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Orthopedics and Traumatology Residencies in Argentina

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Committee of Residencies and/or Equivalent Systems of the AAOT

The medical residency is a postgraduate education and training system that was once associated with residence within the hospital (hence its name).

One of our Committee's goals is to ensure that the quality of resident training is maintained and increased, and that it is implemented properly. However, we are increasingly encountering Residencies that fail to meet the minimum standards for accreditation, leaving us to wonder if we are appropriately training future traumatologists.

The Committee analyzes the number of resident positions available in our country, both in the private and public sectors, and compares it to the number of residents trained in other countries in Latin America and the world. In 2022, 346 positions were offered in 140 centers. Thus, if all of these open positions were filled, no residents quit during their residency, and no graduates departed, our country would gain 346 new orthopedists per year.

We compared the number of Residents trained in Argentina to that of other countries, as well as the relationship between each of them and the number of inhabitants: this year, Argentina trained one traumatologist for every 131,000 inhabitants; Colombia, one for every 678,000; Uruguay, one for every 315,000 inhabitants; Ecuador, one for every 840,000; France, one for every 500,000; Spain, one for every 169,000; and the United States, one for every 379,000 (Table).

Table. Comparison of residents trained in Argentina and in other countries

	Population	Residents of Orthopedics and Traumatology by year	Resident/ inhabitants	Resident/ 100,000 inhabitants	Argentina/other country relationship
ARGENTINA	45,376,763	346	1/131,147	0.76	1
Spain	47,326,687	280	1/169,024	0.59	1.3 / 1
Uruguay	3,474,000	11	1/315,818	0.32	2.4 / 1
USA	329,500,000	868	1/379,608	0.26	2.9 / 1
France	60,110,000	120	1/500,917	0.20	3.8 / 1
Colombia	51,600,000	76	1/678,947	0.15	5.2 / 1
Ecuador	17,640,000	21	1/840,000	0.12	6.4 / 1

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Those who aspire to enter a residency program undoubtedly want as many openings as there are candidates or more Resident opportunities in the best training centers. From the perspective of some hospitals, clinics, and sanatoriums, it is beneficial to have many residents, since they represent the cheapest labor on the market, mainly measured in man-hours. On the other hand, in many of the institutions we visited, residents performed tasks that would normally be assigned to the administrative sector or auxiliaries, such as nurses, orderlies, radiologists, and so on, abusing a dominant position in the system that is often tainted by bad habits.

Regardless of physical location, city, or area, the public health system appears to strive to train a large number of traumatologists. However, we believe that there are no scientific grounds for training such a number of traumatologists. Furthermore, in a practical specialty such as Orthopedics and Traumatology, where knowledge is important but so is practice, the relation between the number of residents and procedures completed is inversely proportional, implying inadequate training.

In this regard, we know that the percentage of failures in our Association's Certification Exam has been increasing in recent years. According to the analysis performed on this evaluation instance, there are Residencies whose residents typically do not access the AAOT Specialist Certification, possibly because they do not intend to do so and, possibly because they fail the exam, and, at the same time, we see residents of centers whose applicants historically passed the exam and who, in recent years, have also had difficulties in that instance.

This circumstance indicates that, at least in some areas, the level of training is likely to be decreasing compared to past years, which concerns us and should concern those in charge of opening new programs or expanding those already existing.

On the other hand, there is a high percentage of vacant positions. Different reasons motivate this desertion, including low pay, high workload, lack of interest in training, etc. Taking these vacant places into account, perhaps we should reconsider the idea of continuing to increase positions or training centers.

In addition to the training aspect, we must consider that introducing more and more colleagues into the system implies a disadvantage to ourselves when calculating fees due to an evident imbalance between supply and demand.

Based on what has been stated so far, we believe that new residencies or new positions for residents should not be opened, but rather that existing residents and traumatologists' training and working conditions should be improved.

For all of these reasons, we feel that the Asociación Argentina de Ortopedia y Traumatología and its Residency Committee must be guides and protagonists of Argentine Orthopedics and Traumatology training and practice.

We believe it is essential that the AAOT collaborate with the National Ministry of Health and the provincial ministries, as well as universities, in the forecasting, regulation, and encouragement of actions that improve the quality of traumatology, rather than delegating that function to other institutions that, unlike the AAOT, lack the training or capacity to carry it out. To that end, the Residency Committee collaborated with the National Ministry of Health and other entities to create a reference framework that should serve as the core regulation for all residencies, but we are certain that much more work remains to be done.

Finally, we invite you to reflect on the number of vacancies offered each year and the quality of the current residency system in many ways, including the number of residents at each training center.

Case Presentation

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Resolution on page 369.

A 36-year-old male with no history of trauma sought treatment for left knee pain after physical activity.

He reported no pain throughout the dynamic or palpatory maneuvers. Anteroposterior and lateral radiographs of the left knee were requested, and the evaluation was completed with an MRI without contrast medium.

FINDINGS AND INTERPRETATION OF IMAGING STUDIES

The anteroposterior and lateral radiographs of the left knee showed a radiolucent lesion, with a geographic-type pattern and well-defined borders, but without a sclerotic halo, in close contact with the external cortex in the distal metaphyseal-diaphyseal sector of the femur (Figure 1).

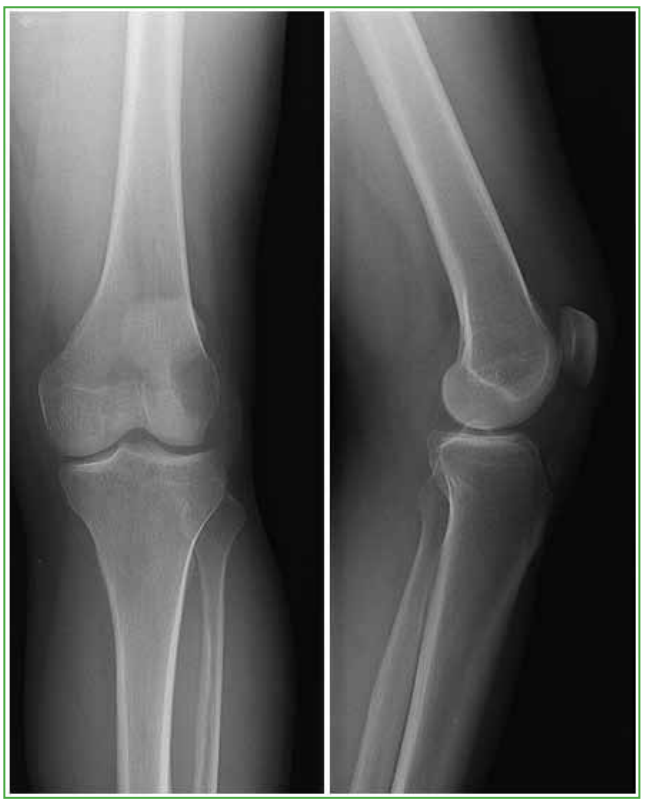

Figure 1. Anteroposterior and lateral radiographs of the left knee. Radiolucent lesion, with a type Ib geographic pattern (with defined borders without sclerotic halo), in the metaphyseal-diaphyseal sector, with thinning of the cortex, but without tearing.

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In the magnetic resonance of the left knee, bone edema could be observed in the external femoral condyle, with involvement of the metaphyseal and epiphyseal sectors. A hypo-intense lesion was also seen on the T1-weighted sequence (Figure 2A), which appeared slightly heterogeneous on fluid-sensitive sequences, with some septa inside (Figure 2B).

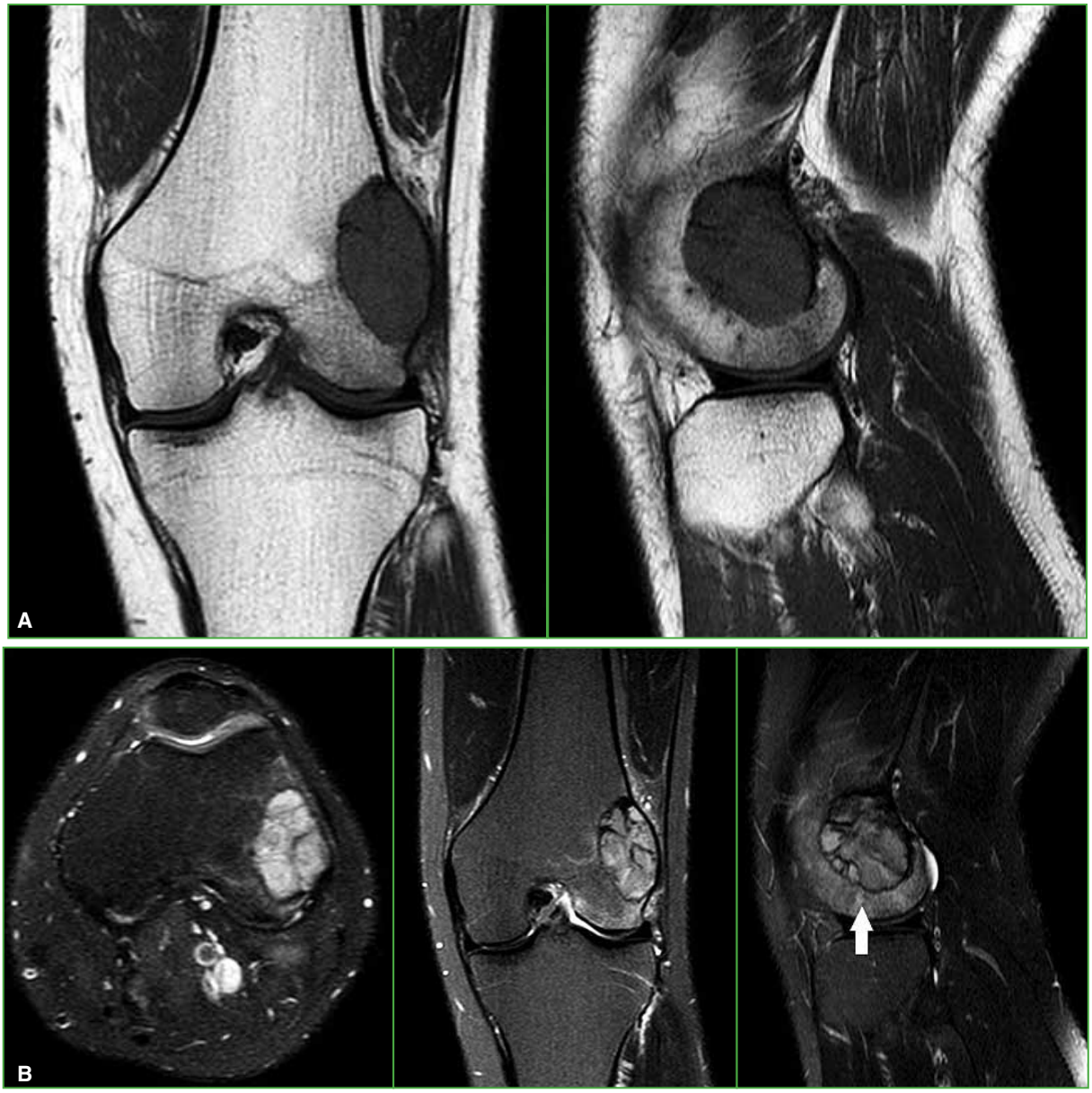

Figure 2. Magnetic resonance imaging of the left knee without contrast medium. **A.** Coronal and sagittal sections in T1-weighted sequence. A hypo-intense lesion that contacts the cortex is visualized, no tear is observed. **B.** Coronal, sagittal, and axial sections in proton density sequences with fat suppression. Significant bone edema (arrow) is visualized with a heterogeneous lesion, predominantly hyperintense, with septa and fluid-fluid levels inside.

The patient was advised to avoid sports and was prescribed analgesics. The case was brought up before the Musculoskeletal Tumors Committee.

A new consultation was scheduled for the patient, and an MRI with contrast medium and computed tomography were ordered.

Facet Fluid Sign and Segmental Instability of the Spine

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ABSTRACT

Introduction: Degenerative lumbar spine disease is prevalent, however, the criteria for instability are still debated. **Objectives:** To analyze the presence of the lumbar facet fluid sign as a criterion for segmental instability of the spine. **Materials and Methods:** Patients with chronic lumbar disease, who present facet hydrarthrosis on MRI and dynamic lumbar spine radiographs. The prevalence of sex, age, main symptomatology, and pain on unilateral or bilateral extension was investigated. **Results:** A total of 139 patients (62% women) were evaluated, with an average age of 50.8 years; the main reason for consultation was low back pain (76%). Sixty-five percent reported pain in extension, with 35% reporting unilateral pain and 30% reporting bilateral pain. Fourteen percent had low-grade spondylolisthesis at L4-L5 and 7% at L5-S1. Hydrarthrosis was unilateral in 20% and bilateral in 80%; the most frequent level of hydrarthrosis was L4-L5 (58%). Six percent had only translational instability and 2% had mixed instability. 8% and 5%, respectively, had Modic I and Modic II changes. **Conclusions:** The presence of facet fluid is not a criterion for segmental instability of the spine, regardless of the level and localized segment, or the unilateral or bilateral lumbar facet presentation.
Keywords: Chronic lumbar disease; angular instability; translational instability; facet fluid; low back pain.
Level of Evidence: IV

Signo del fluido facetario e inestabilidad vertebral segmentaria

RESUMEN

Introducción: La enfermedad degenerativa de la columna lumbar es frecuente, pero aún existen dudas en relación con los criterios de inestabilidad. **Objetivos:** Analizar la relación del signo del fluido facetario lumbar como criterio de inestabilidad vertebral segmentaria. **Materiales y Métodos:** Pacientes con enfermedad lumbar crónica, que presentan hidrartrosis facetaria en la resonancia magnética y las radiografías de columna lumbar dinámicas. Se analizan la prevalencia del sexo, la edad, la sintomatología principal y el dolor a la extensión unilateral o bilateral. **Resultados:** Se evaluó a 139 pacientes (62% mujeres), con un promedio de edad de 50.8 años; el principal motivo de consulta fue lumbalgia (76%). El 65% refería dolor en extensión; el 35%, dolor unilateral y el 30%, dolor bilateral. El 14% tenía espondilolistesis de bajo grado en L4-L5 y el 7%, en L5-S1. La hidrartrosis era unilateral en el 20% y bilateral en el 80%; el nivel de hidrartrosis más frecuente era en L4-L5 (58%). El 6% tenía solo inestabilidad traslacional y el 2%, mixta. Un 8% presentaba Modic I y un 5%, Modic II. **Conclusiones:** La presencia de fluido facetario no es un criterio de inestabilidad vertebral segmentaria, al margen del nivel y el segmento localizado, o la presentación facetaría lumbar unilateral o bilateral.
Palabras clave: Enfermedad lumbar crónica; inestabilidad angular; inestabilidad traslacional; fluido facetario; lumbalgia.
Nivel de Evidencia: IV

INTRODUCTION

Common symptoms of lumbar facet syndrome include spinal claudication, low back pain, especially in extension, or radicular pain in the lower limbs. Magnetic resonance imaging (MRI) of the lumbar spine is often ordered to evaluate these symptoms, and maximum flexion and extension lateral radiographs are generally used to evaluate

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angular (>12ºdifference), translational (>3 mm between both incidences) or mixed instability.[1] Facet joints in the lumbar spine are typical diarthrodial joints that normally support increasing segmental loading until the onset of disc degeneration.[2] MRI findings, including facet joint osteoarthritis, facet joint angle, and facet fluid sign (FFS), defined as the presence of fluid in the joint space, have been associated with instability.[3,4] However, it remains a controversial topic.[5,6]

Hasegawa et al. found that facet opening is the strongest predictor of instability.[6] Rihn et al. described that FFS was significantly correlated with sagittal radiographic instability in patients with degenerative low back disease.[7] In multiple studies, the facet sign on MRI in the supine position has been documented as an indicator of lumbar instability.[7,8]

Some studies[7-9] emphasize that the FFS requires the presence of a gap between the facet joints while the patient is in the supine position, and that the space has time to fill with fluid before the MR is obtained. Wang et al., on the other hand, were the first to describe that FFS exists in the upright weight-bearing posture as well as the supine position.[1]

The prevalence of chronic lumbar spine disease increases day by day, but there are still doubts regarding the criteria for instability and its clinical relationship, despite having complementary studies that are used daily in a spinal clinic.[10]

Therefore, we carried out a study to determine the clinical correlation of FFS with instability in patients presenting for lumbar symptoms with dynamic radiographic studies showing instability parameters and MRI images revealing hydrarthrosis.

The main objective of the study was to determine if lumbar FFS could be a criterion of segmental vertebral instability. The specific objectives were to determine whether there was angular-translational instability, the level of the affected segment, the presence of unilateral or bilateral FFS, the site of presentation, and whether spondylolisthesis was detected.

MATERIALS AND METHODS

Images of patients who attended the Spinal Pathology Unit between September 2019 and March 2020 for symptomatic low back pain with or without radiculopathy were evaluated.

The inclusion criteria were: patients with dynamic lumbar spine radiographs (lateral in maximum flexion and extension) with parameter measurements indicating instability and MRI on axial, T1 and T2 weighted sequences showing hydrarthrosis at the facet level. In addition, the prevalence of sex, age, main symptomatology, the presence of pain on unilateral or bilateral extension were evaluated.

The exclusion criteria were: history of spinal surgery, infection, trauma or tumor in the level to be investigated.

This study was approved by the Teaching and Research Service and its Research Ethics Committee.

The following variables were evaluated: sex, age according to age groups (15-34, 35-54, 55-74 and >74 years); reason for consultation; low back pain on extension (yes or no); unilateral or bilateral, radicular pain; MR Modic 0, I, II, III; dynamic radiographs; angular instability (yes/no), translational instability (yes/no), spondylolisthesis (yes/no).

Statistical Analysis

Student's t-test for dichotomous variables and the chi-squared test were applied. A 95% confidence interval was used. The statistical analysis was performed with the SPPS program.

RESULTS

139 patients with a mean age of 50.8 years (range 20-80) were included; 86 were women and 53 men; 14 women had some type of instability (p 0.07) (Table).

The incidence of translational instability was higher in patients >63 years (p 0.096), this relationship was statistically significant in this group.

Table. Epidemiological data of the patients.

Sex	Female	Male			
	62	38			
Age (years)	Mean	CI95%			
	50.8	20-80			
Reason for consultation	Lumbalgia	Lumbosciatica	Other		
	76	19	5		
Extension pain	No	Unilateral	Bilateral		
	35	35	30		
Spondylolisthesis	No	L2-L3	L3-L4	L4-L5	L5-S1
	77	1	1	14	7
Hydrarthrosis	Unilateral	Bilateral			
	20	80			
	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
	12	24	41	58	56
Instability	No	Translational	Both		
	92	6	2		
Modic	II	II	No		
	8	5	87		

65% of patients with low back pain associated with hydrarthrosis suffered pain on extension of the trunk. Analysis of the MR images revealed that 20% were unilateral and 80% bilateral (Figure 1); the most frequent level of hydrarthrosis was L4-L5 (58%), followed by L5-S1 (56%) and L3-L4 (41%). 8% of patients with hydrarthrosis had a Modic I sign and 5%, Modic II; in 87%, no Modic sign was found.

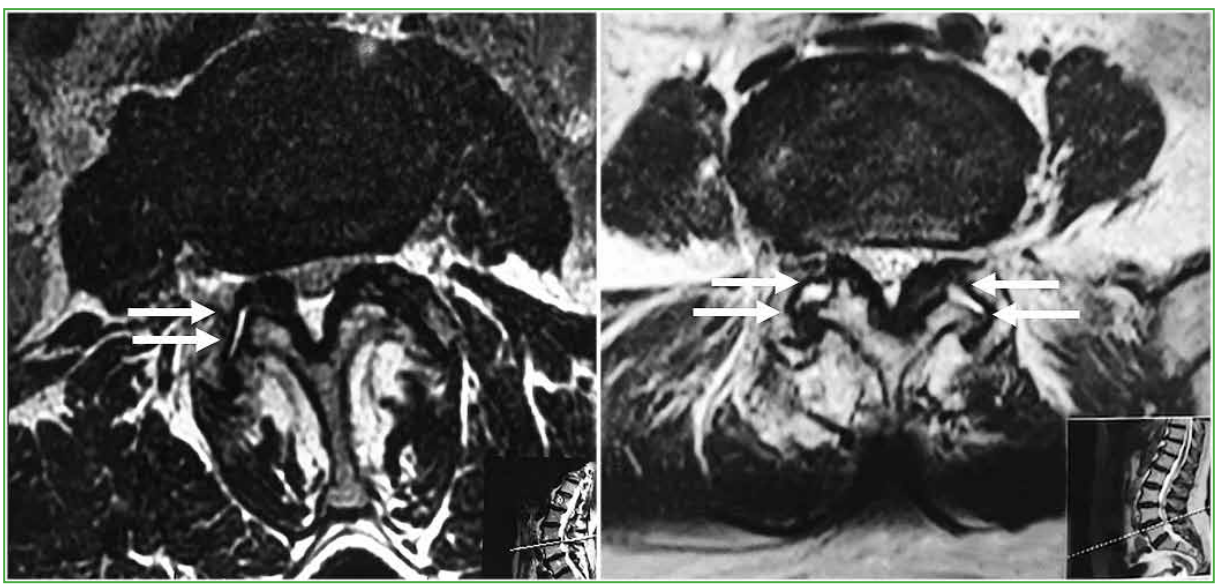

Figure 1. Magnetic resonance imaging of the lumbar spine, axial section. Unilateral and bilateral hydrarthrosis is observed (double white arrow).

92% had no instability; 6% had translational instability and 2% both types of instability (p 0.011). This determines that there is no relationship between hydrarthrosis and the different types of instability (Figure 2).

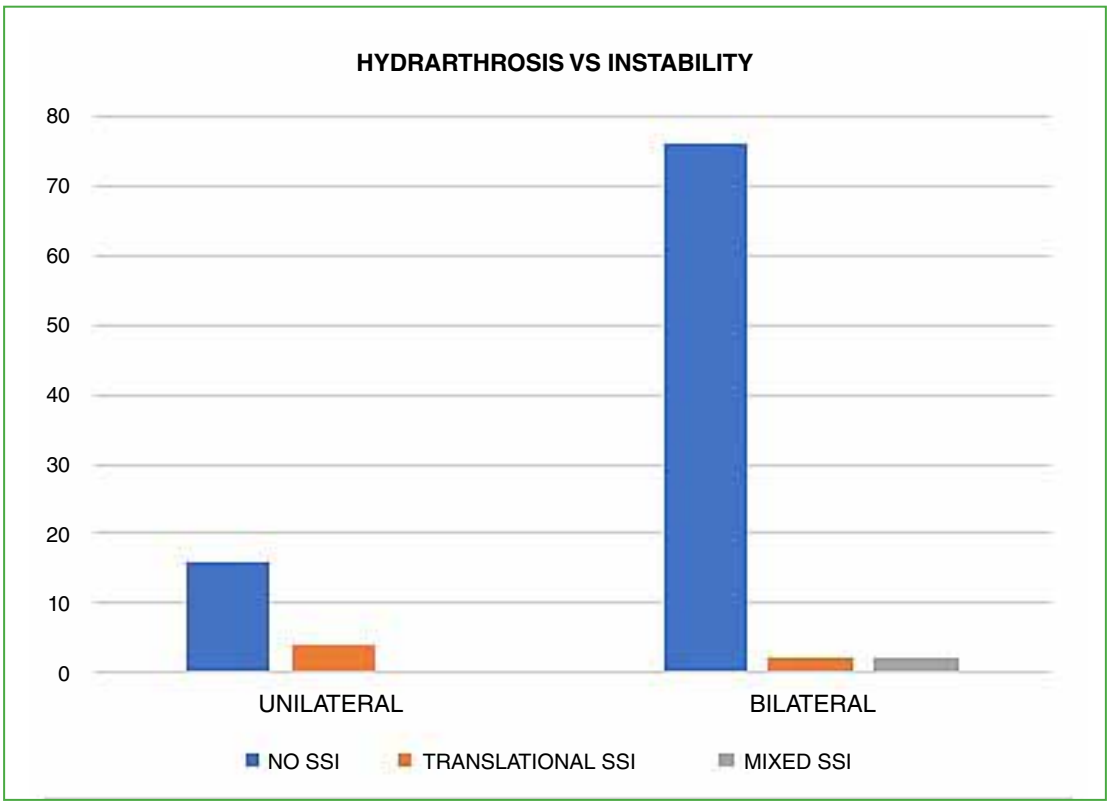

Figure 2. Relationship between hydrarthrosis and the presence and type of segmental spinal instability (SSI).

Likewise, 14% had L4-L5 spondylolisthesis; 7%, from L5-S1 and 77% did not present spondylolisthesis. Those patients who had hydrarthrosis and instability also had vertebral instability, leading to the conclusion that there is a significant association between instability and spondylolisthesis (p 0.001, alpha 0.05, CI 0.95); therefore, it can be pointed out that instability is significantly associated with spondylolisthesis in this study. Breaking down this relationship by age group, the compared Tukey diagram shows the differences between the two groups. The analysis of variance shows a p value of 0.003.

Therefore, it is concluded that the diagnosis of spondylolisthesis is significantly associated with age ($p < 0.003$) (Figure 3).

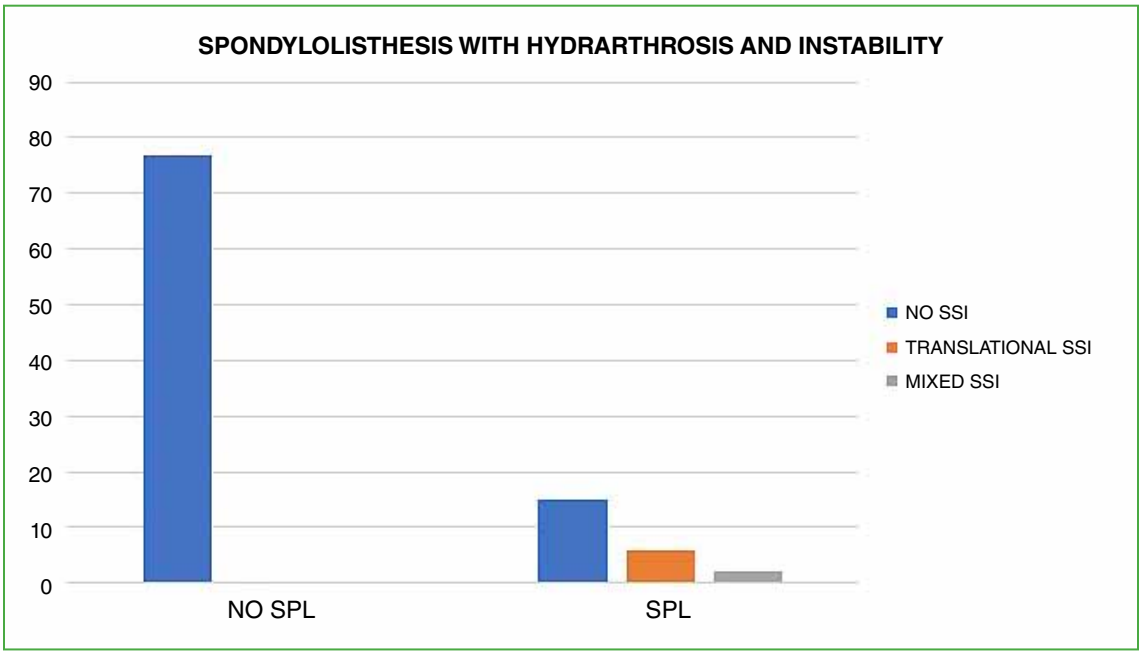

Figure 3. Relationship between patients with spondylolisthesis (SPL) and instability (SSI). Mixed SSI = translational and angular instability.

DISCUSSION

Although lumbar degenerative spondylolisthesis was described in 1932,[11] the definition of instability remains controversial. In multiple investigations, FFS on MRI has been documented as an indicator of lumbar instability.[8] In our study, no statistically significant association was found between instability and hydrarthrosis, so it can be pointed out that the presence of facet hydrarthrosis is not necessarily a fundamental variable in the case of instability.

Flexion-extension radiographs are widely used to determine segmental instability of the lumbar spine. Dupuis et al.[12] defined instability as a sagittal translation >8% of the width of the anterior adjacent vertebra, while Boden and Wiesel[13] defined instability as a significant range of motion (>3 mm of translation movement, greater than 8% of the width above the adjacent vertebra) in the sagittal plane between lateral flexion and extension radiographs.

Hasegawa et al. found that facet opening was the strongest predictor of instability.[6] Rihn et al. reported that the degree of facet effusion was significantly correlated with sagittal radiographic instability in patients with degenerative low back disease.[7]

Bazan et al. analyzed the relationship between the inflammatory Modic sign and instability, and found no correlation between this sign and the presence of translational or angular vertebral instability.[14]

Likewise, it was observed that the average age >63 years is significantly associated with instability and that the main difference is between patients without instability and those with translational instability.

Spondylolisthesis was found to be significantly associated with age >59 years, but this does not define unilateral or bilateral location.

In the study of FFS, differential diagnoses such as facet septic arthritis should be considered, as suggested by Ciccioli et al.[15]

CONCLUSIONS

The presence of facet fluid is not a criterion for segmental vertebral instability, regardless of level and segment, or unilateral or bilateral lumbar facet presentation. It can be concluded that the instability index tends to be higher in the female sex.

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

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Epidemiology and Management of Femoral Gunshot Fractures. Our Experience

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ABSTRACT

Introduction: Gunshot injuries affect the civilian population with increasing frequency. 57% of the patients present bone compromise, with femur fractures being the most common. The lack of a standardized protocol for its treatment prompted the development of this study. **Materials and Methods:** A retrospective, descriptive study was conducted. Patients with femur fractures caused by firearms between 2019 and 2021 were included. The anatomical region, classification, treatment, and complications were analyzed. **Results:** Of a total of 35 patients, 25 (71.43%) had complete fractures and 10 (28.57%) had incomplete fractures. The distal femur was the most affected area (48.57%), according to the location. Reduction and osteosynthesis were used to treat 26 patients, with 9 being treated noninvasively. **Conclusions:** We used a simple classification system to categorize fractures as complete or incomplete. All complete ones were deemed unstable regardless of location, and all incomplete ones were deemed stable, with the exception of those in the proximal third, for which prophylactic fixation is advised. Incomplete shaft fractures can be treated noninvasively, but complete shaft fractures require reduction and osteosynthesis. For zone I and II fractures, the intramedullary nail is the preferred treatment. In zone III, an individualized analysis is required for each pattern. We believe that the initial management and the correct selection of the implant according to the affected area are decisive factors in achieving satisfactory outcomes.
Keywords: Firearm; femur fracture; epidemiology; classification.
Level of Evidence: IV

Epidemiología y manejo de las fracturas de fémur por arma de fuego. Nuestra experiencia

RESUMEN

Introducción: Cada vez con más frecuencia, la población civil sufre lesiones por proyectil de arma de fuego. El 57% de los pacientes presenta compromiso óseo y la fractura de fémur es la más común. La elevada incidencia y la ausencia de un protocolo estandarizado para su tratamiento motivaron este estudio. **Materiales y Métodos:** Estudio retrospectivo, descriptivo. Entre 2019 y 2021, se incluyeron pacientes con fracturas de fémur causadas por arma de fuego. Se analizaron las siguientes variables: región anatómica involucrada, clasificación, tratamiento y complicaciones. **Resultados:** La muestra incluyó a 35 pacientes, 25 (71,43%) con fracturas completas y 10 (28,57%), con fracturas incompletas. Según la localización, el fémur distal fue la zona más afectada (48,57%). Veintiséis pacientes fueron tratados mediante reducción y osteosíntesis y 9, de forma incruenta. **Conclusiones:** Recurrimos a una clasificación sencilla que divide a las fracturas en completas o incompletas. Todas las fracturas completas se consideraron inestables independientemente de su localización; y las incompletas, estables, salvo las del tercio proximal, donde es conveniente realizar una fijación profiláctica. Las fracturas diafisarias incompletas pueden tratarse de forma incruenta y todas las fracturas completas se trataron con reducción y osteosíntesis. El clavo endomedular es el método de elección para las fracturas en las zonas I y II. En la zona III, se requiere un análisis individualizado para cada patrón. Creemos que el manejo inicial y la correcta selección del implante según la zona afectada son factores determinantes para lograr resultados satisfactorios.
Palabras clave: Arma de fuego; fractura de fémur; epidemiología; clasificación.
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INTRODUCTION

Injuries to civilians by firearm projectiles are becoming increasingly common and the major reasons are collective conflicts, violence, crime, or terrorism. They are more common in men and the average age is 32 years, this implies a very large economic impact.[1]

Limb involvement is common, and 57% of patients who sustain non-fatal gunshot injuries have skeletal involvement, with femur fracture being the most common.[2]

To classify gunshot fractures of the femur, universally accepted systems are used. Regardless of the size of the wound, they are included in type III of the Gustilo and Anderson classification.[3] This classification has been questioned, since it does not contemplate the damage caused by the projectile, since the main prognostic factor is the energy dissipated to the tissues. For its part, the classification system proposed by the *Orthopaedic Trauma Association* evaluates the involvement of the integuments, the degree of contamination, vascular injury, and bone loss, generating an order of severity of increasing rank. However, the ideal way to use this scheme has not yet been determined, and it is currently used only in conjunction with other popular classifications.[4,5]

The primary goal of treatment is to reduce the possibility of complications and restore function to the damaged limb. Despite the fact that gunshot fractures are common, there is still controversy about the management of prophylactic antibiotic treatment and, in many trauma centers, there are still no established protocols.[6]

At present, intramedullary nailing is the definitive treatment of choice for diaphyseal fractures in adults, its benefits include less exposure and aggression to the soft tissues.[7] Supracondylar fractures with metaphyseal comminution represent a challenge. In order to determine the best fixation method, numerous biomechanical studies have been carried out to find out which is the most stable configuration.[8] As the fracture approaches neighboring joints, treatment options increase, as do complications. A comminuted gunshot fracture of the femoral neck in a young patient is a rare and potentially devastating injury. Lead toxicity and contaminants increase the risk of nonunion, avascular necrosis, septic arthritis, and joint surface damage.[9]

The high incidence of gunshot wounds in our environment and the lack of a standardized protocol for their treatment motivated this study.

OBJECTIVE

To analyze the epidemiology of femoral gunshot fractures, describe our treatment protocol and communicate the results obtained.

MATERIALS AND METHODS

A retrospective, descriptive study was carried out between 2019 and 2021 that included all patients admitted to our hospital with femoral fractures caused by gunshots.

The variables to be analyzed were collected from the records of our hospital: age, sex, anatomical region involved, classification, initial and definitive treatment. Complications were also analyzed: associated neurovascular injury, osteomyelitis, septic arthritis, pseudarthrosis, and joint stiffness.

Orthopedic evaluation and management were performed after treating immediate danger conditions following the *Advanced Trauma Life Support* (ATLS) guidelines and included systematic inspection of each limb and neurovascular examination. After initial evaluation, control of bleeding, administration of tetanus toxoid, and prophylactic antibiotics (cefazolin 2 g every 8 hours plus gentamicin 240 mg/day for 72 hours), wounds were dressed with sterile bandages and injured limbs were immobilized with splints.

The "injury-antibiotic time" was defined as the time elapsed from the initial injury to the administration of the first dose of antibiotic. The patients were divided into three groups according to the time of the first dose: group 1, early dose, before 30 min; group 2, intermediate dose, between 30 and 180 min, and group 3, late dose, after 180 min.

After diagnosis, the femur was divided into three zones based on clinical and radiological examinations to illustrate the risk of joint involvement. Zone I (hip at risk) includes fractures of the femur proximal to the distal end of the lesser trochanter. Zone II (femoral shaft) is defined as a fracture distal to the distal end of the lesser trochanter and proximal to the distal diaphyseal-metaphyseal junction. Zone III (knee at risk) includes fractures below the distal metaphyseal diaphyseal junction.

To assess bone involvement, the fractures were classified as complete or incomplete according to the radiological continuity of the cortices. When the projectile trajectory resulted in the integrity of at least one cortex, they

were called incomplete fractures. The OTA/AO classification was also used, but we did not rely on it to define therapeutic choices.

Computed tomography was only requested in patients with complex patterns to achieve a better visuospatial characterization or assess joint involvement.

Following the protocol guidelines of our institution for the initial management of open fractures, all patients underwent mechanical-surgical debridement, profuse washing with physiological solution, superficial debridement of devitalized tissue with primary closure of the wound without tension, and stabilization with an external fixator in the case of complete fractures, restoring the length, alignment and rotation of the limb and thus allowing appropriate soft tissue control. This constituted one of the pillars of treatment.

In cases of extensive contamination, torpid evolution of the wound or early signs of phlogosis, the wound was explored 48-72 h later and the sample was taken for microbiological culture.

The following factors were considered when deciding on the definitive treatment: the anatomical position with respect to the damaged area, the type of fracture, and the integrity of the cortices.

Noninvasively treated incomplete fractures required close follow-up. After 45 days, as tolerated, partial weight bearing was advised, with weekly radiological controls during the first month and subsequently every 15 days until signs of bone consolidation were observed.

RESULTS

The sample consisted of 35 patients: 33 men (94.29%) and two women (5.71%), with a mean age of 31.5 years (range 16-59).

Taking into account the classification of the fractures, 25 (71.43%) were complete and 10 (28.57%), incomplete (Figures 1 and 2). Eight (22.86%) had only an entry orifice and 27 (77.14%) had an associated exit orifice.

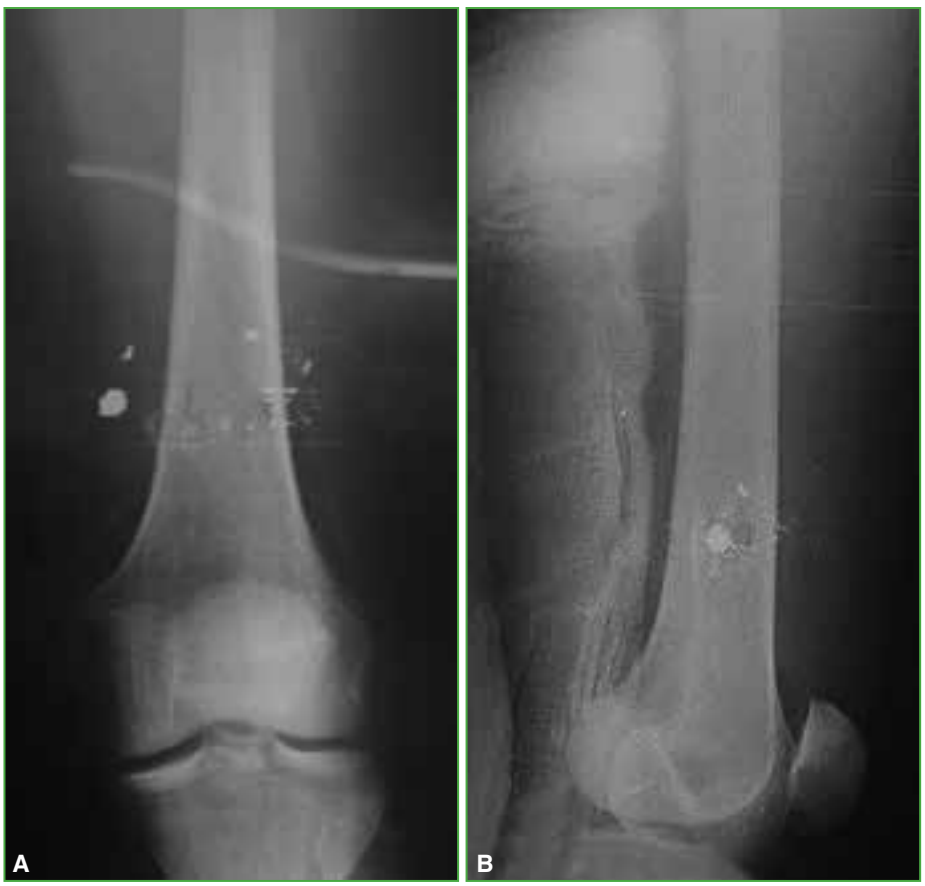

Figure 1. Distal femur radiographs, anteroposterior (**A**) and lateral (**B**). Incomplete fracture of the distal femoral metaphysis, a characteristic pattern described by Smith as a "drill hole".

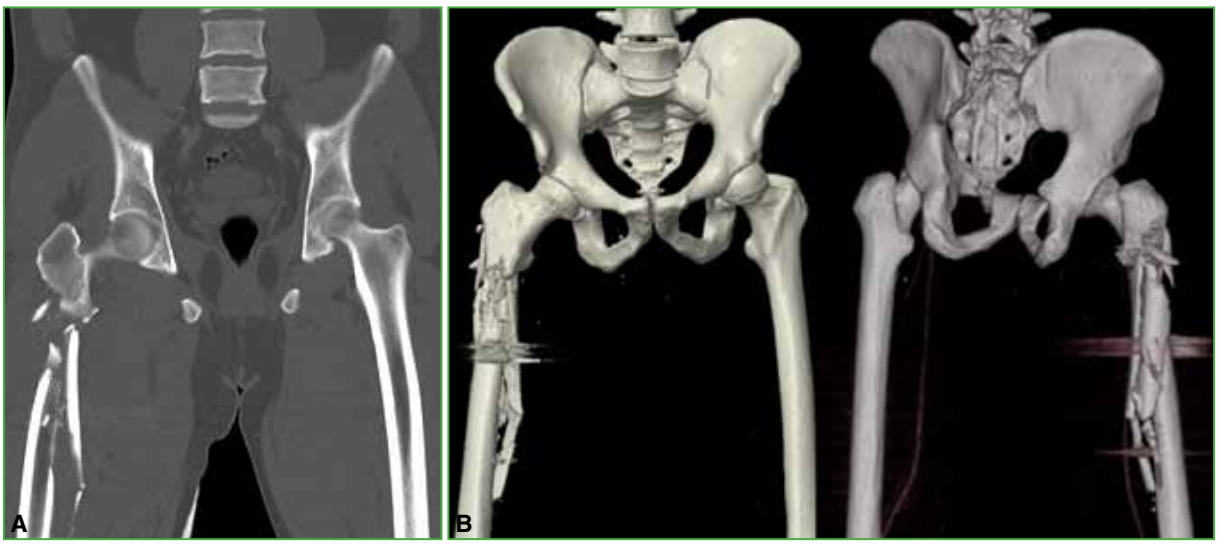

Figure 2. M28, complete multifragmentary fracture of the right femur. **A.** Computed tomography of the pelvis and femur, 2D coronal section. **B.** 3D reconstruction. Fracture of the proximal femur with diaphyseal extension.

