oxford-ankle-foot-questionnaire-for-children-oxafq-c/

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Pedi-IKDC scale

Pedi-IKDC is the pediatric version of the *International Knee Documentation Committee* (IKDC) subjective outcome scale. It was initially described by Kocher et al. and then it was validated into Spanish. It consists of two subscales: symptoms and sports, but all raw scores are added to a total score.

PEDI-IKDC SCALE

SYMPTOMS

• If you were asked to do the activities below, What is the most you could do today **without making your injured knee hurt a lot**?
- Very hard activities like jumping or turning fast to change direction, like in basketball or soccer.
- Hard activities like heavy lifting, skiing or tennis.
- Sort of hard activities like walking fast or jogging.
- Light activities like walking at a normal speed.
- I can't do any of the activities listed above because my knee hurts too much now.

• During the **past 4 weeks** or **since your injury**, how much of the time did your injured knee hurt?
Never hurts | 0 1 2 3 4 5 6 7 8 9 10 | Hurts all the time

• How badly does your injured knee hurt **today**?
Does not hurt at all | 0 1 2 3 4 5 6 7 8 9 10 | Hurts so much I can't stand it

• During the **past 4 weeks** or **since your injury**, how **hard has it been to move or bend** with your injured knee?
- Not at all hard
- A little hard
- Somewhat hard
- Very hard
- Extremely hard

• During the **past 4 weeks** or **since your injury**, how swollen was your injured knee?
- Not at all swollen
- A little swollen
- Somewhat swollen
- Very swollen
- Extremely swollen

• If you were asked to do the activities below, What is the most you could do today without making your injured knee swollen?
- Very hard activities like jumping or turning fast to change direction, like in basketball or soccer.
- Hard activities like heavy lifting, skiing or tennis.
- Sort of hard activities like walking fast or jogging.
- Light activities like walking at a normal speed.
- I can't do any of the activities listed above because my injured knee is swollen even when I rest

• During the **past 4 weeks** or **since your injury**, did your injured knee ever **get stuck in place (lock)** so that you could not move it?
- Yes
- No

• During the **past 4 weeks** or **since your injury**, did your injured knee **ever feel like it was getting stuck (catching)**, but you could still move it?
- Yes
- No

• If you were asked to do the activities below, What is the most you could do **today** without your injured knee **feeling like it can't hold you up**?
- Very hard activities like jumping or turning fast to change direction, like in basketball or soccer.
- Hard activities like heavy lifting, skiing or tennis.
- Sort of hard activities like walking fast or jogging.
- Light activities like walking at a normal speed.
- I can't do any of the activities listed above because my injured knee feels like it can't hold me up

SPORT ACTIVITIES

• What is the most you can do on your injured knee **most of the time**?
- Very hard activities like jumping or turning fast to change direction, like in basketball or soccer.
- Hard activities like heavy lifting, skiing or tennis.
- Sort of hard activities like walking fast or jogging.
- Light activities like walking at a normal speed.
- I can't do any of the activities listed above most of the time.

FUNCTION

• How well did your knee work **before you injured it**?
I could not do anything at all | 0 1 2 3 4 5 6 7 8 9 10 |I could do anything I wanted to

• How well does your knee work **now**?
I am not able to do anything at all | 0 1 2 3 4 5 6 7 8 9 10 |I am able to do anything I want to do

• Who completed the questionnaire?
- Child alone.
- Child with help from parent/adult.

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Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS)

This scale is a validated 8-item instrument designed to quantify the activity of children between 10 and 18 years of age. Normative data on pediatric and adolescent activity level were recently reported by the same authors. The questionnaire is not validated in Spanish.

The scale can be downloaded at:
https://www.prismsports.org/UserFiles/file/HSSPedi-FABSPDFScoring.pdf

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Case Resolution

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Case presentation on page 130.

DIAGNOSIS: Extrapulmonary sarcoidosis.

DISCUSSION

An infiltrative-looking lesion was visualized in the right hip magnetic resonance (Figure 3), at the level of the iliac bone, in the acetabular roof, heterogeneous, hypointense on the T1-weighted sequence and hyperintense on the T2-weighted sequence, with discrete hypersignal in diffusion sequences, associated with cortical thinning. It was accompanied by joint effusion at the coxofemoral level, with a heterogeneous signal, with capsular distension.

