AAOT 1936

Revista de la Asociación Argentina de Ortopedia y Traumatología

AN ORGAN OF THE ASOCIACIÓN ARGENTINA DE ORTOPEDIA Y TRAUMATOLOGÍA

VOL. 87, N.° 6 / DECEMBER 2022 / PAGES. 744-873

www.aaot.org.ar • https://raaot.org.ar
Full english text available. Indexada en SciELO, LILACS, Latindex, Dialnet, Doaj, Redib, AmeliCA y JournalTOCs • Incluida en el Núcleo Básico de Revistas Científicas Argentinas del CONICET.
ISSN 1852-7434 (EN LÍNEA)

Dr. Luis Muscolo, member of the National Academy of Medicine

Dr. Martín Buttaro
Full Member of the AAOT

Dr. Luis Muscolo

It is for me an honor, on behalf of his disciples, to write a brief profile about Dr. Luis Muscolo, mentor of mentors, who has taught us how to perform a type of academic medicine based on the thorough gathering of our findings through registers which date from 30 years ago, as well as their presentation and publication at both national and international level.

Dr. Muscolo graduated as a Doctor in 1996 and received the degree of MD in 1984. He was designated Associate Researcher at the University of Illinois (Chicago, USA). He was in charge of its research laboratory between 1973 and 1976. He obtained by contest the position of Head Professor of Orthopedics and Traumatology at the University of Buenos Aires.

He has more than 100 publications, which are indexed in PubMed, and has written more than 12 chapters of books edited abroad.

He has been a Visiting Professor at the Mayo Clinic (Rochester, USA), at the University of Yamaguchi (Ube, Japan), at the Rush Presbyterian St. Lukes (Chicago, USA) and a lecturer invited by the Presidents of the American, French and Japanese Societies of Orthopedics. Also, he was a Member of Honor of the Spanish Society of Orthopedics and Traumatology in 2012.

Some of his merits include an invitation to be a lecturer at the American Musculoskeletal Tumor Society, appointments as "Campanacci lecturer" at the European Musculoskeletal Society of Oncology, sponsor of the Warthog Society (Cleveland Clinic) and both Presidential Guest Speaker and Marshall Urist lecturer at the annual Congress of the Association of Bone and Joint Surgeons (ABJS) in 1991 and 2006.

He has received 26 prizes, 12 of which were international, and 7 of which were awarded by the National Academy of Medicine.

He obtained by contest the position of Head of Service of Orthopedics and Traumatology at the Hospital Italiano in Buenos Aires in 1999 and is currently the Honorary Director of such institution, where he has ever since instructed several generations of Oncologic Orthopedics residents and interns in continuing education, both national and international.

In 2000, he was appointed President of the Local Committee of the Bone and Articulation Decade (2000-2010), and in 2004 he was chosen President of the Argentine Association of Orthopedics and Traumatology.

In 2020, he was designated Master Surgeon in Orthopedics and Traumatology at the Argentine Association of Orthopedics and Traumatology.

Since November 4, 2022 he has occupied the Seat of Honor number 9 in the National Academy of Medicine, which is named after Professor Dr. Carlos E. Ottolenghi. On behalf of our Association, we congratulate Dr. Luis Muscolo for such a well-deserved award.

Dr. MARTÍN BUTTARO • martin.buttaro@hospitalitaliano.org.ar https://orcid.org/0000-0003-3329-778X

How to cite this article: Buttaro M. Dr. Luis Muscolo, member of the National Academy of Medicine. *Rev Asoc Argent OrtopTraumatol* 2022;87(6):744. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1690

Case presentation

Rodrigo Re,[*] Christian Allende Nores[**]
[*]*Diagnostic Imaging Service, Head of the Osteoarticular/Musculoskeletal Imaging Area - Interventionism, Sanatorio Allende, Córdoba, Argentina*
[**]*Orthopedics and Traumatology Service. Sanatorio Allende, Córdoba, Argentina*

Case resolution on page 858.

A 27-year-old male patient consulted for pain in the distal third of the right wrist, over the volar sector. He referred to having noticed progressive loss of strength in the last 3 months.

Upon physical examination, no tumors were palpable. There were no alterations of the pulses in dynamic maneuvers. The compression of the flexor tendons was painful and Tinel's sign was positive. Anteroposterior and lateral radiographs of the right wrist (Figure 1) and an ultrasound of the right wrist (Figure 2) were requested.

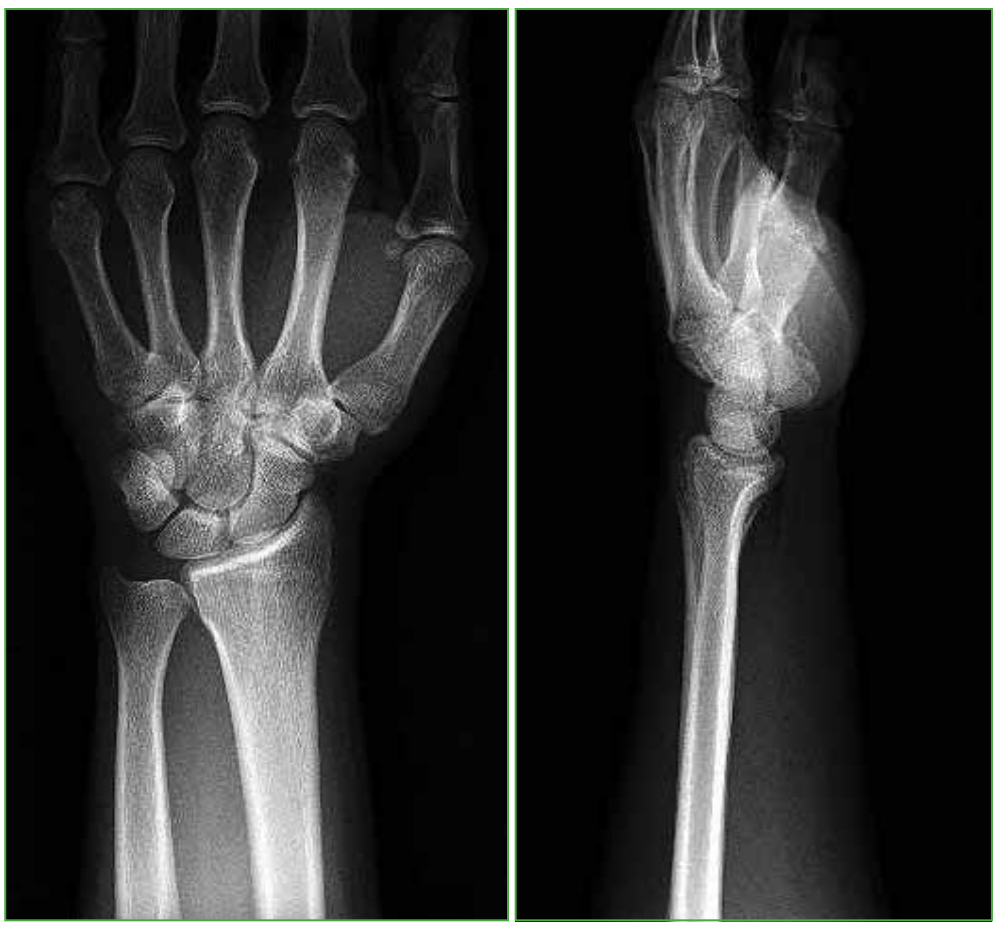


Figure 1. Radiograph of the right wrist, with normal characteristics.

Dr. RODRIGO RE • rodrigo_re@hotmail.com https://orcid.org/0000-0001-7382-9459

How to cite this article: Re R, Allende Nores C. Postgraduate Orthopedic Instruction - Imaging. Case presentation. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):745-747. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1605

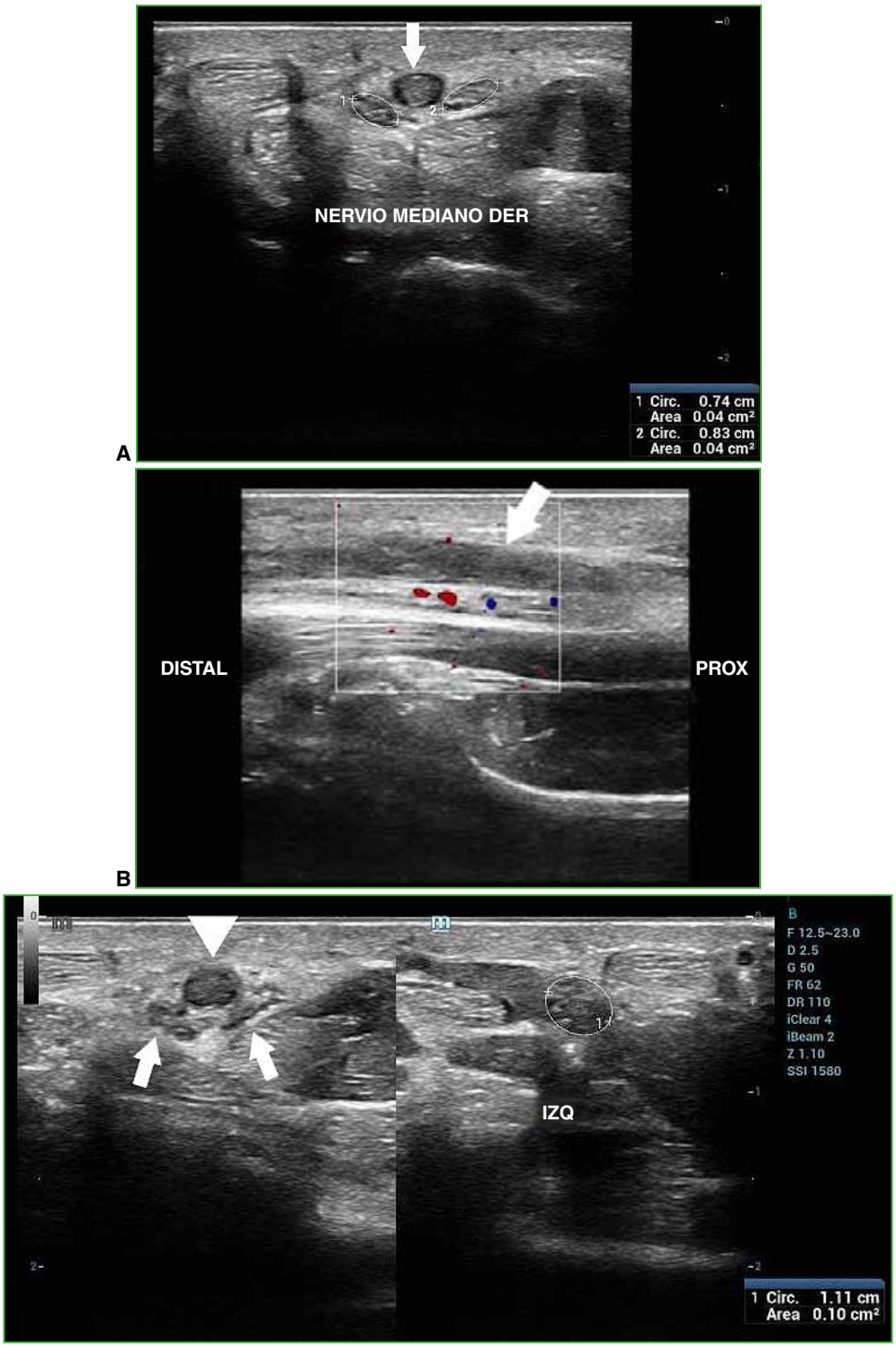


Figure 2. Ultrasound of the right wrist, with a high-frequency transducer. **A.** Cross section of the median nerve, showing its bifid morphology with a rounded tumor that separates it, with a hypoechoic signal (arrow). As a whole, the median nerve has a diameter of 8 mm^2. **B.** Longitudinal section of the wrist, showing a tubular tumor with echogenic material inside (arrow), without flow on Doppler examination. **C.** Cross section with comparative study of the median nerve. Right: study of the right wrist with the bifid median nerve (arrows) and the tumor in the middle (arrowhead). Left: The left median nerve is seen, with normal characteristics.

FINDINGS AND INTERPRETATION OF IMAGING STUDIES

The wrist radiograph (Figure 1) shows no alterations. The right wrist ultrasound (Figure 2) shows a bifid median nerve, with a rounded, hypoechoic tumor that separates it, with no flow on Doppler examination. No alterations are observed at the level of the radial or ulnar nerves. The flexor and extensor tendons are normal. There is no joint effusion.

The imaging examination is completed with magnetic resonance imaging of the right wrist.

C. Allende Nores ORCID ID: https://orcid.org/0000-0002-2336-2157

Radiographic Analysis of the Spinopelvic Parameters Obtained With an Anterior TLIF Device. Multicenter Study

Enrique A. Gobbi,[*,] Máximo de Zavalía[*,**] Felipe Lanari Zubiaur,[**] Ricardo Berjano,[#] Facundo Ortiz,[#] Pablo Zuliani,[##] Rodrigo Pons Belmonte[##,§]**

[*]CEMIC, Autonomous City of Buenos Aires, Argentina
[**]Grupo Médico Vertebral, Autonomous City of Buenos Aires, Argentina
[#]Neurosurgery Service, "Guillermo Rawson" Hospital, San Juan, Argentina
[##]Cirugía de Columna, Hospital "Dr. Marcial Quiroga", San Juan, Argentina
[§]Orthopedics and Traumatology Service, Sanatorio Argentino, San Juan, Argentina

ABSTRACT

Objective: To report the results obtained according to the position of an anterior TLIF device. **Materials and Methods:** Multicenter, observational, analytical, cross-sectional, retrospective recovery study. We evaluated the pre and post-operative spinopelvic parameters of the spinograms of 20 patients who underwent surgery between September 2019 and August 2021. Patients who had undergone lumbar arthrodesis with an anterior TLIF implant were included, whereas patients without a pre or post-surgical spinogram and more than one device were excluded. **Results:** The mean monosegmental lordosis was 13.33º preoperatively and 18.81º postoperatively (p <0.001). The mean monosegmental lordosis was 7.32º, 2.95º, and 6.24º for positions I, II, and III, respectively. The mean disc height was 6.22 mm for the preoperative period and 11.06 mm for the postoperative period (p> 0.001). **Conclusion:** We found encouraging results on the placement of this type of device and its relationship with segmental lordosis, understanding the importance of its placement at the anterior end of the disc space.

Keywords: TLIF; anterior TLIF; interbody fusion; posterior approach; lordosis.
Level of Evidence: IV

Análisis radiográfico de los parámetros espinopélvicos obtenidos con el dispositivo de TLIF anterior. Estudio multicéntrico

RESUMEN

Objetivo: Comunicar los resultados obtenidos según la posición del dispositivo de TLIF anterior. **Materiales y Métodos:** Estudio multicéntrico, observacional, analítico, transversal, de recuperación retrospectiva. Se evaluaron los parámetros espinopélvicos pre y posoperatorios de espinogramas de 20 pacientes que fueron operados entre septiembre de 2019 y agosto de 2021. Se incluyó a pacientes sometidos a artrodesis lumbar con implante de tipo TLIF anterior. Se excluyó a pacientes sin espinograma pre o posquirúrgico y más de un dispositivo. **Resultados:** La media de la lordosis monosegmentaria fue de 13,33º antes de la cirugía y de 18,81º después (p <0,001). La media de la lordosis monosegmentaria fue de 7,32º; 2,95º y 6,24º para las posiciones I, II y III, respectivamente. La media de la altura discal fue de 6,22 mm en el preoperatorio y 11,06 mm en el posoperatorio (p >0,001). **Conclusiones:** Los resultados de la colocación de este tipo de dispositivos y su relación con la lordosis segmentaria fueron alentadores, se comprendió la importancia de la disposición de estos en el extremo anterior del espacio discal.

Palabras clave: Fusión intersomática lumbar transforaminal anterior; dispositivo intersomático; abordaje posterior; lordosis.
Nivel de Evidencia: IV

Received on November 8th, 2021. Accepted after evaluation on May 26th, 2022 • Dr. MÁXIMO DE ZAVALÍA • MAXIMODEZAVALIA@gmail.com https://orcid.org/0000-0002-4022-4100
How to cite this article: Gobbi EA, de Zavalía M, Lanari Zubiaur F, Berjano R, Ortiz F, Zuliani P, Pons Belmonte R. Radiographic Analysis of the Spinopelvic Parameters Obtained With an Anterior TLIF Device. Multicenter Study. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):748-755. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1460

INTRODUCTION

Since Briggs and Milligan[1] first described interbody fusion in 1944, different types of devices have been launched on the market whose main objective is to achieve fusion, decompress nerve structures and restore lumbar lordosis. These devices can be introduced through different approaches: anterior (*anterior lumbar interbody fusion*, ALIF), anterior or lateral oblique (*oblique lateral interbody fusion*, OLIF), lateral lumbar (*lateral lumbar interbody fusion*, LLIF), posterior transforaminal (*transforaminal interbody fusion*, TLIF) or medial posterior (*posterior lumbar interbody fusion*, PLIF). Depending on what is sought and the anatomy of each patient, one method or another is chosen.[2]

At present, by the posterior approach, two techniques are widely used: TLIF and PLIF, which differ by the site of access to the intervertebral disc. PLIF was first described by Cloward in 1952,[3] while Harms and Jeszenszky published the use of TLIF in 1998.[4] Both techniques have achieved good results according to the visual analogue scale and the Oswestry disability index.[5]

Restoration of lordosis is recognized as one of the most important factors for a successful fusion surgery.[6,7] ALIF and LLIF type devices are excellent segmental lordosis restorers, although they are not exempt from complications which are typical of the anterior (retrograde ejaculation, incisional hernia, risk of pulmonary embolism and thrombosis) and lateral procedures (femoral neuropraxia, incisional hernia, and ipsilateral psoas weakness), and have contraindications based on the patient's anatomy. Hsieh et al. published that ALIF is superior to TLIF when it comes to gaining segmental lordosis, with segment lordosis of 8.3º for ALIF and 0.1º for TLIF.[8] Kim et al. reported similar results to those described by Hsieh.[9]

Landham et al. described the importance of the position of the PLIF devices and the generation of segmental lordosis. They found a significant difference when the device was in front of the center of the disk.[10]

The objective of this study was to report the results obtained in spinopelvic parameters, according to the position of the TLIF device (Coroent Anterior TLIF, Nuvasive®, CA, USA).

MATERIALS AND METHODS

Study design

A multicenter, observational, analytical, cross-sectional, retrospective recovery study was performed. It adhered to the STROBE statement. The spinopelvic parameters measured in spinograms before surgery and in the postoperative period of patients operated on between September 2019 and August 2021 were analyzed.

Population and sample

The inclusion criteria were: patients who had undergone pedicle instrumentation associated with an anterior TLIF type implant (Coroent Anterior TLIF, Nuvasive®, CA, USA), regardless of gender, age, and weight. The exclusion criteria were: not having pre- and post-surgical spinograms or inappropriate study technique, and patients with more than one previous TLIF device.

Procedure and technique

Surgical technique

The patient is under general anesthesia, in the prone position. Once the pedicle screws have been inserted, we proceed to work on the segment in which the interbody device will be inserted. Distraction of the segment is performed by placing a distraction forceps in the interspinous space or by placing a rod and distracting the contralateral segment to which the disc is to be worked. A complete facet osteotomy (Smith-Petersen) is performed ipsilateral to the segment and a partial facet osteotomy (grade 1, Schwab classification) is performed on the contralateral side. Next, the protruding root is identified and carefully separated in order to gain access to the disc via the transforaminal route, and an annulotomy and subsequent discectomy are performed. Then, the vertebral plates are prepared with rasps. Using direct fluoroscopy, the interbody device is introduced up to the anterior limit (anterior longitudinal ligament), then the introducer is unblocked and device introduction is continued. If the device does not lie as anteriorly as desired, it is recommended to remove it and complete the discectomy, thereby creating space for more anterior placement (Figures 1 and 2).

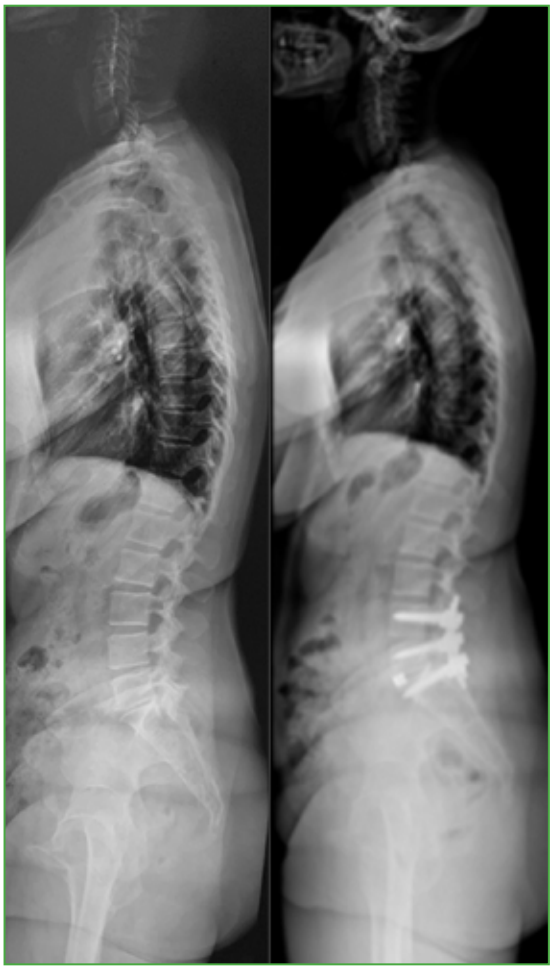


Figure 1. Pre and post-surgical spinograms. Anterior placement of the anterior TLIF interbody device is visualized.

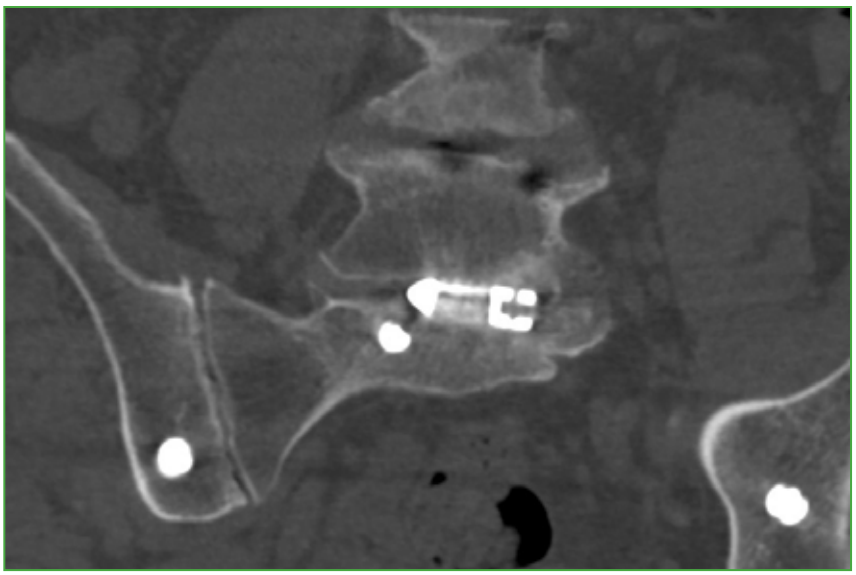


Figure 2. Axial, sagittal and coronal tomographic slices. Anterior placement of the anterior TLIF interbody device is observed.

Image evaluation

The images were analyzed by two spinal surgery specialists and the values of the pre-surgical radiographs were compared with those of the post-surgical ones using the Surgimap® program version 2.3.2.1.

Statistical Analysis

The following spinopelvic parameters were evaluated in the pre- and post-surgical spinograms: lumbar lordosis (L1-S1), monosegmental lordosis in the segment in which the interbody device was placed, L4-S1 lordosis, pelvic tilt, T1-pelvis angle, disc height. and the position where the interbody device was placed (Figure 3). Statistical tests were performed to compare the preoperative and postoperative variables with the IBM SPSS 23.0 Statistics® program. The stipulated significance levels were 95%, that is, it is concluded that there are statistically significant differences with a p-value <0.05.

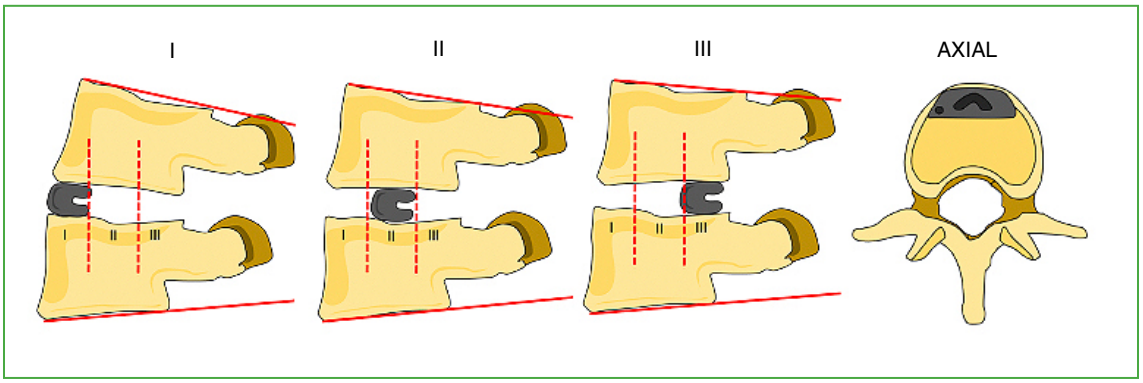


Figure 3. The disc space was divided into three segments: I, the most anterior; II, the medial and III, the most posterior. Axial view of the device layout.

RESULTS

During the study period, 20 patients were selected (Figure 4) who had received a total of 20 anterior TLIF devices: 11 (55%) in the L4-L5 segment and nine (45%) in L5-S1. Eight devices (40%) were placed in position I; seven (35%), in position II and five (25%), in position III.

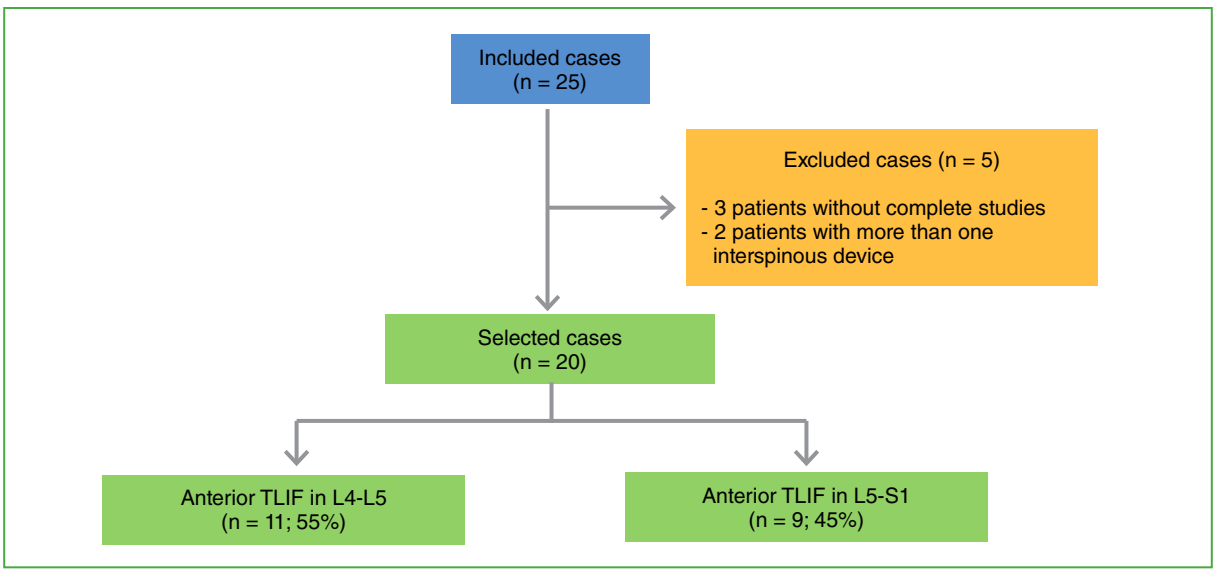


Figure 4. STROBE flowchart for case selection.

When the device was placed in position I, the mean monosegmental lordosis achieved was 7.32º, in position II, 2.95º, and in position III, 6.24º. Mean disc height was 6.22 mm (± 1.81) preoperatively and 11.06 mm (± 1.82) postoperatively, this result was statistically significant (p <0.001). The mean lordosis of L1-S1 was 39.38º (± 16.12) in the preoperative period and 44.22º (± 14.96) in the postoperative period, the result was not statistically significant (p <0.75). On the other hand, the values were statistically significant (p <0.007) for L4-S1 lordosis, with a mean of 26.26º (± 10.88) in the preoperative period and 34.71º (± 9.13) in the postoperative period.

The mean monosegmental lordosis was 13.33º (± 7.62) in the preoperative period and 18.81º (± 5.61) in the postoperative period, the result was statistically significant (p <0.001). The mean pelvic tilt was 21.96º (± 10.66) in the preoperative period and 20.74º (± 7.53) in the postoperative period, with a statistically insignificant result (p = 0.38). Lastly, the mean T1-pelvis angle was 20.03º (± 11.37) in the preoperative period and 15.64º (± 7.51) in the postoperative period, a statistically significant result (p <0.01) (Table, Figure 5).

Table. Results of pre and postoperative spinopelvic parameters

	Preoperative	Postoperative	p
L1-S1 (°)	39.38 ± 16.12	44.22 ± 14.96	0.075
L4-S1 (°)	26.26 ± 10.88	34.71 ± 9.13	0.007
Monosegmental lordosis (°)	13.33 ± 7.62	18.81 ± 5.61	0.010
Disc height (mm)	6.22 ± 1.88	11.06 ± 1.82	0.001
T1-pelvis angle (°)	20.03 ± 11.37	15.64 ± 7.51	0.011
Pelvic tilt (°)	21.96 ± 10.66	20.74 ± 7.53	0.389

The stipulated significance levels were 95%, that is, it is concluded that there are statistically significant differences with a p-value <0.05.

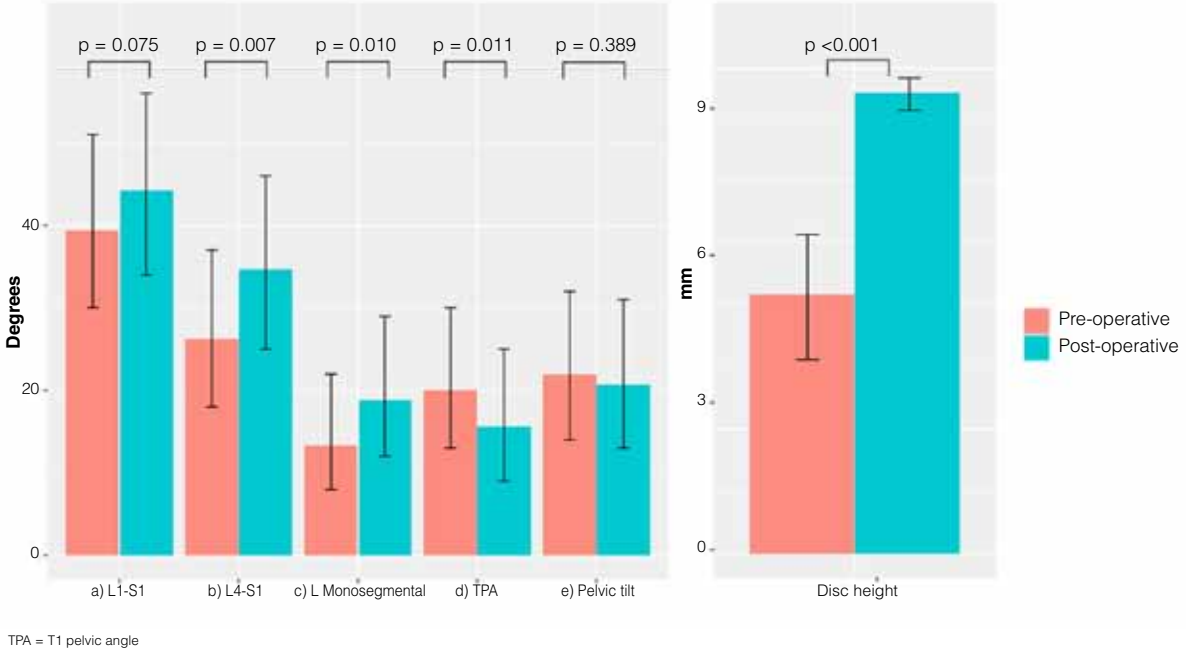


Figure 5. Analysis of pre and postoperative spinopelvic parameters. Statistically significant differences, p <0.05.

Regarding the postoperative L1-S1 lordosis and the position of the anterior TLIF device, it is concluded that there is no linear relationship between the variables, since Tk = 0.127 (p = 0.518) and rho = 0.149 (p = 0.532) values were obtained (Kendall's Tau b and Spearman's Rho correlation coefficient, respectively). When evaluating the relationship between the postoperative monosegmental lordosis and the position of the anterior TLIF device (Figure 6), a statistically significant, weak and indirectly proportional relationship was found between the variables, because an rk = -0.384 (p = 0.055) and an rs = -0.454 (p = 0.045) were obtained.

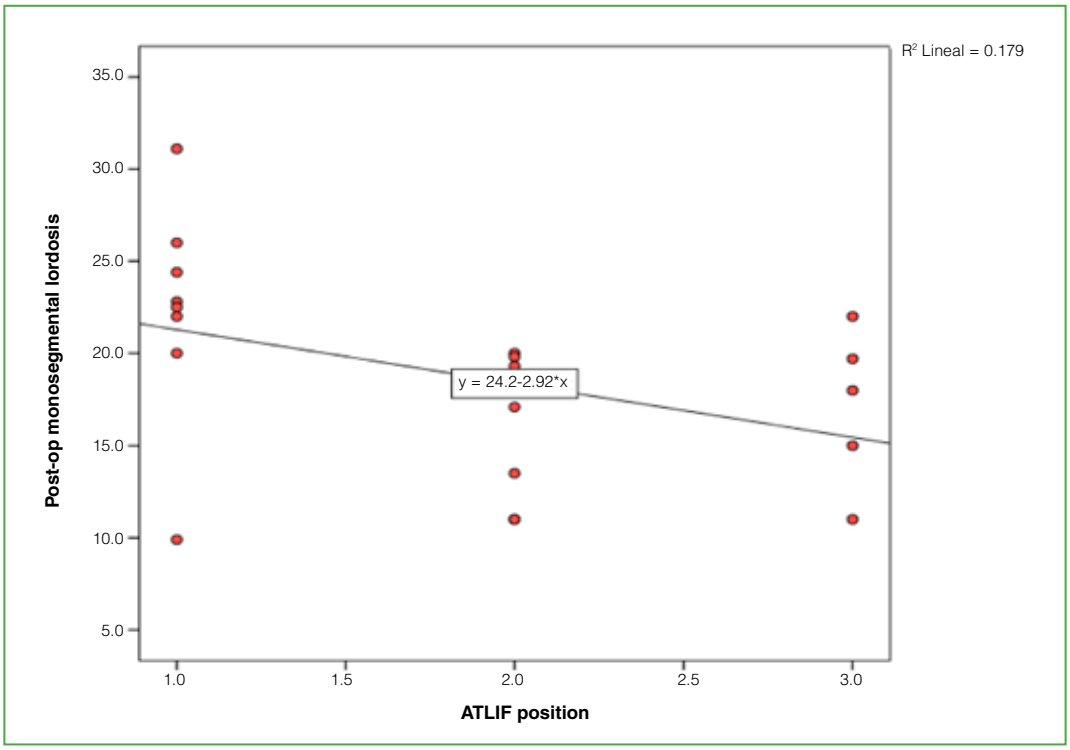


Figure 6. Linear relationship between device placement in position I, II, or III with respect to postoperative monosegmental lordosis.

DISCUSSION

Restoration of normal anatomy, including disc height, foraminal decompression, sagittal balance, and lumbar lordosis, to achieve anterior support in the lower lumbar segments (L4-L5 and L5-S1) is critical to successful outcomes in spinal surgery.[11] The ALIF device meets these requirements, although in certain cases, this type of intervention has contraindications. On the other hand, with the TLIF technique described by Harms and Jeszenszky,[4] the TLIF device is placed at its most anterior end in order to serve as a fulcrum and, together with the compression of the posterior elements, generate more lordosis. Hsieh et al.[8] reported unfavorable results regarding the generation of lordosis by the TLIF-type device, taking as limiting factors precisely the difficulty of placing the device in the most anterior end of the disc space. In our series, we obtained favorable and statistically significant results, on occasions >10º, in terms of monosegmental and L4-S1 lordosis. We believe that these results are obtained, in part, by the anterior position, which allows the device to be inserted, and the fulcrum it generates, as well as by the facet osteotomy that is performed bilaterally.

Assuming that the fusion rates for all interbody devices are similar,[12,13] it is extremely useful to take full advantage of the possibilities offered by the posterior route. Surgeries with two approaches generate not only an economic cost, but also morbidities with an anterior approach.

Regarding the ideal indications for placing this type of device, we focus on those patients with contraindications for an anterior approach, whether absolute or relative, since they cannot count on the lordosis generated by an ALIF device.

The use of expandable TLIF devices to generate greater segmental lordosis has been described in the literature. Rymarczuk et al.[14] published a series of patients in whom this type of device was used and reported an increase of between 4.47° and 10.55° of segmental lordosis per level. Wang et al.[15] published an increase in lumbar lordosis of 14.78º. These authors refer to the failure to preserve lordosis in the follow-up of patients. In our series, we found an average of 5.48º increase in segmental lordosis and it is interesting to note that, when the device was placed in position I, an average of 7.32º was achieved, with increases of up to 14.2º. The monosegmental lordosis obtained after surgery is greater in zone 3 than in zone 2. In this sense, we believe it is necessary to clarify that there is a linear relationship in terms of the area where the device is placed and the lordosis that is generated, this should be corrected simply by increasing the casuistry. In cadaveric[16] and clinical[17] studies that evaluated the impact of implant placement in the anterior segment, no significant increases in lordosis have been detected. This is largely due to the fact that the technique used lacks bilateral facetectomy.

When comparing our results with those published on different techniques (ALIF, LLIF and TLIF),[8,9,18-20] it was observed that they are similar to those described for techniques such as ALIF and LLIF.

The limitations of this study are the low sample size for the outcomes we evaluated. The results regarding the relationship of variables have a weak and inconclusive significance for the same reason. In turn, we also consider that the lack of clinical correlation with the radiological results obtained is a weakness of the study.

Together with another center in our country, we are carrying out a study with a larger number of patients in order to evaluate the results on a larger scale. The use of an objective score would be very useful for the analysis of these patients.

CONCLUSIONS

The results of the placement of this type of device and its relationship with segmental lordosis are encouraging; the importance of the arrangement of these at the anterior end of the disc space is understood. We believe it is vitally important to carry out a study that includes more patients, clinical-radiographic correlation, and registration of complications/long-term follow-up.

Conflict of interest: Dr. Enrique Gobbi declares a conflict of interest with Nuvasive®." por "Dr. Enrique Gobbi receives a payment as a Nuvasive® speaker.

E. A. Gobbi ORCID ID: https://orcid.org/0000-0001-7310-6170
F. Lanari Zubiaur ORCID ID: https://orcid.org/0000-0003-4030-0959
R. Berjano ORCID ID: https://orcid.org/0000-0001-7781-4123
F. Ortiz ORCID ID: https://orcid.org/0000-0002-7733-7889
P. Zuliani ORCID ID: https://orcid.org/0000-0001-8579-664X
R. Pons Belmonte ORCID ID: https://orcid.org/0000-0003-0548-4203

REFERENCES

1. Briggs H, Milligan PR. Chip fusion of the low back following exploration of the spinal canal. *J Bone Joint Surg* 1944;26(1):125-30. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.978.6512&rep=rep1&type=pdf
2. Mummaneni PV, Hussain I, Shaffrey CI, Eastlack RK, Mundis GM, Uribe JS, et al. The minimally invasive interbody selection algorithm for spinal deformity. *J Neurosurg Spine* 2021;34(5):741-8. https://doi.org/10.3171/2020.9.SPINE20230
3. Cloward RB. The treatment of ruptured lumbar intervertebral discs by vertebral body fusion. I. Indications, operative technique, after care: I. Indications, operative technique, after care. *J Neurosurg* 1953;10(2):154-68. https://doi.org/10.3171/jns.1953.10.2.0154

4. Harms JG, Jeszenszky D. Die posteriore, lumbale, interkorporelle Fusion in unilateraler transforaminaler Technik. *Oper Orthop Traumatol* 1998;10:90-102. https://doi.org/10.1007/s00064-006-0112-7
5. de Kunder SL, van Kuijk SMJ, Rijkers K, Caelers IJMH, van Hemert WLW, de Bie RA, et al. Transforaminal lumbar interbody fusion (TLIF) versus posterior lumbar interbody fusion (PLIF) in lumbar spondylolisthesis: a systematic review and meta-analysis. *Spine J* 2017;17(11):1712-21. https://doi.org/10.1016/j.spinee.2017.06.018
6. Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. *Spine (Phila Pa 1976)* 2005;30(6):682-8. https://doi.org/10.1097/01.brs.0000155425.04536.f7
7. Mehta VA, Amin A, Omeis I, Gokaslan ZL, Gottfried ON. Implications of spinopelvic alignment for the spine surgeon. *Neurosurgery* 2012;70(3):707-21. https://doi.org/10.1097/01.brs.0000155425.04536.f7
8. Hsieh PC, Koski TR, O'Shaughnessy BA, Sugrue P, Salehi S, Ondra S, et al. Anterior lumbar interbody fusion in comparison with transforaminal lumbar interbody fusion: implications for the restoration of foraminal height, local disc angle, lumbar lordosis, and sagittal balance. *J Neurosurg Spine* 2007;7(4):379-86. https://doi.org/10.3171/SPI-07/10/379
9. Kim J-S, Lee K-Y, Lee S-H, Lee H-Y. Which lumbar interbody fusion technique is better in terms of level for the treatment of unstable isthmic spondylolisthesis? Clinical article. *J Neurosurg Spine* 2010;12(2):171-7. https://doi.org/10.3171/2009.9.SPINE09272
10. Landham PR, Don AS, Robertson PA. Do position and size matter? An analysis of cage and placement variables for optimum lordosis in PLIF reconstruction. *Eur Spine J* 2017;26(11):2843-50. https://doi.org/10.1007/s00586-017-5170-z
11. Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 9: Lumbar fusion for stenosis with spondylolisthesis. *J Neurosurg Spine* 2014;21:54-61. https://doi.org/10.3171/2014.4.SPINE14274
12. Teng I, Han J, Phan K, Mobbs R. A meta-analysis comparing ALIF, PLIF, TLIF and LLIF. *J Clin Neurosci* 2017;44:11-7. https://10.1016/j.jocn.2017.06.013
13. Phan K, Thayaparan GK, Mobbs RJ. Anterior lumbar interbody fusion versus transforaminal lumbar interbody fusion - systematic review and meta-analysis. *Br J Neurosurg* 2015;29:705-11. https://doi.org/10.3109/02688697.2015.1036838
14. Rymarczuk GN, Harrop JS, Hilis A, Härtl R. Should expandable TLIF cages be used routinely to increase lordosis? *Clin Spine Surg* 2017;30(2):47-9. https://doi.org/10.1097/BSD.0000000000000510
15. Wang MY. Improvement of sagittal balance and lumbar lordosis following less invasive adult spinal deformity surgery with expandable cages and percutaneous instrumentation: Clinical article. *J Neurosurg Spine* 2013;18(1):4-12. https://doi.org/10.3171/2012.9.SPINE111081
16. Faundez AA, Mehbod AA, Wu C, Wu H, Ploumis A, Transfeldt EE. Position of inter- body spacer in transforaminal lumbar interbody fusion: effect on 3-dimensional stability and sagittal lumbar contour. *J Spinal Disord Tech* 2008;21(175-180):0 013 318074 7. https://doi.org/10.1097/BSD.0b013e318074bb7d
17. Kepler CK, Rihn JA, Ke R. Restoration of lordosis and disk height after single-level transforaminal lumbar interbody fusion. *Orthop Surg* 2012;4(1):15-20. https://doi.org/10.1111/j.1757-7861.2011.00165.x
18. Rothrock RJ, McNeill IT, Yaeger K, Oermann EK, Cho SK, Caridi JM. Lumbar lordosis correction with interbody fusion: Systematic literature review and analysis. *World Neurosurg* 2018;118:21-31. https://doi.org/10.1016/j.wneu.2018.06.216
19. Jiang SD, Chen JW, Jiang LS. Which procedure is better for lumbar interbody fusion: anterior lumbar interbody fusion or transforaminal lumbar interbody fusion? *Arch Orthop Trauma Surg* 2012;132(9):1259-66. https://doi.org/10.1007/s00402-012-1546-z
20. Formica M, Quarto E, Zanirato A, Mosconi L, Lontaro-Baracchini M, Alessio-Mazzola, et al. ALIF in the correction of spinal sagittal misalignment. A systematic review of literature. *Eur Spine J* 2021;30(1):50-62. https://doi.org/10.1007/s00586-020-06598-y

Biomechanical Parameters of Foot Function Measured in the Office of a Specialist in Orthopedics and Traumatology

Jorge Castellini
Private practice, Autonomous City of Buenos Aires, Argentina

ABSTRACT

Introduction: Dynamic studies of foot function are usually carried out in highly complex gait analysis laboratories. The objective of this study was to analyze functional parameters using a force platform in a series of asymptomatic patients evaluated in an outpatient clinic. **Materials and Methods:** Cross-sectional study, which included a consecutive series of volunteer asymptomatic patients who underwent a force platform measurement (TekScanMatScan®, Boston, MA, USA) between 2014 and 2020, in the City of Buenos Aires, Argentina. **Results:** 316 records were included, corresponding to 158 individuals with bilateral measurements. Most were women (66.5%), with a mean age of 47 years (SD 16.1). Fourteen variables were evaluated, corresponding to parameters of force, trajectory, and contact time. The total contact time was 0.79 seconds (SD 0.09), and the COF time according to the region of the foot was 20% in the heel, 26% in the midfoot, and 46% in the forefoot. The CPEI (Center of Pressure Excursion Index) value was 16.55% (SD 7.14). **Conclusion:** Foot functional parameters in asymptomatic patients are presented. The contact time of the foot on the ground, the force in the heel, midfoot, and forefoot, and the force trajectory were measured. No ionizing radiation was used. These findings could be used as reference values to detect pathological gaits.

Keywords: Force; center of force; biomechanics; gait analysis; force trajectory; ground reaction force.
Level of Evidence: II

Parámetros biomecánicos de la función del pie medidos en el consultorio del especialista en Ortopedia y Traumatología

RESUMEN

Introducción: Los estudios dinámicos de la función del pie habitualmente se realizan en laboratorios de marcha de gran complejidad. El objetivo de este estudio fue analizar parámetros funcionales utilizando una plataforma de fuerza en una serie de pacientes asintomáticos evaluados en consultorios externos. **Materiales y Métodos:** Estudio de corte transversal que incluyó una serie consecutiva de pacientes asintomáticos voluntarios a quienes se les realizó una medición con una plataforma de fuerza (TekScanMatScan®, Boston, MA, EE.UU.) entre 2014 y 2020, en la Ciudad Autónoma de Buenos Aires, Argentina. **Resultados:** Se incluyeron 316 registros de 158 pacientes con mediciones bilaterales. La mayoría eran mujeres (66,5%) y el promedio de la edad era de 47 años (DE 16.1). Se evaluaron 14 variables, correspondientes a parámetros de fuerza, trayectoria y tiempo de contacto de la fuerza. El tiempo de contacto total fue de 0,79 segundos (DE 0,09), el *CoF time* según la región del pie fue del 20% en el talón, 26% en el mediopié y 46% en el antepié. El CPEI (*center of pressure excursión index)* fue del 16,55% (DE 7,14). **Conclusiones:** Se comunican los parámetros funcionales del pie en pacientes asintomáticos. Se midieron el tiempo de contacto del pie en el suelo, la fuerza (en talón, mediopié y antepié) y la trayectoria de la fuerza con una plataforma de fuerza. No se utilizaron radiaciones ionizantes. Estos hallazgos podrían ser utilizados como valores de referencia para detectar marchas patológicas.

Palabras clave: Fuerza; centro de fuerza; biomecánica; análisis de la marcha; trayectoria de fuerza; fuerza de reacción de la gravedad.
Nivel de Evidencia: II

Received on April 4th, 2022. Accepted after evaluation on May 9th, 2022 • Dr. JORGE CASTELLINI • jorgecastellini@gmail.com https://orcid.org/0000-0002-5665-480X

How to cite this article: Castellini J. Biomechanical Parameters of Foot Function Measured in the Office of a Specialist in Orthopedics and Traumatology. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):756-764. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1557

INTRODUCTION

The foot is one of the most dynamic structures in the human body. The interplay of forces that allows walking is often underestimated and is generally seen as a sculptured image, as if it were a static structure.[1] The complementary diagnostic studies used usually follow this direction (radiography, computed tomography, magnetic resonance, static impression of the foot on support), but it is not usual to evaluate the biomechanics of the foot, despite its eminently functional nature.[2]

Numerous reports have been published in which plantar pressures were evaluated with baropodometry in both asymptomatic and diseased patients.[3-5] But given the highly variable results, plantar pressure assessments tend to be used mainly in diabetic or neurological patients who are at higher risk of ulceration.[6]

Center of Force (CoF) analysis was introduced by Jameson et al., in 2006 to describe trajectory and contact time. The authors found that there was very little difference between the values of the 3D kinematics measurements with the subjective analyses of four observers. The intra- and inter-observer reliability was very high and the division by areas or regions along the longitudinal axis (hindfoot, midfoot, and forefoot) made it possible to analyze the functioning in each region both in asymptomatic patients and in pathological situations.[7] Chiu and Wang, in 2007, and Hagedorn et al., in 2013, provided evaluations using the CoF velocity and trajectory measurement.[8,9]

Most of the published studies on gait biomechanics were carried out in gait analysis laboratories under ideal working conditions, due to the physical space, the number of capture cameras, the force platform in a space of several meters long and the technology to capture and process data.[2,8-11] However, some functional parameters can be captured with a force platform, quantitatively, in a smaller space, such as an outpatient clinic.[4,12]

Although there are gait measurements with proven validity and reliability that can be added to clinical and imaging evaluation, it is not common practice to have this diagnostic method for foot analysis.[13]

The aim of the study was to analyze the results of functional parameters of gait mechanics during the stance phase of the foot, captured in the outpatient clinic using a force platform in a series of asymptomatic patients.

MATERIALS AND METHODS

A cross-sectional, descriptive study of a consecutive series of voluntary asymptomatic patients who underwent a measurement with a force platform between 2014 and 2020, was carried out in the author's private office, in the Autonomous City of Buenos Aires, Argentina.

The inclusion criteria were: asymptomatic patients who were voluntarily asked to undergo a gait study, regardless of the morphological type of foot. All participants signed the informed consent for confidentiality to use the data for scientific analysis and the request for permission to publish the collected data while maintaining the absolute privacy of personal identity (respecting the Declaration of Helsinki).

The exclusion criteria were: fracture or surgery in the lower limbs in the last six months and neurological diseases.

Baropodometric measurement

For the measurements, a force platform (TekScanMatScan®, Boston, MA, USA) of 5 mm thickness and an area of 46 cm by 37 cm with 2288 sensors (1.4 sensors/cm^2) with a transmission speed of 440 Hertz was used. For data collection, each patient underwent a two-step gait initiation protocol that had proven to be reproducible in other studies.[14] The test was repeated in each patient, five steps of the left foot and five steps of the right foot were measured, with adequate validity and reliability.[15]

A force platform similar to that of the Framingham study protocol[8] was used to assess the movement of the CoF during the stance phase. The center of pressure excursion index (CPEI) represents the trajectory of the force during the stance phase (Figure 1).