According to the location, the lesion was located in zone I, in three patients (8.57%); in zone II, in 15 patients (42.86%) and, in zone III, in 17 cases (48.57%) (Figure 3). The distribution of complete and incomplete fractures in relation to the affected area is shown in Figure 4.

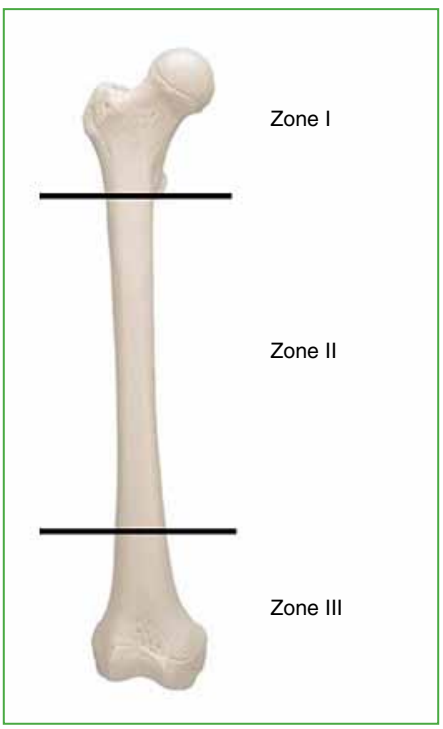

Figure 3. Division of the femur into zones and distribution of injuries according to incidence.

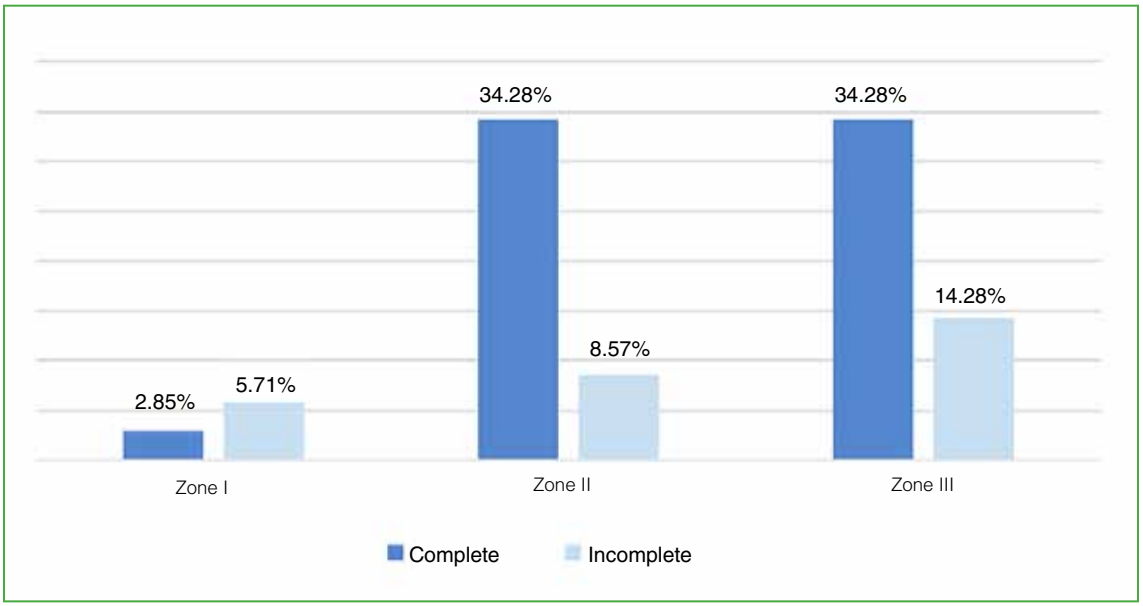

Figure 4. Type of fracture according to location.

Regarding the initial treatment, the patients with complete fractures (71.43%) were stabilized with an external fixator (Figure 5). Patients with incomplete fractures in zone I (5.71%) were prescribed strict bed rest, while those with fractures in zones II or III (22.85%) were immobilized with a plaster cast. In terms of "lesion-antibiotic time," 14 patients in group 1 (40%), 16 in group 2 (46%), and 5 in group 3 (14%), received a first early dose.

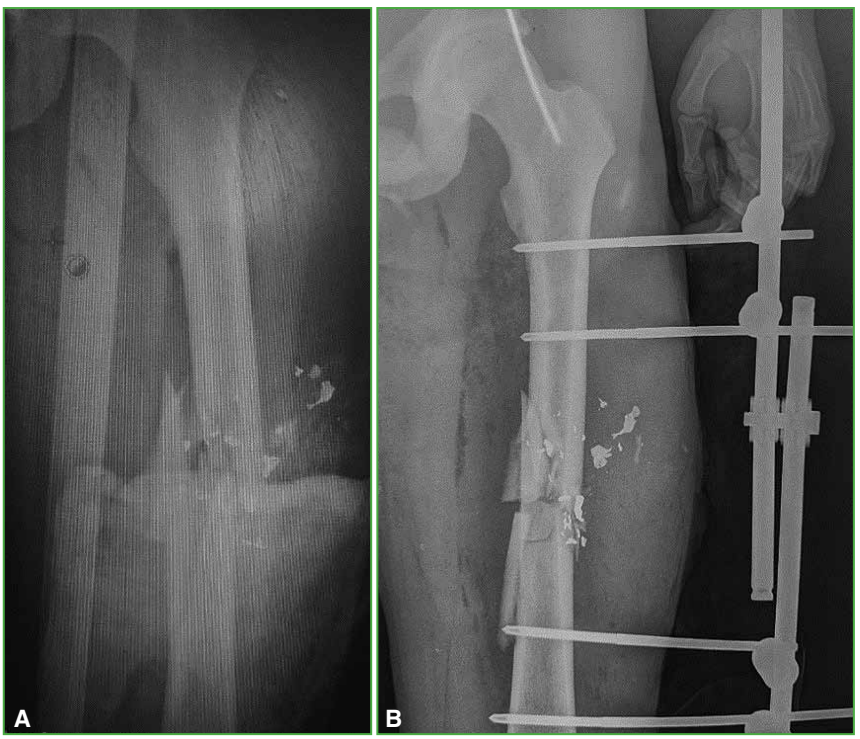

Figure 5. A. Anteroposterior radiograph of a complete fracture of the femur in zone II. **B.** Stabilization with an external fixator.

Regarding the definitive treatment, all the patients with complete fractures were treated by reduction and osteosynthesis, only one with an incomplete fracture underwent prophylactic fixation due to its location in zone I.

The fixation methods used were distributed as follows: 19 (54.29%) with intramedullary nailing (Figures 6 and 7) and seven (20%), which compromised zone III, with anatomic locking plates.

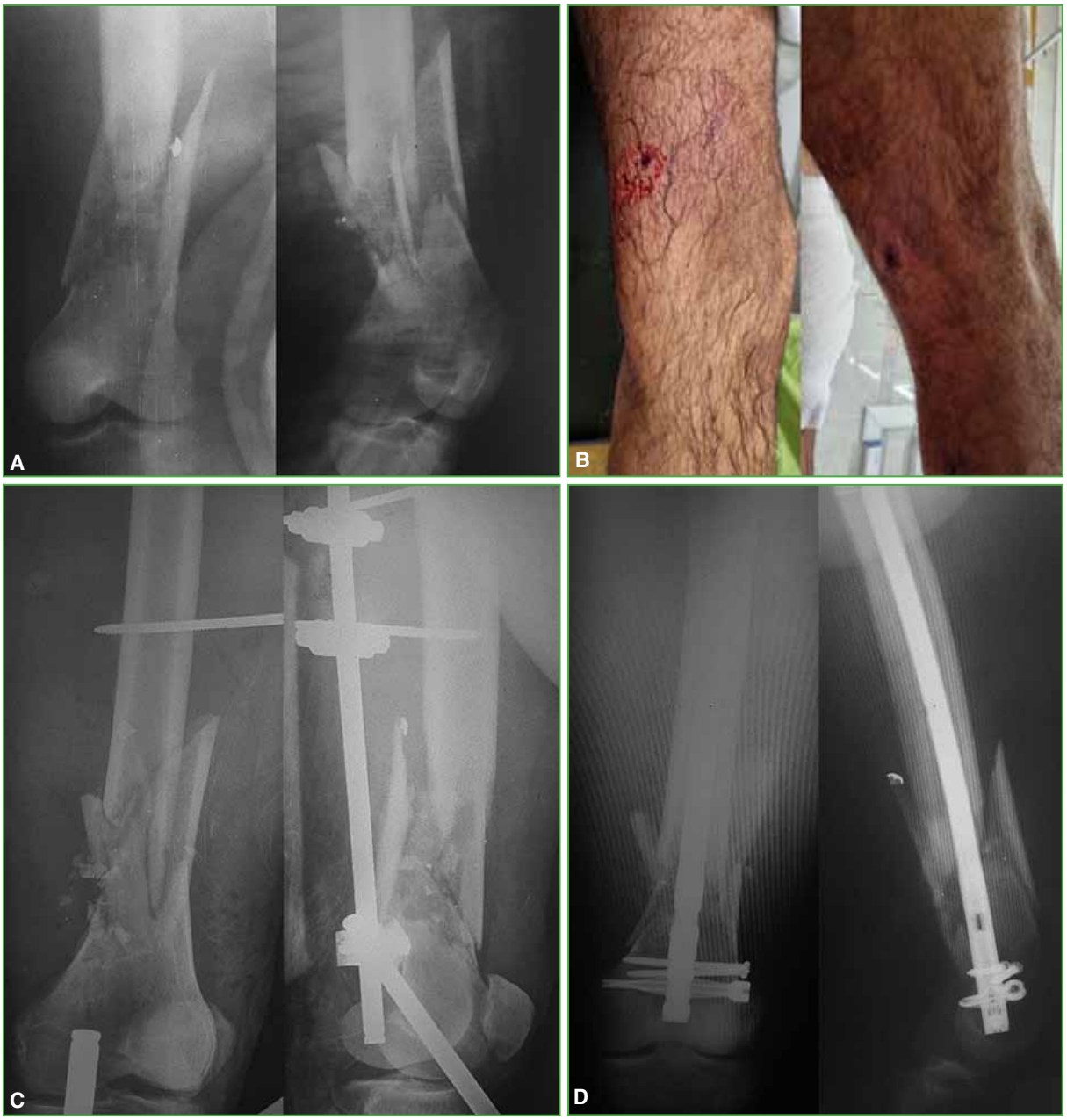

Figure 6. A. Distal femur, anteroposterior and lateral radiographs. Complete comminuted fracture of the left femur in zone III. **B.** Soft tissue with entry and exit orifices. **C.** Stabilization with external transarticular fixator. **D.** Anteroposterior and lateral radiographs. Immediate postoperative period.

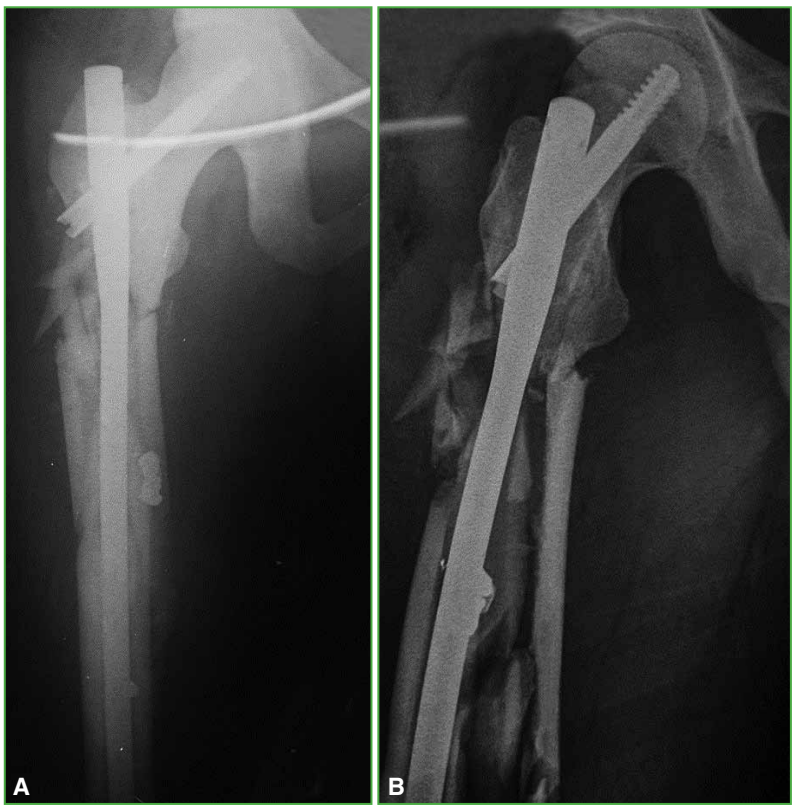

Figure 7. Surgical resolution using a cervicodiaphyseal nail in the patient in Figure 2. **A.** Anteroposterior and lateral ankle radiographs (**B**).

Noninvasive management was chosen in nine patients with incomplete fractures (Figure 8).

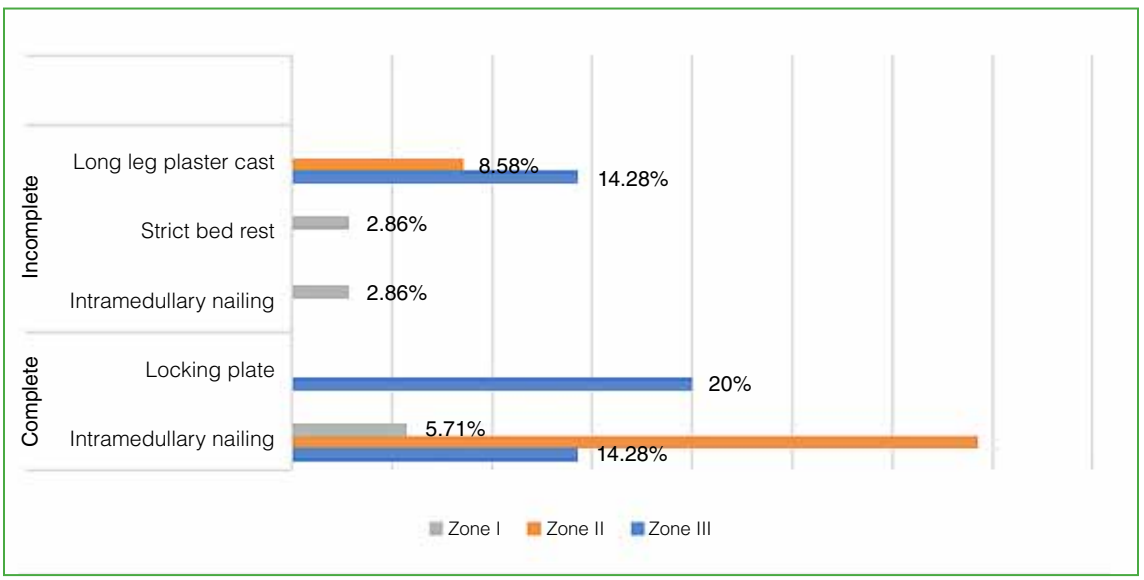

Figure 8. Definitive treatment according to the location and type of fracture.

Complications were: osteomyelitis (1 case; 2.86%), septic arthritis (1 case; 2.86%), pseudarthrosis (2 cases; 5.71%), one (2.86%) patient with complete fracture in Zone III developed a vascular lesion that required revascularization on admission. A fracture treated noninvasively with a long leg plaster cast evolved with joint stiffness of the knee (Table).

The mean follow-up was 15 weeks (range 3-38), only 55% of the patients attended their control at three months. The remaining 45% had a mean follow-up of 8 weeks (range 3-11).

Table. Rate of complications according to anatomical distribution and classification of fractures.

Complication	Fracture type	Classification OTA/AO	Affected zone	Rate
Osteomyelitis	Incomplete	32 B3	Zone II	n = 1 (2.86%)
Infected pseudarthrosis	Complete	32 C3/A2	Zone II/ III	n = 2 (5.71%)
Septic arthritis	Complete	33 C1	Zone III	n = 1 (2.86%)
Vascular injury	Complete	33 C2	Zone III	n = 1 (2.86%)
Joint stiffness	Complete	33 C3	Zone III	n = 1 (2.86%)

DISCUSSION

Ballistic trauma to the musculoskeletal system is a prevalent and growing concern; nonetheless, it is a little-studied injury. According to published articles, 91% of patients are young men.[10,11] In our study, the mean age was 31.5 years and 94.29% were men.

Long bone fractures are the most common orthopedic injuries and are classified as grade IIIA by Gustilo and Anderson as fractures caused by high-energy mechanisms with adequate tissue for coverage. This classification is simple, reproducible and adaptable to the population studied.[3]

The level of damage in gunshot wounds is determined by the distance from the target, the muzzle velocity, and the projectile's properties and caliber. In the civilian population, they are produced, to a large extent, by high-velocity, low-caliber weapons.[12] However, they determine a wide variety of injuries, from a fracture with great bone compromise to a partial fracture with continuity of its cortices. We found fracture patterns that were not fully applicable to the OTA/AO classification, so we resorted to a simple classification described in 1984 by Smith and Wheatley[13] who studied firearm fractures and divided them into complete or incomplete.

In our study, most of the incomplete fractures corresponded to the metaphysis; those located in zone I were considered risky or potentially unstable lesions due to the risk of collapse or extension of the fracture line with subsequent displacement.[14] Complete Fractures represented the predominant pattern in our study (71.48%), which coincides with what was published by Nguyen et al.[15] and all were considered unstable regardless of their location.

Regarding the initial management of these injuries by small-caliber firearms, Sathiyakumar et al.[16] recommend prophylactic antibiotic therapy and superficial debridement of the wound instead of exhaustive debridement to prevent the development of infectious processes. It has also been shown that, in Gustilo type IIIA fractures, infection rates are lower with primary wound closure than with delayed closure, 4% and 17.8%, respectively.[17] All the patients in our series were treated with superficial debridement and primary closure. If a high degree of contamination was detected, greater involvement of the soft tissues, or unfavorable evolution of the wound, deep surgical debridement was performed 48–72 hours later with sample collection for culture.

In complete fractures caused by firearms, due to their high energy, stabilization is a basic principle of treatment. Therefore, external fixation was part of our initial management. The definitive stabilization method was selected on the basis of the location and the degree of compromise and integrity of the cortices. Incomplete fractures of the proximal femur require prophylactic fixation due to stress or compression vectors that are likely to result in future extension of the fracture line.[13]

In our series, there were three fractures of the proximal femur, two of them were incomplete, only one was treated by prophylactic stabilization with cephalomedullary nailing. The other patient was treated with rest and off-loading for 45 days; in this case, the delay in the availability of surgical material represented a limitation for the choice of treatment. The rationale for surgical treatment in these patients is to perform a simple procedure and allow immediate weight-bearing and prevent a complex future procedure in the event of fracture collapse or displacement.

Incomplete fractures of the middle third can be treated noninvasively with a limited period of off-loading.[18] The three patients in our series were treated by immobilization with a long leg plaster cast and off-loading. All zone II complete fractures were treated with reduction and osteosynthesis with locking intramedullary nailing.

Currently, the retrograde or antegrade intramedullary nail is the method of choice for the resolution of femoral gunshot fractures.[19] In a systematic review, an overall rate of 0.18% of septic knee arthritis was found after retrograde intramedullary nail fixation.[20] The only case with this complication was a patient with a supracondylar fracture treated with retrograde intramedullary nailing.

The failure rate of retrograde nailing in distal femur fractures reaches 38% of cases, while the failure rate after osteosynthesis with LISS plate (*less invasive stabilizing system*) reaches 20%.[21]

Delayed union and nonunion may be related to the amount of bullet material retained near the fracture site, due to the cytotoxic effect of lead.[22] We believe that further studies are needed to demonstrate that removal of extra-articular impacted fragments outweighs the risk of inducing iatrogenic soft tissue damage. Our practice is to remove extra-articular bullet remnants only if they are accessible during initial superficial debridement, while we always remove intra-articular remnants (hip or knee), preferably arthroscopically.

Of the two fractures that evolved to pseudarthrosis (5.71%), one corresponded to zone II and the other to zone III. The first was treated with reaming of the canal and replacement of the nail with a larger diameter one, and radiographic signs of consolidation were observed at 14 weeks, while the second case was initially treated with retrograde intramedullary nailing as the only fixation method and later it was necessary to add a locking plate during surgical revision to achieve consolidation at 18 weeks. We believe that, in zone III fractures treated only with intramedullary nailing, insufficient distal locking and not using post screws are determining factors in the outcome. No retained bullet remains were detected in the radiographs or during surgery in either of these two cases.

Gunshot wounds to the extremities are associated with vascular injury in 10-17% of cases.[23] In our study, the percentage was 2.86%, since we limited ourselves to analyzing only femur fractures.

On the other hand, the osteomyelitis rate for Gustilo III high-energy femur fractures ranges from 3.3% to 4.2%.[24] One case (2.86%) of acute osteomyelitis confirmed by the isolation of methicillin-resistant *S. aureus* was detected in all bone samples taken during exploration of a wound with poor evolution. It was successfully treated with intramedullary nailing coated with polymethylmethacrylate with vancomycin plus targeted intravenous antibiotic therapy.

Regarding the time of antibiotic administration and the development of infectious complications (septic arthritis, 1 case; osteomyelitis, 1 case), the patients belonged to group 2 and group 3, respectively.

Johnson et al.[25] reported that patients with gunshot wounds do not comply with follow-up; in our study, only 55% attended their check-up at three months. The remaining 45% had a mean follow-up of two months (range 3-11 weeks). We believe that the main factors associated with incomplete follow-up could be age, short hospitalization, and non-compliance with medical instructions in the population studied.

The limitations of this study include its retrospective nature, and we believe that the absence of continuity in the follow-up of these patients made analyzing the problems in the medium and long term difficult.

CONCLUSIONS

90% of the patients in our series had involvement of zones II and III, so zone I was an infrequent region for this condition. For incomplete fractures in this area, prophylactic fixation is recommended.

Intramedullary nails are the best option for complete fractures in zones I and II, while in zone III, an individualized analysis of each pattern is required to choose the fixation method.

We believe that the early administration of antibiotics in the initial management and the correct selection of the final implant according to the affected area are essential to achieve good outcomes.

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

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Analysis of Patients with Vertebral Gunshot Injuries According to Return to Work

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ABSTRACT

Introduction: Firearm spinal injuries account for 13-17% of all traumatic spinal injuries, with varying clinical manifestations. The goal of this study was to examine the demographic and clinical-therapeutic characteristics of patients who suffered spinal injuries as a consequence of gunshots in the context of workplace incidents, based on how soon they could return to work. **Materials and Methods:** An analytic, observational, and retrospective study of patients with spinal injuries caused by firearms in workplace incidents between January 2012 and March 2022 was conducted. Variables associated with the incident, initial assessment, spinal injury, treatment, progression, and return to work were recorded. **Results:** Twenty-two individuals were evaluated (15 men and 7 women; mean age 32.5 years). 54% were law enforcement officers, yet 82% of the accidents happened on the job. 90% had associated injuries. Twelve (55%) required surgery, while ten (45%) required conservative treatment. 81% had complications. Twelve patients (54%) returned to work, one-third were requalified, and nine needed sick leave. Patients on permanent sick leave had a statistically significant relationship with chest topography (p = 0.005), severe neurological damage (p = 0.004), transfixing or penetrating injuries (p = 0.005), the need for chronic psychiatric treatment (p = 0.012), and more days of temporary incapacity for work (p = 0.001). **Conclusion:** In our series, permanent sick leave was associated with thoracic, transfixing, or penetrating injuries, severe neurological compromise, and the need for chronic clinical-pharmacological psychiatric treatment.

Keywords: Gunshot vertebral injuries; spine; return to work.

Level of Evidence: IV

Análisis de pacientes con lesiones vertebrales por proyectil de arma de fuego según el retorno laboral

RESUMEN

Introducción: Las lesiones vertebrales por arma de fuego representan el 13-17% de las lesiones vertebrales traumáticas con presentación clínica variable. El objetivo de este estudio fue comparar las características demográficas y clínico-terapéuticas de pacientes que sufrieron lesiones vertebrales por arma de fuego en el contexto de accidentes laborales, según la posibilidad de retorno laboral. **Materiales y Métodos:** Estudio analítico, observacional y retrospectivo de pacientes con lesión vertebral por arma de fuego en accidentes de trabajo, entre enero de 2012 y marzo de 2022. Se registraron variables sociodemográficas y relacionadas con el siniestro, la atención inicial, la lesión vertebral, el tratamiento, la evolución y el retorno laboral. **Resultados:** Se evaluó a 22 pacientes (15 hombres y 7 mujeres; media de la edad 32.5 años). El 54% eran trabajadores de fuerzas de seguridad; no obstante, el 82% de los accidentes se había producido *in itinere*. El 90% tenía lesiones asociadas. Doce (55%) requirieron cirugía y 10 (45%), tratamiento conservador. El 81% sufrió complicaciones. Doce (54%) regresaron al trabajo, un tercio fue recalificado y 9 requirieron la baja laboral. Se halló una asociación estadística entre pacientes con baja laboral permanente y topografía torácica (p = 0,005), daño neurológico severo (p = 0,004), incidencia transfixiante o penetrante (p = 0,005), requerimiento de tratamiento psiquiátrico crónico (p = 0,012) y más días de incapacidad laboral temporaria (p = 0,001). **Conclusión:** La baja laboral permanente se asoció con lesiones torácicas, transfixiantes o penetrantes, compromiso neurológico severo y requerimiento de tratamiento psiquiátrico clínico-farmacológico crónico.

Palabras clave: Heridas por proyectil de arma de fuego; columna vertebral; retorno laboral.

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INTRODUCTION

Spinal injuries caused by firearm projectiles have a wide range of presentations, from stable and paucisymptomatic vertebral fractures to potentially fatal lesions caused by neurological, vascular, or clinical involvement.[1,2] It is estimated that they represent 13-17% of traumatic spinal injuries; however, the incidence varies by country.[3]

They frequently occur in young adult patients, so their morbidity has a great social and economic impact, possibly related to potential sequelae that include chronic pain, neurological deficits, infections, and cerebrospinal fluid fistula, among others.[4,5]

The velocity of the projectile, the associated involvement of the abdominal viscera, the stability of the injury, the incidence of the projectile, and the involvement of the spinal canal are all factors to consider when classifying this type of spinal injury.[6,7] In our field, it is worth noting the NOPAL classification, an acronym in Spanish that summarizes the five components that this classification evaluates: neurological compromise (N), bone stability (O), incidence of projectile impact (P), associated injuries (A), and location of the spinal injury (L).[7]

Furthermore, injuries in the civilian population have been separated from those in the military population in the literature.[4,8] Injuries in the military population involve impacts from high-energy weapons (>2000 feet/second) that cause significant indirect injuries due to the effect of shock waves or cavitation. On the contrary, in the civilian population, they are usually from low-energy firearms, and tissue damage occurs mainly as a consequence of the impact of the projectile mass.[4,6,8]

The goal of this study was to examine the demographic and clinical-therapeutic characteristics of patients who sustained spinal injuries from a firearm projectile in the context of occupational accidents based on their ability to return to work.

MATERIALS AND METHODS

An analytical, observational and retrospective study was carried out on a series of patients with spinal injuries due to a gunshot wound in the context of a work accident, who were treated at an occupational disease referral center between January 2012 and March 2022.

The inclusion criteria were: patients of both sexes and >18 years of age with spinal injury due to a gunshot wound while the exclusion criteria were a follow-up <6 months and incomplete clinical and imaging records.

Data were obtained from the institution's medical records and image archives on the following study variables: 1) sociodemographic (age, sex, work, type of work accident); 2) related to the accident and initial care: place of initial care, delay from trauma to initial care at our institution, neurological status according to the *ASIA Impairment Scale* (AIS),[9] hemodynamic status, and Glasgow scale; 3) related to the spinal injury: number of projectiles, type/velocity of the projectile, entry and exit orifices, involvement of abdominal viscera, associated injuries, involved vertebrae, mechanical instability; projectile incidence according to the NOPAL classification,[7] and treatment (conservative, surgical); 4) related to the evolution and return to work: hospital days, days in the intensive care unit, days on mechanical ventilation, neurological status in the last follow-up according to the AIS, job requalification, temporary work incapacity, complications, need for chronic psychiatric treatment (contemplating those patients with regular psychiatric care and who received medication for acute post-traumatic stress).

In terms of mechanical instability, there is no agreement in the literature on how to define instability in spinal injuries induced by a firearm projectile; similarly, applying the same criteria as for blunt force trauma fractures is problematic.[10,11] For this reason, in the imaging analysis, fractures showing signs of displacement, ligament involvement, bilateral involvement of pedicles, or articular facets were considered unstable (Figure 1).[11]

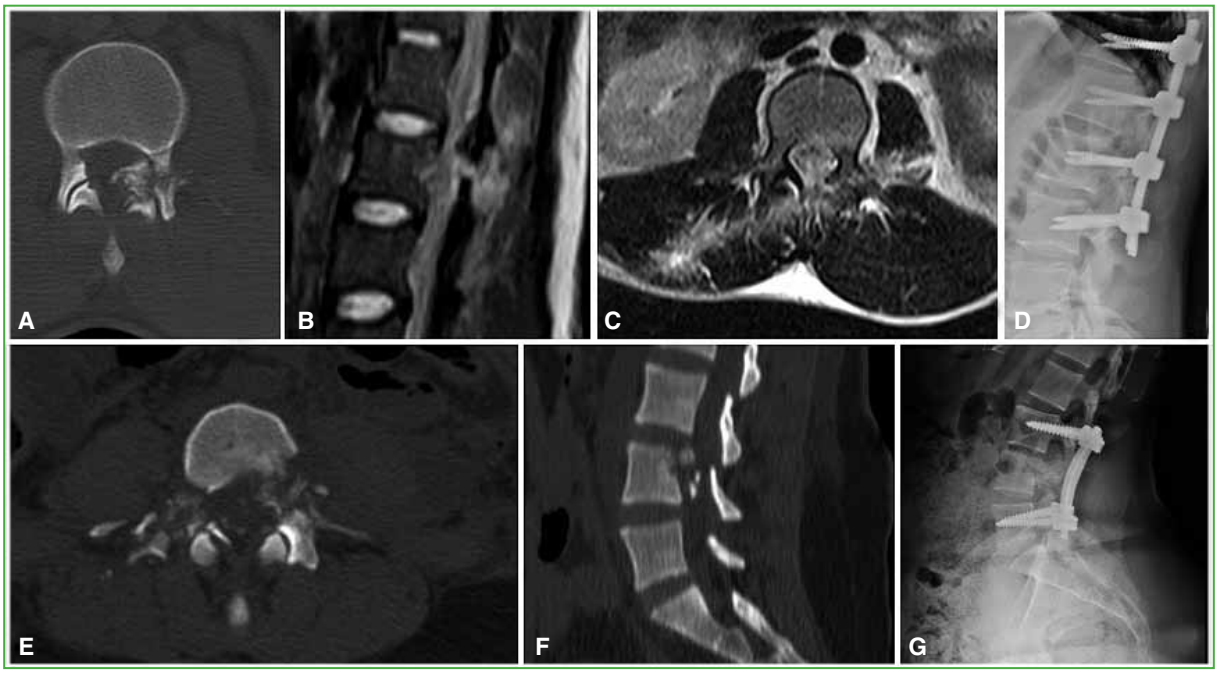

Figure 1. Spinal fractures interpreted as mechanically unstable. **A-D.** Facet fracture and injury to the posterior ligamentous complex. **E-G.** Bilateral fracture of the pedicles and left facet.

Statistical Analysis

Categorical variables were expressed as numbers and percentages, and were analyzed using the chi-squared test or Fisher's test. The interval variables are described with mean and median, according to their distribution and their measures of dispersion, standard deviation (SD), and minimum-maximum interval For the comparison of continuous variables, the Student's t test or the Mann-Whitney U test was used, according to the distribution expressed. A p-value <0.05 was considered statistically significant. For the analysis, the SPSS Statics 25 program was used.

RESULTS

Twenty-two patients with spinal injuries due to firearm projectiles treated at our center during the study period were included. The mean age was 32.5 (SD ± 9), 15 (68.2%) patients were men and 7 (31.8%) were women. Figure 2 shows the topography of the vertebral wounds, in which the thoracic spine predominated (41%). Three patients (13%) had a high cervical spine injury.

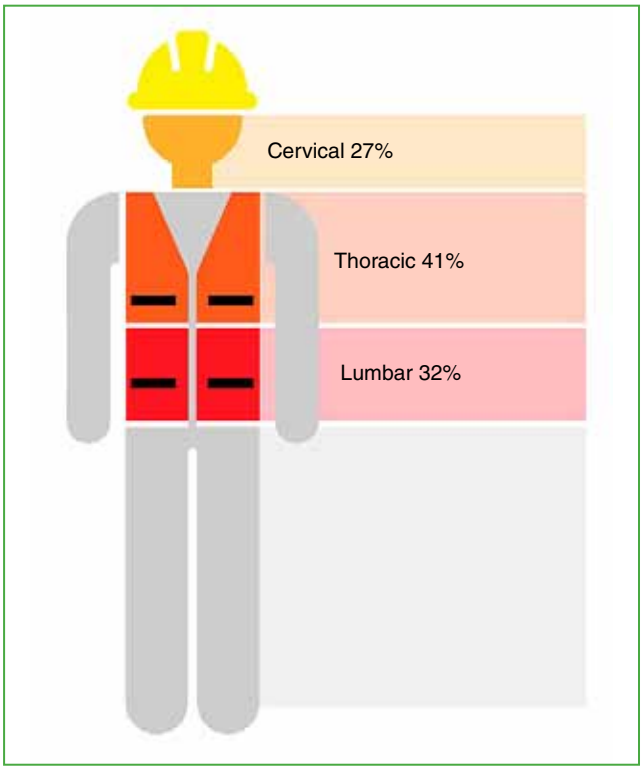

Figure 2. Topography of spinal injuries caused by firearm projectiles in our series.

When describing the sample considering the trauma as an occupational accident, it should be noted that all the patients were referred from other centers (n = 22) where they received initial trauma care and all were referred from public institutions. The median delay from trauma to care at our institution was 12.5 hours (min-max = 1-198). 54% (n = 12) were law enforcement workers (police); however, 82% (n = 18) of the cases were *commuting* accidents and 20 patients suffered an injury from a firearm projectile unrelated to their work activity (assault, n = 19; suicide attempt, = 1) (Figure 3).

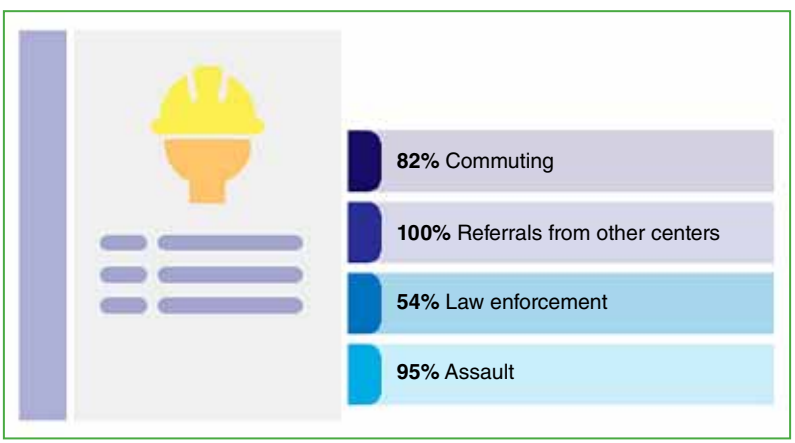

Figure 3. Characteristics of spinal injuries caused by a firearm projectile as a work accident.

The morbidity associated with trauma in the patients in our sample was high: 15 (68%) had a neurological injury, 20 (90%) had associated injuries, nine (40%) had a Glasgow scale <8 on admission, seven (30%) had hollow abdominal viscera perforation, and four (18%) had hemodynamic instability. Specific associated injuries were: fractures (n = 10; 45%), single or multiple abdominal viscera injury (n = 9; 41%), hemothorax (n = 8; 36%), gastrointestinal hollow viscera perforation (n = 7; 27%), lung injury (n = 6; 27%), vascular injury (n = 5; 23%), peripheral neurological injury (n = 3; 14%), maxillofacial trauma (n = 3; 14%), diaphragmatic injury (n = 2; 9%), penetrating skull trauma (n = 1; 5%), tracheal injury (n = 1; 5%).

All cases were the result of attacks by low-velocity projectiles. The entry site was the thorax in 45% (n = 10) of the patients, followed by head and neck (n = 7; 32%). A projectile exit wound was not recorded in 12 cases (54%). The incidence of the projectile was predominantly non-penetrating (n = 7; 32%) or transfixing (n = 6; 27%); followed by penetrating-tangential in five cases (23%) and penetrating in four (18%). In five (23%) patients, the projectile (n = 4) or its fragments (n = 1) were found lodged in the spinal canal. The spinal lesion was considered unstable in six (27%) cases. The description of the sample is summarized in Table 1.

According to the treatment of the spinal lesion, 12 (55%) patients underwent surgery and 10 (45%) received conservative treatment. Two patients with cervical spine injuries wore a halo vest. The median number of total surgeries per patient (including those not related to the spinal injury) was three (min-max = 0-8). The median hospital stay was 26 days (min-max = 7-123), and the median number of days in the intensive care unit was 20 (min-max = 0-63); nine patients required mechanical ventilation, with a median 3 ventilation days (min-max = 1-48).

81% (n = 17) suffered complications. The majority (n = 16; 73%) received chronic treatment with drugs and psychiatric care in inpatient and outpatient settings due to stress associated with trauma (acute stress reaction), the other most frequent complications were neuropathic pain (12 patients, 54%) and infectious diseases (9 patients, 41%). In three (13.5%) cases, the infections were directly related to the gunshot wound: one (4.5%) retroperitoneal abscess secondary to gastrointestinal perforation, one (4.5%) empyema secondary to traumatic hemothorax, and one (4.5%) mediastinitis due to esophageal perforation. The rest were urinary tract infections (n = 5; 22.7%); pneumonia associated with mechanical ventilation (n = 2; 9%), bacteremia (n = 1; 4.5%) and soft tissue infection (n = 1; 4.5%). Almost half of the patients (n = 10; 45%) were readmitted for treatment of a complication related to the accident.

Table 1. Sample description

Variables		Results	
Age, mean (SD)		32.5	(9)
Sex, n (%)	Male	15	(68.2)
	Female	7	(31.8)
Topography, n (%)	High cervical	3	(13.6)
	Subaxial cervical	3	(13.6)
	Thoracic	9	(40.9)
	Lumbar	7	(31.8)
Neurological lesion, n (%)	No	7	(31.8)
	Spinal cord injury	10	(45.5)
	Cauda equina	2	(9.1)
	Root lesion	3	(13.6)
Initial AIS, n (%)	A	6	(27.3)
	C	5	(22.7)
	D	1	(4.5)
	E.	10	(45.5)
Glasgow Scale <8, n (%)		9	(40.9)
Hemodynamic instability, n (%)		4	(18.2)
Projectile type, n (%)	Low speed	22	(100)
Projectile(s) (number), median (min-max)		1	(1-3)
Entry orifice, n (%)	Head and neck	7	(31.8)
	Chest	10	(45.5)
	Abdomen and pelvis	5	(22.7)
Exit orifice, n (%)	Head and neck	2	(9.1)
	Abdomen and pelvis	8	(36.4)
	Without exit orifice	12	(54.5)
Projectile incidence (NOPAL classification)	Transfixing	6	(27.3)
	Penetrating	4	(18.2)
	Penetrating-tangential	5	(22.7)
	Non-penetrating	7	(31.8)
Gastrointestinal perforation		7	(31.8)
Associated injuries		20	(90.9)
Mechanical instability		6	(27.3)
Projectile or fragments in spinal canal.		5	(22.7)

AIS = *ASIA Impairment Scale*; SD = standard deviation; min-max = minimum-maximum.

41% (n = 9) required referral to rehabilitation centers (tertiary care). Twelve (45%) patients suffered some degree of neurological sequelae (AIS A n = 6; AIS C n = 3 and AIS D n = 3) and eight (36%) suffered from neurogenic bladder (Table 2).

Table 2. Treatment and evolution

Variables		Results	
Treatment of the spinal lesion, n (%)	Conservative	10	(45.5)
	Surgical	12	(54.5)
Surgical delay in hours, median (min-max)		307	(12-1272)
Total surgeries, median (min.-max.)		3	(0-8)
Complications, n (%)		17	(81)
Days in intensive care, median (min.-max.)		20	(0-63)
Mechanical ventilation, n (%)		9	(41)
Days on mechanical ventilation, median (min-max)		3	(1-48)
Days of hospitalization, median (min.-max.)		26	(7-123)
Psychiatric treatment, n (%)		16	(72,7)
Tertiary care admission		9	(41)
Readmissions, median (min.-max.)		0	(0-10)

min-max = minimum-maximum.

Regarding the impact on work activity, 12 (54%) patients returned to work and a third of them (n = 4) had to be reclassified. The median of temporary incapacity for work was 572 days (min.-max. 72-3614), with a great dispersion as a consequence of the fact that nine (n = 41) patients required permanent sick leave with outpatient follow-up due to the severity of the sequelae (Table 3).

Table 3. Return to work (days)

Variables		Results	
Return to work (days)		12	(54.5)
TWI (days), median (min-max)		575	(72-3614)
Reclassification, n (%)	No	8	(36.4)
	Yes	4	(18.2)
	Ambulatory with sick leave	9	(40.9)
	Without specialty discharge	1	(4.5)

TWI = temporary work incapacity; min-max = minimum-maximum.