Figure 3. Magnetic resonance imaging of the right hip. **A.** Coronal section in T1-weighted sequence. A hypointense lesion is visualized in the roof of the acetabulum (arrow). **B.** Coronal section in STIR sequence. The lesion becomes hyperintense (arrow) and a heterogeneous hip effusion is observed (asterisk). **C.** Axial section in STIR sequence. Hyperintense lesion (arrow). **D and E.** Axial section in diffusion sequence (**D**) with the corresponding apparent diffusion coefficient map (**E**), showing intermediate cellularity.

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With these radiological findings and the suspicion of a proliferative neoplastic process, other imaging studies and biochemical analyzes were requested.

Gynecological and mammary ultrasounds were performed, which did not reveal particularities. The mammogram was normal and the complete analysis with carcinoembryonic antigen, CA15.3 and alkaline phosphatase were normal.

The evaluation also included a positron emission tomography (Figure 4) that showed a lesion in the upper right lung lobe, with fibrous tracts and bronchiectasis associated with glucose hypermetabolism (SUVmax. 4.2). Also, an osteolytic lesion with disruption of the cortex and intense glucose hypermetabolism was visualized in the anterosuperior sector of the right acetabulum (SUVmax. 14.2). It was accompanied by annular morphology hypermetabolism surrounding the femoral head, which maintained its sphericity, suggesting a capsular pathology. In the external obturator muscle, between the ischium and the trochanter, a hypermetabolic hypodense image of 30 mm (SUVmax 11) was observed.