The data collection was in charge of two assistants (SG and CO) trained and qualified to obtain quality data. The study was repeated from the beginning if the collection was inadequate or erroneous.

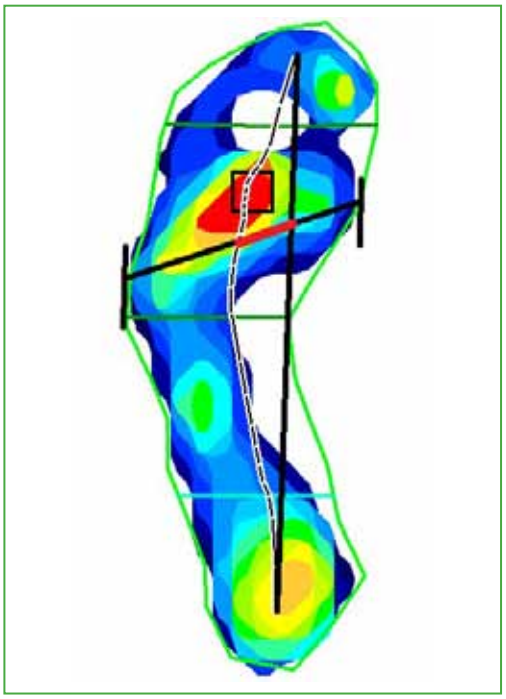


Figure 1. Index of excursion of the center of force measured in %. The center of force is seen on the dotted line. The line of the longitudinal axis is drawn from the starting point of support to the point of toe-off. In the distal third or metatarsal area, a transverse line is drawn that joins both medial and lateral edges of the width of the foot. Then, on this transverse line, the distance between the center of force and the longitudinal line is measured and divided by the total length of the transverse line. The result is the excursion index of the center of force measured in %. In general, the values are positive. The highest values represent supination and the lowest, pronation.

Description of the 3Box system

3Box (TekScan MatScan®) is a computer program that allows dividing the foot into three areas: heel, midfoot and forefoot, discarding the values at the toe level (Figure 2).[12] It measures the reaction force of gravity in relation to time (force/time) and only captures the stance phase of the foot on the ground. It also normalizes force values in percentage of body weight (%BW) in the three regions and describes the trajectory of force (CPEI). The following measurements were taken:

- Contact time (seconds): time elapsed from the first contact of the foot on the floor to the last contact of the same foot (this value is not divided into regions, it takes the whole foot into account).
- CPEI (%): measure of the concavity or medial-lateral deviation of the trajectory of the CoF in relation to the width of the foot. The values are positive.[8]
- *Heel Contact Time* (% contact): Elapsed time from the first contact to the end of the last contact in the heel area, defined by the heel box .
- *Heel Maximum Force* (%BW): Maximum load force during heel contact, defined by the heel box. The value is normalized.
- *Heel Maximum Force* (kg): Maximum load force during heel contact (in kg), defined by the heel box. They are absolute values and are not normalized like the previous one.
- *Heel CoF Time* (time in %) - Time elapsed from the CoF's first contact on the heel until it reaches the anterior limit of the heel box.
- *Midfoot Contact Time* (% contact): elapsed time (in %) from the first contact to the end of the last midfoot contact, where the midfoot is defined between the anterior limit of the heel box and the posterior limit of the metatarsus.

- *Midfoot Maximum Force* (%BW): maximum load force (in %) of body weight during midfoot contact, defined between the anterior limit of the heel and the posterior limit of the metatarsal.
- *Midfoot Maximum Force* (kg): Maximum load force during midfoot contact (in kg), defined by the midfoot area. They are absolute values and are not normalized like the previous one.
- *Midfoot CoF Time* (time in %): time elapsed from when the CoF has just crossed the anterior limit of the heel box until it reaches the posterior limit of the metatarsal box.
- *Metatarsal Contact Time* (% contact): elapsed time (in %) from the first contact to the end of the last contact on the metatarsal, where the metatarsal is defined by the metatarsal box.
- *Metatarsal Maximum Force* (%BW): maximum load force (in %) of body weight during contact time in the metatarsal area.
- *Metatarsal Maximum Force* (kg): maximum load force during contact with the metatarsal (in kg), defined by the metatarsal box.
- *Metatarsal CoF Time* (time in %): elapsed time (in %) from when the CoF has just crossed the posterior limit of the metatarsal box until it reaches the anterior limit of the metatarsal box.

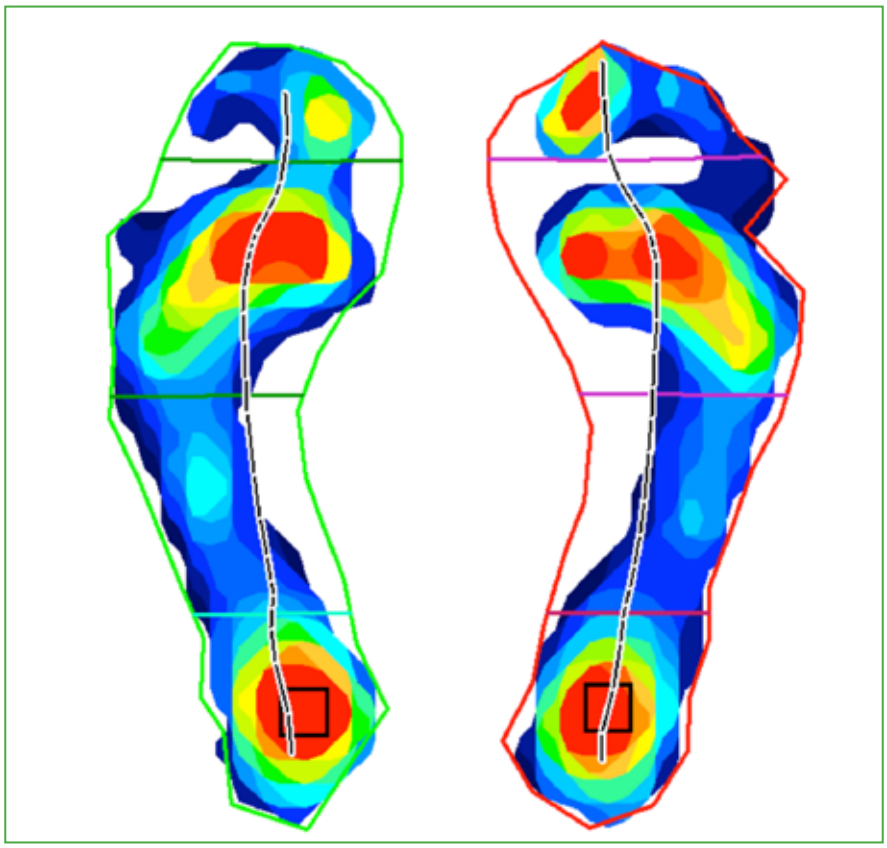


Figure 2. Result of a dynamic gait test with 5 steps for each foot. It is presented with the excursion index of the center of force and the division into three areas or boxes (heel, midfoot and forefoot).

Statistical Analysis

Descriptive statistics with the R program were used. Continuous numeric variables are expressed as mean (or average) and standard deviation.

RESULTS

316 records corresponding to both feet of 158 individuals were included, 105 (66.5%) were women. Age ranged from 18 to 82 years (mean 47.4, standard deviation [SD] 16.1). The body mass index of these patients ranged from 16.9 to 30.9 (mean 23.3; SD 2.9).

Fourteen variables corresponding to foot measurements in asymptomatic patients were analyzed. The mean and SD results of the measurement of both feet of each patient are reported. The results are shown in the Table.

Table. Functional foot results during the stance phase of gait measured with a force platform*

	Asymptomatic feet (n = 316)
	Mean (SD)
Full foot	
Contact time (seconds)	0.79 (0.09)
CPEI (%)	16.55 (7.14)
Heel	
Heel Contact Time (%)	63.25 (6.25)
Heel Maximum Force (%BW)	69.34 (8.46)
Heel Maximum Force (kg)	45.22 (9.70)
Heel CoF Time (%)	20.0 (4.49)
Midfoot	
Midfoot Contact Time (%)	66.73 (5.64)
Midfoot Maximum Force (%BW)	15.9 (8.17)
Midfoot Maximum Force (kg)	10.7 (6.7)
Midfoot CoF Time (%)	25.99 (5.57)
Forefoot	
Metatarsal Contact Time (%)	92.55 (3.71)
Metatarsal Maximum Force (%BW)	87.52 (9.56)
Metatarsal Maximum Force (kg)	57.03 (11.71)
Metatarsal CoF Time (%)	46.20 (5.97)

SD = Standard Deviation, CoF = Center of Force , CPEI = Center of Pressure Excursion Index, %BW = Percentage of Body Weight.
*Measurements were taken in the office and analyzed using a program that divides the foot into three regions (heel, midfoot, and forefoot).

DISCUSSION

The results represent functional measurements of the foot during gait taken in an outpatient clinic, with a simple and reproducible method, using a force platform and a valid and reliable program.[13]

In electromyographic analyses of the function of each muscle during the gait cycle, Anderson and Pandy observed that muscles and ligaments are the main contributors to support and propulsion, representing 50-95% of the reaction force to gravity, while joints and bones have between 20% and 50% of the passive transmission of force.[16]

In the study presented, the force of reaction to gravity was measured, trying to standardize our values with the moment of function of each muscle as described by Anderson et al. At initial heel contact, the stabilizing muscles are active (glutes, quadriceps, hamstrings, biceps femoris, hip adductors and abductors and the muscles in the anterior compartment: tibialis anterior, extensor hallucis longus and extensor digitorum longus); while, in the area of the forefoot, the propulsive and support muscles (soleus and gastrocnemius) intervene only until the moment the foot takes off from the ground. The midfoot would be a connection area between the heel and the forefoot, which we call a "suspension bridge".

Next, the parameters of the force/time relationship during a gait cycle in the stance phase are interpreted with respect to the biomechanical functioning of the foot using the division into three regions (rearfoot, midfoot and forefoot).

Contact time

It allows to infer the speed of the step (it measures the time of support of the complete foot in seconds). Its value could vary depending on age, sex, body mass index and in pathological conditions.[17] However, in 2013, Hillstrom et al.[4] observed that, in asymptomatic patients, the contact time did not vary according to the different types of feet (flat, straight and cavus).

CPEI

It expresses the value of the path of force (CoF) that could help define foot types. Lower values are associated with greater pronation and higher values with supination and could also show variations according to age and contribute to the diagnosis of pathological conditions.[8,12] However, opinions are controversial, since some authors did not find the CPEI useful for defining foot types.[11]

Measurements according to the area of the foot

Heel

Heel Contact Time (% contact): percentage of the time that the heel is flat on the ground while the CoF moves towards the midfoot and forefoot. In this series, the value was 63.45% of the total contact time and it is a parameter that could detect difficulties in heel take-off in pathologies of the triceps surae, osteoarthritis of the knee, ankle or failures in the windlass mechanism. Its prolongation could be related to the collapse of the arch of the foot.[17-19]

Heel Maximum Force (%BW): Heel contact on the ground resembles the descent or landing of an aircraft on the runway. The initial contact is at low speed,[20] but the stabilizing muscles (hip and knee flexors and extensors, and foot dorsiflexors) intervene so that the force is not directed forward violently. The main stabilizers are the glutes, quadriceps, hamstrings and tibialis anterior muscles, as well as the extensor hallucis longus and the extensor digitorum longus. These muscles are already active in the flight phase of the foot, but their power cannot be captured with the force plate. The value is normalized in relation to body weight. In older adults, this value would be decreased by less muscular power that could be linked to a collapse of the internal arch, metatarsalgia, pathologies of the first ray, or loss of balance.[17,19]

Heel CoF Time (time in %): How fast is the force passing through the heel region? This will depend on the ability of the stabilizing muscles to smooth the landing of the foot on the ground and also the ability of the foot dorsiflexors so that the force does not go quickly to the midfoot and metatarsal region. Jameson et al. reported the results in children and the values of this series coincide with them;[7] however, there could be changes in this value when age is taken into account.

Midfoot

Midfoot Contact Time (% contact): percentage of time that the midfoot is in contact with the ground from the moment it lands until only the metatarsal is on the ground. In this sample, the value was 66.73%. If we try to make a comparison, the midfoot, which is anatomically related to the internal longitudinal arch and the transverse arch,[21] behaves like a suspension bridge, where the CoF advances if the structure is healthy. Any pathology that alters it will cause a CoF arrest and further increase the damage to the structure. It could be a parameter to evaluate progressive arch collapse, posterior tibial dysfunction, plantar ligament injury (snap ligament), plantar fasciosis, etc. It could also indicate a failure in the propulsion mechanism and takeoff of the foot from the ground (windlass).[22]

Midfoot Maximum Force (%BW): maximum force supported by the midfoot during the time of support in this area. If the structure is anatomically normal, the force can proceed to the forefoot; on the other hand, if the structure is not normal or is deteriorated, this force could cause the arch to collapse. The value is normalized with body weight.

Midfoot CoF Time (time in %): How fast does the force pass through the midfoot area? It will depend on the resistance of the anatomical structure of the medial longitudinal arch and the transverse arch of the foot, the power of the stabilizing muscles, the greater or lesser power of the soleus and gastrocnemius muscles, and the ability of the knee to be placed in full extension. so that the force can pass into the metatarsal region.[23] This is why the midfoot receives here the denomination of a "suspension bridge". As the years go by, would there be an increase in the time spent on midfoot force in an asymptomatic patient? What about the pathological processes that compromise the arch? Do the surgical procedures we perform modify these parameters?

Forefoot or metatarsal area

Metatarsal Contact Time (% contact): Metatarsal contact is associated with the descending or landing effect of the foot on the ground, similar to landing an airplane on the runway, where the metatarsal area is like the front wheel of the airplane. The time it takes the metatarsal to land will depend on the stabilizers (muscles and tendons) and the—healthy and flexible—joints (hips, knees and ankles). In this study, the value was 92.55% of the total stance phase for asymptomatic patients.

Metatarsal Maximum Force (%BW): the maximum force in the metatarsal area is related to the toe-off at the end of the stance phase and mainly involves the triceps surae muscle (soleus and gastrocnemius) providing support and propulsion.[17] The value is normalized with body weight. In older adults, there could be a reduction in force and, therefore, in propulsion, which could reduce speed and generate pathologies of the forefoot, such as hallux valgus, metatarsalgia, hammer toes, gait instability, and risk of falls.[24] However, Hessert et al. considered this situation as an adaptation to gain stability over the years.[25]

Metatarsal CoF Time (time in %): the time that the CoF remains in the metatarsal area is directly related to its function of support, propulsion and takeoff. Just as a hydraulic jack lifts a vehicle, the metatarsal resting on the ground prepares the takeoff by raising the heel and midfoot, while the propulsive force advances towards the first toe or hallux until the foot is completely lifted off the ground.

Heel, Midfoot and Metatarsal Maximum Force (kg): the absolute values of maximum force in the areas of the heel, midfoot and forefoot are exposed to great modifications due to differences in sex, weight, body mass index and are not normalized, which could generate biases when interpreting the statistical results.

Biomechanical functioning data were recorded without using ionizing radiation, with a short period of data collection and fundamentally, in the outpatient office of a foot and ankle specialist surgeon. This could allow us to obtain new functional parameters, and generate new hypotheses (potentially functioning as a control group, to be used in comparison to pathological cases).It would have been interesting to explore the variability of these findings considering age, sex, body mass index, and type of foot (flat, arched, or straight). However, this was not possible due to the limited number of cases included in the study. In 2013, Hillstrom et al.[4] observed that asymptomatic patients had some similar gait parameters, such as total contact time, regardless of foot type. For this reason, in this study, radiographic measurements, clinical foot morphotype, and characteristics such as stiffness or flexibility were not considered, only functional results. In future research, it would be interesting to compare these functional parameters with scores that take quality of life into account, especially in older people.

CONCLUSIONS

The functional parameters of the foot evaluated in asymptomatic patients were presented, mainly considering the contact time of the foot on the ground, the force in each region of the foot (heel, midfoot and forefoot) quantitatively, and the trajectory of the force. These measurements do not use ionizing radiation, can be performed in an outpatient office, and are simpler than a sophisticated biomechanics laboratory. The findings could be used as reference values to detect pathological gaits.

Acknowledgments

Dr. Débora Chan for the statistical analysis, Dr. Florencia Grande Ratti for the design of the article and the collaboration in the proofreading. Susana Gomez and Celeste Otazúa for collecting and reviewing all the data.

Conflict of interest: The author declares no conflicts of interest.

REFERENCES

1. Elftman H. Dynamic structure of the human foot. *Artif Limbs* 1969;13(1):49-58. PMID: 5363263
2. Menz HB. Alternative techniques for the clinical assessment of foot pronation. *J Am Podiatr Med Assoc* 1998;88(3):119-29. https://doi.org/10.7547/87507315-88-3-119
3. Galica AM, Hagedorn TJ, Dufour AB, Riskowski JL, Hillstrom HJ, Casey VA, et al. Hallux valgus and plantar pressure loading: the Framingham foot study. *J Foot Ankle Res* 2013;6(1):42. https://doi.org/10.1186/1757-1146-6-42
4. Hillstrom HJ, Song J, Kraszewski AP, Hafer JF, Mootanah R, Dufour AB, et al. Foot type biomechanics part 1: Structure and function of the asymptomatic foot. *Gait Posture* 2013;37(3):445-51. https://doi.org/10.1016/j.gaitpost.2012.09.007
5. Mootanah R, Song J, Lenhoff MW, Hafer JF, Backus SI, Gagnon D, et al. Foot Type Biomechanics Part 2: Are structure and anthropometrics related to function? *Gait Posture* 2013;37(3):452-6. https://doi.org/10.1016/j.gaitpost.2012.09.008
6. Ledoux WR, Shofer JB, Smith DG, Sullivan K, Hayes SG, Assal M, et al. Relationship between foot type, foot deformity, and ulcer occurrence in the high-risk diabetic foot. *J Rehabil Res Dev* 2005;42(5):665-72. https://doi.org/10.1682/jrrd.2004.11.0144
7. Jameson G, Anderson J, Davis R, Davids J, Christopher L. A comparison of methods for using center of pressure progression in the classification of foot deformity. *Gait Posture* 2006;24:S83-4. https://doi.org/10.1016/j.gaitpost.2006.11.059
8. Hagedorn TJ, Dufour AB, Golightly YM, Riskowski JL, Hillstrom HJ, Casey VA, et al. Factors affecting center of pressure in older adults: the Framingham Foot Study. *J Foot Ankle Res* 2013;6(1):18. https.//doi.org/10.1186/1757-1146-6-18
9. Chiu M-C, Wang M-J. The effect of gait speed and gender on perceived exertion, muscle activity, joint motion of lower extremity, ground reaction force and heart rate during normal walking. *Gait Posture* 2007;25(3):385-92. https://doi.org/10.1016/j.gaitpost.2006.05.008
10. Liu MQ, Anderson FC, Pandy MG, Delp SL. Muscles that support the body also modulate forward progression during walking. *J Biomech* 2006;39(14):2623-30. https://doi.org/10.1016/j.jbiomech.2005.08.017
11. Song J, Hillstrom HJ, Secord D, Levitt J. Foot type biomechanics. Comparison of planus and rectus foot types. *J Am Podiatr Med Assoc* 1996;86(1):16-23. https://doi.org/10.7547/87507315-86-1-16
12. Grundy M, Tosh PA, McLeish RD, Smidt L. An investigation of the centres of pressure under the foot while walking. *J Bone Joint Surg Br* 1975;57(1):98-103. PMID: 1117028
13. Coda A, Carline T, Santos D. Repeatability and reproducibility of the Tekscan HR-Walkway system in healthy children. *Foot* 2014;24(2):49-55. https://doi.org/10.1016/j.foot.2014.02.004
14. Bus SA, de Lange A. A comparison of the 1-step, 2-step, and 3-step protocols for obtaining barefoot plantar pressure data in the diabetic neuropathic foot. *Clin Biomech (Bristol, Avon)* 2005;20(9):892-9. https://doi.org/10.1016/j.clinbiomech.2005.05.004
15. van der Leeden M, Dekker JHM, Siemonsma PC, Lek-Westerhof SS, Steultjens MPM. Reproducibility of plantar pressure measurements in patients with chronic arthritis: a comparison of one-step, two-step, and three-step protocols and an estimate of the number of measurements required. *Foot Ankle Int* 2004;25(10):739-44. https://doi.org/10.1177/107110070402501008
16. Anderson FC, Pandy MG. Individual muscle contributions to support in normal walking. *Gait Posture* 2003;17(2):159-69. https://doi.org/10.1016/s0966-6362(02)00073-5

17. Liu MQ, Anderson FC, Schwartz MH, Delp SL. Muscle contributions to support and progression over a range of walking speeds. *J Biomech* 2008;41(15):3243-52. https://doi.org/10.1016/j.jbiomech.2008.07.031
18. Anderson FC, Pandy MG. Dynamic optimization of human walking. *J Biomech Eng* 2001;123(5):381-90. https://doi.org/10.1115/1.1392310
19. Pandy MG, Lin Y-C, Kim HJ. Muscle coordination of mediolateral balance in normal walking. *J Biomech* 2010;43(11):2055-64. https://doi.org/10.1016/j.jbiomech.2010.04.010
20. Winter DA. Foot trajectory in human gait: a precise and multifactorial motor control task. *Phys Ther* 1992;72(1):45-53; discussion 54-6. https://doi.org/10.1093/ptj/72.1.45
21. Venkadesan M, Yawar A, Eng CM, Dias MA, Singh DK, Tommasini SM, et al. Stiffness of the human foot and evolution of the transverse arch. *Nature* 2020;579(7797):97-100. https://doi.org/10.1038/s41586-020-2053-y
22. Welte L, Kelly LA, Lichtwark GA, Rainbow MJ. Influence of the windlass mechanism on arch-spring mechanics during dynamic foot arch deformation. *J R Soc Interface* [Internet] 2018;15(145). Available at: https://doi.org/10.1098/rsif.2018.0270
23. Winter DA. Knee flexion during stance as a determinant of inefficient walking. *Phys Ther* 1983;63(3):331-3. https://doi.org/10.1093/ptj/63.3.331
24. Winter DA, Patla AE, Frank JS, Walt SE. Biomechanical walking pattern changes in the fit and healthy elderly. *Phys Ther* 1990;70(6):340-7. https://doi.org/10.1093/ptj/70.6.340
25. Hessert MJ, Vyas M, Leach J, Hu K, Lipsitz LA, Novak V. Foot pressure distribution during walking in young and old adults. *BMC Geriatr* 2005;5:8. https://doi.org/10.1186/1471-2318-5-8

Validation of the Spanish Version of the *Self-Administered Patient Satisfaction Scale* (SAPS) for Total Hip and Knee Arthroplasty

Miguel Mantilla,[*] Paul Stangl-Correa,[*,§] Willy Stangl-Herrera,[*] Erika Cantor,[**] Andrés Echeverry-Vélez,[*] Julio C. Palacio[#]

[*]*Hip and Knee Pathology, Surgery and Joint Replacement Group, Institute of Osteoarticular Diseases, Clínica Imbanaco Grupo Quirónsalud, Cali, Colombia*

[**]*Institute of Statistics, University of Valparaíso, Valparaíso, Chile*

[#]*Clínica Imbanaco Grupo Quirónsalud, Cali, Colombia*

[§]*Infectious Diseases Specialist, Universidad del Rosario, Bogota, Colombia*

ABSTRACT

Introduction: Patient satisfaction is an important parameter when evaluating clinical outcomes after total hip (THA) or knee (TKA) arthroplasty. The objective of this work was to validate the Spanish version of the Self-Administered Patient Satisfaction scale (SAPS) for THA or TKA, as well as to study its psychometric properties. **Materials and Methods:** A cross-sectional validation study was carried out to evaluate the content, internal consistency, and criterion validity of the SAPS scale. A total of 105 subjects who were treated with THA or TKA were included. Criterion validity was assessed with the WOMAC scale (Western Ontario and McMaster Universities Osteoarthritis Index) and SF-36 (Short Form 36 Health Survey). **Results:** Fifty patients undergoing THA and 55 undergoing TKA were analyzed at a median follow-up of 14 months (Interquartile range, 11-19) after surgery, with a mean age of 71.3 ± 11.6 years; 73.3% (77) were women. Cronbach's alpha was 0.797, indicating an acceptable internal consistency. A moderate correlation was found between the SAPS scale and the WOMAC scale (Spearman's coefficient: 0.488, p <0.05), as well as with the physical component of the SF-36 (Spearman's coefficient: 0.525, p <0.05).

Conclusion: The Spanish version of the SAPS scale is a valid and reliable tool to measure patient satisfaction after THA or TKA, with psychometric properties similar to those of the original scale.

Keywords: Satisfaction; functionality; total hip arthroplasty; total knee arthroplasty; clinical outcomes.

Level of Evidence: II

Validación al español del instrumento Self-Administered Patient Satisfaction Scale (SAPS) para reemplazo total de cadera o de rodilla

RESUMEN

Introducción: La satisfacción del paciente es un indicador importante al evaluar los resultados clínicos de un reemplazo total de cadera o rodilla. El objetivo de este estudio fue validar al idioma español el instrumento *Self-Administered Patient Satisfaction Scale* (SAPS) para reemplazo total de cadera o rodilla, y estudiar sus propiedades psicométricas. **Materiales y Métodos:** Se realizó un estudio de validación de corte transversal para evaluar el contenido, la consistencia interna y la validez de criterio de la SAPS. Se incluyó a 105 pacientes con reemplazo total de cadera o rodilla. La validez de criterio fue valorada con las escalas WOMAC (*Western Ontario and McMaster Universities Osteoarthritis Index*) y SF-36 (Short form 36 health survey). **Resultados:** Se analizó a 50 pacientes con reemplazo total de cadera y 55 con reemplazo total de rodilla y una mediana de seguimiento de 14 meses (rango intercuartílico, 11-19), con una edad de 71.3 ± 11.6 años; 73,3% (77) eran mujeres. El coeficiente alfa de Cronbach fue de 0,797 indicando una consistencia interna aceptable. La correlación entre las escalas SAPS y WOMAC fue moderada (coeficiente de Spearman 0,488; p <0,05), al igual que con el componente físico de la SF-36 (coeficiente de Spearman 0,525; p <0,05).

Conclusión: La versión en español de la SAPS es una herramienta válida y confiable para medir el grado de satisfacción de los pacientes sometidos a reemplazo total de cadera o rodilla, con propiedades psicométricas similares a las de la escala original.

Palabras clave: Satisfacción; funcionalidad; reemplazo total de cadera; reemplazo total de rodilla; resultados clínicos.

Nivel de Evidencia: II

Received on March 8th, 2022. Accepted after evaluation on May 24th, 2022 • Dr. JULIO C. PALACIO • jcpavilo@gmail.com https://orcid.org/0000-0001-7886-7489

How to cite this article: Mantilla M, Stangl-Correa P, Stangl-Herrera W, Cantor E, Echeverry-Vélez A, Palacio JC. Validation of the Spanish Version of the Self-Administered Patient Satisfaction Scale (SAPS) for Total Hip and Knee Arthroplasty. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):765-771. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1535

INTRODUCTION

Osteoarthritis is a common disease in adults >60 years and is considered one of the main causes of pain and disability.[1] Joint replacements in patients with severe osteoarthritis of the hip or knee have been shown to be successful surgical procedures, relieving pain and restoring function for the patient.[2,3] Traditionally, the clinical outcomes of these procedures have been evaluated by measuring objective variables, such as implant survival, range of motion, joint stability, and radiographic results.[4] However, in recent years, the need to involve the opinion of patients has been recognized, and this has led to the implementation of measurement instruments based on the outcomes reported by the patient, known as *Patient-Reported Outcome Measures*, which are focused in determining the degree of relief experienced by the patient in areas such as pain, function and sensation of stiffness.[5,6] The most widely used instruments to assess clinical outcomes after total hip replacement (THR) or total knee replacement (TKR) are: *Western Ontario and McMaster Universities Arthritis Index* (WOMAC),[7] *Harris Hip Score* (HHS),[8] *Knee Society Score* (KSS)[9] and *36-Item Short Form Health Survey* (SF-36).[10] However, none of these scales measure patient satisfaction in isolation and provide a global score aimed at evaluating function or quality of life, and they are also extensive instruments.[11] In 2011, Mahomed et al.[12] proposed the *Self-Administered Patient Satisfaction scale* (SAPS). The SAPS is a short four-item instrument that integrates patient satisfaction and assessment of functional outcomes after a THR or TKR. This scale assesses four areas: overall patient satisfaction with the joint replacement, pain relief, ability to perform house or yard work, and ability to perform recreational activities. It has been shown that the SAPS scale is an instrument with adequate psychometric properties that allows determining patient satisfaction with the results obtained after joint replacement based on their own perception of their state of health.[13,14] This scale is in English and, therefore, the objective of this study was to validate the SAPS scale for TKR or THR in Spanish, as well as to study its psychometric properties.

MATERIALS AND METHODS

An observational, cross-sectional study was carried out to validate the Spanish version of the SAPS scale, analyzing its psychometric properties in terms of content validity, internal consistency, and criterion validity in patients undergoing THR or TKR.

This study was approved by an Institutional Ethics Committee and was carried out according to the principles of the Declaration of Helsinki. All participants gave their informed consent for the study.

Men and women >18 years of age who had undergone a primary TKR or THR between January 2013 and December 2014 were included. Illiterate patients or patients with cognitive alterations that prevented them from answering the questionnaire correctly were excluded. The sample size was determined following the recommendation to include at least 10 participants per item and a minimum of 100 participants.[15] Finally, the analysis included 105 patients who answered all the study questionnaires.

SAPS scale

The SAPS scale was developed in the United States, in English, to assess the degree of patient satisfaction after a THR or TKR.[12] For its preparation, a panel of experts (rheumatologist, orthopedic surgeon and behavioral specialist) defined four research areas (questions/items) and determined scenarios or activities in which patients undergoing a THR or TKR could have a greater degree of disability due to the surgical procedure. Each question is scored on a Likert-type scale (25 points: very dissatisfied, 50 points: somewhat dissatisfied, 75 points: somewhat satisfied, and 100 points: very satisfied) and the overall score is obtained by performing an unweighted average of the four items, with a minimum and maximum score of 25 and 100, respectively. Values close to 100 indicate a higher degree of satisfaction. Each patient responded to the SAPS scale independently and without the presence of their attending physician.

Translation and adaptation of the SAPS scale

The SAPS scale was translated and adapted using the translation - back translation methodology. First, it was translated from English to Spanish by two bilingual translators (translators A and B) independently. Within a week, translator A's version was delivered to translator B and translator B's version was delivered to translator

A for a reverse translation from Spanish to English. In both the translation and back-translation stages, a review committee made up of a rheumatologist and three orthopedic subspecialists in joint replacements analyzed the meaning of the translated questions until a single translation was reached by consensus. The preliminary version of the SAPS scale was applied to a pilot sample of 10 patients in order to assess the appropriate meaning, clarity, and comprehension of the questions. A focus group was created with the objective of obtaining feedback from the patients and thus arriving at the final version in Spanish of the scale. During this stage, the content validity of the scale was assessed.

Other instruments

In addition to the SAPS scale, all the participants were asked to answer the WOMAC and SF-36 instruments to perform the criteria validation. The WOMAC scale was originally created to assess the general state of health in patients with osteoarthritis. It consists of three components: pain, stiffness and function in a total of 24 items, with a total score that varies between 0 and 100 (from best to worst result).[7] For the analysis, the WOMAC scale scores were inverted and therefore scores close to 100 indicated better clinical outcomes. Likewise, the quality of life related to health status was analyzed using the SF-36 questionnaire, which is made up of 36 questions grouped into two dimensions: physical health and mental health. The values of this questionnaire range from 0 to 100, where 100 reflects an optimal state of health.[16]

Statistical Analysis

Continuous variables are represented as mean ± standard deviation or median (interquartile range [IQR]). The adjustment to the normal distribution was analyzed with the Shapiro-Wilk test. Qualitative variables are summarized as absolute frequencies and percentages. Initially, a comparison of the characteristics of the patients who underwent THR or TKR was performed to ensure the homogeneity of the entire cohort. Continuous variables were compared using Student's t test for independent data or the nonparametric Mann-Whitney U test. In the case of qualitative variables, the X2 test or Fisher's exact test was used.

Internal consistency was assessed with Cronbach's alpha coefficient, where values greater than 0.70 represent acceptable reliabilities and those greater than 0.90, the presence of redundant items.[17] The correlation between the SAPS scale and the scores of the WOMAC and SF-36 instruments was evaluated with Spearman's rank correlation coefficient. A p-value <0.05 was considered statistically significant. All analyses were performed using Stata version 13.0 (StataCorp, College, Station, TX, USA).

RESULTS

105 participants were included, 50 had undergone a THR and 55, a TKR. The average age was 71.3 ± 11.6 years and 77.3% were women. All three scales were answered by study participants at a median follow-up of 14 months (IQR 11-19). The reported scores of the SAPS, WOMAC, SF-36 physical component and SF-36 mental component scales were 100 (IQR 93.7-100), 95.0 (90.5-97.0); 50.2 (43.7-55.3) and 60.0 (52.3-63.1), respectively. No statistically significant differences were found regarding age, sex, laterality, and follow-up time between patients with a THR or TKR (p>0.05). The degree of satisfaction reported with the SAPS scale, as well as the scores of the WOMAC scale and the SF-36 questionnaire were similar between the groups (p>0.05) (Table 1).

The majority stated that they were somewhat or very satisfied with the results of the joint replacement in the four items of the SAPS scale. The degree of satisfaction was lower in the items related to the ability to perform domestic, work or recreational activities. The internal consistency analysis showed that the SAPS scale has an acceptable grade, with a Cronbach's alpha coefficient of 0.797. The internal consistency of the SAPS scale did not change when removing any of the items and remained in a range of 0.711 to 0.782 (Table 2).

The WOMAC scale and the SF-36 physical component questionnaire were considered as criteria measures to determine the degree of 'satisfaction' of the patients undergoing a THR or TKR. A statistically significant moderate correlation was obtained between the SAPS scale and the rest of the assessed scales (p <0.05). The correlation between the SAPS and WOMAC scales did not vary according to the type of joint replacement performed. A slight change in the correlation coefficient between the SAPS scale and the SF-36 physical component questionnaire was observed among the group of patients with THR or TKR, the correlation was stronger among the patients who underwent TKR (p <0.05) (Figure).

Table 1. Description of the participants

Characteristics	THR (n = 50)	TKR (n = 55)	p
Age, years, mean ± SD	69.3 ± 13.8	73.1 ± 8.9	0.106
Sex, n (%) Female Male	 34 (68.0) 16 (32.0)	 43 (70.2) 12 (21.8)	0.239
Laterality, n (%) Right Left	 27 (54.0) 23 (46.0)	 34 (61.8) 21 (38.2)	0.417
Follow-up time median (IQR)	14 (11-19)	14 (10-19)	0.799
SAPS, median (IQR)	100 (93.7-100)	100 (87.5-100)	0.311
WOMAC, median (IQR)	95.0 (90.7-98.0)	94.0 (89.0-97.0)	0.322
SF-36 Physical, median (IQR)	51.0 (43.7-57.2)	49.8 (43.6-54.3)	0.333
SF-36 Mental, median (IQR)	60.7 (56.4-63.0)	58.3 (48.8-63.5)	0.277

THR = total hip replacement, TKR = total knee replacement, SD = standard deviation, IQR = interquartile range, SAPS = *Self-Administered Patient Satisfaction scale*, WOMAC = *Western Ontario and McMaster Universities Arthritis Index* , SF-36 = *36-Item Short Form Health Survey*.

Table 2. Distribution of SAPS scale responses and Cronbach's alpha coefficient

SAPS scale	THR (n = 50)	TKR (n = 55)	Total (n = 105)	Cronbach's alphato
How satisfied are you with the results of your surgery? Very satisfied Somewhat satisfied Somewhat dissatisfied Very unsatisfied	 44 (88.0) 5 (10.0) 1 (2.0) 0 (0.0)	 48 (87.3) 6 (10.9) 1 (1.8) 0 (0.0)	 92 (10.5) 11 (10.5) 2 (1.9) 0 (0.0)	0.782
How satisfied are you with the results of your surgery for improving your pain? Very satisfied Somewhat satisfied Somewhat dissatisfied Very unsatisfied	 43 (86.0) 6 (12.0) 0 (0.0) 1 (2.0)	 48 (87.3) 6 (10.9) 0 (0.0) 1 (1.8)	 91 (86.7) 12 (11.4) 0 (0.0) 2 (1.9)	0.711
How satisfied are you with the results of surgery for improving your ability to do home or yard work? Very satisfied Somewhat satisfied Somewhat dissatisfied Very unsatisfied	 43 (86.0) 5 (10.0) 2 (4.0) 0 (0.0)	 41 (74.5) 11 (20.0) 2 (3.6) 1 (1.8)	 84 (80.0) 16 (15.2) 4 (3.8) 1 (0.9)	0.722
How satisfied are you with the results of surgery for improving your ability to do recreational activities? Very satisfied Somewhat satisfied Somewhat dissatisfied Very unsatisfied	 41 (82.0) 5 (10.0) 3 (6.0) 1 (2.0)	 37 (67.3) 12 (21.8) 1 (1.8) 5 (9.1)	 78 (74.3) 17 (16.2) 4 (3.8) 6 (5.7)	0.767

[a]Cronbach's alpha coefficient when removing the question from the SAPS scale.
SAPS = *Self-Administered Patient Satisfaction scale*, THR = total hip replacement, TKR = total knee replacement.

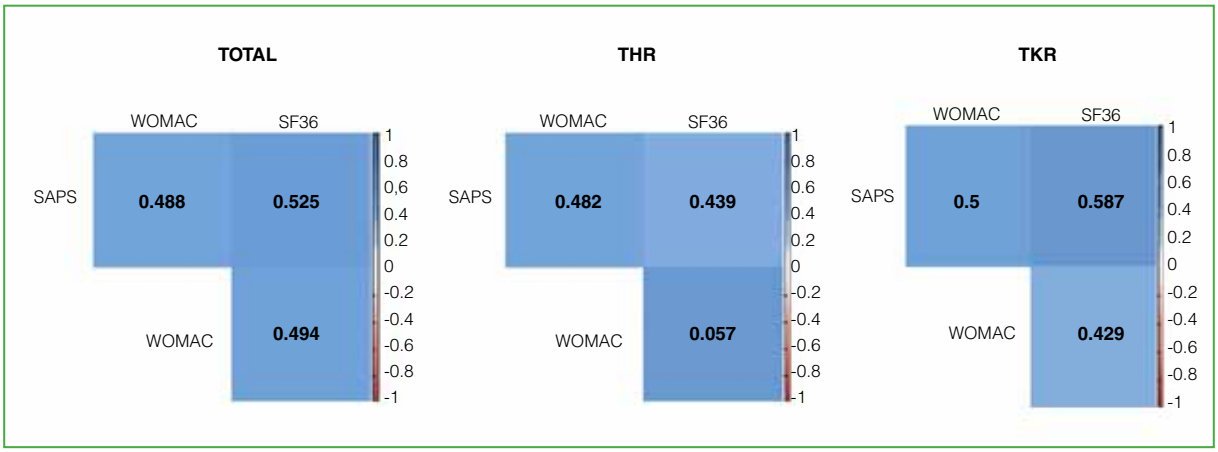


Figure. Spearman's correlation coefficients between the SAPS scale, WOMAC and SF-36 physical component for the total sample and according to the type of joint replacement. THR = total hip replacement, TKR = total knee replacement. SAPS = *Self-Administered Patient Satisfaction scale*, WOMAC = *Western Ontario and McMaster Universities Arthritis Index*, SF-36 = *36-Item Short Form Health Survey*.

DISCUSSION

Pain relief and improvement in function have been the mainstays in determining the efficacy of THR or TKR in patients with severe osteoarthritis. The subjective measurement of these components based on the patient's expectations constitutes a challenge for specialists, since they must be assessed directly by them and not by their treating physician.[4] This has motivated the development of multiple scales that attempt to quantify patient satisfaction after a THR or TKR. However, most of them continue to involve objective measures, such as the range of motion, and are only available in English, in addition to the fact that they cannot be extrapolated to Spanish-speaking populations. The objective of this study was to validate the SAPS scale in Spanish, a brief, easy-to-use instrument designed to directly quantify patient satisfaction with the treatment received, involving personal preferences and expectations.[4,12]

The SAPS scale can be considered a relatively new instrument; therefore, until now, no validation of this instrument in Spanish had been carried out and this study is the first to analyze the psychometric properties of this scale for Spanish-speaking populations. Our results showed that the Spanish version of the SAPS scale has the same psychometric properties as the original version, with acceptable internal consistency and adequate construct validity.[12]

In general, it is possible to divide the concept of satisfaction into two dimensions: determinants and components.[4] Among the determinants are all the factors specific to the patient that are not modifiable by the surgeon (age, sex, comorbidities, degree of osteoarthritis) and that will directly influence their expectations regarding the intervention. On the other hand, the components of satisfaction include the factors associated with hospital care (waiting times, surgical technique, type of anesthesia, dose of analgesia, among others), which are modifiable. For example, a higher degree of satisfaction has been reported after a THR or TKR as the age of the patient increases, especially after 80 years, because this age range has less functional demand.[18,19] Other authors, such as Bourne et al.,[20] have reported that the degree of patient satisfaction is related to postoperative complications, those who suffered at least one complication are 86% more likely to be dissatisfied than those who did not have complications after TKR.

Measurement of satisfaction has been interpreted in different ways, ranging from the use of isolated questions focused on pain reduction (How much pain do you have after surgery?), functional scales (WOMAC, HHS, KSS) to implementation. of validated satisfaction scales (SAPS).[4,21,22] For example, in a systematic review that included 208 articles aimed at measuring patient satisfaction with TKR, Kahlenberg et al. found that only 13% (27 studies) used validated scales that measured function or satisfaction. In six of 27 (22.2%), the SAPS scale had been used and 21% did not explain how they did the measurement.[22] These findings show that there is a

need to introduce standardized instruments that make it possible to objectively measure patient satisfaction after joint replacement.

As with other instruments, the SAPS scale can be used as part of clinical follow-up in order to assess how patient satisfaction evolves. With the SAPS scale, it has been shown that patient satisfaction increases as follow-up time elapses and is correlated with functional improvement and pain relief, as well as being sensitive to the presence of complications.[13,14] Because the SAPS scale is an instrument answered by the patients themselves, it can also represent a valid tool from a legal point of view when there are differences in the perception of the postoperative result between the patient, the treating physician, and the insurers.

This study has limitations. First, due to the research design, it was not possible to measure the sensitivity to change of the SAPS scale in its Spanish version. However, due to the similarity of our results with the original validation, it is expected that this version will also be sensitive to change in the same way as the English version.[12] Second, the sample size did not allow quantifying the internal consistency of the SAPS scale, in a stratified manner, according to the type of joint replacement. However, given the similarity of the observed responses, we do not believe that there are differences depending on the affected joint.

CONCLUSION

The Spanish version of the SAPS scale is a valid and reliable tool to measure the degree of satisfaction of patients undergoing a THR or TKR, with psychometric properties similar to those of the original scale.

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

M. Mantilla ORCID ID: https://orcid.org/0000-0002-6042-9760
P. Stangl-Correa ORCID ID: https://orcid.org/0000-0002-7104-3396
W. Stangl-Herrera ORCID ID: https://orcid.org/0000-0002-7100-3677
E. Cantor ORCID ID: https://orcid.org/0000-0003-3320-6032
A. Echeverry-Vélez ORCID ID: https://orcid.org/0000-0003-3253-8131

REFERENCES

1. Kloppenburg M, Berenbaum F. Osteoarthritis year in review 2019: epidemiology and therapy. *Osteoarthr Cartil* 2020;28(3):242-8. https://doi.org/10.1016/j.joca.2020.01.002
2. Finch DJ, Martin BI, Franklin PD, Magder LS, Pellegrini VD Jr, PEPPER Investigators. Patient-reported outcomes following total hip arthroplasty: A multicenter comparison based on surgical approaches. *J Arthroplasty* 2020;35(4):1029-35.e3. https://doi.org/10.1016/j.arth.2019.10.017
3. Carr AJ, Robertsson O, Graves S, Price AJ, Arden NK, Judge A, et al. Knee replacement. *Lancet* 2012;379(9823):1331-40. https://doi.org/10.1016/S0140-6736(11)60752-6
4. Lau RL, Gandhi R, Mahomed S, Mahomed N. Patient satisfaction after total knee and hip arthroplasty. *Clin Geriatr Med* 2012;28(3):349-65. https://doi.org/10.1016/j.cger.2012.05.001
5. Carpenter CVE, Blackburn J, Jackson J, Blom AW, Sayers A, Whitehouse MR.Validated repeatability of patient-reported outcome measures following primary total hip replacement: a mode of delivery comparison study with randomized sequencing. *Acta Orthop* 2018;89(6):628-33. https://doi.org/10.1080/17453674.2018.1521183
6. Wilson I, Bohm E, Lübbeke A, Lübbeke A, Lyman S, Overgaard S, et al. Orthopaedic registries with patient-reported outcome measures. *EFORT Open Rev* 2019;4(6):357-67. https://doi.org/10.1302/2058-5241.4.180080
7. Escobar A, Quintana JM, Bilbao A, Azkárate J, Güenaga JI. Validation of the Spanish version of the WOMAC questionnaire for patients with hip or knee osteoarthritis. Western Ontario and McMaster Universities Osteoarthritis Index. *Clin Rheumatol* 2002;21(6):466-71. https://doi.org/10.1007/s100670200117
8. Söderman P, Malchau H. Is the Harris hip score system useful to study the outcome of total hip replacement? *Clin Orthop Relat Res* 2001;(384):189-97. https://doi.org/10.1097/00003086-200103000-00022

9. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res* 1989;(248):13-4. PMID: 2805470
10. Brazier JE, Harper R, Jones NM, O´Cathain A, Thomas KJ, Usherwook T, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *BMJ* 1992;305(6846):160-4. https://doi.org/10.1136/bmj.305.6846.160
11. Hamilton DF, Lane J V, Gaston P, Patton JT, Macdonald D, Simpson AHRW, et al. What determines patient satisfaction with surgery? A prospective cohort study of 4709 patients following total joint replacement. *BMJ Open* 2013;3(4):e002525. https://doi.org/10.1136/bmjopen-2012-002525
12. Mahomed N, Gandhi R, Daltroy L, Katz JN. The Self-Administered Patient Satisfaction Scale for Primary Hip and Knee Arthroplasty. *Arthritis* 2011;2011:591253. https://doi.org/10.1155/2011/591253
13. Carpenter CVE, Wylde V, Moore AJ, Sayers A, Blom AW, Whitehouse MR. Perceived occurrence of an adverse event affects patient-reported outcomes after total hip replacement. *BMC Musculoskelet Disord* 2020;21(1):1-8. https://doi.org/10.1186/s12891-020-3127-6
14. Miravete-Galvez A, Serrano-Ardila A, Camacho-Galindo J. Correlation between functionality and satisfaction index after total hip or knee replacement. *J Musculoskelet Surg Res* 2020;4:213-7. https://doi.org/10.4103/jmsr.jmsr_48_20
15. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quiñonez HR, Young SL. Best practices for developing and validating scales for health, social, and behavioral research: A primer. *Front Public Heal* 2018;6:149. https://doi.org/10.3389/fpubh.2018.00149
16. Lugo A LH, García G HI, Gómez R C. Confiabilidad del cuestionario de calidad de vida en salud SF-36 en Medellín, Colombia. *Rev Fac Nac Salud Pública* 2006;24(2):37-50. Available at: https://revistas.udea.edu.co/index.php/fnsp/article/view/243/173
17. Tavakol M, Dennick R. Making sense of Cronbach's alpha. *Int J Med Educ* 2011;2:53-5. https://doi.org/10.5116/ijme.4dfb.8dfd
18. Clement ND, MacDonald D, Howie CR, Biant LC. The outcome of primary total hip and knee arthroplasty in patients aged 80 years or more. *J Bone Joint Surg Br* 2011;93(9):1265-70. https://doi.org/10.1302/0301-620X.93B9.25962
19. Lee SH, Kim DH, Lee YS. Is there an optimal age for total knee arthroplasty?: A systematic review. *Knee Surg Relat Res* 2020;32(1):60. https://doi.org/10.1186/s43019-020-00080-1
20. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charronet KDJ. Patient satisfaction after total knee arthroplasty: Who is satisfied and who is not? *Clin Orthop Relat Res* 2010;468(1):57-63. https://doi.org/10.1007/s11999-009-1119-9
21. Klem N-R, Kent P, Smith A, Dowsey M, Farya R, et al. Satisfaction after total knee replacement for osteoarthritis is usually high, but what are we measuring? A systematic review. *Osteoarthr Cartil Open* 2020;2:100032. https://doi.org/10.1016/j.ocarto.2020.100032
22. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient satisfaction after total knee replacement: A systematic review. *HSS J* 2018;14(2):192-201. https://doi.org/10.1007/s11420-018-9614-8

Unicompartmental Knee Arthroplasty. Clinical-Radiographic Results and Analysis of Implant Survival

Vicente Marquina Moraleda, Gema Gastaldi, Sara Fuentes, Rafael Colomina, Pablo Jover, Lorenzo Hernández
Orthopedic Surgery and Traumatology Service, Consorcio Hospital General Universitario de Valencia, Valencia, Spain

ABSTRACT

Objective: To assess the clinical and radiological outcomes of patients who underwent a unicompartmental knee arthroplasty (UKA), as well as the complication rate and implant survival. **Materials and Methods:** We present a retrospective descriptive study of 68 consecutive patients (70 knees) who underwent UKA between 2013 and 2020, with an average follow-up of 57.7 months (range 24-105) and an average age of 61 years (range 34-79). 46.5% of the patients were male. The average BMI was 29.9 (range 20-39). The most frequent etiology was osteoarthritis of the medial femorotibial compartment with a varus >7°. To assess the outcomes, the visual analog scale (VAS) for pain and the Knee Society Score (KSS) were used. The complication and implant survival rates were evaluated. **Results:** The average decrease in the VAS pain scale was 4.4 ± 1.9. The average score on the postoperative KSS functional and clinical scales were 77.4 ± 13.7 and 70.2 ± 17.7, respectively. The postoperative complication rate was 7% (5 cases). The surgical reoperation rate was 15.5% (11 patients): nine cases for persistent pain, one case for joint stiffness, and one case for aseptic loosening. **Conclusions:** UKA is an effective therapeutic option for patients with unicompartmental knee osteoarthritis, providing good clinical results with an acceptable rate of complications; however, it provides a considerable implant revision rate.

Keywords: Unicompartmental prosthesis; knee; unicompartmental involvement; survival.
Level of Evidence: IV

Prótesis unicompartimental de rodilla. Resultados clínico-radiográficos y análisis de la supervivencia del implante

RESUMEN

Objetivo: Evaluar los resultados clínicos y radiográficos en pacientes sometidos a artroplastia unicompartimental de rodilla, así como la tasa de complicaciones y la supervivencia del implante. **Materiales y Métodos:** Estudio descriptivo retrospectivo de 68 pacientes consecutivos (70 rodillas) sometidos a artroplastia unicompartimental de rodilla entre 2013 y 2020, con un seguimiento medio de 57.7 meses (rango 24-105) y una media de la edad de 61 años (rango 34-79). El 46,5% eran hombres. El índice de masa corporal medio era de 29,9 (rango 20-39). El diagnóstico más frecuente fue la artrosis del compartimento femorotibial medial con un varo <7°. Los resultados se evaluaron con la escala analógica visual para dolor y el *Knee Society Score* (KSS). Se evaluó la incidencia de complicaciones y la tasa de supervivencia del implante. **Resultados:** La disminución media en la escala analógica visual para dolor fue de 4,4 ± 1,9. Las puntuaciones medias posoperatorias en las escalas funcional y clínica del KSS fueron de 77,4 ± 13,7 y 70,2 ± 17,7, respectivamente. La tasa de complicaciones posquirúrgicas fue del 7% (5 casos). La tasa de reintervención quirúrgica fue del 15,5% (11 pacientes): nueve casos por persistencia del dolor, uno por rigidez articular y otro por aflojamiento aséptico. **Conclusiones:** La artroplastia unicompartimental de rodilla es una opción terapéutica eficaz para pacientes con gonartrosis unicompartimental de rodilla; se logran buenos resultados clínicos con una aceptable tasa de complicaciones; sin embargo, la tasa de revisión del implante es considerable.