Patients with definitive discharge from spinal injury (n = 21; 95%) were grouped based on return to work for their comparison (return to work n = 12; permanent sick leave n = 9). In our sample, patients with permanent sick leave were associated, in a statistically significant way, with chest topography (p = 0.005), severe neurological damage according to the AIS (AIS A, B or C) (p = 0.004), transfixing or penetrating wound (p = 0.005), chronic psychiatric treatment (p = 0.012) and days of temporary incapacity for work (p = 0.001) (Table 4).

Table 4. Comparison according to return to work.

	Return to work (days)		p
	Yes = 12	No = 9*	
Age, mean (SD)	32 (11)	34 (6)	0.589
Sex, n (%)			
Male	8 (67)	6 (67)	1.000
Female	4 (33)	3 (33)	
Topography, n (%)			
Cervical	5 (42)	1 (11)	0.296
Thoracic	2 (16)	7 (78)	**0.005**
Lumbar	5 (42)	1 (11)	0.125
Neurological lesion, n (%)	6 (50)	8 (89)	0.061
AIS (A/B/C vs. D/E), n (%)			
A/B/C	3 (25)	8 (89)	**0.004**
D/E	9 (75)	1 (11)	
Glasgow Scale <8, n (%)	5 (42)	4 (44)	0.899
Hemodynamic instability, n (%)	1 (8)	3 (33)	0.149
Associated injuries, n (%)	11 (92)	9 (100)	0.375
Mechanical instability, n (%)	2 (17)	4 (44)	0.163
Projectile in the spinal canal, n (%)	1 (8)	3 (33)	0.149
Projectile incidence, n (%)			
Transfixing/penetrating	2 (17)	7 (78)	**0.005**
Penetrating-tangential or non-penetrating	10 (83)	2 (22)	
Gastrointestinal perforation	4 (33)	3 (33)	1.000
Total surgeries, mean (SD)	3 (2.5)	4 (2.1)	0.402
Complications, n (%)	8 (67)	9 (100)	0.089
Days in intensive care, median (min.-max.)	11 (0-40)	24 (2-63)	0.129
Mechanical ventilation, n (%)	5 (42)	4 (44)	0.899
Days of hospitalization, median (min.-max.)	25 (7-130)	44 (18-97)	0.382
Psychiatric treatment, n (%)	6 (50)	9 (100)	**0.012**
Readmission, n (%)	4 (33)	5 (55)	0.309
TWI, median (min-max)	349 (72-1707)	1507 (459-3614)	**0.001**

*For the purposes of comparison, a patient without return to work was excluded because he was not discharged at the last follow-up.
SD = standard deviation; AIS = *ASIA Impairment Scale*; TWI = temporary work incapacity.

DISCUSSION

Latin America is the continent with the highest homicide rate according to international records.[12] Our country is no stranger to this reality. In Argentina, there were 2,416 fatalities from intentional homicides in 2020, with a rate of 5.3 victims per 100,000 inhabitants, which represents the third leading cause of violent death in our environment after suicide and road traffic accidents. 38.5% of the deaths are concentrated in the province of Buenos Aires, the most violent in the country. 50% of homicides are by gunshots.[13]

Spinal fractures caused by gunshots represent 13-17% of traumatic spinal injuries and, in the case of the civilian population, they occur more frequently in young men of working age, with a significant socioeconomic impact.[6-8,10,11] The demographic characteristics of our sample coincide with those recorded in the literature, with a predominance of male victims (68%) and a mean age of 32.5 years.

Our study retrospectively evaluated a specific subgroup of patients who suffered penetrating injuries from a firearm in the context of an occupational accident, and who were treated under the coverage of the occupational risk insurance system. It should be noted that, although 54% of the injured worked in jobs with the use of weapons, most of the accidents were *in itinere* (82%), that is, outside the workplace and as a consequence of violent attacks when commuting from home to work, and vice versa.

Due to the characteristics of the health system in our country, primary trauma care in all cases was carried out by public system providers and patients were referred to our institution for definitive treatment with an unavoidable delay (median 12.5 h). However, a large dispersion of this variable was recorded, ranging from 1 to 198 hours.

In line with other publications, spinal injuries were predominantly thoracic (41%) and 90% of patients had associated injuries with a predominance of fractures in other bones, injuries to solid and hollow abdominal viscera, and hemothorax.[6,10] There is consensus in the literature on the early initiation of broad-spectrum antibiotic treatment in patients with fractures induced by a firearm projectile, particularly when perforation of the gastrointestinal viscera is present.[6,10] In our series, two patients suffered infectious complications associated with perforation of the colon and esophagus, regardless of the initial antibiotic prophylaxis. 27% had a perforation of hollow abdominal viscera, a rate similar to that reported in the literature (23.7%).[6]

Surgical treatment is still controversial. The indications in most published studies include decompression of patients with incomplete or progressive neurological deficits, removal of projectile or bone splinters at the cauda equina level, stabilization of unstable lesions, and approach to dural fistulas.[6-8,10,11] In our series, 54% had a neurological injury, with a predominance of spinal cord injuries (45%) and stable fractures (73%). In five patients, the projectile or its fragments were lodged in the spinal canal.

The magnitude of the morbidity of the patients included in our study is reflected in the distribution of patients with permanent sick leave (41%; n = 9). The comparison of groups based on return to work allowed us to attain a higher level of characterization of this subgroup, estimating a strong relationship with thoracic spine transfixing or penetrating injuries, as well as severe neurological injury (AIS A, B, or C). It is also worth noting that these patients had a much higher requirement for clinical-pharmacological psychiatric treatment. All required hospitalization in rehabilitation or tertiary care centers and with a statistically significant difference in the days of temporary incapacity for work. Under the work risk insurance system, this created a subset of patients that required a high consumption of health resources.

The weakness of our study is its retrospective nature with a small sample of cases treated in a single center, which prevents drawing generalizable conclusions. However, it represents the description of a specific subgroup of patients with gunshot wounds in the context of occupational accidents. This population is not well explored in the literature, which confers hierarchy and interest to the research.

CONCLUSIONS

In our study, patients with spinal injuries caused by firearm projectiles in the setting of occupational accidents had significant morbidity linked with the initial trauma, as well as related injuries and frequent complications. Thoracic fractures and mechanically stable injuries predominated. Permanent sick leave was associated with thoracic, transfixing or penetrating injuries, with severe neurological compromise and the requirement of chronic clinical-pharmacological psychiatric treatment.

Conflict of interest: Ricciardi GA is section editor of the Journal of the Asociación Argentina de Ortopedia y Traumatología. No other conflicts of interest to declare.

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Facet and Selective Nerve Root Blocks as a Diagnostic and Therapeutic Alternative in Patients with Chronic Low Back Pain

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ABSTRACT

Introduction: Intra-articular facet blocks and selective nerve root blocks are useful as a diagnostic and therapeutic method for the management of chronic low back pain. The objective of this study was to describe and analyze the results of these blocks. **Materials and Methods:** A retrospective cohort study was conducted with data from patients undergoing CT-guided intra-articular facet block and selective nerve root block between January 2014 and February 2015. The demographic information, the visual analog scale's score before and after the block, and their relationships to the outcomes were analyzed. **Results:** The study included 68 patients with intra-articular facet block and 89 with selective nerve root block. In both groups, pain improved significantly ($p < 0.05$). There was an association between the improvement in pain with intra-articular facet blocks and gender and age, and between the improvement achieved by selective nerve root blocks and the type of initial pain. **Conclusions:** Intra-articular facet blocks and selective nerve root blocks are a useful diagnostic method in the management of chronic low back pain and their therapeutic action is significant, although studies are needed to know their analgesic effect in the medium and long term, in order to improve the quality of life of patients.
Keywords: Low back pain; facet block; selective nerve root block; computed tomography; radioscopy.
Level of Evidence: IV

Bloqueos facetarios y radiculares selectivos como alternativa diagnóstica y terapéutica en pacientes con dolor lumbar crónico

RESUMEN

Introducción: Los bloqueos facetarios intrarticulares y radiculares selectivos son útiles como método diagnóstico y terapéutico para el manejo del dolor lumbar crónico. El objetivo de este estudio fue describir y analizar los resultados de dichos bloqueos. **Materiales y Métodos:** Se realizó un estudio de cohorte retrospectivo con datos de pacientes sometidos a bloqueos facetarios intrarticulares y radiculares selectivos guiados por tomografía computarizada, entre enero de 2014 y febrero de 2015. Se analizaron los datos demográficos, el puntaje en la escala analógica visual antes del bloqueo y después, y se analizó la asociación de estos factores con los resultados. **Resultados:** El estudio incluyó a 68 pacientes con bloqueo facetario intrarticular y 89 con bloqueo radicular selectivo. En ambos grupos, el dolor mejoró significativamente ($p < 0,05$). Hubo una asociación entre la mejoría del dolor con los bloqueos facetarios intrarticulares y el sexo y la edad, y entre la mejoría lograda por los bloqueos radiculares selectivos y el tipo de dolor inicial. **Conclusiones:** Los bloqueos facetarios intrarticulares y los bloqueos radiculares selectivos son un método diagnóstico útil en el manejo del dolor lumbar crónico y su acción terapéutica es significativa, aunque hacen falta estudios para conocer su efecto analgésico a mediano y largo plazo, y así poder mejorar la calidad de vida de los pacientes.
Palabras clave: Lumbalgia; bloqueo facetario; bloqueo radicular selectivo; tomografía computarizada; radioscopia.
Nivel de Evidencia: IV

INTRODUCTION

Low back pain is considered one of the main reasons for consultation in emergency services and general and specialized medical consultation; it is presumed that two-thirds of adults will experience an episode of low back pain in their lifetime.[1] For this reason, it continues to be an entity that requires a great economic demand and an important use of health resources for health systems.[2]

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The causes of chronic low back pain are mainly mechanical and are related to degenerative facet and disc disease.[3] The facets are innervated by the medial branches of the posterior rami of the spinal nerves, which provide sensory innervation. Capsular distension due to inflammation of these joints stimulates the nociceptive endings and causes low back pain.[4] On the other hand, disc disease can generate mechanical compression of the nerve roots, triggering an inflammatory cascade that affects the transmission of the spinal nerves and, in this way, causes pain with a dermatomeric pattern (radicular pain).[5]

The precise diagnosis of the etiology of low back pain is often inconclusive, and neither clinical evaluation nor complementary studies are sufficient to reach the diagnosis. In turn, the treatment of this condition is still under discussion, and there are numerous articles with variable evidence that propose different alternatives.[6]

Intra-articular facet blocks (IFB) and selective nerve root blocks (SNRB) have the primary goal of confirming the etiology of pain and, as a secondary goal, alleviating or eliminating pain caused by the structures to be injected. The indications for both blocks are not comparable.

The objective of this study was to describe and analyze the outcomes of IFB and SNRB in the diagnosis and treatment of low back and radicular pain, and to analyze possible factors that influence these outcomes.

MATERIALS AND METHODS

A retrospective cohort study was conducted with data from patients who underwent IFB and SNRB guided by computed tomography between January 2014 and February 2015.

Patients with chronic low back pain (>12 weeks) of mechanical origin unresponsive to analgesics and who underwent computed tomography-guided percutaneous blocks were included. An IFB was used in patients who had non-radiating pain, symptoms that worsened with spine extension, and images suggestive of degenerative facet disease (joint space narrowing, osteophytes, subchondral cysts, facet hydrarthrosis); SNRBs were used in patients who had radicular pain, and magnetic resonance imaging of foraminal or extraforaminal hernia that coincided with clinical signs.

Patients with other causes of low back pain and a history of spinal surgery were excluded.

All were subjected to the same block technique described below; the choice of the type of block was determined by the complementary studies.

Technique for blocking

The technique for the blocks is performed with the patient in the prone position, on the CT scan table. First, a bone scan is taken and the area to be blocked is identified (articular facet in the IFB and foramen in the SNRB) in the axial slices. The distance on the skin surface from the midline to the area to be blocked (facet or corresponding foramen) and the distance from this point in depth to the area to be blocked are measured. Skin antisepsis is carried out. Skin anesthesia is administered to the entry site with 2% lidocaine. Then, pencil-point needles for spinal anesthesia (25 or 27G in diameter) are placed, following the orientation and previous measurements. Tomographic control is carried out to confirm the location and, if necessary, rearrange the needles. 1 ml of the anesthetic agent (2% lidocaine) and 1 ml of depot corticosteroids (6 mg/ml betamethasone acetate + 7.8 mg/ml betamethasone sodium phosphate) are instilled. Finally the needle is withdrawn and the entry point is covered after applying the antiseptic.

Variables and statistical analysis

The patients were divided according to the intervention: IFB group and SNRB group. Demographic data such as gender, age (≤45 years and >45 years), and comorbidities were recorded. The injected site and whether the block was unilateral or bilateral were also taken into account.

The visual analog scale (VAS) score for pain was recorded before the block and a second record was obtained after the procedure, before the patient left the institution (we told them to stay in the institution 20-40 min to monitor adverse effects). A decrease in the initial VAS score was considered a positive outcome, and a decrease of 5 points or more in that value was considered a significant improvement.

Firstly, the results of the blocks were analyzed by evaluating the VAS score before and after, and observing if there was a significant decrease in pain using the Student's t-test for related variables. Then, the association between the significant improvement in pain and the sex and age of the patients was analyzed using the chi-square test, as well as whether the initial VAS score (disabling pain with scores ≥8, and non-invalidating with values <8) influenced the results. For the analysis of the variables, the IBM SPSS Static 26.0® program was used.

RESULTS

A total of 157 patients were included, 68 with IFB (69.4% were >45 years) and 89 with SNRB (82% >45 years) (Figure 1).

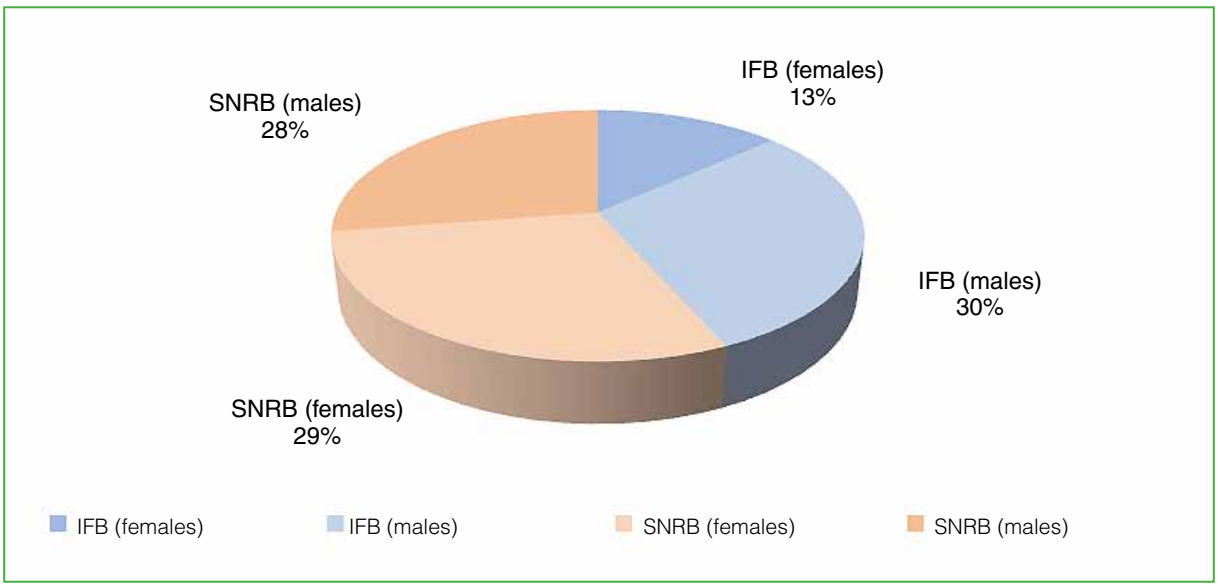

Figure 1. Distribution of patients according to the intervention (intra-articular facet block and selective nerve root block) and sex.

The most frequent intervention sites were segments L5-S1 (52.9%) and L4-L5 (39.7%), followed by L2-L3 (4.4%) and L3-L4 (2.9%) in the IFB group (8 unilateral and 60 bilateral) and segments L5-S1 (41.5%), L4-L5 (39.3%), followed by L3-L4 (13.5%), L2-L3 (3.3%) and L1-L2 (2.2%) in the SNRB group (83 unilateral and 6 bilateral).

With respect to the IFB data analysis, the average VAS score was 8.14 before the block and 3.39 after. In 91% of the patients in the group (61 individuals), the initial score decreased and 65.5% of them (40 patients) had a statistically significant improvement ($p < 0.05$) (Figure 2). A relationship was found between the improvement in pain and the variables sex and age (the results were better in the group >45 years and in the female sex).

Mean VAS scores in the SNRB group were similar: 8.15 before the procedure and 3.68 after it. 87% (79 patients) obtained scores lower than the initial ones and, of these, 69.6% (55 patients) had a significant improvement (Figure 2). This initial pain improvement was also statistically significant ($p < 0.05$). Unlike the previous group, there was an association between the initial VAS score and the improvement after the block (patients with initial disabling pain obtained better results). However, no statistically significant relationship was found between the improvement in pain and the variables of sex and age.

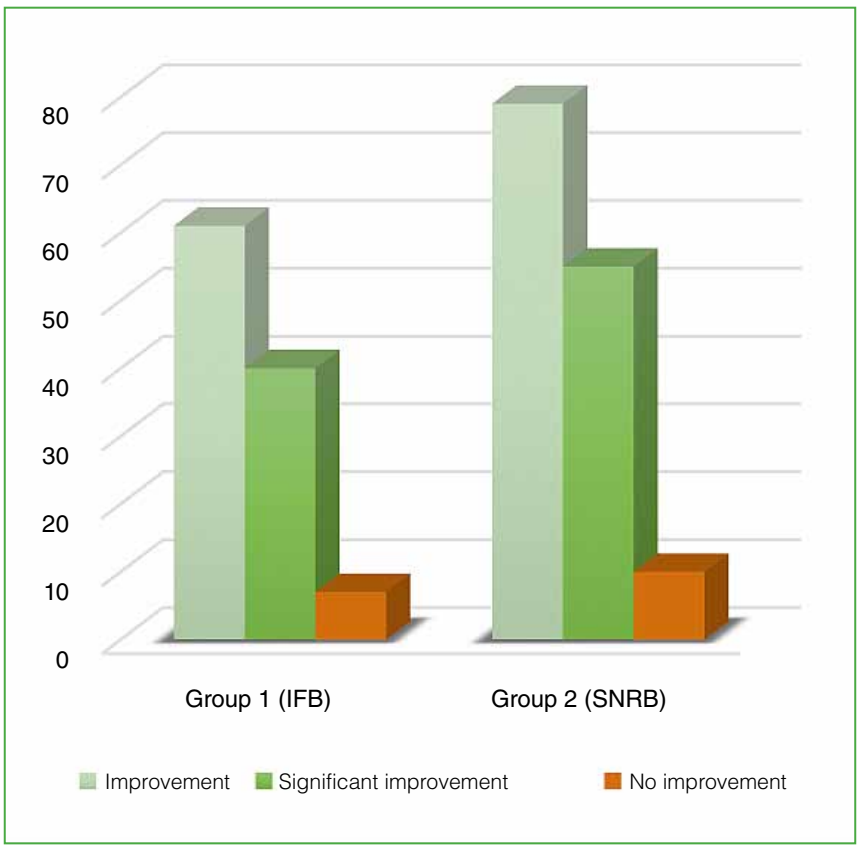

Figure 2. Operated patients with favorable outcomes (pain improvement or significant improvement) and unfavorable outcomes (no pain improvement).

DISCUSSION

Low back pain usually manifests as acute pain lasting <4 weeks, subacute pain lasting 4 to 12 weeks, and chronic pain lasting more than 12 weeks.[7] Traditionally, it was accepted that the episodes were brief; however, this notion has been called into question as a high number of patients experience recurrences. It is estimated that low back pain can persist for a year or more after the first episode in 35-60% of patients,[8] therefore, in these cases, it is important to identify the cause of the pain in order to administer targeted treatment.

Facet blocks work by injecting an anesthetic agent and corticosteroids into the facet joint to relieve pain, whereas radicular blocks work by injecting drugs into the nerve root to lessen inflammation and hence the intensity of radicular pain.[9,10] The main objective is to diagnose the anatomical cause of pain and identify the area to be operated on. The secondary goal is to provide analgesia and a better quality of life to patients who are not candidates for surgical treatment, reducing the use of analgesics and maintaining work activities.[5,11] Traditionally, blocks were performed using anatomical repairs or were guided by fluoroscopy, but with computed tomography, not only is the required level correctly obtained, but essential structures are also avoided due to improved vision and precision.[12] In our study, all patients underwent CT-guided percutaneous blocks. In 91% of the patients with IFB and 87% with SNRB, the symptoms improved, so it is assumed that said inoculated structure was the one causing the low back pain. In turn, 65.6% and 69.6%, respectively, had a significant improvement in pain, so an analgesic effect was also obtained.

Regarding the results that have been published, in a prospective study of 76 patients, Kanaan et al.[13] reported that surgical treatment could be avoided in 54% of patients undergoing SNRB, and that pain was relieved in the long term in 29% of them. On the other hand, in their systematic review of 108 articles, Viswanathan et al.[14] conclude that SNRB obtains good outcomes in 78-88% of patients, and there are factors that influence these outcomes, such as the duration and severity of symptoms, or imaging factors such as osteoporosis, location, size and type of disc disease.

Regarding IFBs, in a systematic review by Cohen et al.,[15] it is pointed out that, despite the fact that some articles do not confirm the efficacy of intra-articular injections with corticosteroids, others report that said intervention can alleviate pain, at least in the first three months, in 75% of patients. In a retrospective study with 323 patients, Ospina et al.[16] found symptomatic improvement in 78% of patients and considered IFBs an effective diagnostic and therapeutic method.

In our research, we obtained a significant sample and were able to affirm our main study hypothesis, confirming that the blocks are a useful diagnostic tool and, in some cases, have therapeutic action. In turn, it was possible to analyze the different factors that influence the results, such as the sex, age and intensity of pain of the patients. We believe that prospective studies with medium- and long-term analyses are still needed, but this research opens the way to new questions oriented mainly to the selection of patients to be operated on.

CONCLUSION

The IFBs and the SNRBs were useful diagnostic methods in the management of chronic low back pain and had a significant therapeutic action in the short term, although studies are needed to determine their analgesic action in the medium and long term and thus be able to achieve an improvement in the quality of life of these patients.

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

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Magnetically-Controlled Growing Rods. Outcomes and Complications

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ABSTRACT

Introduction: Magnetic Expansion Control (MAGEC) Spinal Growing Rods are a novel treatment for early-onset scoliosis (EOS). Although its efficacy is supported by the literature, it is not without complications. **Materials and Methods:** The aim of this study was to retrospectively analyze a series of 37 cases treated with MAGEC between 2014 to 2019. We performed a retrospective study and divided the population into two groups: GI (primary procedures with MAGEC) and GII (conversions from traditional system to MAGEC). **Results:** The study included 19 girls and 18 boys with a mean age of 8 years and a variety of etiologies. The average postoperative follow-up time for Group I (n=28) and Group II (n=9) was 3.6 years. The average preoperative angular value (AV) of scoliosis was 64° (39°-101°) and kyphosis 51° (7°-81°). The postoperative scoliosis AV was 41º (17°-80°) and kyphosis 34° (7°-82°). We found 2 rod ruptures and one proximal union kyphosis, two proximal screw loosenings, one MAGEC distraction system failure, and one surgical site infection. **Conclusions:** Although our preliminary results are short term, they suggest that MAGEC could be an effective method.

Keywords: Early onset scoliosis; magnetic controlled growth rods; scoliosis; pediatric spine surgery; spinal deformity.
Level of Evidence: IV

Sistema de barras magnéticas. Resultados y complicaciones

RESUMEN

Introducción: El uso de sistema de barras magnéticas para el tratamiento de la escoliosis de comienzo temprano es un método utilizado en los últimos 10 años; su eficacia está respaldada por la bibliografía, pero no está exento de complicaciones. **Objetivo:** Analizar retrospectivamente una serie de 37 pacientes tratados con barras magnéticas en escoliosis de comienzo temprano. **Materiales y Métodos:** Se realizó un estudio retrospectivo entre 2014 y 2019. Se dividió a los pacientes en: grupo 1 (procedimientos primarios con barras magnéticas) y grupo 2 (conversiones de sistema tradicional a barras magnéticas). **Resultados:** Se incluyó a 19 niñas y 18 niños (edad promedio 8 años al operarse), las etiologías fueron variadas. Entre el grupo 1 (n = 28) y el grupo 2 (n = 9), el seguimiento promedio posoperatorio fue de 3.6 años. El valor angular promedio preoperatorio de escoliosis era de 64° (rango 39°-101°) y el de cifosis, de 51° (rango 7°-81°). El valor angular promedio de escoliosis en el posoperatorio inmediato fue de 41° (rango 17°-80°) y el de cifosis, de 34° (rango 7°-82°). Se produjeron 2 roturas de barra y una cifosis de unión proximal, 2 aflojamientos de tornillos proximales, una falla del sistema de distracción de barras magnéticas y una infección del sitio quirúrgico. **Conclusiones:** Nuestros resultados preliminares, aunque son a corto plazo, sugieren que la barra magnética podría ser un método eficaz en este tipo de enfermedad.

Palabras clave: Escoliosis; comienzo temprano; barras de crecimiento controlado magnéticamente; cirugía; columna; deformidad de columna; pediatría.
Nivel de Evidencia: IV

INTRODUCTION

Scoliosis in children <10 years of age is defined as early-onset scoliosis (EOS),[1,2] and may have a neuromuscular, syndromic, congenital, or idiopathic origin.[3] Its natural progression would possibly lead to severe progression of the scoliotic or kyphotic curve and compromise the development of growing organs, most frequently the lungs and heart.[4,5] This alteration motivates an early treatment protocol to stop the progression of the deformity and achieve physiological development.[6]

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Under normal conditions, the physiological development of the thorax and its contents occurs with a variable rate of growth that extends from birth to skeletal maturity.[7] Early spinal fusion surgery results in potential loss of spinal growth. The international literature suggests to avoid it, even more so when it involves the growing thoracic spine, due to the possibility of restriction of the development of the rib cage during the growth of the skeletally immature child.[8] Multiple orthopedic and surgical techniques with instrumentation of the spine or without this procedure try to modulate the growth of the deformed spine, as well as the development of the thoracic cage and its contents.[9] Yang et al. described the use of classifications to opt for a certain treatment,[10] although the various causes of EOS continue to be a challenge when selecting an appropriate treatment for each particular patient.

The term "growth-guided" or "growth-friendly" refers to a method of instrumenting the spine that allows for the development of the rib cage, abdomen, and pelvis in young patients.[11,12] In 2019, Cheung et al. published the first series of EOS patients treated with magnetically controlled growing rods (MCGR).[13] As of 2014, the US Food and Drug Administration authorized the use of the MCGR system (MCGR Magnetically Controlled Growing Rods; NuVasive, CA, USA).[13,14] Since then, our institution began using MCGRs to treat EOS. Other authors have published encouraging results with this technique, and highlight the possibility of reducing the number of successive distractions in the operating room.[14,15] Choi et al., and Obid et al. highlighted the advantage of being able to control the progression of the scoliotic curve in an effective and non-invasive manner, after the first surgery.[15,16] Once the system is placed by conventional surgery, subsequent monitoring and distraction are performed on an outpatient basis, and consequently could not only decrease the number of surgeries and complications, and hospital cost, but also improve the child's quality of life.[17,18]

MCGRs, however, are not without complications as compared to standard growth-guided systems. Their short period of use and follow-up does not produce certainty about the full profile of potential complications, either intrinsic to the mechanical system or for inherent causes, as other forms of instrumentation do.

The aim of this study was to retrospectively evaluate our experience in a series of EOS patients treated with the MCGR system during an average follow-up of three years.

MATERIALS AND METHODS

Thirty-seven children diagnosed with EOS were retrospectively evaluated at a tertiary level institution. The MCGR system was used in a conventional surgery, four *senior* surgeons were in charge of the interventions between 2014 and 2020.

The inclusion criteria were: patients with EOS operated with MCGR and complete clinical records and pre- and postoperative imaging studies. The exclusion criteria were: patients with EOS treated with other methods, previous thoracic/abdominal surgery, and a history of infections or thoracoabdominal tumors.

Using full-length spine radiographs, variations in the Cobb angle of the main scoliotic curve and the kyphosis/lordosis angle were analyzed before and after MCGR placement (n = 37).

Variations of T1-T12 and T1-S1 distance on scale were recorded. Distances from T1 to T12 and from T1 to S1 were defined as the distances between the line parallel to the superior endplate of T1 and inferior to T12, and superior to T1 and superior to S1 on a posteroanterior spine radiograph, respectively. The types of construction systems and the levels of fixation were documented.

RESULTS

37 patients were evaluated, 19 girls and 18 boys, with a mean age of 8.2 years at the time of surgery (range 4-12). The etiologies of EOS were: neuromuscular scoliosis (spinal cord atrophy, myopathic, chronic non-developing encephalopathies) (17 patients), syndromic scoliosis (Silver-Rusell, William, Prader-Willi, Escobar, Marfan, neurofibromatosis, genetic, skeletal dysplasia) (14 patients), infantile idiopathic scoliosis (3 patients), congenital scoliosis (3 patients) (Figure 1).

Conversions to MCGR were performed in patients with syndromic scoliosis (6 cases), congenital scoliosis (1 case), neuropathic scoliosis (1 case), and another with idiopathic infantile scoliosis treated from the age of 2 with a plaster corset under anesthesia, successive thermoplastic corsets, and traditional growth rods, after the possibility of elongation was exhausted. (Figure 2).

The decision to use double-rod (n = 22) and single-rod (n = 15) MCGR constructions was based on height, weight, soft tissue coverage, and condition severity. The average of instrumented levels was 5.1 (range 4-6).

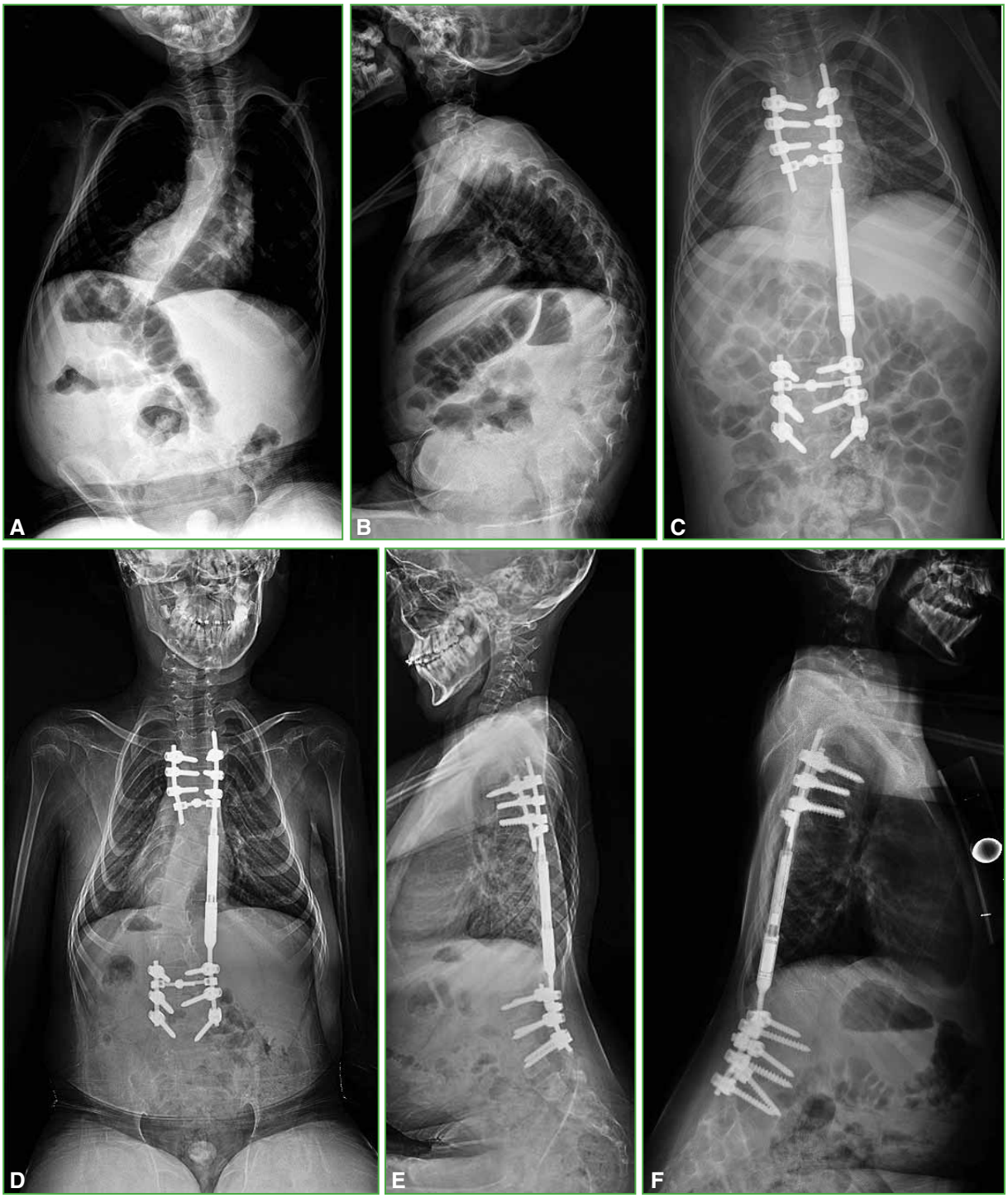

Figure 1. 7-year-old patient with type II spinal atrophy. **A.** Anteroposterior full-length spine radiograph in the preoperative period.**B.** Preoperative lateral full-length spine radiograph. **C.** Anteroposterior full-length spine radiograph, after placing the magnetically controlled rod. **D.** Anteroposterior full-length spine radiograph, after placing the magnetically controlled rod. **E.** Lateral full-length spine radiograph. Culmination of the distractions of the magnetically controlled rod. **F.** Lateral full-length spine radiograph. Culmination of the distractions of the magnetically controlled rod.

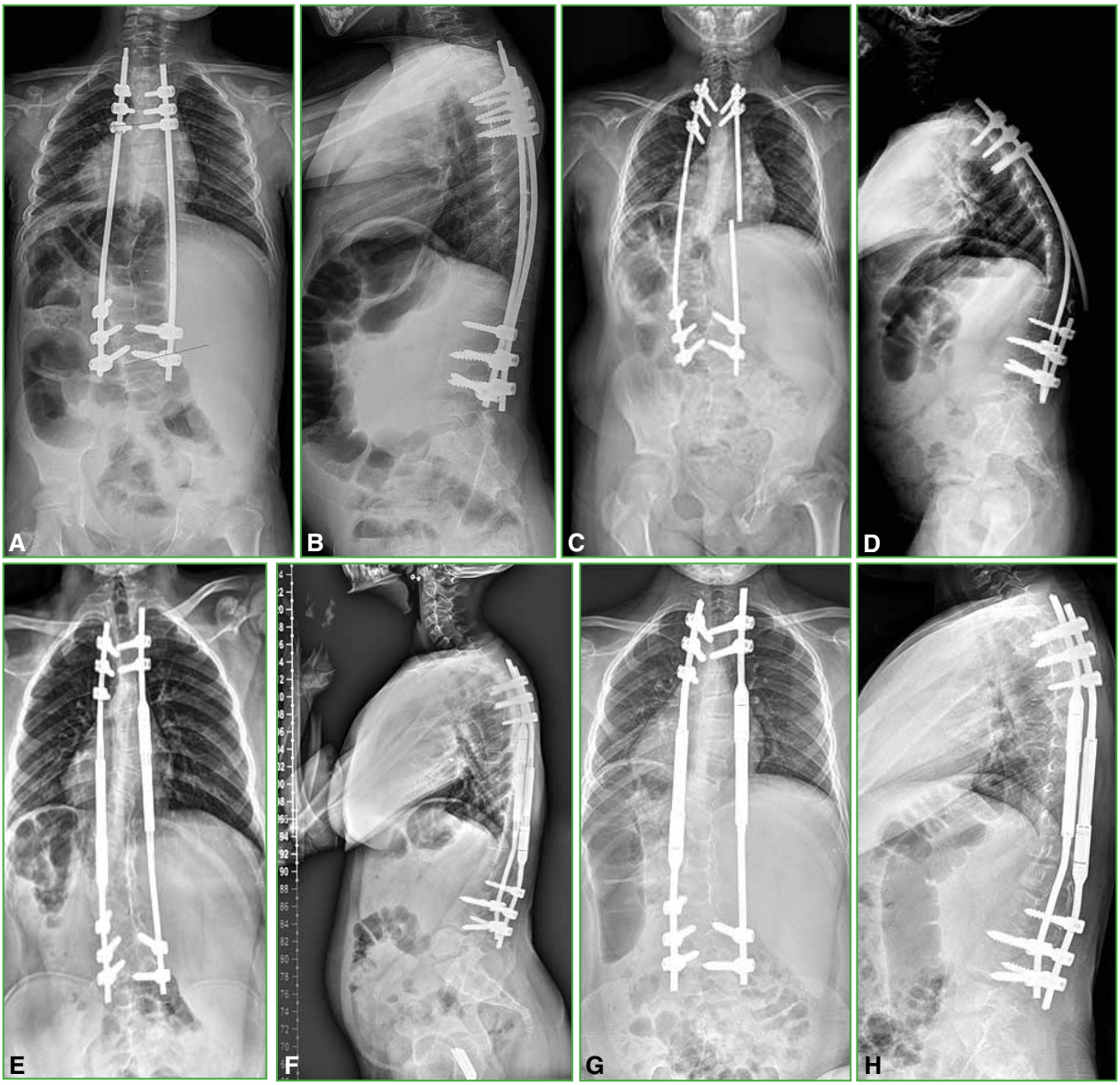

Figure 2. 8-year-old patient with skeletal dysplasia. **A.** Preoperative anteroposterior full-length spine radiograph. **B.** Preoperative lateral full-length spine radiograph. **C.** Anteroposterior full-length spine radiograph. Fatigue of the distraction material is noted. **D.** Lateral full-length spine radiograph. Fatigue of the distraction material is noted. **E.** Anteroposterior full-length spine radiograph. Removal of material and placement of magnetically controlled rods. **F.** Anteroposterior full-length spine radiograph. Culmination of the successive distractions with magnetically controlled rods. **G.** Lateral full-length spine radiograph. Removal of material and placement of magnetically controlled rods. **H.** Lateral full-length spine radiograph. Culmination of the successive distractions with magnetically controlled rods.

The 37 patients were divided into two groups: group 1 (n = 28), those who initially underwent treatment with the MCGR system, the average age at surgery was 8.1 years (range 4-12), with an average follow-up of 3.1 years (range 1-6), from 2014 to 2020.

In group 1, the mean angular value of scoliosis was 64° (range 39°-101°) before surgery, and 41° (range 17°-80°) in the immediate postoperative period. The mean angular value of kyphosis preoperatively was 51° (range 22°-111°) and 34° (range 7°-82°) postoperatively.

The average recorded preoperative distance T1-T12 was 147 mm (range 95-190) and 169 mm (range 104-217) in the immediate postoperative period. The mean preoperative T1-S1 distance was 253 mm (range 205-288) and 306 mm (range 215-354) in the immediate postoperative period (Table 1).

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Table 1. Primary MCGR system placement.