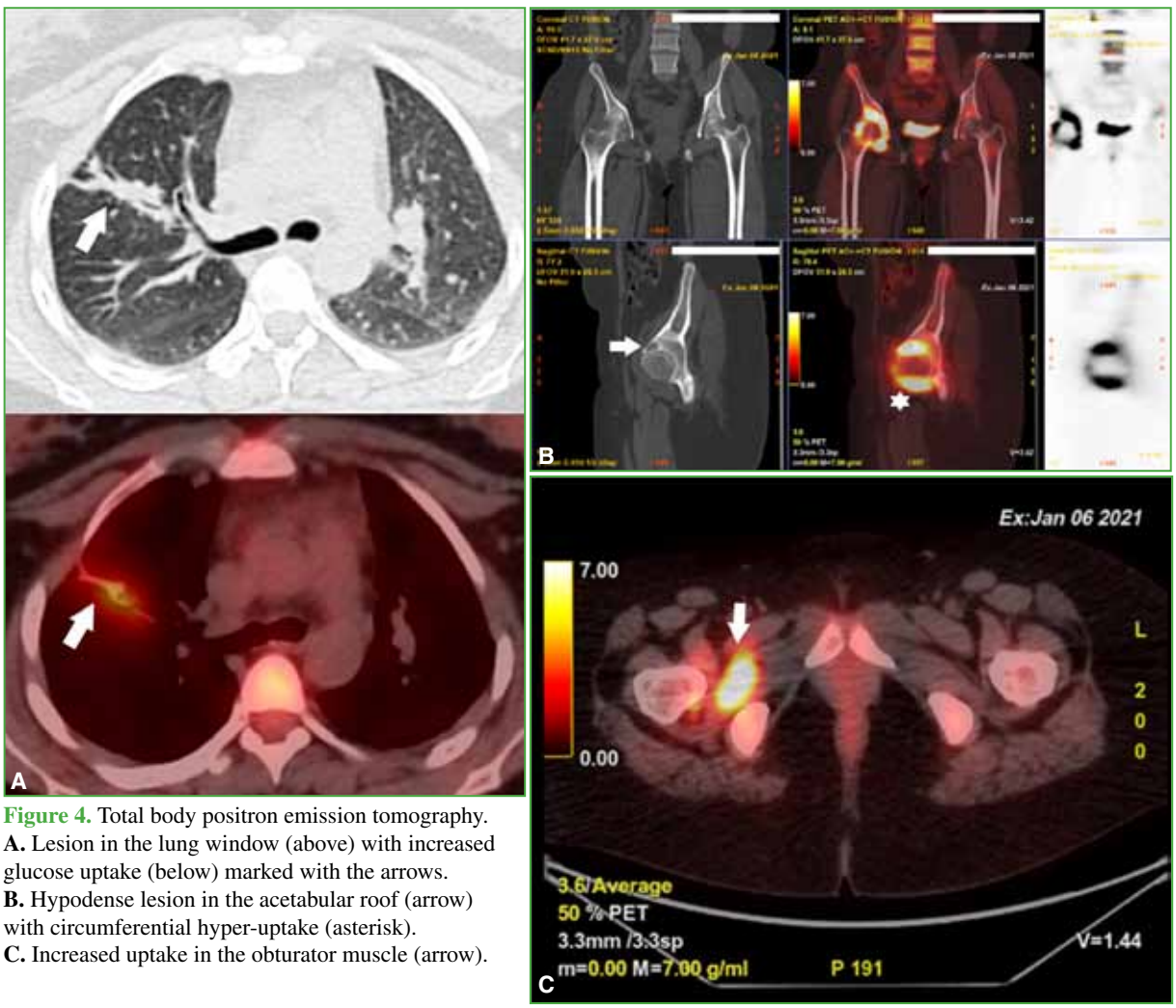

Figure 4. Total body positron emission tomography.
A. Lesion in the lung window (above) with increased glucose uptake (below) marked with the arrows.
B. Hypodense lesion in the acetabular roof (arrow) with circumferential hyper-uptake (asterisk).
C. Increased uptake in the obturator muscle (arrow).

The patient reported that she had had COVID-19 four months earlier. In the workplace, she had had close contact with patients who presented upper respiratory symptoms.

Due to the findings in the magnetic resonance and positron emission tomography, it was decided to perform a CT-guided biopsy of the acetabular lesion (Figure 5).

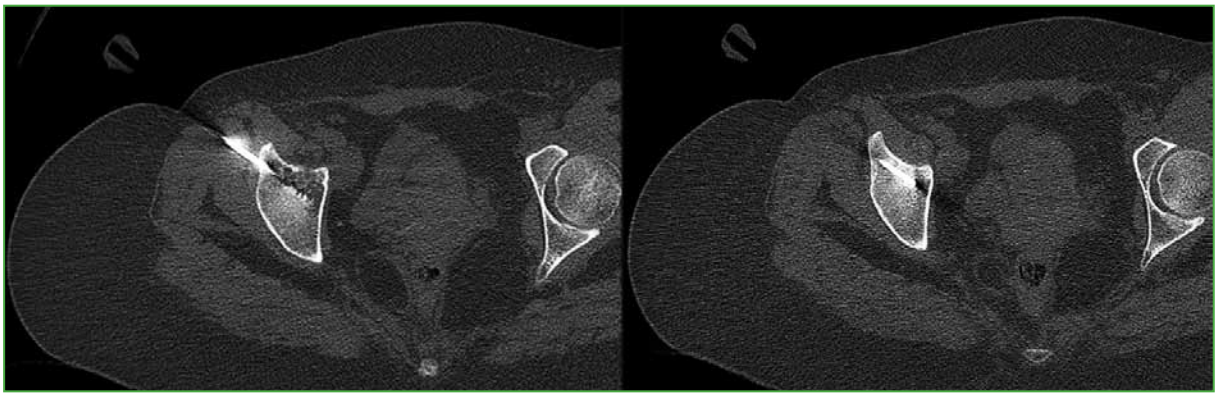

Figure 5. CT-guided biopsy at the level of the acetabulum.

A sample with fragmented trabecular structures that appeared devitalized in sectors was observed in the pathology anatomy study. There were no signs of malignancy.

Because of the lesions seen on the positron emission tomography, the physicians on the tumor committee decided to request a pulmonary evaluation.

The patient was reassessed in the Pulmonology Department; she denied having a systemic history and stated that she did not smoke. A respiratory function test and a chest radiograph were ordered in light of the COVID-19 diagnosis and the positron emission tomography image.

In the functional test, the patient had a restrictive pattern, and the chest radiograph revealed alveolar opacity in the right upper lobe.

With the results of the respiratory evaluation, it was decided to complete the studies with a contrast-enhanced chest CT scan that showed condensation with dense linear trajectories and an air bronchogram, subpleural nodules with a tree-in-bud pattern (Figure 6).