Palabras clave: Prótesis unicompartimental; rodilla; compromiso unicompartimental; supervivencia.
Nivel de Evidencia: IV

Received on March 16th, 2022. Accepted after evaluation on July 14th, 2022 • Dr. VICENTE MARQUINA MORALEDA • vmarquina94@gmail.com https://orcid.org/0000-0003-4030-5215
How to cite this article: Marquina Moraleda V, Gastaldi G, Fuentes S, Colomina R, Hernández PJL.Unicompartmental Knee Artrhoplasty. Clinical-Radiographic Results and Analysis of Implant Survival. *Rev Asoc Argent OrtopTraumatol* 2022;87(6):772-780. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1540

INTRODUCTION

The surgical treatment of degenerative disease of a single compartment of the knee continues to be a subject of controversy that varies depending on the schools of thought and the experience of the surgeon.[1]Likewise, the annual demand for gonarthrosis arthroplasties is expected to increase considerably in the near future due to the aging of the population.[2,3]

Among the current therapeutic options, we can highlight unicompartmental knee arthroplasty (UKA), total knee arthroplasty (TKA),[4] arthroscopic lavage, alignment osteotomies[5] and, very recently, osteochondral grafting and cultured cartilage cell transplants.[6] Specifically, UKA is a procedure that preserves bone stock and cruciate ligaments, which allows good kinematics, while preserving knee proprioception.

Although the scientific evidence indicates that functional outcomes in the medium and long term are favorable in patients undergoing UKA,[7] there are studies that report a considerable rate of implant revision. In addition, it is a technically demanding procedure and its indication remains a controversial issue.[8]

The aim of this study was to evaluate the clinical and radiographic results in patients undergoing UKA, as well as the rate of complications and implant survival.

MATERIALS AND METHODS

Study design

A retrospective descriptive study of 70 knees (68 patients) operated on by the same surgical team at our institution between September 2013 and March 2020 using a fixed polyethylene cemented UKA was performed. The minimum follow-up was two years. Inclusion criteria for UKA were the involvement of a single compartment of the knee, the presence of competent cruciate ligaments, <10º flexion or none at all, and <7º varus-valgus deformity on preoperative anteroposterior and lateral radiographs.

The exclusion criteria were: involvement of more than one compartment, inflammatory arthritis, and ligamentous instability. Body mass index (BMI), age and level of physical activity of the patient were not considered exclusion criteria.

Surgical technique

All patients underwent the placement of a fixed-bearing Triathlon® PKR (Stryker®, NJ, USA) unicompartmental prosthesis according to the usual technique. The patient is placed in the supine position. Under aseptic and ischemic conditions, a medial parapatellar approach is performed, dislocating the patella laterally. All patients were administered antibiotic prophylaxis with cefazolin, and a redon drain and a compression bandage were placed at the end of the intervention.

The tibial component is always approached first, pinning the assembly to the proximal end of the tibia, just anterior to the anterior cruciate ligament insertion. In this way, the assembly is anterior to the tibial crest and centered in the ankle joint, ensuring parallelism with the tibia and, therefore, the tibial inclination of the implant. Afterwards, the varus/valgus adjustment of the prosthesis is performed by modifying the adjustment knob that regulates the mounting medially or laterally. Varus deformity should not be overcorrected, because this approach will place undue stress on medial soft tissue structures, causing pain and increased contact forces in the contralateral compartment, predisposing to further wear. Then, the vertical tibial resection is performed at the tibial spine, just medial to the insertion of the anterior cruciate ligament to avoid damaging its fibers, and reaching up to the upper surface of the tibial resection guide. The transverse tibial resection is continued to the posterior part of the joint. The flexion gap is checked, the minimum component of which comprises a thickness of 8 mm, the tibial cut can be increased if this spacer does not fit and then the extension gap is determined and, by subtracting both gaps, the distal resection guide for femoral preparation is determined. The distal resection guide is attached to the spacer with the leg in extension, this assembly is below the distal femoral bone; before performing the distal femoral osteotomy (using the 2-in-1 cutting block system, in extension and in flexion), the good alignment of the assembly is verified. Tibial rotation and knee flexion are adjusted so that the spacer block rests on the tibial resection and the posterior part of the 2-in-1 cutting block rests on the resected distal femur. The tibial size is then calculated using a caliper, the knee is placed at 90º of flexion and the trial femoral component is placed, which is considered adequate when it leaves 2-3 mm of exposed bone above its anterior edge. If the femoral component is between two

sizes, the smaller one is chosen in order to promote better patellar tracking. The tibial trial is then placed. Stability, placement, and alignment in all axes of the knee are verified.

Then, the femoral and tibial pivots are prepared by drilling. The tibial and femoral components are cemented, and both final components are impacted. Finally, the insert is inserted by pushing it posteriorly until it engages with the tibial tray in the posterior part, impacting it after its placement.

All patients were immobilized with a compression bandage. As of the second post-surgical day, active range of motion exercises of the joint began, at which time the redon and bandage were removed.

Demographic data

The study included 37 women (52.9%) and 33 men (47.1%), with a mean age of 60.8 years (range 34-79). The diagnoses were: gonarthrosis (grade III or IV of the Ahlbäck classification) (48 cases, 68.6%), osteonecrosis (13 cases, 18.6%), osteochondritis (5 cases, 7.1%) and post-traumatic osteoarthritis (4 cases, 5.7%).

91.4% (64 cases) had involvement of the medial compartment and 8.6% (6 cases) of the lateral compartment. In 31 cases (44.3%), the operated knee was the left and, in the remaining 39 cases (55.7%), the right.

The mean BMI was 29.9 (range 20-39). Twenty-nine patients (41.4%) had been infiltrated with intra-articular corticosteroids before surgery, without clinical improvement; four (5.7%), with intra-articular platelet-rich plasma, without improvement; and five (7.1%) had received both treatments on different occasions. The rest (32 cases; 45.7%) had no previous infiltrations.

Half of the patients had already undergone knee arthroscopy and, in all, a partial meniscectomy of the affected compartment had been performed. Two had been operated on for a post-traumatic lateral tibial plateau fracture, by open reduction and internal fixation with screw-retained plates; and another had undergone patellar realignment.

Assessment methods

The cases were retrospectively analyzed by three surgeons—different from the main surgeon—who reviewed the medical records. The clinical and radiographic follow-up was carried out in outpatient offices of the center at one month, three, six and 12 months, and then annually after surgery.

The pre- and post-surgical radiographic anatomical axes were determined and the presence or absence of radiolucencies in the last clinical follow-up was evaluated using anteroposterior weight-bearing and lateral radiographs at 45º, taking into account the method proposed by Kalra et al.[9] Pre- and postoperative pain was assessed using the visual analog scale (VAS). In the last follow-up visit, the clinical result was evaluated by measuring the joint balance of the operated knee with a goniometer and the use of the Knee Society Score (KSS), and these values were compared with those of the preoperative period.[10]

In addition, applying the multiple linear regression model, we analyzed whether age, BMI, and sex affected the functional outcome.

A survival study of the implant was carried out with the Kaplan-Meier survival analysis, associating the survival curve of the series presented and assuming as "rescue" all those patients who required a new surgery for the replacement of some component of the prosthesis or the entire implant. We evaluated whether implant survival was significantly modified by any of the factors measured (sex, BMI, and age) separately, using the logarithmic order test, which takes into account the differences in survival between the different groups in all the follow-up stages. In addition, these factors were analyzed using a multivariable analysis with the Cox regression model, in order to determine the effects of these variables over time until prosthesis salvage.

The incidence of intra- and postoperative complications was determined, as well as the implant revision rate.

Statistical Analysis

The descriptive analysis of the categorical variables is expressed as absolute and relative frequency; quantitative variables are described with mean and standard deviation (SD). The normality of both quantitative and qualitative variables was verified using the Kolmogorov-Smirnov test. In all statistical analyses, the significance level was set at 5%. Data were analyzed with the statistical programs SPSS 22 and XLSTAT for MAC OS.

RESULTS

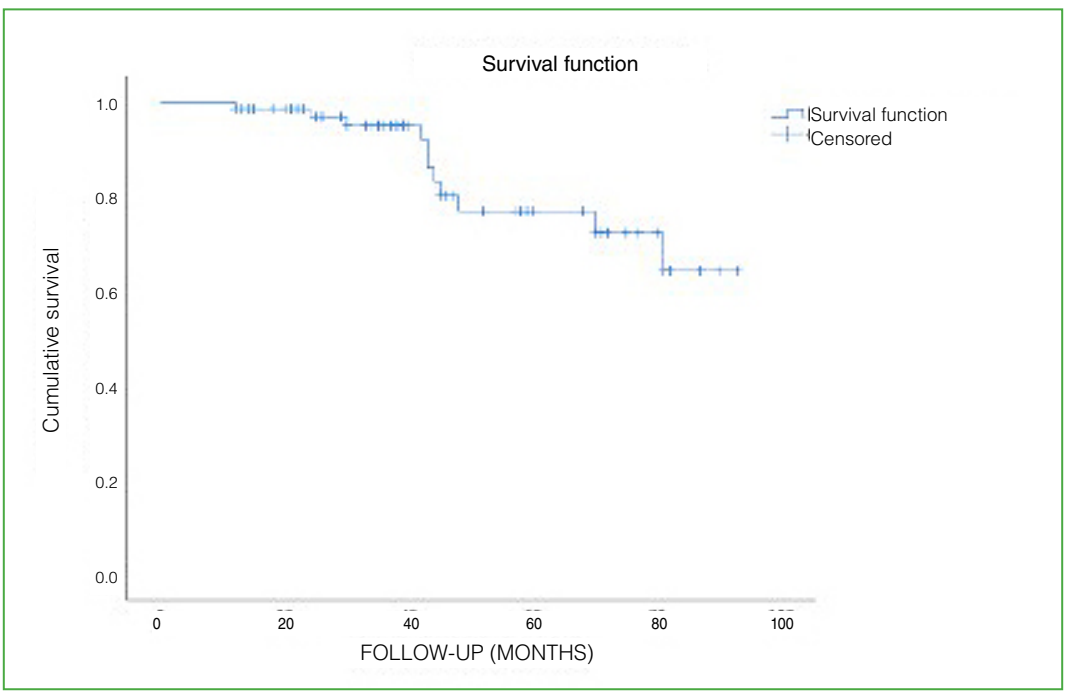
Mean follow-up was 57.7 months (range 24-105). The functional outcomes are shown in Table 1.

In the analysis using the multiple linear regression model of the age, sex and BMI variables and their influence on the functional result in the KSS, statistically significant differences were observed in terms of sex: the results were better in men (CI95% of -14.25 to -1.6, p = 0.014). There were no significant differences in terms of age and BMI. The implant survival rate was 84.3% (Figure 1).

Table 1. Clinical-functional outcomes of the series

	VAS	KSS	Anatomical axis
Preoperative	6.8 ± 1.2	56.8 ± 16.3	5.2 ± 7.5º
Posoperative	2.3 ± 1.8	77.4 ± 13.7	4.1 ± 7.7º
p	**28**	**1**	**7**

Results are expressed as mean and standard deviation. VAS = visual analog scale, KSS = Knee Society Score.



Means and medians for survival time

	Median				Median			
			95% confidence interval				95% confidence interval	
	Estimate	Standard error	Limit inferior	Limit superior	Estimate	Standard error	Limit inferior	Limit superior
	78.645	3.738	71.319	85.971	.	.	.	.

a. If censored, the estimate is limited to the longest survival time.

Figure 1. Implant survival rate. Kaplan-Meier survival curve.

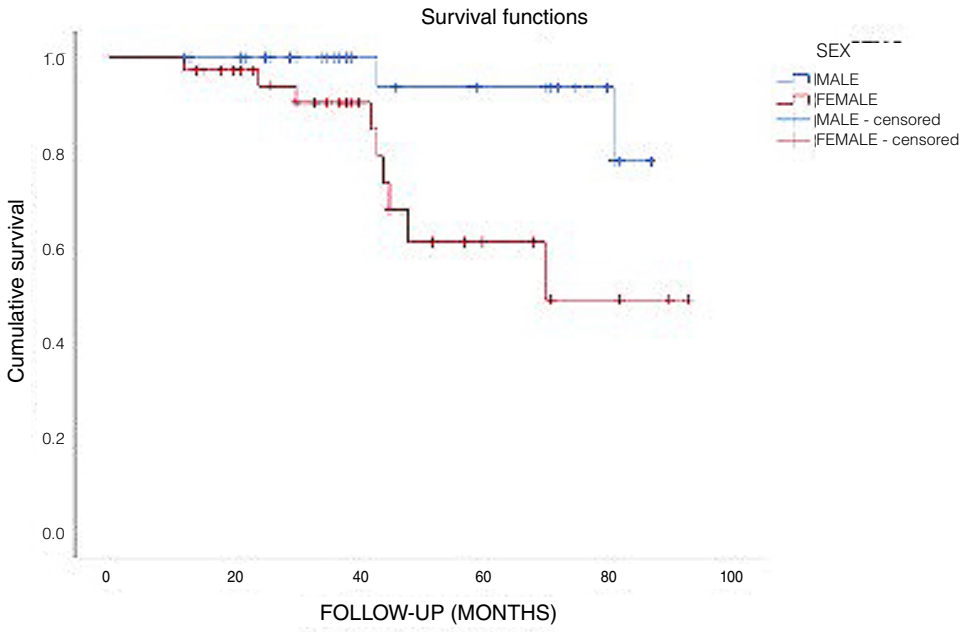
Taking into account that our study is limited to the maximum follow-up period (specifically, a maximum follow-up of 105 months), the median survival time is 78.7 months (CI95% 71.3-85.9) (Table 2). If the 5-year survival time is calculated, the result is 88.6%.

Table 2. Implant survival time.

Mean estimation	Standard deviation	Inferior limit CI95%	Superior limit CI95%
78.6	**3.7**	**71.3**	**85.9**

CI95% = 95% confidence interval.

The results of the univariate log-rank survival analysis test were not statistically significant for the BMI and age variables. However, significant differences were obtained in the sex variable for implant survival ($X^2(1) = 6.04$; $p = 0.014$) (Figure 2).



Variables in the equation

	B	SE	Wald	df	Sig.	Exp(B)
AGE	-.022	.027	.648	1	.421	.978
SEX	1.936	.804	5.793	1	.016	6.929
BMI	-.134	.076	3.120	1	.077	.875

Figure 2. Kaplan-Meier survival curve by sex.

B = coefficient, SE = standard error of B, Wald = Wald test, df = degrees of freedom. Sig. = p value (significance level $p<0.05$), Exp(B) = estimated odds ratio

The results in the multivariable analysis according to the Cox regression model (Table 3) were not significant for the variables age (p = 0.421) and BMI (p = 0.077); while, for the sex variable, the differences were significant (p = 0.016), the revision rate was higher in women.

Table 3. Cox regression for the variables age, sex and body mass index*

	B*	SE*	Wald*	df*	Sig.*	Exp (B)*
Age	-22	27	648	1	421	978
Sex	1936	804	5793	1	16	6929
Body mass index	-134	76	3120	1	77	875

*Significant for the sex variable.
B = coefficient, SE = standard error of B, Wald = Wald test, df = degrees of freedom. Sig. = p value (significance level p<0.05), Exp(B) = estimated odds ratio.

The complication rate in the series was 7% (5 cases): a hematoma that was resolved by conservative treatment; a surgical wound dehiscence that was treated with the Friedrich method and closure of the wound; a surgical wound infection healed with antibiotic treatment; one case of joint stiffness and another of aseptic loosening of the prosthesis, in which it was necessary to replace the prosthesis to TKA.

The implant revision rate was 15.7% (11 cases), there were complete conversions from unicompartmental arthroplasty to TKA. All revision surgeries were in patients with UKA of the medial compartment. The causes of the reinterventions were: persistent postoperative pain that did not improve with conservative treatment (9 cases); aseptic loosening of the implant detected by radiolucency in control radiographs (1 case) and joint stiffness that did not improve with rehabilitation treatment (1 case).

DISCUSSION

The treatment of single compartment gonarthrosis continues to be a subject of study, and UKA occupies a prominent place. In fact, recent research has shown the profitability of this implant when the surgical indication is adequate.[11] On the other hand, a wrong indication can generate a higher revision rate and worse clinical outcomes.[12]

In this sense, in 1989, Kozinn and Scott established the indications and the inclusion and exclusion criteria to select UKA candidate patients, which are the same as those taken for this study.[13] However, these indications have expanded, as can be seen in a review of five cohort studies carried out by van der List et al., in which good clinical outcomes were obtained in patients with mild to moderate patellofemoral involvement, without any differences in functional outcomes or in the risk of implant revision.[14] Likewise, Johal et al., and Jennings et al. obtained good clinical outcomes in patients >60 years and BMI >30.[8,11] The absence of an anterior cruciate ligament as a contraindication to UKA has recently been questioned. Several studies show acceptable results in patients who underwent ACL and UKA reconstruction at the same surgical stage, without increased revision rates, when compared to patients with competent ACL and knee kinematics similar to those of patients with an intact anterior cruciate ligament.[8]

The affected compartment is usually the medial one, while the lateral one is involved in 10% of the cases, according to some studies.[15] In our series, the incidence of lateral involvement was 8.6% (6 cases).

Regarding the implant, UKA is characterized by its minimal replacement design of the affected joint compartment. It is necessary to take into account that, when implanting this prosthesis, an elasticity gradient is created between the operated compartment and the non-operated compartment, which can affect the transmission of forces in the joint. While TKA imposes its own biomechanics on the operated knee, UKA should resemble the native knee anatomy as closely as possible to maintain patient-specific force patterns with improved dynamic proprioception and postural control in comparison to that of TKA.[16] In this regard, it should be noted that, in our specific case, the mean post-surgical anatomical axis was 4.1 ± 7.7º; while the mean pre-surgical axis was 5.2 ± 7.5º. A mean undercorrection of 1.1º was obtained, preserving the elasticity gradient and allowing a clinical-functional improvement of up to 20.6 points in the KSS.

As described by Schaafer et al., overcorrections of 5° in the operated compartment can increase mechanical forces by 88% over the other compartment, so this type of implant should be placed with an undercorrection of 3° to 5°, thus preserving the tibial epiphyseal bone stock and the good functionality and proprioception of the intervened joint.[7]

Regarding implant revision rates, UKA has been associated with higher revision rates when compared to the TKA since its introduction in 1970.[17] In a systematic review by Arirachakaran et al.,[4] three studies were included that compared the functional outcomes and revision rate of patients undergoing UKA or TKA. The authors found that there were no significant differences in terms of short-term functional outcomes; however, UKA patients had a 5.4 times higher revision rate than TKA patients.

The implant revision rate in our series was 15.7% (11 cases) and the calculated 5-year survival rate was 88.6%. There is considerable discrepancy between cohort studies and national prosthetics records on UKA implant survival, a mean survival rate of 90.5% was observed in cohort studies and 84.1% in national records. Wilson et al. conducted a systematic review of 60 studies divided into three groups: seven publications from six randomized clinical trials, 17 joint national records and national database studies, and 36 cohort studies. The 5-year revision rates were higher for UKA than TKA in all three study groups (hazard ratio 5.95 (1.29-27.59), 2.50 (1.77-3.54) and 3.13 (1.89-5.17), respectively).[18] Similarly, a systematic review of cohort studies and national records found that the mean 10-year UKA survival was 90.5% in the cohort studies, but only 84.1% in the national records. The 15-year survival was 87% and 69.6%, respectively.[19] The revision of a UKA with another UKA obtains a worse survival than the revision with TKA.[20]

Revision rates in national records are the highest overall, because surgeons who perform the most surgeries tend to publish their own series, while surgeons who perform fewer UKAs annually are included in national records.[2]Regarding the most frequent causes of revision, the most common are aseptic loosening (43-30%), disease progression (29-20%), unexplained pain (23-10%), instability (6%), infection (5%) and polyethylene wear (4%).[11,19,22-24] In our series, the most frequent reason for revision was persistent pain (9 cases), which coincides with other research, such as a systematic review of 39 studies carried out by Thienpont, which describes that UKA revision rate for unexplained pain was 6.76 times higher than that for TKA.[15]

From this study, we highlight the need for further research to clarify the probable cause of this persistent pain.

There are different risk factors that influence an earlier UKA revision. According to the Australian registry of prosthetics, which includes 46,094 UKAs, the risk factors are female gender and young age, with a 10- and 15-year revision rate of 14.6% and 21%, respectively.[11] In our study, the female gender was a risk factor that significantly influenced implant survival, but the same did not occur with age and BMI.

Other factors that influence UKA revision are the surgeon's preference and the difficulty perceived by the surgeon for the conversion to total knee replacement.[22] Thus, if UKA revision is perceived as an easy procedure, surgeons may be more inclined to revise implants in patients with unexplained pain, thus increasing revision rates.[24] In a systematic review of five studies and 536 patients carried out by Sun et al. to compare the clinical outcomes of UKA converted to TKA and primary TKA, the primary TKA group outperformed the revised UKA group in terms of scores on the WOMAC, KSS, and active joint balance scales.[1] However, although revision from UKA to TKA may not have similar results to primary TKA, morbidity has been shown to be lower than with revision TKA.[25]

In addition, the number of UKAs that the surgeon performs per year is a factor to take into account in implant revision.[26] As reported in some studies, the revision rate may be higher if surgeons perform fewer than 15 UKAs per year.[15] In a meta-analysis by Sun et al., UKA revision rates increased from 8.3% in surgeons who placed one unicompartmental implant per year to 1% in those who performed more than 12 UKAs per year.[1] In addition, these less experienced surgeons can increase the inclusion of total knee replacements in patients who are candidates for unicompartmental replacements (usage phenomenon) due to the high revision rate that they can cause due to the low volume of annual surgeries, which reaches 11% according to national records.[21] As described in the study by Hamilton et al., this fact has been associated with a lower revision rate.[27] It should be noted that one of the advantages of our study is that all the implants were placed by the same surgical team from the knee unit

of the same hospital and that the number of UKAs per year is higher than the minimums reflected in published studies.

The type of implant in all cases was a fixed polyethylene cemented unicompartmental prosthesis. A recent systematic review of cohort studies and national registries found higher rates of aseptic loosening in mobile polyethylene implants than in fixed ones, but higher rates of disease progression in fixed ones. In contrast, medium-term survival for cemented and uncemented implants was comparable between groups with survival rates greater than 95%.[11]

The limitations of this study are that it does not have a control group of patients who underwent TKA to compare results between groups and that more specific complementary tests, such as computed tomography or magnetic resonance imaging, were not performed to more accurately assess the outcome and the presence of loosening of the implant, as well as for preoperative planning.

CONCLUSION

UKA is a therapeutic option that provides good clinical results with an acceptable rate of complications in patients with unicompartmental gonarthrosis of the knee; however, the implant revision rate is higher than with TKA.

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

REFERENCES

1. Sun X, Su Z. A meta-analysis of unicompartmental knee arthroplasty revised to total knee arthroplasty versus primary total knee arthroplasty. *J Orthop Surg Res* 2018;13(1):158. https://doi.org/10.1186/s13018-018-0859-1
2. Pollock M, Somerville L, Firth A, Lanting B. Outpatient total hip arthroplasty, total knee arthroplasty, and unicompartmental knee arthroplasty: A systematic review of the literature. *JBJS Rev* 2016;4(12):e4. https://doi.org/10.2106/JBJS.RVW.16.00002
3. Ford MC, Walters JD, Mulligan RP, Dabov GD, Mihalko WM, Mascioli AM, et al. Safety and cost-effectiveness of outpatient unicompartmental knee arthroplasty in the ambulatory surgery center: A matched cohort study. *Orthop Clin North Am* 2020;51(1):1-5. https://doi.org/10.1016/j.ocl.2019.08.001
4. Arirachakaran A, Choowit P, Putananon C, Muangsiri S, Kongtharvonskul J. Is unicompartmental knee arthroplasty (UKA) superior to total knee arthroplasty (TKA)? A systematic review and meta-analysis of randomized controlled trial. *Eur J Orthop Surg Traumatol* 2015;25(5):799-806. https://doi.org/10.1007/s00590-015-1610-9
5. Fernández Fernández R, Ordóñez Parra JM. El papel actual de la osteotomía de rodilla en la artrosis. *Rev Esp Cir Ortopédica Traumatol* 2002;46(5):465-75. IBECS ID: 18542
6. Brucker PU, Braun S, Imhoff AB. Mega-OATS technique – Autologous osteochondral transplantation as a salvage procedure for large osteochondral defects of the femoral condyle. *Orthop Traumatol* 2008;20:188-98. https://doi.org/10.1007/s00064-008-1301-3
7. Schaefer R. Prótesis unicompartimental de rodilla. *Rev Asoc Argent Ortop Traumatol* 1999;64(4):290-5. Disponible en: http://aaot.org.ar/revista/1993_2002/1999/1999_4/640406.pdf
8. Johal S, Nakano N, Baxter M, Hujazi I, Pandit H, Khanduja V. Unicompartmental knee arthroplasty: The past, current controversies, and future perspectives. *J Knee Surg* 2018;31(10):992-8. https://doi.org/10.1055/s-0038-1625961
9. Kalra S, Smith TO, Berko B, Walton NP. Assessment of radiolucent lines around the Oxford unicompartmental knee replacement: sensitivity and specificity for loosening. *J Bone Joint Surg Br* 2011;93(6):777-81. https://doi.org/10.1302/0301-620X.93B6.26062
10. Martínez JP, Arango AS, Castro AM, Martínez Rondanelli A. Validación de la versión en español de las escalas de Oxford para rodilla y cadera. *Rev Colomb Ortop Traumatol* 2016;30(2):61-6. https://doi.org/10.1016/j.rccot.2016.07.004

11. Jennings JM, Kleeman-Forsthuber LT, Bolognesi MP. Medial unicompartmental arthroplasty of the knee. *J Am Acad Orthop Surg* 2019;27(5):166-76. https://doi.org/10.5435/JAAOS-D-17-00690
12. Murray DW, Liddle AD, Judge A, Pandit H. Bias and unicompartmental knee arthroplasty. *Bone Joint J* 2017;99-B(1):12-5. https://doi.org/10.1302/0301-620X.99B1.BJJ-2016-0515.R1
13. Kozinn SC, Scott R. Unicondylar knee arthroplasty. *J Bone Joint Surg Am* 1989;71(1):145-50. PMID: 2643607
14. van der List JP, Chawla H, Zuiderbaan HA, Pearle AD. The role of preoperative patient characteristics on outcomes of unicompartmental knee arthroplasty: A meta-analysis critique. *J Arthroplasty* 2016;31(11):2617-27. https://doi.org/10.1016/j.arth.2016.04.001
15. Thienpont E. Conversion of a unicompartmental knee arthroplasty to a total knee arthroplasty: can we achieve a primary result? *Bone Joint J* 2017;99-B(1 Suppl A):65-9. https://doi.org/10.1302/0301-620X.99B1.BJJ-2016-0272
16. Isaac SM, Barker KL, Danial IN, Beard DJ, Dodd CA, Murray DW. Does arthroplasty type influence knee joint proprioception? A longitudinal prospective study comparing total and unicompartmental arthroplasty. *Knee* 2007;14(3):212-7. https://doi.org/10.1016/j.knee.2007.01.001
17. Insall J, Aglietti P. A five to seven-year follow-up of unicondylar arthroplasty. *J Bone Joint Surg Am* 1980;62(8):1329-37. PMID: 7440612
18. Wilson HA, Middleton R, Abram SGF, Smith S, Alvand A, Jackson WF, et al. Patient relevant outcomes of unicompartmental versus total knee replacement: systematic review and meta-analysis. *BMJ* 2019;364:1352. https://doi.org/10.1136/bmj.l352
19. van der List JP, McDonald LS, Pearle AD. Systematic review of medial versus lateral survivorship in unicompartmental knee arthroplasty. *Knee* 2015;22(6):454-60. https://doi.org/10.1016/j.knee.2015.09.011
20. Hang JR, Stanford TE, Graves SE, Davidson DC, de Steiger RN, Miller LN. Outcome of revision of unicompartmental knee replacement. *Acta Orthop* 2010;81(1):95-8. https://doi.org/10.3109/17453671003628731
21. Murray DW, Parkinson RW. Usage of unicompartmental knee arthroplasty. *Bone Joint J* 2018;100-B(4):432-5. https://doi.org/10.1302/0301-620X.100B4.BJJ-2017-0716.R1
22. Lombardi AV, Kolich MT, Berend KR, Morris MJ, Crawford DA, Adams JB. Revision of unicompartmental knee arthroplasty to total knee arthroplasty: Is it as good as a primary result? *J Arthroplasty* 2018;33(7S):S105-8. https://doi.org/10.1016/j.arth.2018.03.023
23. van der List JP, Zuiderbaan HA, Pearle AD. Why do medial unicompartmental knee arthroplasties fail today? *J Arthroplasty* 2016;31(5):1016-21. https://doi.org/10.1016/j.arth.2015.11.030
24. Baker PN, Petheram T, Avery PJ, Gregg PJ, Deehan DJ. Revision for unexplained pain following unicompartmental and total knee replacement. *J Bone Joint Surg Am* 2012;94(17):e126. https://doi.org/10.2106/JBJS.K.00791
25. Leta TH, Lygre SHL, Skredderstuen A, Hallan G, Gjertsen JE, Rokne B, et al. Outcomes of unicompartmental knee arthroplasty after aseptic revision to total knee arthroplasty: A comparative study of 768 TKAs and 578 UKAs revised to TKAs from the Norwegian Arthroplasty Register (1994 to 2011). *J Bone Joint Surg Am* 2016;98(6):431-40. https://doi.org/10.2106/JBJS.O.00499
26. Liddle AD, Pandit H, Judge A, Murray DW. Effect of surgical caseload on revision rate following total and unicompartmental knee replacement.*J Bone Joint Surg Am* 2016;98(1):1-8. https://doi.org/10.2106/JBJS.N.00487
27. Hamilton TW, Rizkalla JM, Kontochristos L, Marks BE, Mellon SJ, Dodd CAF, et al. The interaction of caseload and usage in determining outcomes of unicompartmental knee arthroplasty: A meta-Analysis. *J Arthroplasty* 2017;32(10):3228-37.e2. https://doi.org/10.1016/j.arth.2017.04.063

Adhesive Capsulitis of the Shoulder: Comparison Between Conservative Treatment Methods

Joao A. Bonadiman, Nelson Esteve, Felipe R. Triervelier Paiva, Paulo Piluski, Carlos H. Castillo Rodriguez, Osvandré Lech

São Vicente de Paulo Hospital, Passo Fundo Institute of Orthopedics and Traumatology, Rio Grande do Sul, Brazil

ABSTRACT

Objective: To evaluate the functional outcomes of three different conservative treatment protocols in patients with adhesive capsulitis of the shoulder. **Materials and Methods:** Reviews of medical records were carried out on patients treated at the institution for adhesive capsulitis in the period between January 2016 and January 2019. 3 different treatment protocols were compared. Group 1; Suprascapular nerve block (SSNB) with local anesthetic and corticosteroid, analgesics, and physiotherapy after pain reduction. Group 2: SSNB with local anesthetic without corticosteroids, analgesics, and physiotherapy, and group 3: analgesics and physiotherapy, without SSNB. The functional outcomes were determined with the ASES scale and the subjective results were assessed with the SSV. Results: A total of 46 patients treated for adhesive capsulitis were divided into 3 groups. Group 3 presented a higher mean number of physiotherapy sessions (30.31). Group 2 had the highest mean number of SSN blocks (3.27). The results of the functional scores were: group 1 (15 patients): mean ASES 84 and mean SSV 84; group 2 (15 patients): mean ASES 93.40 and mean SSV 91.67; group 3 (16 patients): mean ASES 79.4 and mean SSV 80.63. **Conclusion:** The various forms of conservative treatment for adhesive capsulitis achieve excellent outcomes. Analgesia through serial blocks of the suprascapular nerve with an anesthetic and corticosteroid achieved better functional and subjective outcomes and decreased the need to administer analgesics and physiotherapy sessions (group 1).

Keywords: Adhesive capsulitis; conservative treatment.

Level of Evidence: IV

Capsulitis adhesiva del hombro. Comparación entre métodos de tratamiento conservador

RESUMEN

Objetivo: Evaluar los resultados funcionales de tres protocolos distintos de tratamiento conservador en pacientes con capsulitis adhesiva del hombro. **Materiales y Métodos:** Se revisaron las historias clínicas de los pacientes tratados por capsulitis adhesiva en nuestra institución, entre enero de 2016 y enero de 2019. Se compararon tres protocolos diferentes de tratamiento: grupo 1, bloqueo del nervio supraescapular con un anestésico local y corticoide, analgésicos y fisioterapia después del alivio del dolor; grupo 2: bloqueo del nervio supraescapular con anestésico local sin corticoide, analgésicos y fisioterapia; grupo 3, analgésicos y fisioterapia, sin bloqueo del nervio supraescapular. Se determinaron los resultados funcionales con la escala ASES y el resultado subjetivo con el SSV. **Resultados:** Se dividió en tres grupos a 46 pacientes tratados por capsulitis adhesiva. Los pacientes del grupo 3 tuvieron, en promedio, más sesiones de fisioterapia (30,31±21,07). Los del grupo 2 recibieron la mayor cantidad promedio de bloqueos del nervio supraescapular (3,27 ± 1,22). Los resultados de los puntajes funcionales fueron: grupo 1 (15 pacientes): media 84 ASES y 84 SSV; grupo 2 (15 pacientes): media 93,40 ASES y 91,67 SSV; grupo 3 (16 pacientes): media 79,4 ASES y 80,63 SSV. **Conclusión:** Las distintas formas de tratamiento conservador para la capsulitis adhesiva logran excelentes resultados. La analgesia mediante bloqueos seriados del nervio supraescapular con un anestésico y corticoide logró mejores resultados funcionales y subjetivos, y disminuyó la necesidad de administrar analgésicos y de sesiones de fisioterapia (grupo 1).

Palabras clave: Capsulitis adhesiva; tratamiento conservador.

Nivel de Evidencia: IV

Received on July 17th, 2022. Accepted after evaluation on September 24th, 2022 • Dr. JOAO A. BONADIMAN • joaoartur10@gmail.com https://orcid.org/0000-0001-8613-4461

How to cite this article: Bonadiman JA, Esteve N, Triervelier Paiva FR, Faiad Piluski PC, Castillo Rodriguez CH, Lech O. Adhesive Capsulitis of the Shoulder: Comparison Between Conservative Treatment Methods. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):781-788. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1625

INTRODUCTION

Adhesive capsulitis of the shoulder (ACS) is a disease that manifests with pain and stiffness. The shoulder joint capsule is an elastic and flexible structure, made up of collagen, that surrounds the joint, and helps in the stability and function of the shoulder.[1] Inflammation of the capsule alters its morphological characteristics, thickening it and thus losing its elasticity. This condition evolves with pain, muscle contracture and myotendinous retractions that cause joint stiffness. 2-5% of the general population suffer from ACS, mainly between the 4th. and 6th. decades of life.[1-3]

Zuckerman et al. classified the causes of ACS as: idiopathic, when, by definition, there are no known causes, and secondary, when the cause or associated disease has been identified.[1] In the secondary forms, intrinsic shoulder lesions have been largely responsible for the initiation of the condition.[4-6]

This disease has four stages, as described by Neviaser. Stage 1, also called pre-adhesive, is characterized by a synovial inflammatory reaction; in stage 2, adhesions of the capsule to the humeral head begin; in stage 3, there is synovial regression with narrowing of the axillary recess; and stage 4 is the chronic phase.[7] Patients experience an insidious onset of rapidly aggravating pain and a decrease in active and passive ranges of motion that progresses to joint stiffness. In most cases, the clinical history and physical examination allow the diagnosis to be made. When an imaging study is necessary, MRI is the test of choice.[8-10]

Surgery is indicated when conservative treatment fails for at least six months. That time can range from 6 weeks to 12 months, depending on published data.[5,6,11] Procedures described as invasive are hydraulic distension of the joint capsule (high recurrence rate), joint manipulation under anesthesia, and open or arthroscopic capsular release.[4-6,11]

The objectives of this study were to evaluate and compare the functional outcomes of three different methods of conservative treatment in patients with ACS.

MATERIALS AND METHODS

A retrospective, comparative study was carried out at our institution between January 2016 and January 2019. 107 patients with ACS were evaluated, and 46 of them were included in the study after applying the inclusion and exclusion criteria.

The inclusion criteria were: patients with unilateral or bilateral idiopathic ACS who were willing to participate in the study. The exclusion criteria were: ACS secondary to other associated diseases, such as rotator cuff injuries, acromioclavicular conditions, sequelae of proximal humerus fractures, and degenerative diseases, such as primary glenohumeral osteoarthritis. Patients with treatment protocols other than those proposed, those who dropped out of outpatient follow-up or refused to participate in the study, those who could not respond due to neurological conditions, who could not be contacted due to a change in telephone number, or who had died were also excluded.

Three conservative treatment protocols for ACS were applied. The protocol for group 1 (15 patients) consisted of weekly serial suprascapular nerve (SSN) blocks with 2% lidocaine without a vasoconstrictor, and corticosteroids (betamethasone dipropionate and betamethasone disodium phosphate) along with analgesics and physical therapy to regain range of motion after pain relief. The protocol for group 2 (15 patients) included weekly serial SSN blocks with 2% lidocaine, without corticosteroids, and analgesics and physical therapy after pain relief. The group protocol for group 3 (16 patients) consisted of two doses of intramuscular corticosteroids (betamethasone dipropionate and betamethasone disodium phosphate) every seven days, analgesics and nonsteroidal anti-inflammatory drugs, rest, and immediate initiation of physical therapy.

In order to compare these three different treatment protocols, the ASES scale (*American Shoulder and Elbow Surgeons*)[12] was used for the functional evaluation of the shoulder and the SSV scale (*Subjective Shoulder Value*) was used for the subjective evaluation of each patient.[13] The average number of physical therapy sessions in each group, as well as complications and the need for surgical treatment were also recorded.

SSN block technique

The blocks were performed in a special room with the help of a nursing technician. The technique consists of injecting an anesthetic agent (with or without corticosteroid) into the suprascapular fossa of the scapula, with the patient seated and with the upper limbs at the sides of the body. Anatomical landmarks are identified: clavicle, acromioclavicular joint, acromion, spine of the scapula, and coracoid process (Figure 1).

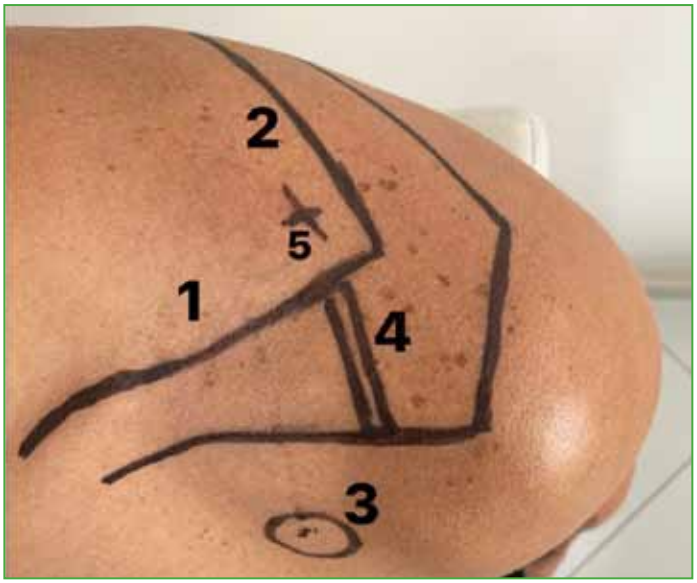


Figure 1. Identification of anatomical landmarks for suprascapular nerve block.
1. Posterior border of the clavicle. 2. Spine of the scapula. 3. Coracoid.
4. Acromioclavicular joint. 5. Suprascapular fossa.

After asepsis and antisepsis with alcoholic chlorhexidine, the needle is inserted medially to the apex of the lines obtained between the posterior border of the clavicle and the anterior border of the spine of the scapula, lateral to the base of the coracoid tubercle. (Figure 2).

Figure 2. Needle medial to the apex of the lines drawn on the posterior border of the clavicle and the posterior border of the spine of the scapula, lateral to the coracoid tubercle.

The needle is advanced in a craniocaudal direction, perpendicular to the skin, passing through the trapezius and supraspinatus muscles, until reaching the suprascapular fossa (3-4 cm), next to the base of the coracoid.[14] Aspiration is performed before injecting the anesthetic agent to avoid the risk of encountering the suprascapular artery and injecting directly into the bloodstream.

Statistical Analysis

A descriptive analysis of the results was carried out to obtain graphs and frequency tables, with the aim of characterizing the participants. Results are described as absolute frequency and percentage for categorical variables. Numerical variables are presented as mean, standard deviation, minimum, median, and maximum.

The distributions of the scores between the groups were analyzed with box plots. The box plot gives an idea of the position, dispersion, skewness and discrepant data, and is built by quartiles of data distribution.[15]

To compare the scores of the instruments between the treatment groups, and given that the distribution of the scores was asymmetric, the Kruskal-Wallis parametric test was chosen, which is indicated when the assumptions made in the parametric tests are not verified. In the Kruskal-Wallis test, the data of the samples of each group is put in order, where n_1,….n_k is the sample size of groups 1, … k, respectively. The study compared three types of treatment. There are two possible approaches to discover which of them had the best performance: the first is the parametric approach that requires, among other conditions, the assumption of normality of the data that does not comply with the nature of this study; the second approach is the non-parametric one that, when working with other types of variables such as rankings, does not require as many conditions on the variables and, therefore, turned out to be ideal for the study. The non-parametric technique adopted was the Kruskal-Wallis test. This technique considers each of the three groups of interest and analyzes the size of each group, that is, n1 is the number of individuals in group 1, n2 is the number of individuals in group 2, and n3 is the number of individuals in group 3. Then, for each of the three sample groups, the values collected for each individual in that sample are looked at and ranked in order of importance (lowest to highest values). If there are ties, the score is given by the mean of the orders of the repeated observations. Then the sum of the positions R1….Rk of each group is made. According to Sheskin (2003), the H-statistic is given by the following formula:

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \left| \frac{(\sum R_i)^2}{n_i} \right| - 3(n+1).$$

The X2 distribution is used to approximate the H-statistic, with k-1 degrees of freedom. If the result of the Kruskal-Wallis test is significant, it indicates that there are significant differences between at least 2 medians in the groups.[16] All analyses were performed with the help of the R statistical environment (R Development Core Team), version 3.5.

RESULTS

The majority of the sample was female (Table 1). The mean number of physical therapy sessions (14.67 ± 13.29) and SSN blocks (2.4 ± 1.06) was lower in group 1 patients. On the other hand, the highest number of physical therapy sessions (30.31 ± 21.07) was recorded in group 3, reaching a maximum of 100 sessions. Group 2 patients received the greatest number of blocks (3.27 ± 1.22) (Table 2).

Table 1. Absolute and relative frequencies of the sex variable, by treatment group

Group	Sex		Total
	Female	Male	
1	12 (80%)	3 (20%)	15 (100%)
2	12 (80%)	3 (20%)	15 (100%)
3	12 (75%)	4 (25%)	16 (100%)
Total	**36 (78%)**	**10 (22%)**	**46 (100%)**

Table 2. Descriptive measures of the physiotherapy and blocks variables, by treatment group

Variable	Group	Mean	Standard deviation	Minimum	Median	Maximum
Physiotherapy	1	14.67	13.29	0.00	15.00	50.00
	2	18.13	5.55	10.00	20.00	30.00
	3	30.31	21.07	2.00	29.00	100.00
Blocks	1	2.40	1.06	1.00	3.00	4.00
	2	3.27	1.22	1.00	3.00	6.00
	3	-	-	-	-	-

The results of the ASES and SSV scales were compared between the patients of the three groups (Figure 3). Most of the patients in the three treatment groups had high scores. In group 2, the results had less variability, while the lowest values were recorded in group 3 (Table 3).

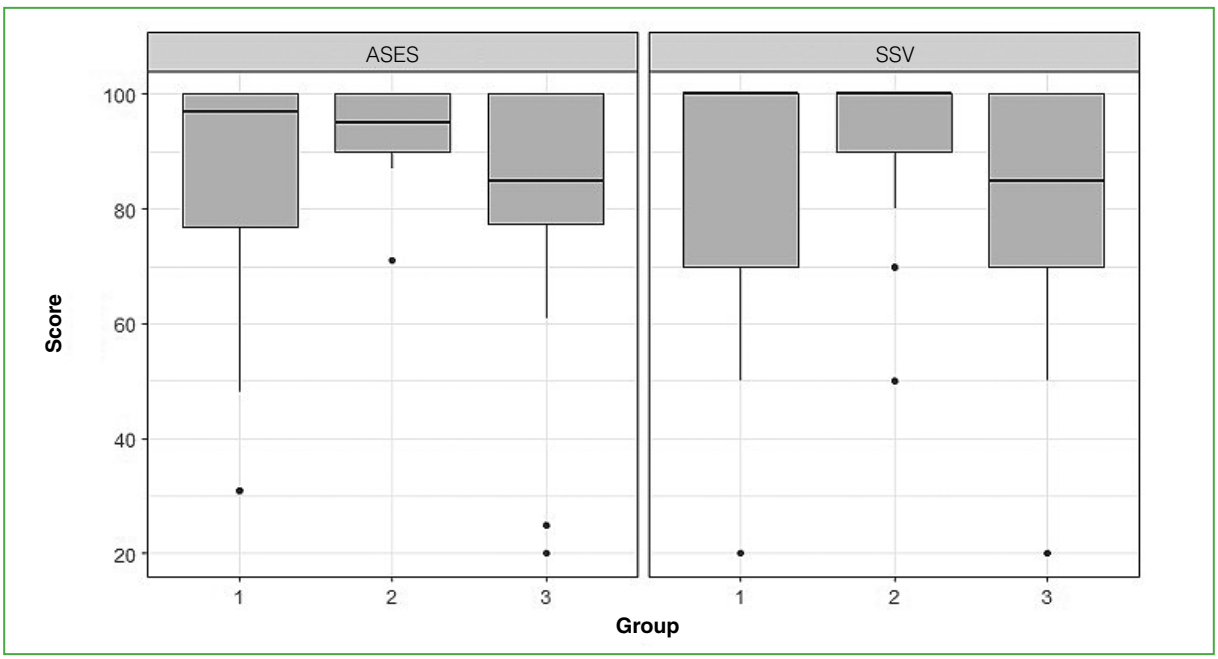


Figure 3. Box plot of the ASES (*American Shoulder and Elbow Surgeons*) and SSV (Subjective Shoulder Value) scores, by treatment group.

Table 3. Descriptive measures and result of the Kruskal-Wallis test for the comparison of two scores,* by treatment group

Variable	Group	Mean	Standard Deviation	Minimum	Median	Maximum	p
ASES	1	84.00	23.48	31.00	97.00	100.00	0.192
	2	93.40	7.97	71.00	95.00	100.00	
	3	79.44	24.92	20.00	85.00	100.00	
SSV	1	84.00	24.73	20.00	100.00	100.00	0.450
	2	91.67	14.60	50.00	100.00	100.00	
	3	80.63	23.80	20.00	85.00	100.00	

*_American Shoulder and Elbow Surgeons_ (ASES) and _Subjective Shoulder Value_ (SSV), by treatment group.

Complementing the results shown in Figure 3, Table 3 shows that all the groups obtained the maximum score of 100 on the two scales, while the minimum score was 20.

The lowest scores were recorded in group 3, both in the mean (79.44 and 80.63 for the ASES and SSV scales, respectively) and in the median (885 for both).

Group 2 averages on the ASES and SSV scales were 93.40 and 91.67, respectively, the highest among the three groups. According to the results of the Kruskall-Wallis test at a significance level of 5%, there is insufficient evidence of a significant difference between the three groups evaluated (p 0.192 for the ASES scale and p 0.450 for the SSV scale).

DISCUSSION

The objective of this study was to compare the functional and subjective outcomes of three different protocols for the conservative treatment of ACS. Reeves and Gray referred to the natural course of ACS and stressed its self-limiting condition, whereby symptoms and movement restrictions gradually and spontaneously normalize in patients with primary idiopathic ACS.[8,9] Based on these movement limitations, we decided to compare the functional outcomes of patients treated conservatively with three different therapeutic protocols.

In our study, the prevalence of ACS was 78% in females, a percentage similar to that reported in the literature.[3,11,17]

The realization that ACS is a self-limiting condition led Godinho et al. to propose a treatment that could follow the natural evolution of the disease, making it less disabling, with a shorter recovery, intensifying pain relief in phase 1 and providing good support for the following phases.[6,18]

In a randomized study, Ranalletta et al. compared the administration of oral nonsteroidal anti-inflammatory drugs with the application of a single intramuscular injection of corticosteroids. The injection relieved pain more quickly and improved function and movement of the shoulder sooner.[19] In our study, the group treated with SSN block with corticosteroids and anesthetic required fewer blocks to relieve pain and improve range of motion.

The SSN block is a method adopted in many shoulder surgery departments. In a meta-analysis, Chang et al. compared SSN block with physical therapy, placebo and intra-articular injection for chronic shoulder pain. In that study, the outcomes were superior with the SSN block compared with placebo and physical therapy, results similar to the block with intra-articular injection.[20] In our study, SSN block yielded better outcomes and the patients required fewer physical therapy sessions.

Checcia et al. performed a retrospective study in 133 patients treated with serial SSN blocks and physical therapy to recover range of motion. They observed that the blocks promoted a rapid and lasting improvement in pain, and this made it easier to start range of motion exercises.[2] In our study, comparing the two SSN block methods (with and without corticosteroids), the final functional and subjective outcomes were better.

There is no consensus in the literature on which treatment method—surgical, conservative, or combined—is the most effective for the management of ACS. Treatment methods (surgical and conservative) do not alter the natural

course of the disease; however, they do promote short-term pain relief and improvement in shoulder range of motion.[21] It has been shown that patients who do not undergo SSN blocks require more physical therapy sessions and more analgesics.

According to the classification of the causes of ACS, analgesia is an important factor in the treatment; the functional use of the shoulder is the only non-invasive method to restore its non-elastic capsule. Motivation and the ability to perform capsule stretching with active exercises, withstanding some degree of physical discomfort, are also required.[2,18,22] Taking into account this important function, SSN block with corticosteroids achieves the best outcomes in order to start physical therapy sessions more quickly.

Drugs, anesthetic blocks and physical therapy are the basis of conservative treatment, whether alone, in the early stages, or in combination with other therapeutic modalities in the later stages. For Ramírez et al., the most effective treatment for ACS is uncertain.[10]

Conservative treatment includes the use of nonsteroidal anti-inflammatory agents, short-term oral corticosteroids, SSN blocks with or without corticosteroids, physical therapy, acupuncture, and capsule hydrodilatation.[4,6,11,22]

Complications of conservative treatment are chronic pain and limited movement. When symptoms do not improve with conservative treatment, some patients require surgery that can cause complications, including fractures, labral injuries, dislocations, and rotator cuff injuries.[4,23]

CONCLUSIONS

ACS is a prevalent disease in females. Excellent outcomes can be achieved with various forms of conservative treatment. Analgesia through serial SSN blocks with corticosteroids achieved the best functional and subjective outcomes, and decreased the need for analgesics and physical therapy sessions.