Case	Sex	Base etiology	Age (years)	Primary/ Conversion	4.5/5.5 mm	N°. of rods	N°. of distractions	Apical and distal levels	Distraction (mm)	Preop. Cobb (°)	Preop. kyphosis (°)	T1-T12 preop. (mm)	T1-S1 preop. (mm)	Postop. Cobb. (°)	Postop. kyphosis (°)	T1-T12 postop. (mm)	T1-S1 postop. (mm)	Intraoperative complications	Mechanical complications	Infection (SSI)	Follow-up (year + month)
1	M	Williams syndrome	6	Primary	5.5	2	6	T2-T3 L2-L3	ST 30 OF 32	70	37	143	258	36	11	170	335	No		No	2014/9
2	M	NF1	10	Primary	5.5	2	10	T2-T3-T4 T12-L1-L2	ST 39 OF 35	98	28	162	258	46	19	217	354	No		No	2017/5
3	M	NECE	7	Primary	5.5	1	3	T3-T4-T5 L2-L3-L4	12	47	60	159	247	43	60	183	295	No		No	2017/6
4	F	NECE	7	Primary	5.5	1	6	T2-T3 L2-L3	32	100	111	157	242	80	77	171	293	No		No	2016/8
5	F	NECE	4	Primary	5.5	1	8	T2-T3 L2-L3-L4	32	95	86	95	205	75	82	104	215	No		No	2017/6
6	M	Neuropathic scoliosis	5	Primary	4.5	2	6	T2-T3-T4 L3-L4-L5	24-25	91	51	118	210	29	17	154	271	No		No	2018/11
7	M	Bone dysplasia syndrome	9	Primary	5.5	2	8	T3-T4 L3-L4	ST 27 OF 28	46	22	190	313	17	42	168	313	No		No	2017/9
8	F	Prader-Willi syndrome	6	Primary	4.5	2	6	T2-T3-T4 L1-L2-L3	ST 35 OF 35	65	64	160	278	22	31	171	312	No		No	2018/11
9	F	Myopathic scoliosis	9	Primary	4.5	2	7	T4-T5-T6 T12-L1	35	68	22	162	288	22	11	202	351	No		No	2016/4
10	M	SMA	7	Primary	4.5	1	7	T4-T5-T6 L5-S1	35	45	103	132	212	36	40	168	321	No		No	2017/12
11	M	SMA	7	Primary	4.5	1	1	T3-T4-T5 L3-L4-L5	5	60	60	136	256	23	7	170	333	No		No	2016/11
12	M	Neuropathic scoliosis	7	Primary	4.5	2	5	T3-T4-T5 L3-L4	20 mm	47	49	201	352	20	45	215	350	No		No	2019/9
13	F	Idiopathic scoliosis	5	Primary	4.5	2	5	T3-T4 L2-L3	20 mm	57	58	151	270	21	26	161	303	No		No	2020/2
14	M	Syndromic scoliosis	10	Primary	5.5	2	2	T2-T3-T4 L4-L5-pelvis	ST 10 OF 10	51	40	187	346	25	27	195	360	No		No	2019/4
15	F	Neuropathic scoliosis	7	Primary	5.5	2	2	T3-T4 L3-L4	ST 10 OF 12	71	27	152	280	36	60	174	310	No		No	2019/9
16	F	Prader-Willi syndrome	9	Primary	5.5	2	7	T3-T4-T5 L3-L4-L5	ST 34 OF 35	57	48	182	318	15	25	208	357	No		No	2019/1
17	F	Myopathic scoliosis	12	Primary	5.5	1	5	T3-T4-T5 L3-L4-L5	25	89	60	150	186	37	30	196	315	No	Rod rupture	No	2016/1
18	F	Myopathic scoliosis	10	Primary	5.5	1	6	T2-T3-T4 L2-L1	30	69	90	154	260	29	39	172	273	No		No	2016/3
19	F	Congenital muscular dystrophy	12	Primary	5.5	1	7	T3-T4-T5 L2-L3-L4	35	70	40	150	267	27	30	167	287	No		No	2018/1
20	M	Myopathic scoliosis	8	Primary	5.5	1	5	T2-T3-T4 L2-L3-L4	20	88	67	179	271	43	43	196	317	No		No	2018/5
21	M	EIJ	10	Primary	5.5	1	5	T2-T3-T4 L1-T12	20	60	51	162	261	40	21	186	303	No		No	2018/11
22	F	Syndromic scoliosis	10	Primary	5.5	1	4	T3-T4-T5 T12-L1-L2	16	68	30	156	283	27	16	177	315	No		No	2018/10
23	F	Congenital scoliosis	8	Primary	5.5	2	1	T3-T4 L3-L4	ST 5 OF 5	74	18	179	305	23	17	184	307	No		No	2019/5
24	F	Escoliosis sindrómica	10	Primary	5.5	1	3	T3-T4-T5 L2-L3	15	84	44	168	281	24	23	203	322	No	Rod failure	No	2017/6
25	F	Syndromic scoliosis	9	Primary	5.5	1	1	T3-T4-T5 L2-L3-L4	5	58	82	154	232	43	40	176	278	No		No	2019/3
26	M	Congenital scoliosis	5	Primary	5.5	1	6	T4-T5 L2-L4	24	43	28	140	245	16	14	160	256	No		No	2019/3
27	F	Neuropathic scoliosis	11	Primary	5.5	2	5	T2-T3 L3-L4	ST 19 OF 19	67	40	164	262	40	35	217	330	No		No	2019/4
28	M	SMA	11	Primary	5.5	2	0	T3-T4-T5 L2-L3-L4	0	60	46	178	295	180	46	295	317	No		No	2019/10

M = male; F = female; NF1 = neurofibromatosis type 1; NECE = non-evolving chronic encephalopathy; JIS = juvenile idiopathic scoliosis; SMA = spinal muscular atrophy; preop. = preoperative; postop. = postoperative; intraop. = intraoperative; ST = standard; OF = offset.

Group 2 was made up of the population converting from a traditional system to MCGR. It consisted of nine patients, with a mean age at the time of surgery of 7 years (range 4-12). The mean angular value of preoperative scoliosis was 56° (range 39°-101°) and 46° (range 30°-76°) in the immediate postoperative period. The mean angular value of preoperative kyphosis was 39° (range 7°-81°) and 32° (range 4°-52°) in the immediate postoperative period.

The mean preoperative T1-T12 distance was 174 mm (range 117-275) and 183 mm (range 138-275) in the immediate postoperative period. The mean preoperative T1-S1 distance was 317 mm (range 234-507) and 329 mm (range 249-507) in the immediate postoperative period (Table 2).

Table 2. Conversion of conventional distraction rod system to magnetically controlled rods.

Case	Sexe	Base etiology	Age	Primary/ Conversion	4.5/5.5 mm	N.° of rods	N.° of distractions	Apical and distal levels	Distraction (mm)	Preop. Cobb (°)	Preop. kyphosis (°)
1	M	Congenital scoliosis	10	Conversion	5.5	2	5	T2-T3 L3-L4	ST 15, OF 15	45	55
2	M	Silver's syndrome	12	Conversion	5.5	2	9	T3-T4-T5 L1-L2	ST 29, OF 29	39	33
3	M	NECE	4	Conversion	5.5	1	3	T2-T3 L2-L3-L4	12	101	50
4	F	Syndromic scoliosis	9	Conversion	5.5	2	6	T2-T3-T4 L1-L2-L3	ST 39 OF 35	67	56
5	F	Marfan syndrome	5	Conversion	5.5	2	7	T2-T3-T4 L2-L3-L4	ST 32 OF 30	44	7
6	M	Idiopathic scoliosis	7	Conversion	4.5	2	4	T2-T2 L2-L3	ST 20-20	43	11
7	M	Chondro-dysplasia	9	Conversion	5.5	2	5	T3-T4-T5 L2-L3-L4	ST 25 OF 25	51	81
8	F	Escobar syndrome	8	Conversion	5.5	2	8	T2-T3-T4 L2-L3	ST 32 OF 30	48	41
9	M	Syndromic scoliosis	9	Conversion	5.5	2	4	T2-T3-T4 L2-L3	ST 23 20	70	93

Case	Sex	Preop. T1-T12	Preop. T1-S1	Postop. Cobb. (°)	Postop. kypho-sis (°)	T1-T12 posop. (°)	Postop. T1-T12	Intraoperative complications	Mechanical complica-tions	Surgical site infection	Other complica-tions	Follow-up (year/ months)
1	M	157	271	36	36	157	283	No	Rod rupture	No		2017/5
2	M	275	507	39	33	275	507	No		No		2013/5
3	M	117	234	76	50	138	249	No		Yes	Material exposure	2017/5
4	F	168	283	59	52	172	292	No	PSL	No		2018/9
5	F	182	309	43	4	173	315	No		No		2016/6
6	M	185	334	40	14	191	341	No	*Proximal screw pull out*	No		2018/11
7	M	122	238	30	46	158	280	No	Rod failure	No		2018/5
8	F	170	317	38	30	180	319	No		No		2016/9
9	M	166	320	36	50	180	350	No		No		2019/12

M = male; F = female; NECE = non-evolving chronic encephalopathy; PSL = proximal screw loosening; preop. = preoperative; postop. = postoperative; intraop. = intraoperative.

Seven complications occurred. In group 2, there were two cases of loosening of proximal screws, one kyphosis of the proximal joint, and one of mechanical failure at the level of the BM drum. There was one case of rod rupture and one of mechanical failure in the magnet in Group 1, but no reason could be determined. Distal screw loosening occurred only in group 2, with double-rod systems (Figures 3 and 4).

A distant complication was detected in group 2, it was exposure of the implant and deep infection by *Staphylococcus aureus*, in a patient with neuropathic scoliosis. Treatment consisted of cleaning, debridement, and removal of the implant, with good results.

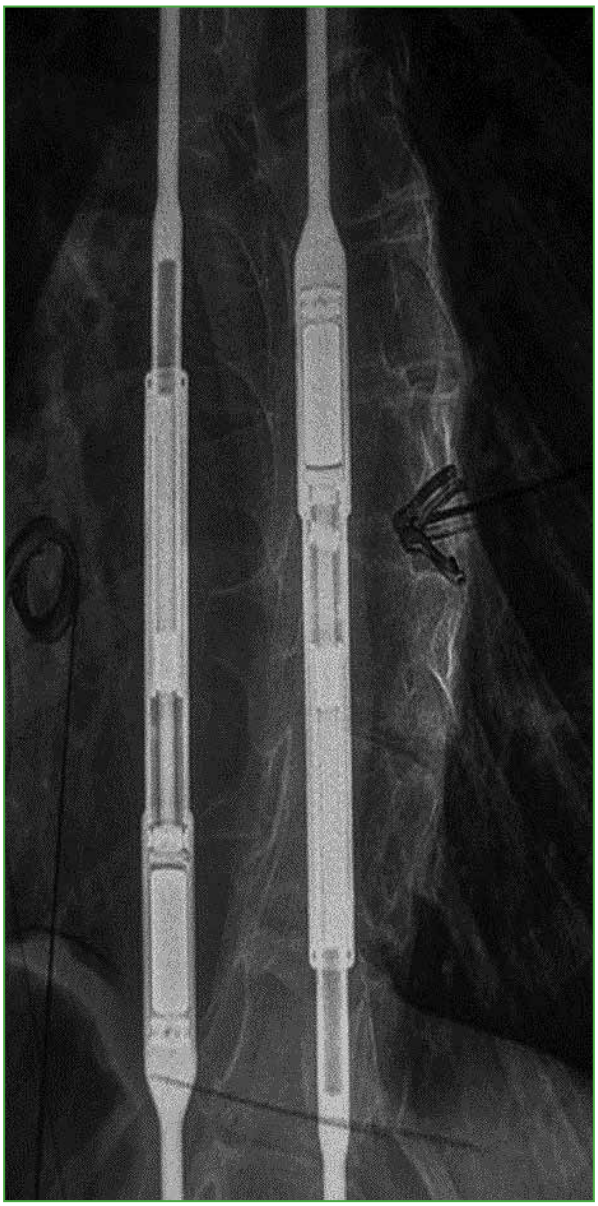

Figure 3. Breakage of the pin of the rod magnet.

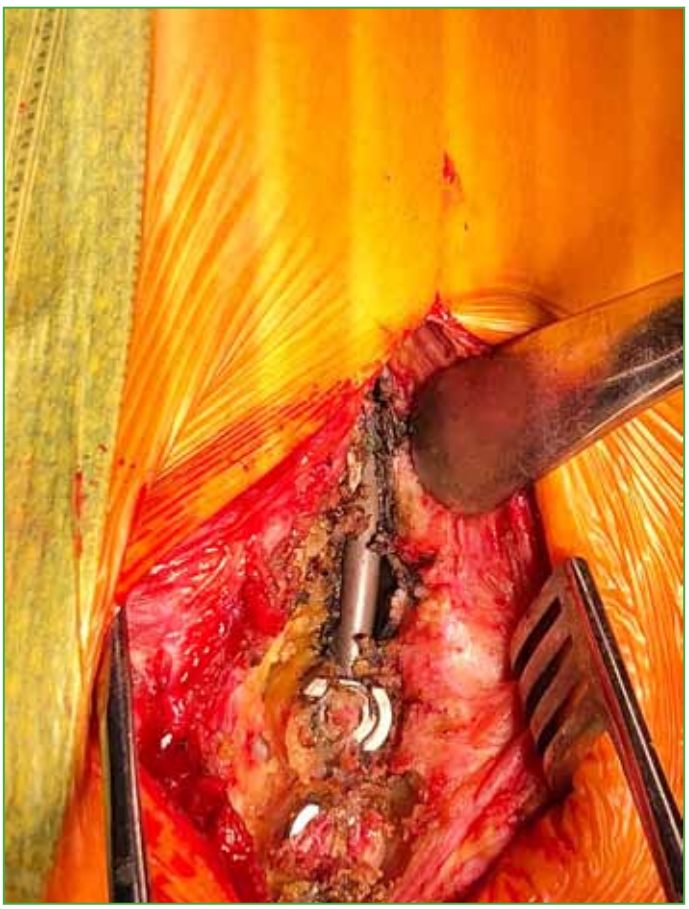

Figure 4. Removal of the magnetically controlled rod. Metallosis is observed.

DISCUSSION

Traditional distraction systems require many surgeries in children with spinal deformity, which predisposes them to more frequent complications, such as infections or spontaneous fusion due to continuous surgical damage to the tissues surrounding the implant. Even when the interval between procedures is extended, the rate of complications remains significant.[19]

The possibility of psychological damage and a worse quality of life due to the multiple surgeries and hospitalizations, such as successive reinterventions for distraction,[20,21] and the socioeconomic impact, due to the high costs for the medical care system and also for the relatives, should be taken into account to decide a treatment according to each patient.[17,22,23]

The MCGR distraction technique was designed as one more treatment option for EOS. The ability to perform repeated non-invasive and ambulatory distractions, together with the fact that it does not require anesthetic procedures, makes this device a particularly appealing alternative for patients with EOS.[9-12]

Bekmez et al. found that using the MCGR system (n = 10) instead of conventional rods (n = 10) resulted in fewer procedures.[19] Although Rolton et al. reported the possibility of cost savings starting in the third year when compared to conventional growth rods,[18,24] Rushton et al., in 2019, suggested that rods should be changed after approximately three years of placement due to the possibility of failure of the distraction system, which can increase costs.[25]

MCGR placement is technically similar to a conventional procedure, but the distraction of the system is performed by an internal mechanism of magnets. Such movement can be confirmed by ultrasound,[26] which also reduces the risk of excessive radiation.[27,28] In our practice, we started using this ultrasound method several years

ago, which does estimate distractions in millimeters, but does not assess implant status or curve angle, and is subject to inter- and intra-observer subjective variability. For this reason, we believe that it is necessary to take a radiograph at least once a year to examine the evolutionary state of the deformity and the instrumentation.

The comparison between single- and double-rod MCGR systems is important, although the double-rod system would achieve greater stability and better mechanical control of the spine,[29,30] many times, the size of the patient and skin coverage can not provide optimal conditions, this suggests opting for a single-rod system.

The time intervals for distraction and the number of millimeters to distract in each procedure can vary from as little as two months for the first distraction or six months between the first and second. There is insufficient data in the literature on the subject,[31] or on the number of millimeters that must be distracted, although it is known that distractions before three months are associated with a higher risk of instrumentation failure.[32]

Our protocol included distractions every three months, all procedures were conducted in the office, and the use of the operating room was unnecessary, even with two cases of pain. The average number of distractions was four in group 1 (n = 28) and five in group 2 (n = 9). System distraction was, on average, 4.49 mm for group 1 and 4.37 mm for group 2.

Complications are not uncommon with the MCGR system.[33] Some authors, such as Teoh et al., and Lebon et al., have published high complication rates at two years of follow-up, such as broken rods or actuator, loosening of proximal anchors, local metallosis, possible increase of titanium in blood with or without vanadium and surgical site infection.[34,35] However, in the latest reports, the frequency of complications is variable, and can be compared with those of traditional distraction systems, as shown by Akbarnia et al.,[36] with 66.7% complications in a population of 12 patients and Heydar et al., with a complication rate of 6% in a population of 16 patients.[37]

In our series of 37 patients, the rate of complications was 18.9%, comparable to that of the series by Ridderbusch et al.,[38] and Keskinen et al.[39] reporting 20% (n = 24) and 30% (n = 50), respectively. Loosening of proximal screws, mechanical failure of the rod, and MCGR rupture were the most frequent complications in our series (5.4% each). It was not possible to determine the origin of the rod's mechanical failure, and severe metallosis was found around the MCGR during the definitive fusion surgery in several of our patients that passed the postoperative follow-up of this study. Although the publications by Cheung et al. and other authors mention rod slippage failure, they connect it with a greater BMI, age, distances between the ends of the structure, and shorter distances between the internal magnets.[40,41]

Rod fracture occurred in our groups 1 and 2, both with single- and double-rod systems. Hosseini et al.[42] published a similar fracture rate for both single (1/8) and double (2/15) rod systems. Choy et al. reported a similar difference in fracture rate for 4.5 mm and 5.5 mm systems; in our cases, they occurred only in 5.5 mm rods.[15] There was a late complication: removal of the implant associated with exposure of the material and infection of the wound. This complication is not frequent in the published series.

Soft tissue infection is frequent in most series, our only case of infection was associated with material exposure, this association is even less frequent, Choi et al. only reported one case similar to ours.[15] Deep or superficial infections due to dehiscence have also been described, but they are rare.[34,35]

The limitations of this study are the small number of cases and the inclusion of patients treated at a single institution, so homogeneity for a better analysis is not reached, and the short-term follow-up, despite the patients' continued control.

CONCLUSIONS

Our results show that the use of MCGRs as a treatment for EOS is currently reliable, as they control and maintain the physiological development of thoracolumbar growth. The low rate of complications, particularly infections, and the low comorbidity associated with the few surgical interventions, lead us to maintain that it is a safe and effective method for the treatment of EOS.

Although the short- and medium-term results in our series are encouraging, there are still major obstacles and unknowns about the mechanical behavior of the implant in long-term follow-up.

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Meniscal Suture in Athletes: Failure Analysis and Return to Sport

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ABSTRACT

Introduction: Meniscal suturing is a technique increasingly used in patients with meniscal lesions, with good outcomes in the general population. However, research on athletes is limited. Meniscal suture failures and return to sport in athletes were analyzed, and possible contributing factors were identified. **Materials and Methods:** Sixty-one meniscal sutures in athletes (Tegner score ≥6) with a minimum follow-up of 12 months were retrospectively evaluated. Forty-nine were isolated lesions and 12 were associated with anterior cruciate ligament reconstruction. The average follow-up was 61 months and patients were evaluated with Tegner and Lysholm scores. **Results:** Meniscal suture failure was noted in 12 (19.67%) patients; failure occurred, on average, 14 months post-surgery. Nine failures occurred in isolated sutures and 3 were associated with anterior cruciate ligament reconstruction ($p<0.05$). The meniscus that failed the most was the internal meniscus. Seventy-five percent corresponded to patients who practiced pivot-contact sports ($p <0.05$). Patients who did not suffer failure were able to continue with the same sporting activity as before the injury and the Lysholm score had significantly improved ($p<0.05$). **Conclusions:** Failures were significantly more frequent in internal menisci, isolated sutures, bucket-handle injuries, and pivot-contact sports. We believe that meniscal suture is an excellent surgical option for athletic patients because a high percentage of them return to sports.

Keywords: Meniscal suture; athletes; meniscal injury; meniscal suture failure.
Level of Evidence: IV

Sutura meniscal en deportistas: análisis de fallas y retorno al deporte

RESUMEN

Introducción: La sutura meniscal es una técnica cada vez más utilizada en pacientes con lesiones meniscales, y se obtienen buenos resultados en la población general. Sin embargo, los estudios realizados en pacientes deportistas son escasos. Se analizaron las fallas de la sutura meniscal y el retorno al deporte en pacientes deportistas, y se identificaron posibles factores asociados. **Materiales y Métodos:** Se evaluaron retrospectivamente 61 suturas meniscales en deportistas (puntaje de Tegner ≥6) con un seguimiento mínimo de 12 meses. Cuarenta y nueve eran lesiones aisladas y 12 se asociaban con plástica del ligamento cruzado anterior. El seguimiento promedio fue de 61 meses y los pacientes fueron evaluados con los puntajes de Tegner y de Lysholm. **Resultados:** Se constató la falla de la sutura meniscal en 12 (19,67%) pacientes; la falla ocurrió, en promedio, 14 meses poscirugía. Nueve fallas se produjeron en suturas aisladas y 3 se asociaron con plástica del ligamento cruzado anterior ($p <0,05$). El menisco que más falló fue el interno. El 75% corresponde a pacientes que practicaban un deporte de contacto y pivote ($p <0,05$). Los pacientes que no sufrieron falla pudieron continuar con la misma actividad deportiva que antes de la lesión y el puntaje de Lysholm había mejorado significativamente ($p <0,05$). **Conclusiones:** Las fallas fueron significativamente más frecuentes en meniscos internos, suturas aisladas, lesiones en asa de balde, y deportes de contacto y pivote. Consideramos que la sutura meniscal es una excelente opción quirúrgica para pacientes deportistas, ya que un alto porcenaje de ellos retorna al deporte.

Palabras clave: Sutura meniscal; deportistas; lesión meniscal; falla de sutura meniscal.
Nivel de Evidencia: IV

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INTRODUCTION

Meniscus injury is one of the most common conditions in the arthroscopic surgeon's practice and is highly related to sports activity.[1-3]These injuries can occur isolated or associated with other conditions, such as anterior cruciate ligament (ACL) tear (57-80%).[4] The menisci play an important role in load transmission, shock absorption, joint stability and lubrication, and proprioception.[1,2]

Some surgical options are: partial and total meniscectomy, and meniscal repair techniques that, in recent years, have acquired greater prominence.[4,5] There are several studies that compare the clinical results of total and partial meniscectomy and show the importance of the menisci and their protective function for joint preservation.[1,2] It has been published that, although more than 30% of meniscal tears can be repaired, less than 10% of these are finally sutured.[4]

The meniscal suture options are: inside-out, outside-in, and all-inside.[1,3,6] The failure rate of these techniques ranges from 10% to 25% in the general population[4,7-9] and, in numerous studies, a lower failure rate has been reported in lateral menisci and those associated with ACL plastic surgery.[3,9] Athletes represent a group of patients that imposes a greater demand on the menisci and, consequently, a maximum stress on the meniscal suture.[2] Few published studies have evaluated the results of meniscal suture in this type of patient.

The objective of this study was to evaluate a population of athletes who received a meniscal suture. By comparing the data obtained with those of the national and international literature, we sought to specifically analyze suture failures, and identify possible associated factors, return to sport, and functional outcomes.

MATERIALS AND METHODS

Between July 2005 and June 2020, 1,473 knee arthroscopies were performed and, in 104 of them, a meniscal suture was performed, either alone or associated with another procedure. The patients were evaluated and classified retrospectively, according to the Tegner activity score, defining as athletes those patients with a score ≥6 before the injury.

The inclusion criteria were: Tegner score ≥6, lesions in the red-red or red-white zones, without degenerative changes verified by both magnetic resonance imaging and arthroscopy, operated by the same surgical team and with a minimum follow-up of 12 months. Patients with a Tegner score <6, degenerative lesions, lesions in the white-white zone, follow-up <12 months, and limb alignment disorders were excluded.

Regarding surgical techniques, the outside-in suture was used for lesions of the body and anterior horn, and the all-inside suture for posterior horn lesions. If the lesions were combined, the hybrid technique was used. The all-inside systems used in our study were: Meniscal Cinch (Arthrex, Naples, FL, USA), RapidLoc (DePuy Mitek Inc, Raynham, MA, USA), Viper (Arthrex, Naples, FL, USA), Fast Fix (Smith & Nephew, Andover, MA, USA) and True Span (DePuy Mitek Inc, Raynham, MA, USA) (Figure 1).

Figure 1. Radial tear of the lateral meniscus diagnosed by magnetic resonance and arthroscopic images before suturing with the hybrid technique (two all-inside sutures and one outside-in suture) and after.

The sample was made up of 61 athlete patients, 54 (88.5%) were men and seven (11.5%) were women, with an average age at surgery of 26 years (range 14-53). The time elapsed between the meniscal tear and surgery was variable, between three days and three months (average 26 days). The average follow-up was 60 months (range 12-36). 12 months, max. 191 months). The external meniscus was the most affected (35 patients, 57.38%), while lesions to the internal meniscus were 26 (42.62%). Meniscal injuries were isolated in 49 cases (80.33%) and were associated with ACL tears in 12 (19.67%). Regarding the techniques used: 31 (51%) patients were treated only with the outside-in technique; nine (15%), with the all-inside technique and 21 (34%), with the hybrid technique, and the average number of suture stitches was 2.4 (range 1-6). Regarding the sports practiced, contact and pivot sports (43 cases) predominated, such as soccer (31 patients), rugby (10 cases) or hockey (2 patients).

During the postoperative period, offloading with crutches was indicated for two weeks and immobilization with a knee extension splint for four weeks. In the first six weeks, joint flexion was limited to 90° to avoid increasing tension in the joint capsule and, at week 16, return to previous sports activity was authorized. Patients who had an ACL lesion underwent meniscus suture and ACL plastic surgery at the same surgical stage, with its own treatment protocol.

The patients were evaluated with the Tegner and Lysholm scores before and after surgery. The criteria applied to define the failure were: pain in the joint line, joint effusion, blockage and positive Murray test. The presence of at least one of them was sufficient to consider meniscal repair as failed, according to the Barrett et al. criteria.[8] All failures were confirmed by arthroscopy during a second surgery.

RESULTS

Failure of the meniscal suture was confirmed in 12 patients (19.67%). 75% were men and the average age was 28 years (range 16-53), slightly higher than that of the patients without failures (25 years) ($p > 0.05$). The failure was located in the internal meniscus, in eight cases (66.66%) and in the external one, in four ($p < 0.05$). In nine (75%) patients, the failure presented as an isolated injury, while in the remaining three, it was associated with ACL tears. Regarding the type of injury, seven (58.33%) were bucket handle injuries ($p < 0.001$) and the rest were horizontal-vertical injuries. Failure of all the techniques used was recorded: five (41.66%) outside-in sutures, three (25%) all-inside sutures, and four (33.33%) with the hybrid technique. The average number of suture stitches in these patients was 2.6 (range 1-6), which did not represent a determining factor for failure ($p > 0.05$). 75% of the failures occurred in patients who practiced contact and pivot sports ($p < 0.05$): 50% (6 patients) practiced soccer; 16.7% (2 cases), rugby and the remaining four, volleyball, dancing, hockey, and climbing (Table 1).

Table 1. Summary of patients with meniscal suture failure

n	Sex	Age (years)	Sport	Follow-up (months)	Meniscus	ACL	Suture	Number of sutures	Re-tear	Postoperative time
1	M	35	Football	141	Internal	Yes	Outside-in	1	Traumatic	14
2	F	16	Hockey	126	Internal	Yes	Hybrid	3	Spontaneous	8
3	M	30	Football	137	Internal	No	Outside-in	2	Spontaneous	16
4	M	26	Rugby	86	Internal	Yes	Outside-in	2	Traumatic	19
5	M	31	Football	57	External	No	Outside-in	2	Traumatic	48
6	M	21	Rugby	61	External	No	All-inside	2	Traumatic	16
7	M	53	Football	61	External	No	All-inside	1	Spontaneous	10
8	M	18	Football	49	External	No	Hybrid	6	Traumatic	7
9	M	30	Climbing	24	Internal	No	Hybrid	3	Traumatic	12
10	F	19	Dancing	16	Internal	No	Outside-in	1	Spontaneous	9
11	F	26	Football	14	Internal	No	Hybrid	5	Traumatic	5
12	M	34	Volleyball	12	Internal	No	All-inside	3	Spontaneous	6

M = male; F = female; ACL = anterior cruciate ligament.

Failure occurred, on average, 14 months after surgery (range 5-48). The Kaplan-Meier graph shows the estimated average survival for the study sample, which was 134 months, with a survival rate of 95% at 12 months and 94% at 24 months (Figure 2). Seven of the 12 patients (58.33%) with failure reported a new traumatic episode, all related to sports, while the remaining five (41.67%) consulted for pain in the joint line at variable times after surgery, without an associated traumatic episode. Treatment of the failure consisted of segmental partial meniscectomy of the unstable fragments (11 patients, 91.66%) and a new meniscal suture in the remaining case (8.33%).

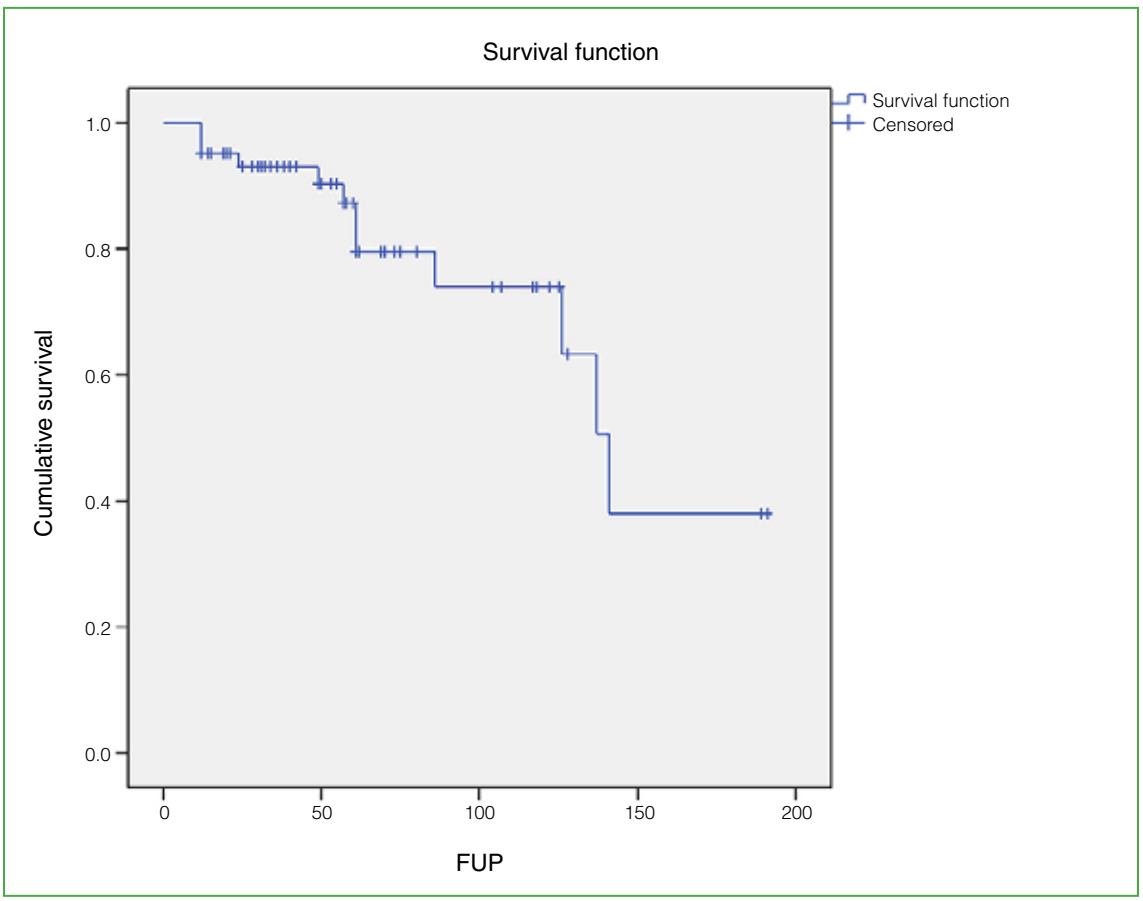

Figure 2. Kaplan-Meier survival plot.

In relation to the return to sport, the Tegner score decreased from 7.02 (range 6-9) to 6.94 (range 6-9) in the 49 patients who had no failure ($p>0.05$), that is, most of them continued to practice the same sport as before surgery, or one of similar intensity. In contrast, the same score decreased from 6.75 to 4.41 in patients without failure, a decrease of 2.34 points ($p <0.05$).

The functional outcomes were evaluated with the Lysholm score and revealed an average improvement of 26.31 in the patients without failure ($p <0.05$), while in the patients with failure the improvement was only 2.09. ($p >0.05$) (Table 2).

Table 2. Comparison of scores in patients with or without failure of the meniscal suture.

	Patients WITHOUT failure (n = 49)		Patients WITH failure (n = 12)	
	Preoperative	**Postoperative**	**Preoperative**	**Postoperative**
Tegner score	7.02	6.94	6.75	4.41
Difference	-0.8		-2.34	
Lysholm Score	71.55	97.86	67.33	69.42
Difference	26.32		2.09	

DISCUSSION

Due to the degenerative changes reported in patients undergoing partial or total meniscectomy, the number of meniscal repairs has increased markedly in the last two decades.[10] This is due to the attempt to carry out a biological repair in order to preserve as much of the meniscal surface as possible, thus restoring the biomechanical properties of the joint.[1,2] In various international studies, successful outcomes have been obtained in 70-90% of the general population,[6,11] and these outcomes have been even superior when compared to partial meniscectomy.[12,13] In national studies, the success rate is similar: between 72% and 85%.[14-16]

Several risk factors responsible for meniscal failure have been published, such as chronic injuries, size and area of the injury, among others.[2,4] Some of them were refuted in various investigations, since it was verified, for example, a great healing potential even in patients with bucket-handle injuries, longitudinal >10 mm injuries, and radial injuries in zones I and II.[4] Our sample is represented by a wide variety of injuries, either by type or size, which require different types of suture for repair. However, we have not obtained significant differences in the failure rate when analyzing factors such as type of suture, technique or number of sutures used ($p>0.05$). On the contrary, we have found factors associated with the incidence of meniscal suture failure ($p <0.05$), such as injuries to the medial meniscus, isolated meniscal sutures, bucket-handle injuries, and contact and pivot sports.

Regarding the healing capacity, several studies indicate a greater regenerative capacity of the external meniscus over the internal one, and the latter has a higher failure rate.[3,6,17,18] Ronnblad et al. retrospectively evaluated 918 cases of meniscal suture with a minimum follow-up of three years and obtained failure rates four times higher in the internal meniscus than in the external one.[19] This agrees with the results of our study, in which the internal meniscus failed significantly more than the external one ($p <0.05$).

Different studies have evaluated the outcomes of meniscal sutures performed together with plastic surgery of the ACL; in these cases, the success rates were higher than those obtained with isolated sutures.[3,6,10,20-22] This is mainly due to the release of stem cells from the bone marrow originating from the femoral tunnel.[6] One of them is the study by Cannon and Vittori published in 1992,[6] in which they compared meniscal sutures performed together with ACL plastic surgery and isolated meniscal sutures and obtained success rates of 93% and 50%, respectively. These results are consistent with those of our study, in which significantly better outcomes ($p <0.05$) were achieved in patients who underwent meniscal suture together with ACL repair.

Age has been suggested as a risk factor for failure of meniscal repairs. Barrett et al. studied meniscal repairs in a population of patients >40 years of age and obtained 87% good clinical outcomes at two years of follow-up.[8] Lyman et al. also achieved significant improvements in sutures performed in patients >40 years. These outcomes would be explained by the lower demand that these patients place on the suture.[9] In our study, age did not behave as a risk factor for meniscal suture failure, since the age difference between patients with failure and those without failure was only 2.5 years higher ($p>0.05$).

Meniscal injuries are common in young patients and athletes, and due to their mechanism, they are even more prevalent in contact and pivot sports.[2] In this type of patients, they represent a challenge in terms of treatment, rehabilitation and return to sport.[2,23] It is believed that, due to the greater demand and stress to which meniscal

sutures are subjected, the failure rate in athletes should be higher than in the general population. According to different international studies, the failure rate of meniscal sutures in athletes ranges from 7% to 24%.[2,20,23,24]

In our country, published studies are scarce. Villalba et al. evaluated 11 contact sports patients, with a minimum follow-up of two years and the failure rate was 9%.[25] On the other hand, Bitar et al. evaluated 41 athletes with bucket handle injuries, and their failure rate was 15.2%.[26] With a bigger sample, our failure rate was 19.67%, which was greater than the previously indicated figure but coincided with the global figure.

80.33% of the patients managed to resume the sports activity they practiced before the injury, maintaining practically the same Tegner score. This is slightly lower than what has been published in several studies, in which the average return to sport varies between 86% and 100%.[23,24]

The limitations of this study include its retrospective nature, the lack of a control group or an arthroscopic examination to confirm the meniscal repair, and the inclusion of individuals with varying levels of sports intensity. Future studies could look into the relationship between the outcomes of meniscal suture failure in athletes and non-athletes. As a strength, we can state that it is a novel subject, having only examined athlete patients, which comprised the greatest sample size in our country, and that the results were comparable to those published in the international literature.

CONCLUSIONS

In the series analyzed, the meniscal suture failure rate in athletes coincides with that reported in the literature. Failures were statistically more frequent in internal menisci, isolated sutures, bucket handle injuries, and contact and pivot sports.

Based on the results of our study, we consider that the meniscal suture is an excellent surgical option for athletes, since it achieves a high rate of return to sport. However, the lack of a control group does not allow us to be conclusive on this point.

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

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Floating Spine and Other Types of Associated Multiple Simultaneous Unstable Spinal Fractures

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ABSTRACT

Introduction: We intend to present a series of patients with associated multiple and simultaneous unstable spinal fractures (Type B or C). **Materials and Methods:** A descriptive analysis of patients with high-energy spinal cord injuries and associated multiple unstable and simultaneous spinal fractures from January 2015 to January 2021 was conducted. Patients with type B (ligament injury) and/or type C (subluxation/dislocation) multiple spinal fractures were included. Patients with incomplete medical records, osteoporotic or pathological fractures, or fewer than 3 months of follow-up were excluded. **Results:** We included 5 patients (1 woman and 4 men) with two simultaneous unstable spinal fractures, including 4 cases (80%) of non-contiguous fractures and 3 (60%) with two simultaneous non-contiguous fracture dislocations ("floating spine"); 2 (40%) cases had a type B fracture associated with a type C fracture. The median age was 35 years. High-energy trauma with associated injuries occurred in all cases. All patients were surgically treated with a conventional posterior approach, reduction, and long arthrodesis. In two patients, neurological recovery was confirmed. **Conclusion:** A case series of multiple simultaneous unstable spinal fractures (type B or C) caused by high-energy trauma is presented. This is a rare injury association with significant morbidity associated with spinal, systemic, and neurological trauma.

Keywords: Multiple unstable spinal fractures; floating spine; trauma; high energy.
Level of Evidence: IV

Columna vertebral flotante y otras variantes de la asociación de múltiples fracturas vertebrales inestables simultáneas

RESUMEN

Introducción: El objetivo de este estudio fue evaluar a una serie de pacientes con la asociación de múltiples fracturas vertebrales inestables (tipo B o C) simultáneas. **Materiales y Métodos:** Estudio descriptivo de pacientes con trauma vertebromedular de alta energía y asociación de múltiples fracturas vertebrales inestables simultáneas entre enero de 2015 y enero de 2021. Se incluyó a pacientes con fracturas vertebrales múltiples tipo B (asociación de lesión ligamentaria) o tipo C (evidencia de subluxación/luxación). Se excluyó a pacientes con registros incompletos de historias clínicas, fracturas por osteoporosis o patológicas y seguimiento <3 meses. **Resultados:** Se constataron 5 pacientes (1 mujer y 4 hombres) con dos fracturas vertebrales inestables simultáneas, con 4 casos (80%) de fracturas no contiguas y 3 casos (60%) con 2 luxofracturas simultáneas no contiguas ("columna flotante"); 2 (40%) pacientes presentaron la asociación de una fractura tipo B con una tipo C. La mediana de la edad era de 35 años. Todos tenían traumatismos de alta energía con lesiones asociadas. Los pacientes fueron operados por vía posterior convencional, con reducción y artrodesis larga. Se constató la recuperación neurológica en 2 pacientes. **Conclusión:** Presentamos una serie de casos de múltiples fracturas vertebrales inestables (tipo B o C) y simultáneas por traumatismos de alta energía. Esta asociación de lesiones es poco frecuente y tiene una elevada morbilidad relacionada con el trauma vertebral, sistémico y neurológico.

Palabras clave: Fracturas vertebrales múltiples inestables; columna flotante; trauma; alta energía.
Nivel de Evidencia: IV

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INTRODUCTION

The association of multiple simultaneous spinal fractures has been extensively described in the literature, especially in the context of high-energy trauma.[1-5]

The subgroup of associated fractures separated by an undamaged spinal segment can be distinguished as non-contiguous fractures. Numerous publications have estimated their incidence and prioritized the importance of timely diagnosis, since approximately 28% of non-contiguous spinal fractures can go unnoticed.[5] In the last decades, some investigations that evaluated patients with magnetic resonance imaging recorded a variable incidence of non-contiguous spinal fractures (17-34%).[5,6]

In the context of this association of injuries, it should be noted that the coexistence of two non-contiguous unstable spinal fractures is less frequent and the number of publications in this regard is much lower, with case reports or brief series predominating.[7-11] The association of two non-contiguous spinal dislocations or dislocations-fractures has received different names in the literature. The "en bloc" dislocation of the lumbar spine can be mentioned in a case of simultaneous dislocations of the thoracolumbar and lumbosacral joints[8] and as "floating spine" in reference to spinal injuries that compromise the three regions at two non-contiguous levels.[7,10,11]

The objective of this study was to analyze a series of patients with spinal cord trauma and association of multiple simultaneous unstable vertebral fractures (type B or C).

MATERIALS AND METHODS

A series of patients with high-energy spinal cord trauma treated by the same surgical team was analyzed, with the objective of evaluating the cases that presented the association of multiple simultaneous unstable spinal fractures during the period between January 2015 and January 2021.

Patients with type B (association of ligament injury) and type C (evidence of subluxation/dislocation) multiple spinal fractures according to the AOSpine thoracolumbar and low cervical vertebral injury classification systems were included. Patients with incomplete medical records, osteoporotic fractures, pathological fractures, and follow-up <3 months were excluded.

The description of the cases was carried out considering the following study variables: age, sex, trauma, vertebral topography, classification according to the AOSpine system,[12] involvement of non-contiguous vertebrae; configuration of the floating spine injury; pre- and postoperative neurological status according to the *ASIA Impairment Scale* (AIS),[13] presence of associated injuries and comorbidities, surgical approach, levels of instrumentation involved, complications, radiographic evolution, clinical evolution according to the visual analog scale and the Functional Independence Measure (FIM) upon discharge. The FIM is an instrument developed as a measure of disability that includes measures of independence for self-care, sphincter control, transfers, locomotion, communication, and cognition.[14]

This research was carried out in accordance with the principles set forth in the Declaration of Helsinki, respecting the anonymous nature and confidentiality of the data. The patients gave their consent for its publication.

Statistical Analysis

In the description of our case series, categorical variables are expressed as number and percentage, and numerical variables, as median and range. Count, percentage, and summary measures were obtained using the SPSS Statistics 25 program.

RESULTS

During the study period, there were five patients (1 woman and 4 men) with two simultaneous unstable spinal fractures, with four cases (80%) of non-contiguous fractures. According to the type of associated fractures, three (60%) had two non-contiguous simultaneous dislocation fractures (AOSpine: type C), an association called 'floating spine', according to previous publications. As an injury variant, two (40%) patients had the association of a type B fracture with a type C. The median age was 35 years (range 23-49). All had suffered high-energy trauma (3 traffic accidents, 2 high-altitude falls) with associated injuries. Severe chest trauma with rib fractures and hemothorax predominated (n = 3, 60%). Few previous comorbidities were recorded: one patient with a history of major depression and suicide attempt, and one with ossification of the cervical posterior longitudinal ligament. Table 1 summarizes the description of the sample and Table 2 describes the cases (Figures 1-4).