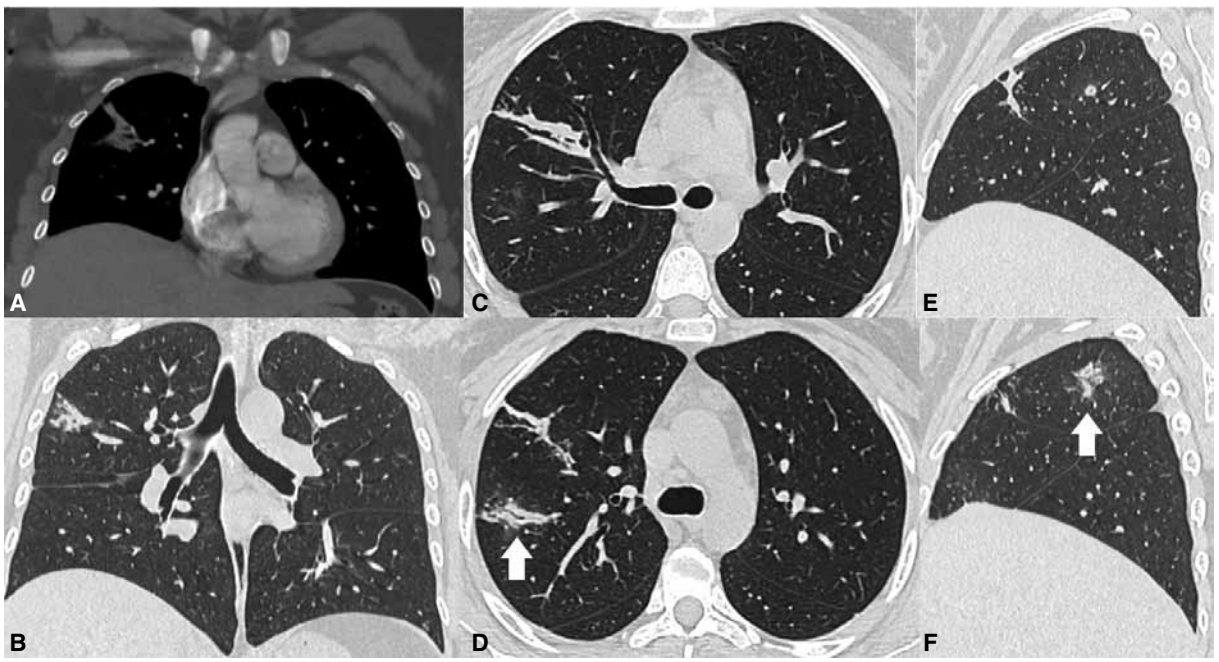

Figure 6. Chest CT scan with contrast. **A.** Mediastinal window in coronal section. Lesion in the right lung field. **B.** Parenchymal window in coronal section. Lesion at the level of the right upper lobe. **C.** Parenchymal window in axial section. Lesion with fibrous tracts and bronchiectasis. **D.** Parenchymal window in axial section. Tree-in-bud patterned lesion (arrow). **E.** Parenchymal window in sagittal section of the right lung with fibrotic lesion. **F.** Parenchymal window in sagittal section of the right lung with a tree-in-bud lesion (arrow).

After ruling out an acute respiratory condition and a neoplastic process in the hip, an interconsultation with the Rheumatology Service was carried out. A new evaluation of the hip with tomography was requested (Figure 7).