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

N. Esteve ORCID ID: https://orcid.org/0000-0002-8456-9020
F. R. Triervelier Paiva ORCID ID: https://orcid.org/0000-0001-6127-2980
P. C. Faiad Piluski ORCID ID: https://orcid.org/0000-0002-1887-8861
C. H. Castillo Rodriguez ORCID ID: https://orcid.org/0000-0002-4968-8390
O. Lech ORCID ID: https://orcid.org/0000-0002-9727-2330

REFERENCES

1. Zuckerman JD, Rokito A. Frozen shoulder: A consensus definition. *J Shoulder Elbow Surg* 2011;20(2):322-5. https://doi.org/10.1016/j.jse.2010.07.008
2. Checchia SL, Fregoneze M, Miyazaki AN, Doneux Santos P, Andrade da Silva L, Ossada A, et al. Tratamento da capsulite adesiva com bloqueios seriados do nervo supra-escapular. *Rev Bras Ortop* 2006;41(7):245-52. Available at: https://cdn.publisher.gn1.link/rbo.org.br/pdf/41-6/2006_jul_08.pdf
3. Malavolta EA, Gracitelli ME, Assunção JH, Pinto GM, Silveira AZ, Ferreira Neto A. Shoulder disorders in an outpatient clinic: An epidemiological study. *Acta Ortop Bras* 2017;25(3):78-80. https://doi.org/10.1590/1413-785220172503170849
4. Miyazaki AN, Santos PD, Silva LA, Sella GdV, Carrenho L, Checchia SL. Clinical evaluation of arthroscopic treatment of shoulder adhesive capsulitis. *Rev Bras Ortop (English ed.)* 2017;52(1):61-8. https://doi.org/10.1016/j.rboe.2016.12.004
5. Endres NK, ElHassan B, Higgins LD, Warner JJP. The stiff shoulder. En: *Rockwood and Matsen´s The shoulder.* 4th ed. Philadelphia: Saunders; 2009:1405-1435. https://doi.org/10.1016/B978-1-4160-3427-8.50035-0
6. Georgiannos D, Markopoulos G, Devetzi E, Bisbinas I. Adhesive capsulitis of the shoulder. Is there consensus regarding the treatment? A comprehensive review. *Open Orthop J* 2017;11:65-76. https://doi.org/10.2174/1874325001711010065
7. Neviaser JS. Adhesive capsulitis and the stiff and painful shoulder. *Orthop Clin North Am* 1980;11(2):327-31. https://doi.org/10.1016/S0030-5898(20)31482-6

8. Grey R. The natural history of 'idiopathic' frozen shoulder. *J Bone Joint Surg Am* 1978;60(4):564. https://doi.org/10.2106/00004623-197860040-00029
9. Reeves B. The natural history of the frozen shoulder syndrome. *Scand J Rheumatol* 1975;4(4):193-6. https://doi.org/10.3109/03009747509165255
10. Ramirez J. Adhesive capsulitis: Diagnosis and management. *Am Fam Physician* 2019;99(5):297-300. PMID: 30811157
11. Lech O, Sudbrack G, Valenzuela CN. Capsulite adesiva ("ombro congelado"). abordagem multidisciplinar. *Rev Bras Ortop* 1993;24:617-24. Available at: https://rbo.org.br/detalhes/951/pt-BR
12. Michener LA, McClure PW, Sennett BJ. American shoulder and elbow surgeons standardized shoulder assessment form, patient self-report section: Reliability, validity, and responsiveness. *J Shoulder Elbow Surg* 2002;11(6):587-94. https://doi.org/10.1067/mse.2002.127096
13. Gilbart MK, Gerber C. Comparison of the subjective shoulder value and the constant score. *J Shoulder Elbow Surg* 2007;16(6):717-21. https://doi.org/10.1016/j.jse.2007.02.123
14. Dangoisse MJ, Wilson DJ, Glynn CJ. MRI and clinical study of an easy and safe technique of suprascapular nerve blockade. *Acta Anaesthesiol Belg* 1994;45(2):49-54. PMID: 7976163
15. Morettin PA, Bussab WO. *Estatística básica,* 7ª. ed. São Paulo: Editora Saraiva; 2011.
16. David J. *Handbook of parametric and nonparametric statistical procedures.* 3rd ed. New York: Chapman & Hall/CRC; 2004.
17. Cohen C, Tortato S, Bento Souza Silva O, Ferreira Leal M, Ejnisman B, Faloppa F. Association between frozen shoulder and thyroid diseases: Strengthening the evidences. *Rev Bras Ortop* 2020;55(4):483-9. https://doi.org/10.1055/s-0039-3402476
18. Pardini A, Godinho G. Capsulite adesiva: Tratamento conservador. In: Pardini A. *Clínica ortopédica.* Rio de Janeiro: Medsi; 2000:197-202.
19. Ranalletta M, Rossi LA, Bongiovanni SL, Tanoira I, Elizondo CM, Maignon GD. Corticosteroid injections accelerate pain relief and recovery of function compared with oral NSAIDs in patients with adhesive capsulitis: A randomized controlled trial. *Am J Sports Med* 2016;44(2):474-81. https://doi.org/10.1177/0363546515616238
20. Chang KV, Hung CY, Wu WT, Han DS, Yang RS, Lin CP. Comparison of the effectiveness of suprascapular nerve block with physical therapy, placebo, and intra-articular injection in management of chronic shoulder pain: A meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil* 2016;97(8):1366-80. https://doi.org/10.1016/j.apmr.2015.11.009
21. Yip M, Francis A, Roberts T, Rokito A, Zuckerman JD, Virk MS. Treatment of adhesive capsulitis of the shoulder: A critical analysis review. *JBJS Rev* 2018;6(6):e5. https://doi.org/10.2106/JBJS.RVW.17.00165
22. Lafosse L, Boyle S, Kordasiewicz B, Guttierez-Arramberi M, Fritsch B, Meller R. Arthroscopic arthrolysis for recalcitrant frozen shoulder: A lateral approach. *Arthroscopy* 2012;28(7):916-23. https://doi.org/10.1016/j.arthro.2011.12.014
23. Redler LH, Dennis ER. Treatment of adhesive capsulitis of the shoulder. *J Am Acad Orthop Surg* 2019;27(12):e544-e554. https://doi.org/10.5435/JAAOS-D-17-00606

WALANT in Carpal Tunnel Release. Comparative Study of Two Technical Variants in 89 Cases

Luciano Poitevin, María Solange Ferraguti
Department of Orthopedics and Traumatology, Hospital de Clínicas "José de San Martín", University of Buenos Aires, Argentina

ABSTRACT

Objective: To evaluate the intraoperative and postoperative efficacy and comfort of two variants of anesthesia in two groups with carpal tunnel syndrome (CTS). **Materials and Methods:** Descriptive, comparative, retrospective, observational study using a 12-item telephone questionnaire on local anesthesia without a tourniquet. We included patients with CTS who underwent surgery between 2008 and 2019 with a mini-open approach and divided them into two groups: 1) 2% lidocaine plus 0.5% bupivacaine plus 1:200,000 epinephrine plus light sedation (n = 32) and 2) 2% lidocaine plus epinephrine 1:200,000 (n = 57). **Results:** 89 patients were evaluated (mean age 66.9 years). All patients were satisfied and confirmed they would choose this procedure again. There were no significant differences in comfort or the possible development of intra- or postoperative symptoms between the two groups. The postoperative stay was 1-3 hours; hospitalization was not required. The bleeding was minimal. **Conclusion:** Carpal tunnel release under local anesthesia with lidocaine + epinephrine, without a tourniquet, has proven to be a safe procedure with no complications. The patients did not complain of local immediate intraoperative or postoperative pain or pain at the site of the tourniquet. The stay in the healthcare facility was shorter. The short stay and the fewer elements used (anesthetics, tourniquet) imply a reduction in the costs of the procedure. Though the presence of an anaesthesiologist is recommended, the procedure can be performed in appropriate settings without one. We do not recommend its use without preoperative studies or outside the operating room.
Keywords: Hand; carpal tunnel syndrome; local anesthesia; epinephrine.
Level of Evidence: III

Anestesia local con epinefrina, sin manguito hemostático, para la liberación del túnel carpiano. Estudio comparativo de dos variantes técnicas en 89 casos

RESUMEN

Objetivo: Evaluar la eficacia intra y posoperatoria, y la comodidad para el paciente de dos variantes de la anestesia en dos grupos con síndrome del túnel carpiano. **Materiales y Métodos**: Estudio descriptivo, comparativo, retrospectivo, observacional mediante un cuestionario telefónico de 12 ítems sobre la anestesia local sin manguito. Se incorporó a pacientes con síndrome del túnel carpiano operados entre 2008 y 2019, mediante un miniabordaje abierto, y se los dividió en: grupo 1: lidocaína al 2% más bupivacaína al 0,5% más epinefrina 1:200.000 más sedación ligera (n = 32) y grupo 2: lidocaína al 2% más epinefrina 1:200.000 (n = 57). **Resultados:** Se evaluó a 89 pacientes (media de edad 66.9 años). Todos se mostraron satisfechos y confirmaron que volverían a elegir este procedimiento. No hubo diferencias significativas en la comodidad o el posible desarrollo de síntomas intra o posoperatorios entre ambos grupos. La permanencia posoperatoria fue de 1-3 h, sin hospitalización. El sangrado fue mínimo. **Conclusiones**: La liberación del túnel carpiano bajo anestesia local más epinefrina, sin manguito hemostático, resultó segura y sin complicaciones. Los pacientes no refirieron dolor local intraoperatorio ni posoperatorio inmediato, ni en el sitio del torniquete. La permanencia en el centro asistencial fue breve. La estancia corta y la menor cantidad de elementos empleados (anestésicos, manguito) implican una reducción de los costos del procedimiento. Si bien es recomendable la presencia de un anestesiólogo, puede llegar a realizarse en ámbitos adecuados sin él. No se recomienda su empleo sin estudios prequirúrgicos ni fuera del quirófano.
Palabras clave: Mano; síndrome del túnel carpiano; anestesia local; epinefrina.
Nivel de Evidencia: III

Received on November 19th, 2021. Accepted after evaluation on July 4th, 2022 • Dr. MARÍA SOLANGE FERRAGUTI • solangeferraguti@yahoo.com.ar https://orcid.org/0000-0002-3225-4561
How to cite this article: Poitevin L, Ferraguti MS. WALANT in Carpal Tunnel Release. Comparative Study of Two Technical Variants in 89 Cases. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):789-797. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1466

INTRODUCTION

In recent years, the use of epinephrine local anesthesia without the use of a hemostatic cuff has become popular for many ambulatory hand and wrist surgical procedures.[1] Epinephrine has also been shown to be safe at the digital level: a study evaluating a large number of digital blocks has refuted this concern as long as the concentration is more diluted than 1:100,000.[2] This technique is known as WALANT (*Wide Awake Local Anesthesia – No Tourniquet*). It allows the evaluation of the mobility and function of the fingers during surgery.

The main objective of this study was to evaluate patient comfort and the efficacy of this method of anesthesia during surgery and in the postoperative period, as well as its level of safety in carpal tunnel release procedures. In addition, two technical variants of local anesthesia with epinephrine were compared in two groups of patients, with different surgeons and in different institutions.

The hypotheses proposed were: 1) that the method offers benefits compared to what is observed with conventional methods (brachialgia due to the tourniquet does not appear, nor paresthesias secondary to regional anesthesia, nor ischemic or other complications; bleeding is minimal and it does not hinder surgery, a final hemostasis stage is not required, the surgical procedure lasts a short time, the patients are satisfied and the postoperative stay in the health center is short); 2) that there should be no significant differences between the two groups studied.

MATERIALS AND METHODS

A descriptive, comparative, retrospective, observational study was carried out. The population included two groups of patients diagnosed with carpal tunnel syndrome operated on between August 2008 and December 2019. The exclusion criteria were: age <18 years, previous carpal tunnel release treatment, unwillingness of the patient to consider this therapeutic option and previous adverse reactions to local anesthetics. The demographic characteristics recorded were: sex, age, affected hand, work activity (active or retired).

The 89 patients with carpal tunnel syndrome who underwent a palmar mini-incision were divided into: group 1 (n = 32), who were administered a mixture of lidocaine and bupivacaine with buffer, sedation by an anesthetist, and topical anesthetic solution during surgery, as described further below; and group 2 (n = 57), who received 20 cc of 2% lidocaine with epinephrine, without sedation, and without the participation of an anesthesiologist.

The patients gave their consent to answer a telephone questionnaire on the following items:

1) Did you feel pain when the needle was inserted, when the anesthetic fluid was injected, and during surgery (0-10 visual analog scale)?

2) Did you feel pain during the surgery which needed a reinforcement of anesthesia?

3) Did you feel short of breath?

4) Brachialgia (pain proximal to the elbow) intra or postoperatively,

5) Nausea, vomiting,

6) Need for hospitalization,

7) Need for care by third parties,

8) Timing of food intake

9) Postoperative medication,

10) Sleep quality,

11) Soiling of dressings,

12) Would you choose the same anesthesia?

Anesthetic technique

Before changing and placing the fields, the surgeon administers local anesthesia using an aseptic technique; this step allows time for the anesthesia and epinephrine to work.

Anesthetic solution

Group 1: 20 cc of 2% lidocaine plus 20 cc of 0.5% bupivacaine, both with epinephrine 1:200,000 plus 20 cc of saline solution plus 2 drops of epinephrine 1:1000 (1 ml ampoule with 1 mg epinephrine) plus 4 cc of 1 M sodium bicarbonate solution plus prior sedation with 0.5 mg midazolam by an anesthesiologist. Injection of approximately 40 cc of the mixture. During the intervention, gauze soaked in a mixture of 200 cc of physiological solution plus an epinephrine ampoule are used, which are placed on the tissues as an adjunct to hemostasis. Administration of light sedation by an anesthesiologist.

Group 2: 20 cc of 2% lidocaine with epinephrine, without sedation.

Skin puncture: 1 cm proximal to the proximal crease of the wrist, in the axis of the 3rd commissure, avoiding the superficial veins, with a 15/5 needle. Infiltration of 1 cc, 30-second wait.

Infiltration: proximally and distally, progressing the anesthesia before the needle. Needle change: 50/8, placed in the same orifice. Infiltration towards proximal, distal, medial and lateral (Figure 1).

Figure 1. Proximal injection with 50/8 needle.

More distal puncture, if necessary, to complete the infiltration. The skin should be ischemic (white) (Figure 2).

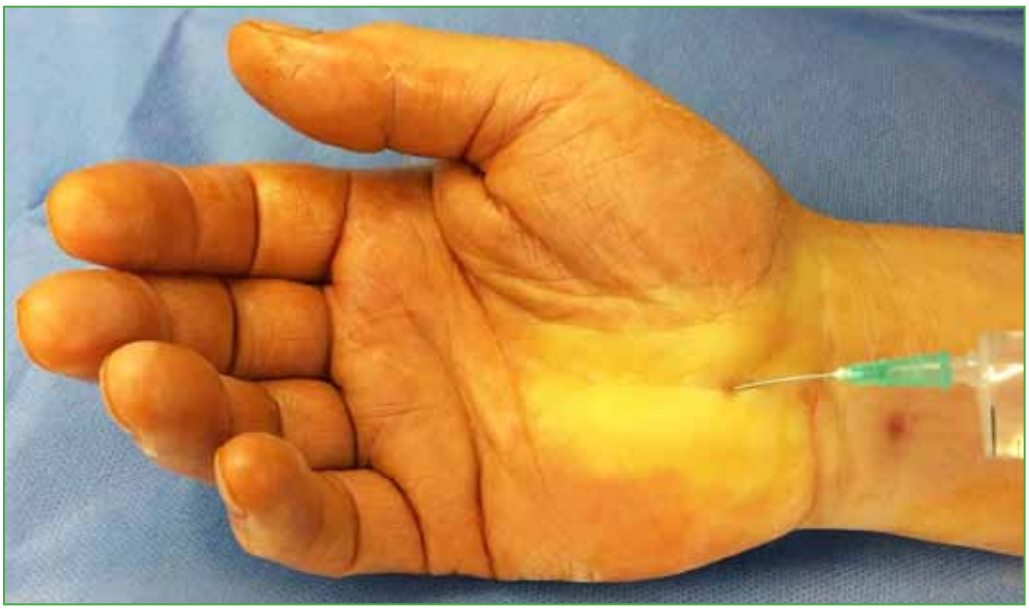


Figure 2. Distal injection with 50/8 needle. Note the skin ischemia.

In both groups, the technical details indicated by Lalonde were followed:

a. Insertion of the needle perpendicular to the skin.

b. Subdermal wheal (not intradermal) 1 cc and wait 30 seconds.

c. Slow needle progression causing the anesthetic to precede the needle.

d. Injecting a large volume of anesthetic fluid (principle of tumescence).

e. Waiting 30 min to start surgery in order to obtain maximum vasoconstriction, as recommended by McKeey et al.[3] Meanwhile, the surgical team washes, changes, and drapes.

Surgical technique

A 3 cm incision is made, distal to the distal crease of the wrist, in the axis of the 3rd commissure. The distal edge of the flexor retinaculum is identified. The entire retinaculum is sectioned, including the distal antebrachial fascia, following the ulnar border of the palmaris minor tendon (Figure 3).

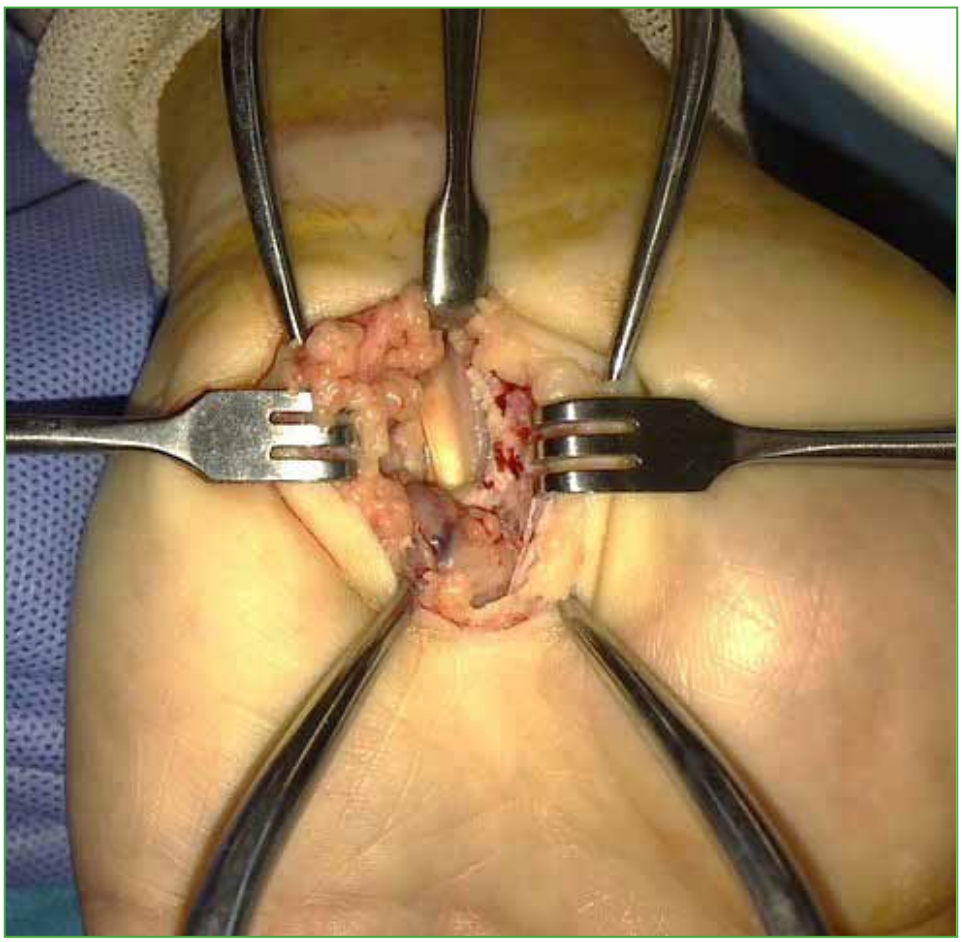


Figure 3. Decompressed median nerve. Note the skin ischemia and the bloodless field.

Statistical Analysis

A two-tailed Student's t test for independent data and the Mann-Whitney U test were used. A p-value <0.05 was considered statistically significant.

RESULTS

89 patients with carpal tunnel syndrome were evaluated. The demographic characteristics of each study group were comparable (Table 1). No statistically significant differences were observed in the demographic variables, with the exception of work activity. The affected hands were 21 right and 11 left in group 1, and 37 right and 20 left in group 2. The patients were 23 men and 66 women, with a mean age of 66.9 years (range 21-90); the predominant age ranged between the sixth and seventh decades of life.

Table 1. Demographic characteristics of the groups.

	Group 1 n (%)	Group 2 n (%)	Total	p
Sex				0.38
Male	10 (31.2)	13 (22.8)	23	
Female	22 (68.8)	44 (77.2)	66	
Age (mean), years	67.5	66.81	66.97	0.4
Affected hand				0.94
Left	21 (65.7)	37 (64.9)	58	
Right	11 (34.3)	20 (35.1)	31	
Work activity				0.007
Active	25 (78.2)	28 (49.1)	53	
Retired	7 (21.8)	29 (50.9)	36	

All patients reported being satisfied with the anesthetic procedure. The pain intensity evaluated by the visual analog scale (Figure 4 and Table 2) was higher in group 2, with statistical significance. The mean response to pain during the introduction of the needle was 0.94 ± 1.24 in group 1 and 1.63 ± 3.03 in group 2 (p = 0.006) and, during the injection of the liquid, it was of 0.62 ± 1.15 in group 1 and 1.91 ± 1.54 in group 2 (p = 0.004). Lastly, the pain score during surgery was 0.16 ± 1.24 in group 1 and 1.91 ± 1.54 in group 2 (p = 0.001).

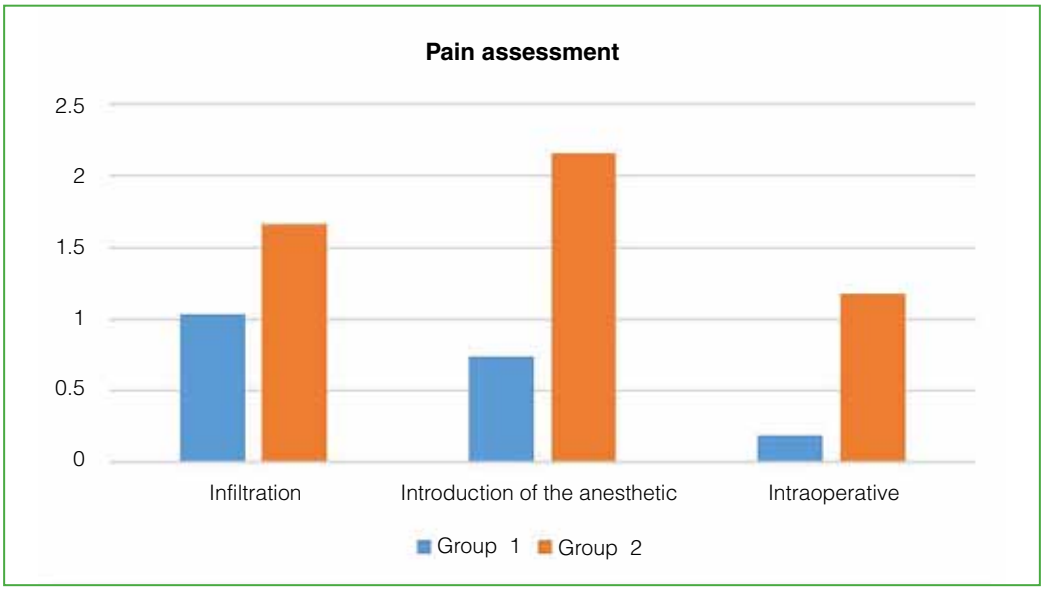


Figure 4. Comparison of pain assessment in three different situations.

Table 2. Statistical analysis

			Group 1			Group 2	
Pain (VAS)	Mean	SD	95%CI	Mean	SD	95%CI	p
Infiltration	0.94	1.24	0.49-1.38	1.63	3.03	0.82-2.43	0.006
Introduction of the anesthetic	0.62	1.15	0.2-1.04	1.91	1.54	1.5-2.31	0.004
Intraoperative (h)	0.16	1.24	0.29-0.64	1.91	1.54	1.5-2.31	0.001
Food intake (h)	6.75	2.88	5.71-7.78	6.57	2.53	5.97-7.17	0.37

VAS = visual analog scale; SD = standard deviation; 95% CI = 95% confidence interval.

There were no statistically significant differences between both groups in the possible development of intra- or postoperative symptoms. Postoperative food intake was 6.75 ± 2.88 h in group 1 and 6.57 ± 2.53 h in group 2 (p = 0.37). No patient required hospitalization and the stay in the healthcare center after surgery ranged from 1 to 3 hours (Table 3). There were no ischemic complications. Bleeding was minimal and did not hinder the surgical procedure.

Most of the patients studied did not report complications in the immediate postoperative period, except one from group 2 who suffered brachialgia and one from group 1 who reported nausea (Table 3).

81.25% of group 1 and 87.72% of group 2 required postoperative medication (p = 0.4). 96.88% of group 1 and 98.25% of group 2 reported that sleep quality was good (p = 0.67).

Almost all the members of group 1 (except one) confirmed that they would choose this procedure instead of general anesthesia or a regional block, which gave 96.9% of positive responses, compared to 100% in group 2 (p = 0.27).

Table 3. Comparison of symptoms and other items

	Group 1	Group 2	p
Dyspnea	0%	0%	
Brachialgia	0%	1.75% (1)	
Hospitalization	0%	0%	
Care by relative	3.13% (1)	0%	
Nausea, vomiting	3.13% (1)	0%	
Postoperative medication	81.25% (26)	87.72% (50)	0.4
Sleep quality	96.88% (31)	98.25% (56)	0.67
Same anesthesia	96.8% (31)	100%	0.27

DISCUSSION

In 1979, Lichtman et al.[4] were one of the first authors to publish their results with local anesthesia for the release of the carpal tunnel under a tourniquet, without sedation. The results as an outpatient procedure were satisfactory in 93 patients.

Lalonde[5] has been the author who most disseminated the use of WALANT in hand surgery. This author stated that the cases of digital necrosis described above were caused by procaine and not by epinephrine.

A survey of members of the *American Society for Surgery of the Hand* conducted by Duncan et al.[6] revealed that 2.4% of those surveyed exclusively used general anesthesia and 19.9% used regional anesthesia in all their patients. The use of general anesthesia would have greatly increased the costs of the procedure in the hospital.

There were no ischemic complications in either group, although anesthesia was not applied to the fingers, due to the nature of the surgical procedure. Also, by not using a hemostatic cuff and avoiding regional block or general anesthesia, the procedure was simplified and the discomfort of paresthesias usually described with axillary or supraclavicular block was not produced.

In a randomized comparative case-control study evaluating lidocaine injection with or without the use of a tourniquet for hemostasis in patients undergoing bilateral release, Braithwaite et al.[7] demonstrated that intraoperative pain could be up to twice as intense with the use of a tourniquet than with only local infiltration plus epinephrine. They used a visual analog scale to measure intraoperative pain and obtained scores of 4.7 with the use of a tourniquet and 2.2 without a tourniquet (haemostasis by infiltration of xylocaine plus adrenaline) ($p < 0.01$). Ralt et al.[8] published similar conclusions.

Coinciding with Braithwaite et al.,[7] since in the local anesthesia procedure performed in this study only lidocaine, alone or associated with bupivacaine, is used, in both cases with epinephrine (as administered in dental offices around the world), the comorbidities of the patients are rarely a concern.

Post-anesthetic recovery was rapid, although only the patients in group 1 of our study received sedation and, in the other group, there was no anesthesiologist. This modality was forced by the lack of an anesthesiologist in each of the operating rooms of the corresponding public hospital. However, there was an anesthesiologist in the adjacent operating rooms. It is understood that there may be objections from the medico-legal point of view. For this reason, it is considered that the ideal is to have an anesthesiologist in the operating room.

Contrary to Lalonde's recommendation,[9] we consider that it would not be advisable to carry out these interventions in outpatient clinics, nor to dispense with previous studies of surgical risk.

Gordley and Basu[10] reported that lidocaine with epinephrine contains acidic preservatives that produce a pH of 3.5 to 4.5 and plain lidocaine has a pH of 6.5 to 6.8. Therefore, the use of lidocaine (especially with epinephrine) often requires buffering with sodium bicarbonate to minimize the burning sensation. Regarding the statistical

comparison between the two groups analyzed in this study, the buffering effect of 1cc of 1M sodium bicarbonate solution every 10cc of lidocaine plus bupivacaine in group 1 could presumably decrease the pain of anesthetic agent injection.

The impact of sedation administered by an anesthesiologist in group 1 could also explain the significant difference in pain during the injection and the surgical procedure between the two groups. In any case, in group 2, the main value of pain on the visual analog scale was 1.91, which is significantly low.

There were no significant differences between the two groups, except in the pain item.

Regarding the form of administration of the solution, the technique described by Lalonde and Wong was used, as already indicated.[11]

It should be noted that the analysis of long-term surgical results is not the objective of this study.

The procedure of carpal tunnel release under local anesthesia with lidocaine plus epinephrine and the optional addition of bupivacaine and sodium bicarbonate buffer, without a tourniquet, has been shown to be safe and cause no complications. The addition of bupivacaine is recommendable, although when our two groups were compared, anesthesia did not last longer with said addition.

The anesthesia time is similar to or less than that of a general or regional anesthesia and, as in conventional anesthesia, it is performed before placing the fields. As the bleeding is minimal, it does not prolong the surgery and does not require additional hemostasis time to release the tourniquet.

Thus, this anesthetic procedure makes it possible to avoid both more invasive anesthesia and the discomfort of the tourniquet without causing ischemic complications or excessive bleeding. However, one of the limiting factors of our study is the lack of a control group with patients operated on for carpal tunnel syndrome in whom a tourniquet was used to compare the results. Therefore, estimates of this type are qualitative and based on published studies and the authors' personal experience with conventional anesthesia.

Not using a tourniquet, Esmarch® bandage, or ultrasound device to guide the regional block and having a shorter estimated duration of the procedure in comparison to conventional methods—because the anesthetic procedure takes less time and no additional hemostasis time is necessary as it happens when releasing the tourniquet— imply a reduction in costs. Although the presence of an anesthesiologist is recommended, it could be performed in suitable settings without this professional. Its use is not recommended without pre-surgical studies or in settings outside the operating room.

Bleeding was minimal and visualization of the surgical field was very good, which did not prolong surgery time. The benefits for the patients were not suffering immediate intra- or postoperative local pain or in the usual tourniquet site. Likewise, a shorter stay in the healthcare center was qualitatively noted compared to the usual stay after procedures with regional block or general anesthesia.

Conflict of interest: The authors do not declare conflicts of interest.

L. Poitevin ORCID ID: https://orcid.org/0000-0002-8652-4723

REFERENCES

1. Lalonde DH, Wong A. Dosage of local anaesthesia in wide awake hand surgery. *J Hand Surg Am* 2013;38(10):2025-8. https://doi.org/10.1016/j.jhsa.2013.07.017
2. Lalonde D, Bell M, Benoit P, Sparkes G, Drenkel K, Chang P. A multicentre prospective study of 3,110 consecutive cases of elective epinephrine use in the fingers and hand: the Dalhousie project clinical phase. *J Hand Surg Am* 2005;30(5):1061-7. https://doi.org/10.1016/j.jhsa.2005.05.006

3. McKee DE, Lalonde DH, Thoma A, Glennie DL, Hayward JE. Optimal time delay between epinephrine injection and incision to minimize bleeding. *Plast Reconstr Surg* 2013;131(4):811-4. https://doi.org/10.1097/PRS.0b013e3182818ced
4. Lichtman DM, Florio RL, Mack GR. Carpal tunnel release under local anaesthesia: evaluation of the outpatient procedure. *J Hand Surg Am* 1979;4(6):544-6. https://doi.org/10.1016/s0363-5023(79)80007-6
5. Lalonde DH. "Hole-in-one" local anaesthesia for wide awake carpal tunnel surgery. *Plast Reconstr Surg* 2010;126(5):1642-4. https://doi.org/10.1097/PRS.0b013e3181f1c0ef
6. Duncan KH, Lewis RC Jr, Foreman KA, Nordyke MD. Treatment of carpal tunnel syndrome by members of the American Society for Surgery of the hand: results of a questionnaire. *J Hand Surg Am* 1987;12(3):384-91. https://doi.org/10.1016/s0363-5023(87)80011-4
7. Braithwaite BD, Robinson GJ, Burge PD. Haemostasis during carpal tunnel release under local anaesthesia: a controlled comparison of a tourniquet and adrenaline infiltration. *J Hand Surg Br* 1993;18(2):184-6. https://doi.org/10.1016/0266-7681(93)90103-m
8. Ralte P, Selvan D, Morapudi S, Kumar G, Waseem M. Haemostasis in open carpal tunnel release: tourniquet vs local anaesthetic and adrenaline. *Open Orthop J* 2010;4:234-6. https://doi.org/10.2174/1874325001004010234
9. Lalonde DH. *Wide awake hand surgery*. New York: Thieme Medical Publishers; 2016.
10. Gordley KP, Basu CB. Optimal use of local anaesthetics and tumescence. *Sem Plast Surg* 2006;20 (4):219-24. https://doi.org/10.1055/s-2006-951579
11. Lalonde DH, Wong A. Local anaesthetics: what's new in minimal pain injection and best evidence in pain control? *Plast Reconstr Surg* 2014;134(4 Suppl 2):40S-49S. https://doi.org/10.1097/PRS.0000000000000679

Patellar Resurfacing in Primary Total Knee Replacement: A Comparative Study at Two Years of Follow-up

Saúl Martínez,[*] Tamy Ron-Translateur,[**] Erika Cantor,[#] Julio C. Palacio[##]
[*]*Universidad del Bosque, Bogota, Colombia.*
[**]*National University of Colombia, Bogota, Colombia*
[#]*Institute of Statistics, University of Valparaíso, Valparaíso, Chile*
[##]*Clínica Imbanaco Grupo Quirónsalud, Cali, Colombia*

ABSTRACT

Objective: To compare the functional outcomes of total knee replacement (TKR) with and without patellar resurfacing at two years of follow-up. **Materials and Methods:** We carried out a retrospective observational study of patients with osteoarthritis who had undergone TKR with or without patellar resurfacing between January 2014 and December 2016 in two hospitals in Colombia. All patients received a cemented Exatech Optetrak prosthesis. Function was evaluated before surgery and after two years of follow-up with the Knee Society Score (KSS), Hospital for Special Surgery (HSS) and Oxford Knee Score (OKS). **Results:** a total of 206 TKRs were included, 94 in the group with resurfacing and 112 in the group without resurfacing. The mean age was 66.9 ± 9.7 years and 76.7% (n = 155) were female. Surgical time was longer in the group with resurfacing with a median of 100 minutes (Interquartile range-IQR: 90-110) compared to 85 minutes in the group without resurfacing (IQR: 70-90), p <0.001). Although functional improvement was observed before and after TKR in both groups, the change in clinical KSS, functional KSS, and OKS scores before and after TKR was better in the resurfacing group (p <0.05). **Conclusion:** Patellar resurfacing during TKR was associated with better functional outcomes at two years of follow-up. However, patients without resurfacing also reported functional improvement after TKR.

Keywords: Patellar resurfacing; osteoarthritis; total knee replacement; function.
Level of Evidence: III

Resuperficialización de rótula en reemplazo primario total de rodilla: Estudio comparativo a dos años de seguimiento.

RESUMEN

Objetivo: Comparar los resultados funcionales del reemplazo total de rodilla con resuperficialización de rótula o sin resuperficialización, a los dos años de seguimiento. **Materiales y Métodos:** Estudio observacional retrospectivo de grupos comparativos de pacientes con osteoartritis sometidos a un reemplazo total de rodilla primario con resuperficialización de rótula o sin este procedimiento, entre enero de 2014 y diciembre de 2016, en dos centros de Colombia. A todos se les colocó una prótesis cementada Optetrak®. La función se evaluó antes de la cirugía y a los dos años mediante las escalas *Knee Society Score* (KSS), *Hospital for Special Surgery* (HSS) y *Oxford Knee Score* (OKS). **Resultados:** Se incluyeron 206 reemplazos totales de rodilla: 94 (grupo con resuperficialización) y 112 (grupo sin resuperficialización). La media de la edad en la cohorte de estudio era de 66.9 ± 9.7 años y el 76,7% (n = 155) eran mujeres. El tiempo quirúrgico fue más prolongado en el grupo con resuperficialización (mediana 100 min, RIC 90-110) que en el otro grupo (mediana 85 min, RIC 70-90; p <0,001). Aunque se observó una mejoría funcional antes del reemplazo total de rodilla y después, en ambos grupos, el cambio en el KSS clínico, el KSS funcional y el OKS fue mejor en el grupo con resuperficialización (p <0,05). **Conclusiones:** La resuperficialización de rótula durante el reemplazo total de rodilla se asoció a mejores resultados funcionales a los dos años. No obstante, los pacientes sin resuperficialización también refirieron una mejoría funcional después del reemplazo total de rodilla.

Palabras clave: Resuperficialización de rótula; osteoartritis; reemplazo total de rodilla; función.
Nivel de Evidencia: III

Received on October 20th, 2021. Accepted after evaluation on February 15th, 2022 • Dr. SAÚL MARTÍNEZ • smart7406@yahoo.com.co https://orcid.org/0000-0003-1417-3984
How to cite this article: Martínez S, Ron-Translateur T, Cantor E, Palacio JC. Patellar Resurfacing in Primary Total Knee Replacement: A Comparative Study at Two Years of Follow-up. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):798-803. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1453

INTRODUCTION

Total knee replacement (TKR) is a cost-effective procedure for the treatment of osteoarthritis, relieving pain and restoring function to the joint, muscles, ligaments, and other soft tissues involved in its movement. TKR is a procedure in constant evolution, which has made it possible to achieve up to 90% satisfactory outcomes.[1] However, persistent anterior knee pain continues to be one of the main complaints reported by patients after TKR (5-10%);[2] for this reason, patellar resurfacing has been proposed as a strategy to treat this complication.[3,4]

Patellar resurfacing during a TKR remains a source of disagreement among surgeons, with use rates ranging from 2% to 90%.[5,6] The decision whether or not to resurface the patella has been left primarily to the surgeon, as the reported evidence is not conclusive regarding its impact on functional outcomes and revision rates.[3,5] For example, in the meta-analysis by Longo et al., better scores on the functional scales were found, as well as a lower revision rate in patients who underwent TKR with patellar resurfacing.[7] In contrast, authors such as Grassi et al. have published comparable functional outcomes between the groups.[8] Recently, Parsons et al. reported that patellar resurfacing can be considered a cost-effective intervention, and that it has a low revision rate, although functional outcomes are equivalent between patients undergoing TKR with resurfacing and without it.[9] Therefore, the objective of this study was to compare the functional outcomes of TKR with patellar resurfacing with those without resurfacing at two years of follow-up.

MATERIALS AND METHODS

An observational, retrospective study of comparative groups of patients with osteoarthritis who had undergone primary TKR with or without patellar resurfacing was carried out between January 2014 and December 2016, in two centers in Colombia. The patients with patellar resurfacing were operated on in a single Center, in Cali, and the patients without resurfacing underwent surgery in Bogotá. For this study, 230 primary TKRs in the two cities, which had been followed up for a minimum of two years, were initially reviewed. Twenty-three patients with inflammatory arthritis and one patient with a history of fracture were excluded. All cases were identified through institutional records. This study was approved by an Institutional Ethics Committee and carried out according to the principles of the Declaration of Helsinki.

Surgical technique

With the patient in the supine position and under regional anesthesia, a medial parapatellar anterior approach was performed and the knee joint was exposed. Subsequently, the soft tissues of the joint were released, from the medial side to the pes anserinus insertion and from the lateral side to the joint capsule. The cruciate ligaments and menisci, and the medial and intercondylar osteophytes were removed. All patients received an Optetrak® cemented prosthesis (Exactech, Gainesville, FL, USA). The implant was placed using tibial extramedullary and femoral intramedullary guides. Patellar resurfacing was performed before component reduction maneuvers and varus and valgus flexion stability tests.

The rehabilitation process began 24 h after surgery with assisted passive isometric exercises for short periods, in order to recover the range of motion and strengthen the muscles. In addition, standing with the help of a walker or crutches was indicated. Once independence for short distances was recovered, active and passive exercises of the lower limbs began.

Data collection

All information was extracted from institutional medical records. The following data were recorded: age, sex, body mass index, range of motion, and total surgery time. Function was assessed preoperatively and at two years using the *Knee Society Score* (KSS), the *Hospital for Special Surgery* (HSS) scale, and the *Oxford Knee Score* (OKS).

Statistical Analysis

Variables are expressed as mean ± standard deviation or median (IQR interquartile range), according to the normality criteria assessed using the Shapiro-Wilk test. The comparison of demographic and clinical characteristics between the resurfacing and non-resurfacing groups was performed using the X^2 test for qualitative variables and

Student's t-test or nonparametric Mann-Whitney U-test for continuous variables. To compare function between groups, the change or difference between KSS, HSS, and OKS scores before the TKR and after two years was calculated. The significance of the change within each of the groups was tested with the nonparametric Wilcoxon signed-rank test for paired data and, between groups, with the Mann-Whitney U test. A p-value <0.05 was considered statistically significant. All analyses were performed using the Stata 16.0 program (StataCorp, College Station, TX, USA).

RESULTS

206 TKRs were included in the analysis: 94 in the resurfacing group and 112 in the non-resurfacing group. The mean age in the study cohort was 66.9 ± 9.7 years and 76.7% (n = 155) were women, with a body mass index of 28.4 kg/m^2 (IQR 25.4-31.6). As described in Table 1, no statistically significant differences were observed between the groups regarding age, sex and body mass index (p > 0.05). In contrast, patients who underwent TKR without resurfacing had lower ranges of motion than those with resurfacing, as well as lower scores on functional scales, at the preoperative assessment (Table 2). Surgery time was longer in the resurfacing group (p < 0.05). In most TKRs, a posterior-stabilized prosthesis (Optetrak®, Exactech, Gainesville, FL, USA) was used.

Table 1. Demographic and clinical characteristics of patients with and without resurfacing

Characteristics	Without resurfacing (n = 112)	With resurfacing (n = 94)	p
Sex, n (%), no. Female Male	109 83 (76.1) 26 (23.9)	93 72 (77.4) 21 (22.6)	0.831
Age Mean ± SD <55 years 55-75 years >75 years	 66.3 ± 9.3 9 (8.0) 81 (72.3) 22 (19.7)	 67.1 ± 10.2 8 (8.5) 64 (68.1) 22 (23.4)	0.549
BMI (kg/m^2) Median (IQR)	 28.0 (25.4-30.9)	 28.9 (25.7-32.1)	0.186
Extension Median (IQR)	 90.0 (90.0-105.7)	 110.0 (100.0-130.0)	0.000
Flexion Median (IQR)	 5.0 (0.0-10.0)	 0.0 (0.0-5.0)	0.000
Prosthesis, n (%) Cemented condylar constrained Classic cruciate retaining Classic posterior stabilized	 4 (3.6) 0 (0.0) 108 (96.4)	 0 (0.0) 12 (12.8) 82 (87.2)	0.000
Surgical time Median (IQR)	 85.0 (70.0-90.0)	 100.0 (90.0-110.0)	0.000

SD = standard deviation, BMI = body mass index, no. = number of complete data, IQR = interquartile range.

Table 2. Comparison of functional scale scores between patellar resurfacing and non-resurfacing groups.

Scale	Non-resurfacing (n = 112)	Resurfacing (n = 94)	p[a]
Clinical KSS[*]			
Preoperative	41.0 (33.0-54.0)	44.0 (36.1-48.0)	
2 years of follow-up	85.0 (73.1-92.0)	93.0 (89.0-93.0)	
Change (Δ)	40.0 (25.3-55.1)	47.0 (42.0-55.0)	0.000
p[b]Δ	0.000	0.000	
Functional KSS[*]			
Preoperative	45.0 (30-50.0)	50.0 (30.0-55.0)	
2 years of follow-up	70.0 (55.0-80.0)	100.0 (100.0-100.0)	
Change (Δ)	30.0 (10.0-40.0)	50.0 (45.0-70.0)	0.000
p[b]Δ	0.000	0.000	
HSS[*]			
Preoperative	55.5 (46.1-63.0)	61.5 (55.1-66.6)	
2 years of follow-up	79.9 (72.6-87.0)	89.0 (89.0-89.0)	
Change (Δ)	24.0 (13.6-34.1)	26.4 (20.5-32.1)	0.089
p[b]Δ	0.000	0.000	
OKS[*]			
Preoperative	15.0 (12.0-18.0)	14.0 (10.0-18.0)	
2 years of follow-up	37.0 (30.0-42.0)	44.0 (44.0-44.0)	
Change (Δ)	22.0 (14.0-26.0)	30.0 (27.0-34.0)	0.000
p[b]Δ	0.000	0.000	

KSS = *Knee Society Score,* HSS = *Hospital for Special Surgery*, OKS = *Oxford Knee Score*.
[*]Median (interquartile range).
[a]P-value between the groups with resurfacing and without resurfacing.
[b]P-value between the preoperative period and at the end of follow-up within each group.

Table 2 describes the scores of the functional scales before the TKR and after two years in the groups with resurfacing and without this procedure. Significant improvement in patient function after TKR was observed in both groups, based on the scores of the clinical KSS, functional KSS, HSS and OKS scales. However, the change in clinical KSS, functional KSS, and OKS scores before and after TKR was better in the resurfacing group ($p < 0.05$). On the HSS scale, the change before TKR and after it was not statistically significant between the groups ($p > 0.05$).

DISCUSSION

The decision to resurface the patella during TKR has been a matter of debate among surgeons. The main result of this study demonstrated that patients who underwent TKR with resurfacing of the patella had a greater change in the scores of the KSS and OKS functional scales at two years of follow-up compared to the preoperative evaluation.

Several authors have described the benefits of patellar resurfacing on functional outcomes and revision rates after TKR.[7,9,10] Those who oppose this procedure justify their conduct based on the potential complications associated with this additional step, such as instability, fracture, polyethylene wear, soft tissue impingement, and osteolysis.[11,12] For example, Schiavone Panni et al. published a patellofemoral complication rate of 7% in a cohort of patients with resurfacing, and reported cases of anterior pain, malalignment, and loosening of the patellar component.[13] However, a higher incidence of anterior pain (*odds ratio* [OR] 1.76; 95%CI 1.36-2.27) and revision surgeries (OR 3,24; 95%CI 2.11-4.99) has been described in patients without resurfacing, which has led surgeons to justify performing this procedure.[10]

In countries such as the United States, at least 80% of TKRs are performed along with patellar resurfacing; the trend of its use has not changed between 2004 and 2014. In other countries, such as Australia, England, and Denmark, the percentage of patients with resurfacing has increased. In contrast, in Sweden and Norway, the use of patellar resurfacing does not reach 10%, with a downward trend.[5] In Latin America, it is unknown how much this clinical practice is used, mainly due to the lack of national records.

On the other hand, some surgeons do not suggest the routine use of patellar resurfacing; instead, they recommend its selective use based on specific patient criteria, considering it in cases with a history of rheumatoid arthritis, advanced tibiofemoral osteoarthritis, patellofemoral osteoarthritis, anterior knee pain, genu valgum, and in revision surgeries.[14] However, the analyses that have compared the clinical outcomes between surgeons who usually, selectively or rarely conserve the patella, indicate better functional outcomes at five years of follow-up in patients treated by surgeons who usually conserve the patella, followed by those who perform this procedure selectively, with no differences in revision rates between the three use strategies.[15]

Regarding functional outcomes based on patient-reported outcomes, published meta-analyses have found inconclusive results on whether or not there is a benefit in favor of patella resurfacing. Longo et al.[7] reported better functional outcomes with patella preservation, as well as Migliorini et al.[10] who also reported a lower frequency of anterior pain (11.1% vs. 17.4%). Instead, Chen et al.[16] described better function in patients with patella resurfacing after five years of follow-up; however, in the third year after surgery, the results were statistically similar between the groups. On the other hand, Grassi et al.[8] published comparable functional outcomes between patients who underwent TKR with patellar resurfacing and those without this procedure.

These findings allow us to conclude that, despite the many published studies, it is still not possible to determine if patellar resurfacing improves the functional outcomes of TKR. However, it is important to highlight that, to the best of our knowledge, no meta-analyses have been published describing better functional outcomes in patients without resurfacing. In recent times, clinical outcomes have also not revealed differences between patients with patella resurfacing and those without this procedure, when they have been fitted with a patella-friendly knee prosthesis whose design has been modified to prevent problems associated with the extensor mechanism of the knee.[17,18]

Based on our findings and the literature, it can be concluded that the decision whether or not to resurface the patella during TKR will continue to be a matter of debate among orthopedists around the world. However, it is important to take into account that, although the decision may depend on the preferences of the surgeon, there has been a marked tendency to reduce revision rates when patellar resurfacing is performed, so it can be considered a cost-effective intraoperative approach, as suggested by Parsons et al.[9]

This study has limitations. First, the data analyzed comes from only two healthcare centers; therefore, their findings must be interpreted with caution. Second, patients were only followed up for the first two years after surgery, which can be considered a limited follow-up time to report, for example, the rate of secondary resurfacing. Furthermore, although significant differences in preoperative function were observed, the comparison between the groups is valid because the outcome variable was the change experienced in each group relative to the preoperative measurement. Third, due to the retrospective nature of this study, it was not possible to record complications in this group of patients; therefore, we recommend that the decision whether to resurface or not be made taking into consideration the findings provided by other published studies with a higher level of evidence.

CONCLUSION

Resurfacing of the patella during a TKR was associated with better functional outcomes at two years of follow-up. However, patients without resurfacing also reported functional improvement after TKR.