Table 1. Sample description

Variables		Results
Age, median (min-max)		35 (23-49)
Sex, n (%)	Male	4 (80)
	Female	1 (20)
Topography, n (%)	Cervical + Thoracic	2 (40)
	Thoracic + Lumbar	2 (40)
	Lumbar	1 (20)
Number of fractured vertebrae, median (min-max)		3 (2-6)
Associated injuries, n (%)		5 (100)
Fusion levels, median (min-max)		11 (8-12)
Floating spine, n (%)		3 (60)
AIS at admission, n (%)	A	2 (40)
	C	1 (20)
	D	2 (40)
Type of trauma, n (%)	Car accident	3 (60)
	Fall from height	2 (40)

AIS = *ASIA Impairment Scale.*

Table 2. Description of the cases

n	Age (sex)	AOSpine	Injury association	AIS (pre.)	Associated injuries
1	35 (M)	C7-T1: C (T3-T4: C; T1:A1; T4:A1; N4)	FS	A	Metatarsal fracture
2	29 (F)	T7-T8: C (T12-L1: C; T7:A4; T8:A3; T9:A1; T10:A1; L1:A3; L2:A4; N3)	FS	D	Humerus, pelvis and rib fractures Chest trauma with hemothorax TBI
3	38 (M)	T1-T2: C (C3-C4: B3; T2 A1)	C + B	C	TBI with skull fracture Atlas fracture
4	49 (M)	L4-L5: C (L1-L2: B2; L2: A4; L3:A3; N3)	C + B	D	Chest trauma with rib fractures and hemothorax
5	23 (M)	T8-T9: C (T12-L1: C; L1: A3; T9: A1; N4)	FS	A	Chest trauma with rib fractures and hemothorax TBI

AIS (pre.) = preoperative *ASIA Impairment Scale*; M = male; F = female; FS = floating spine; TBI = traumatic brain injury; C + B = association of type C fracture and type B fracture.

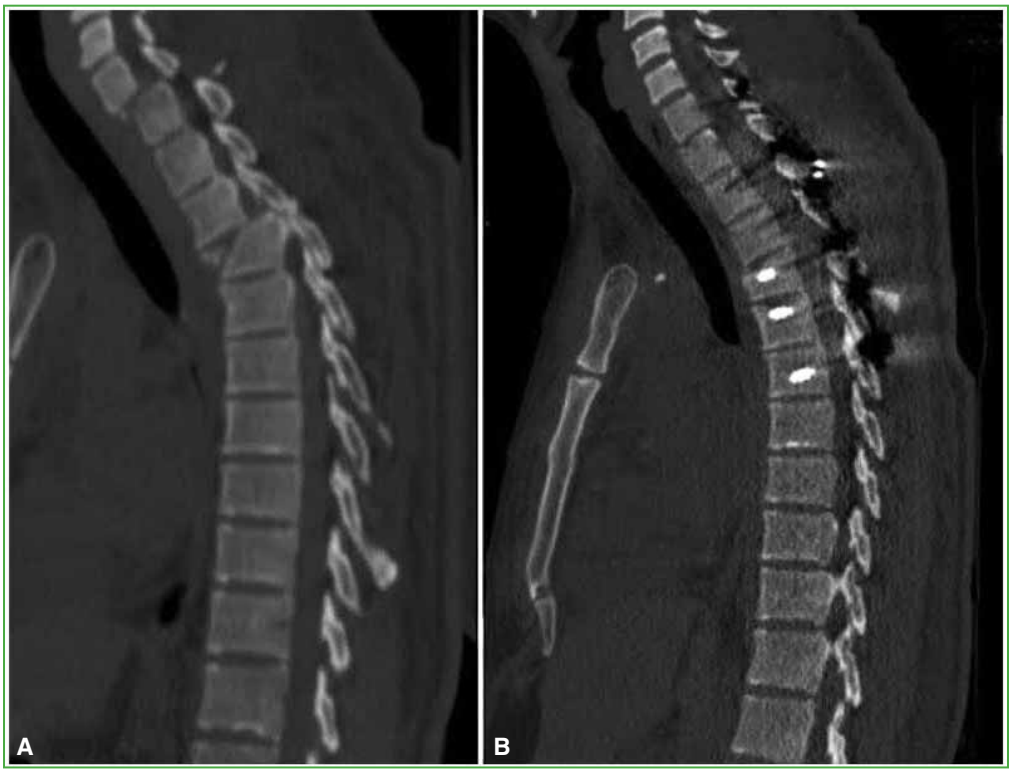

Figure 1. Computed tomography of the cervicothoracic spine without contrast, sagittal section. **A.** Upon admission of the patient. Evidence of 'floating thoracic spine'. **B.** Postoperative period. Evidence of reduction of both injuries.

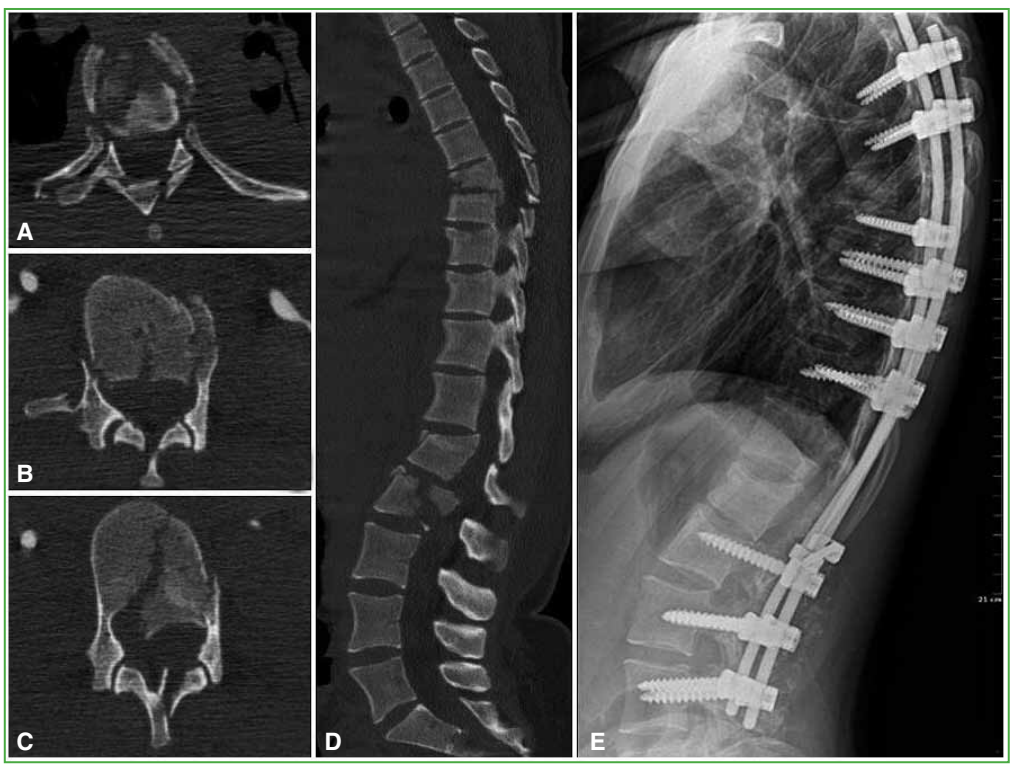

Figure 2. Case 2. **A-D.** Initial computed tomography of the thoracolumbar spine, axial sections in T7, L1, and L2, respectively. **E.** Postoperative lateral radiograph of the thoracolumbar spine. Pedicle instrumentation.

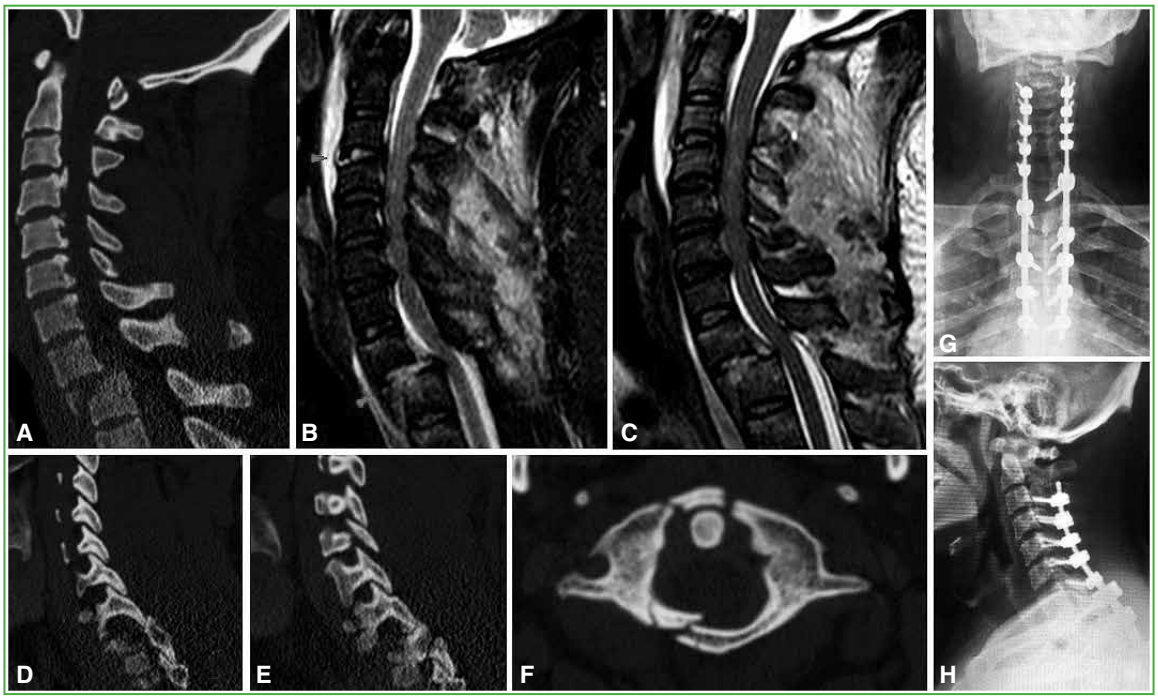

Figure 3. Case 3. **A, D-F.** Initial cervical spine computed tomography. Evidence of fracture-dislocation of C7-T1 with bilateral facet dislocation, ossification of the posterior longitudinal ligament, and atlas fracture. **B and C.** Magnetic resonance imaging of the cervical spine with evidence of a C3-C4 B3 injury. **G and H.** Anteroposterior and lateral radiographs of the cervicothoracic spine, respectively. Postoperative control.

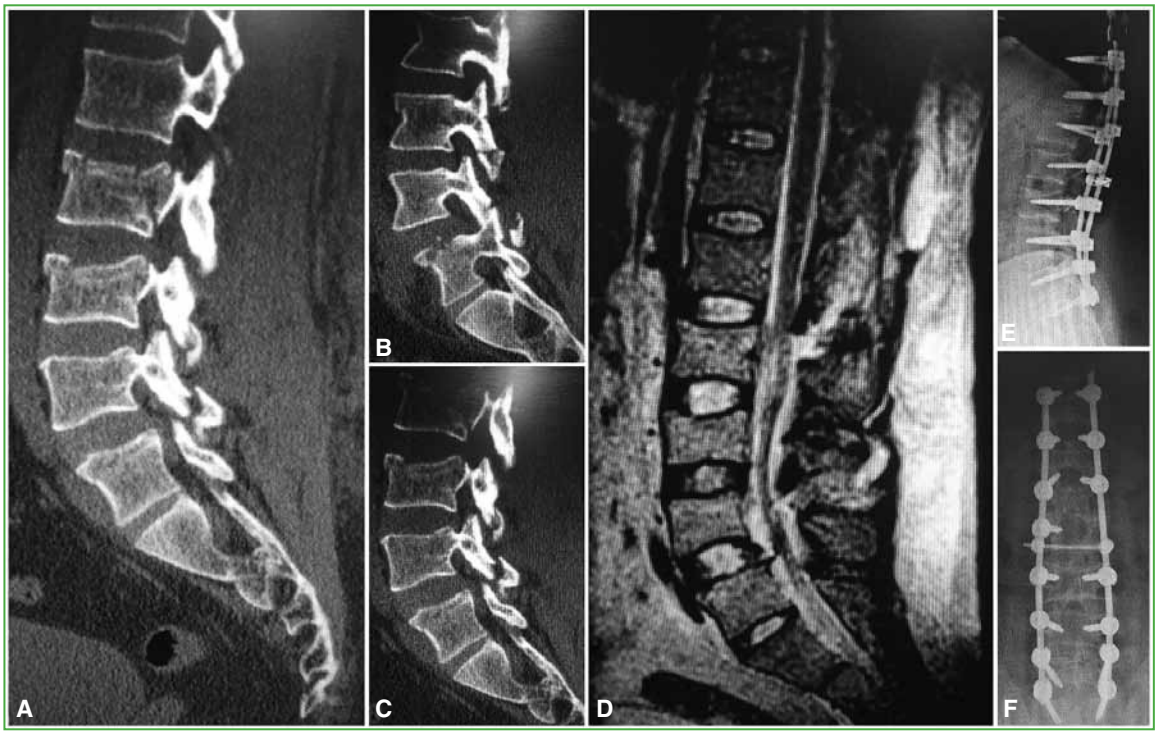

Figure 4. Case 4. **A-C.** Initial lumbosacral spine computed tomography. Evidence of fracture dislocation of L4-L5 (traumatic spondylolisthesis), associated with A3 fracture of the vertebral body of L2 and A1 of L3. **D.** Magnetic resonance imaging of the lumbosacral spine with evidence of a type B2 L1-L2 lesion. **E and F.** Postoperative radiographic control.

All patients suffered neurological injury (4, spinal cord/conus medullaris injury; 1, cauda equina injury). The degree of initial neurological injury was severe in three cases (2 with complete AIS A syndrome; one with incomplete AIS C syndrome).

All were operated using the conventional posterior approach, with release, reduction, and long arthrodesis. In one case, dural repair was also performed. One patient was referred from another center, he had been treated in the Emergency Department with laminectomy of both injuries without instrumentation (Figure 5).

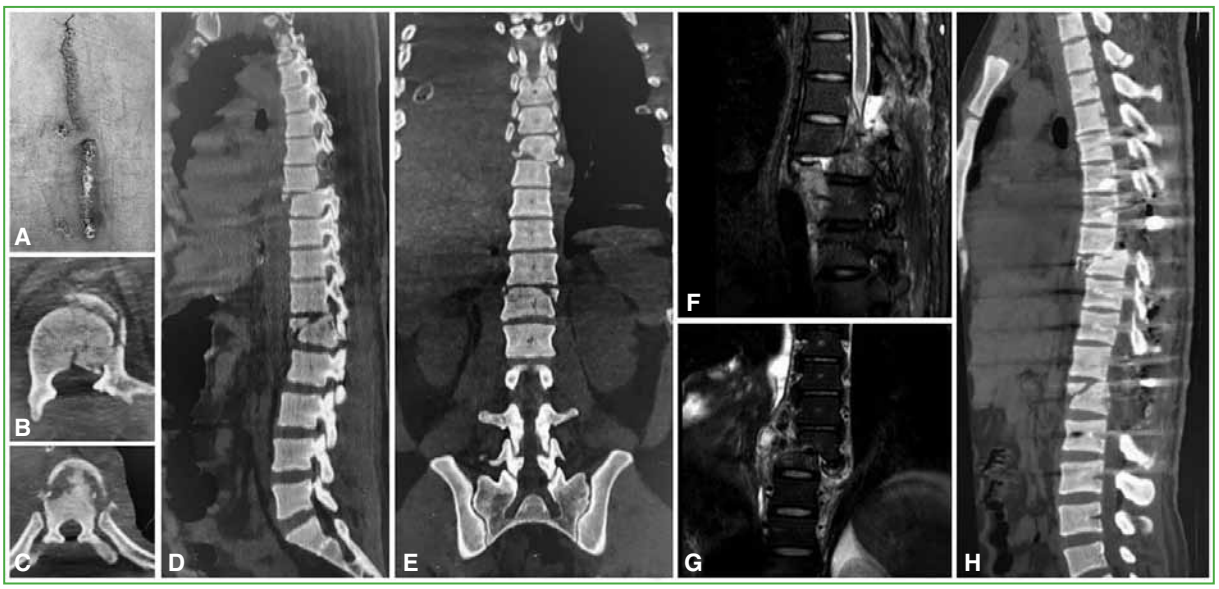

Figure 5. Case 5. **A.** Non-instrumented laminectomy scar performed in the referral Emergency Service. **B-E.** Spinal computed tomography. Evidence of associated dislocation-fractures at T8-T9 and T12-L1. **F and G.** Magnetic resonance imaging of the thoracic spine in STIR sequence. Evidence of preoperative progression of the displacement of a proximal dislocation-fracture of T8-T9. **H.** Postoperative thoracolumbar spine computed tomography with evidence of incomplete reduction of the proximal injury.

Neurological recovery was confirmed in at least 1 grade of the AIS classification in two patients. One AIS D patient fully recovered and one with severe AIS C quadriparesis partially improved to AIS D. In this last case, the recovery of the neurological state was incomplete; however, the patient was able to regain independence in walking with partial offloading. Patients with initial AIS A neurological injury did not recover their neurological status and therefore had greater postoperative functional dependence. Almost all suffered at least one complication (n = 4; 80%), most of which was related to the associated neurological injury (chronic neuropathic pain [4 cases], intrahospital urinary tract infection [2 cases]; neurogenic bladder [2 cases], neurogenic bowel [1 case]). One patient suffered septic shock with a urinary focus that forced him to be readmitted to the intensive care unit. In two (40%) cases, the complications were related to surgery: one patient with hematoma at the surgical site with ambulatory drainage (negative cultures) and one case of "floating spine" with incomplete reduction of the proximal fracture-dislocation without the need for revision (Table 3, Figure 6).

The median follow-up was 501 days (min.-max. 113-2024).

Table 3. Evolution

Variables	Results
FIM, median (min-max)	113 (72-126)
Axial VAS, median (min-max)	2 (0-5)
Complications, n patients (%) Related to surgery Clinical Associated with spinal cord trauma	4 (80) 2 (40) 2 (40) 4 (80)

FIM = *Functional Independence Scale*; EAV = visual analog scale; min-max = minimum-maximum.

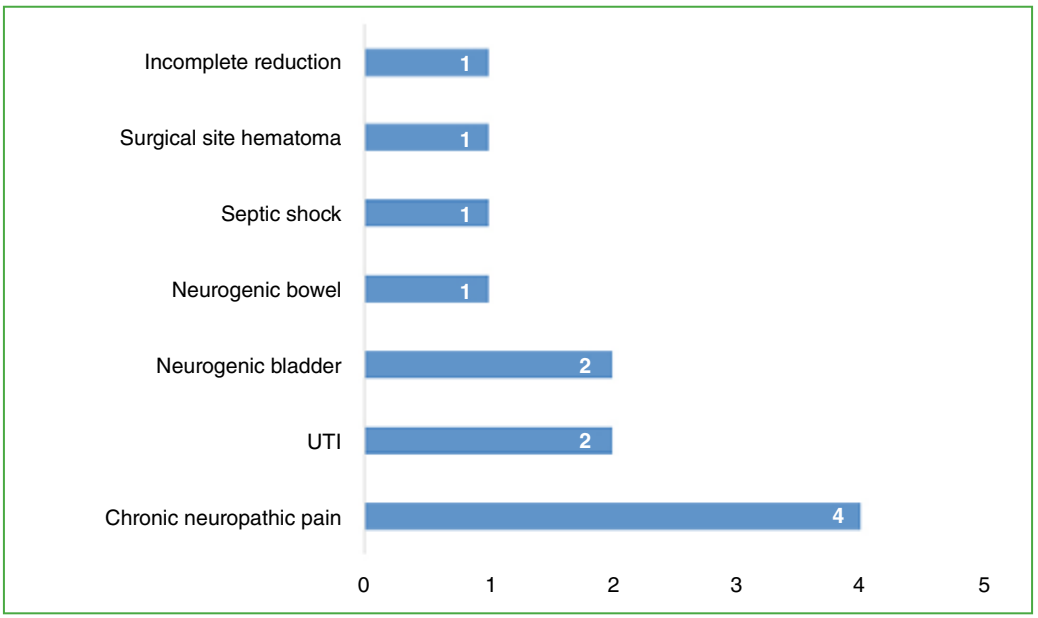

Figure 6. Distribution of complications.

DISCUSSION

In the context of the initial evaluation of patients with high-energy spinal cord trauma, it is common to detect the association of multiple adjacent or non-contiguous spinal fractures.[15] This finding is extensively described in the literature from which it appears that the altered level of consciousness that prevents the neuro-orthopedic examination and the high-energy traumatic history are risk factors for not noticing the second fracture.[16-18] In addition, the combination of cervical-thoracic and thoracic-lumbar topographies stands out as the most frequent patterns.[16-18] Therefore, the available evidence indicates that the presence of a cervical or thoracic vertebral lesion in high-energy trauma, especially in unresponsive patients, entails the imperative need to study the entire spine with computed tomography to avoid ignoring hidden or unnoticed injuries.[15-21] Even in the era of tomography and magnetic resonance imaging, a median delay in diagnosis of associated spinal fractures of 5.1 days has been reported.[15] Magnetic resonance imaging offers as an additional advantage the possibility of assessing for edema (trabecular fractures), direct estimation of ligament lesions, and complete evaluation of the neuraxis.[5]

Multilevel spinal fractures are defined as fractures of the spine at more than one site and separated by at least three normal vertebrae. Other authors define them as "non-contiguous" or "alternating" when there is at least one normal vertebral segment.[18,20]

It should be noted that the association of non-contiguous and simultaneous unstable fractures involving ligament compromise (type B) or vertebral translation (type C) is typically rare and there are few published cases.[7-11] Takami et al. reported 2.5% non-contiguous unstable spinal fractures in a registry of 710 patients, with only nine cases of floating spine.[7] In our environment, we highlight the publications by Sarotto et al., and Bazán et al.[18,22] Sarotto et al. carried out a descriptive study of 120 patients with alternating spinal fractures from the records of five hospitals in the Autonomous City of Buenos Aires over a 10-year study period with a detailed demographic and clinical description, although without emphasis on the association of simultaneous type B or C spinal injuries. In a cross-sectional and multicenter study on multiple spinal fractures that involved 15 centers, Bazán et al. reported 66 patients in two years, with no cases of associated simultaneous unstable fractures (type B or C).[22] In our opinion, this gives our series a hierarchy, despite the low number of cases (n = 5; 3 cases of 'floating spine').

There is agreement on the surgical treatment of associated unstable spinal fractures.[7-11] In this group of patients, aside from the factors usually considered in decision-making for spinal cord trauma (clinical stability, mechanical stability, neurological compromise, local deformity, ligament compromise, vertebral translation), other factors have been suggested, such as number of undamaged segments that separate both fractures, to estimate the possibility of carrying out focal instrumentation with preservation of mobile intermediate segments.[15] From a current perspective and with the advent of new technologies, there are alternatives to conventional long arthrodesis that include long percutaneous fixation and combined minimally invasive approaches (anterior/posterior) with the possibility of eventual material removal to recover mobility.[22] This is particularly controversial in cases of type B or C fractures. In our series, all the patients were treated by conventional posterior approach with reduction and long arthrodesis involving numerous segments in the instrumentation. This strategy was determined by the severity of the instability of the associated injuries, the presence of neurological injury in all cases in the series, and the presence of other fractures in intermediate segments.

In general, this type of injury causes high morbidity and mortality on admission and during its evolution. Takami et al. reported an associated injury rate of 66.7%.[7] In agreement with the literature, associated injuries were recorded in all the cases of our series, with a predominance of severe chest trauma. Additionally, we documented a high rate of complications, which were predominantly related to neurological injury. Neurological recovery was possible in two of the five cases.

The strength of our study is the contribution of cases on a rare association of unstable traumatic spinal injuries: three cases of floating spine. Likewise, as a novelty according to the literature, the simultaneous association of type B and type C fractures is proposed as a variant. We consider this appreciation valid, since there is a consensus regarding instability and the standard surgical management of spinal injuries with ligament involvement. These types of injuries often involve opting for long fusions. Treatment, particularly in young patients and with lumbar fractures, can be difficult in order to preserve mobile segments, which, in the author's opinion, also occurs in non-contiguous associated vertebral dislocation-fractures.

The weaknesses of this study are its descriptive-retrospective design and the small sample size that prevent reaching generalizable conclusions. However, it has the strength of adding our knowledge in treating this association of injuries with high morbidity and mortality, complexity, and low frequency.

CONCLUSION

We present a series of patients with multiple simultaneous unstable spinal fractures (type B or C) due to high-energy trauma. A rare association of injuries, with high morbidity related to vertebral and systemic trauma and neurological injury.

Conflict of interest: Ricciardi GA is section editor of the AAOT Journal.

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Aneurysmal Bone Cyst of the Cuboid. Case Report and Review of the Literature

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ABSTRACT

A rare clinical case of an aneurysmal bone cyst located at the level of the cuboid in a 13-year-old boy is presented. The diagnosis was reached through clinical evaluation, imaging studies (radiograph-MRI), and a pathological anatomy analysis. Its treatment consisted of thorough intralesional curettage, high speed burring, electrocautery, and filling with lyophilized bone allograft with cortical/cancellous chips. Despite the late diagnosis, we would like to highlight the favorable clinical evolution of the patient, with ad integrum remission of the symptoms and return to his sport activities, without elements of local recurrence.

Keywords: aneurysmal bone cyst.

Level of Evidence: IV

Quiste óseo aneurismático en el cuboides de un niño de 13 años. Presentación de un caso clínico

RESUMEN

Se presenta un caso clínico poco frecuente de un quiste óseo aneurismático localizado en el cuboides de un niño de 13 años. Se llegó al diagnóstico mediante la tríada de síntomas, estudios por imágenes (radiografía, resonancia magnética) y anatomía patológica. El tratamiento consistió en el abordaje y curetaje minuciosos dentro de la lesión, el fresado de alta velocidad, la electrocauterización y el relleno con aloinjerto óseo liofilizado con chips cortico-esponjosos. Pese al diagnóstico tardío, la evolución clínica fue favorable con remisión completa de los síntomas y retorno a las actividades deportivas, sin recidiva local.

Palabras clave: Quiste óseo aneurismático.

Nivel de Evidencia: IV

INTRODUCTION

Jaffe and Lichtenstein published the first description of an aneurysmal bone cyst (ABC) in 1942.[1,2,3] It is a rare condition and represents about 1% of all primary bone tumors. Although it can occur at any age, it is most common between the ages of 10 and 20, with around 75% of cases corresponding to individuals aged <20.[1,2,3] It can manifest as a primary lesion (70%) or as a secondary lesion to an existing lesion.[1,2,3] It is defined as a benign cystic lesion of the bone composed of blood-filled spaces separated by connective tissue septa containing fibroblasts, osteoclast-like giant cells, and reactive bone tissue.[1,2,3]

Its clinical presentation can go unnoticed, and it can develop with pain, inflammation, or without symptoms depending on whether it sits on a weight-bearing bone or not.

In some cases, it can present as a pathologic fracture.[1,2,3,4,5]

It should be noted that it is a locally destructive process and has high recurrence rates.

ABC treatment is determined by the patient's age, location, extent, degree of aggressiveness, and size. There are currently several treatment modalities available, such as intralesional curettage, resection plus bone grafting, local

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adjuvants, such as high-speed drilling, electrocautery, phenol, liquid nitrogen, and embolization, which have the advantage of expanding the zone of necrosis of tumor tissue cells.

There are different opinions about which is the best method of treatment for the pediatric population as opposed to adults, because it is based on immature bone and can appear in areas adjacent to the growth plate.[1,2,3]

The first description of an ABC in the cuboid bone dates from 1977 and, since then, few cases of this clinical presentation have been published in this very atypical topography, either in its primary form or associated with other lesions, such as chondroblastoma.[6,7,8,9,10,11,12,13] Tables 1 and 2 detail the cases published to date.

Table 1. Published cases of aneurysmal bone cyst.

Year	Title	Authors
1977	Aneurysmal bone cysts: a clinicopathological study of 105 cases	Ruiter DJ et al.
1990	Aneurysmal bone cyst of the cuboid	Kashuk KB et al.
1999	Le kyste osseux anévrysmal du cuboide: etude d'un cas et reveu de la litterature	Essadki B et al.
2003	Aneurysmal bone cyst of the cuboid	Verrina F et al.
2010	Curettage of aneurysmal bone cysts of the feet	Chowdhry M et al.
2016	A rare case of aneurysmal bone cyst of cuboid bone in a 10-year-old girl	Bojovic N et al.

Table 2. Published cases of cuboid aneurysmal bone cyst/chondroblastoma

Year	Title	Authors
2005	Chondroblastoma with associated aneurysmal bone cyst of the cuboid	Sessions W et al.
2007	Chondroblastoma of the cuboid with an associated aneurysmal bone cyst: a case report	Sepah YJ et al.

In our Service (Centro Hospitalario Pereyra Rosell), curettage and filling with bone allograft is the most widely used therapeutic option.[3]

The aim of this article is to report our outcomes in this extremely rare clinical case.

It is critical that the interdisciplinary team that performed the diagnostic research on this type of patient remains in charge of the condition's definitive treatment. The team should include traumatologists, pediatricians, imaging specialists, pathologists, and pediatric oncologists.

CLINICAL CASE

After repeated emergency consultations for persistent pain in the neck of the foot and left foot as a result of multiple traumatisms, a healthy 13-year-old boy from the city of Minas, Uruguay, was referred to our external polyclinic service.

The patient suffered from pain with inflammatory characteristics (it did not subside with non-steroidal anti-inflammatory drugs or at rest, with a nocturnal component, without elements of general adaptation syndrome) and had a slow-growing tumor located in the midfoot that had evolved over seven months.

During the initial physical examination, the patient was found to be in good general condition, free of systemic symptoms, and requiring crutches for standing and ambulation. When asked to bear weight on the affected limb, he would use support and an antalgic gait to avoid the outer region of the foot.

The evaluation of the hip, knee and ankle revealed no alterations in passive/active range of motion and the distal neurovascular examination was normal.

The tumor was located on the external side of the midfoot, in the sector of the cuboid bone, it measured 3 x 3 cm, and had ill-defined limits, an ovoid shape, an irregular surface, a stony consistency, was immobile, associated with deep planes, and painful to the touch (Figures 1 and 2).

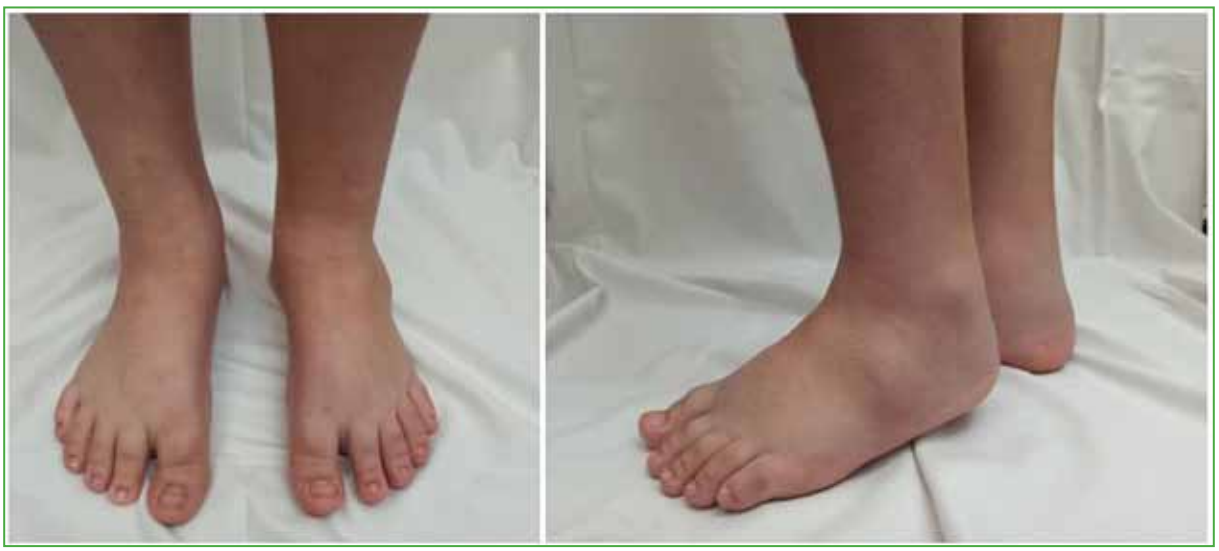

Figure 1. A and B. Clinical appearance of the patient's foot at the time of consultation. Tumor mass at the level of the external side of the midfoot at the level of the topography of the cuboid bone.

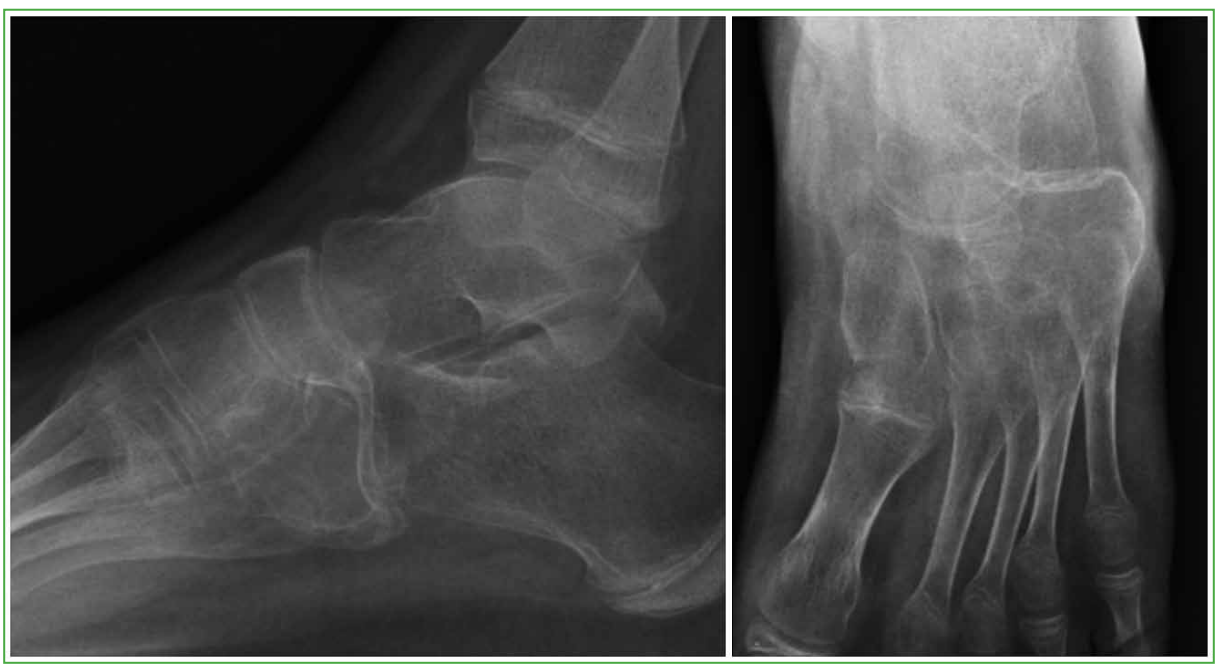

Figure 2. Anteroposterior and lateral foot radiograph. Due to diffuse osteopenia, an alteration of the normal morphological bone structure of the midfoot is evident; at the cuboid level, a lytic image is visible, with poorly defined margins, a narrow transition zone, hyper-inflated, with cortical thinning, and no soft tissue component.
Stage 2 Enneking.

Faced with a tumor of bone origin, he was evaluated using our institution's standard protocol, which included radiographs of the afflicted area, paraclinical blood tests for general and infectious evaluation, and magnetic resonance imaging (Figure 3).

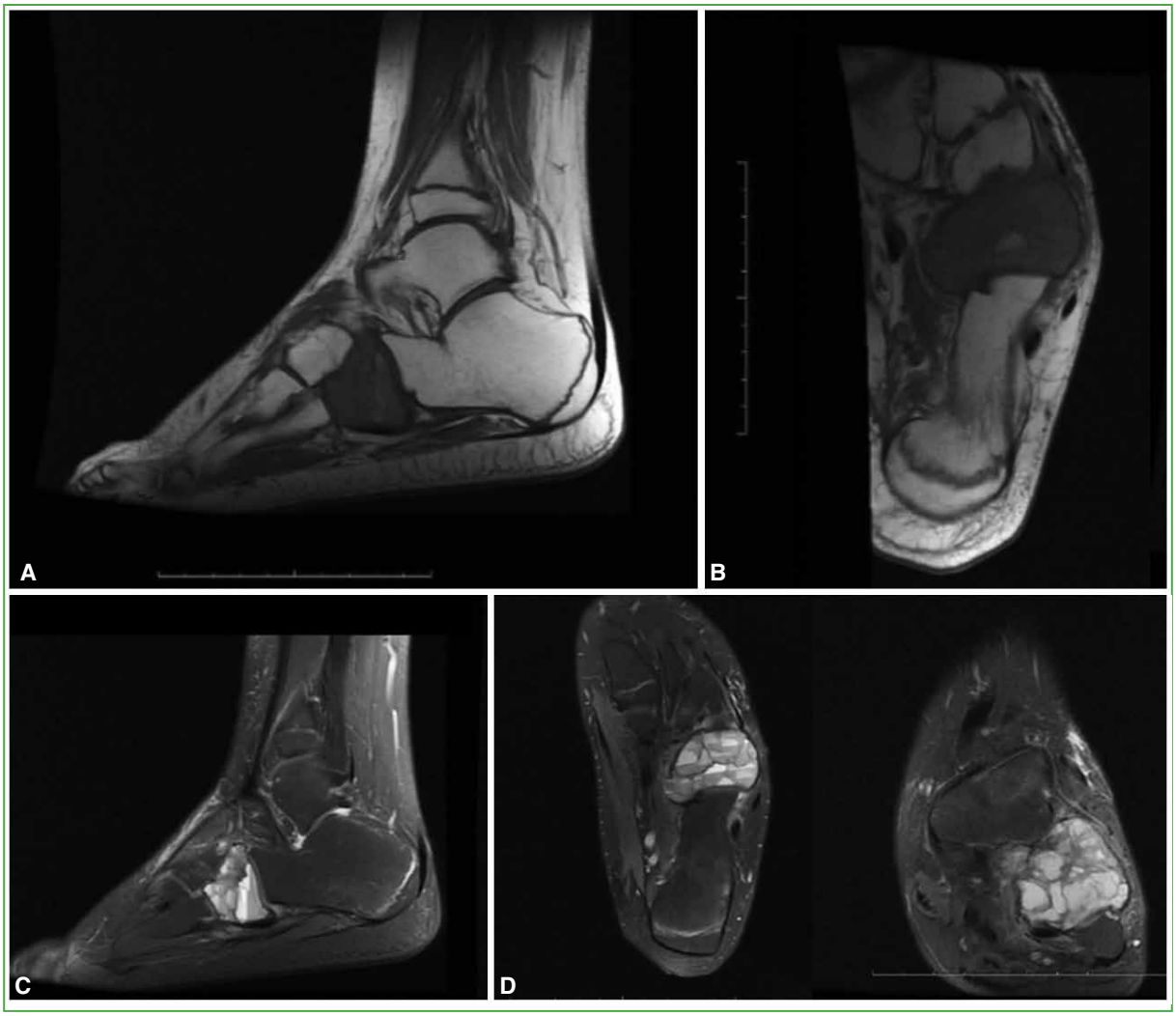

Figure 3. MRI of the neck of the foot and foot. T1 (A/B) -T2 (C/D) weighted images show the expansive cystic lytic lesion at the cuboid level with fluid-fluid levels within it, the presence of internal septa with a soap-bubble appearance, without changes at the soft tissue level or at the level of the calcaneus/cuboid, cuboid/4th and 5th metatarsal joints.

After the corresponding imaging studies, and despite the fact that they were highly suggestive of ABC, it was imperative to complete the diagnostic triad with a planned biopsy of the lesion (Figure 4). In published studies, it is argued that definitive treatment should not be administered without a diagnosis.

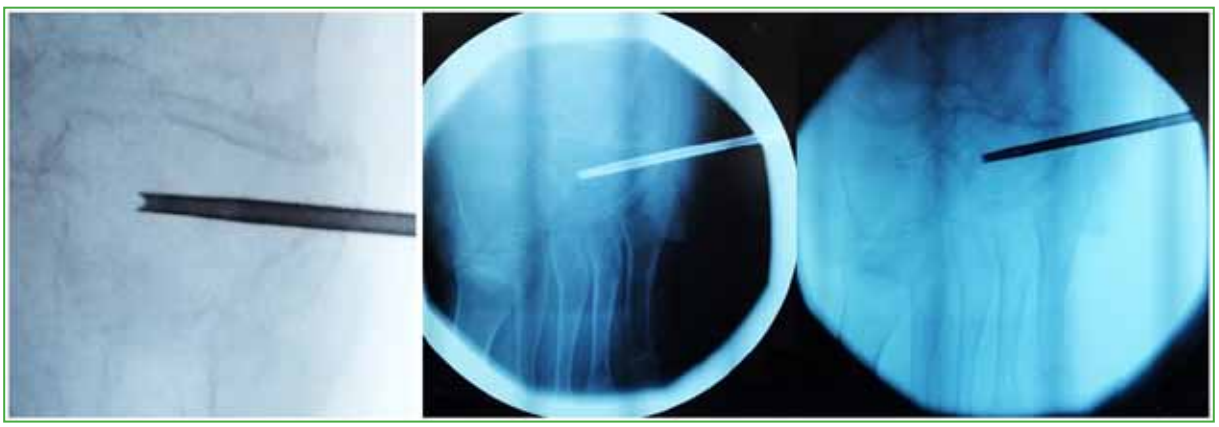

Figure 4. Intraoperative images of the percutaneous biopsy with bone trocar.

The procedure was carried out in the surgical unit under general anesthesia under strict aseptic conditions. The percutaneous biopsy was carried out through an approach on the long axis of the bone (longitudinal incision) as the last diagnostic step in order to confirm the nature of the tumor through pathological anatomy studies and bacteriological culture (Figure 5). Eight red-brown fragments measuring 0.4 x 0.5 and 0.2 x 0.2 cm were sent for examination. The microscopic analysis revealed fibrous wall flaps covered with histiocytic tissue and osteoclast-type giant cells, fibrous collagenic flaps, associated edematous fibrous tissue, and extensive hemorrhage in biopsy sections of bone. The histopathological diagnosis was ABC.