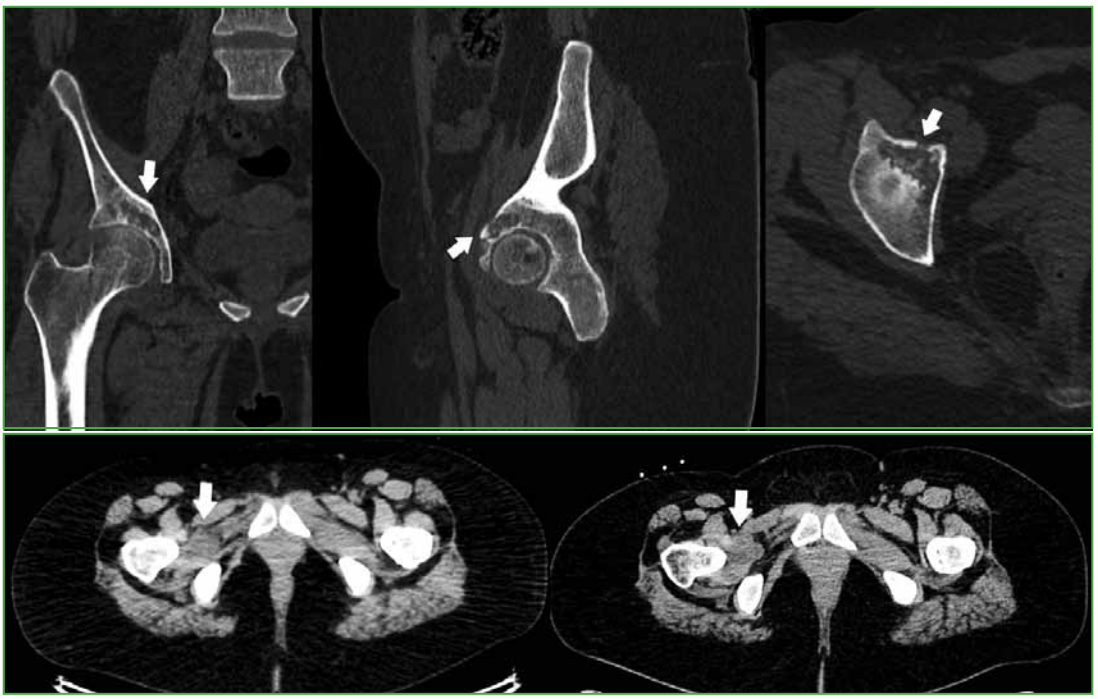

Figure 7. CT scan of the right hip. The progression of the lesion is visualized, now with a lytic component, with compromise of the cortex in the coronal (**A**), sagittal (**B**) and axial (**C**) sections. **D.** Soft tissue window. When compared to the previous month's study (left), there is a slight increase in the size of the lesion adjacent to the joint (right).

Given the increase in the soft tissue component that surrounds the acetabulum, a new obturator plane biopsy was performed, (Figure 8) with samples sent for bacteriology and pathology analysis.

Figure 8. CT-guided soft tissue biopsy.

The bacteriological study was negative and the anatomical pathology study indicated chronic synovitis with sarcoidosis granulomas.

The poor response to medical treatment led to the indication of a total hip replacement with intraoperative debridement and biopsy (Figure 9). The diagnosis of chronic granulomatous synovitis was confirmed.

Figure 9. Radiograph of the right hip with a total hip replacement.

DIAGNOSIS

With all these findings, musculoskeletal sarcoidosis was diagnosed.

Sarcoidosis is a multisystemic, inflammatory, granulomatous disease of unknown cause, most common in young adults (between 35 and 50 years of age). There is a slight predominance in the female sex. Clinically it can present with pulmonary sarcoidosis, bilateral hilar adenopathy (90%), or extrapulmonary sarcoidosis. It can also affect, in order of frequency, the skin, eyes, and musculoskeletal system (Table).

Table. Manifestations of musculoskeletal sarcoidosis

Joint	Myopathy	Bones
Acute. Rare identification on x-ray Löfgren's syndrome (arthralgia, erythema nodosum, and bilateral hilar lymph nodes) Chronic arthritis, non-deforming granulomatous synovitis, or non-erosive deforming arthritis (Jaccoud's deformity) Dactylitis or tenosynovitis, most common in ankles, knees, elbows, and phalanges Joint impingement is unusual	Diaphragm or extraocular muscles Chronic proximal myopathy or acute simulant polymyositis Nodular (single or multiple painful nodules) Periosseous compromise	More frequent in hands and phalanges Bone destruction in the metaphysis Cystic bone lesions with well-defined margins and lytic bone lesions with periosteal reaction Sclerotic bone lesions Osteopenia or osteoporosis

Diagnosis requires detection of a noncaseating granuloma and compatible presentations after excluding other identifiable causes. It submits spontaneously.

Treatment consists of glucocorticoids or biological drugs.

The most frequent differential diagnoses are neoplastic processes (Figure 10), infections or other granulomatous processes (tuberculosis).

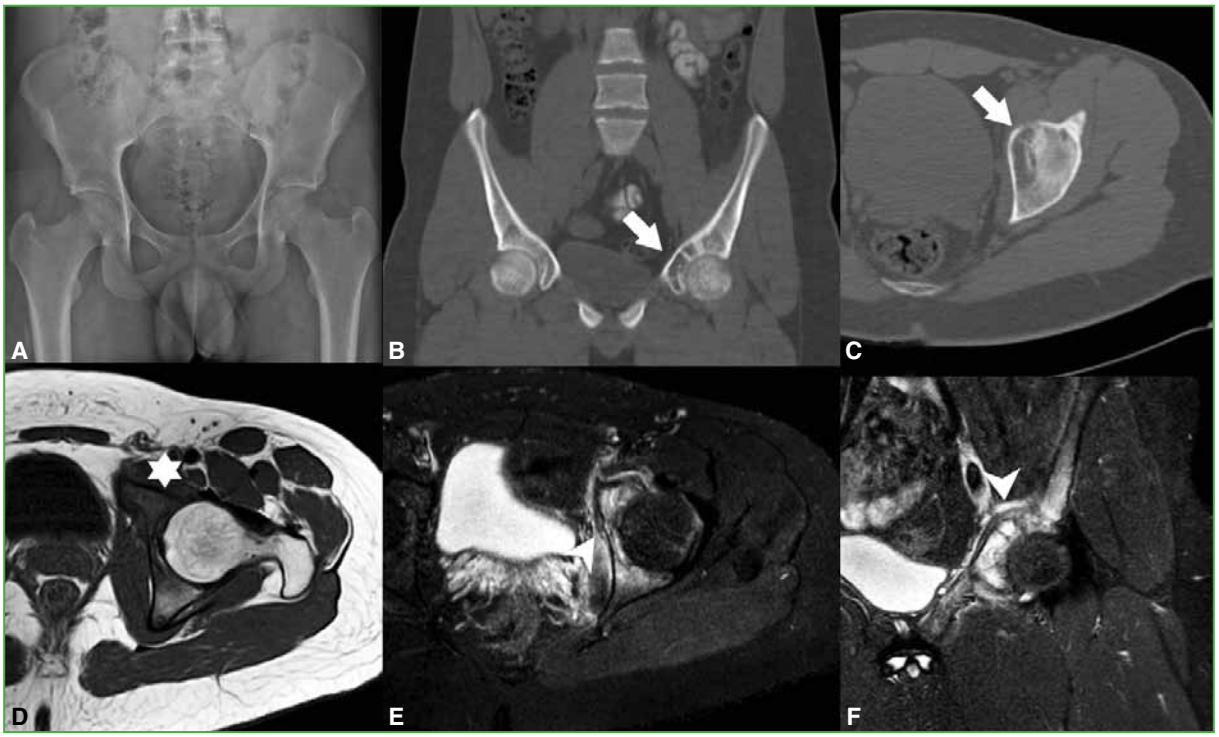

Figure 10. Proliferative neoplastic process. Ewing's sarcoma. A 13-year-old patient with left hip pain of months of evolution. **A.** Panoramic radiograph of the pelvis without particularities. **B.** Computed tomography of the pelvis in bone window, coronal section. A hypodense lesion (arrow) is visualized with septa inside, and bulging and disruption of the cortex. **C.** Computed tomography of the pelvis in bone window, axial section. Cortical disruption is confirmed (arrow). **D.** Magnetic resonance imaging of the pelvis, axial section, in T1-weighted sequence. A hypointense infiltrative lesion is seen in the left acetabulum (asterisk). **E and F.** Magnetic resonance, axial and coronal slices, in STIR sequence. A hyperintense lesion with detachment of the periosteum and involvement of soft tissues is visualized (arrowhead).

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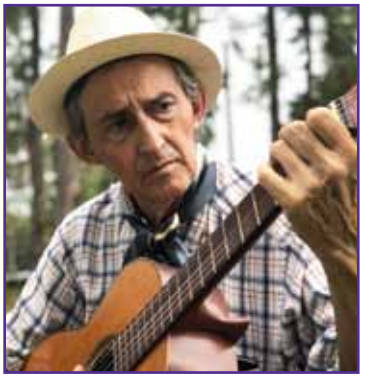
Dr. José Antonio Piñeiro



The AAOT mourns the passing of Dr. José Antonio Pieiro ("Yacaré"), Full Life Member of this Association, on February 21, 2023 in the city of Corrientes.

Dr. José Antonio Piñeiro completed his Medical Residency in Orthopedics and Traumatology at the Orthopedics and Traumatology Department of the Hospital de Clínicas "Gral. José de San Martín" dependent on the School of Medical Sciences of the University of Buenos Aires, where he became Head of Residents.

He served as Head of the Orthopedics and Traumatology Service of the "Juan Pablo II" Pediatric Hospital in Corrientes, Professor of the Departments of Prosthetics and Orthotics and Surgical Kinesics Technique of the Kinesiology degree course of the Universidad Nacional del Nordeste(UNNE), Head Professor of the Department of Orthopedics and Traumatology of the Medicine degree course of the UNNE and Director of the Diploma in Orthopedics and Traumatology.

We ask for a prayer in his memory and may his soul be at rest.

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