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

T. Ron-Translateur ORCID ID: https://orcid.org/0000-0002-5351-422X
E. Cantor ORCID ID: https://orcid.org/0000-0003-3320-6032
J. C. Palacio ORCID ID: https://orcid.org/0000-0001-7886-7489

REFERENCES

1. Harris IA, Harris AM, Naylor JM, Adie S, Mittal R, Dao AT. Discordance between patient and surgeon satisfaction after total joint arthroplasty. *J Arthroplasty* 2013;28(5):722-7. https://doi.org/10.1016/j.arth.2012.07.044
2. Martinus Breugem SJ, Haverkamp D. Anterior knee pain after a total knee arthroplasty: What can cause this pain? *World J Orthop* 2014;5(3):163-70. https://doi.org/10.1177/2309499020918947
3. Van Der Merwe JM, Mastel MS. Controversial topics in total knee arthroplasty: A 5-year update (Part 1). *J Am Acad Orthop Surg Glob Res Rev* 2020;4(1):p e19.00047. https://doi.org/10.5435/JAAOSGlobal-D-19-00047
4. Benazzo F, Perticarini L, Jannelli E, Ivone A, Ghiara M, Rossi SMP. Controversy: supporting patellar resurfacing in total knee arthroplasty – do it. *EFORT Open Rev* 2020;5(11):785-92. https://doi.org/10.1302/2058-5241.5.190075
5. Fraser JF, Spangehl MJ. International rates of patellar resurfacing in primary total knee arthroplasty, 2004-2014. *J Arthroplasty* 2017;32(1):83-6. https://doi.org/10.1016/j.arth.2016.06.010
6. Allen W, Eichinger J, Friedman R. Resurfaced versus non-resurfaced patella in total knee arthroplasty. *J Knee Surg* 2019;32(7):611-5. https://doi.org/10.1055/s-0039-1681077
7. Longo UG, Ciuffreda M, Mannering N, D'Andrea V, Cimmino M, Denaro V. Patellar resurfacing in total knee arthroplasty: Systematic review and meta-analysis. *J Arthroplasty* 2018;33(2):620-32. https://doi.org/10.1016/j.arth.2017.08.041
8. Grassi A, Compagnoni R, Ferrua P, Zaffagnini S, Berruto M, Samuelsson K, et al. Patellar resurfacing versus patellar retention in primary total knee arthroplasty: a systematic review of overlapping meta-analyses. *Knee Surg Sport Traumatol Arthrosc* 2018;26(11):3206-18. https://doi.org/10.1007/s00167-018-4831-8
9. Parsons T, Al-Jabri T, Clement ND, Maffulli N, Kader DF. Patella resurfacing during total knee arthroplasty is cost-effective and has lower re-operation rates compared to non-resurfacing. *J Orthop Surg Res* 2021;16(1):1-9. https://doi.org/10.1186/s13018-021-02295-8
10. Migliorini F, Eschweiler J, Niewiera M, El Mansy Y, Tingart M, Rath B. Better outcomes with patellar resurfacing during primary total knee arthroplasty: a meta-analysis study. *Arch Orthop Trauma Surg* 2019;139(10):1445-54. https://doi.org/10.1007/s00402-019-03246-z
11. Schindler OS. The controversy of patellar resurfacing in total knee arthroplasty: Ibisne in medio tutissimus? *Knee Surg Sport Traumatol Arthrosc* 2012;20(7):1227-44. https://doi.org/10.1007/s00167-012-1985-7
12. Christopher ZK, Deckey DG, Chung AS, Spangehl MJ. Patellar osteolysis after total knee arthroplasty with patellar resurfacing: a potentially underappreciated problem. *Arthroplasty Today* 2019;5(4):435-41. https://doi.org/10.1016/j.artd.2019.09.005
13. Schiavone Panni A, Cerciello S, Del Regno C, Felici A, Vasso M. Patellar resurfacing complications in total knee arthroplasty. *Int Orthop* 2014;38(2):313-7. https://doi.org/10.1007/s00264-013-2244-3
14. Sandiford NA, Alao U, Salamut W, Weitzel S, Skinner JA. Patella resurfacing during total knee arthroplasty: Have we got the issue covered? *CiOS Clin Orthop Surg* 2014;6(4):373-8. https://doi.org/10.4055/cios.2014.6.4.373
15. Maney AJ, Koh CK, Frampton CM, Young SW. Usually, selectively, or rarely resurfacing the patella during primary total knee arthroplasty: Determining the best strategy. *J Bone Joint Surg Am* 2019;101(5):412-20. https://doi.org/10.2106/JBJS.18.00389
16. Chen K, Dai X, Li L, Chen Z, Cui H, Lv S. Patellar resurfacing versus nonresurfacing in total knee arthroplasty: an updated meta-analysis of randomized controlled trials. *J Orthop Surg Res* 2021;16(1):83. https://doi.org/10.1186/s13018-020-02185-5
17. Karachalios T, Komnos G, Hantes M, Varitimidis S. Evaluating the "patella-friendly" concept in total knee arthroplasty: A minimum 15-year follow-up outcome study comparing constant radius, multiradius cruciate-retaining, and nonanatomical cruciate-retaining implants. *J Arthroplasty* 2021;36(8):2771-8. https://doi.org/10.1016/j.arth.2021.03.007
18. Koh IJ, Kim MS, Sohn S, Song KY, Choi NY, In Y. Patients undergoing total knee arthroplasty using a contemporary patella-friendly implant are unaware of any differences due to patellar resurfacing. *Knee Surg Sports Traumatol Arthrosc* 2019;27(4):1156-64. https://doi.org/10.1007/s00167-018-5120-2

Aggressive Aneurysmal Bone Cyst of the Spine. Case report and Literature Review

José F. Baigorria, Micaela Besse, José A. Rosado Pardo, Alejandro Steverlynck, Aníbal J. Sarotto
Orthopedics and Traumatology Service, Victorio Franchin Sanatorium, Autonomous City of Buenos Aires, Argentina

ABSTRACT

Introduction: An aneurysmal bone cyst is an expansive, lytic, pseudotumoral lesion that consists of blood-filled spaces separated by septa. It represents 15% of primary spinal tumors. An aggressive presentation is even rarer. Different therapeutic options are described depending on its stage and recurrence rate. We present the case of a patient with neurological involvement due to the aggressive behavior of an aneurysmal bone cyst in the thoracic spine, which required surgical treatment. **Conclusion:** Treatment options for aneurysmal bone cysts must adapt to each case, depending on its characteristics.

Keywords: Aneurysmal bone cyst; thoracic spine; myelopathy.
Level of Evidence: IV

Quiste óseo aneurismático vertebral agresivo: presentación de un caso y revisión bibliográfica

RESUMEN

Introducción: El quiste óseo aneurismático es una lesión pseudotumoral lítica, expansiva, compuesta por espacios llenos de sangre separados por tabiques. En columna representa el 15% de los tumores primarios, y su presentación de comportamiento agresivo es aún más infrecuente. Se han descrito diferentes opciones terapéuticas en función de su estadío y tasa de recurrencia. Presentamos el caso de un paciente con compromiso neurológico por la presencia de un quiste óseo aneurismático en columna torácica, de comportamiento agresivo, que requirió resolución quirúrgica. **Conclusión:** Las opciones de tratamiento del quiste óseo aneurismático se deben adecuar a cada caso en particular, según sus características.

Palabras clave: Quiste óseo aneurismático; columna torácica; mielopatía.
Nivel de Evidencia: IV

INTRODUCTION

The aneurysmal bone cyst (ABC) was first described by Jaffe and Lichtenstein in 1942 as an intraosseous and osteolytic lesion, differentiating it from hemangiomas and other giant cell tumors.[1] It is an expansive, lytic pseudotumoral bone lesion composed of blood-filled spaces separated by connective tissue septa formed by reactive bone tissue, fibroblasts, and osteoclast-type giant cells.[2]

ABC is a benign tumor and represents between 1% and 1.4% of all primary bone tumors.[3] Most cases have been identified in the first two decades of life; it is rare to find them after the age of 30. In the spine, they represent 15% of primary tumors.[4]

Their behavior can vary in the different stages, from latent to aggressive, as described by Enneking,[5] in such a way that its clinical presentation can involve anything from an imaging finding to compressive symptoms such as pain, neurological deficit, spinal instability or deformity. [6]

Received on November 25th, 2021. Accepted after evaluation on January 17th, 2022. • Dr. JOSÉ F. BAIGORRIA • jfbaigorria@gmail.com https://orcid.org/0000-0002-3453-2246
How to cite this article: Baigorria JF, Besse M, Rosado Pardo JA, Steverlynck A, Sarotto AJ. Aggressive Aneurysmal Bone Cyst of the Spine. Case report and Literature Review. *Rev Asoc Argent Ortop Traumatol* 2022;87(6): 804-813. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1470

Complementary studies reveal pathognomonic images of fluid-fluid levels. The definitive diagnosis is obtained by biopsy. Different therapeutic options have been described according to their behavior, location and recurrence rate.

Because there are few reported aggressive case reports of spinal ABC, diagnostic and treatment algorithms remain controversial and variable. Treatments have ranged from simple curettage, with or without bone graft, injection of a fibrosing agent, complete resection surgery, radiotherapy and selective arterial embolization to a combination of these methods.[7]

Although treatment outcomes are usually good, local recurrence is described in all therapy protocols, which cannot be accurately predicted, since in the published literature these rates are highly variable, even reaching figures of up to 25%.[8]

We present the case of a patient with a diagnosis of spinal ABC with aggressive behavior, with symptoms of spinal cord injury, treated by surgical approach.

CLINICAL CASE

A 32-year-old male patient, with no relevant clinical or surgical history, consulted at our institution due to back pain of 1 month's evolution. He did not report any history of trauma.

The medical history and physical examination revealed hypoesthesia in both feet, paresthesia, and Achilles clonus in the lower limbs. His strength was decreased, 4/5 according to the MRC (Medical Research Council) scale of muscle strength.[9]

On admission, imaging studies were requested. The radiograph showed the winking owl sign at the level of the tenth thoracic vertebra (T10) (Figure 1).

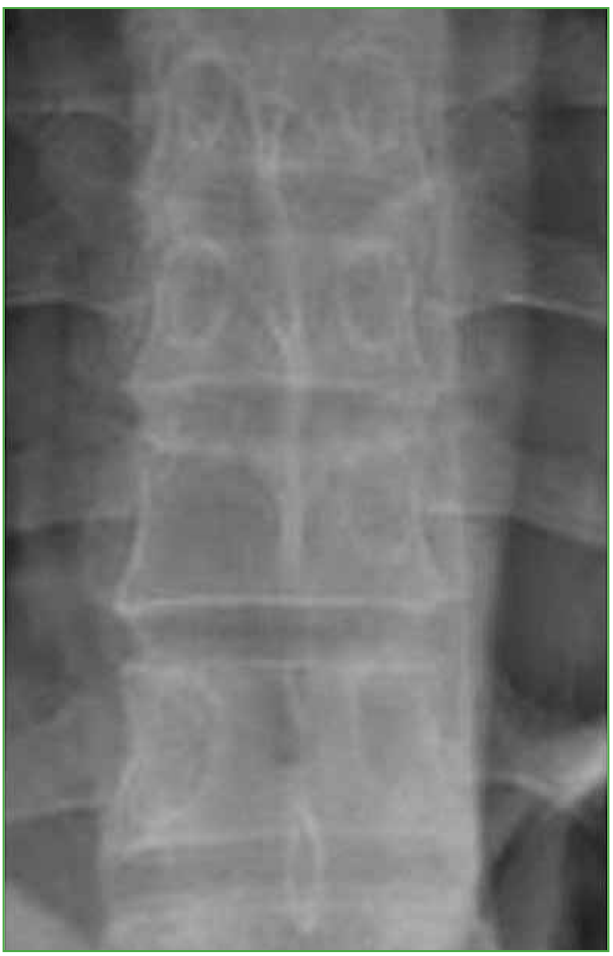


Figure 1. Anteroposterior dorsal spine radiograph. Lytic lesion centered on the right pedicle of the T10 vertebra. Winking owl sign.

The computed tomography showed an expansive lytic image, with disruption of the cortex, which compromised the pedicle, transverse process, posterior arch (predominantly on the right), and body of T10 (<50%) (Figure 2).

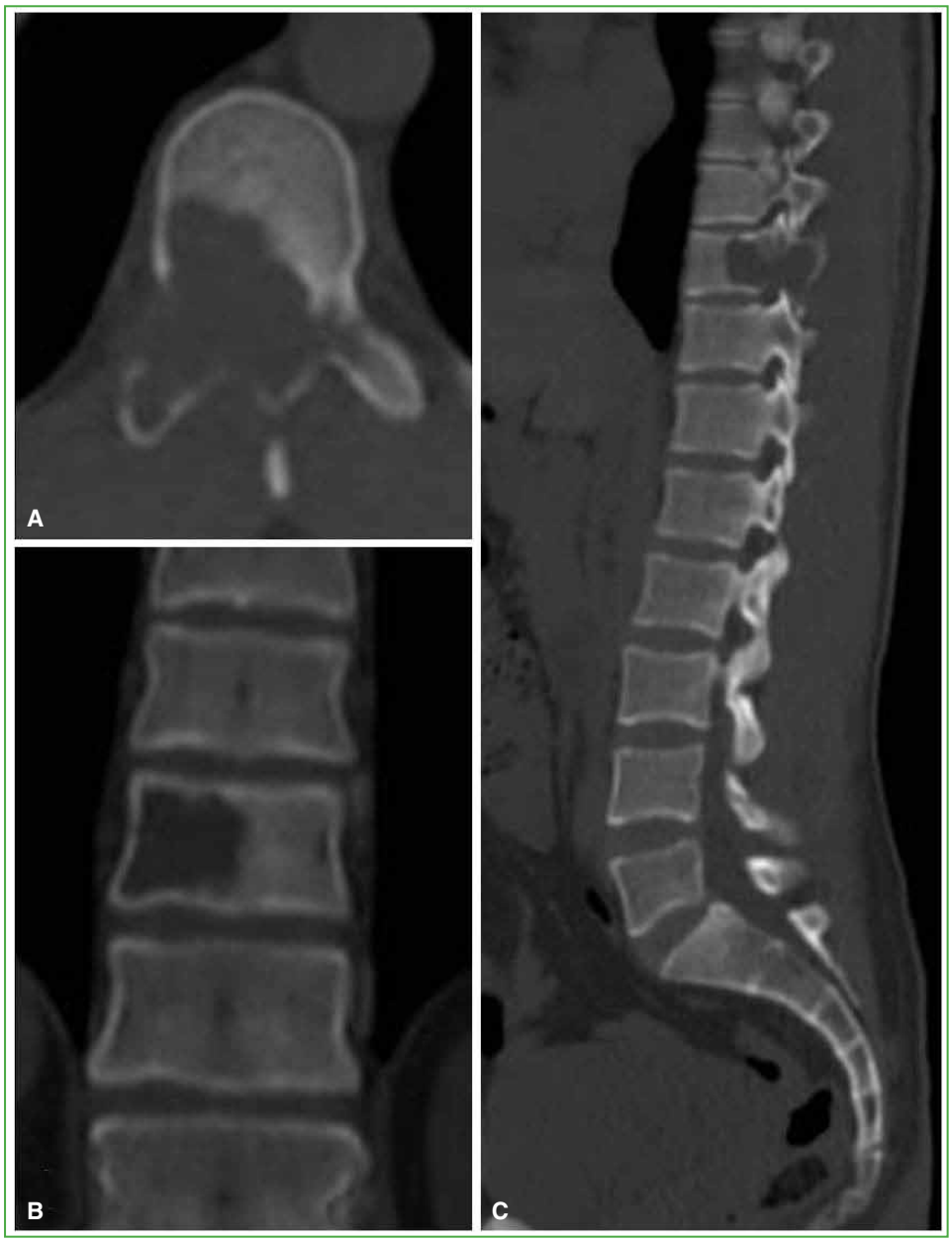


Figure 2. CT scan of the lumbosacral spine. **A.** Axial section. **B.** Coronal section. **C.** Sagittal section. A lytic, expansive image, with cortical thinning and interrupted edges compromising the pedicle, right transverse process, posterior arch, and vertebral body.

In the thoracic spine MRI, the same expansive lesion was identified, with liquid content and extension to the thoracic canal, which generated spinal cord compression and stenosis of the canal, obstructing the passage of cerebrospinal fluid (CSF) (Figure 3).

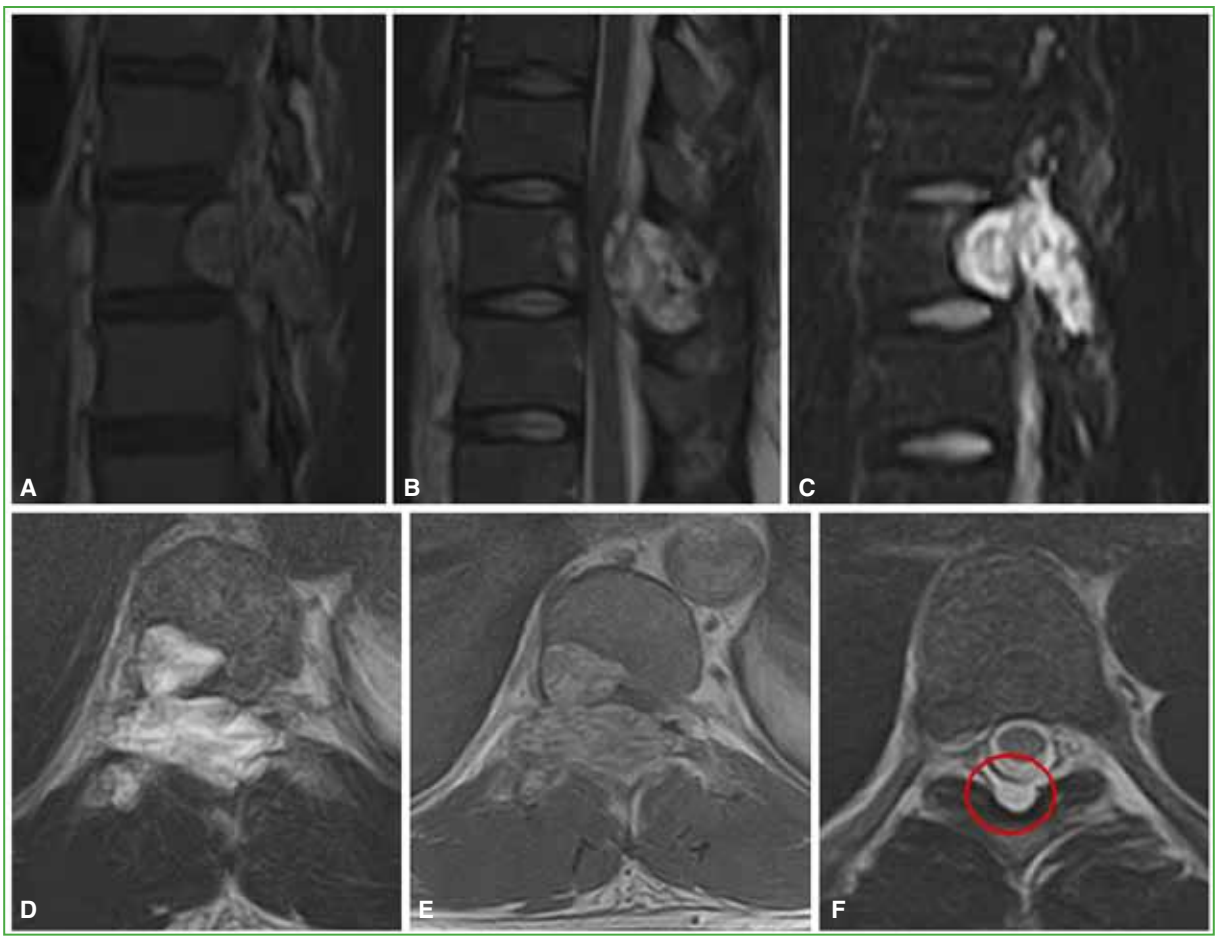


Figure 3. Thoracic spine MRI. **A.** T1, sagittal section. **B.** T2, sagittal section. **C.** STIR, sagittal section. **D.** T2, axial section. **E.** Axial section, with contrast. Expansive lesion with fluid signal intensity (hyperintense on T2 and STIR sequences and hypointense on T1 sequences), with septa inside. Complete stenosis of the medullary canal without passage of CSF. **F.** Epidural tumor cuff.

These sequences evidenced the compromise of somatosensory pathways in the lower thoracic segment/thoracolumbar junction.

A CT-guided punch biopsy was performed through a right T10 pedicle access; 3 cm^3 of hematic material for the cytological study and a bone plug fragment for the histological study were obtained. There were no complications during the procedure. In the histological sections of all the samples, fibrous septa with reticular bone, oval and spindle-shaped mononuclear cells without atypia, and osteoclast-like giant cells were observed, which led to the final diagnosis of ABC (Figure 4).

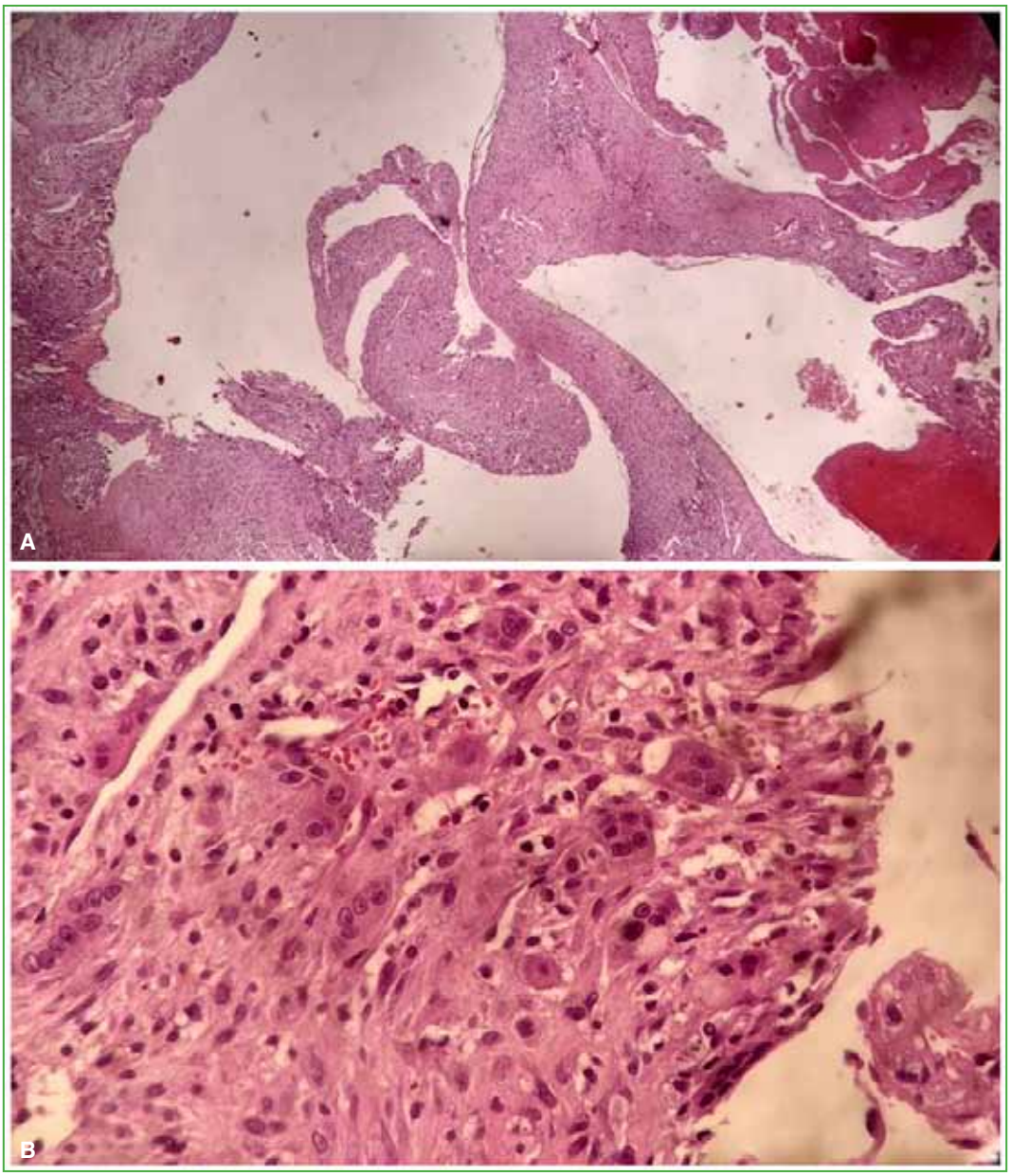


Figure 4. Pathological anatomy analysis. **A.** 40x. **B.** 100x. Histological sections show fibrous septa with trabecular bone, oval and spindle-shaped mononuclear cells without atypia, and osteoclast-like giant cells. These morphological findings are linked to an aneurysmal bone cyst.

Based on the patient's diagnosis and symptoms, it was decided to perform a surgical procedure. A digital spinal cord angiography was performed under general anesthesia (Figure 5), which showed right T10-dependent hypervascularization. In the same stage, endovascular embolization treatment with embospheres was performed.

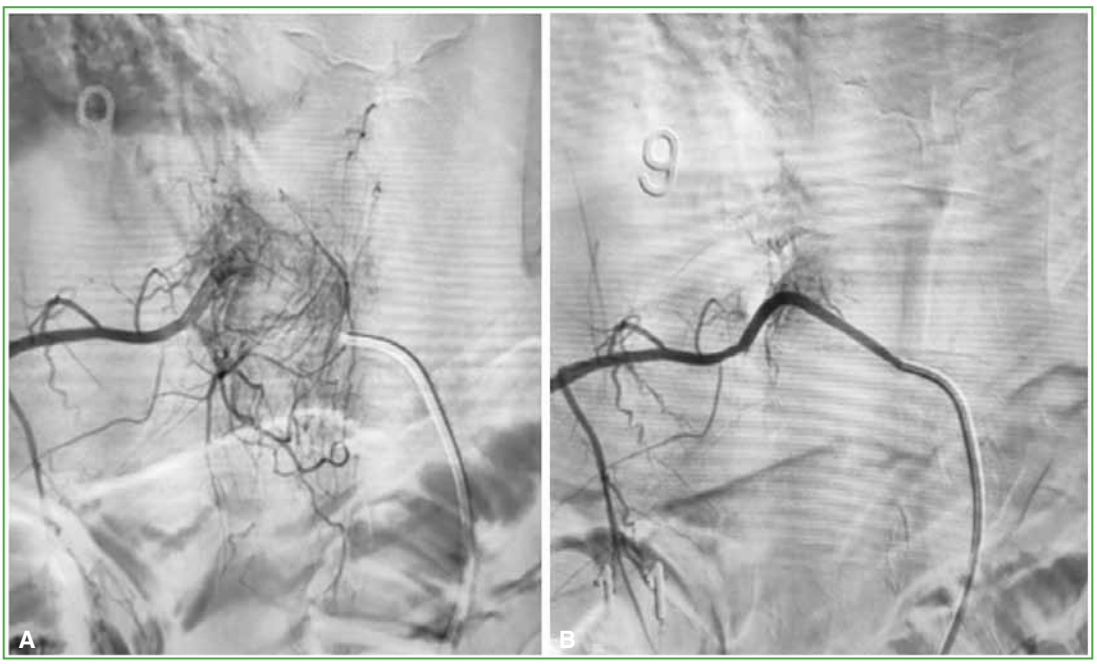


Figure 5. Digital spinal angiography. **A.** T10 vertebra preembolization. **B.** T10 vertebra postembolization.

24 h later, surgery was carried out, which consisted of extended excision of the posterior arch of T10. Extensive curettage, reaming, and phenolization of the cavity were performed. An embolized epidural tumor cuff was found, which was resected (Figure 6).

Figure 6. Wide decompression of the posterior arch of T10. T10 right pedicle emptying. Curettage, reaming and alcoholization of the residual cavity.

Finally, it was stabilized by implanting pedicle screws and rods from T9 to T11 (Figure 7).

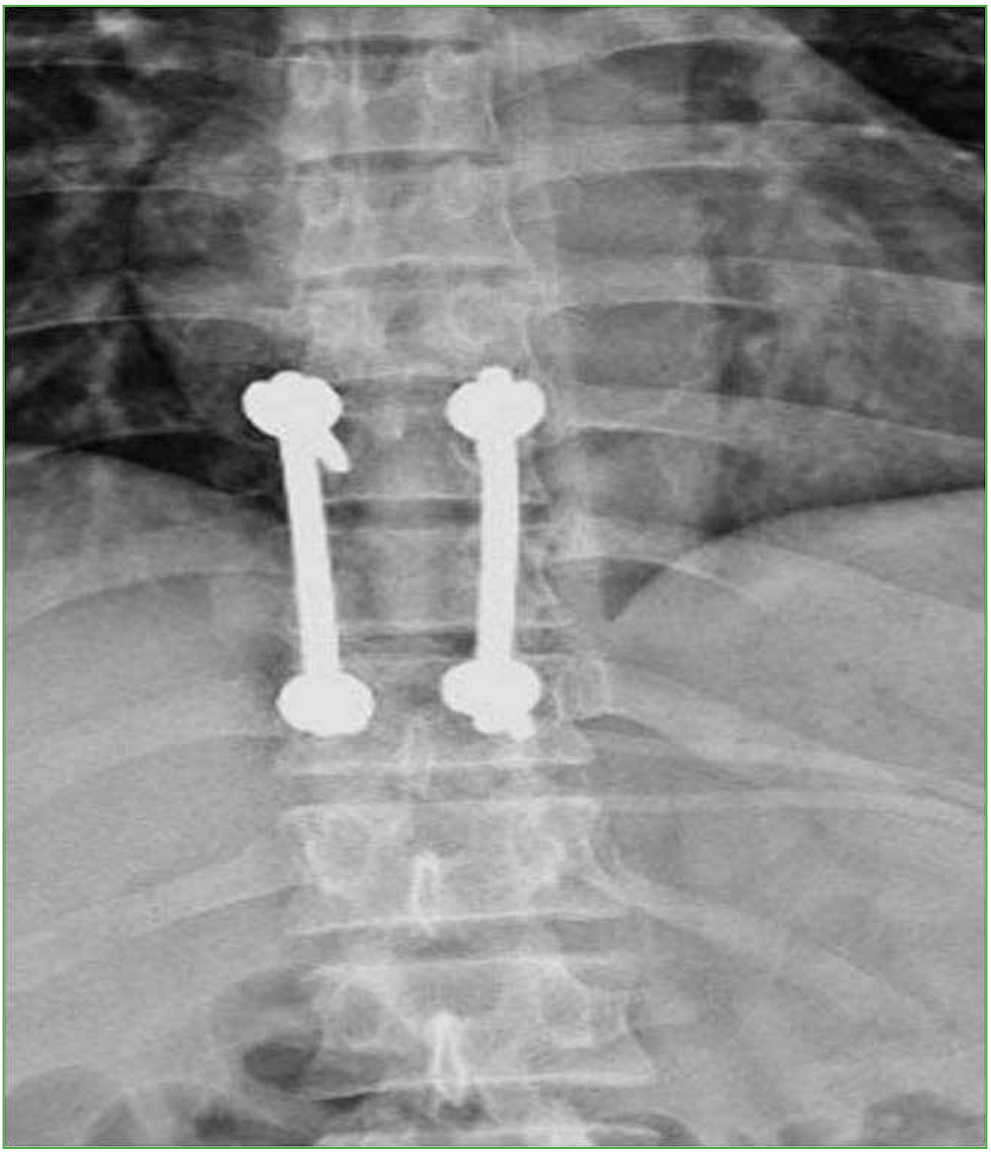


Figure 7. Anteroposterior dorsal spine radiograph in the postoperative period. Transpedicular instrumentation of T9-T11.

With good evolution and no progression of the neurological deficit, the patient was discharged 4 days later. Six months after surgery, the patient shows unrestricted ambulation and improvement in muscle strength, with no progression of neurological deficit on clinical follow-up examination.

DISCUSSION

ABC is included within the group of benign primary bone tumors. Although its histology defines it as such, ABC can present behavior that leads to rapid growth, with local destruction. It is a highly vascularized lesion composed of cavities of blood content, separated by connective tissue septa, and is surrounded by a layer of cortical bone, with the potential ability to expand.[10]

Common sites of occurrence are the femur, tibia, humerus, spine, pelvis, mandible, clavicle, ribs, and hand and foot bones. In the spine, the cervical region is compromised in 30-40% of cases, the thoracic spine in 25-50% and the lumbar segment in 40-45%.[11] It generally originates on the posterior elements; the vertebral body is a site with less frequent involvement.

The cause of ABC has not been discovered to date, although different hypotheses have been proposed, including the development of post-traumatic subperiosteal hemorrhage, vascular alteration of the bone, or hemorrhage from a pre-existing lesion.[12]

As in our case, the most frequent reason for consultation is patient-reported local pain.[13] With the development and expansive aggressive behavior of the lesion, neurological symptoms appear.

Imaging studies constitute a fundamental pillar in the diagnostic process of ABCs, since they present characteristic features. The lytic appearance, of an expansive nature, with fluid-fluid levels, are pathognomonic findings. The next step is the punch biopsy, which will confirm the result of the histopathology analysis.[14]

The treatment of ABCs continues to be a matter of controversy, due to the lack of defined guidelines. Multiple options have been described, to be used alone or in combination, including curettage with or without bone grafting, complete tumor resection, selective preoperative embolization, radiotherapy, chemotherapy, and intralesional injections.[15]

Curettage with bone grafting has a recurrence rate of 20%, which requires a more aggressive excision. Surgical stabilization should always be considered if a deformity develops postoperatively or due to the degree of bone resection.[16]

Radiotherapy is an option currently reserved for patients at high risk of not withstanding surgery or for those who are resistant to surgical treatment, even more so considering the potential risks of post-radiation myelopathy or sarcomatous transformation.[17,18]

Denosumab, a human monoclonal antibody that binds to the cytokine receptor activator of nuclear factor kappa B ligand, is one of the chemotherapy options. It prevents the action of agonists that act through RANKL receptors and prevents the subsequent activation and proliferation of osteoclasts. Although the reports of its use in cases of ABC are limited, chemotherapy has been considered a valid treatment option for those symptomatic ABCs that cannot be treated surgically or that have presented frequent recurrences.[9,20]

Intralesional injections of calcitonin, steroids, and concentrated bone marrow, among other options, are mentioned in the current literature, mostly in case series or reports. Although these represent a percutaneous method with few complications and adverse effects, the publications show variable results, in which partial remission predominates.[21,22]

Finally, in the face of large hypervascular tumors with a high risk of bleeding, selective preoperative embolization should be considered. As performed in our case as part of the preoperative treatment, embolization has been preferred in recent years as the first option when it is technically feasible, the diagnosis is solid, and there is the possibility of surgical intervention within 24–48 hours. Cure rates approaching 87% have been reported with this strategy.[23,24]

In this case, aggressive curettage was performed along with emptying of the lesion, associated with phenolization of the bed as a local method. It was associated with extensive decompression of the posterior arch, for which the need for instrumented fusion was imperative. Preoperative digital embolization was extremely helpful; it not only contributed to subsequent treatment, but also served to prevent massive intraoperative bleeding, since the patient had a fully thrombosed extensive epidural vascular tree, which could be seen on preoperative MRI.

CONCLUSIONS

ABC is a benign tumor with the potential to behave aggressively and with a considerable risk of local recurrence. Although there are numerous treatment options, these must be adapted to each particular case, taking into account the characteristics of the cyst.

In conclusion, surgical treatment was necessary in this case, given the clinical findings, the results of complementary studies and the tumor stage.

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

M. Besse ORCID ID: https://orcid.org/0000-0002-4388-1384
J.A. Rosado Pardo ORCID ID: https://orcid.org/0000-0001-8467-3453
A. Steverlynck ORCID ID: https://orcid.org/0000-0003-1968-4572
A. J. Sarotto ORCID ID: https://orcid.org/0000-0002-2199-5524

REFERENCES

1. Jaffe HL, Lichtenstein L. Solitary unicameral bone cyst, with emphasis on the Roentgen picture, the pathologic appearance, and the pathogenesis. *Arch Surg* 1942;44:1004-25. Available at: https://jamanetwork.com/journals/jamasurgery/article-abstract/545805
2. Muratori F, Mondanelli N, Rizzo AR, Beltrami G, Giannotti S, Capanna R, et al. Aneurysmal bone cyst: A review of management. *Surg Technol Int* 2019;35:325-35. PMID: 31476792
3. Lam Y. Bone tumors: Benign bone tumors. *FP Essent* 2020;493:11-21. PMID: 32573182
4. Kiu A, Fung T, Chowdhary P, Jung S, Powell T, Boily M. Aneurysmal bone cyst in thoracolumbar spine. *BJR Case Rep* 2020;6(3):20190133. https://doi.org/10.1259/bjrcr.20190133
5. Enneking WF. A staging system for musculoskeletal neoplasms. *Clin Orthop Relat Res* 1986;204:9-24. PMID: 3456859
6. Abrar WA, Sarmast A, Sarabjit Singh AR, Khursheed N, Ali Z. Aneurysmal bone cysts of spine: an enigmatic entity. *Neurol India* 2020;68(4):843-9. https://doi.org/10.4103/0028-3886.293465
7. Desai SB, O'Brien C, Shaikh R, Hedequist D, Proctor M, Orbach DB, et al. Multidisciplinary management of spinal aneurysmal bone cysts: A single-center experience. *Interv Neuroradiol* 2019;25(5):564-9. https://doi.org/10.1177%2F1591019919848130
8. Frassanito P, D'Onofrio GF, Pennisi G, Massimi L, Tamburrini G, Muto M, et al. Multimodal management of aggressive recurrent aneurysmal bone cyst of spine: Case report and review of literature. *World Neurosurg* 2019;126:4237. https://doi.org/10.1016/j.wneu.2019.02.246
9. Medical Research Council. Aids to the examination of the peripheral nervous system, Memorandum no. 45. London, UK: Her Majesty's Stationery Office; 1981.
10. Jiménez-Ávila JM, Rodríguez-Pacheco AB, Bitar-Alatorre E, Ramírez-Consuegra A. Quiste óseo aneurismático de columna vertebral lumbar. Experiencia médico-quirúrgica. Reporte de un caso. *Acta Ortop Mex* 2011;25(2):130-4. Available at: https://www.medigraphic.com/pdfs/ortope/or-2011/or112k.pdf
11. Eun J, Oh Y. A case report of aneurysmal bone cyst of the thoracic spine treated by serial anterior and posterior fusion. *Medicine (Baltimore)* 2019;98(44):e17695. https://doi.org/10.1097/MD.0000000000017695
12. Jaiswal A, Vijay V, Kori P, Shukla R. Aneurysmal bone cyst of thoracic spine: case report and brief review of literature. *BMJ Case Reports* 2013:bcr2013009265. https://doi.org/10.1136/bcr-2013-009265
13. Rodríguez-García R, Antonio-Hernández JA, Santiago-Ortiz R, Sosa-Guzmán JJ, Rodríguez-Cordova R. Quiste óseo aneurismático gigante de columna vertebral. *Rev Fac Med UNAM* 2003;46(6):218-21. Available at: https://www.medigraphic.com/pdfs/facmed/un-2003/un036c.pdf
14. Zhao Q, Xu H, Min X, Yang L, Ren Y. Imaging features of vertebral aneurysmal bone cyst and the clinical value of interventional embolization. *Exp Ther Med* 2020;20(4):3832-6. https://doi.org/10.3892/etm.2020.9099
15. Wang T, Jia Q, Gao X, Fan R, Wu Z, Guo W, et al. Secondary aneurysmal bone cyst of the spine: Clinicopathological features, surgical modalities and outcomes. *Clin Neurol Neurosurg* 2020;188:105595. https://doi.org/10.1016/j.clineuro.2019.105595
16. Kumar BY, Thirumal R, Chander SG. Aneurysmal bone cyst of thoracic spine with neurological deficit and its recurrence treated with multimodal intervention - A case report. *Surg Neurol Int* 2020;11:274. https://doi.org/10.25259/SNI_466_2020

17. Kamikonya N, Hishikawa Y, Kurisu K, Taniguchi M, Miura T. Aneurysmal bone cyst treated by high-energy, low-dose radiation therapy: a case report. *Radiat Med* 1991;9(2):54-6. PMID: 1947203.
18. Harrop JS, Schmidt MH, Boriani S, Shaffrey CI. Aggressive "benign" primary spine neoplasms: osteoblastoma, aneurysmal bone cyst, and giant cell tumor. *Spine (Phila Pa 1976)* 2009;34(22 Suppl):S39-47. https://doi.org/10.1097/BRS.0b013e3181ba0024.
19. Skubitz KM, Peltola JC, Santos ER, Cheng EY. Response of aneurysmal bone cyst to denosumab. *Spine (Phila Pa 1976)* 2015;40(22): E1201-4. https://doi.org/10.1097/BRS.0000000000001027
20. Kulkarni AG, Patel A. Denosumab: A potential new treatment option for recurrent aneurysmal bone cyst of the spine. *SICOT J* 2019;5:10. https://doi.org/10.1051/sicotj/2019007
21. Barbanti-Brodano G, Girolami M, Ghermandi R, Terzi S, Gasbarrini A, Bandiera S, et al. Aneurysmal bone cyst of the spine treated by concentrated bone marrow: clinical cases and review of the literature. *Eur Spine J* 2017;26(Suppl 1):158-66. https://doi.org: 10.1007/s00586-017-4978-x
22. Chang CY, Kattapuram SV, Huang AJ, Simeone FJ, Torriani M, Bredella MA. Treatment of aneurysmal bone cysts by percutaneous CT-guided injection of calcitonin and steroid. *Skeletal Radiol* 2017;46(1):35-40. https://doi.org/10.1007/s00256-016-2503-7
23. Sertbas I, Karatay M. Combined preoperative embolization and surgical treatment of a giant aneurysmal bone cyst in the lumbar spine: A case study. *Turk Neurosurg* 2020;30(3):462-4. https://doi.org/10.5137/1019-5149.JTN.24614-18.2
24. Amendola L, Simonetti L, Simoes CE, Bandiera S, De Iure F, Boriani S. Aneurysmal bone cyst of the mobile spine: the therapeutic role of embolization. *Eur Spine J* 2013;22(3):533-41. https://doi.org/10.1007/s00586-012-2566-7

Isolated Capitate Fracture Associated With a Traumatic Synovial Cyst: A Pediatric Case Report

Isabel Parada Avendaño, Jorge Gil Albarova
Department of Orthopedic Surgery and Traumatology, Miguel Servet University Hospital, Zaragoza, Spain

ABSTRACT

Introduction: Isolated capitate fractures, caused by high-energy trauma, are rare in children. They can be missed at the initial assessment of the patient and radiographs only allow the identification of lesions in ossified bones, so complementary tests such as magnetic resonance imaging are necessary to rule out possible associated carpal lesions, especially in children under 10 years old. We present the case of an isolated capitate bone fracture with the appearance of a synovial cyst due to trauma in a pediatric patient, treated by immobilization with a short arm cast for four weeks, with good evolution. **Conclusion:** The management of these cases depends on the severity of the injury. In most cases, conservative treatment is enough but early diagnosis allows us to choose the best option and avoid possible complications such as nonunion or avascular necrosis.

Keywords: Capitate bone; fracture; synovial cyst
Level of Evidence: IV

Fractura aislada del hueso grande asociada a quiste traumático sinovial: presentación de un caso en un niño

RESUMEN

Introducción: Las fracturas aisladas del hueso grande son muy infrecuentes en los niños y se producen por traumatismos de alta energía. Pueden pasar desapercibidas en la valoración inicial y las radiografías solo permiten identificar las lesiones en huesos osificados, por lo que son necesarias pruebas complementarias, como la resonancia magnética, para descartar posibles lesiones del carpo asociadas, sobre todo en menores de 10 años. Se presenta el caso de una fractura aislada del hueso grande con aparición de quiste sinovial por causa traumática en un paciente pediátrico, tratado mediante inmovilización con yeso antebraquial durante cuatro semanas, con buena evolución. **Conclusión:** El manejo de estos casos depende de la gravedad de la lesión y, aunque por lo común evolucionan bien con un tratamiento conservador, su diagnóstico precoz nos permite elegir la mejor opción y evitar posibles complicaciones, como la no unión o la necrosis avascular.

Palabras clave: Hueso grande; fractura; quiste sinovial.
Nivel de Evidencia: IV

INTRODUCTION

Scaphoid fracture is the most frequent injury to the carpus both in adults and in pediatric patients. In children, capitate bone fracture, although rare, represents the second most frequent. In the first decade of life, it is usually associated with or involves other carpal bones; on the other hand, an isolated capitate fracture represents a very unusual entity and is even rarer when not associated with a dislocation.[1]

In an immature patient under 10 years of age, the carpus does not present a complete ossification of all the bones that compose it; therefore, for the most part, they are still covered by a thick layer of cartilage around the ossification center, which gives them greater elasticity, and requires high-energy trauma to cause damage to them.[2]

Received on November 13th, 2021. Accepted after evaluation on May 26th, 2022 • Dr. ISABEL PARADA AVENDAÑO • iparada@salud.aragon.es https://orcid.org/0000-0002-5259-4109
How to cite this article: Parada Avendaño I, Gil Albarova J. Isolated Capitate Fracture Associated With a Traumatic Synovial Cyst: A Pediatric Case Report. *Rev Asoc Argent Ortop Traumatol* 2022;87(6): 814-818. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1461

The capitate bone is the first to ossify in the carpus, after the first year of life, which can lead to greater vulnerability in the event of this type of trauma.[3] In isolated injuries, the most frequent scenario involves minimal displacements in the fracture area and treatment by immobilization tends to be satisfactory, but it is important to rule out associated injuries, since there are reports of their relationship with scaphoid fractures, as in the so-called scaphocapitate syndrome.

Regarding the synovial cyst, it is the most common tumor of the wrist and hand in the general population, but the publications referring to this pathology in children are scarce, since its appearance is less frequent than in adults: it comprises only 10% of the cases. It does not usually cause symptoms and, due to its benign nature with high rates of spontaneous remission (79%) and the high rate of recurrence with surgical treatment (43%), conservative treatment tends to be used.[4] Although not the most common, one of the theories about its origin is based on the fact that injuries to the wrist joint, such as a possible ligament injury around the scaphoid, can cause synovial fluid leaks in the periarticular tissue. In their series of a pediatric population, Bracken and Barlett[5] showed that the synovial cyst is associated with traumatic injury to the carpus in 20% of cases and that the cyst is predominantly located in the palmar area. In this same age range, Calif et al.[6] described 0.8% of synovial cysts also due to traumatic causes.

CLINICAL CASE

A 5-year-old patient was treated in the emergency department after high-energy polytrauma due to a fall on a bicycle, after not being able to stop it on a slope and colliding with a wall. The patient suffered mainly head trauma—as he was not wearing a helmet—thoracic and abdominal trauma, the latter due to direct impact with the handlebars. The constants were correct, maintaining a Glasgow score of 15 at all times and preserving strength and sensitivity. Upon examination, he presented bruising and swelling in the left frontal area and erosion and pain in the lateral area of the thorax and the center of the abdomen, which on palpation was soft, depressible and without signs of peritoneal irritation, with discomfort in the pubic area. Regarding the extremities, the child reported pain in both knees, with preserved joint range of motion.

A cranial computed tomography (CT) scan was performed, which revealed a small acute subdural hematoma and a left frontal fracture that affected the superomedial wall of the orbit and ethmoidal air cells. In the body CT, no noteworthy incidents were found, nor in the simple knee radiographs.

The child was admitted for control of the cranial injuries and, on his second day of hospital stay, the parents commented that he had a lump at the palmar level of the right hand, which did not exist previously. This tumor, soft on palpation, was not painful and was located in the radial region of the carpus, over the area of the scaphoid; its size was 9 x 5 mm. The transillumination test was positive.

In the central area of the carpus there was a slight hematoma, with slight pain on palpation. Additional tests were requested. Plain radiology allowed visualization of a transverse large bone fracture, with minimal displacement (Figure 1).

Subsequently, an ultrasound was carried out in the area of the tumor, which was described as an ovoid echogenic lesion with possible blood content secondary to trauma, without vascularization in the Doppler study, adjacent to the medial part of the scaphoid and the tendon of the flexor carpi radialis, but without being able to rule out possible injuries to the underlying cartilaginous bone. Since most of the cases in the literature of capitate bone fractures in the pediatric age are associated with other injuries of the carpus, such as scaphoid fracture, and taking into account that there were symptoms and an ultrasound suggestive of a synovial cyst of traumatic cause, a magnetic resonance imaging (MRI) was performed (Figure 2) in order to rule out other associated injuries. In this case, no alteration was observed in the rest of the carpus or associated ligaments, and the presence of a hyperintense image in the T2 sequence, corresponding to a synovial cyst, was confirmed as the most probable lesion.

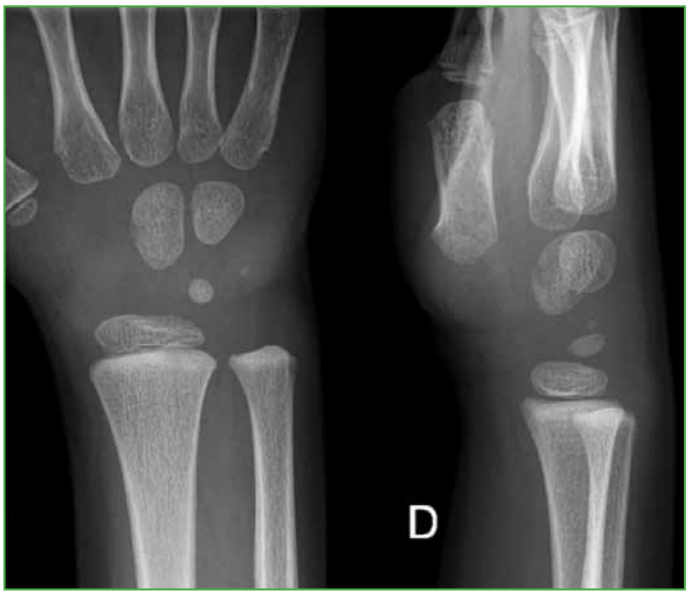


Figure 1. Anteroposterior and lateral radiographs of the right hand. Bone age: 5 years. Ossification of the capitate bone can be seen, with a transverse fracture line, as well as ossification of the hamate bone and early stages of ossification of the lunate and triquetral bones.

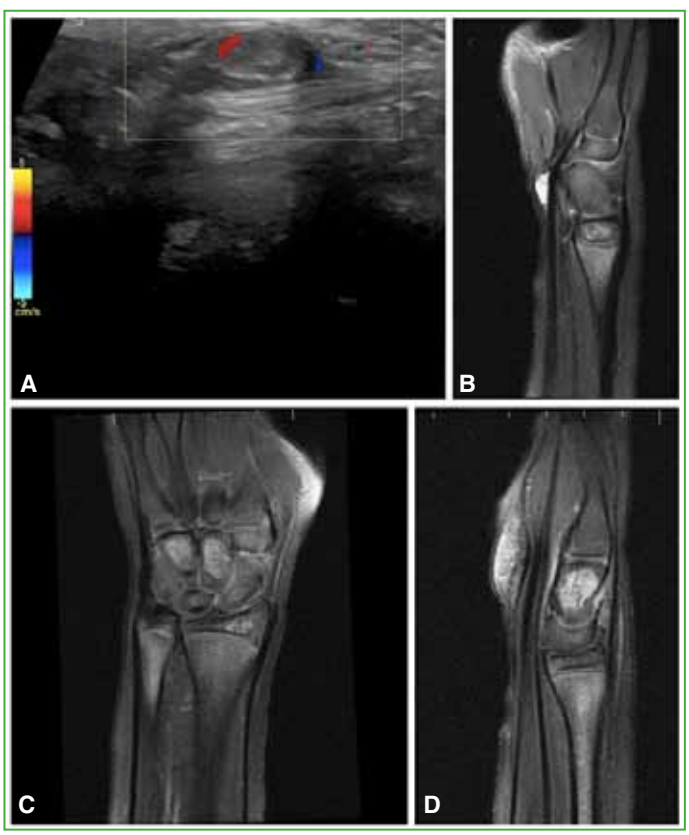


Figure 2. A. Anechoic ultrasound image of the tendon structure. **B.** Sagittal MRI PD FSE FS showing a hyperintense synovial cyst. **C and D.** Coronal and sagittal MRI PD FSE FS with bone lesion in the capitate bone, without associated bone lesions.

The patient continued treatment by immobilization with a short arm cast for 4 weeks, with subsequent progressive mobilization exercises at home, without incidents. Radiographic controls were carried out at 1 week, 1 month and 3 months, and the child achieved complete union of the capitate bone without complications. Due to the good evolution and the lack of other associated lesions, follow-up with other complementary tests was not proposed. The synovial cyst decreased in size until its complete disappearance at 6 months.