Figure 5. Puncture area and hemostasis with nylon suture.

Definitive treatment

Once the diagnostic triad was completed, we proceeded to complete the resection of the cyst in a second surgical stage (Figures 6-11).

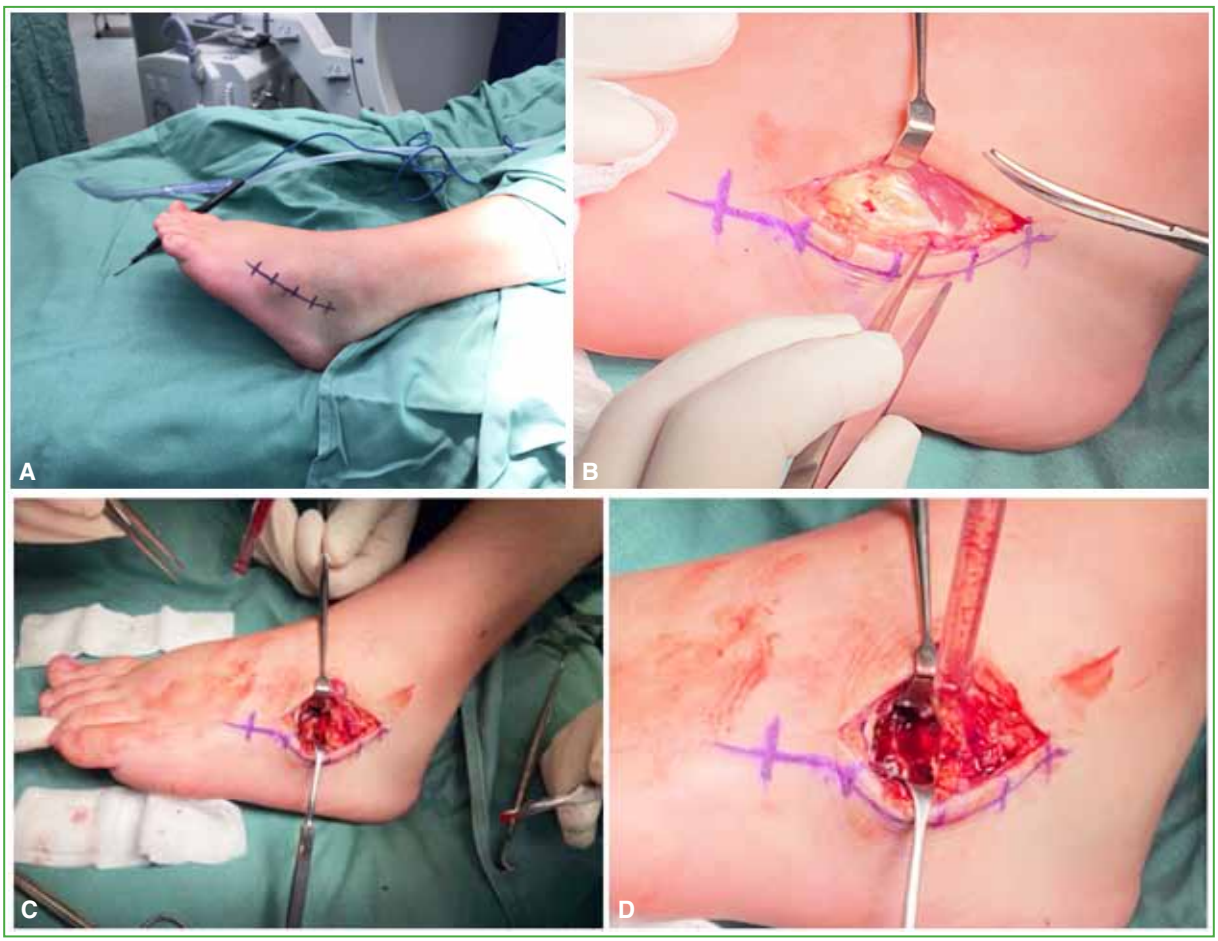

Figure 6. **A/B** Longitudinal approach centered on the topography of the cuboid bone. A bone window is made with a fine chisel to open the cyst. **C/D** The cavity is meticulously curetted using a simple curette to remove the internal connective tissue membranes and adherents to the walls.

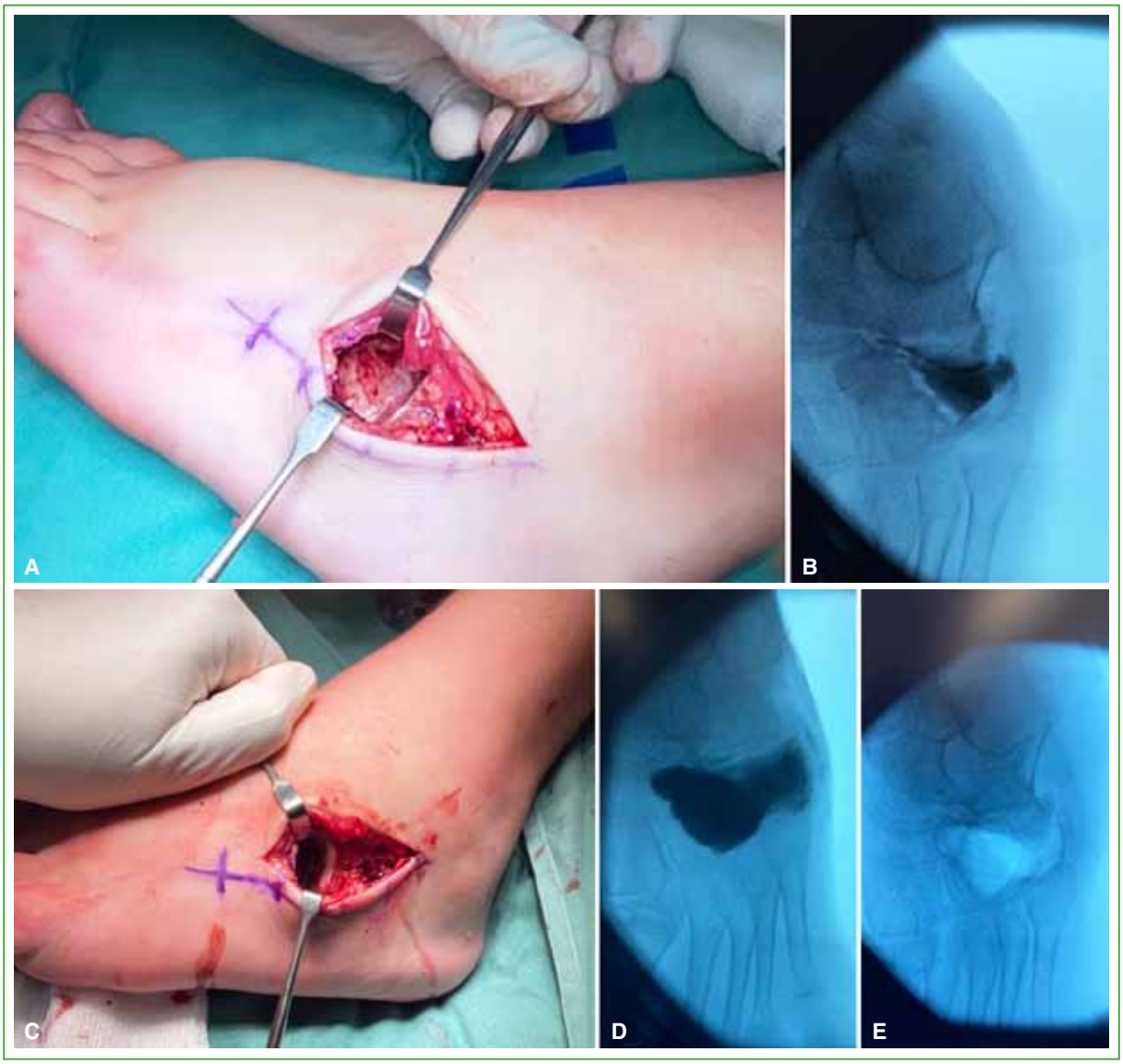

Figure 7. **A/B** Curettage of membranes, use of contrast medium to evaluate the resection of the cavity, the septated cyst can be seen. **C/D/E** After extraction of all the membranes, cautious curettage is required to avoid fracturing the cortical walls. It is then assessed with contrast, the difference between the **B-D**images can be appreciated.

Figure 8. The allograft of lyophilized bone from the INDT bank was rehydrated with saline solution for 20 minutes and cut before placement.

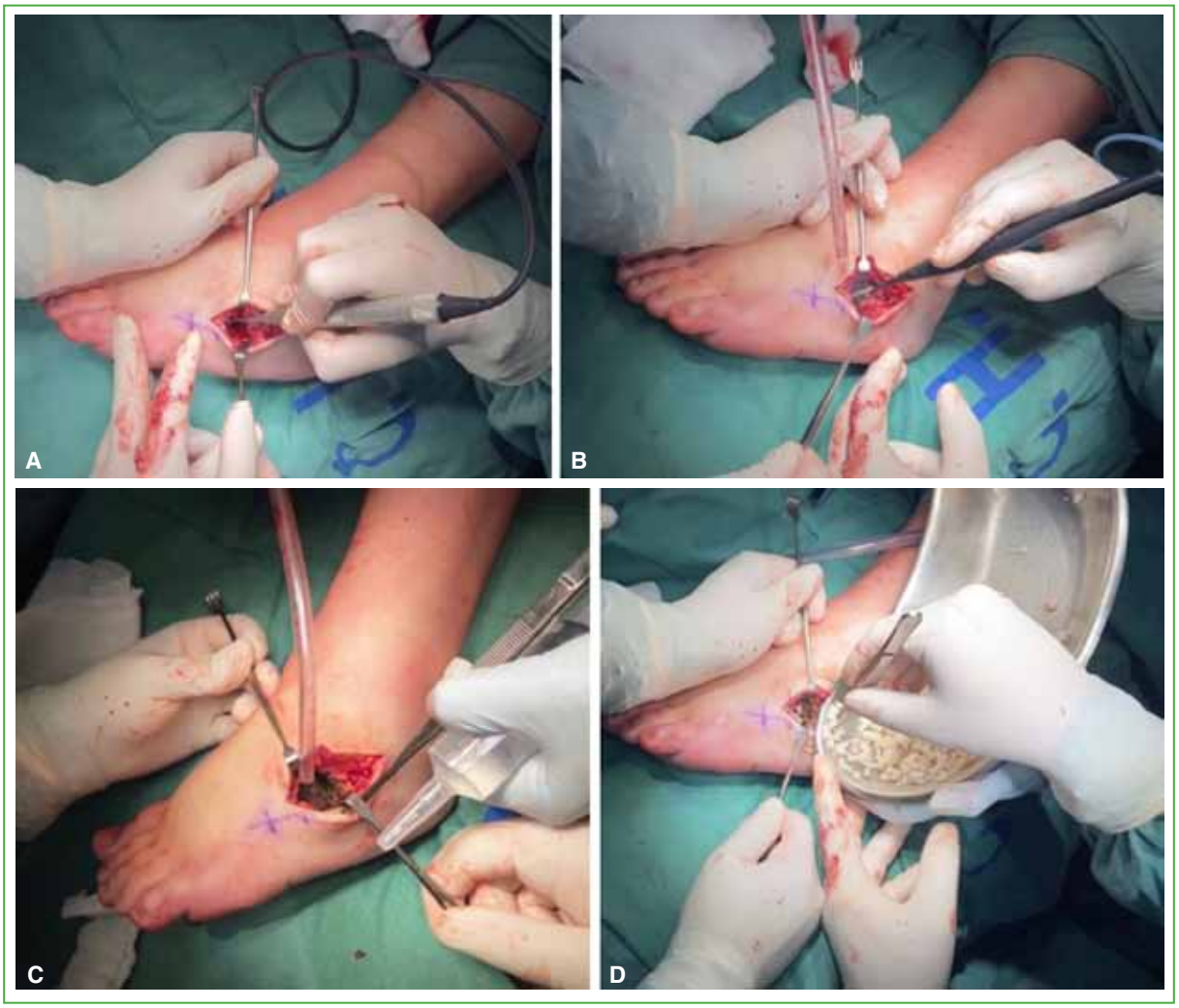

Figure 9. **A-B** High-speed drilling, electrocautery in spray mode as an adjuvant method for the excision of the membranes. **C-D** Cavity filling with lyophilized bone allograft with cortico-cancellous chips.

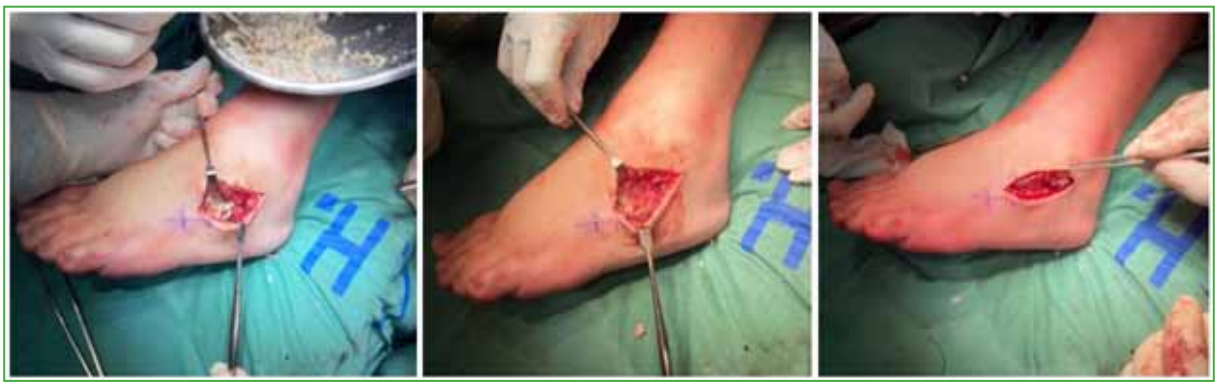

Figure 10. After filling the cavity, closure of the bone window and closure by planes is performed.

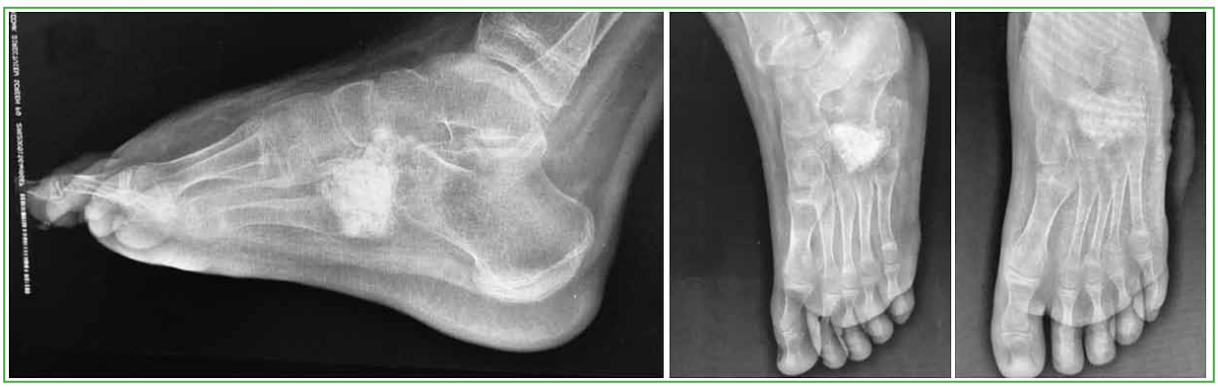

Figure 11. Postoperative foot radiographs, lateral, oblique and AP views. Graft filling can be appreciated without invading the cortices of the cuboid bone.

Postoperative period

The patient suffered no complications in the immediate postoperative period (Figure 11). He was discharged 48 hours later, with instructions to rest, avoid weight-bearing on the limb (walking on crutches), and take nonsteroidal anti-inflammatory drugs. Partial weight-bearing was allowed one month after surgery and the load began to be increased progressively every week.

One week after the operation, he consulted in the emergency department due to local swelling accompanied by serosanguineous exudate at the surgical site (Figure 12). He had no symptoms of other major physiological systems, no fever, and no elements of osteoarticular infection in the hip, knee, or ankle. The laboratory analysis revealed acute phase reactants in the normal range.

The symptoms disappeared after watchful waiting with physical measures (rest, nonsteroidal anti-inflammatory drugs).

Figure 12. Clinical images a week after surgery. Swelling and local serosanguineous exudate; acute phase reactant analyses were performed, which were normal.

Follow-up

One month following surgery, partial weight-bearing was permitted, with the load gradually increasing weekly.

We want to highlight that the follow-up of the patient was carried out bi-monthly for the first 6 months (Figures 13, 14, 15) and then after a year because he could not attend for personal reasons (Figures 16, 17).

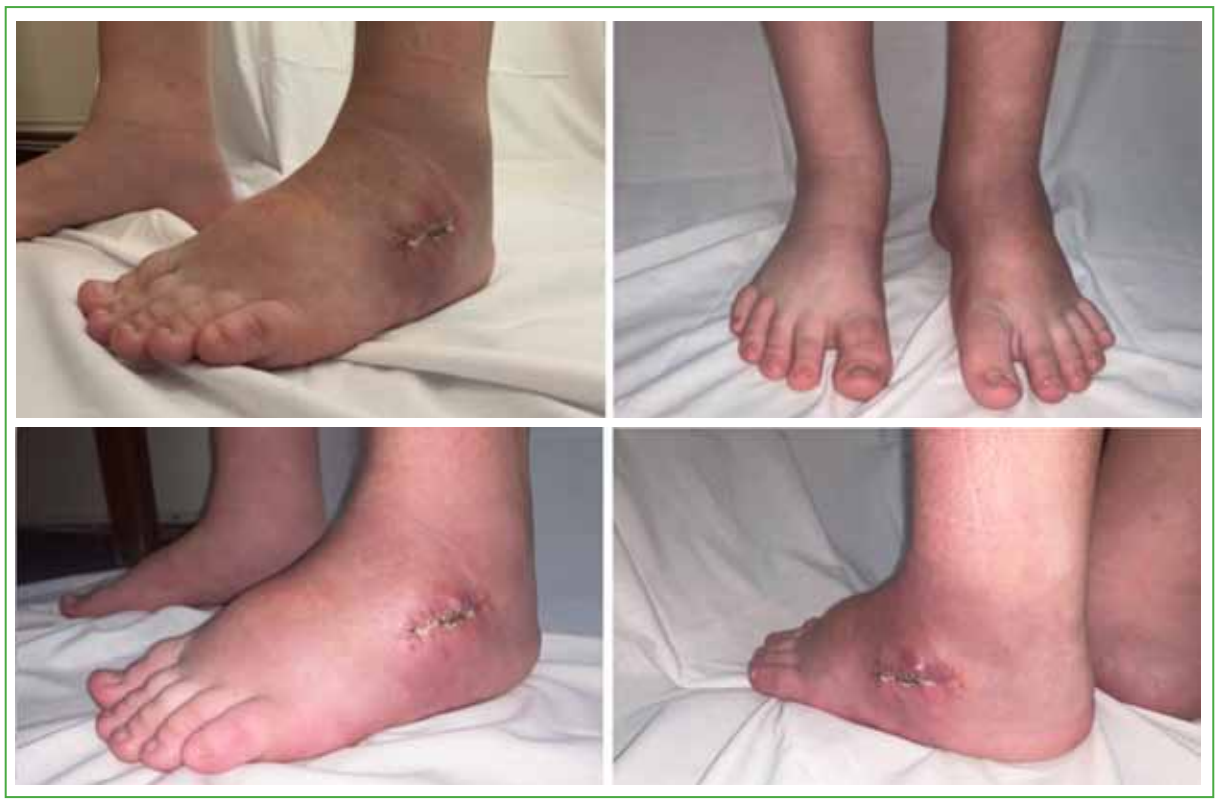

Figure 13. Clinical appearance after 2 months. Patient walking without crutches, without pain, reintegrating into all his activities of daily living.

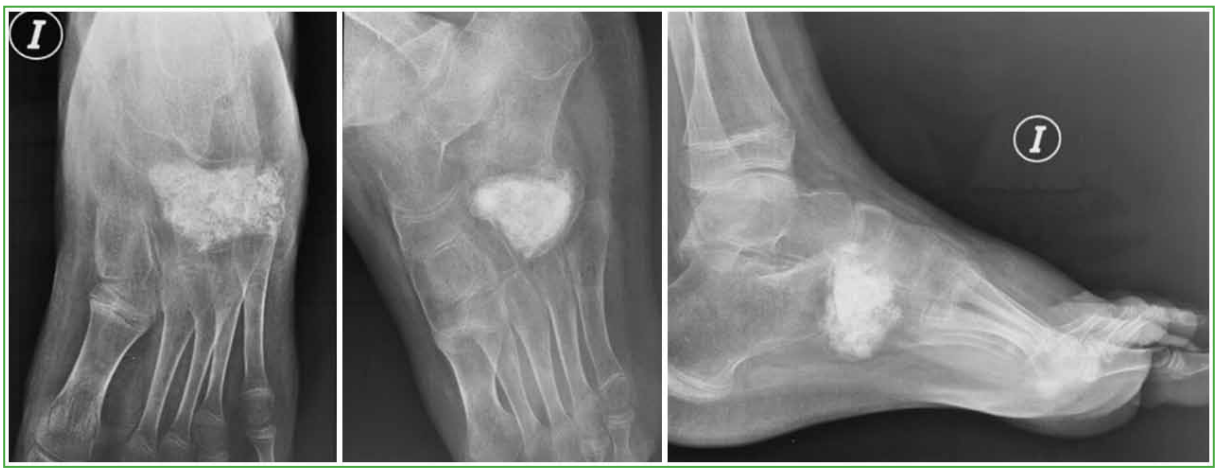

Figure 14. Foot radiographs after 2 months, AP, oblique, and lateral views. The bone graft can be seen at the level of the cuboid, without fractures, preservation of its joint relations with the calcaneus at the level of the hindfoot and the 4th and 5th metatarsals at the level of the forefoot. The skeleton progressively begins to reossify when given mechanical stimulation.

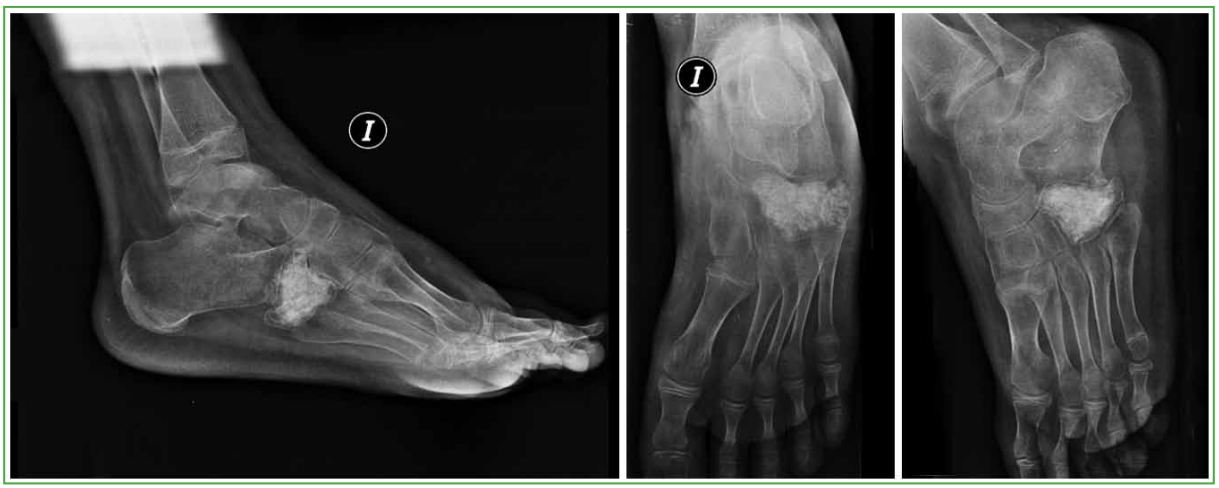

Figure 15. Radiographic postoperative control at 4 months. Lateral, AP, and oblique foot views.

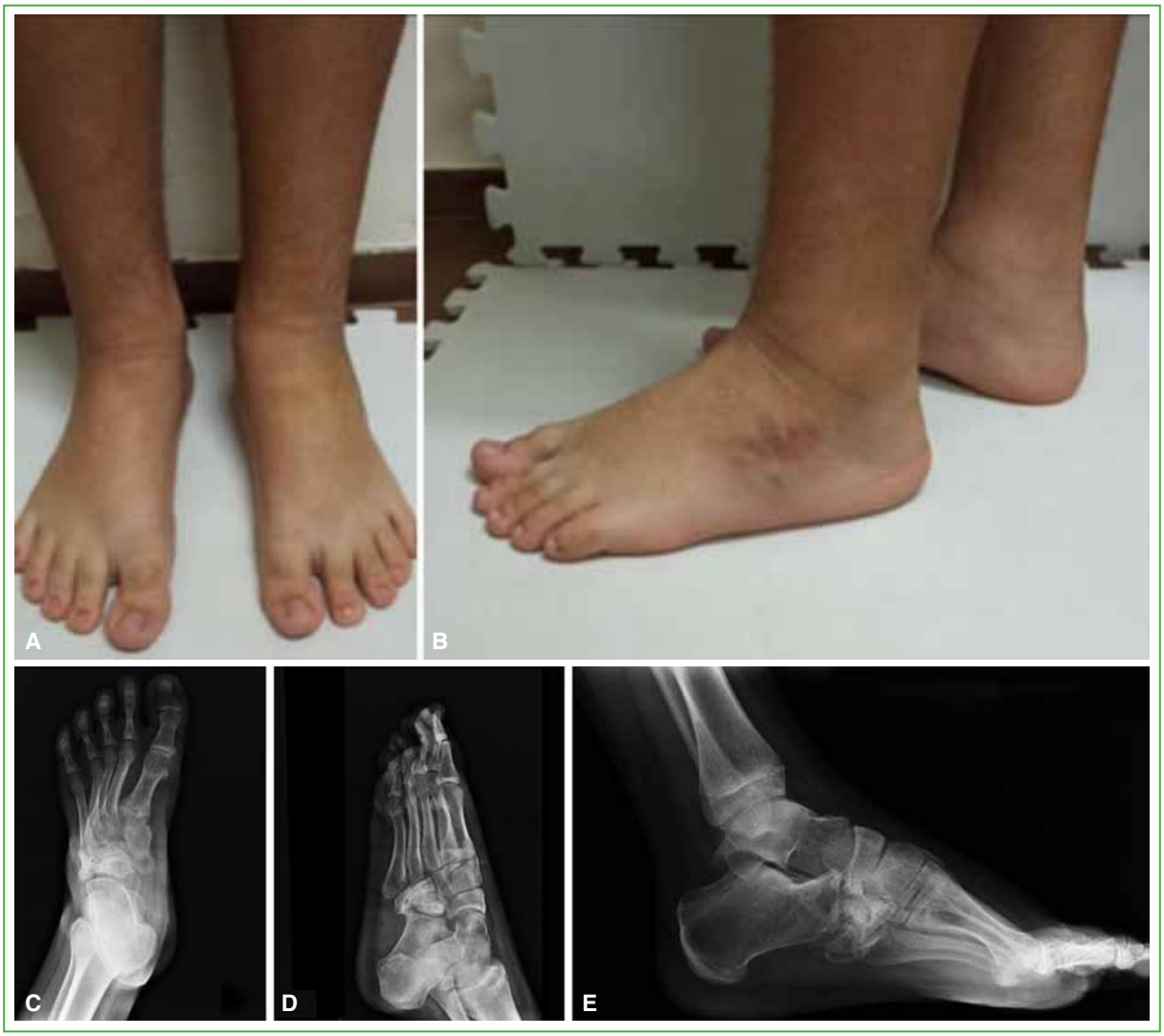

Figure 16. **A/B** Clinical - Radiographic control at 12 months **C/D/E**.

Figure 17. Clinical control / Walking without crutches, without pain.

DISCUSSION

The location of an ABC in the foot is rare and, in the cuboid bone, it is exceptional. Although it is suggested that its etiology is unknown, one of the theories that is used today is that ABC may correspond to intraosseous arteriovenous malformations surrounded by a thin layer of periosteum, and beyond the fact that it can appear in any bone, the vast majority manifest at the metaphyseal or metaphyseal-diaphyseal level of long bones. It is estimated that the incidence in the bones of the foot is 5-9% and its incidence in the cuboid is unknown.[2,3,6,7,8,9,10,11,12,13]

It should be noted that this patient had a late diagnosis. He was referred to our center after multiple consultations for foot neck trauma in the emergency department where he was not evaluated with radiographic approaches and was treated with physical rest, nonsteroidal anti-inflammatory drugs, and local ice, as if he had a sprain.

Our initial clinical-radiological approach was correlated with the results of the biopsy, and it was possible to administer a successful treatment.

The evolutionary phase of the ABC can be classified according to the Enneking stages; in our case, it corresponded to stage 2 (active).

The indications for surgery after diagnosis are: pain, pathological fracture, risk of fracture, large cysts located in weight-bearing areas. The symptoms that prevailed in our patient were: pain and inability to use the limb for weight-bearing, standing, and walking.

Multiple therapeutic modalities for ABC have been described; the traditional method of intralesional curettage plus grafting has a recurrence rate ranging between 20% and 41.6%.[14,15,16,1718] In our center, it was 37.5%.

At present, several techniques such as phenol, alcohol, polymethylmethacrylate, high-speed drilling, electrocautery, liquid nitrogen, and argon laser coagulation are used as adjuvant procedures to curettage in order to increase surgical oncological margins and prevent recurrence.[1,2,3,6-13,19,20,21,22,23,24,25]

It should be noted that the graft filling in the bone cavity is of vital importance, and that it can be carried out with bone autograft or allograft. In our patient, we opted for curettage and scraping of the membranes, electrocautery in spray mode, and high-speed drilling, in order to increase the margin of tumor cell necrosis. Lyophilized bone allograft was used for filling.

The recurrence is diagnosed by classification based on the radiological result of the treatment, according to the Capanna scheme that specifies four possible types of therapeutic response: grade 1, cured; grade 2, incomplete healing; grade 3, recurrence; grade 4, no response. Grades 1 and 2 are defined as success, while grades 3 and 4 represent therapeutic failure.[1,2,3,4,5,6,7,8,9,10,11,12,13] Our case was grade 1. Recurrence in this type of location is not described.

Our patient was monitored bi-monthly during the first semester, and then after a year, because the patient could not attend the controls for personal reasons.

We finally managed to contact him after a year in our external polyclinic service, his clinical evolution was very favorable, he did not suffer pain in the ankle and the neck of the foot, the symptoms had completely disappeared and he had resumed his school and sports activities.

CONCLUSIONS

ABC is uncommon in foot bones, with the metatarsal being the most afflicted and, in rare cases, the cuboid. This condition poses diagnostic difficulties and its location may go unnoticed. Clinical suspicion should always be maintained in young patients who suffer low-energy trauma and come to the emergency department with long-standing pain associated with a tumor process.

Despite the late diagnosis, the indication of correct therapy made it possible to timely prevent the natural progression of the disease with one of its possible complications, such as fracture, and an improvement in the patient's quality of life.

Given the scarcity of published cases, we believe it is important to share our experience in managing the lesion and recommend that the treatment of ABC with intralesional curettage, high-speed drilling, electrocautery, and filling with lyophilized bone allograft with cortico-cancellous chips is safe for patients.

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

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Gait Disturbance and Polyarthralgia as a Manifestation of Scurvy in a Pediatric Patient. Case Report.

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ABSTRACT
Vitamin C or ascorbic acid is essential for the correct functioning of the organism. As it cannot be synthesized by humans, it is obtained from external food sources. Deficiency of ascorbic acid produces scurvy, which includes symptoms as fatigue, myalgia and polyarthralgia, associated with skin hemorrhage and bleeding gums. Scurvy is a rare entity. Most of the reported cases involve children with food restrictions due to neurodevelopmental disorders. The early detection of the clinical signs of this condition would avoid unnecessary complementary tests, and early treatment would help reverse symptoms and prevent complications. Case Report: a 13-year-old male patient presented with pain in both hips radiating to the knees associated with loss of strength and hematomas in the lower limbs. Objective: to highlight the importance of a complete nutritional assessment to avoid a late approach with multiple interventions.
Keywords: Scurvy; vitamin C; polyarthralgia.
Level of Evidence: IV

Alteración de la marcha y poliartralgia como manifestación de escorbuto en un niño. Presentación de un caso

RESUMEN
La vitamina C o ácido ascórbico es imprescindible para el correcto funcionamiento del organismo. Los seres humanos no pueden sintetizarla; en consecuencia, dependen estrictamente de su aporte exógeno. Su déficit causa escorbuto, un cuadro que se manifiesta con fatiga, mialgias y poliartralgias, hemorragias en la piel y sangrado de las encías. Es una enfermedad infrecuente. La mayoría de los casos publicados corresponden a niños con restricciones alimentarias por trastornos del neurodesarrollo. La respuesta satisfactoria al aporte de ácido ascórbico confirma el diagnóstico. La sospecha de esta enfermedad evitaría exámenes complementarios innecesarios y el tratamiento temprano ayudaría a revertir los síntomas y prevenir complicaciones. Se presenta el caso de un varón de 13 años que consulta por dolor en ambas caderas con progresión hacia las rodillas, sumado a pérdida de la fuerza y hematomas en los miembros inferiores. El objetivo de esta presentación es resaltar la importancia de la anamnesis alimentaria completa y evitar un abordaje tardío con múltiples intervenciones.
Palabras clave: Escorbuto; poliartralgia; vitamina C.
Nivel de Evidencia: IV

INTRODUCTION

Vitamin C or ascorbic acid is essential for the proper functioning of the body. Human beings cannot synthesize it; therefore, they strictly depend on exogenous contribution through the consumption of various fruits and vegetables. Its deficiency causes scurvy. This disease manifests with asthenia, fatigue, myalgia and polyarthralgia, predominantly in the lower limbs and often with skin hemorrhages, oral disease with bleeding gums and loss of teeth.[1] Its diagnosis is clinical and can be confirmed with a biochemical analysis.

In pediatrics, this condition is often misdiagnosed, confusing it with osteomyelitis, septic arthritis, bone tumors, leukemia, bleeding disorders, and rheumatic diseases.[2]

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A case is presented with the goal of emphasizing the importance of conducting a complete dietary assessment together with a multidisciplinary approach in order to suspect, early and effectively, these types of alterations that typically lead to a late diagnosis with multiple unnecessary interventions.

CLINICAL CASE

A 13-year-old male was taken by his parents to the Orthopedics and Traumatology Service in March 2021. One week earlier, the patient had begun to feel pain in both hips, with progression to both knees, without previous trauma, associated with loss of strength, gait disturbance, and small bruises on both lower limbs. After several consultations and due to the increase in symptoms, he was hospitalized. During the anamnesis, the mother reported that the child had lost 2.500 kg of weight in the last three months and that he had a severe food selectivity (diet without fruits, meats, and vegetables). She stated that he was a full-term newborn with a birth weight of 3300 g, negative serologies, and no allergies, and that there were no maternal perinatal disorders.

The physical examination revealed a regular general state, generalized skin and mucous pallor, symmetrical lower limbs, grade 2 edema (depression up to 4 mm and disappearance in 15 minutes), abundant petechiae and bruises of various evolutionary stages, slightly painful lower limb mobility, mobile joints without signs of phlogosis, and marked muscle weakness. The neurological examination was consistent with his age; he had a negative Romberg's sign, 3/5 bilateral strength, a gait with increased support polygon, and he rose up with difficulty and assistance. The biochemical analysis upon admission yielded the following results: normocytic and hypochromic anemia (hematocrit 23%; hemoglobin 7.5 g/dl; leukocytes 5,500/mm^3; mean corpuscular volume 75.4 fl; mean corpuscular hemoglobin 24.6 pg, platelet count 306,000/mm^3, C-reactive protein 0.8 mg/l). Anteroposterior long bone radiographs were taken (Figures 1 and 2).

A non-contrast skull computed tomography was requested. The images showed a cisterna magna as an anatomical variant, without other alterations. Magnetic resonance images of the spine, skull, and lower limbs revealed no alterations. The echocardiogram and abdominal ultrasound did not present particularities.

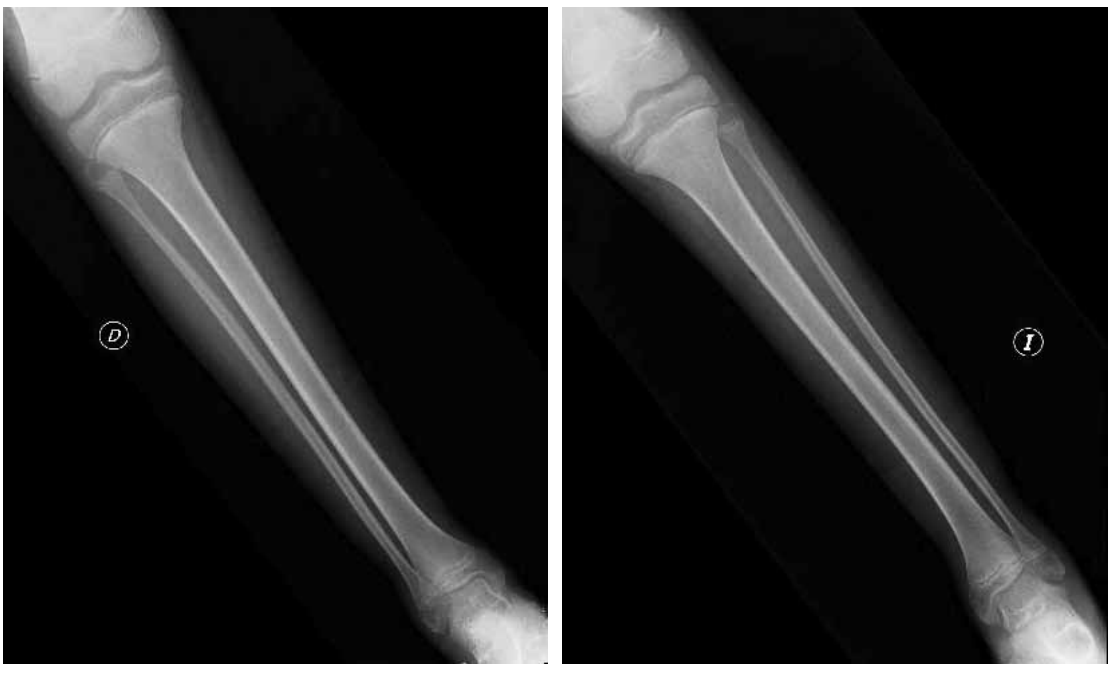

Figure 1. Anteroposterior radiographs of the right and left legs. No alterations are observed.

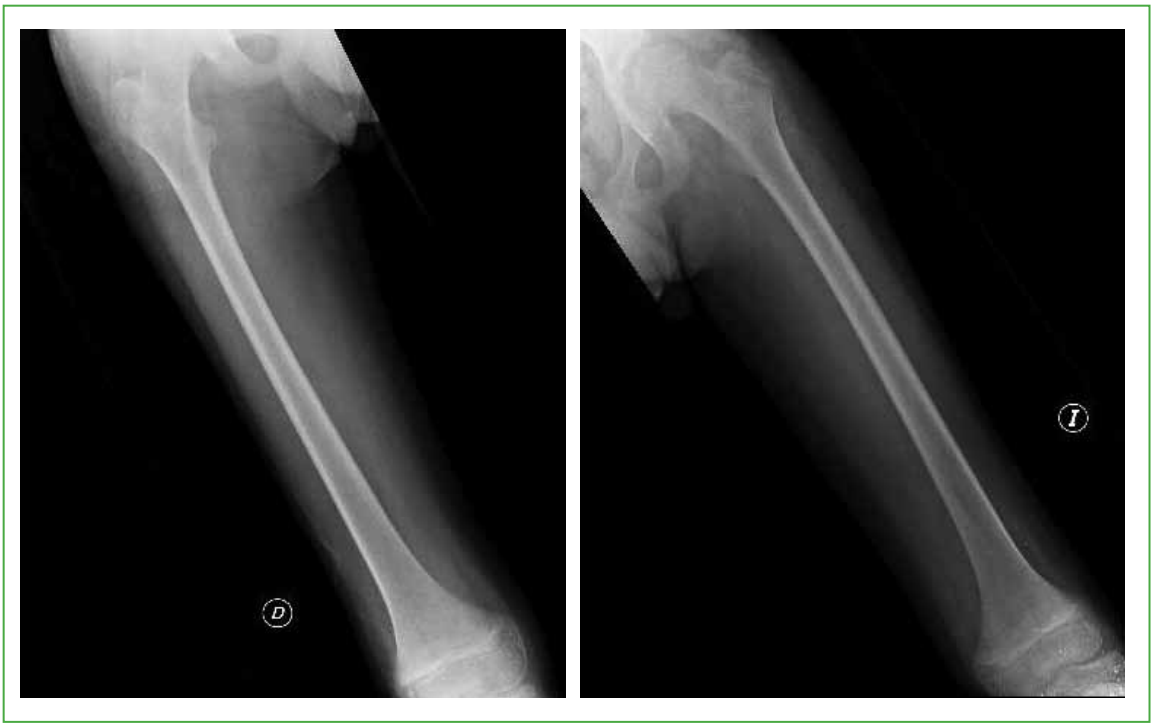

Figure 2. Anteroposterior radiographs of the right and left femurs. No alterations are observed.

After consultation with the Hematology Department, a smear test was performed that revealed sickle cell disease with normal electrophoresis. Sickle cell anemia was ruled out, and a bone marrow aspiration was performed, the result of which was normal cell tissue for the age, with a predominance of red cells without hierarchical maturational abnormalities. The doctors from the Rheumatology Service ruled out dermatomyositis and polymyositis, after which a biopsy of the skin and muscle lesions was taken, with normal results. The patient was evaluated by doctors from the Dermatology Service who, based on the symptoms and history, suggested the diagnosis of scurvy. A vitamin C analysis was requested, which returned a value of 1.5 mg/dl.

Given this presumed diagnosis, 100 mg of ascorbic acid were administered every 24 hours (h). After 48 h, the patient's symptoms and laboratory values improved (hematocrit 29%; hemoglobin 9.9 g/dL; mean corpuscular volume 82.3 fl). The patient was discharged seven days later, with complete symptom remission. He was instructed to continue the treatment for two weeks and to introduce changes in the diet guided by a nutritionist.

At the first outpatient orthopedic and pediatric follow-up seven days later, the evolution was good. During the second follow-up visit, 15 days after discharge, the mother reported that the child continued with his bad eating habits, so it was decided to prolong the treatment with daily ascorbic acid. A month later, after the third and last follow-up visit, and with normal laboratory tests, he was discharged.

DISCUSSION

Currently, scurvy is a rare disease in pediatrics that is caused by an exogenous nutritional deficiency of ascorbic acid. Cases of iron overload due to hematological diseases, infants fed boiled cow's milk, and, more frequently, children with dietary restrictions due to neurodevelopmental abnormalities have been documented in the literature.[3]

The deficiency of vitamin C or ascorbic acid produces defects in the formation of collagen and alterations in the production of chondroitin sulfate.[4] The musculoskeletal manifestations, which were the reason for our patient's consultation, may be generalized pain, polyarthralgia and edema predominantly in the lower limbs, together with the refusal to walk. This condition is usually associated, as our patient presented, with hemorrhagic lesions on the skin, such as ecchymosis and petechiae of different sizes and stages of evolution.[5]

Signs and symptoms of scurvy have been reported to develop after one to three months of inadequate vitamin C intake (<10 mg/day).[6] The diagnosis is clinical, although several supplementary testing can help. The complete blood count usually reveals, as in our patient, mild anemia and slightly elevated acute phase reactants (erythrocyte sedimentation rate and C-reactive protein).

Currently, given the low index of suspicion for scurvy, patients undergo many complementary studies to rule out, primarily, oncohematological, rheumatological, or neurological illnesses, according to documented cases.[7]

The satisfactory response to the contribution of ascorbic acid constitutes diagnostic confirmation. In published studies, between 100 and 300 mg are recommended every 24 hours for a month. According to case reports, the general condition improves within the first 24 hours of treatment, pain relief occurs after two or three days, and musculoskeletal symptoms resolve within a few weeks.[8] In this case, the clinical status and laboratory parameters improved 48 hours after starting treatment.

A low value of ascorbic acid can support the diagnosis, the normal value is 0.5-1.5 mg/dl, and a value <0.2 mg/dl is considered a deficiency. According to published studies, patients with scurvy in whom ascorbic acid was measured had values of 0.2 mg/dl, 0.5 mg/dl, 1.2 mg/dl and 31.9 ng/dl (>30 ng/dl as a normal parameter), some were lower than those found in our patient (1.5 mg/dl). However, the signs and symptoms developed and the prompt response to treatment with vitamin C confirmed the diagnostic suspicion.

CONCLUSION

The evaluation of nutritional characteristics should be part of the routine health control. The diagnosis of scurvy should be considered when a patient presents with unexplained polyarticular pain, refuses to ambulate, and has petechiae, ecchymosis, or gingival hypertrophy, even if laboratory values are within normal parameters. Persistent suspicion of this disease would avoid unnecessary additional tests and early treatment would help reverse symptoms and prevent complications.

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

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MRI-based Planning for an Extreme Lateral Interbody Fusion Procedure. Is It Safe? An MRI Study Describing the Statistical Distribution of Safe and Danger Zones

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ABSTRACT

Objective: The objective of this study is to provide an anatomical description of the structures involved in the extreme lateral interbody fusion (XLIF) technique based on MRI images in the dorsal decubitus position. **Materials and Methods:** An observational, descriptive, and retrospective study of 200 patients treated at our institution was conducted using MRI images of the lumbosacral spine. The vena cava, aorta artery, and the width and height of the psoas muscle were measured in axial images to establish the safe and danger zones. **Results:** The final sample consisted of 164 patients, with a mean age of 50.4 for males and 50.6 for females. The abdominal aorta artery is located predominantly on the left side zone A on its path to the L3-L4 space. When it reaches the L4-L5 area, the iliac arteries bifurcate in 95.7% of the patients. The vena cava tends to be located on the right side, bifurcating at the L4-L5 level. **Conclusions:** Preoperative planning and safe zone delimitation are simple methods for determining the relative position of neural and vascular anatomical structures in relation to the surgical area. This technique can help spine surgeons prevent perioperative complications.

Keywords: XLIF; big blood vessels; lateral interbody fusion; nuclear magnetic resonance; psoas.
Level of Evidence: IV

Planificación basada en imágenes de resonancia magnética para la cirugía de columna de acceso lateral. ¿Es un procedimiento seguro? Estudio descriptivo de distribución de grandes vasos y psoas

RESUMEN

Objetivo: Realizar una descripción anatómica de las estructuras involucradas en el abordaje para la técnica de abordaje lateral (fusión intersomática lateral extrema) basada en imágenes de resonancia magnética en decúbito dorsal. **Materiales y Métodos:** Se llevó a cabo un estudio observacional, descriptivo, retrospectivo, de 200 pacientes evaluados con resonancia magnética de columna lumbosacra. Se tomaron mediciones en cortes axiales para determinar el posicionamiento de la vena cava, la arteria aorta, y el ancho y la altura del músculo psoas a fin de delimitar zonas de seguridad y de riesgo. **Resultados:** La muestra final incluyó a 164 pacientes con una edad media de 50.4 años en los hombres y 50.6 años en las mujeres. La arteria aorta abdominal en su recorrido hasta el espacio L3-L4 se ubica predominantemente del lado izquierdo en la zona A y, al llegar al espacio L4-L5, en el 95,7% de los pacientes, se observó la bifurcación de las arterias ilíacas. La vena cava mostró una tendencia de localización hacia el lado derecho y su bifurcación a nivel de L4-L5. **Conclusiones:** La planificación preoperatoria y la delimitación de la zona segura representan un método sencillo para evaluar la posición relativa de las estructuras anatómicas neurales y vasculares en relación con el área quirúrgica. Este método puede ayudar a los cirujanos de columna a prevenir complicaciones perioperatorias.

Palabras clave: Fusión intersomática lateral extrema; grandes vasos; resonancia magnética; psoas.
Nivel de Evidencia: IV

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INTRODUCTION

Currently, spinal surgery is in transition between what is known as conventional surgery and minimally invasive spinal surgery. There are advantages and disadvantages to choosing one type of procedure over another, and it is clear that the path is leading us to become less aggressive and invasive, but we also cannot ignore the problems that various spinal centers around the world face, where they lack the necessary technology to perform this type of surgery safely.

The primary goal of spinal surgery is to relieve pain and correct any neurological deficits that may exist; what is sought with minimally invasive methods is a more ambitious goal that aims to improve quality of life through three important actions: preserve the anatomical vertebral structures, preserve the paravertebral musculature, and preserve the functionality of the segment. To achieve these objectives, three concepts emerged: a) minimal surgery; b) minimal access surgery; c) surgery to preserve mobility. These three concepts are covered by a single term: minimally invasive spine surgery.[1]

In 2006, Ozgur et al. described a new type of minimally invasive surgery called *extreme lateral interbody fusion* (XLIF).[2] The XLIF approach passes through the retroperitoneal space, separates the psoas major between the middle third and the anterior third, and reaches the lumbar intervertebral spaces. It is vital to choose the exact location at which it is entered through the psoas. This precision is necessary to reach the lumbar intervertebral space and avoid injury to the great vessels and nerves. If the puncture site is too anterior, the great vessels may be injured. However, if the puncture site is too posterior, lumbar nerve roots that have descended into the psoas muscle may be damaged.[3,4,5,6,7,8,9,10]. In addition, the width of the psoas at the entry point location also influences the safety of the procedure. If the psoas is very wide, the peritoneum is easily dissected, the retroperitoneal space is larger, surgery is safer, and the risk of peritoneal and abdominal viscera injury is reduced.[11] However, the distribution of the great abdominal vessels and psoas major muscles in each lumbar intervertebral space is inconsistent.[12,13,14,15]

There are few publications describing anatomy using magnetic resonance imaging (MRI),[12,16] and the samples are small.

Our objective was to describe the statistical distribution of important structures in order to propose safe zones and risk zones for the XLIF approach using a larger sample size than the rest of the published statistics.

MATERIALS AND METHODS

Study design

We developed a research protocol that was approved by the teaching and research committee of the Hospital Alemán de Buenos Aires, Argentina.

A descriptive, retrospective, observational analysis was performed. We included 200 patients over the age of 18 of both sexes who were treated at our institution and underwent an MRI for any reason between 2017 and 2020. The sample was selected randomly until 200 people were included. The exclusion criteria were: scoliosis (Cobb angle >10º), spondylolisthesis (grade >1 of the Meyerding classification), vertebral fracture and oncological lesions. The patients were contacted by telephone and their approval to be included in the study was requested.

Lumbar spine MRI was performed with Philips© 1.5 Tesla and General Electric© 3 Tesla equipment. Measurements were taken in axial sections of the segments L1-L2, L2-L3, L3-L4 and L4-L5, in which the position of the vena cava, the aorta artery, and the width and the height of the psoas in the area of each segment on both sides were determined. It was also recorded if the position of the psoas was too anterior (*Mickey Mouse* or *rising psoas sign*).[16]

The Moro[17] method was used, which divides the intervertebral space into six zones that go from anterior to posterior (Figures 1 and 2). The anterior aspect of the anterior margin of the vertebral body was defined as zone A; the posterior aspect of posterior margin, as zone P; zones I, II, III, IV were equally distributed between the anterior margin and the posterior margin, from anterior to posterior. The distribution of the great abdominal vessels in each zone of each lumbar intervertebral space was analyzed on the basis of the MR images. The width of the psoas in each zone of each lumbar intervertebral space on both sides was measured with the PACS Carestream© image analysis program. Psoas thickness was defined as the distance between the midpoints of the inner and outer margins of the psoas major in each zone (Figure 3).

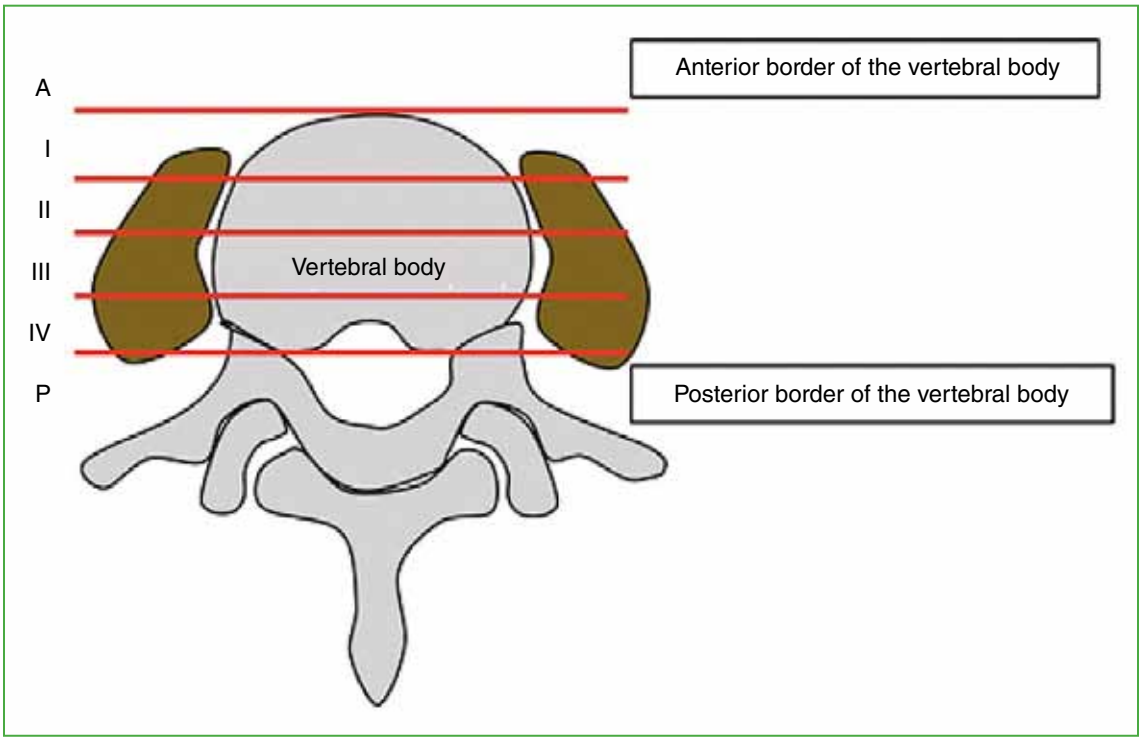

Figure 1. Moro's method describes six sections from anterior to posterior (A, I, II, III, IV and P).

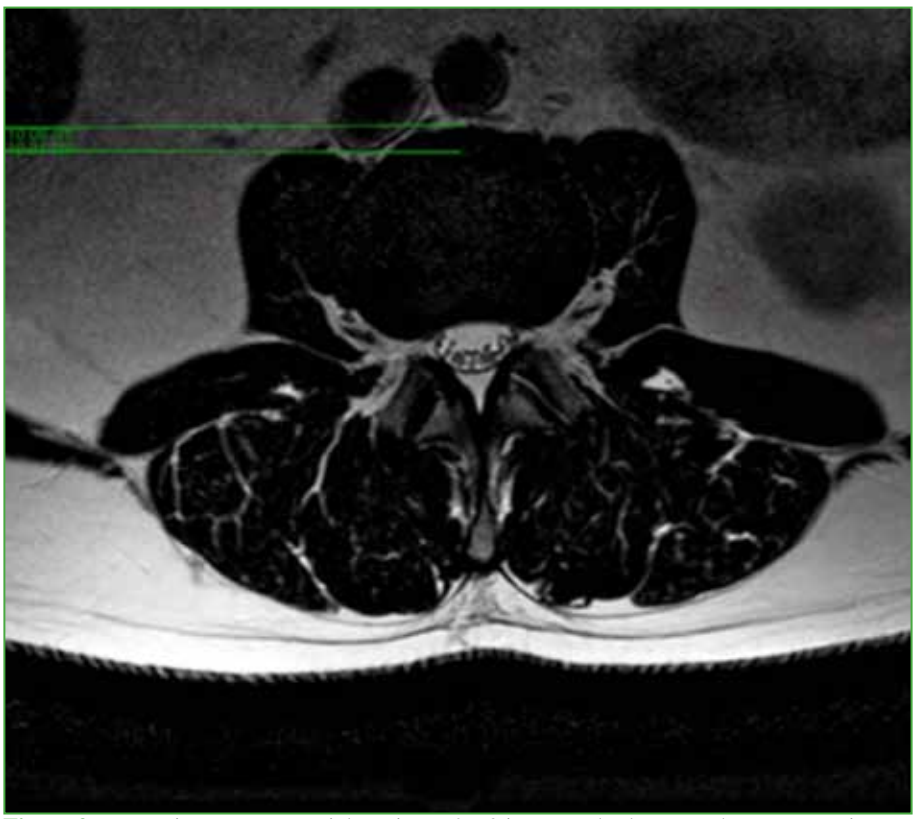

Figure 2. Magnetic resonance, axial section, L2-L3 intervertebral space. The vena cava is observed in position A and I (RA + RI).

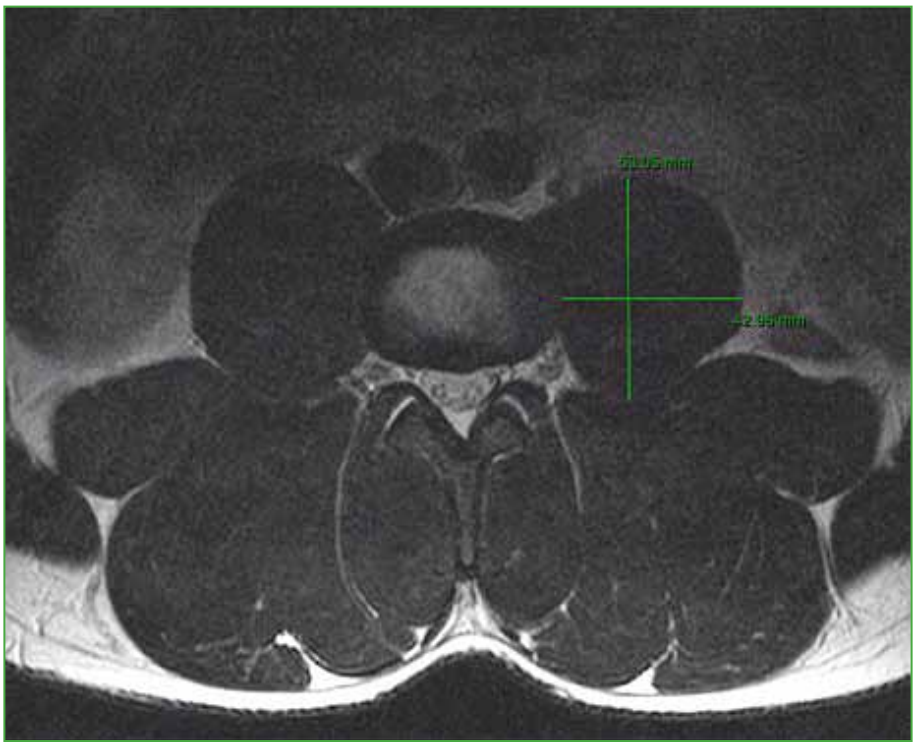

Figure 3. MRI, axial section, L3-L4 intervertebral space. Measurement of the length and width of the left psoas muscle is shown.

RESULTS

200 MRI of the lumbar spine that were performed at our institution were analyzed. Thirty-six patients were excluded for meeting any of the exclusion criteria (tuberculosis, spondylolisthesis, scoliosis, and vertebral fracture). The final sample consisted of 164 patients, 87 women and 77 men. The mean age was 50.4 years for men and 50.6 years for women (Figure 4).

Distribution of the abdominal aorta

The abdominal aorta artery in its route through the levels L1-L2, L2-L3 and L3-L4 is located predominantly on the left side, in zone A (n = 159, n = 157 and n = 137, respectively). Upon reaching L4-L5, 95.7% (n = 157) of the patients presented the bifurcation to the iliac arteries at that level (Figure 5).

Inferior vena cava distribution

In its course through the L1-L2 level, the vena cava shows a 67.7% tendency to be located on the right side, in zone A (n = 111) and 32.3% on the right side, in zone A and zone I (n = 53). In L2-L3, 51.2% (n = 84) are found to the right, between zones A and I, while 48.8% (n = 80) are found on the right side, in zone A. In L3-L4, 68.3% (n = 112) were on the right, between zones A and I; 28.7% (n = 47) were on the right, in zone A; 1.8% (n = 3) had a bifurcation at this level; and 1.2% (n = 2) were on the right, in zone I. Finally, in L4-L5, 73.2% (n = 120) of patients had the bifurcation at that level; 21.3% (n = 35) had it on the right side, between zones A and I; in 2.4% of patients (n = 4), the vena cava was located on the right side in zone A; in 2.4% (n = 4), on the right side, between zone I and zone II; and in 0.6% (n = 1), on the right side, in zone I (Figure 6).

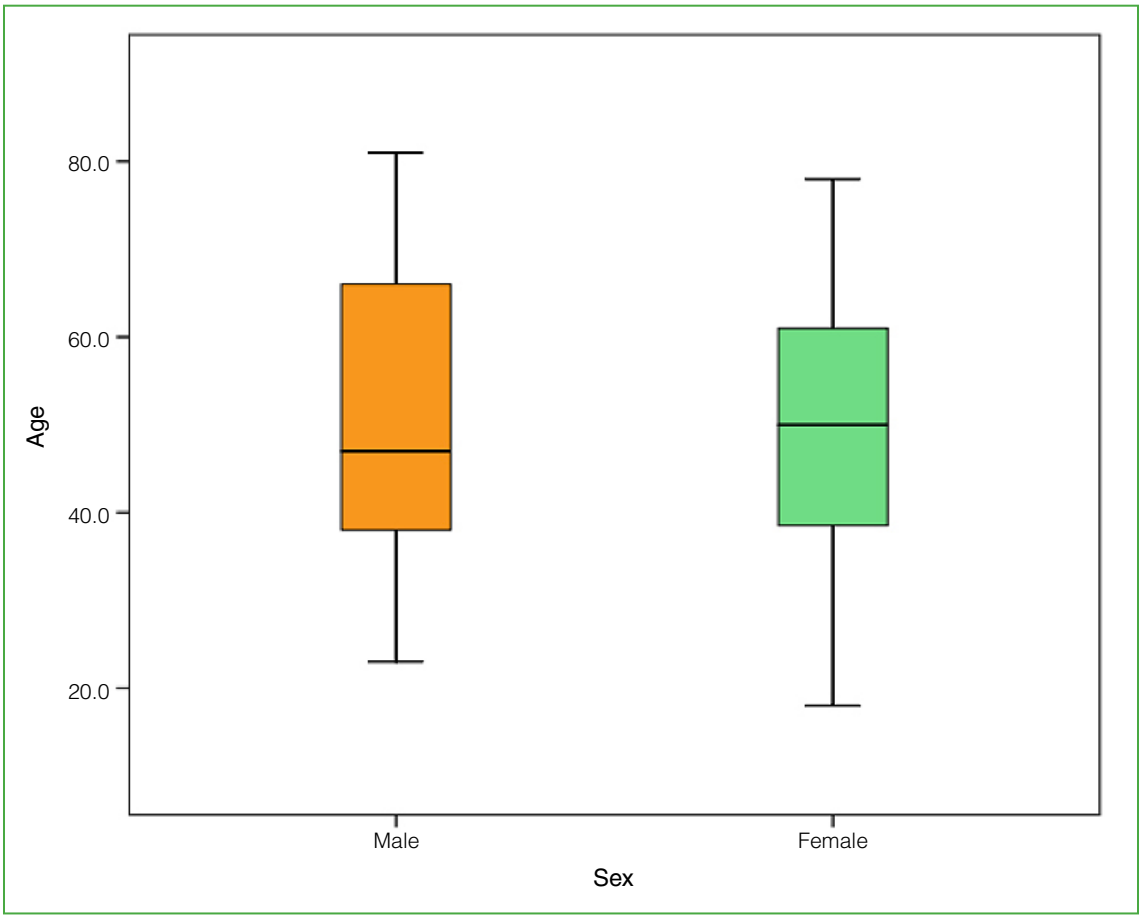

Figure 4. Representation of the sample according to sex and age.

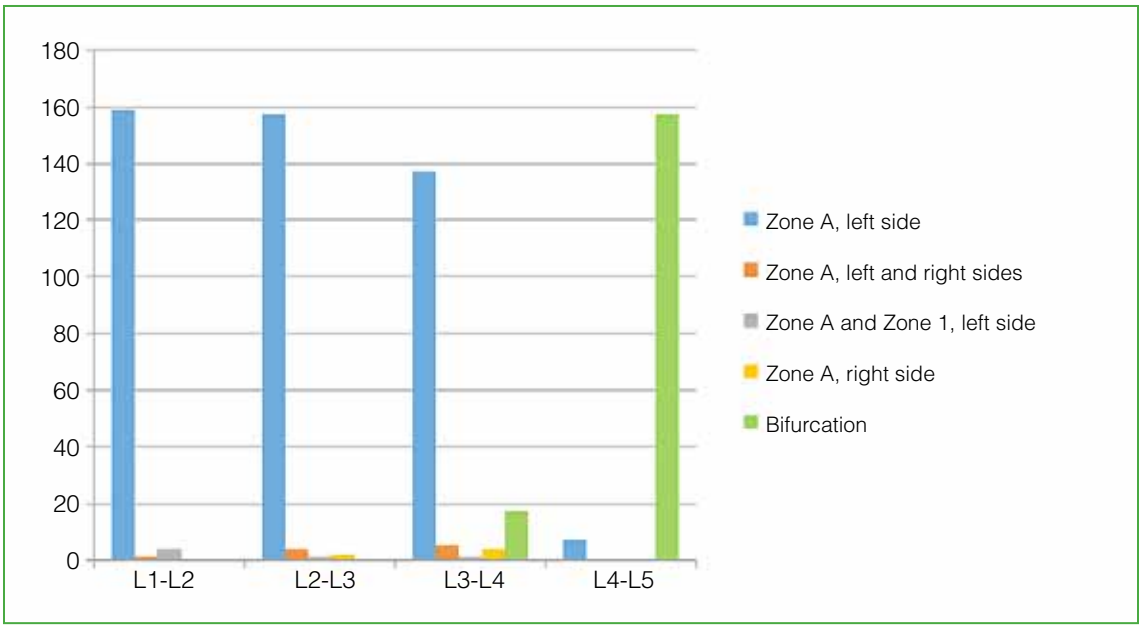

Figure 5. Distribution of the abdominal aorta artery at each level and according to Moro's zones.

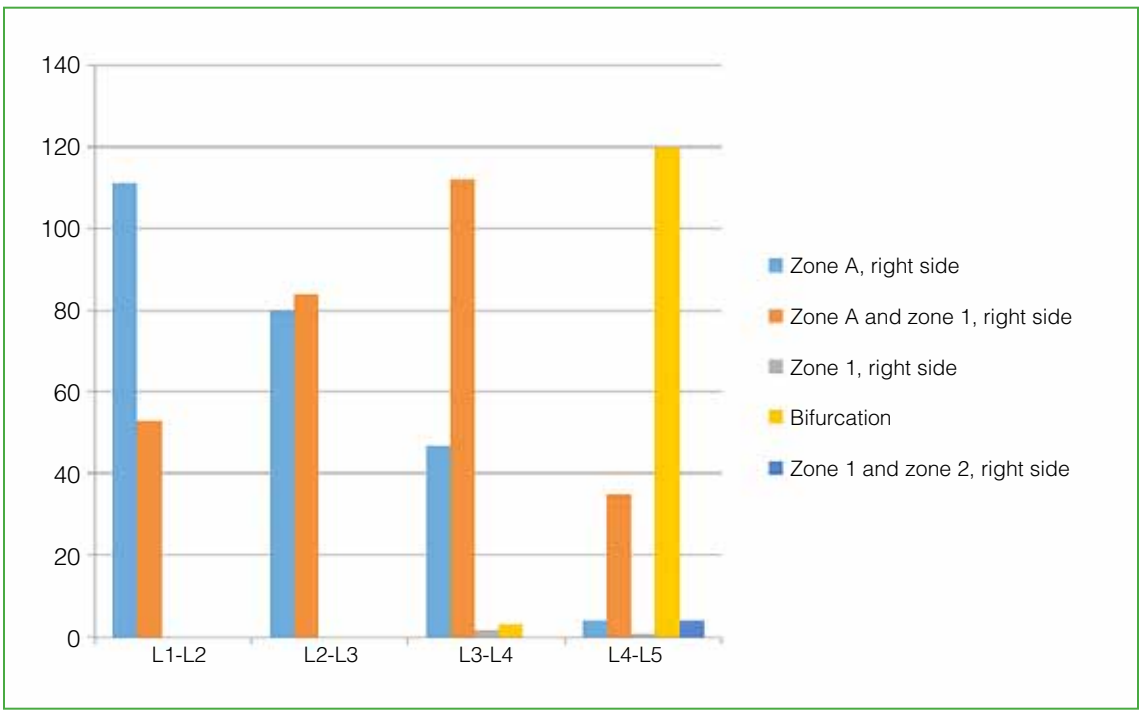

Figure 6. Distribution of the inferior vena cava at each level according to Moro's zones.

Distribution of the right psoas major

The thickness of the right psoas muscle was evaluated at each level and in zones I, II, III, and IV. In L1-L2, women presented an average of 0.24 mm for zone I; 2.94 mm for zone II; 6.46 mm for zone III and 11.05 mm for zone IV. In L2-L3, a mean of 1.81 mm was observed for zone I; 9.87 mm for zone II; 13.85 mm for zone III and 17.04 mm for zone IV. In L3-L4, the means were: 6.44mm; 18.31mm; 22.98mm and 25.19mm, respectively. Finally, in L4-L5, the means were: 21.47mm; 30.81mm; 31.93 mm and 26.03 mm, respectively (Table 1).

Table 1. Female sex Mean, median, minimum and maximum values measured for the right psoas major muscle at each level (L1-L5) and in zones I, II, III and IV

Female sex		Right															
		L1-L2				L2-L3				L3-L4				L4-L5			
		Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV
n	Valid	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87
	Lost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		0.24	2.94	6.46	11.05	1.81	9.87	13.85	17.04	6.44	18.31	22.98	25.19	21.47	30.81	31.93	26.03
Median		0.00	2.50	6.70	10.33	0.00	10.44	13.80	17.11	0.00	19.00	23.19	25.10	22.45	30.99	34.00	28.07
Minimum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.63	0.00	0.00	7.15	11.80	0.00	0.00	0.00	0.00
Maximum		6.84	12.73	12.79	99.90	19.70	24.60	27.96	29.09	33.13	38.69	38.66	39.54	52.03	47.94	44.10	46.09

In L1-L2, men presented an average of 1.30 mm for zone I; 6.73 mm for zone II; 11.07 mm for zone III and 15.55 mm for zone IV. In L2-L3, a mean of 8.55 mm was observed for zone I; 18.27 mm for zone II; 21.63 mm for zone III and 24.37 mm for zone IV. In L3-L4, the means were: 21.22mm; 30.31mm; 32.70mm and 31.94mm, respectively. Finally, in L4-L5, the means were: 37.96mm; 41.16mm; 37.29 mm and 27.05 mm, respectively (Table 2).

Table 2. Male sex Mean, median, minimum and maximum values measured for the right psoas major muscle at each level (L1-L5) and in zones I, II, III and IV

Male sex		Right															
		L1-L2				L2-L3				L3-L4				L4-L5			
		Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV
n	Valid	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
	Lost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		1.30	6.73	11.07	15.45	8.55	18.27	21.63	24.37	21.22	30.31	32.70	31.94	37.96	41.16	37.29	27.05
Median		0.00	6.48	10.78	15.39	6.53	18.06	21.18	22.91	23.10	29.88	32.34	31.99	37.90	42.20	38.50	28.69
Minimum		0.00	0.00	0.00	2.41	0.00	4.37	8.52	10.06	0.00	9.19	16.40	15.82	0.00	8.20	5.90	0.00
Maximum		15.88	22.70	24.41	28.05	30.95	33.40	37.32	41.70	48.18	49.40	51.10	54.86	56.95	57.99	55.80	47.80

Distribution of the left psoas major

The thickness of the left psoas muscle was evaluated at each level and in zones I, II, III, and IV. At the L1-L2 level, women presented an average of 0.41 mm for zone I; 4.12 mm for zone II; 7.32 mm for zone III and 10.51 mm for zone IV. At L2-L3, a mean of 2.67 mm was observed for zone I; 10.56 mm for zone II; 14.08 mm for zone III and 16.76 mm for zone IV. In L3-L4, the mean was 8.80 mm for zone I; 18.78 mm for zone II; 22.33 mm for zone III and 24.06 mm for zone IV. Finally, in L4-L5, the mean was 23.89 mm for zone I; 30.26 mm for zone II; 30.83 mm for zone III and 24.49 mm for zone IV (Table 3).

Table 3. Female sex Mean, median, minimum and maximum values measured for the left psoas major muscle at each level (L1-L5) and in zones I, II, III and IV

Female sex		Left															
		L1-L2				L2-L3				L3-L4				L4-L5			
		Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV
n	Valid	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87
	Lost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		0.41	4.12	7.32	10.51	2.67	10.56	14.08	16.76	8.80	18.78	22.33	24.06	23.89	30.26	30.83	24.29
Median		0.00	4.17	7.10	10.66	0.00	10.90	13.90	15.95	6.69	17.40	22.40	23.51	24.90	30.92	32.20	26.40
Minimum		0.00	0.00	0.00	2.10	0.00	0.00	0.00	8.10	0.00	0.00	11.19	8.50	0.00	0.00	0.00	0.00
Maximum		7.77	12.87	14.34	21.56	21.40	26.78	25.71	31.58	32.34	36.43	37.21	36.74	49.06	47.57	42.00	40.55

At the L1-L2 level, men presented an average of 1.87 mm for zone I; 8.31 mm for zone II; 12.18 mm for zone III and 15.92 mm for zone IV. In L2-L3, a mean of 9.57 mm was observed for zone I; 18.68 mm for zone II; 21.68 mm for zone III and 24.38 mm for zone IV. In L3-L4, the average was 22.62 mm for zone I; 30.56 mm for zone II; 32.26 mm for zone III and 30.77 mm for zone IV. Finally, in L4-L5, the mean was 39.24 mm for zone I; 40.94 mm for zone II; 36.59 mm for zone III and 25.65 mm for zone IV (Table 4).

Table 4. Male sex Mean, median, minimum and maximum values measured for the left psoas major muscle at each level (L1-L5) and in zones I, II, III and IV

Male sex		Left															
		L1-L2				L2-L3				L3-L4				L4-L5			
		Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV	Zone I	Zone II	Zone III	Zone IV
n	Válido	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
	Perdidos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		1.67	8.31	12.18	15.92	9.57	18.68	21.68	24.38	22.62	30.56	32.26	30.77	39.24	40.94	36.59	25.65
Median		0.00	8.58	11.90	15.20	10.60	18.44	20.44	22.71	22.39	30.07	31.84	30.70	39.19	42.03	38.74	25.75
Minimum		0.00	0.00	0.00	2.41	0.00	4.57	9.57	9.71	0.00	10.90	14.73	11.98	2.60	8.60	0.00	0.00
Maximum		17.90	20.18	26.20	34.00	30.93	35.51	39.00	43.30	46.06	46.24	47.00	50.70	59.38	61.12	60.76	47.40

The results in both sexes are shown in Figure 7.

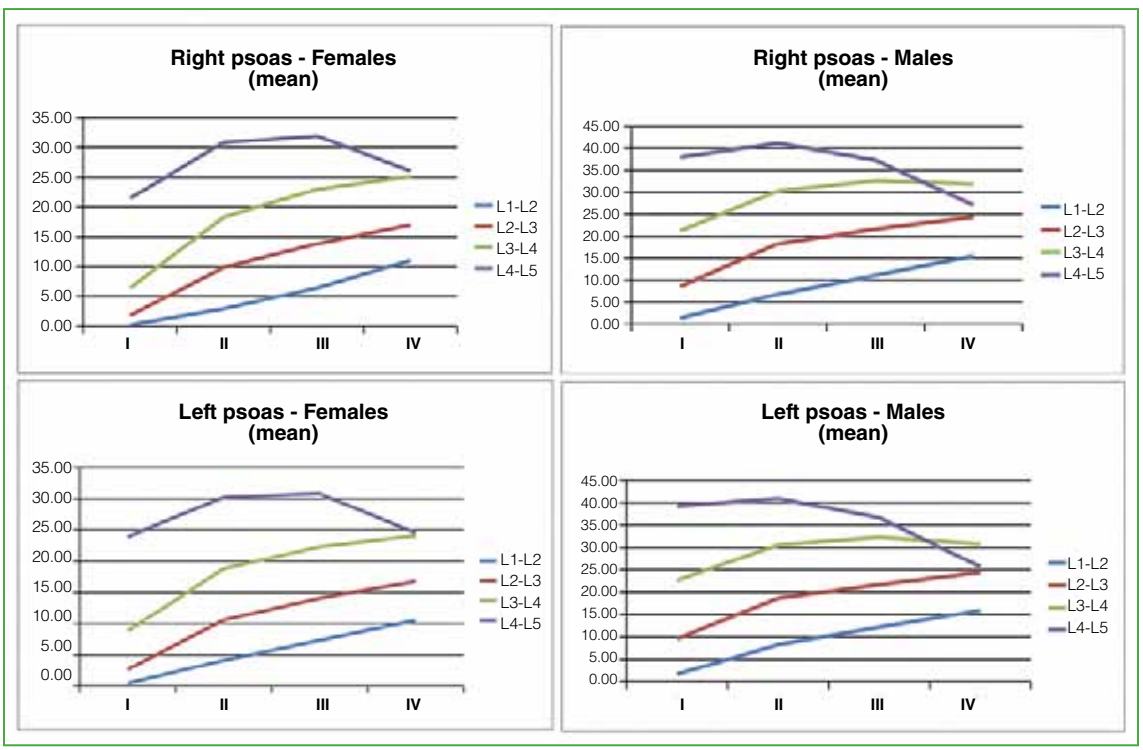

Figure 7. Distribution of the mean of the right and left psoas in both sexes according to Moro's zones.

Mickey Mouse sign or rising psoas sign

8.5% of the patients evaluated had the rising psoas sign.

DISCUSSION

The objective of this study was to describe, through MR images, the positioning of vital structures when performing extreme lateral interbody fusion (XLIF) and to correlate them with safety corridors in lateral approaches.

The lumbar plexus is made up of the anterior rami of L1-L4 in close relationship with the iliopsoas muscle. The safe zone for the lateral pathway is between these roots. There are multiple anatomical variants, both in relation to the morphology and location of said muscle, such as the rising psoas sign, as well as the lumbar plexus and its branches. The psoas major muscle is elevated lateral or anterior to the level of L4-L5, separating from the most posterior part of the disc space, leaving the lumbar plexus unprotected, which is a contraindication for lateral access surgery; therefore, proper pre-surgical planning is essential to avoid complications. This anatomical variant is called the Mickey Mouse sign or rising psoas sign.[18]

Moro published anatomical studies based on posterior peritoneal laparoscopic spinal surgery, the results of which revealed that the lumbar plexus is located in zone P, in the L1-L2 intervertebral space; in zone IV, in L2-L3; in zone III, in L3-L4 and L4-L5.[17] This is very useful for assessing which zones are least likely to cause neurological injury. In this way, for XLIF accesses in L1-L2 and L2-L3, it is recommended to carry them out in zones II or III. On the other hand, in L4-L5, it is recommended to separate the psoas major in zone II where the nerves ascend in the upper part of the muscle mass and thus reduce the risk of injury. At L3-L4, the plexus passes obliquely across the psoas major in a posterior to anterior direction. Because of this, those approaches at this level pose a greater risk of injury if performed in zone II.

Based on the measurements obtained in this study, we established safe zones depending on whether the approach was right or left. In right approaches, depending on the distribution of the vena cava, it is not injured in zones II/III/IV/P, at all lumbar levels. If this information is combined with the distribution of the plexus according to Moro, the safe zone in L1-L2 is located in zone II-IV; in L2-L3, in zone II-III; in L3-L4 and L4-L5, in zone II.

The thickness of the psoas in men is larger in zone IV in L1-L2 and L2-L3, whereas it is in zone III in L3-L4 and in zone III in L4-L5. In women, on the other hand, in L1-L2, L2-L3 and L3-L4, the thickness of the psoas is greater in zone IV, and, in L4-L5, in zone III.

Regarding the left approaches, according to the distribution of the aorta artery, the safe zones are located in zone II in L1-L2, L2-L3 and L3-L4, while, in L4-L5, they are in zone I. If this information is combined with the distribution of the plexus according to Moro, the safe zone in L1-L2 is located in zone II-IV; in L2-L3, in zone II-III; in L3-L4, in zone II and, in L4-L5, in zone I-II.

Based on the thickness of the psoas in men, we discovered that it is thickest in zone IV in L1-L2 and L2-L3, zone III in L3-L4, and zone I-II in L4-L5. In women, as on the right side, the thickness is greater in L1-L2, L2-L3 and L3-L4, in zone IV, and in L4-L5, in zone III.

The limitations of this study were that several of the included patients had already undergone spinal surgery, leading to a possible change in normal anatomy. On the other hand, the MRIs were searched in the database system of our center, since the MRIs were performed for some reason and not for the mere fact of collaborating with the study. On the other hand, there are variables that can modify the anatomy according to different situations in the same patient. Buckland et al. describe compensatory mechanisms, such as trunk flexion and increased thoracic kyphosis in patients with mild and moderate canal stenosis,[19] which were not taken into account when including patients in the study. Finally, because the patient is in lateral decubitus with the hips and knees flexed during the procedure, this causes changes in the vasculature as well as both psoas, which is a different anatomical relationship than the one that occurs with the patient in dorsal decubitus during the procedure.

CONCLUSIONS

We can affirm that knowing the anatomy and the use of safe access routes for the placement of implants through lateral access is of the utmost importance, since most of the complications in these surgeries derive from this. The main challenge posed by this type of intervention is having direct visualization of the neurovascular structures, which can result in damage, which is why preoperative planning with the corresponding studies is essential, given the anatomical variations of the segment, in order to carry out a safe and correct procedure.

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Participation of Women at the Societal and Institutional Level in the Asociación Argentina de Ortopedia y Traumatología

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ABSTRACT

Objective: To analyze the representation of women at the societal level within the Asociación Argentina de Ortopedia y Traumatología (AAOT). **Materials and Methods:** An observational and descriptive study was conducted analyzing data obtained from the period between January 1, 2015 and December 31, 2019. The proportion of women members of the AAOT, as well as their participation at the institutional, hierarchical, and academic levels, was assessed. **Results:** Women represent 10.6% of all AAOT members. Twelve women actively participate in the different Committees of the Association, which represents 16% of the total number of members. During the study period, 2.8% of the positions on the Board of Directors were held by women. In the history of the AAOT, only one woman has served as President. In 2019, women made up 6.9% of teachers who taught the Biannual Official National Orthopedics and Traumatology Certification Course. **Conclusion:** Women represent 10.6% of AAOT members. Knowing their situation within the AAOT allows laying the foundations to implement measures aimed at improving equity in Orthopedics and Traumatology.

Keywords: Women in Orthopedics and Traumatology; female representation; diversity in Orthopedics and Traumatology.

Level of Evidence: IV

Participación de la mujer a nivel societario e institucional en la Asociación Argentina de Ortopedia y Traumatología

RESUMEN

Objetivo: Analizar la representación de la mujer a nivel societario dentro de la Asociación Argentina de Ortopedia y Traumatología (AAOT). **Materiales y Métodos:** Se realizó un estudio observacional y descriptivo analizando datos obtenidos del período entre el 1 de enero de 2015 y el 31 de diciembre de 2019. Se evaluó la proporción de mujeres que son miembros de la AAOT y su participación a nivel institucional, jerárquico y académico. **Resultados:** La mujer representa el 10,6% de todos los miembros de la AAOT. Doce mujeres participan activamente en los diferentes Comités de la Asociación, lo que representa un 16% del total de los integrantes. Durante el período de estudio, el 2,8% de los cargos de la Comisión Directiva fueron ocupados por mujeres. Una mujer fue Presidenta en la historia de la AAOT. En 2019, el 6,9% de los docentes que dictaron el Curso Oficial Nacional Bianual de Certificación de Ortopedia y Traumatología fueron mujeres. **Conclusión:** La mujer representa el 10,6% de los miembros de la AAOT. Conocer su situación dentro de la AAOT permite sentar las bases para implementar medidas orientadas a mejorar la equidad en la Ortopedia y Traumatología.

Palabras clave: Mujer en Ortopedia y Traumatología; representación femenina; diversidad en Ortopedia y Traumatología.

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INTRODUCTION

The representation of women in medicine has been progressively increasing in the world, but this increase is not reflected equally in the different specialties.[1-3] The surgical specialties have the lowest female representation. In turn, if we analyze the increase in the percentage of women over time within the surgical specialties, orthopedics lags behind in comparison with the rest.[4,5] In 2008, data from the United States *Accreditation Council for Graduate Medical Education* (ACGME) indicated that Neurosurgery, Orthopedics and Traumatology, and Thoracic Surgery had the lowest percentage of female residents (11%, 12%, and 13%, respectively).[5,6] A decade later, the percentage of women residents in Neurosurgery increased to 18%, that of Thoracic Surgery doubled to 26%, while in Orthopedics and Traumatology it only increased by 3% and reached 16%.[5-7] On the other hand, women represent 6% of all active traumatologists in this country.

The importance of diversity has been widely validated in various disciplines. Diversity in medicine improves communication, patient satisfaction and access to care for patients with fewer resources.[8] On the other hand, it is essential to create strong organizations that maximize the talents and abilities of their members. Organizations that include diversity attract the most capable professionals, increase innovation, and exhibit better quality decision-making. In the fields of medicine, business, and politics, the critical mass to consider that a group's diversity is effective is between 25% and 30%.[9] The importance of diversity in the specialty of orthopedics and traumatology has recently been addressed internationally, and the *American Association of Orthopedic Surgeons* (AAOS) made this one of its strategic objectives for the period 2019-2023, with the election of the first female president in 2019.[3,10]

In Argentina, female representation in Orthopedics and Traumatology today is 13% in the residency system[11] and there are no reports that analyze this issue at the institutional level within the Asociación Argentina de Ortopedia y Traumatología (AAOT).[12] The objective of our study was to analyze the representation of women at the institutional level in the AAOT. The secondary objective was to analyze the participation of women in the different institutional strata (academic participation, participation in hierarchical positions, etc.).

MATERIALS AND METHODS

An observational and descriptive study was carried out to characterize the participation of women in the AAOT. The study was conducted by analyzing data obtained from a period between January 1, 2015 and December 31, 2019. Information was obtained from the administrative area of the AAOT by requesting permission from the Board of Directors.

The primary objective of the study was to assess the proportion of women who are members of the AAOT. Our secondary objectives were: 1) to determine the proportion of women who opted for Full Membership in the AAOT between 2015 and 2019; 2) to determine the proportion of women who perform functions within the AAOT's various hierarchical strata (participation in committees, Board of Directors, Presidency); 3) to determine the proportion of women who actively participate as lecturers in the Biannual Course as of December 2019; and 4) to determine the percentage of female heads of service in the AAOT-accredited services up to December 2019.

The following data were collected:

- Number of female AAOT members out of the total number of members up to December 2019.
- Number of female members that are part of Committees within the AAOT out of the total number of participants in the Committees up to December 2019.
- Number of female members who were part of the Board of Directors during the period 2015-2019 out of the total number of participants in the Board.
- Number of female AAOT Presidents and the total number of AAOT Presidents throughout its history.
- Number of women who actively participated as lecturers in the Biannual Course over the total number of lecturers in the course up to December 2019.
- Number of female Heads of Service within the AAOT Accredited Services in relation to the total number of Heads of Service positions within the AAOT Accredited Services up to December 2019.

RESULTS

The AAOT has 5,746 members, 612 are women, which represents 10.65% of the members. Among the female members, 124 are Residents (20.26%), 127 are Adherent Members for less than 10 years (20.75%), 227 are Adherent Members for more than 10 years (37.09%), 114 are Certified Members (18.62%), 18 are Full Members (2.9%), one is an Honorary Member (0.16%), and one is a Life Member (0.16%).

During the period 2015-2019, 89 members opted to be full members of the AAOT. Seven were women, this represented 7.8% of the total applicants and 1.4% of all female members; and 82 were men, 92.2% of all applicants and 1.5% of all male members.

The 10 committees that work in the AAOT are made up of 75 professionals, 12 of them are women, which represents 16% of the total.

The AAOT Board of Directors is made up of 13 or 14 members who hold office for one year. Between 2015 and 2019, the Board of Directors had two female members (2.8% of the total) out of 71 positions. Both were members of the 2018 Board of Directors, which had a total of 13 positions (15.3%).

From its founding to December 31, 2019, the AAOT has had 67 presidents, Dr. Sara Satanowsky was the only woman to hold the position between 1952 and 1954.

During 2019, 72 lecturers taught the Official National Biennial Certification Course in Orthopedics and Traumatology, five of them were women (6.9% of the lecturers).

The AAOT had accredited 135 Orthopedics and Traumatology Services in the country as of December 2019. Four women were Heads of Service (3%) and worked in the provinces of Buenos Aires, Córdoba, Chaco, and Neuquén.

DISCUSSION

Women represent 10.65% of the members of the AAOT. Out of a total of 5,746 members, 612 are women. These results are comparable with those of international institutions. In 2018, the *Canadian Orthopedic Association* (COA) reported that 17.6% of its members were women, and 11.6% of its members were active practicing Orthopedic and Trauma specialists.[13] Women orthopedists, on the other hand, make up 6.5% of the AAOS membership.

Medicine has undergone a steady feminization process in recent years, with an increase in the number of women studying and practicing this profession, which is not reflected in the distribution of women in our specialty. According to 2019 data released by the Department of University Information of the National Ministry of Education, the participation of women in medical schools represented 69% of new enrollees and 65% of new graduates.[14] On the other hand, according to the results of the 2011 Census, the number of women admitted to the Medical Residency System of the Autonomous City of Buenos Aires increased from 58% to 66% in 2012.[1] However, women residents of Orthopedics and Traumatology represent only 13% of residents in Argentina, according to a study conducted by Cafruni et al.[11] These values are comparable to those published in the United States, where female medical trainees had reached parity in medicine with their male colleagues in 2001,[5] but female Orthopedic and Trauma trainees accounted for less than 14% of all medical residents in the period 2016-2017,[3] and currently make up 16.1%.[6] Increasing the number of women in surgical specialties is a challenge, especially in Orthopedics, a specialty in which the percentage of women has remained relatively the same over the past decades.

Orthopedic surgery is the least gender-diverse specialty recognized by the US ACGME.[6,15] According to the most recently published AAOS data, 6.5% of orthopedic surgeons are actively working in the profession, which is substantially below the 34% of all practicing physicians.[6,15] The importance of diversity (race, gender, sexual orientation, etc.) has been well documented in a variety of disciplines.[16] Diversity in work groups as well as in leadership positions improves productivity by bringing a broader perspective and an innovative approach that leads to improved patient satisfaction and clinical outcomes. In turn, the presence of new women leaders acts as a catalyst for positive change in all areas of the specialty, including promoting diversity and inclusion from a broader perspective; defending salary and academic equality, addressing issues such as well-being and job exhaustion, among others.[17] The need for diversity in medicine has been recognized by both the ACGME and the AAOS as a vital component in ensuring the delivery of quality, culturally competent care to patients.[10]

A series of factors must be examined in order to explain women's lack of interest in the Orthopedics and Traumatology specialization. Initially, this can be explained by the term "horizontal segregation", which refers to the low representation of women in certain medical specialties.[18] Women generally favor specialties traditionally associated with care roles considered "feminine", such as Pediatrics, Family and Community Medicine, Clinical Medicine, and Mental Health. On the other hand, specialties considered "masculine", for example, General Surgery, Traumatology and Neurology, continue to be exercised mainly by men.[18] On the other hand, the low exposure to the subject during medical training may represent another barrier in choosing this specialty. In this sense, Bernstein et al.[19] reported that exposure to mandatory musculoskeletal medicine in college led to a 12% increase in overall Orthopedics and Trauma residency applications, much more pronounced among women (75%). In turn, Baldwin et al.[20] prospectively analyzed factors that affect interest in the specialty on the part of medical students. In the case of women, the factor that was most correlated with interest in the specialty was personal exposure to the specialty during training, either by attending classes or by accessing literature related to the subject, and the exposure to Orthopedics and Traumatology aside from college. Furthermore, the detracting factors in the choice of the specialty were the long working hours, the physical demand and the male predominance.[20] The latter leads to stressing the importance of role models, and tutoring and mentoring to favor the choice of the specialty and demolish existing myths in relation to it.[17] The absence of a "critical mass" of female traumatologists may represent another barrier that contributes to medical students not choosing the specialty. Van Heest et al.[7] studied the differences in the distribution of women among the various Orthopedics and Traumatology residency programs in the United States and discovered that places where women made up more than 20% of the residents had a high proportion of women in leadership positions on the faculty.

The leadership of specialized societies should ideally link a percentage of women on the board of directors with a percentage of membership. Saxena et al.[21] analyzed the relationship between the proportion of women in leadership roles in specialized societies and their gender composition. They found a strong correlation between the percentage of women in a society and the percentage of women on its board of directors. However, this correlation is not linear (societies with higher percentages of female members and higher percentages of women on boards of directors) and was not related to the presence of women in junior member positions.[21] Within the AAOT, 16% of the members of the different committees are women, but of the total positions on the Board of Directors in the study period, only 2.8% were held by women. Only one woman has held the position of President in the history of the AAOT. On the other hand, within the 135 AAOT Accredited Services in the country, only four Service Head positions are held by women (4%).

The so-called "pipeline theory" (i.e., the lowest gross number of female authors in academic medicine and in leadership positions is due to the lower gross number of women in the practice of the specialty) has been proposed as the only explanation for the persistent discrepancies in an attempt to explain the low representation of women in leadership positions and the difficulty in advancing in academic medicine.[22] On the other hand, some authors suggest that the predisposition of women to leave their practice to start a family contributes to this plateau in academic growth and in their arrival at hierarchical positions.[23] In the United States, the most important research grants that will contribute to the academic advancement of the professional are usually awarded in the first decade of the career and this often coincides with the childbearing age of the woman.[22] However, interpreting these variables as the only justification is to simplify an otherwise complex situation. Rather, this topic involves a number of barriers. Subjective barriers are challenging to study scientifically since they are not entirely tangible and thus difficult to objectify.

The implicit bias linked to gender "vertical segregation" refers to the unbalanced distribution at different levels of activity and the concentration of women in positions of low responsibility.[18] There is a low representation of women in senior professional, academic and union positions. If we analyze women's participation in the Argentine university system in 2020, we see that, while there is parity in the number of teachers at all levels (full professor, associate professor, adjunct, etc.), women make up 35% of Deans and 11% of Rectors/Presidents.[14] This is even more marked in other countries of America. According to the *American Association of Medical Colleges* (AAMC) 2014 data on the distribution of the faculty of medical schools in the United States in relation to gender and rank, women represent 27.5% of the Instructors, 19.5% of Assistant Professors, 13.6% of Associ-

ate Professors and 6.8% of Full Professors. The proportion of women in higher academic levels has increased very slowly and is inversely proportional to the rank of the position.[23] In the AAOT's Official National Biannual Certification Course in Orthopedics and Traumatology, in 2019, there were five women lecturers, which represented 6.9%.

Other factors that have been identified as barriers to women's advancement in academic and hierarchical levels include difficulties in obtaining and maintaining relationships with academic mentors or sponsors (defined as a superior proposing a professional for a leadership position) and disparities in research grant allocation.[22,24] In turn, the presence of microaggressions and experiences of intimidation or harassment can influence and negatively impact women's careers.[24] Impostor syndrome is a psychological term understood as the fear of being exposed as a fraud as expectations and responsibility increase. The person expresses doubts about their achievements and abilities, despite factual evidence to the contrary. It is more prevalent in ambitious people, women, and racial, ethnic, and religious minorities.[22,24] All of these mentioned factors suggest and contribute to a "leaky pipe" in the advancement of women in academic medicine. Traditionally, the term "glass ceiling" has been used to refer to invisible but effective barriers that limit women's advancement in organizations to a given level in the hierarchical scale. Today, however, the concept of a "maze" is favored, recognizing that women are not barred from achieving the highest positions, but that they must overcome various difficulties and travel difficult paths to do so.

In 2018, the *American College of Physicians* (ACP) announced its dedication to achieving gender equality in medical compensation and career advancement, and the AAOS made diversity one of its 2019-2023 strategic goals. When a vulnerable minority reaches "critical mass" (the critical size of a group to initiate social change), the social system reaches a tipping point in which the minority's influence over the group becomes significant. Values of 25% to 30% have been proposed to reach this point.[15] Furthermore, understanding that this change must be implemented collaboratively is critical. Men are essential allies for diversity, and it is crucial that they embrace the mission to diversify orthopedic surgery in order to retain quality in patient care and fight for thought diversity. Several strategies have proven to be effective in achieving this change: 1) early exposure to the specialty; 2) addressing educational gaps; 3) tutoring; 4) the presence and interaction in the faculty of women and minority groups; and 5) the development of a culture or institutional network that supports women and minority physicians.[25] In the United States, initiatives such as the "Pipeline Initiative" and the mentoring programs and exposure to the specialty run by the "Perry Initiative" (non-profit organization) are carried out to achieve an increase in the recruitment of women and minorities to the specialty.[25] There are also numerous organizations focused on women and other minorities around the world today. These strategies and organizations seek to change attitudes and myths in relation to the specialty in order to attract the best students, regardless of gender.[4]

The main limitation of our analysis, which is observational and cross-sectional, is that it can only describe trends and cannot establish the causes of women's poor participation at the academic and hierarchical levels. However, we believe that knowing the current situation of women in the AAOT will allow us to lay the foundations for subsequent analysis.

CONCLUSION

Women represent 10.6% of the active members of the AAOT. Knowing the current situation regarding the proportion of women in the association, as well as their participation in academic areas and in hierarchical positions, allows us to make the situation visible and provide the foundation for carrying out action plans and implementing measures aimed at improving equality in the specialty.

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

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Case Resolution

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Case presentation on page 267.

DIAGNOSIS: Giant cell tumor.

DISCUSSION

Magnetic resonance imaging with contrast media was used to examine the lesion and the inflammatory process in the soft tissues (Figure 3).

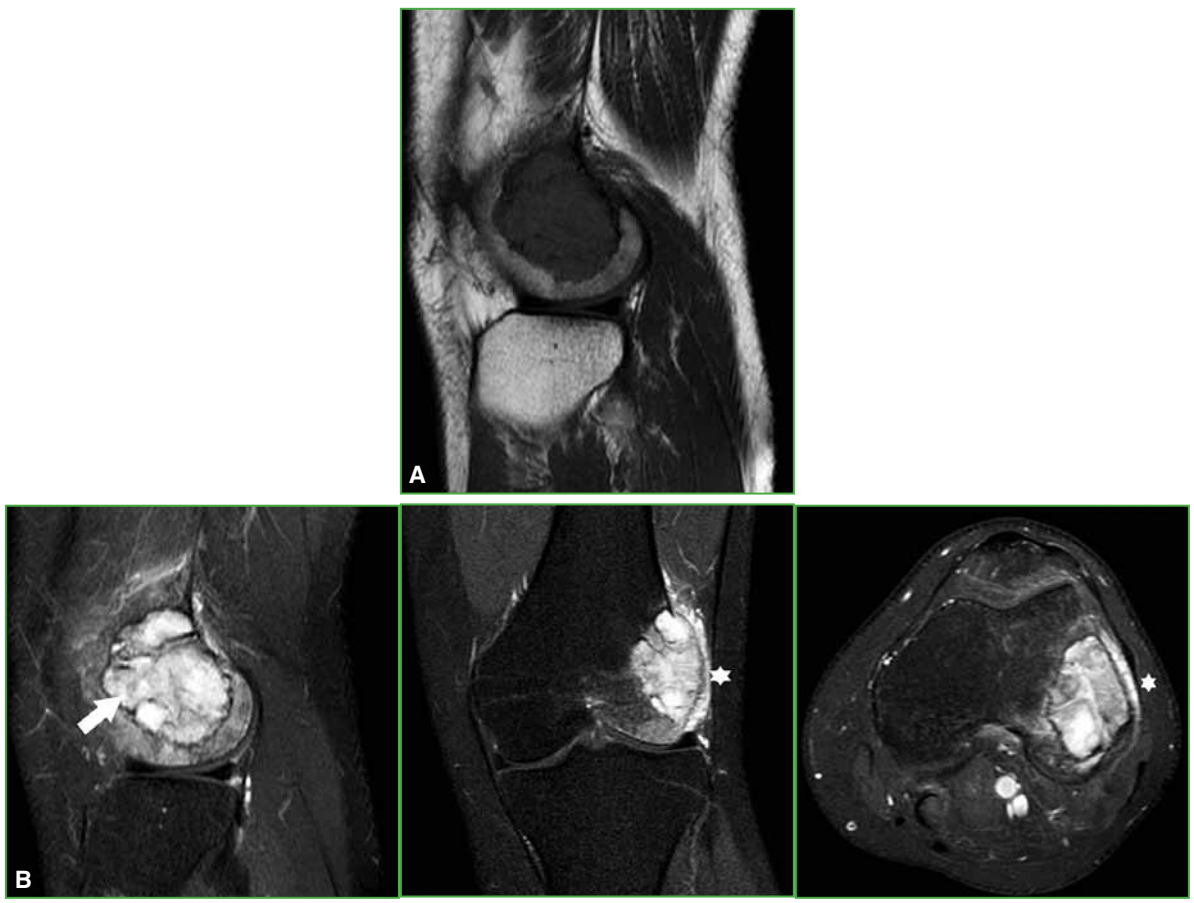

Figure 3. Magnetic resonance imaging of the left knee with contrast medium. **A.** Sagittal section in T1-weighted sequence. The lesion persists with characteristics similar to those of the previous study. **B.** Sagittal, coronal and axial sections in T1-weighted sequences with injection of contrast medium and fat suppression. Contrast uptake in the lesion (arrow) and minimal soft tissue edema adjacent to the lateral retinaculum (asterisk) are visualized.

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The computed tomography (Figure 4) revealed a lesion with cortical thinning and, in some sectors, cortical destruction.

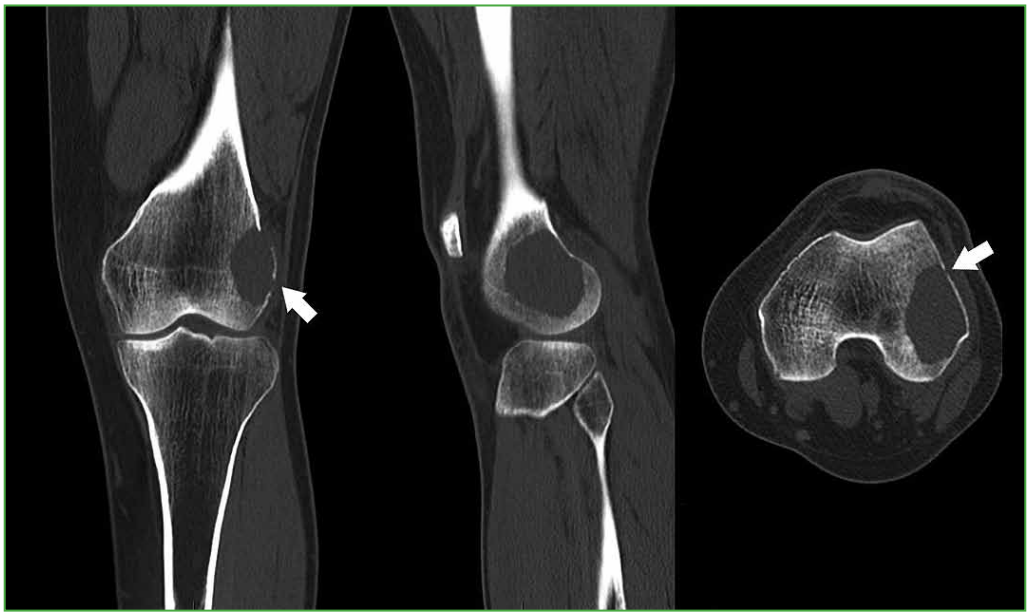

Figure 4. Computed tomography of the left knee, coronal, sagittal, and axial sections. A hypodense lesion with fine septa inside that thins the cortex and produces endosteal erosion (arrow).

With the information from the studies, the head traumatologist and the doctors from the Musculoskeletal Tumors Committee decided to perform a CT-guided biopsy (Figure 5) and stage the lesion with a chest tomography. The patient never experienced weight loss or changes in muscle mass.

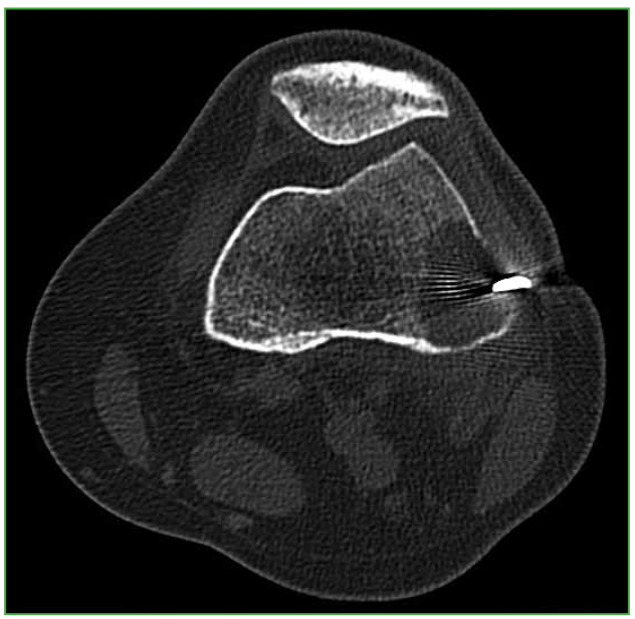

Figure 5. CT-guided bone biopsy of the external condyle with an 11G-4 core needle. A geographic pattern is identified.

The anatomical pathology study reported that the sections showed a tumor consisting predominantly of numerous multinucleated giant cells of the osteoclastic type interspersed in sectors with mononuclear fused cells. A focus of spindle cell proliferation with a whorled arrangement was recognized, in which foam cells were distinguished (Figure 6).

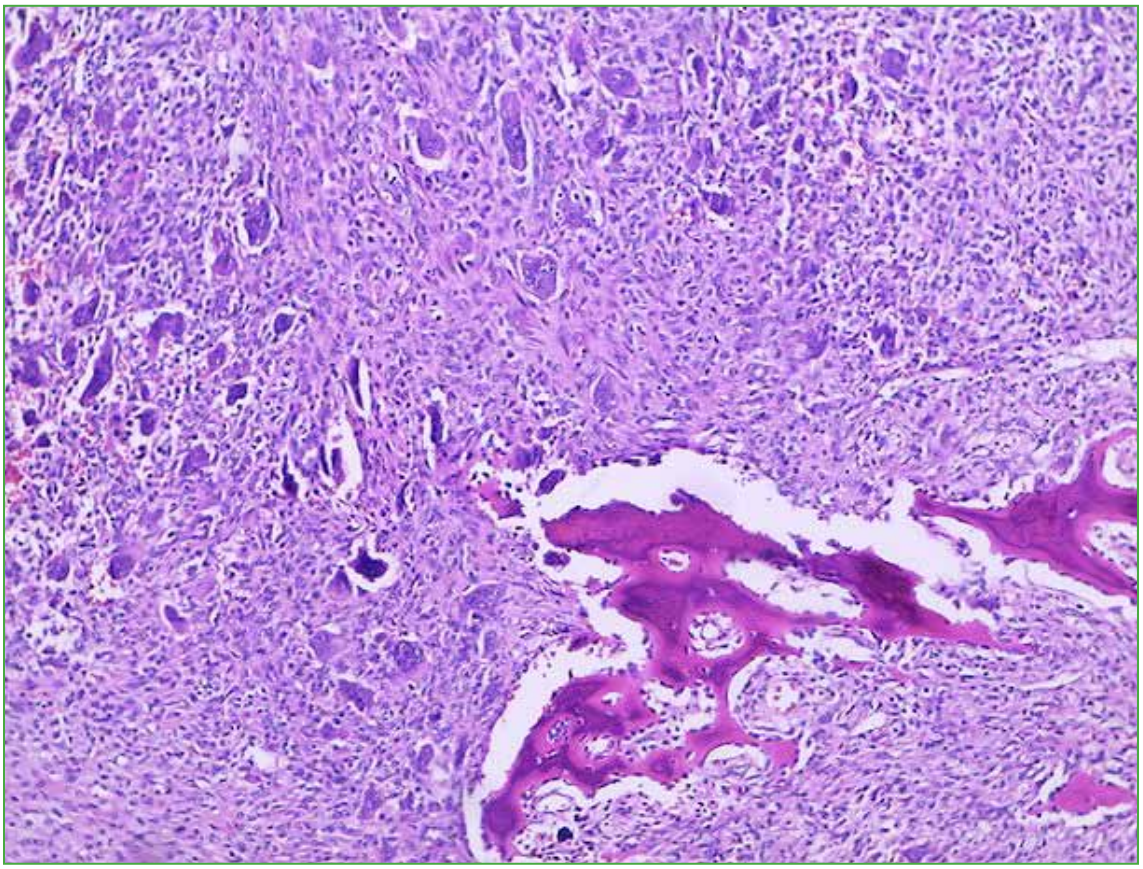

Figure 6. Histological preparation of a distal femoral tumor, whose current histomorphological characteristics (predominantly giant cells), in conjunction with radiological findings and clinical evolution, led to its classification as a giant cell tumor.

The possibility of neoadjuvant treatment with subsequent surgery or extensive surgery with placement of bank bone filler and autologous iliac crest graft emerged with the diagnosis of giant cell tumor without a distant lesion.

Curettage surgery with bank bone filling and autologous iliac crest graft was performed, with which good outcomes were obtained (Figure 7).

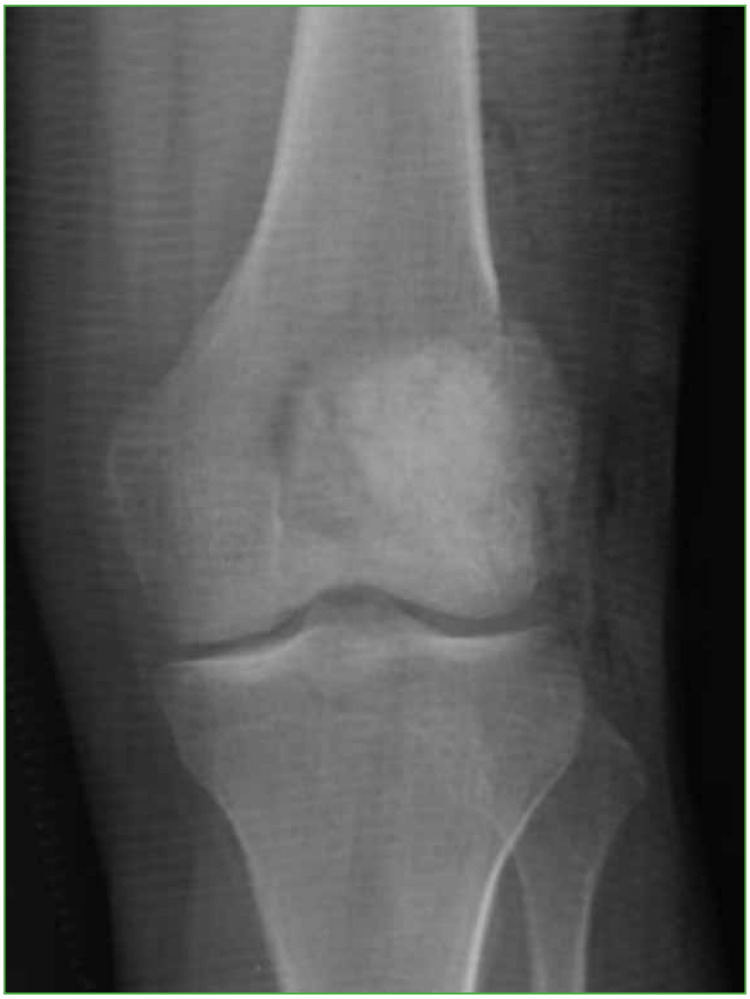

Figure 7. Anteroposterior radiograph of the left knee for immediate post-surgical control.

DIAGNOSIS

With all these findings, the diagnosis of giant cell tumor was reached. It is a generally benign bone tumor, formed by two sheets of oval mononuclear cells interspersed with giant cells. This tumor is rarely malignant (5% of all giant cell tumors). It originates in the metaphysis, with possible extension towards the epiphysis. Involves, in order of frequency, the distal femur, proximal tibia, and distal radius.

It is characterized by signs and symptoms such as pain, inflammation, limitation of movement, and pathological fracture (5-10%). The maximum incidence is at 20-50 years (80%). There is a slight predominance in the female sex (1.5:1) and the recurrence rate is high after marginal resection (25%). Wide resection is preferred.

On radiographs, it appears as an eccentric, lytic lesion originating from the metaphysis. The geographic borders have a narrow transition zone, no sclerotic margin, and cortical thinning. On computed tomography, cortical thinning with penetration is confirmed.

On MRI, T1-weighted sequence images show low to intermediate, heterogeneous signal intensity. In fluid-sensitive sequences, the signal intensity is high, not homogeneous. After injection of contrast medium, heterogeneous enhancement can be seen.

In histological preparations, the Campanacci grading system should be taken into account:
I: Radiology and histology studies show low aggressiveness.
II: Radiology studies show aggressiveness and intact periosteum. Benign histology.
III: Aggressive growth and soft tissue mass in both radiology and histology studies.

The most frequent differential diagnoses are: chondroblastoma (Figure 8), aneurysmal bone cyst (Figure 9) and telangiectatic osteosarcoma.

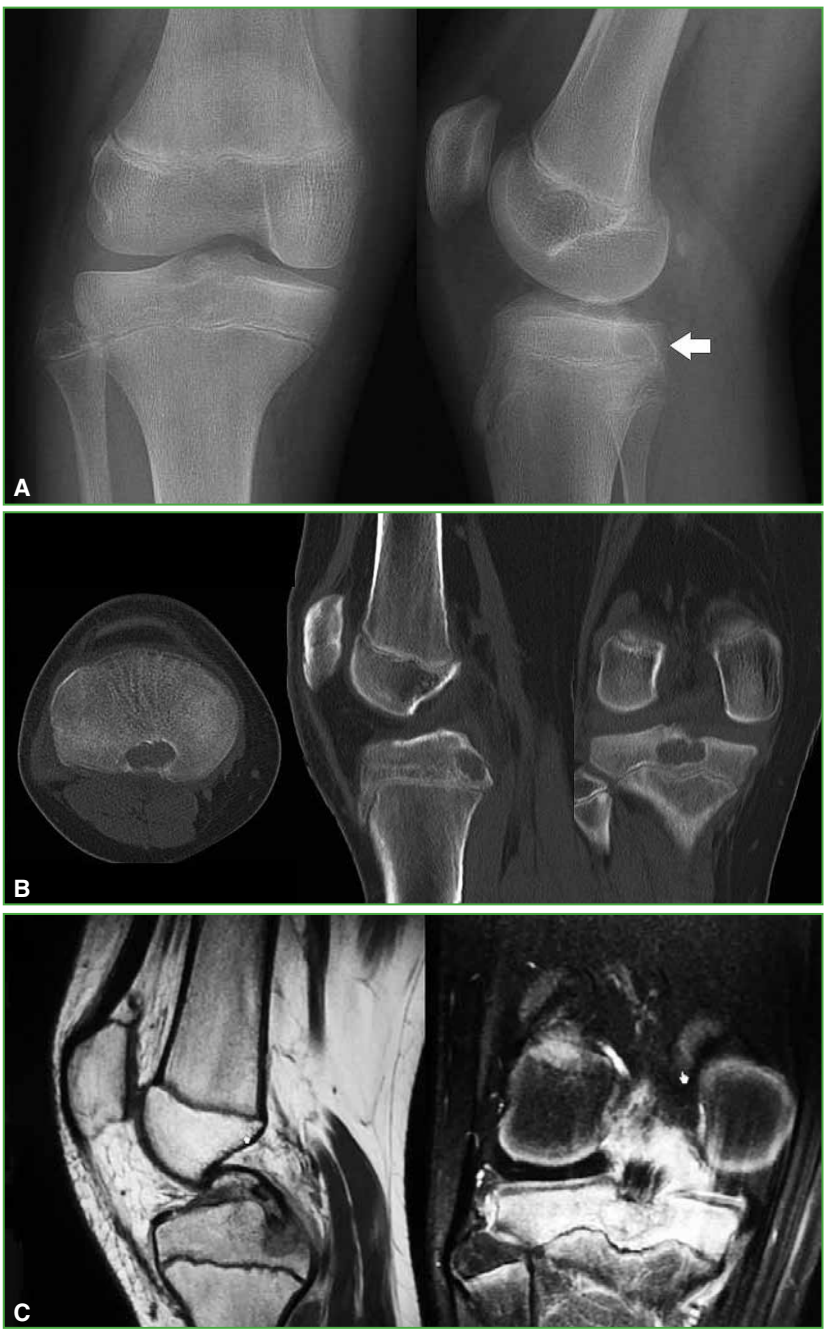

Figure 8. Chondroblastoma. 11-year-old patient with pain located in the popliteal fossa of the right knee, of six months of evolution. **A.** Radiograph of the right knee with a geographic Ia lesion, with a sclerotic border at the level of the epiphyseal sector of the tibia (arrow). **B.** Computed tomography showing a hypodense lesion with sclerotic borders. **C.** Magnetic resonance imaging of the knee, sagittal section on T1-weighted sequences and coronal section on STIR sequence. The lesion is visualized with significant bone edema.

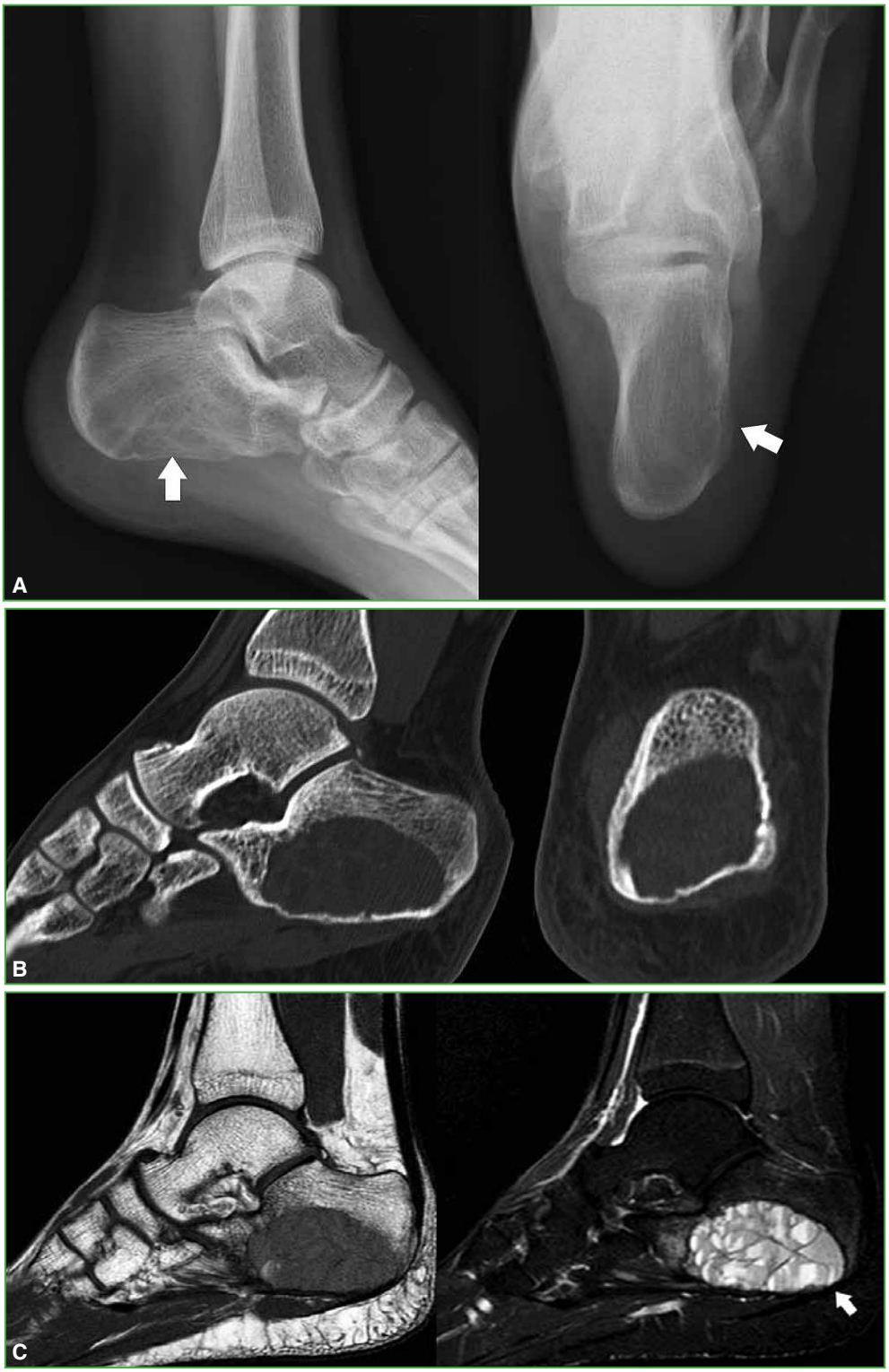

Figure 9. Aneurysmal bone cyst. A 20-year-old patient with pain in the hindfoot of several months' evolution. **A.** Lateral and axial radiographs of the calcaneus. A radiolucent lesion with poorly defined borders can be seen, with septa inside it and without cortical rupture (arrow). **B.** Computed tomography, sagittal and coronal sections. Endosteal involvement. **C.** Ankle MRI, sagittal sections in T1-weighted and STIR sequences. A hypointense and hyperintense lesion are visualized, respectively, with fluid-fluid levels (arrow).

Dr. Andrés Aníbal Silberman (1962-2023)

Dr. Andrés Aníbal Silberman passed away on May 23, 2023.
He was born in the City of Buenos Aires. He completed his secondary studies at the Colegio Nacional de Buenos Aires and received his physician degree with honors from the School of Medicine of the University of Buenos Aires.

He completed his residency in Orthopedics and Traumatology at the Dupuytren Institute and later specialized in Hip and Knee Reconstructive Surgery at Rush Presbyterian St. Luke Medical Center; in Sports Medicine, in Chicago, USA; and at the A.O.A.S.I.F. center in Aarau, Switzerland.

He completed internships at various internationally recognized centers, such as: Mayo Clinic (Minnesota, USA), Kantonsspital (Basel, Switzerland), Anderson Clinic (Arlington, USA), Nuremberg Hospital (Germany) and Clinic des Lilas (Paris, France).

He began his teaching career in the Chair of Anatomy and held all positions in Orthopedics and Traumatology: Teaching Assistant, Instructor, Adjunct Professor and Full Professor since 2013, at the Hospital de Clínicas of the University of Buenos Aires.

He never put aside his passion for academic activity, he became President of the Sociedad de Osteosíntesis, Biomateriales e Injertos Óseos (SOBI) in 2014; President of the Asociación Argentina para el estudio de la Cadera y la Rodilla (ACARO) in 2018; Secretary General of the Sociedad Latinoamericana de Ortopedia y Traumatología (SLAOT) between 2007 and 2009; and he culminated his fruitful career as President of our Asociación Argentina de Ortopedia y Traumatología (AAOT) in 2021. During his tenure, the Legal Status of the Agremiación Argentina de Ortopedia y Traumatología was signed and two subcommittees of great importance were created (Digital Media and Women).

He was co-author with his father and Dr. Oscar Varaona of the book Ortopedia y Traumatología published by Editorial Médica Panamericana, as well as numerous scientific papers published in our country and abroad.

In terms of healthcare, he was an excellent surgeon respected by his peers and, what is more important, by his patients, to whom he was very affectionate and close. Together with his father, Fernando, they began their surgeries at 6 am, a practice he continued until the end of his career.

He was a great friend, for which I am grateful.

His family was his pride; it was numerous and close, consisting of his brothers Laura and Marcos and their families, his adored wife Flavia, and their three daughters: Brenda, Stephy and Cindy.

Dear Andy, you will be greatly missed and remembered by your patients, friends, and family.

Dr. Daniel Vaineras
Adjunct Professor of Orthopedics and Traumatology
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Letter to the Editor

Dear Dr. Bersusky,

As the main author of the manuscript "Partial sacrectomy by single posterior approach",[1] which you recently mentioned in your Editorial in the most recent issue of our Journal,[2] and on behalf of all the co-authors, we would like to thank you for your mention and the gesture of citing our study.

Unfortunately, we are solely trained as surgeons and do not put as much effort into training as researchers, let alone writers.

Fortunately, we have the support we need in our Journal to increase the quality of our articles and ensure that our efforts are not in vain.

From the user-friendly platform used to upload the data to be published to the Editorial Team who ensures that nothing is missing and that everything follows the suggested instructions.

As well as the quality of the Reviewers, who take the time to read the article and use their remarks to assist in the creation of a quality article, where if the authors accept said criticism and respect the peer's effort, they will be one step closer to that goal.

We are aware of this since we have been fortunate enough to produce knowledge by forming a large team with similar goals.

As an author, I am certain that this journal is on the verge of reaching maximum international indexing, which I know is its primary goal, and hence we aim to publish here.

I have the privilege of knowing you personally and sharing more than the passion for healthcare and academics, and I am aware of the caliber of the person who leads the vital and well-trained Editorial Board.

Thank you again for your support over the years and for your recognition and current words.

Dr. Pedro L. Bazán
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