DISCUSSION

There is little literature related to isolated capitate fractures in children. We found a total of 38 cases described to date,[3,7,8] the most frequent being those associated with scaphoid fractures[9] or multiple carpal fractures.[10]

The main mechanism of injury occurs by direct trauma and, although the location may be variable, in general, these fractures can be classified into three groups as graphically described by Kadar et al.[3] One of the groups is fractures of the body, which includes comminuted, oblique and transverse fractures; this last location is the most frequent.[2] On the other hand, there are avulsion fractures, both dorsal and volar, and, finally, depression fractures. On many occasions, these fractures are not detected on a simple radiograph; in addition, they may not be clinically evident. Also, in children who still have bone immaturity, ruling out other carpal injuries becomes difficult. For this reason, it is advisable to perform an MRI,[7,8] taking into account that, in young children, sedation or anesthesia is required to keep the limb immobilized. MRI should include coronal T1-weighted images to assess the anatomic relationships and fracture location, and coronal STIR images to assess bone marrow edema. In non-ossified bones, T1 and T2-weighted images should be assessed. There, the fracture line appears as a discrete linear lesion with low signal intensity or a solution of continuity, which can also be seen on STIR, T2 fat saturated, and T2 with magnetization transfer sequences; however, visualization of edema in the surrounding bone marrow can also hide subtle fractures.[11,12]

Regarding the possibly associated ligament lesions, they are identified as a discontinuity and signal alteration of both the ligament and the adjacent soft tissues in most cases. 3D gradient echo, STIR, or fat-suppressed T2 sequences with thin sections are the best options for its visualization, although the alternative of magnetic resonance imaging with intra-articular gadolinium injection could also be considered.[13] When surgery is necessary, this test also helps us to know what injuries we are facing in order to minimize exposure and damage to the intercarpal ligaments.

The complications described in large bone fractures are non-union, which usually occurs in cases of late diagnosis and surgical management in displaced fractures, and avascular necrosis of the proximal pole in relation to its retrograde blood supply, which enters through the palmar middle and the distal third and is directed retrogradely to the proximal pole, which means that this area is the one that, due to a fracture, may be left without vascularization.[3,7,8]

Capitate bone injury usually involves minimal displacement and resolves uneventfully with conservative treatment. However, in cases of greater displacement or severity, closed or open reduction with percutaneous Kirschner wires, resorbable pins, or screws are the described options.[2] In cases of non-union, good results are achieved with treatment by bone graft and internal fixation.[2,8]

The clinical case presented is the first known to date of the association of an isolated capitate bone fracture with the appearance of a synovial cyst due to trauma in a pediatric patient. Thanks to this finding, it was possible to diagnose the bone lesion and rule out possible lesions associated with non-ossified bones at an early age, such as that of this patient. Being aware of this type of presentation and maintaining suspicion when faced with minor patients with high-energy trauma and signs of injury to the carpus can prevent late diagnosis and complications in more serious cases.

The authors declare no conflicts of interest.

J. Gil Albarova ORCID ID: https://orcid.org/0000-0002-1563-9136

REFERENCES

1. Celiktas M, Kose O, Sagiroglu S. Simultaneous fractures of capitate and hamate in a child. *Hong Kong J Emerg Med* 2010;17(2):183-5. https://doi.org/10.1177/102490791001700215
2. Goddard N. Carpal fractures in children. *Clin Orthop Relat Res* 2005;(432):73-6. https://doi/10.1097/01.blo.0000156003.24374.ab
3. Kadar A, Morsy M, Sur YJ, Akdag O, Moran SL. Capitate fractures: A review of 53 patients. *J Hand Surg Am* 2016;41(10):e359-66. https://doi.org/10.1016/j.jhsa.2016.07.099
4. Colberg RE, Sánchez CF, Lugo-Vicente H. Aspiration and triamcinolone acetonide injection of wrist synovial cysts in children. *J Pediatr Surg* 2008;43(11):2087-90. https://doi.org/10.1016/j.jpedsurg.2008.04.004
5. Bracken J, Bartlett M. Ganglion cysts in the paediatric wrist: magnetic resonance imaging findings. *Pediatr Radiol* 2013;43(12):1622-8. https://doi/org/10.1007/s00247-013-2751-9
6. Calif E, Stahl S, Stahl S. Simple wrist ganglia in children: a follow-up study. *J Pediatr Orthop B* 2005;14(6):448-50. https://doi.org/10.1097/01202412-200511000-00012
7. Kuniyoshi K, Toh S, Nishikawa S, Kudo S, Ogawa T, Pegoli L. Long-term follow-up of a malunited, isolated fracture of the capitate in a 6-year-old boy. *J Pediatr Orthop B* 2005;14(1):46-50. https://doi.org/10.1097/01202412-200501000-00008
8. Ochen Y, Emmink BL, Kootstra TJM, Bosman WM, Wittich P, Keizer J. Nonunion of the capitate due to delayed diagnosis of an isolated fracture: A case report. *JBJS Case Connect* 2019;9(4):e0382. https://doi.org/10.2106/JBJS.CC.18.00382
9. Fujioka H, Tanaka J, Tomatsuri M. Scaphoid non-union after simultaneous fractures of the scaphoid and the capitate in a child: a case report. *Hand Surg* 2006;11(3):151-2. https://doi.org/10.1142/S0218810406003280
10. Bhatnagar G, Crone D, Ahmed H. Paediatric multiple carpal fractures: A case report. *Injury Extra* 2008;39(7):247-9. https://doi.org/10.1016/j.injury.2008.01.013
11. Obdeijn MC, van der Vlies CH, van Rijn RR. Capitate and hamate fracture in a child: the value of MRI imaging. *Emerg Radiol* 2010;17(2):157-9. https://doi.org/10.1007/s10140-009-0815-9
12. Chang AL, Yu HJ, von Borstel D, Nozaki T, Horiuchi S, Terada Y, et al. Advanced imaging techniques of the wrist. *AJR Am J Roentgenol* 2017;209(3):497-510. https://doi.org/10.2214/AJR.17.18012
13. Bateni CP, Bartolotta RJ, Richardson ML, Mulcahy H, Allan CH. Imaging key wrist ligaments: what the surgeon needs the radiologist to know. *AJR Am J Roentgenol* 2013;200(5):1089-95. https://doi.org/10.2214/AJR.12.9738

Capillary Hemangioma in the Hallux: Case Report

Leonel A. Rega
Foot and Leg Sector, Orthopedics and Traumatology Service, General Acute Hospital "José María Penna", Autonomous City of Buenos Aires, Argentina

ABSTRACT

Introduction: Hemangiomas are benign neoplasms originating from endothelial cells and may rarely be malignant. The most common symptom is pain, due to the compression of a nerve or nerve trunk by the hemangioma. We present the case of a patient with this type of tumor in an infrequent location. The patient was a 35-year-old female with a painful, brown-colored and friable tumor in the distal region of the hallux which had increased in size in the last months before treatment. Complete surgical resection of the tumor was performed, with a histopathological diagnosis of capillary hemangioma. No recurrence was observed during the 36-month follow-up. **Conclusion:** We recommend a complete resection of these neoplasms and their posterior histopathology analysis.

Keywords: Capillary hemangioma; foot, hallux.
Level of Evidence: IV

Hemangioma capilar en hallux: presentación de un caso

RESUMEN

Introducción: Los hemangiomas son neoplasias benignas que se originan de células endoteliales; rara vez resultan malignas. Su síntoma más común es dolor debido a que el hemangioma comprime un tronco nervioso cercano o un nervio directamente. Presentamos un caso de hemangioma en una región muy poco frecuente. Se trató de una mujer de 35 años que presentaba una tumoración friable, de coloración marrón, dolorosa, en la región distal del hallux, con aumento de tamaño en los últimos meses. Se realizó la exéresis completa de la tumoración en forma quirúrgica, con diagnóstico anatomopatológico de hemangioma capilar, sin recidiva luego de 36 meses de seguimiento. **Conclusión:** Frente a estas neoplasias, se recomienda la exéresis de la pieza y su posterior estudio.

Palabras claves: Hemangioma capilar; pie; hallux.
Nivel de evidencia: IV

INTRODUCTION

Hemangiomas are benign neoplasms that originate from endothelial cells and are rarely malignant. They are blood vessels that cause damage to the skin and mucous membranes in childhood. Most of these injuries are in the head and neck area.[1-4]

The tumor may first be seen as a flat, circumscribed lesion, with telangiectasia in the superficial layers of the skin. The lesion grows rapidly and often becomes pedunculated.[1,3] The most common symptom is pain due to the hemangioma compressing a nearby nerve trunk or a nerve directly. The impairment of function depends on the location of the tumor.[1]

We present a case of hemangioma in a very rare location, the hallux, with its resolution, and we carry out a literature review on the subject.

Received on November 15th, 2021. Accepted after evaluation on May 30th, 2022 • Dr. LEONEL A. REGA • leonelarielrega@gmail.com https://orcid.org/0000-0002-6850-5318
How to cite this article: Rega LA. Capillary Hemangioma in the Hallux: Case Report. *Rev Asoc Argent Ortop Traumatol* 2022;87(6): 819-824. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1464

CLINICAL CASE

A 35-year-old woman, with no relevant personal or family history, came to the clinic due to a painful and bleeding tumor in the distal region of the hallux of the left foot, which had increased in size in recent months, making it difficult for her to use of any footwear. The patient reported that it had started as a macule, and that she suspected that it was a boil. On clinical examination, a friable tumor was observed, painful on palpation, round, with a diameter of approximately 2 cm, brown in color, not attached to deep planes, located on the distal region of the second phalanx of the hallux (Figure 1).

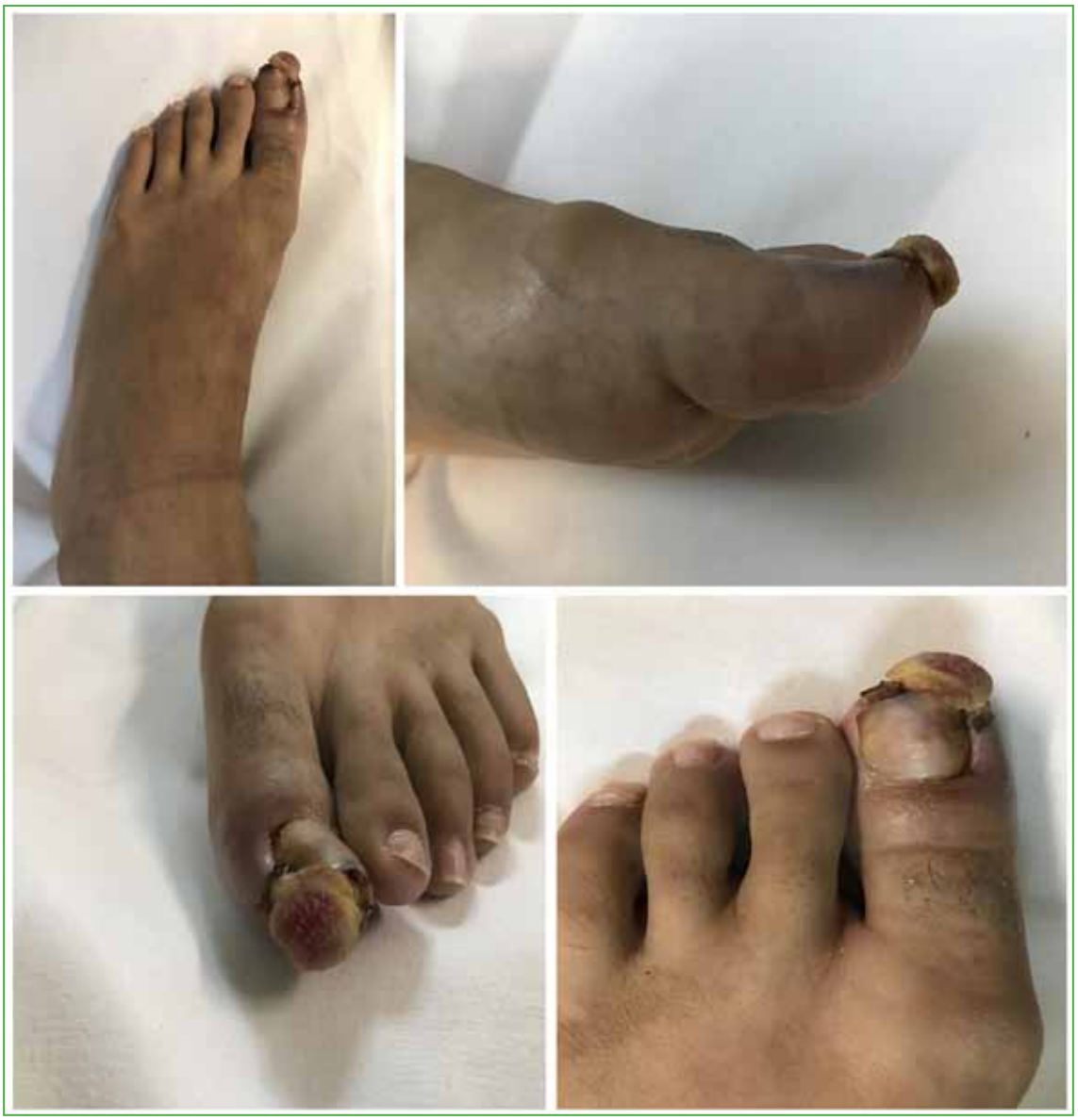


Figure 1. Clinical image of the tumor, friable, round, approximately 2 cm, located in the distal region of the second phalanx of the hallux.

The radiographic and analytical examinations did not provide data of interest. MRI revealed a hyperintense image in the distal region, which did not compromise the bone region (Figure 2).

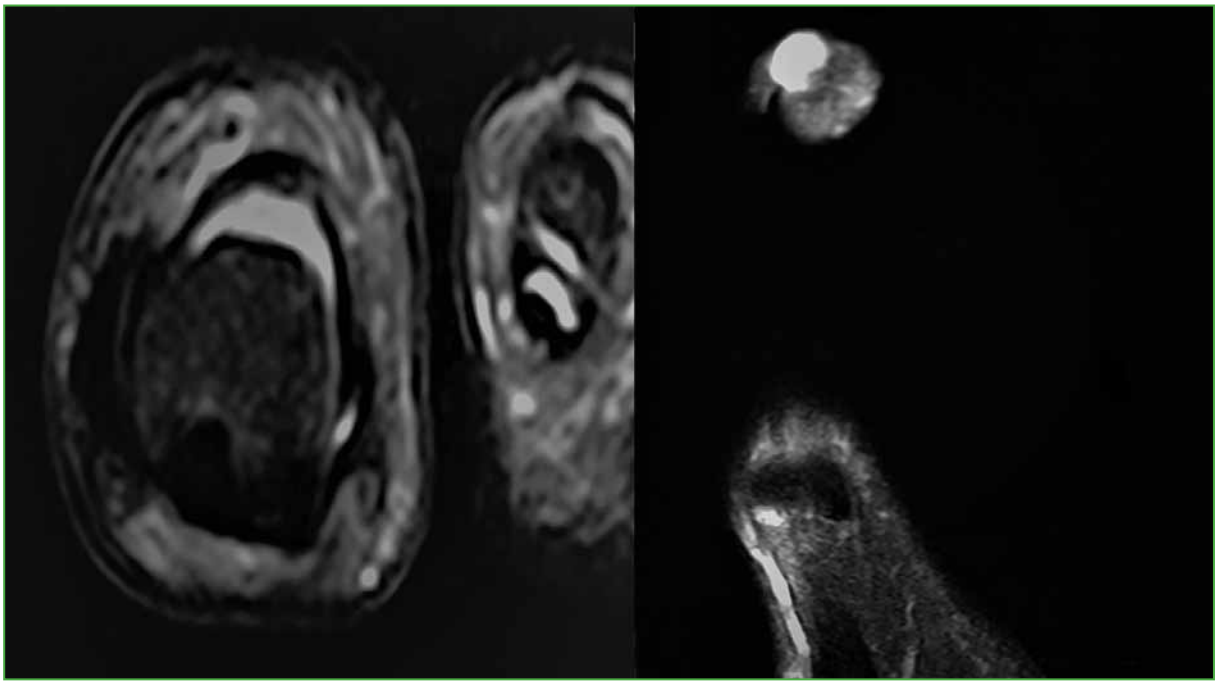


Figure 2. MRI, coronal and sagittal slices. No bone involvement is observed. Right: hyperintense image in the distal region of the toe, compatible with hemangioma

Under regional anesthesia, the tumor was removed through a longitudinal incision over the left hallux. A lobulated lesion with a bleeding and friable pedicle was identified; the excision of the lesion was carried out extensively up to the bone region (Figure 3).

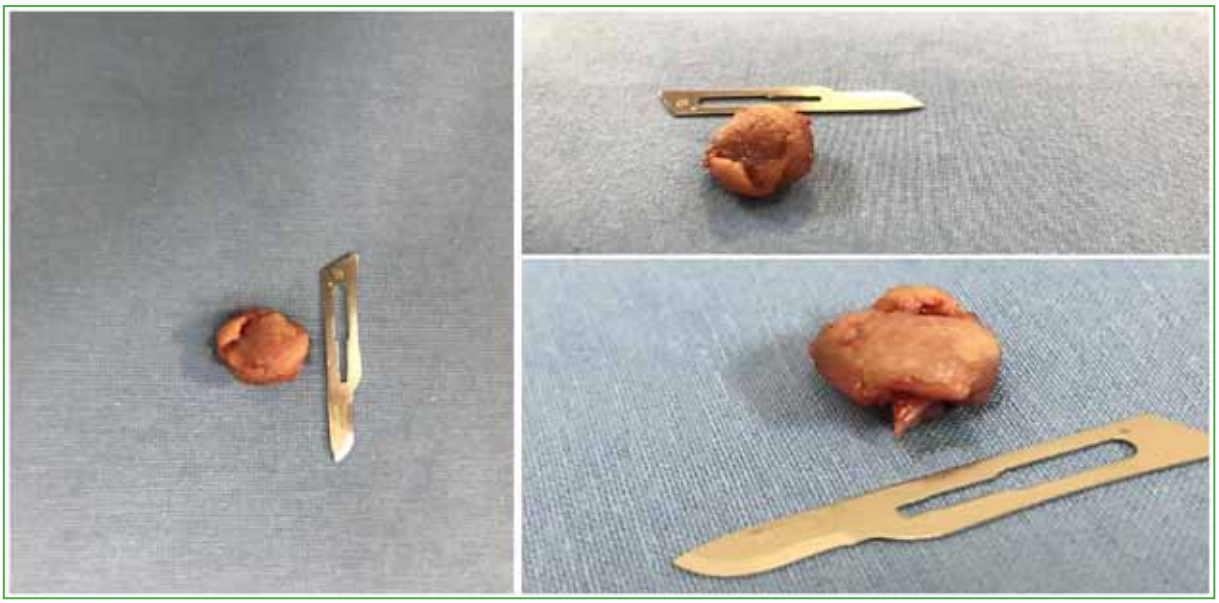


Figure 3. Resected piece. A lobulated tumor with a pedicle is observed. Total excision of the mass together with a border of healthy skin surrounding the neoplasm.

By pathology analysis, a capillary hemangioma with wide margins and lesion was diagnosed, with complete excision (Figure 4).

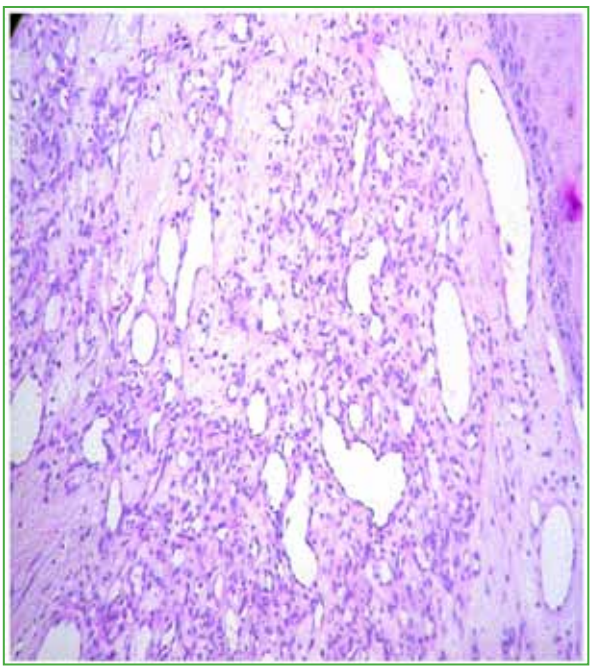


Figure 4. Pathological image stained with hematoxylin-eosin, showing capillaries grouped in tangles.

The patient evolved with a painless, healed wound, and was followed up for 36 months, with no signs of recurrence.

DISCUSSION

Hemangiomas are classified by the International Society for the Study of Vascular Anomalies (ISSVA), an entity established in April 2014, in Melbourne, Australia. They can be classified into three types: cavernous (large vessels, >140 mm), capillary (small vessels, <140 mm), and mixed, according to the predominant vascular pattern. On the other hand, depending on their location, hemangiomas can be superficial (cutaneous or subcutaneous) or deep (intramuscular).[4-9]

Hemangiomas are common and can occur in superficial or deep tissues; they rarely involve the foot.[4,5] They are characterized by presenting three phases: a first proliferative phase, in which the lesion grows rapidly, a period of stability and, finally, an involutional phase in which, regardless of treatment, the lesion fades in color and decreases in size. The duration of each stage varies depending on the type of hemangioma.[4]

They are considered sporadic lesions; however, an autosomal dominant pattern of inheritance (chromosome 9p21-22) has been identified in 1-2%. Hemangiomas are the most common vascular pathology in the pediatric population, occurring in 4% to 10% of Caucasian children, more frequently in premature neonates weighing less than 1200 g, with a history of chorionic villus sampling during pregnancy, female gender and white race.[3]

In a review of 178 cases, Patrice et al. found that lesions were most commonly located in the head and neck area (62.4%), followed by the trunk (19.7%), upper extremity (12.9%), and lower extremity (5.0%).[10] The etiology of capillary hemangioma is unknown.

In a study of 256 cases, Jenkins and Delaney found that 47% were of congenital origin and trauma was the main factor in 17% of cases.[11] One-third of all orbital capillary hemangiomas are diagnosed at birth, and virtually all are diagnosed by 6 months of age. In a study of 600 hemangiomas, Lampe and Latouretter found that 61% were present at birth and 86% appeared in the first month of life.[12]

Kirby et al. reviewed 83 soft tissue tumors and tumor lesions of the foot and found only one hemangioma.[13] González-Guerra et al. described a case of capillary hemangioma with a superficial extension on the sole of the foot, in which they performed an excision, without recurrence in the follow-up of the patient.[2]

Planelles et al. described a case of intramuscular hemangioma in the 4th layer of the foot. It was surgically removed and there was no recurrence after 2 years of clinical follow-up.[7]

The tumor may first be seen as a flat, circumscribed lesion with telangiectasia in the superficial layers of the skin. The lesion grows rapidly and often becomes pedunculated. There may be discoloration of the skin that may vary from red to brown or blue to purple when the soft tissue mass is very close to the epidermis.[1]

Capillary hemangiomas can vary in consistency from soft and spongy to a hard mass, and can be fixed or mobile under the epidermis. They often ulcerate and protrude from the epidermis.[1]

Pulsations are rare, but if found, they are usually adjacent to the lesion and felt distal to it. A history of ulceration and spontaneous bleeding is common in capillary hemangioma. The first visit to the doctor is usually due to the onset of an epidermal crisis, scabbing, and bleeding.[1]

The typical microscopic appearance of a hemangioma is a well-circumscribed exophytic mass attached to a narrow stalk, consisting of aggregates of proliferating capillaries located within an edematous matrix.[1,6]

The tumor is composed of tightly packed, thin walls, arranged in lobes. The epidermal surface often shows focal areas of atrophy or ulceration.[1,6]

The clinical diagnosis of capillary hemangioma is difficult to make before a pathologic evaluation. Differential diagnoses may include a cyst, arteriovenous fistulas, senile angioma-like eruptions, pyogenic granulomas, angioblastomas, verrucous hemangiomas, tufted hemangiomas, and angiosarcoma.[1,6]

The usual treatment is cauterization with silver nitrate, electrodesiccation, curettage or tangential excision and cauterization.[1,4,6,7] Commonly used sclerosing agents include ethyl alcohol, ethanolamine oleate, and polidocanol. Ethyl alcohol is very effective; however, tissue necrosis, peripheral nerve injury, pulmonary embolism, pulmonary vasospasm, arrhythmia, and electromechanical dissociation may occur.[6]

Surgical excision of a hemangioma may be indicated at any stage of its life cycle. To avoid recurrence, the resection must be complete.[4,14] In published series, recurrence rates, especially after incomplete excision, have ranged from 18% to 61%. The risk factors for recurrence reported are, firstly, incomplete surgical margins and secondly, tumor size.[6,7]

CONCLUSIONS

In summary, capillary hemangiomas, although not life-threatening, represent a diagnostic challenge. Their rarity, variable radiographic appearance, and sometimes enigmatic biopsy tissue pattern require close cooperation between the pathologist and the radiologist to arrive at the correct diagnosis.

Hemangiomas are benign vascular tumors. They are congenital and rarely hereditary, although trauma may be a predisposing factor. Common symptoms include pain, swelling, skin discoloration, and an associated mass. The definitive diagnosis is made through macroscopic and microscopic examination of the mass. Surgical excision is the standard treatment; percutaneous sclerotherapy is an alternative treatment.

Complete excision is important, since partial resection usually presents local recurrence. For this reason, a careful histological study of the limits of the resected specimen must be performed to confirm that the excision has been complete.

Conflict of interest: The author declares no conflicts of interest.

REFERENCES

1. Cione JA, Cozzarelli J. Capillary hemangioma of the foot. *J Am Podiatr Med Assoc* 2014;92(3):155-7. https://doi.org/10.7547/87507315-92-3-155
2. González-Guerra E, Haro MR, Angulo J, Fariña MC, Martín L, Requena L. Hemangioma capilar de extensión superficial: descripción de un caso. *Actas Dermosifiliogr* 2009;98(6):430-2. https://doi.org/10.1016/S0001-7310(07)70097-2
3. Maldonado MJ, Pérez SA, Casas Mateus A. Timolol tópico para el manejo de cutis marmorata telangiectásica y hemangiomas ulcerados. Reporte de caso. *Medicina* 2018;40(3):354-9. Available at: http://www.revistamedicina.net/ojsanm/index.php/Medicina/article/view/1373/1680
4. Ariza Rodríguez A. Hemangioma en el pie: Estudio de prevalencia y revisión. 2017. Tesis. Universitat de Barcelona. Director de Tesis: Zalacain A. Available at: http://hdl.handle.net/2445/114022
5. Yetkin H, Kanatli U, Guzel VB, Poyraz A. Multiple hemangiomas of the foot: A case report. *Foot Ankle Int* 2001;22(2):150-2. https://doi.org/10.1177/107110070102200212
6. Uslu M, Beşir H, Turan H, Bozkaya H, Erdem H. Two different treatment options for intramuscular plantar hemangioma: Surgery versus percutaneous sclerotherapy. *J Foot Ankle Surg* 2014;53(6):759-62. https://doi.org/10.1053/j.jfas.2014.06.008
7. Planelles AA, Iturriagagoitia AC, Martínez TP. Hemangioma intramuscular localizado en el pie. *Rev Esp Cir Osteoar* 1994;29(169):49-52. Available at: http://www.cirugia-osteoarticular.org/adaptingsystem/intercambio/revistas/articulos/1489_49.pdf
8. Davies J, Stone P, McGarry J. Mixed cavernous and capillary intraosseous hemangioma of the foot. *J Am Podiatr Med Assoc* 2014;87(10):478-82. https://doi.org/10.7547/87507315-87-10-478
9. Wassef M, Borsik M, Cerceau P, Faucon B, Laurian C, Le Clerc N, et al. Classification des tumeurs et malformations vasculaires. Apport de la classification ISSVA 2014/2018. *Ann Pathol* 2021;41(1):58-70. https://doi.org/10.1016/j.annpat.2020.11.004
10. Patrice SJ, Wiss K, Mulliken JB. Pyogenic granuloma (lobular capillary hemangioma): a clinicopathologic study of 178 cases. *Pediatr Dermatol* 1991;8(4):267-76. https://doi.org/10.1111/j.1525-1470.1991.tb00931.x
11. Jenkins HP, Delaney PA. Benign angiomatous tumors of skeletal muscles. *Surg Gynecol Obstet* 1932;55:4464-80.
12. Lampe I, Latourette HB. The management of cavernous hemangiomas in infants. *Postgrad Med* 1956;19(3):262-70.
13. Kirby EJ, Shereff MJ, Lewis MM. Soft-tissue tumors and tumor-like lesions of the foot. An analysis of eighty-three cases. *J Bone Joint Surg Am* 1989;71(4):621-6. PMID: 2703521
14. Ferrando MA, Carbia S, Marrero M, Etchart C, La Forgia M. Hemangioma arteriovenoso (aneurisma cirsoide) subungueal. *Med Cutan Ibero Lat Am* 2011;39(5):238-40. Available at: https://www.medigraphic.com/pdfs/cutanea/mc-2011/mc115g.pdf

Multimodal Perioperative Pharmacological Protocol in Pediatric Spine Surgery

Lucas Piantoni, Carlos A. Tello, Rodrigo G. Remondino, Eduardo Galaretto, Mariano A. Noel
Department of Spinal Pathology, Hospital de Pediatría Prof. Dr. Juan P. Garrahan. Buenos Aires, Argentina

ABSTRACT

Introduction: Spine surgery has one of the highest morbimortality rates in the pediatric population. Pain management has not been standardized on said population. Multimodal analgesia (MMA) was developed to resolve that problem. **Objective:** To develop, based on a systematic review, a detailed and original pain management multimodal pharmacology protocol for pre and post-operative (intra and extra-hospital) periods for the pediatric population undergoing spine surgery. **Materials and Methods:** We conducted a systematic review of full texts in English and Spanish from PubMed, Embase, Cochrane Library, and LiLacs Database from 2000 to 2021. We used the PRISMA flow diagram. **Results:** From a total of 756 papers, 38 were included in the final evaluation. Considering the bioethical difficulties to develop a manuscript from clinical trials with drugs and drug combinations in the pediatric population, we developed an original and detailed pain management protocol for pre and post-operative (intra and extra-hospital) periods for the pediatric population undergoing spine surgery. **Conclusion:** Based on a systematic review, we succeeded in developing a simple and easily reproducible perioperative multimodal pain management protocol (intra and extra-hospital), intending to expedite the patient's functional recovery and reduce global socioeconomic costs.

Level de Evidence: II

Keywords: spine surgery; pediatrics; post-operative pain; multimodal analgesia

Protocolo multimodal farmacológico perioperatorio en cirugía de columna pediátrica

RESUMEN

Introducción: La cirugía de columna es uno de los procedimientos con mayor morbimortalidad dentro de la población pediátrica; el manejo farmacológico del dolor en dicha población aún no se encuentra estandarizado. La analgesia multimodal (MMA) trata de responder a esta problemática. **Objetivo:** Desarrollar, basados en una revisión sistemática de la literatura, un detallado protocolo multimodal farmacológico para el manejo del dolor pre- y posoperatorio intra/extrahospitalario en cirugía de columna pediátrica. **Materiales y Métodos:** Se realizó una revisión sistemática de textos completos en inglés o español en PubMed, Embase, Cochrane Library y LILACS Database publicados entre 2000 y 2021; se aplicó el diagrama de flujo PRISMA. **Resultados:** De 756 artículos preseleccionados, 38 fueron incluidos en la evaluación final. Dada la dificultad bioética de desarrollar trabajos en formato de ensayos clínicos con fármacos y combinaciones de ellos en la población pediátrica, desarrollamos un protocolo detallado de manejo de dolor pre- y posoperatorio EV/VO, intra- y extrahospitalario, para aplicar en niños llevados a cirugía de columna. **Conclusión:** Logramos desarrollar un detallado protocolo multimodal farmacológico para el perioperatorio intra- y extrahospitalario de cirugía de columna en niños, sencillo y reproducible, tendiente a acelerar la recuperación funcional del paciente y disminuir los costos socioeconómicos globales.

Palabras clave: cirugía de columna, pediatría, dolor posoperatorio, analgesia multimodal

Nivel de Evidencia: II

Received on May 1th, 2022. Accepted after evaluation on July 20th, 2022 • Dr. LUCAS PIANTONI • lucaspiantoni@gmail.com https://orcid.org/0000-0002-6616-9314

How to cite this article: Piantoni L, Tello CA, Remondino RG, Galaretto E, Noel MA. Multimodal Perioperative Pharmacological Protocol in Pediatric Spine Surgery. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):825-837. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1490

INTRODUCTION

Scoliosis is a three-dimensional deformity of the spine, which generates a pathological angulation. Treatment may eventually require surgery, its objective is to prevent the progression of the deformity and to correct and obtain a solid arthrodesis. This surgery is recognized as one of the most invasive orthopedic procedures performed on pediatric patients.[1-4]

Spinal surgery in the pediatric population is associated with considerable postoperative pain, which frequently requires the parenteral use of opioids. The counterpart is the usual adverse effects, such as nausea, vomiting, pruritus, urinary retention and respiratory depression. At the same time, states of moderate sedation could delay the patient's functional recovery and discharge.[1,4-32]

The other pharmacological group usually associated with opioids and used in pediatric surgery are NSAIDs (non-steroidal anti-inflammatory drugs). These are considered analgesic, anti-inflammatory, antipyretic and antiplatelet agents for the most part. They have a peripheral and central mechanism of action, less analgesic efficacy than opioids, with a ceiling effect of toxicity. The adverse effects to take into account are gastrotoxicity, hepatotoxicity, neurotoxicity, cardiotoxicity, anaphylaxis and inhibition of platelet aggregation, among others. [1-12,16-19,22-24,32-41]

In some patients and their families, fear of Post-Op Pain creates stress, and this negatively affects recovery. In turn, the literature describes postoperative pain associated with spinal surgery as one of the most frequent variables for hospital readmission, among others.[42]

Pain management after spinal surgery in the pediatric population can be approached in different ways. To our knowledge, this topic does not appear clearly standardized in the literature, so there are innumerable references to multiple drugs, routes of administration, and possible combinations associated with pre-, intra-, and postoperative pain management. [1-15,32-39,43-45] Among them, we can mention the use of opioid derivatives, administered by health personnel or through a patient-controlled analgesia (PCA) device. Continuous epidural infusion (CEI) of opioids or intrathecal injection (IDD) of morphine in a single dose (pre- or intraoperative) are also indicated. These regimens, added to the use of adjuvants, have been used intravenously (IV) and orally (PO) during the postoperative period during hospitalization and after discharge.[1-21,23-39,46,47]

Multimodal analgesia (MMA), first described in 1993 by Kehlet and Dahlj, arises in response to this problem. It is based on the combination of different analgesic and anti-inflammatory drugs, taking into account the different underlying pathophysiological mechanisms. This approach proposes to achieve a more adequate control of pain using lower doses of drugs, thus reducing their adverse effects. [1-21,23-39,47]

The pharmacological management of postoperative pain after pediatric spine surgery, which includes MMA, is not clearly standardized in the international literature. It is possible to find various papers that propose alternative, not completely defined algorithms for pre-, intra- and postoperative medication, for intra- or extra-hospital use. We understand that the development and subsequent implementation of such a protocol, with an adequate detail of the complete dosage, frequency, and days, both in the in-hospital and out-of-hospital context (within the availability of each means), would improve the quality of life of the patient and accelerate their functional recovery while decreasing the socioeconomic costs of the family group and the health system. [1-21,23-39,47]

The objective of this research was to develop, through a systematic review of the literature, a detailed and original multimodal pharmacological protocol for the management of pre- and postoperative pain, intra- and extra-hospital, in spinal surgery in the pediatric population.

MATERIALS AND METHODS

We conducted a literature search of full texts in English or Spanish published between 2000 and 2021 in the PubMed, Embase, Cochrane Library and LILACS Databases. For the literature search, the following combination of MeSH (Medical Subject Headings) terms was used: "spine surgery", "postoperative pain" and "pediatrics". Additionally, a manual search was performed. The extracted information was ordered by main author, year of publication, department in charge, study design, drugs used and recommended doses, conclusions, and recommendations.

A total of 756 articles were found, of which 38 were included in the final evaluation. Inclusion criteria were patients aged 10-18 years who had undergone primary instrumented spinal surgery and had received a multimodal management protocol for postoperative pain.

As this is a systematic review, approval by an ethics committee or institutional review board (IRB) was deemed unnecessary. The flowchart standard known as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was followed, as summarized in Figure 1.

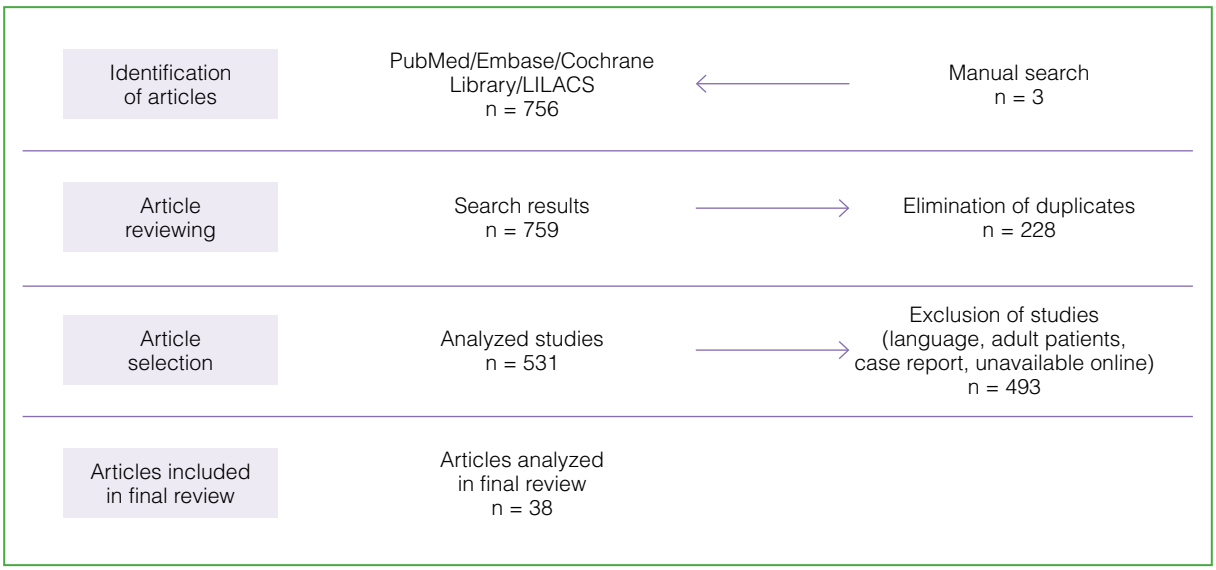


Figure. 1. Flowchart (PRISMA)

RESULTS

756 articles were found, of which 718 were excluded because they had not met the inclusion criteria, because they were duplicated, because they were not available online, or because they were case reports. In short, the final analysis included 38 studies and significant heterogeneity was detected among them in terms of methodology, population evaluated, and arbitrary comparisons between drugs and doses.

Most of the 38 papers considered had a multidisciplinary approach; 14 papers were in charge of anesthesiologists, 13 were authored by trauma surgeons, 7 responded to clinical medicine, 3 to the specialty of palliative care, and 2 were approached by neurosurgeons. Within the methodologies followed, we registered 14 systematic reviews, 11 case series, 5 were not clearly specified, and 3 were expert recommendations.

The vast majority of these works described the need to introduce a multimodal analgesia scheme, be it preoperative, intraoperative (in its various routes of administration) or postoperative, or their combinations. Some of them were inconclusive and made little reference to intra- and extra-hospital postoperative pain management.

The work of Lee et al. is worth noting, a systematic review in which they developed an intraoperative and postoperative pain MMA scheme (admission and discharge), where opioids were used with PCA. In this work, no reference was made to preoperative medication, and extensive reference was made to the difference between intraoperative and epidural opioids versus intrathecal opioids.[32]

On the other hand, Frizzell et al., included general orthopedic patients, with a methodology not fully specified, where various tools were listed for the management of postoperative pain, with drugs and possible doses not clearly defined, and they developed an intra- and extra-hospital protocol with opioids (with PCA).[39]

In a case series with 57 patients who underwent spinal surgery, Anderson et al. described a protocol with opioids and PCA. The doses of the different drugs were not detailed and regarding the frequency, it was indicated "as needed". They did not describe it according to days of postoperative pain nor with respect to the out-of-hospital period.[30]

Yoo et al. comprehensively described the physiopathogenesis of pain; the methodology of work is not completely clear. An MMA pain management protocol was described on postoperative days 1 and 2 only, and no reference was made to management at hospital discharge.[23] In a retrospective study of 29 patients with Post-Op Pain of the pectus in pediatrics, Man et al. described an interesting and rich MMA pain management protocol during the postoperative period and after discharge, but did not clarify the dose or relationship with Post-Op Pain days.[37]

Rao et al. referred to the importance of pain management in a MMA format within an ERAS (Enhanced Recovery After Surgery) protocol, and supported the use of opioids with PCA. They did not detail the doses of the Post-Op Pain drugs and the study lacked an analgesic plan at discharge.[25] Table 1 summarizes the information collected from the works finally evaluated.

Table 1. Main characteristics of the selected works

#	Authors/ Year	Department/s in charge of research	Study design	Pediatric population included	Described MMA pain scheme (drugs/dose)	Drugs/doses described	Strengths and/or limitations of the work
1	Wong et al./2017	Orthopedics/ Rehabilitation/Physical Therapy	Systematic review	Yes	No	NSAIDs, paracetamol	Promoted patient and family education
2	Rawal et al./2016	Anesthesia	Not specified	Not specified	No	NSAIDs, ketamine, gabapentinoids, opioids	Promoted communication between palliative care specialists, nurses, and surgeons
3	Joshi et al./2019	General Surgery	Not specified	Not specified	No	NSAIDs, ketamine, gabapentinoids, opioids	Collaborated with ERAS
4	Kaye et al./2020	Anesthesia	Systematic review	Not specified	No	Dexmedetomidine	Promoted use of dexmedetomidine
5	Borgeat et al./2008	Anesthesia	Systematic review	Yes	No	NSAIDs, acetaminophen, gabapentin, opioids, corticosteroids, and muscle relaxants	Promoted use of epidural analgesia
6	Chou et al./2018	Orthopedics / Neurology / Epidemiology	Systematic review	Not specified	No	NSAIDs, acetaminophen, antidepressants, gabapentinoids	No corticosteroids/BZD, adaptation of analgesia to low-resource countries. Patient education
7	Oliveira et al./2018	Clinical / Physical Therapy	Systematic review	Not specified	No	NSAIDs, acetaminophen, opioids, antidepressants	Promoted practical pain treatment guidelines
8	Hsu et al./2019	Orthopedics / Palliative care	Expert recommendation	Not specified	No	NSAIDs, acetaminophen, gabapentin, opioids	Promoted MMA treatment/ physical and cognitive therapy
9	Zielinski et al./2020	Head and neck surgery	Systematic review	Yes	No	NSAIDs, opioids, paracetamol	Promoted practical pain treatment guidelines
10	Koes et al./2010	Clinic	Systematic review	Not specified	No	NSAIDs, acetaminophen, antidepressants, corticosteroids, gabapentinoids	Using how-to guides are challenging
11	Aubrun et al./2019	Clinic / Palliative	Expert recommendation	Not specified	No	NSAIDs, ketamine, gabapentin, opioids	Addition of opioids, dexamethasone, NSAIDs

12	Apfelbaum et al./2012	Anesthesia	Case series	Not specified	Partially	Paracetamol, fentanyl, opioids, NSAIDs, ketamine.	Promoted MMA treatment, did not describe it with doses/days
13	Yousefifard et al./2019	Anesthesia / Emergencies / Physiology	Systematic review	Adult and pediatric	No	Paracetamol, fentanyl, opioids, NSAIDs, ketamine.	Did not recommend unimodal use of opioids
14	Joshi et al./2017	Anesthesia	Expert recommendation	Not specified	No	Paracetamol, fentanyl, opioids, NSAIDs, ketamine.	Review methodology to develop pain guidelines
15	Creary et al./2020	Anesthesia / Clinic / Palliative	Retrospective study (n= 1505)	Yes	No	NSAIDs, opioids	Stimulating work with opioids in pediatric guidelines
16	Dabbagh et al./2020	Emergency	Not specified	Yes	No	No	Adding non-pharmacological therapies
17	Frizzell et al./2017	Orthopedics	Not specified	Yes	Partially	Acetaminophen, NSAIDs, opioids, gabapentinoids, BZDs.	Methodology not specified; did not dose all drugs; opioids with PCA; orthopedic surgery; High MMA without dose.
18	Young/2017	Emergency	Systematic review	Yes	No	No	Promoted rapid diagnosis and treatment of pain, adding non-pharmacological therapies
19	Lee et al./2020	Anesthesia	Systematic review	Yes	Yes, w/ PCA	Opioids, ketamine, gabapentin, BZD.	Systematic review; opioid differences EPI vs. ITM; no pre-OP drugs; opioids with PCA; MMA day/day with dose
20	Jones et al./2014	Anesthesia	Retrospective study (n= 163)	Yes	No	Dexmedetomidine, opioids	No differences between groups with or without dexmedetomidine
21	Hong et al./2017	Anesthesia	Retrospective study (n= 40)	Yes	No	Fentanyl, oxycodone, ketorolac, paracetamol, diazepam	Promoted MMA treatment
22	Mc Nicol et al./2018	Anesthesia	Systematic review	Yes	No	Opioids, ketorolac	Insufficient data to support use of ketorolac
23	Aoki et al./2021	Anesthesia	Retrospective study (n= 142)	Yes	No	Dexmedetomidine, opioids, NSAIDs, acetaminophen	MMA and fentanyl use need to be better studied
24	Sheffer et al./2017	Orthopedics	Non-systematic review	Yes	No	NSAIDs, ketamine, gabapentinoids, opioids	Promoted MMA treatment
25	Shah et al./2020	Orthopedics / Clinic	Systematic review	Yes	No	NSAIDs, acetaminophen, gabapentin, opioids	Promoted MMA treatment
26	Johnson et al./2021	Orthopedics	Systematic review	Yes	No	NSAIDs, opioids, gabapentinoids, corticosteroids	Reduction of pain to improve recovery

27	Anderson et al./2020	Orthopedics	Case series (n= 57)	Yes	Partially	NSAIDs, gabapentin, opioids, acetaminophen	prospective; idiopathic PIA; opioids with PCA; Post-Op Pain drugs without doses; drugs "according to pain"; high MMA without dose
28	Yoo et al./2019	Orthopedics / Anesthesia	Non-systematic review	Yes	Partially	NSAIDs, acetaminophen, gabapentin, opioids, corticosteroids, and muscle relaxants	Methodology not specified; detailed pain pathophysiology; Post-Op Pain day 1-2 only; no discharge MMA protocol
29	Rajpal et al./2010	Orthopedics / Neurosurgery	Case series	Not specified	No	NSAIDs, acetaminophen, gabapentin, opioids	Promoted MMA treatment
30	Devin et al./2015	Orthopedics / Neurosurgery	Systematic review	Not specified	No	NSAIDs, acetaminophen, gabapentin, opioids	Promoted MMA treatment
31	Man et al./2017	Anesthesia / Clinic	Case series (n= 29)	Yes	Partially	NSAIDs, acetaminophen, gabapentin, opioids and muscle relaxants, ketamine, corticosteroids	Retrospective; Post-Op Pain pectus; did not give Post-Op Pain dose; discharge MMA without dose
32	Rao et al./2021	Orthopedics	Case series (n= 117)	Yes	Partially	NSAIDs, acetaminophen, gabapentin, opioids	Retrospective; did not give dosage; opioids with PCA; no discharge MMA protocol
33	Song et al./2014	Orthopedics / Anesthesia	Case series (n= 155)	Yes	No	NSAIDs, acetaminophen, gabapentin, opioids, and muscle relaxants	Promoted ERAS in Post-Op Pain and MMA
34	YaDeau et al./2019	Orthopedics / Anesthesia	Case series (n= 154)	No	Partially	Acetaminophen, NSAIDs, opioids	Shoulder arthroplasty, MMA for Post-Op Pain without doses/days, no discharge MMA protocol
35	Pagnotto et al./2012	Not specified	Technique description	No	Partially	Acetaminophen, NSAIDs, opioids	Knee arthroplasty; includes pre-OP MMA, no post-OP MMA doses/days, no discharge MMA protocol
36	Bean et al./2018	Orthopedics	Case series (n= 61)	No	Partially	Acetaminophen, NSAIDs, opioids, gabapentinoids, antipsychotics	knee arthroplasty Post-Op Pain; uses trade names of drugs; MMA Post-Op Pain protocol without clear dosage and without days
37	Li et al./2021	Orthopedics	Case series (n= 216)	No	Yes, Post-Op Pain knee arthroplasty	Acetaminophen, NSAIDs, opioids, gabapentinoids	Post-Op Pain knee arthroplasty; uses trade names of drugs; MMA Post-Op Pain protocol without days/dosage
38	Karam et al./2021	Orthopedics	Non-systematic review	No	Partially	Acetaminophen, NSAIDs, opioids, gabapentinoids, corticosteroids	MMA Post-Op Pain hip/knee arthroplasty; no regulated opioids, no dosage/days

MMA, multimodal analgesia; NSAIDs, non-steroidal anti-inflammatory drugs; ERAS, Enhanced Recovery After Surgery; BZD, benzodiazepines; PCA, patient-controlled analgesia; EPI, epidural morphine; ITM; intrathecal morphine; PIA, posterior instrumented arthrodesis; n, number of patients.

DISCUSSION

Spinal surgery is one of the procedures with the highest morbidity and mortality among surgeries performed in the pediatric population.[1-3,20,32,33,37,42-45] postoperative pain is frequently severe and requires advanced pharmacological management in the pre-, intra- and postoperative period through intrathecal, intravenous and oral administration and a combination of other methods. [1-21,25-38] In regimens used as the main or only drug, systemic opioids are associated with numerous adverse effects such as nausea, constipation, pruritus, urinary retention, sedation, respiratory depression, deep vein thrombosis, pulmonary embolism, depression and insomnia, and greater probabilities of developing chronic pain, prolonged hospitalization, hospital readmissions, possibility of addiction and effects on the hypothalamus-pituitary axis.[1-3,21,32,33,37,43-45]

Within the other group of drugs commonly used in schemes for the management of perioperative pain, NSAIDs, their gastrotoxicity, hepatotoxicity, neurotoxicity, cardiotoxicity, anaphylaxis and inhibition of platelet aggregation, among others, must be taken into account. [1-12,16-19,22-24,32-38,40] The prevention and effective multimodal management of acute pain could improve clinical outcomes and the quality of life of the patient and their family, avoiding complications and reducing family and health system costs.[1-19,21-47]

It is vitally important to contextualize, within the possibilities of each demographic region and availability of the health group, the variables of each patient, such as weight, age, comorbidities and contraindications for the appropriate use of opioids, NSAIDs and multiple other pharmacological options detailed in this work. Our objective was to propose a rational and balanced multimodal pharmacological scheme for pain, which implies lower doses and a more reduced profile of expected adverse effects, in a context suitable for the patient, as a unique individual, which is a difficult task.

In a prospective study whose objective was to evaluate the concerns in the perioperative period of both the patients and their relatives, Chan et al. found that the greatest concern was postoperative pain, at 55%.[48] For their part, Landaman et al. concluded that postoperative pain management success has been measured by radiographic images, classifications, and magnitudes of correction; however, the system has consistently failed to report pre- and postoperative pain.[49]

Members of the American Society of Anesthesiology (ASA) strongly recommend the evaluation of pediatric patients who are about to undergo surgical procedures for timely perioperative management. Analgesic therapy will depend on age, weight, comorbidities and contraindications, within an important multidisciplinary work. postoperative pain management has to be aggressive and proactive in bringing to fruition a generally undertreated problem.[13]

It is not possible to achieve optimal management of postoperative pain with a single drug or a single method without significant adverse effects.[1-5,32,34,37,39,43-45] Piantoni et al. reported that 80% of the pediatric population reported a poor experience in post-surgery pain management, and only half of these patients resolved their pain satisfactorily in the following days.[4] Wong et al. found that 7-10% of adolescent patients reported back pain more than 12 months after surgery.[50]

During pediatric spinal surgery, several anesthetic techniques involve high doses of opioids, but with short durations of action, such as remifentanil, to facilitate neurophysiological monitoring.[51] PCA, described in all postoperative pain protocols in the international literature, has the loss of control during the night as its first disadvantage; regardless of this, it is not available in all media. Other articles refer to the use of morphine EPI in scoliosis surgery, the difficulty of which is placement and maintenance of the catheter in the epidural space. The application of an MMA regimen in the pediatric population has been delayed due to the lack of literature focused on this age group. The current concern about the adverse effects of drugs in children is, today, the basis of countless investigations, and the published studies focus on finding ways to reduce opioid use and its adverse effects.[1-4,6,7,9,10,13-15,23-31,34,35,39,38,45,52]

There are new trends to reinforce the idea of this modality, for example, the addition of NSAIDs and antineuritics.[1-20,22-40,42-45,47] It has been shown that the administration of postoperative pain NSAIDs would reduce the probability of prolonged use of opioids, their adverse effects and hospital stay.[2-15,37-37,43-45] Muhly et al. recently examined a way to rapidly recover and decrease postoperative pain after spinal instrumentation using preoperative gabapentin and acetaminophen, and postoperative intravenous acetaminophen, opioid PCA, gabapentin, and ketorolac.[31]

Milbrant et al. reported that a simple IT morphine infusion would produce fewer adverse effects compared to EPI and PCA, which can range from pruritus or transient neurological changes to respiratory depression.[1] In a system-

atic review, Zielinski et al . promoted the use of MMA in the pediatric population,[21] like Hsu et al.[7] and Oliveira et al.[6] Along the same lines, Sha et al.[9] and Sheffer et al.[10] referred to the need to promote an MMA scheme. PCA involves, on the one hand, a problem of equipment availability, and, on the other, an organizational and patient monitoring inconvenience. The epidural catheter, in addition to being expensive and technically complex, is not the choice for surgery in our setting, because one of the primary objectives is the rapid mobilization of the patient, and this would hinder said functional recovery.

Chou et al. concluded that the use of NSAIDs, acetaminophen and antidepressants is convenient.[33] In turn, Aubrun et al. recommended the use of NSAIDs, ketamine, opioids, and gabapentin.[8] Yousefifard et al. recommended the use of paracetamol, fentanyl and opioids, and did not advise the isolated use of opioids, both in the adult and pediatric population.[5]

The use of muscle relaxants and benzodiazepines was widely developed as an important adjunctive tool within MMA regimens in the works of Walker et al.,[2] Lee et al.,[32] Oliveira et al., [6] Parrish et al., [34] Frizzell et al., [39] Hong et al., [35] Koes et al., [36] Borgeat et al., [12] Man et al., [37] Yoo et al., [23] and Song et al., [47] among others. In turn, there is an extensive description of the incorporation of glucocorticoids in MMA schemes, for example, in Cozowicz et al.,[3] Chou et al., [33] Parrish et al., [34] Johnson et al., [11] Koes et al., [36] Borgeat et al., [12] Man et al., [37] Ntalouka et al., [43] Mathiensen et al., [44] Momon et al., [45] and Yoo et al., [23] among others.

Being aware of the bioethical difficulty of conducting research in the form of clinical trials with drugs and their combinations in the pediatric population and considering the scant international literature on physiopathogenesis and pharmacodynamics in this population, in this report we propose a basic perioperative pain management protocol— IV/PO, intra- and extra-hospital—to be applied in the pediatric population subjected to spinal surgery. This protocol is supported by treatment guidelines such as Cochrane, ASA "American Society of Anesthesiology" and others, and published case series (see Table 1). This protocol includes drugs and devices available in our setting (not PCA) and is described by agent, dose, route, and day.

The drugs and their doses were adjusted to the availability and regulations of the hospital handbook, after the consensus of the Sociedad Argentina de Pediatría.[53] During the postoperative period, pain assessment was performed daily according to the Numerical Assessment Scale, with a diet rich in fiber and supervision by the palliative care team (referral). Hospital discharge: same pharmacological scheme for 7 days and outpatient control by the palliative care team, taking into account that the aim is a short-term pharmacological intervention.

Special considerations with respect to the original pharmacological protocol

Regarding the adjustment of the morphine dose as rescue, this will be done as needed; which will be evaluated with the FLACC pain scale, VAS/VNS, Wong & Baker, every 6 h. Depending on the value it returns, different measures will be taken, namely:

a) 4-5 (moderate pain): administer rescue doses and reassess after 10 minutes, wait for a decrease or control of pain.

b) 6-8 (intense pain): administer rescue doses and increase the infusion rate of the analgesic plan by 15%. Reassess after 10 minutes, wait for a decrease or control of pain.

c) 9-10 (maximum pain): administer rescue doses and increase analgesic plan by 30%. Reassess after 10 minutes, wait for a decrease or control of pain.

Balance dose/adverse effects at all times, check co-analgesics and adjuvants, rule out complications. Oral reassessment could be considered every 60 minutes.

In the event of adverse effects:

-*Nausea and vomiting*: adjust ondansetron 0.1 mg/kg/dose IV up to 3 times/day, without exceeding 4 mg/dose. If the episodes continue, add metoclopramide 0.15 mg/kg/dose IV infused over 20 minutes, every 8 h.

-*Pruritus (more common in subcutaneous administration)*: naloxone 1 mcg/kg/ IV dose in 20 minutes, with the possibility of repeating the infusion every 4 h.

-*Urinary retention*: if there is a bladder balloon, perform a bladder catheter, gradually evacuating its contents. Naloxone 1 mcg/kg/ IV dose will then be administered over 20 minutes, with the possibility of repeating the infusion every 4 hours (the same if there is urinary retention without a bladder balloon).

-*Respiratory depression*: assess the respiratory rate (RR) according to age (<1 year: 30 to 60 rpm, 1-4 years: 24-40 rpm, 4-5 years: 22 to 34 rpm, 6-12 years: 18 to 30 rpm and 13-18 years: 12 to 16 rpm).

Table 2. Perioperative pain management protocol in pediatric spine surgery

Preoperative period
Single dose gabapentin (10 mg/kg) PO
Single dose paracetamol (20 mg/kg) PO

Postoperative day 0 (POp-D0 - from the operating room)
Morphine 0.4 mg/kg/day IV (continuous infusion/CI)
Rescue with morphine 0.04 mg/kg/IV dose (administer max. every 4 h)
Paracetamol 12.5 mg/kg/dose IV every 6 h (CI)
Ibuprofen 5 mg/kg/ IV dose every 6 h (CI)
Ketamine (0.2 mg/kg/h) (CI)
Dexmedetomidine (0.3 mcg/kg/h) (CI)
Ondasentron 0.15 mg/kg/dose IV every 8 h IV (CI)
Omeprazole 1 mg/kg/dose IV every 24 h (CI)

Postoperative day 1 (POp-D1)
Morphine 0.3 mg/kg/day IV (continuous infusion)
Rescues with morphine 0.03 mg/kg/IV dose (administer max. every 4 h)
Paracetamol same dose/frequency PO
Ibuprofen same dose/frequency PO
Dexamethasone same dose/frequency PO
Ketamine (0.2 mg/kg/h) (CI)
Dexmedetomidine (0.3 mcg/kg/h) (CI)
Ondasentron same dose/frequency VO
Omeprazole same dose/frequency PO
Gabapentin 100 mg/dose PO every 8 h PO
PKT (physiokinesiotherapy) - exercises (GMFCSI-V); sitting and standing on the edge of the bed (GMFCS I-II-III)-

Postoperative day 2 (POp-D2)
Morphine 0.6 mg/kg/day PO
Rescues with morphine 0.06 mg/kg/dose PO (administer max. every 4 h)
Paracetamol same dose/frequency PO
Ibuprofen same dose/frequency PO
Dexamethasone same dose/frequency PO
Ondasentron same dose/frequency PO
Omeprazole same dose/frequency PO
Gabapentin 300 mg/dose every 8 h PO
PKT - exercises (GMFCSI-V); free ambulation (GMFCS I-II-III)-

Postoperative day 3 (POp-D3) and subsequent days…
Tramadol 1.5 mg/kg/dose every 8 h PO
Rescues with morphine 0.05 mg/kg/dose PO (administer max. every 4 h)
Paracetamol same dose/frequency PO
Ibuprofen same dose/frequency PO
Ondasentron same dose/frequency VO
Omeprazole same dose/frequency PO
Gabapentin same dose/frequency PO
PKT (same)

Out-of-hospital protocol (see palliative/medication reduction plan)
Tramadol 1.5 mg/kg/dose every 8 h PO
Rescues with PO morphine (10% of the oral morphine dose)
Paracetamol same dose/frequency PO
Ibuprofen same dose/frequency PO
Ondasentron same dose/frequency PO (optional)
Omeprazole same dose/frequency PO
Gabapentin same dose/frequency PO

POp-D0-1-2-3, postoperative day 0-1-2-3; IV, intravenous; PO, orally; GMFCS: gross motor function classification system; CI, continuous infusion.

If there is a 30% decrease in the minimum value established according to age, the treating physician in charge will be notified and the use of naloxone will be evaluated. If the patient is sedated and there is a RR <50% of expected, put on an oxygen mask, stop the opioid infusion, and administer naloxone 1 mcg/kg until the RR returns to normal values for the age group. Due to its half-life, the glucocorticoid will be administered during the intraoperative period, without repeating it regularly during the postoperative period. Bear in mind that its half-life is much shorter than that of morphine, if it is used to reverse respiratory depression.

During the first 48 hours, pain will be managed with morphine associated with NSAIDs and adjuvants (ketamine/dexmedetomidine, see options), in continuous infusion according to the rules established in the treating center. After this period, tramadol will be rotated for 24 to 48 h in continuous infusion. The intention of continuous infusion is to avoid periods of low effective drug concentration, with subsequent onset of pain. Given the need for rescue, this would be performed with IV morphine and after the IV catheter is removed, it is changed to PO. In order to avoid the appearance of tolerance in patients in whom it is difficult to gradually decrease the dose of morphine, it is recommended to associate methadone to the plan, although it is difficult to develop tolerance to the opioid in 48/96 h.

Patients should be assessed daily for catharsis and fed high-fiber diets, with plenty of hydration, during the time opioids are being administered. The goal is to reduce the appearance of constipation. If this appears, the recommended laxatives are osmotic. The first choice of treatment in children of any age is polyethylene glycol 3350 due to its safety, effectiveness and tolerance. Its dose varies between 0.25 to 1.5 g/kg. In our country, peripheral μ-receptor inhibitors are not yet available.

With this report we begin the definition of a multidisciplinary protocol for pain management in pediatric spinal surgery, which ranges from the preoperative period and covers the intra- and extra-hospital postoperative period. Its purpose is to improve the quality of care and hospital stay, and reduce the appearance of adverse effects, for which the multidisciplinary approach is essential.

As limitations, it should be noted that we limited the systematic review to the English and Spanish languages, that we limited the search for articles to those published between 2000 and 2021, and that we found significant heterogeneity in the materials and methods described in the papers.

CONCLUSION

This systematic review evidences, on the one hand, the profound problems regarding standardized postoperative pain management, and, in turn, highlights the need to develop a detailed, simple and easily reproducible multimodal pharmacological protocol for the intra- and extra-hospital perioperative period of spinal surgery in the pediatric population. We believe we have achieved it. New research will be required to optimize postoperative analgesia protocols in this group of patients, due to their various pathologies.

Acknowledgments

Dr. Luciano H.R. Ronconi and Dr. Merlina A Conti, from the Anesthesia Department of “Hospital de Pediatría “Prof. Dr. Juan P. Garrahan”.

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

Carlos A Tello ORCID ID: https://orcid.org/0000-0002-1733-1004
Rodrigo G Remondino ORCID ID: https://orcid.org/0000-0002-8388-298X
Eduardo Galaretto ORCID ID: https://orcid.org/0000-0003-4121-8228
Mariano A Noel ORCID ID: https://orcid.org/0000-0002-6668-1342

REFERENCES

1. Milbrandt TA, Singhal M, Minter C, McClung A, Talwalkar VR, Iwinski HJ, et al. A comparison of three methods of pain control for posterior spinal fusions in adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2009;34(14):1499-503. https://doi.org/10.1097/BRS.0b013e3181a90ceb
2. Walker CT, Gullotti DM, Prendergast V, Radosevich J, Grimm D, Cole TS, et al. Implementation of standardized multimodal postoperative analgesia protocol improves pain control, reduces opioid consumption, and shortens length of hospital stay after posterior lumbar spinal fusion. *Neurosurgery* 2020;87(1):130-6. https://doi.org/10.1093/neuros/nyz312
3. Cozowicz C, Bekeris J, Poeran J, Zubizarreta N, Schwenk E, Girardi F, et al. Multimodal pain management and postoperative outcomes in lumbar spine fusion surgery: A population-based cohort study. *Spine (Phila Pa 1976)* 2020;45(9):580-9. https://doi.org/10.1097/BRS.0000000000003320
4. Piantoni L, Tello CA, Francheri Wilson IA, Remondino R, Galaretto E, et al. Manejo del dolor posoperatorio por cirugía de columna en la población pediátrica. Resultados preliminares. *Rev Asoc Argent Ortop Traumatol* 2019;84(3):224-35. https//doi.org/10.15417/issn.1852-7434.2019.84.3.9314
5. Yousefifard M, Askarian-Amiri S, Madani Neishaboori A, Sadeghi M, Saberian P, Baratloo A. Pre-hospital pain management; a systematic review of proposed guidelines. *Arch Acad Emerg Med* 2019;7(1):e55. PMID: 31875209
6. Oliveira CB, Maher CG, Pinto RZ, Traeger AC, Lin CWC, Chenot JF, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. *Eur Spine J* 2018;27(11):2791-803. https://doi.org/10.1007/s00586-018-5673-2
7. Hsu JR, Mir H, Wally MK, Seymour RB. Orthopaedic Trauma Association Musculoskeletal Pain Task Force. Clinical practice guidelines for pain management in acute musculoskeletal injury. *J Orthop Trauma* 2019;33(5):e158-e182. https://doi.org/10.1097/BOT.0000000000001430
8. Aubrun F, Nouette-Gaulain K, Fletcher D, Belbachir A, Beloeil H, Carles M, et al. Revision of expert panel's guidelines on postoperative pain management. *Anaesth Crit Care Pain Med* 2019;38(4):405-11. https://doi.org/10.1016/j.accpm.2019.02.011
9. Shah SA, Guidry R, Kumar A, White T, King A, Heffernan MJ. Current trends in pediatric spine deformity surgery: multimodal pain management and rapid recovery. *Global Spine J* 2020;10(3):346-52. https://doi.org/10.1177/2192568219858308
10. Sheffer BW, Kelly DM, Rhodes LN, Sawyer JR. Perioperative pain management in pediatric spine surgery. *Orthop Clin North Am* 2017;48(4):481-6. https://doi.org/10.1016/j.ocl.2017.06.004
11. Johnson MA, Andras LM, Andras LE, Ellington MD, Upasani VV, Shah AS. What's new in pain management for pediatric orthopaedic surgery. *J Pediatr Orthop* 2021;41(10):e923-3928. https://doi.org/10.1097/BPO.0000000000001956
12. Borgeat A, Blumenthal S. Postoperative pain management following scoliosis surgery. *Curr Opin Anaesthesiol* 2008;21(3):313-6. https://doi.org/10.1097/ACO.0b013e3282f82baa
13. Practice Guidelines for Acute Pain Management in the Perioperative Setting: An Updated Report by the American Society of Anesthesiologists Task Force on Acute Pain Management. *Anesthesiology* 2012;116:248–273. https://doi.org/10.1097/ALN.0b013e31823c1030
14. Aoki Y, Iwata H, Akinaga C, Shiko Y, Kawasaki Y, Kobayashi K, et al. Intraoperative remifentanil dosage in surgery for adolescent idiopathic scoliosis does not increase postoperative opioid consumption when combined with epidural analgesia: A retrospective cohort study. *Cureus* 2021;13(8):e17361. https://doi.org/10.7759/cureus.17361
15. Bean BA, Connor PM, Schiffern SC, Hamid N. Outpatient shoulder arthroplasty at an ambulatory surgery center using a multimodal pain management approach *J Am Acad Orthop Surg Glob Res Rev* 2018;2:e064. https://doi.org/10.5435/JAAOSGlobal-D-18-00064
16. Creary SE, Chisolm DJ, Wrona SK, Cooper JN. Opioid prescription filling trends among children with sickle cell disease after the release of state-issued guidelines on pain management. *Pain Med* 2020;21(10):2583-92. https://doi.org/10.1093/pm/pnaa002
17. Joshi GP, Kehlet H. Postoperative pain management in the era of ERAS: An overview. *Best Pract Res Clin Anaesthesiol* 2019;33(3):259-67. https://doi.org/10.1016/j.bpa.2019.07.016
18. Joshi GP, Kehlet H; PROSPECT Working Group. Guidelines for perioperative pain management: need for re-evaluation. *Br J Anaesth* 2017;119(4):703-6. https://doi.org/10.1093/bja/aex304

19. Jones JS, Cotugno RE, Singhal NR, Soares N, Semenova J, Nebar S, et al. Evaluation of dexmedetomidine and postoperative pain management in patients with adolescent idiopathic scoliosis: conclusions based on a retrospective study at a tertiary pediatric hospital. *Pediatr Crit Care Med* 2014;15(6):e247-52. https://doi.org/10.1097/PCC.0000000000000119
20. Rawal N. Current issues in postoperative pain management. *Eur J Anaesthesiol* 2016;33(3):160-71. https://doi.org/10.1097/EJA.0000000000000366
21. Zieliński J, Morawska-Kochman M, Zatoński T. Pain assessment and management in children in the postoperative period: A review of the most commonly used postoperative pain assessment tools, new diagnostic methods and the latest guidelines for postoperative pain therapy in children. *Adv Clin Exp Med* 2020;29(3):365-74. https://doi.org/10.17219/acem/112600
22. McNicol ED, Rowe E, Cooper TE. Ketorolac for postoperative pain in children. *Cochrane Database Syst Rev* 2018;7(7):CD012294. https://doi.org/10.1002/14651858.CD012294.pub2
23. Yoo JS, Ahn J, Buvanendran A, Singh K. Multimodal analgesia in pain management after spine surgery. *J Spine Surg* 2019;5(2):S154-9. https://doi.org/10.21037/jss.2019.05.04
24. Rajpal S, Gordon DB, Pellino TA, Strayer AL, Brost D, Trost GR, et al. Comparison of perioperative oral multimodal analgesia versus IV PCA for spine surgery. *J Spinal Disord Tech* 2010;23(2):139-45. https://doi.org/10.1097/BSD.0b013e3181cf07ee
25. Rao KE, Krodel D, Toaz EE, Fanelli J, Hajduk J, Kato K, et al. Introduction of an enhanced recovery pathway results in decreased length of stay in patients with adolescent idiopathic scoliosis undergoing posterior spinal fusion: A description of implementation strategies and retrospective before-and-after study of outcomes. *J Clin Anesth* 2021;75:110493. https://doi.org/10.1016/j.jclinane.2021.110493
26. YaDeau JT, Dines DM, Liu SS, Gordon MA, Goytizolo EA, Lin Y, et al. What pain levels do TSA patients experience when given a long-acting nerve block and multimodal analgesia? *Clin Orthop Relat Res* 2019;477:622-32. https://doi.org/10.1097/CORR.0000000000000597
27. Pagnotto MR, Pagnano MW. Multimodal pain management with peripheral nerve blocks for total knee arthroplasty. *Instr Course Lect* 2012;61:389-95. PMID: 22301247
28. Li WT, Bell KL, Yayac M, Barmann JA, Star AM, Austin MS. A postdischarge multimodal pain management cocktail following total knee arthroplasty reduces opioid consumption in the 30-day postoperative period: A group-randomized trial. *J Arthroplasty* 2021;(36) 164e172. https://doi.org/10.1016/j.arth.2020.07.060
29. Karam JA, Schwenk ES, Parvizi J. An update on multimodal pain management after total joint arthroplasty. *J Bone Joint Surg Am* 2021;103:1652-62. https://doi.org/10.2106/JBJS.19.01423
30. Anderson DE, Duletzke NT, Pedigo EB, Halsey MF. Multimodal pain control in adolescent posterior spinal fusion patients: a double-blind, randomized controlled trial to validate the effect of gabapentin on postoperative pain control, opioid use, and patient satisfaction. *Spine Deform* 2020;8(2):177-85. https://doi.org/ 10.1007/s43390-020-00038-z
31. Muhly WT, Beltran RJ, Bielsky A, Bryskin RB, Chinn C, Choudhry DK, et al. Perioperative management and in-hospital outcomes after minimally invasive repair of pectus excavatum: a multicenter registry report from the society for pediatric anesthesia improvement network. *Anesth Analg* 2019;128(2):315-27. https://doi.org/10.1213/ANE.0000000000003829
32. Lee CS, Merchant S, Chidambaran V. Postoperative pain management in pediatric spinal fusion surgery for idiopathic scoliosis. *Paediatr Drugs* 2020;22(6):575-601. https://doi.org/10.1007/s40272-020-00423-1
33. Chou R, Côté P, Randhawa, Torres P, Yu H, Nordin M, et al. The Global Spine Care Initiative: applying evidence-based guidelines on the non-invasive management of back and neck pain to low- and middle-income communities. *Eur Spine J* 2018;27(6):851-60. https://doi.org/10.1007/s00586-017-5433-8
34. Parrish JM, Jenkins NW, Brundage TS, Hrynewycz NM, Podnar J, Buvanendran A, et al. Outpatient minimally invasive lumbar fusion using multimodal analgesic management in the ambulatory surgery setting. *Int J Spine Surg* 2020;14(6):970-81. https://doi.org/10.14444/7146
35. Hong RA, Gibbons KM, Li GY, Holman A, Voepel-Lewis T. A retrospective comparison of intrathecal morphine and epidural hydromorphone for analgesia following posterior spinal fusion in adolescents with idiopathic scoliosis. *Paediatr Anaesth* 2017;27(1):91-7. https://doi.org/ 10.1111/pan.13037
36. Koes BW, van Tulder M, Lin CW, Macedo LC, McAuley J, Maher C. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. *Eur Spine J* 2010;19(12):2075-94. https://doi.org/10.1007/s00586-010-1502-y

37. Man JY, Gurnaney HG, Dubow SR, DiMaggio TJ, Kroeplin GR, Adzick S, et al. A retrospective comparison of thoracic epidural infusion and multimodal analgesia protocol for pain management following the minimally invasive repair of pectus excavatum. *Paediatr Anaesth* 2017;27(12):1227-34. https://doi.org/10.1111/pan.13264
38. Devin CJ, McGirt MJ. Best evidence in multimodal pain management in spine surgery and means of assessing postoperative pain and functional outcomes. *J Clin* Neurosci 2015;22(6):930-8. https://doi.org/10.1016/j.jocn.2015.01.003
39. Frizzell KH, Cavanaugh PK, Herman MJ. Pediatric perioperative pain management. *Orthop Clin North Am* 2017;48(4):467-80. https://doi.org/10.1016/j.ocl.2017.06.007
40. Wong JJ, Côté P, Sutton DA, Randhawa K, Yu H, Varatharajan S, et al. Clinical practice guidelines for the noninvasive management of low back pain: A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *Eur J Pain* 2017;21(2):201-16. https://doi.org/ 10.1002/ejp.931
41. Young VB. Effective management of pain and anxiety for the pediatric patient in the emergency department. *Crit Care Nurs Clin North Am* 2017;29(2):205-16. https://doi.org/10.1016/j.cnc.2017.01.007
42. Bull J, Grogan S. Children having spinal surgery to correct scoliosis: A qualitative study of parents' experiences. *J Health Psychol* 2010;15(2):299-309. https://doi.org/10.1177/1359105309351607
43. Ntalouka MP, Brotis AG, Bareka MV, Stertsou ES, Fountas KN, Arnaoutoglou EM. Multimodal analgesia in spine surgery: An umbrella review. *World Neurosurg* 2021;149:129-39. https://doi.org/10.1016/j.wneu.2021.02.040
44. Mathiesen O, Dahl B, Thomsen BA, Kitter B, Sonne N, Dahl JB, et al. A comprehensive multimodal pain treatment reduces opioid consumption after multilevel spine surgery. *Eur Spine J* 2013;22(9):2089-96. https://doi.org/10.1007/s00586-013-2826-1
45. Momon A, Verdier B, Dolomie JO, Gardette M, Pereira B, Curt I, et al. A Single preoperative administration of dexamethasone, low-dose pregabalin, or a combination of the 2, in spinal surgery, does not provide a better analgesia than a multimodal analgesic protocol alone. *Clin J Pain* 2019;35(7):594-601. https://doi.org/10.1097/AJP.0000000000000719
46. Kaye AD, Chernobylsky DJ, Thakur P, Siddaiah H, Kaye RJ, Eng LK, et al. Dexmedetomidine in Enhanced Recovery After Surgery (ERAS) Protocols for postoperative pain. *Curr Pain Headache Rep* 2020;24(5):21. https://doi.org/10.1007/s11916-020-00853-z
47. Song K, Melroy MJ, Whipple OC. Optimizing multimodal analgesia with intravenous acetaminophen and opioids in postoperative bariatric patients. *Pharmacotherapy* 2014;34(Suppl 1):14-21S. https://doi.org/10.1002/phar.1517
48. Chan P, Skaggs DL, Sanders AE, Villamor GA, Choi PD, Tolo VT, et al. Pain is the greatest preoperative concern for patients and parents before posterior spinal fusion for adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2017;42(21):E1245-50. https://doi.org/10.1097/BRS.0000000000002147
49. Landman Z, Oswald T, Sanders J, Diab M. Spinal Deformity Study Group. Prevalence and predictors of pain in surgical treatment of adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)* 2011;36(10):825-9. https://doi.org/10.1097/BRS.0b013e3181de8c2b
50. Wong GT, Yuen VM, Chow BF, Irwin MG. Persistent pain in patients following scoliosis surgery. *Eur Spine J* 2007;16(10):1551-6. https://doi.org/10.1007/s00586-007-0361-7
51. Pestieau SR, Finkel JC, Junqueira MM, Cheng Y, Lovejoy JF, Wang J, et al. Prolonged perioperative infusion of low-dose ketamine does not alter opioid use after pediatric scoliosis surgery. *Paediatr Anaesth* 2014;24(6):582-90. https://doi.org/10.1111/pan.12417
52. Hwang SW, Pendleton C, Samdani AF, Bastrom TP, Keeny H, Lonner BS, et al. Preoperative SRS pain score is the primary predictor of postoperative pain after surgery for adolescent idiopathic scoliosis: an observational retrospective study of pain outcomes from a registry of 1744 patients with a mean follow-up of 3.4 years. *Eur Spine J* 2020;29, 754–760. https://doi.org/10.1007/s00586-020-06293-y
53. Vademecum Intranet. Hospital Nacional de Pediatría Prof. Dr. Juan P. Garrahan. Sitio web. 2021. Available at: https://farmacia.garrahan.gov.ar/Vademecum/Busqueda

ROSA Robotic-Assisted Total Knee Replacement

Andrés Zuain, Julián Costantini, Carlos Yacuzzi, Matías Costa Paz
Knee Sector, Orthopedics and Traumatology Service, Hospital Italiano, Autonomous City of Buenos Aires, Argentina

ABSTRACT
Total knee replacement is a procedure with excellent outcomes as long as the objectives of alignment and ligament balance are met. Postoperative comfort and well-being are achieved through a suitable implant for each patient and the correct positioning of the prosthesis. The ROSA robotic system uses information collected before and during surgery, and provides the surgeon with the necessary tools to reproduce the specific anatomy of each patient. In this way, personalized implants are achieved based on the anatomical landmarks of each individual and planning based on specific biometric data.
Keywords: ROSA; robotics; robotic-assisted TKR
Level of Evidence: IV

Reemplazo total de rodilla asistido por robot ROSA

RESUMEN
El reemplazo total de rodilla es un procedimiento con excelentes resultados siempre y cuando se cumplan los objetivos de alineación y balance ligamentario. El confort y bienestar posoperatorio se logra mediante un implante adecuado para cada paciente y el correcto posicionamiento de la prótesis. El sistema robótico ROSA utiliza información recolectada previamente a la cirugía y durante la misma, y le otorga las herramientas necesarias al cirujano para reproducir la anatomía específica de cada paciente. De esta manera, se logran implantes personalizados basados en los reparos anatómicos de cada individuo y una planificación a partir de datos biomètricos concretos.
Palabras clave: ROSA; robótica; RTR asistido
Nivel de evidencia: IV

INTRODUCTION

The main objectives in total knee replacement (TKR) surgery are the restoration of limb alignment, the correct positioning of the prosthetic components, and proper ligament balance. With proper alignment and kinematics of the knee through a correct surgical technique, TKR can achieve excellent functional outcomes. In the literature, there are reports of up to 20% of patient dissatisfaction with the postoperative outcome. Pain, instability, and limited range of motion are the most common symptoms.[1,2] With the conventional technique, alignment values of 3° or more from the neutral axis have been observed.[3-5] For this reason, in recent years, technologies have been developed to improve the precision of bone cuts and location of components.[6-9] These techniques, in principle, are associated with less need for soft tissue release. These advances, coupled with ROSA robot-assisted surgery, have proven effective in achieving more precise and reproducible alignment, which in turn leads to better results and greater patient satisfaction.

The development of robot-assisted surgery is closely related to the technological advances of the last 20 years, beginning with computer assistance and navigation in the early 2000s. Different types of robotic systems have been designed with various characteristics, such as robot autonomy, the need for prior 3D planning, the use of cutting guides or a built-in saw.[10,11]

Received on May 18th, 2022. Accepted after evaluation on September 15th, 2022 • Dr. ANDRÉS ZUAIN • andres.zuain@hospitalitaliano.org.ar https://orcid.org/0000-0001-5904-3847
How to cite this article: Zuain A, Costantini J, Yacuzzi C, Costa Paz M. ROSA Robotic-Assisted Total Knee Replacement. *Rev Asoc Argent Ortop Traumatol* 2022;87(6): 838-850. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1579

The ROSA robot assistant is a new, recently introduced system applied to TKRs. Previous systems available on the market differ from it in terms of the method of use (some have the saw built into the robot, for example). During the last decade, these systems have demonstrated their efficacy and safety,[12] but also some difficulties for the surgeon in terms of handling, since their action is restricted to predetermined limits.[13-15] Thus, the surgeon may have the feeling of not being in control of the procedure or being limited with certain movements.

The new assistant presented here is intended to keep the surgeon active, performing the cut while the robotic arm maintains the guide at the location defined in the pre-operative plan at all times. This can be considered robot assistance, since the surgeon remains in charge of the procedure and is supported by this intelligent robotic instrument. It was introduced in March 2019, and since then, its use has spread throughout the world. The abbreviation ROSA stands for "Robotic Surgical Assistant"; this equipment is capable of placing the guides in the ideal position, allowing the surgeon to perform the procedure with high precision and reproducibility (Figure 1). It can be used without previous images or based on radiographs of the patient, which are then converted to a 3D model of the knee. This, together with the analysis of intraoperative ligament balance, allows for personalized prosthetic replacements.

At Hospital Italiano, we have begun to use this technology to achieve better results in our joint replacement surgeries. As objectives of this work, we will describe the concept and the surgical technique of the ROSA robot, showing a case surgically treated with the robot in the hospital. We will highlight its advantages and limitations and we will review what has been reported so far regarding ROSA in the scientific literature.

Figure 1. ROSA robot

ROSA CONCEPT

The goal during the development of the ROSA technology was to keep the surgeon active and in the main stage of surgery. With this system, the surgeon has control of the saw and performs the cuts, while the robotic arm, equipped with a cutting guide, locates and maintains it in the correct position, with high efficiency and reproducibility. After intraoperative planning, the robot is positioned with its guide, according to the surgical plan, to perform the distal femur and proximal tibia cuts, and determines the position of the 4-in-1 cutting guide.

The robotic arm has three modes of action: automatic, collaborative and static. In automatic mode, when the robot is away from the surgical field, the robot moves independently. As it gets closer to the knee and the surgical field, the robot switches to collaborative mode. In this mode, the surgeon collaborates with the robotic arm, exerting a gentle force on the guide until it is placed in the cutting plane on the bone to be resected. In this stage, the movement of the robotic arm is restricted to the cutting plan, but it accompanies and adapts to any movement of the knee. Then, the cutting position of the guide is verified by observing the cuts to be made on the screen, it is fixed with pins, and then the robot switches to static mode, in which the surgeon will be allowed to make the different cuts. Correct cuts can be obtained with a conventional saw blade due to the rigidity of the robotic arm. After the cuts are made, the pins are removed and the robot returns to collaborative mode to make the next cut. The ultimate goal is to achieve a fluid surgical rhythm, increasing the efficiency, safety, and reliability of the cuts made compared to the conventional technique. ROSA is designed to assist the surgeon in cutting both the femur and the tibia, in the sizing of the implants to be used and their positioning (including the rotation of the femoral component), and in the ligament balance.[16]

Surgical technique

The robotic system has two options to approach the case and plan it: it can use a virtual 3D model that comes from the panoramic radiographs that were previously taken from the patient, or no images at all, exclusively basing itself on the anatomical landmarks acquired intraoperatively.

In the first case, standard radiographs are taken on the patient, which are then converted to a 3D model of the knee.[17,18] These radiographs are conventional, adding a calibrated marking (one Velcro positioned on the patient's thigh and another on the ankle) (Figure 2). These images are used to create the 3D model that will serve as planning for the surgeon. With this technique, the size and positioning of the prosthetic components are already available in this step.

Figure 2. Radiographs taken with calibrated marking, from which the 3D model is obtained for preoperative planning.

For the second option, radiographs are taken preoperatively in the same way as for the conventional technique. Intraoperative planning is based on bone landmarks and ligament balance, information collected at the beginning of the procedure. Both options have proven to be highly effective.

Configuration

The ROSA robotic system comprises two main parts, which are located on each side of the surgical field. One is a robotic unit consisting of the robotic arm and a touch screen, and the other is an optical unit, which includes an infrared camera detached from a robotic arm and a touch screen (Figure 3). ROSA's universal cutting guide is located at the end of the arm of the robotic system. Different implants compatible with the system can be used (Persona/NexGen/Vanguard, Zimmer, Biomet). Both the robotic arm and the optical unit, as well as the instruments and the patient's knee, are connected by infrared vision.

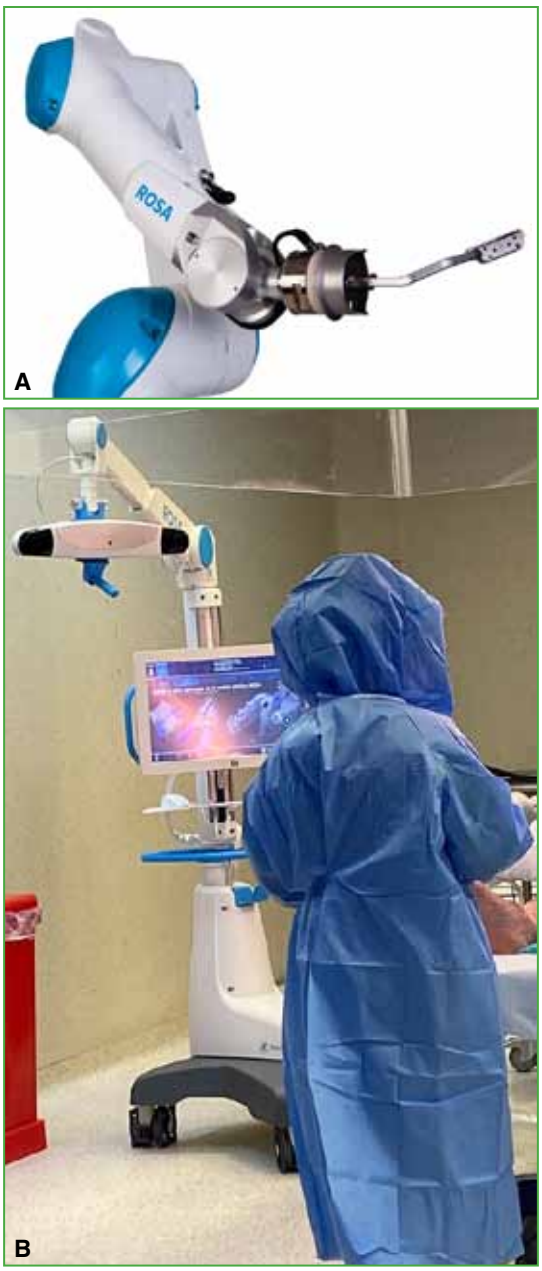


Figura 3. Robotic arm with cutting guide (**A**) and optics (**B**).

The surgeon and the robot are located on the same side of the surgical field and the vision system is placed on the opposite side (Figure 4). The first step is to set up the robot in relation to the patient's knee and then calibrate the robotic arm with the optics.

Figure 4. Positioning of the robot in the operating room.

Recording and planning

The procedure with the robot requires the installation of two rigid elements, one in the femur and one in the tibia, as in most robotic systems. These elements, called 'trackers', can be placed inside or outside the incision, depending on the surgeon. They should be positioned far enough from the knee to avoid any conflict between the instrumentation during surgery, and the tibial tracker should be distal enough not to interfere with the placement of the tibial component.

Once the trackers are placed on the bone, the femoral and tibial landmarks are obtained. First, the location of the center of the femoral head is established, capturing 14 different hip positions along its circumduction. The mechanical axis of the femur is determined by the center of the femoral head and the distal entry point of the femoral canal. The remainder of the distal femur landmarks comprise the medial and lateral distal femoral condyles and the medial and lateral epicondyles. The posterior condyles are landmarks for the posterior condylar axis, and the anterior and posterior trochlear groove reflects Whiteside's line. The anterior cortex gives us the size of the femoral component and its position, and determines if notching is taking place. The mechanical axis of the tibia is determined by the medial and lateral to distal malleoli and by the entry point to the tibial intramedullary canal. The references for tibial rotation are the middle third of the anterior tuberosity of the tibia and the insertion of the posterior cruciate ligament. The bone cuts to be made in the medial and lateral plateau are also obtained. An important step at this point is not to perforate the articular cartilage with the pointer when taking these landmarks.

The next step consists of verifying ligament laxity by performing stress in varus and valgus, at different points of knee flexion. The most important values are those taken with the knee in extension and at 90° flexion. Laxity can also be assessed at 30°, 45°, 60° and 120° of flexion. The values obtained will serve to guide the placement of the prosthesis in the different planes, the sizes of the implants and, consequently, the ligament balance. This evaluation of the ligament balance can be carried out before planning, but after the approach and resection of the osteophytes, during the making of the cuts with a spacer (if necessary), or at the end of the procedure with the trial or definitive implant. It can be done at any time to adapt the plan, if desired. The surgeon may also decide not to assess the ligaments and perform the procedure using a technique based exclusively on bone cuts.

Once the bone landmarks have been collected and the ligament laxity evaluation has been carried out, the surgeon decides the final planning according to his or her preferences. During this planning, many parameters are determined: the size of the femoral and tibial components, the orientation of the bone cuts (distal, anterior, posterior, and tibial femurs), and their thickness, based on all the information provided. Predictive values of the final gaps and alignment are obtained (Figure 5).

Figure 5. The orientation of the bone resections and the position and size of the implants allow adjustment of the gaps in extension and flexion, and the final alignment of the entire limb. Modifying all of these values will give instant feedback on alignment and gaps.

Bone resections

Once the planning is done, the screen will continue with the "Resection Panel". The sequence of cuts, whether tibia or femur first, is at the surgeon's preference. By choosing one or the other on the touch screen, ROSA will automatically move the robotic arm toward the knee. Once it reaches the surgical field, the collaborative mode is activated and the surgeon guides the cutting guide to the position where it should be placed, while ROSA remains in the indicated coronal and sagittal planes, and at the planned resection height. The values of the cuts to be made are instantly obtained on the screen, so that they can be checked against the planned values (compensating for any movement of the knee). Once the guide is aligned with the cut, it is fixed with two pins and the resection is performed using a conventional saw (Figure 6). Once carried out, a validation system is supported on the bone to confirm that it was in accordance with what was planned. Each cut can be modified at any time, if necessary.

Figure 6. When the guide is attached to the bone and the robot is locked in position, a firm construct is achieved, upon which the surgeon is allowed to make bone cuts.

The conventional technique aims to achieve a neutral alignment of the operated lower limb (within a range of 0 to 3°), placing the femoral and tibial components perpendicular to their respective mechanical axes. The bone cuts are made independently of each other (usually starting with the distal femur), but have a close relationship, since both the cut of the distal femur and that of the posterior condyles must be parallel to the tibial cut. Ligament balance is obtained by sequential soft tissue release to balance the medial and lateral compartments, both in flexion and extension. The stability of the knee replacement is based on the correct positioning of the prosthetic implants and the adequate gaps throughout the range of motion.

We describe the case of a 76-year-old patient who underwent a left TKR with the assistance of the ROSA robot. Upon physical examination, the patient reported knee pain, secondary to tricompartmental knee osteoarthritis (Figure 7). She had good preoperative ranges of motion, with predominantly internal pain, with a varus malalignment of approximately 12°.

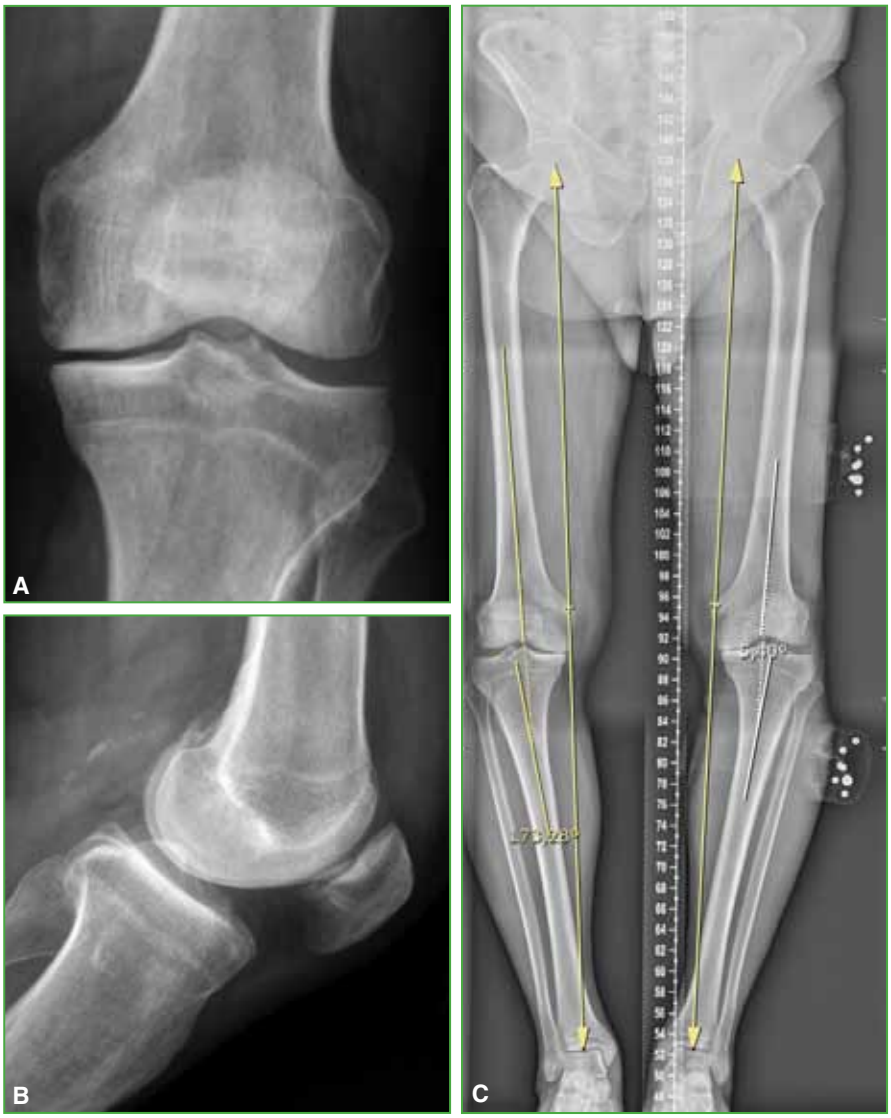


Figure 7. A and B. Anteroposterior and lateral knee radiographs. **C**. Preoperative scanogram.

Once the trackers are installed and the medial parapatellar approach is performed, the menisci are completely resected together with the cruciate ligaments. The medial osteophytes are resected, which opens the gap medially and generates sufficient release to balance both compartments. At this point, the previously described bone landmarks are taken. Preoperative ligament laxity and range of motion are assessed and the femur cuts are first planned on the screen. In the genu varum replacement technique, typically, the amount of bone removed in the tibia will be greater from the lateral plateau than from the medial, greater in the medial to distal femoral condyle, and greater from the medial side in the posterior condyles. All cuts are made and the gap in extension is measured with a spacer. The screen is checked to corroborate the presence of residual varus or a flexion contracture. The soft tissues

are released sequentially, if necessary. The knee is flexed and the ROSA cutting guide is placed to make the rest of the femur cuts. Rotation is verified by aligning it with the transepicondylar axis, which presents external rotation of 3° in relation to the posterior condylar axis. The cuts are made as planned. Trial components are placed and a final assessment is made, considering full range of motion, alignment, and stability in flexion and extension. If all this is satisfactory, the final components are placed (Figures 8 and 9).

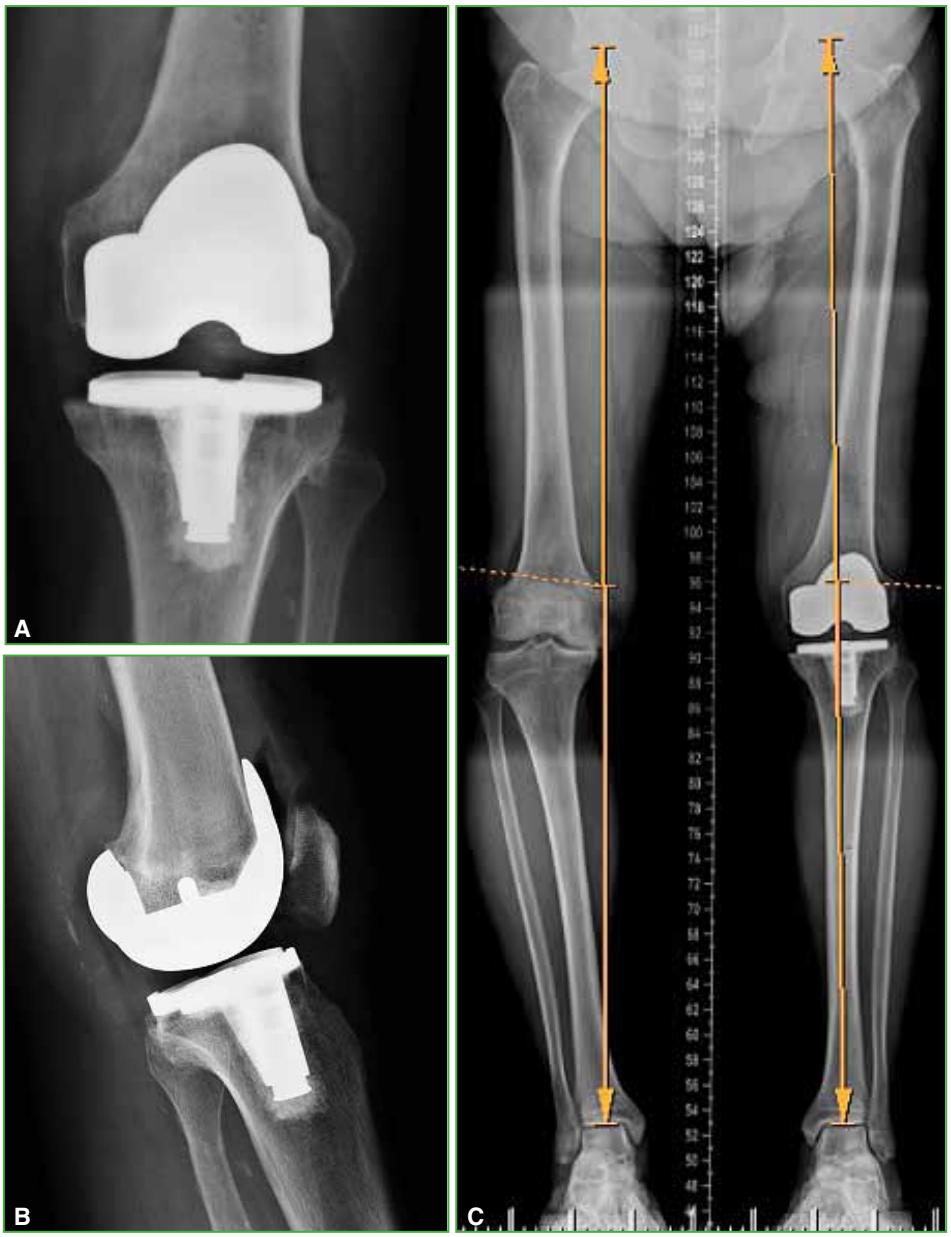


Figure 8. A and B. Anteroposterior and lateral knee radiographs. **C.** Postoperative scanogram.

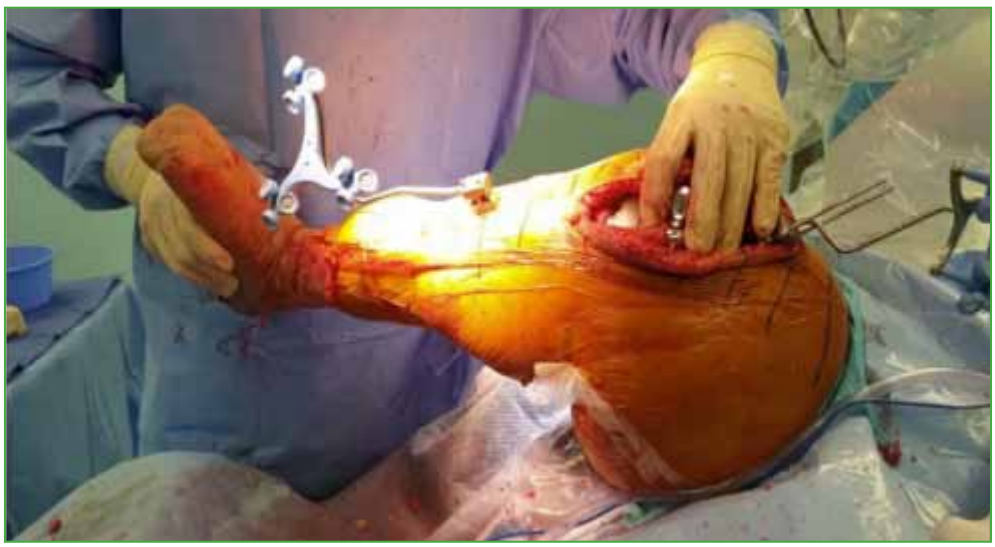


Figure 9. Final evaluation (with trial or definitive components) of range of motion and ligament balance in flexion and extension.

Indications

The current indications for the use of the ROSA robot are unicompartmental prostheses and complex primary replacements such as those presenting large malalignments, sequelae of fractures, or extra-articular deformities. It is currently being used in conventional primary replacements to achieve good robot handling, although the ultimate goal is to use it in the aforementioned cases, since robotic assistance would help to achieve better alignment results and ligament balance in those complex cases.

Advantages and limitations

The characteristics of this system are its simplicity and that it allows maintaining a smooth surgical rhythm, as well as minimizing the set-up time of the robot, which, in turn, provides high accuracy rates for the orientation of the components and the bone cuts.

Among the advantages, the following can be mentioned:

- Use of radiographs for planning (less expensive, less radiation than CT, and simpler for the patient). These radiographs are weight-bearing, so they represent a more functional position on which to plan. It is not essential to perform them, since ROSA has the option of planning by taking intraoperative parameters as a reference (this can be considered another advantage).
- Collaborative robotic system, where the robot keeps the cutting guide in the precise place and the surgeon is in constant control and with the tactile sensation of the saw and the rest of the instruments. ROSA's aim is to complement the surgeon's skills and not to replace them. The sequence of the cuts, the positioning of the implant, the mechanical axis and the ligament balance are individualized for each patient, at the preference of the surgeon.
- Easy to manipulate and does not require much time to set up.
- A single cutting guide, easily manipulated with three modes of action.
- Greater accuracy and precision in bone cuts.
- Less blood loss (by not invading the intramedullary canals with the cutting guides).
- Less damage to soft tissues (the exposure is the minimum necessary for the visualization of the pins by the robot).
- Shorter hospital stay.
- Faster post-surgical recovery
- Possibly better functional recovery and range of motion.

Regarding the limitations, we can mention the following:

- Significant cost (not affordable for all surgeons).
- The improvement in the functional outcomes of patients operated with robotic assistance has not yet been demonstrated.
- Learning curve (especially for intraoperative planning). The information provided on the screen in this step is abundant and can be confusing. Experience is needed in this step: at the moment, if the planning is not appropriate, there is no automatic re-adjustment by the system.
- Complications specific to the robotic system, such as pin breakage or pin location fracture, are rare and can be avoided with a better placement technique.

This robotic system is recent and there are still no clinical studies with sufficient follow-up to report functional outcomes. However, two cadaveric studies have reported the accuracy of this technique. Parratte et al. have demonstrated the accuracy and reproducibility of this device in a series of 30 cadaveric knees.[19] The authors compared three different measurements: the preoperative planning of the bone cuts to be made with ROSA, the actual size of the cut made, and the thickness of bone resected for each cut. To standardize the procedure, a final alignment of 0° was targeted, making cuts perpendicular to the mechanical axis of both the femur and tibia in the coronal plane. The cuts made using the ROSA system had a high precision. Regarding the angulation of the cuts, there were no significant differences between the planned and measured values, except for femoral flexion, which had an average difference of less than 1°. No differences were observed in the values of the resected bone thickness, except in the distal cut of the medial femoral condyle and in the medial tibial plateau. The average difference in the final alignment of the limb was less than 1°.

In another cadaveric study, Seidenstein et al. compared the accuracy of ROSA with the conventional technique for TKRs.[20] Two groups were analyzed: one made up of 20 knees operated with the conventional technique and the other of 14 knees operated with ROSA assistance. All the cuts made were validated with the ROSA device designed for that specific function and the bone resections were measured with a caliper. The accuracy of the angulation values of the cuts improved significantly in the group operated with robotic assistance. For these, the difference was less than 0.6°. Regarding the measurement of the resected bone, the values were all less than 0.7 mm. 100% of the values in the group operated with ROSA were within 2 mm of what was planned, except for the distal femur resection (93%). The robotic system led to exact bone resections with less error, compared to the conventional technique. The distal femur cut was less accurate than the rest, but still more accurate than with the standard technique. These results coincide with those reported by other robotic systems. Clinical studies are underway to compare functional outcomes and patient satisfaction.

WHAT IS AHEAD OF US?

With the advent of robotic surgery and new technologies, procedures tend to be simplified, more precise, and their results become more reliable, which represents an important step towards improving functional outcomes and patient satisfaction after TKR. Analyzing all the variables that influence this (in addition to the surgical technique), such as the specific characteristics of each patient, the deformities, the preoperative clinical situation, we can realize the importance of each of them, and how they modify the postoperative results. Considering all these points (pre-, intra- and postoperative), the surgeon could improve his or her daily practice and decision-making. Regarding robotic-assisted surgery itself, the use of this system will lead the surgeon to learn from each of the procedures and achieve a better performance in the following surgery.

CONCLUSIONS

ROSA is a semi-autonomous robotic assistance system with specific characteristics compared to previous systems of this type. The objective of this surgical assistant is to improve the accuracy and reliability of bone cuts and ligament balance, without replacing the surgeon's hand in any of the steps. Preliminary results from this system proved to be reproducible and accurate for performing TKRs.

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

J. Costantini ORCID ID: https://orcid.org/0000-0001-8900-6254
C. Yacuzzi ORCID ID: https://orcid.org/0000-0002-7732-7883
M. Costa Paz ORCID ID: https://orcid.org/0000-0002-8217-1086

REFERENCES

1. Halawi MJ, Jongbloed W, Baron S, Savoy L, Williams VJ, Cote MP. Patient dissatisfaction after primary total joint arthroplasty: the patient perspective. *J Arthroplasty* 2019;34(6):1093-6. https://doi.org/10.1016/j.arth.2019.01.075
2. Palazzo C, Jourdan C, Descamps S, Nizard R, Hamadouche M, Anract P, et al. Determinants of satisfaction 1 year after total hip arthroplasty: the role of expectations fulfilment. *BMC Musculoskelet Disord* 2014;15:53. https://doi.org/10.1186/1471-2474-15-53
3. Hetaimish BM, Khan MM, Simunovic N, Al-Harbi HH, Bhandari M, Zalzal PK. Meta-analysis of navigation vs conventional total knee arthroplasty. *J Arthroplasty* 2012;27(6):1177-82. https://doi.org/10.1016/j.arth.2011.12.028
4. Bollars P, Boeckxstaens A, Mievis J, Kalaai S, Schotanus MGM, Janssen D. Preliminary experience with an image-free handheld robot for total knee arthroplasty: 77 cases compared with a matched control group. *Eur J Orthop Surg Traumatol* 2020;30(4):723-9. https://doi.org/10.1007/s00590-020-02624-3
5. Liow MHL, Xia Z, Wong MK, Tay KJ, Yeo SJ, Chin PL. Robot-assisted total knee arthroplasty accurately restores the joint line and mechanical axis. A prospective randomised study. *J Arthroplasty* 2014;29(12):2373-7. https://doi.org/10.1016/j.arth.2013.12.010
6. Smith AF, Eccles CJ, Bhimani SJ, Denehy KM, Bhimani RB, Smith LS, et al. Improved patient satisfaction following robotic-assisted total knee arthroplasty. *J Knee Surg* 2021;34(7):730-8. https://doi.org/10.1055/s-0039-1700837
7. Figueroa F, Wakelin E, Twiggs J, Fritsch B. Comparison between navigated reported position and postoperative computed tomography to evaluate accuracy in a robotic navigation system in total knee arthroplasty. *Knee* 2019;26(4):869-75. https://doi.org/10.1016/j.knee.2019.05.004
8. Hampp EL, Chughtai M, Scholl LY, Sodhi N, Bhowmik-Stoker M, Jacofsky DJ, et al. Robotic-arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan compared with manual techniques. *J Knee Surg* 2019;32(3):239-50. https://doi.org/10.1055/s-0038-1641729
9. Mullaji A, Kanna R, Marawar S, Kohli A, Sharma A. Comparison of limb and component alignment using computer-assisted navigation versus image intensifier-guided conventional total knee arthroplasty: a prospective, randomized, single-surgeon study of 467 knees. *J Arthroplasty* 2007;22(7):953-9. https://doi.org/10.1016/j.arth.2007.04.030
10. Bautista M, Manrique J, Hozack WJ. Robotics in total knee arthroplasty. *J Knee Surg* 2019;32(7):600-6. https://doi.org/10.1055/s-0039-1681053
11. Sires JD, Craik JD, Wilson CJ. Accuracy of bone resection in MAKO total knee robotic-assisted surgery. *J Knee Surg* 2021;34(7):745-8. https://doi.org/10.1055/s-0039-1700570
12. Marchand RC, Sodhi N, Anis HK, Ehiorobo J, Newman JM, Taylor K, et al. One-year patient outcomes for robotic-arm-assisted versus manual total knee arthroplasty. *J Knee Surg* 2019;32(11):1063-8. https://doi.org/10.1055/s-0039-1683977
13. Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad FS. Robotic-arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced time to hospital discharge compared with conventional jig-based total knee arthroplasty: a prospective cohort study. *Bone Joint J* 2018;100-B(7):930-7. https://doi.org/10.1302/0301-620X.100B7.BJJ-2017-1449.R1
14. Biant LC, Yeoh K, Walker PM, Bruce WJM, Walsh WR. The accuracy of bone resections made during computer navigated total knee replacement. Do we resect what the computer plans we resect? *Knee* 2008;15(3):238-41. https://doi.org/10.1016/j.knee.2008.01.012
15. Casper M, Mitra R, Khare R, Jaramaz B, Hamlin B, McGinley B, et al. Accuracy assessment of a novel image-free handheld robot for total knee arthroplasty in a cadaveric study. *Comput Assist Surg (Abingdon)* 2018;23(1):14-20. https://doi.org/10.1080/24699322.2018.1519038

16. Batailler C, Hannouche D, Benazzo F, Parratte S. Concepts and techniques of a new robotically assisted technique for total knee arthroplasty: the ROSA knee system. *Arch Orthop Trauma Surg* 2021;141(12):2049-58. https://10.1007/s00402-021-04048-y
17. Massé V, Ghate RS. Using standard X-ray images to create 3D digital bone models and patient-matched guides for aiding implant positioning and sizing in total knee arthroplasty. *Comput Assist Surg (Abingdon)* 2021;26(1):31-40. https://doi.org/10.1080/24699322.2021.1894239
18. Lustig S, Fleury C, Goy D, Neyret P, Donell ST. The accuracy of acquisition of an imageless computer-assisted system and its implication for knee arthroplasty. *Knee* 2011;18(1):15-20. https://doi.org/10.1016/j.knee.2009.12.010
19. Parratte S, Price AJ, Jeys LM, Jackson WF, Clarke HD. Accuracy of a new robotically assisted technique for total knee arthroplasty: A cadaveric study. *J Arthroplasty* 2019;34(11):2799-803. https://doi.org/10.1016/j.arth.2019.06.040
20. Seidenstein A, Birmingham M, Foran J, Ogden S. Better accuracy and reproducibility of a new robotically-assisted system for total knee arthroplasty compared to conventional instrumentation: a cadaveric study. *Knee Surg Sports Traumatol Arthrosc* 2021;29(3):859-66. https://doi.org/10.1007/s00167-020-06038-w

Scores V

Ernesto Bersusky,[*] Ignacio Arzac Ulla,[**] Lidia G. Loterzo,[#] Guillermo Ricciardi,[##] Gerardo Zanotti,[ŧ] Juan M. Patiño[ŧŧ]
[*]*Pediatric Hospital "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina*
[**]*BR Traumatología, Azul, Buenos Aires, Argentina*
[#]*Hospital Central de San Isidro "Dr. Melchor Ángel Posse", Buenos Aires, Argentina*
[##]*Hospital General de Agudos "Dr. Teodoro Álvarez", Autonomous City of Buenos Aires, Argentina*
[ŧ]*Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina*
[ŧŧ]*Hospital Militar Central "Cirujano Mayor Dr. Cosme Argerich", Autonomous City of Buenos Aires, Argentina*

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

Puntajes V

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

INTRODUCTION

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

We carried out a review of the most used scales, defining their use and including original and updated literature. In this opportunity, we dealt with the section of spine scores.

Spine Instability Neoplastic Score

The Spine Oncology Study Group (SOSG), a group of international experts dedicated to the study of spinal tumors, defines neoplastic vertebral instability as the "loss of spinal integrity as a result of a neoplastic process that is associated with movement-related pain, symptomatic or progressive deformity and/or neural compromise under physiological loads." Mechanical instability due to vertebral metastases is an indication for surgical stabilization (conventional or percutaneous), regardless of neurological compression or sensitivity to cancer treatment of the tumor (chemotherapy/radiotherapy). The SOSG has proposed the Spine Instability Neoplastic Score (SINS) as an instrument to assess oncological vertebral mechanical instability through 6 components: location

Received on July 20th, 2021. Accepted after evaluation on December 14th, 2021 • Dr. GUILLERMO RICCIARDI • guillermoricciardi@gmail.com https://orcid.org/0000-0002-6959-9301
How to cite this article: Bersusky E, Arzac Ulla I, Loterzo LG, Ricciardi G, Zanotti G, Patiño JM. Scores V. *Rev Asoc Argent Ortop Traumatol* 2022;87(6):851-857.
https://doi.org/10.15417/issn.1852-7434.2022.87.6.1676

of the lesion, presence and type of pain, nature of the lesion (lytic or blastic), radiographic alignment , collapse of the vertebral body and compromise of posterior vertebral structures. Each parameter is assigned a numerical score. The SINS is obtained by adding each score of the 6 individual components. The minimum score is 0 and the maximum is 18. The total score is interpreted according to the following intervals: 0 to 6, stable; 13 to 18, unstable; 7 to 12, potentially unstable. Patients with SINS scores of 7 to 18 warrant surgical consultation.

Spine Instability Neoplastic Score (SINS)	
Components	**Score**
Location	
Junctional (occiput-C2; C7-T2; T11-L1; L5-S1)	3
Mobile spine (C3-C6; L2-L4)	2
Semi-rigid spine (T3-T10)	1
Rigid spine (S2-S5)	0
Pain that subsides with recumbency or pain that occurs with movement or loading of the spine	
Yes	3
No (occasional pain, but not mechanical)	1
Pain free lesion	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Radiographic spinal alignment	
Presence of subluxation/translation	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of the spinal elements (fractures or tumor infiltration of the facet, pedicle, or costovertebral joint)	
Bilateral	3
Unilateral	1
None of the above	0
Interpretation 0 to 6 = stable 7 to 12 = potentially unstable (possibly imminent) 13 to 18 = unstable	

REFERENCES

- Fisher CG, DiPaola CP, Ryken TC, Bilsky MH, Shaffrey CI, Berven SH, et al. A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. *Spine (Phila PA)* 2010;35:E1221-E1229. https://doi.org/10.1097/BRS.0b013e3181e16ae2
- Fisher CG, Versteeg AL, Schouten R, Boriani S, Varga PP, Rhines LD, et al. Reliability of the spinal instability neoplastic scale among radiologists: an assessment of instability secondary to spinal metastases. *AJR Am J Roentgenol* 2014;203(4):869-74. https://doi.org/10.2214/AJR.13.12269

Thoracolumbar AOSpine Injury score (TL AOSIS)

Over time, multiple classification systems have been proposed for traumatic thoracolumbar spinal injuries. As relevant precedents, we can highlight the classifications by Denis, Magerl (AO) and Vaccaro (TLICS, Thoracolumbar Injury Classification System). In 2013, Vaccaro et al. published the AOSpine Thoracolumbar Spine Injury Classification system, which is currently the most widely used international system for classifying this type of injury. Based on this system, the Thoracolumbar AOSpine Injury score (TL AOSIS) was developed (Table 2), which gives a score to each of the classification variables. Subsequently, the therapeutic algorithm based on the TL AOSIS was published, which is interpreted according to the following intervals: 3 points or less, initial conservative treatment; greater than 5 points, surgical treatment; 4 or 5 points, conservative or surgical treatment, according to clinical criteria.

Thoracolumbar AOSpine Injury score (TL AOSIS)

Classification	Points
Type A (compression)	
A0	0
A1	1
A2	2
A3	3
A4	5
Type B (tension band injury)	
B1	5
B2	6
B3	7
Type C (translation injury)	
C	8
Neurological status	
N0	0
N1	1
N2	2
N3	4
N4	4
NX	3
Modifiers	
M1	1
M2	0

Interpretation
3 or less = initial conservative treatment
4 or 5 = conservative or surgical treatment, according to clinical criteria
>5 = surgical treatment

REFERENCES

- Vaccaro AR, Oner C, Kepler CK, Dvorak M, Schnake K, Bellabarba C, Reinhold M, Aarabi B, Kandziora F, Chapman J, Shanmuganathan R, Fehlings M, Vialle L; AOSpine Spinal Cord Injury & Trauma Knowledge Forum. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. *Spine (Phila Pa 1976)* 2013;38(23):2028-37. https://doi.org/10.1097/BRS.0b013e3182a8a381
- Kepler CK, Vaccaro AR, Schroeder GD, Koerner JD, Vialle LR, Aarabi B, et al. The Thoracolumbar AOSpine Injury Score. *Global Spine J* 2016;6(4):329-34. https://doi.org/10.1055/s-0035-1563610
- Vaccaro AR, Schroeder GD, Kepler CK, Cumhur Oner F, Vialle LR, Kandziora F, et al. The surgical algorithm for the AOSpine thoracolumbar spine injury classification system. *Eur Spine J* 2016;25(4):1087-94. https://doi.org/10.1007/s00586-015-3982-2

Scoliosis Research Society 22r Patient Questionnaire (SRS-22r)

The SRS-22r is a questionnaire prepared by the Scoliosis Research Society to evaluate outcomes in patients operated on for idiopathic scoliosis. Since its first version published in 1999, it has undergone successive modifications (originally with 24 items).

The questionnaire covers 5 dimensions: pain (5 questions), function (5 questions), mental health (5 questions), self-image (5 questions) and satisfaction with treatment (2 questions). In each dimension, the items have 5 possible answers that are associated with a score (1 to 5) (Table 3). The point average is calculated for each dimension and for the total of the items in the questionnaire. Therefore, the best score, total and for each domain, is 5 and the worst score is 1. The higher the score, the better quality of life. If there are unanswered items, the "answered questions" denominator is reduced to the appropriate number. Items with more than one answer are removed from the calculation. The dimensions cannot be scored if less than 3 items are answered, with the exception of satisfaction with the treatment.

SRS 22r				
1. Which one of the following best describes the amount of pain you have experienced during the past 6 months?				
☐ None	☐ Mild	☐ Moderate	☐ Moderate to severe	☐ Severe
2. Which one of the following best describes the amount of pain you have experienced over the last month?				
☐ None	☐ Mild	☐ Moderate	☐ Moderate to severe	☐ Severe
3. During the past 6 months, have you been feeling very nervous?				
☐ None of the time	☐ A little of the time	☐ Some of the time	☐ Most of the time	☐ All of the time
4. If you had to spend the rest of your life with your back the way it is now, how would you feel?				
☐ Very happy	☐ Somewhat happy	☐ Neither happy nor unhappy	☐ Somewhat unhappy	☐ Very unhappy
5. What is your current level of activity?				
☐ Bedridden	☐ Primarily no activity	☐ Light tasks and light sports	☐ Moderate tasks and moderate sports	☐ Full activities without restriction
6. How do you look in clothes?				
☐ Very good	☐ Good	☐ Fair	☐ Bad	☐ Very bad
7. In the past 6 months, have you felt so low that nothing could cheer you up?				
☐ Very often	☐ Often	☐ Sometimes	☐ Rarely	☐ Never
8. Do you experience back pain when at rest?				
☐ Very often	☐ Often	☐ Sometimes	☐ Rarely	☐ Never
9. What is your current level of work or school activity?				
☐ 100% normal	☐ 75% normal	☐ 50% normal	☐ 25% normal	☐ 0% normal
10. How would you describe the appearance of your body (without taking into account that of the face and extremities)?				
☐ Very good	☐ Good	☐ Fair	☐ Poor	☐ Very poor
11. Do you take medication for your back?				
☐ None	☐ Non-narcotics weekly or less	☐ Non-narcotics daily	☐ Narcotics weekly or less	☐ Narcotics daily

12. Does your back limit your ability to carry out your usual activities at home?				
☐ Never	☐ Rarely	☐ Sometimes	☐ Often	☐ Very often
13. Have you felt calm and peaceful during the past 6 months?				
☐ All of the time	☐ Often	☐ Sometimes	☐ Rarely	☐ Never
14. Do you think that the state of your back affects your personal relationships?				
☐ No	☐ Slightly	☐ Mildly	☐ Moderately	☐ Severely
15. Are you and/or your family experiencing financial difficulties because of your back?				
☐ Severely	☐ Moderately	☐ Mildly	☐ Slightly	☐ No
16. In the last 6 months, have you felt down and sad?				
☐ Never	☐ Rarely	☐ Sometimes	☐ Often	☐ Very often
17. In the last 3 months, how many days have you missed work or school due to back pain?				
☐ 0 days	☐ 1 day	☐ 2 days	☐ 3 days	☐ 4 days or more
18. Does your back condition limit your going out with friends/family?				
☐ Never	☐ Rarely	☐ Sometimes	☐ Often	☐ Very often
19. Do you feel attractive with your current back condition?				
☐ Yes, very	☐ Yes, somewhat	☐ Neither attractive nor unattractive	☐ No, not very much	☐ No, not at all
20. Have you been a happy person during the past 6 months?				
☐ Never	☐ Rarely	☐ Sometimes	☐ Often	☐ Very often
21. Are you satisfied with the results of your back management?				
☐ Very satisfied	☐ Satisfied	☐ Neither satisfied nor unsatisfied	☐ Unsatisfied	☐ Very unsatisfied
22. Would you have the same management again if you had the same condition?				
☐ Definitely yes	☐ Probably yes	☐ Not sure	☐ Probably not	☐ Definitely not

REFERENCES

- Haher TR, Gorup JM, Shin TM, Homel P, Merola AA, Grogan DP, et al. Results of the Scoliosis Research Society instrument for evaluation of surgical outcome in adolescent idiopathic scoliosis. A multicenter study of 244 patients. *Spine (Phila Pa 1976)* 1999;24(14):1435-40. https://doi.org/10.1097/00007632-199907150-00008
- Climent JM, Bago J, Ey A, Perez-Grueso FJ, Izquierdo E. Validity of the Spanish version of the Scoliosis Research Society-22 (SRS-22) Patient Questionnaire. *Spine (Phila Pa 1976)* 2005;30(6):705-9. https://doi.org/10.1097/01.brs.0000155408.76606.8f
- Glattes RC, Burton DC, Lai SM, Frasier E, Asher MA. The reliability and concurrent validity of the Scoliosis Research Society-22r patient questionnaire compared with the Child Health Questionnaire-CF87 patient questionnaire for adolescent spinal deformity. *Spine (Phila Pa 1976)* 2007;32(16):1778-84. https://doi.org/10.1097/BRS.0b013e3180dc9bb2
- Crawford CH 3rd, Glassman SD, Bridwell KH, Berven SH, Carreon LY. The minimum clinically important difference in SRS-22R total score, appearance, activity and pain domains after surgical treatment of adult spinal deformity. *Spine (Phila Pa 1976)* 2015;40(6):377-81. https://doi.org/10.1097/BRS.0000000000000761

Oswestry Disability Index

The Oswestry Disability Index (ODI) is an outcome measure designed to assess the impact of acute or chronic low back pain on the level of activities of daily living. It consists of 10 questions addressed to the patient, whose responses are arranged as 6-point Likert scales. Alternatively, the total score can be expressed as a percentage and ranges from 0% (no disability) to 100% (most severe disability).

Oswestry Disability Index (ODI)	
Pain intensity	I can handle pain without taking painkillers. The pain is strong, but I manage without taking painkillers. Painkillers completely relieve my pain. Painkillers ease the pain a bit. Painkillers barely ease the pain. Painkillers do not take away the pain and I do not take them.
Personal care (washing, dressing, etc.)	I can look after myself normally without causing extra pain. I can look after myself normally but it causes extra pain. It is painful to look after myself and I am slow and careful. I need some help but manage most of my personal care. I need help every day in most aspects of self-care. I do not get dressed, I wash with difficulty and stay in bed.
Lifting	I can lift heavy weights without extra pain. I can lift heavy weights but it gives extra pain. Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently placed (e.g. on a table). Pain prevents me from lifting heavy objects, but I can lift light to medium objects if they are conveniently positioned. I can only lift very light weights. I cannot lift or carry anything at all.
Walking	Pain does not prevent me from walking any distance. Pain prevents me from walking more than 1 kilometer. Pain prevents me from walking more than 500 meters. Pain prevents me from walking more than 250 meters. I can only walk using a cane or crutches. I stay in bed most of the time.
Sitting	I can sit in any type of chair for as long as I want. I can only sit in my favorite chair for as long as I want. Pain prevents me from sitting for more than an hour. Pain prevents me from sitting for more than half an hour. Pain prevents me from sitting for more than ten minutes. Pain prevents me from sitting at all.
Standing	I can stand as long as I want without extra pain. I can stand as long as I want but it gives me extra pain. Pain prevents me from standing for more than 1 hour. Pain prevents me from standing for more than half an hour. Pain prevents me from standing for more than ten minutes. Pain prevents me from standing at all.
Sleeping	My sleep is never disturbed by pain. I can only sleep if I take pills. Even taking pills I sleep less than six hours. Even taking pills I sleep less than four hours. Even taking pills I sleep less than two hours. The pain completely prevents me from sleeping.

Sexual activity	My sexual activity is normal and causes no extra pain. My sexual activity is normal but causes some extra pain. My sexual activity is nearly normal but very painful My sexual activity is severely restricted by pain. My sexual activity is nearly absent because of pain. Pain prevents me from all kinds of sexual activity.
Social life	My social life is normal and gives me no extra pain. My social life is normal but the increases the degree of pain. Pain has no significant effect on my social life but it does limit my more energetic interests (e.g., dancing, etc.). Pain has restricted my social life and I do not go out as often . Pain has restricted my social life to my home. I have no social life because of pain.
Travelling	I can travel anywhere without pain. I can travel anywhere but it gives me extra pain. Pain is strong but I manage journeys over two hours. Pain restricts me to journeys of less than one hour. Pain restricts me to short necessary journeys under 30 minutes. Pain prevents me from travelling except to receive treatment.

REFERENCES

- Baker D, Pynsent P, Fairbank J. The Oswestry Disability Index revisited. En: Roland M, Jenner J, eds. *Back pain: New Approaches to Rehabilitation and Education*. Manchester: Manchester University Press; 1989:174-86.
- Fairbank JC, Pynsent PB. The Oswestry Disability Index. *Spine (Phila Pa 1976)* 2000;25(22):2940-52; discussion 2952. https://doi.org/10.1097/00007632-200011150-00017
- Selva-Sevilla C, Ferrara P, Gerónimo-Pardo M. Psychometric properties study of the Oswestry Disability Index in a spanish population with previous lumbar disc surgery: Homogeneity and validity. *Spine (Phila Pa 1976)* 2019;44(7):E430-E437. https://doi.org/10.1097/BRS.0000000000002867

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

E. Bersusky ORCID ID: http://orcid.org/0000-0002-3121-9326
Arzac Ulla ORCID ID: http://orcid.org/0000-0002-5038-7720
L. G. Loterzo ORCID ID: https://orcid.org/0000-0001-5465-1747
G. Zanotti ORCID ID: https://orcid.org/0000-0001-8090-4832
J. M. Patiño ORCID ID: https://orcid.org/0000-0002-9036-0442

Case Resolution

Rodrigo Re[*], Christian Allende Nores[**]
[*]*Diagnostic Imaging Service, Osteoarticular/Musculoskeletal Area - Interventionism, Sanatorio Allende, Córdoba, Argentina*
[**]*Orthopedics and Traumatology Service. Sanatorio Allende, Córdoba, Argentina*

Case presentation on page 745.

DIAGNOSIS: Persistent median artery thrombosis

DISCUSSION

In the magnetic resonance of the right wrist (Figure 3) thrombosis of a vascular structure that runs in close contact with the median nerve is observed, producing, at the level of the carpal canal, its dissection, with a marked surrounding inflammatory process. The thrombosis shows hyperintensity both on T1 and fat suppression sequences, and is surrounded by the two components of the median nerve at the level of the carpal tunnel.

Due to the ultrasound and magnetic resonance findings, surgical treatment was decided.

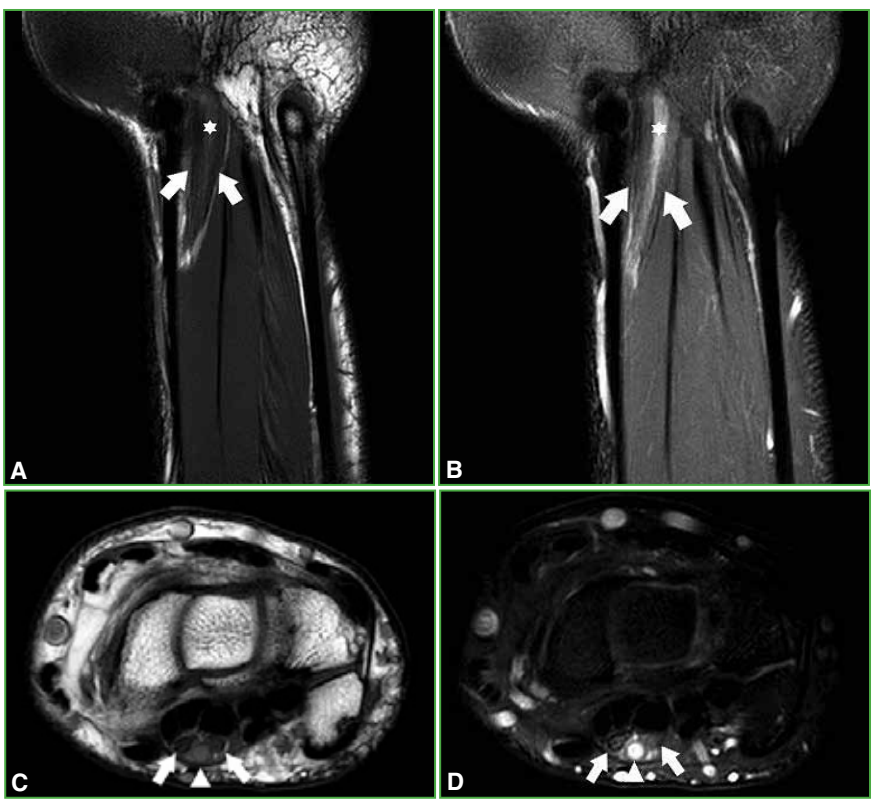


Figure 3. Non-contrast magnetic resonance imaging of the right wrist. **A and B.** Coronal T1 and STIR sequences, respectively. Median nerve with bifid morphology (arrows) with a hyperintense tubular image (asterisk). **C and D.** Axial T1 and STIR sequences, respectively. Divided median nerve (arrows) with rounded mass in the middle (arrowhead).

Dr. RODRIGO RE • rodrigo_re@hotmail.com https://orcid.org/0000-0001-7382-9459

How to cite this article: Re R, Allende Nores C. Postgraduate Orthopedic Instruction - Imaging. Case resolution. Rev Asoc Argent Ortop Traumatol 2022;87(6):858-861. https://doi.org/10.15417/issn.1852-7434.2022.87.6.1605

DIAGNOSIS

With all these findings, a persistent median artery thrombosis with bifid median nerve is diagnosed.

The vascular system of the upper limb is very complex and can give rise to numerous anomalies, such as the absence of arteries, alterations in their origins and courses, or the persistence of embryonic arteries. One of these variants is the persistence of the median artery. Structures associated with a persistent median artery may also be abnormal. The presence of a median artery is associated with an anatomical variation of the median nerve, which can present a bifid morphology.

When the persistent median artery exceeds 1.5 mm in diameter, symptoms of median nerve compression may appear. The artery can increase in size due to the presence of calcifications, thrombosis, atherosclerosis, trauma, and dilation.

The most common differential diagnoses are carpal tunnel syndrome (Figure 4) or fibrolipomatous hamartoma of the median nerve (Figure 5).

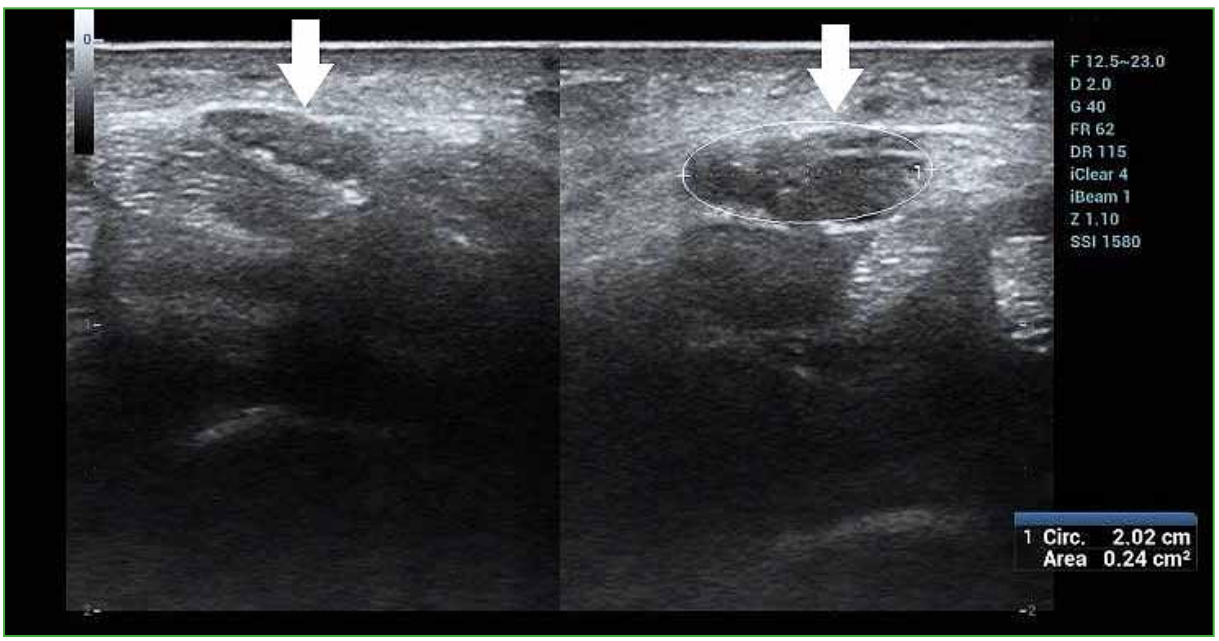


Figure 4. Comparative left and right wrist ultrasound showing the enlarged left median nerve, measuring 24 mm^2.

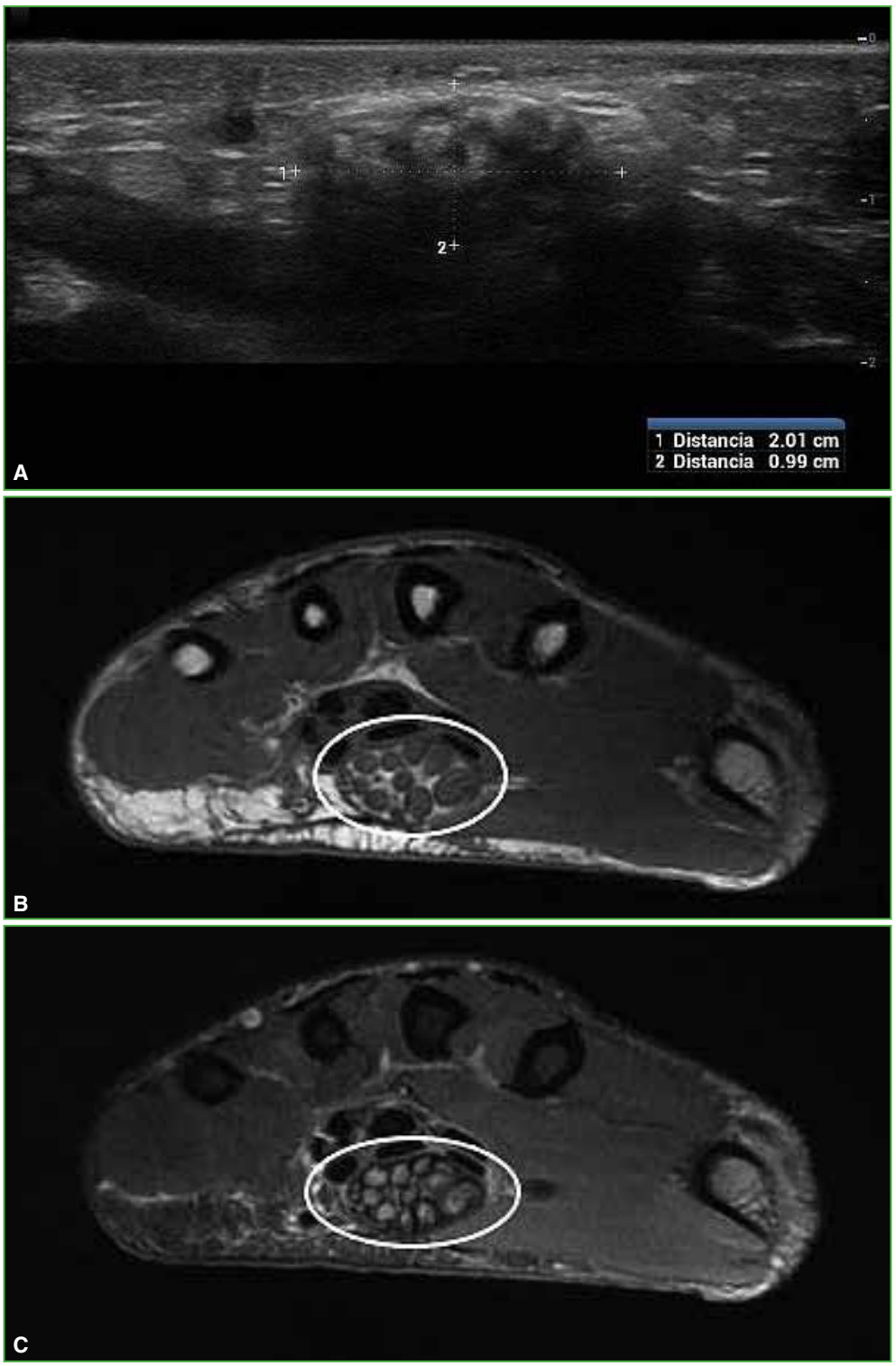


Figure 5. **A.** Ultrasound of the right wrist with a heterogeneous tumor in the carpal canal. Alternating hypo and hyperechogenic areas. **B and C.** MRI of the right wrist, axial slice, on T1-weighted and STIR sequences, respectively, showing a marked thickening of the median nerve fibers, which shows hypointensity on T1 sequences and slight hyperintensity on fat suppression sequences, with interspersed linear images which are hyperintense on T1 and hypointense on STIR, compatible with fat. Lipomatous hamartoma of the median nerve.

Given the significant symptoms presented by our patient, surgical treatment was decided with the placement of a clip in the artery and the release of the median nerve (Figure 6).

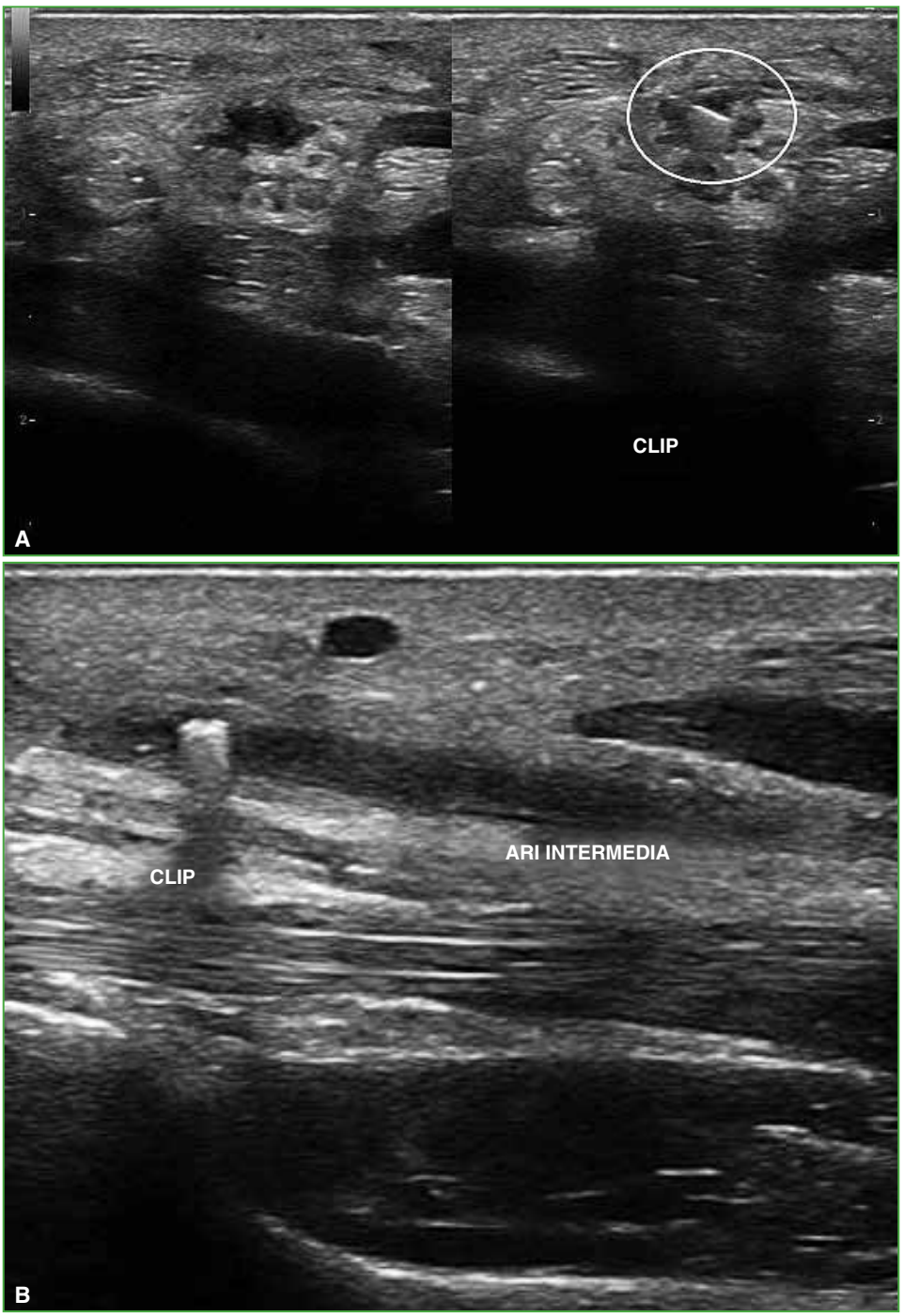


Figure 6. Post-surgical ultrasound of the right wrist showing the presence of a clip in the artery and release of the median nerve. **A.** Transverse slice. Right: persistent median artery before clip placement. Left: clip placement site. **B.** Longitudinal slice; clip inside the artery.

C. Allende Nores ORCID ID: https://orcid.org/0000-0002-2336-2157

Index by Topic 2022

Upper Limb

Lower Limb

General Topics

Sports

Obituaries

Letters To The Editor

Index by Author 2022

The Journal of the Argentine Association of Orthopedics and Traumatology (Asociación Argentina de Ortopedia y Traumatología, AAOT) thanks the following authors for choosing us to publish their work. We look forward to continuing this valuable collaboration with all of them.

2022 Reviewers

The Journal of the Argentine Association of Orthopedics and Traumatology is grateful to the following reviewers for their considerable efforts in reviewing the received papers and hopes that they will continue to support our journal with their valuable contribution.

Allende, Bartolomé L.	Sanatorio Allende, Córdoba, Argentina
Altube, Gonzalo	Sanatorio Allende, Córdoba, Argentina
Alvarado Gómez, Fernando	Fundación Santa Fe de Bogotá, Colombia
Argüelles, Santiago	Hospital Municipal de Vicente López "Bernardo Houssay", Buenos Aires, Argentina
Arroquy, Damián	Clínica María Auxiliadora, Buenos Aires, Argentina
Bazán, Pedro L.	Hospital Interzonal General de Agudos "Gral. José de San Martín", La Plata, Buenos Aires, Argentina
Berardinelli, Daniel	Sanatorio Rivadavia, San Miguel de Tucumán, Tucumán, Argentina
Bittelman, Sacha	Instituto Seguridad del Trabajo, Viña del Mar, Chile
Bonilla, Gonzalo J. H.	Hospital Militar Central "Cirujano Mayor Dr. Cosme Argerich", Ciudad Autónoma de Buenos Aires, Argentina
Cabrera, Marcos N.	Sanatorio Güemes, Autonomous City of Buenos Aires, Argentina
Carabelli, Guido	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Carbó, Lisandro	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Caruso, Juan	Hospital Militar Central "Cirujano Mayor Dr. Cosme Argerich", Autonomous City of Buenos Aires, Argentina
Castellini, Jorge	Swiss Medical Group, Autonomous City of Buenos Aires, Argentina
Castiglioni, Alejandro E.	Sanatorio Británico, Rosario, Santa Fe, Argentina
Charosky, Sebastien	Instituto Clavel, Barcelona, Spain
Cima, José I.	Clínica Privada Vélez Sarsfield, Córdoba, Argentina
Conti, Leonardo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Costa Paz, Matías	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
De Elias, Manuel	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Della Rosa, Luciano A.	Hospital Interzonal General de Agudos "Eva Perón" (Ex Castex), Buenos Aires, Argentina
Denari, Ricardo G.	Hospital General de Agudos "Carlos G. Durand", Autonomous City of Buenos Aires, Argentina
Díaz-Borjón, E.	Hospital Ángeles Lomas, Hacienda de las Palmas, México
Dohmen, Aurelia L.	Hospital Interzonal General de Agudos "Presidente Perón", Buenos Aires, Argentina
Escobar, Darío E.	Policlínico Neuquén, City of Neuquén, Argentina
Fazio, Alejandro	Hospital Privado de Córdoba, Argentina
Fernández Comber, S.	Hospital del Trabajador, Santiago, Chile
Ferraris, Luis	Werner-Wicker-Klinik, Bad Wildungen, Germany
Ferreyra, Martín L.	Instituto Oulton, Córdoba, Argentina
Gallucci, Gerardo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Garabano, Germán	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
García Rey, Eduardo	Hospital Universitario La Paz, Madrid, Spain

Gelosi, Jorge F.	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Genovesi, Marcelo E.	Centro Médico La Barraca, Guaymallén, Mendoza, Argentina
Gómez, Diego J.	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Gruenberg, Marcelo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Guyot, Juan Pablo	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Innocenti, Sergio	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Jorge, Fernando D.	Hospital Alemán, Autonomous City of Buenos Aires, Argentina
Lencina, Omar	Clínica La Pequeña Familia, Junín, Buenos Aires, Argentina
López, Juan José	School of Medicine of the Universidad de Buenos Aires (UBA), Argentina
López Millán, Lucas M.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Lopez Ovenza, Juan Manuel	Centro Artro, Buenos Aires, Argentina
Lopreite, Fernando A.	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Lucero, Carlos M.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Maletti, Pablo	Hospital Provincial de Neuquén, Neuquén, Argentina
Mangione, José I.	Hospital Italiano de Mendoza, Argentina
Mangupli, Martín M.	Sanatorio Allende, Córdoba, Argentina
Manzone, Patricio	Hospital Pediátrico "Dr. Avelino Lorenzo Castelán", Chaco, Argentina
Masaragian, Héctor	Cirugiadelpie.net, Autonomous City of Buenos Aires, Argentina
Masquijo, Julio J.	Sanatorio Allende, Córdoba, Argentina
Miscione, Horacio F.	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Mizdraji, Luciano	Clínica Bazterrica, Autonomous City of Buenos Aires, Argentina
Monteagudo de la Rosa, Manuel	Hospital Universitario Quironsalud, Madrid, Spain
Moya, Daniel	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Natiello, Néstor	GETAP, Buenos Aires, Argentina
Oettinger, Michael	Hospital Alemán, Autonomous City of Buenos Aires, Argentina
Oñativia, José I.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Paganini, Federico	Sanatorio Allende, Córdoba, Argentina
Pantoja Contreras, Samuel T.	Clínica Universidad de los Andes, Santiago, Chile
Pastrana, Martín J.	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Pelaez, Carlos R.	Hospital Interzonal General de Agudos "Gral. José de San Martín", La Plata, Buenos Aires, Argentina
Peratta, Marcela	Centro Artro, Buenos Aires, Argentina
Pereira, Sebastián	Hospital Sirio Libanés, Ciudad Autónoma de Buenos Aires, Argentina
Perrone, Juan Martín	Complejo Médico Churruca-Visca, Autonomous City of Buenos Aires, Argentina
Piantoni, Lucas	Hospital de Pediatría "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Pioli, Ignacio	Sanatorio Allende, Córdoba, Argentina
Poitevin, Luciano	School of Medicine of the Universidad de Buenos Aires (UBA), Argentina
Raimondi, Nicolás	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Rellán, Ignacio	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Remondino, Rodrigo	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Reyes Sánchez, Alejandro A.	Instituto Nacional de Rehabilitación "Luis Guillermo Ibarra Ibarra", Ciudad de México, México
Río, Marcelo W.	Clínica Zabala, Autonomous City of Buenos Aires, Argentina

Ríos, Hugo	School of Medicine of the Universidad de Buenos Aires (UBA), Argentina
Robador, Nicolás A.	Asunción Klinika, Spain
Rodríguez, Javier L.	Hospital General de Niños "Pedro de Elizalde", Autonomous City of Buenos Aires, Argentina
Rojas Llevano, Jorge L.	Hospital Universitario Fundación Santa Fe de Bogotá, Colombia
Romagnoli, Julián	Hospital General de Agudos "Dr. Juan A. Fernández", Autonomous City of Buenos Aires, Argentina
Rossi, Luciano A.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Santamarta, Laura	Hospital Central de San Isidro "Dr. Melchor Ángel Posse", Buenos Aires, Argentina
Sanzana, Edgardo S.	Universidad de Concepción, Chile
Schiappacasse, Carolina	Las Araucarias, Clínica de Rehabilitación, Buenos Aires, Argentina
Sepúlveda Oviedo, Matías	Hospital Base Valdivia, Chile
Simesen de Bielke, Harold	Sanatorio Modelo de San Miguel de Tucumán, Argentina
Slullitel, Pablo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Soria, Roberto D.	Hospital Santa Isabel de Hungría, Guaymallén, Mendoza, Argentina
Soutullo, Jorge L.	Instituto Argentino de Diagnóstico y Tratamiento, Autonomous City of Buenos Aires, Argentina
Sperone, Enzo D.	Hospital de Trauma y Emergencias "Dr. Federico Abete", Buenos Aires, Argentina
Stonski, Eduardo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Tello, Carlos A.	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Teruya, Gustavo	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Torrens Canova, Carlos	Hospital Universitario del Mar, Barcelona, Spain
Torres, Byron	Hospital Metropolitano, Quito, Ecuador
Trebino Molteni, Juan Manuel	Hospital Militar Campo de Mayo H Grl 602 - Cirujano Primero Dr. Juan Madera, Buenos Aires, Argentina
Trueba, Ricardo	Grupo Médico Rostagno, Autonomous City of Buenos Aires, Argentina
Valbuena, Sebastián E.	Hospital El Cruce, Universidad Nacional Arturo Jauretche, Florencio Varela, Buenos Aires, Argentina
Vega Mayer, Rafael	Clínica San Carlos de Apoquindo, Santiago, Chile
Vindver, Gabriel	Hospital Sirio Libanés, Autonomous City of Buenos Aires, Argentina
Vivas, Mauro R.	Hospital de Alta Complejidad en Red "El Cruce", Dr. Néstor C. Kirchner, Florencio Varela, Buenos Aires, Argentina
Yurac, Ratko	Clínica Alemana de Santiago, Santiago, Chile
Zaidenberg, Carlos	Universidad de Buenos Aires, Buenos Aires, Argentina
Zaidenberg, Ezequiel E.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina