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Editorial

SBOT Turns 90

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A group of doctors interested in a new specialty from general and pediatric surgery founded the Brazilian Orthopedic Society 90 years ago.

The only thing they had in common was the desire to share knowledge and ignorance about several aspects of the treatment and etiology of diseases and traumas affecting the musculoskeletal system.

Most had some training abroad in different places and had divergent orientations and conducts. They came together to start an inclusive institution, distinct from extractive institutions – terms used by the winners of the 2024 Nobel Prize in Economics to explain why some nations have prospered over the last few years (those with inclusive institutions) and others did not (those with extractive institutions).

The idea was to develop the new specialty, teach it, and disseminate its principles.

With this spirit, the Society developed despite a few disagreements between the founding leaders, always with the idea of teaching by creating new orthopedists in the various national centers.

In 1945, the first medical residency in Brazil was created in orthopedics and traumatology, based on the vision of Godoy Moreira, one of the precursors of the new specialty.

The world was going through one of the most changing times in history, with the emergence of communist doctrine and the reaction of the rest of humanity to it. Great revolutions were beginning in Europe (Germany, Italy, Spain, Russia), parallel to the Industrial Revolution, requiring new doctors capable of rehabilitating traumatized workers and those limited by its post-effects.

The multiplication of orthopedists was proportional to the advance of the specialty, driven by the scourge of World War II, with large-scale traumas and industrial accidents requiring a growing number of specialists. Locomotor system disorders resulting from viruses, such as polio and tuberculosis, created the need for developing specialists in the study of the treatment and rehabilitation of patients with severe limitations as sequelae of these diseases.

This outlined the future of orthopedics: treating and rehabilitating people with musculoskeletal system injuries.

The Brazilian Society of Orthopedics and Traumatology (*Sociedade Brasileira de Ortopedia e Traumatologia* [SBOT]) has seen significant development in several regions, especially in the Rio de Janeiro-São Paulo region: Pernambuco, Bahia, Goias, Minas Gerais, Parana, and Rio Grande do Sul were the first centers, but soon followed by other states teaching orthopedics and traumatology in their medical schools and sending their young doctors to specialize in centers already structured in the country. The specialty needed a publication to promote it; after unsuccessful attempts, the publication of *Revista Brasileira de Ortopedia* started to occur periodically in Minas Gerais, in 1966. Read and admired by current SBOT members, the journal promotes Brazilian orthopedics worldwide after its indexation in PubMed in 2015. The initial spirit of the founders, i.e., promoting the specialty by teaching it to young doctors, lives on.

In the 1970s, SBOT members, in addition to requiring a minimum of two years of supervised training, decided to create an exam to qualify those who deserved the title of orthopedist, giving rise to the Title of Specialist in Orthopedics and Traumatology (*Título de Especialista em Ortopedia e Traumatologia* [TEOT]).

This SBOT exam evolved so much that it became an example for several specialties.

In the 1980s, knowledge, as a consequence of all this growth, required a division into areas of study, resulting in the rise of specialties within orthopedics. One by one, the specialties were born and developed like the original Society, always teaching to disseminate their knowledge.

Like branches of a tree that never separate from the trunk, a tree that Nicolas Andry used as a symbol of the specialty correcting pediatric deformities in the book *Orthopedics or the Art of Correcting and Preventing Deformities in Children*, from 1741, the specialties organized themselves.

After 90 years, disagreements, although rarer, persist, as does ignorance about some specialty areas. However, the drive to teach and disseminate information remains growing.

The first CBOT occurred in July 1936 and has been held ever since. This year marks the 57th SBOT meeting. The presidents continue to be elected by SBOT members and still

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perform their roles of teaching and keeping the unity of the specialty.

Today, SBOT has over 15,000 members and offers numerous modern instruction and teaching systems to them.

It recently opened an international standard training center and laid the cornerstone for a building that will house all its administrative and teaching activities.

I wonder if Rezende Puech, Achilles de Araujo, and Barros Lima would have imagined, in September 1935, that they were founding a society with such a future.

Conflict of Interest
The author has no conflict of interest to declare.

Painful Borderline Acetabular Dysplasia: What's New?

Displasia acetabular limítrofe dolorosa: O que há de novo?

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Abstract

Developmental dysplasia of the hip (DDH) is a complex static-dynamic condition resulting in chronic joint instability and osteoarthritis. Borderline acetabular dysplasia refers to slightly abnormal patterns in the acetabular shape and coverage that are not within the dysplastic range. However, they can predispose to mechanical dysfunction and hip instability. Diagnosis and treatment remain controversial topics in hip preservation, with little current comparative literature to guide accurate diagnosis and treatment decision-making. Historically, the diagnosis of borderline DDH relied on assessments of the acetabular anatomy on anteroposterior pelvic radiography, most commonly the lateral central-edge angle (LCEA), with normal values ranging from 20 to 25° or, in some more recent studies, 18 to 25°. Surgical treatment decision-making debates the use of isolated hip arthroscopy or periacetabular osteotomy, considering the difficulty in determining a fundamental mechanical diagnosis (instability versus femoroacetabular impingement) in subjects with borderline DDH. Therefore, for effective surgical decision-making, the evaluation of additional bone anatomy characteristics, instability, and patients' features is essential.

Keywords

- decision-making
- diagnostic imaging
- femoroacetabular impingement
- hip dislocation
- hip joint

Resumo

A displasia do desenvolvimento do quadril (DDQ), é uma patologia estática-dinâmica complexa que conduz à instabilidade articular crônica e à artrose. Já a displasia acetabular *borderline* (limítrofe) refere-se a padrões levemente anormais na forma e na cobertura acetabular que não estão dentro dos valores para serem considerados displásicos. Entretanto, tais padrões podem predispor a disfunção mecânica e instabilidade quadril. O diagnóstico e o tratamento continuam sendo um tópico controverso na preservação do quadril, com pouca literatura comparativa atual para orientar o diagnóstico preciso e a tomada de decisão do tratamento. Historicamente o diagnóstico da DDQ limítrofe foi baseado em avaliações da anatomia acetabular na radiografia pélvica anteroposterior, mais comumente o ângulo da borda central lateral (LCEA), com valores normais entre 20 e 25°, ou, em alguns estudos mais recentes, 18 a

Palavras-chave

- articulação do quadril
- diagnóstico por imagem
- impacto femoroacetabular
- luxação do quadril
- tomada de decisões

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25°. Quanto a tomada de decisão de tratamento em casos cirúrgicos, há grande debate entre a utilização artroscopia isolada do quadril ou osteotomia periacetabular, tendo em vista que diagnóstico mecânico fundamental (instabilidade versus impacto femoroacetabular) pode ser difícil de determinar nos casos de DDQ limítrofe. Assim, para uma tomada de decisão cirúrgica efetiva, a avaliação de características adicionais da anatomia óssea, instabilidade e características dos pacientes é fundamental.

Introduction

Developmental dysplasia of the hip (DDH) is a significant musculoskeletal condition. Although around 80% of cases are present from birth, such changes often remain without an appropriate diagnosis. Even though most DDH cases are asymptomatic, the condition can cause biomechanical changes in the hip region, potentially predisposing to the development of hip osteoarthritis.[1]

The classification of this condition often relies on the Wiberg lateral center-edge angle (LCEA) values lower than 20°.[2] However, studies show that hips with values between 20 and 25° also present signs of dysplasia but with different imaging, biomechanical, and clinical presentations from established DDH. Thus, we refer to these cases as borderline DDH.

The term "borderline" is somewhat controversial, and its definition in the literature is variable. It is important to note that this term does not indicate that an acetabular deficiency is insignificant but, rather, it recognizes that the primary diagnosis of these hips can fall on either side of the impact and instability spectrum established in the literature.[3,4]

One of the major dilemmas related to borderline DDH is that, unlike the established condition, some patients present structural instability (similar to those with established dysplasia), while other patients present femoroacetabular impingement (FAI) and microinstability.[5,6] Therefore, surgical decision-making in borderline acetabular dysplasia is challenging because of the lack of clinical standards to differentiate hips with significant structural instability from those with FAI and microinstability/no instability.[7]

Therefore, given the relative scarcity and heterogeneity of the literature regarding borderline DDH, this study aimed to perform a literature review to identify the most current concepts regarding diagnosis, classification, treatment, and clinical outcomes of this condition.

Methods

Literature Narrative Review

The article searching and acquisition process relied on a broad literature review in the following databases: Medline (PubMed), OVID, Google Scholar, and Scielo. We created a search strategy for each database to identify articles of interest. Examples of search engines are the following: *borderline hip dysplasia* AND *imaging diagnostic* OR diagnostic OR x-ray OR *magnetic resonance* OR computer tomography or *borderline hip dysplasia* AND *treatment* OR *surgical treatment* OR *hip arthroscopy* OR *periacetabular osteotomy*.

Next, we excluded articles not mentioning hip dysplasia, not written in Portuguese or English, and inaccessible.

Epidemiology

As it is a borderline condition and there are many debates regarding its classification, the actual prevalence of borderline DDH is not yet completely understood, considering that many studies classify hips with this condition as healthy or do not report their values. Identification can use multiple parameters, including LCEA angles ranging from 20 to 25°, Sharp angles higher than 45°, and Tönnis angles higher than 10°.[5,8]

Epidemiology – General Population

Jacobsen et al.[9] studied 3,859 asymptomatic patients and reported that the prevalence of borderline DDH was 19.2%, while only 3.4% of patients had established DDH.

Furthermore, Engesæter et al.,[8] in a prospective study with 2,072 subjects, aged 19-years-old, identified that 16.7% of patients showed signs of borderline DDH and 3.3% had signs of established dysplasia. More recently, a North American study with 2,596 patients collected from a database between 1990 and 1997 to detect the prevalence of osteoarthritis in Johnston County, North Carolina, showed that borderline DDH was around 18.8%.[10]

Freiman et al.[11] did a meta-analysis aiming to identify the general prevalence of borderline DDH. These authors reported a rate of 6.7% asymptomatic patients. Furthermore, they pointed out that this condition occurs 3.5 times more often than classic DDH in the general asymptomatic population. However, in symptomatic populations, this difference decreases to 1.3 times.

Epidemiology – Professional Athlete Population

Kapron et al.[12] analyzed a population of 67 asymptomatic American football players and detected that 19.4% had borderline DDH. A study by the same group with 63 asymptomatic

female athletes, with an average age of 19 years, found that 46% of them had borderline and 20% established DDH.[13] Finally, Harris et al.[14] investigated 47 professionals from a ballet company and found that 51% of them had borderline DDH.

Epidemiology – Symptomatic Population

Regarding the prevalence of borderline DDH in patients with hip pain, Kraeutler et al.[15] studied 341 subjects and diagnosed borderline dysplasia in 14% of them. Matsuda et al.[16] investigated 1,053 patients waiting for hip arthroscopy and identified a prevalence of 12.6%.

Imaging Diagnosis

The establishment of borderline DDH diagnosis requires imaging tests and the measurement of angles associated with dysplasia-related abnormalities. ►**Table 1** compares the values for established and borderline dysplastic hips.

The most frequently used measurement is LCEA (►**Fig. 1A**), which defines the superolateral acetabular coverage of the femoral head. Its measurement requires two lines originating at the center of the femoral head. One line extends superiorly and perpendicular to the transverse axis of the pelvis, and the other passes through the lateral edge of the acetabulum. This last line has a more specific definition to intersect the most superolateral point of the sclerotic weight-bearing zone of the acetabulum (sourcil). Studies indicated that LCEA values lower than 20° indicate established DDH. Although some authors consider values from 18 to 25° as borderline dysplasia, the most used and accepted limits in the literature are 20 to 25°.[4]

Another measurement to assist borderline DDH diagnosis is the Tönnis angle (►**Fig. 1B**). In normal hips, this angle ranges from 0 to 10°, and higher values are common in dysplastic hips. This angle is the caudal-to-cranial inclination of the mid-to-far lateral portion of the acetabular socket with loss of normal lateral acetabular concavity. High Tönnis angle values may indicate borderline DDH, and authors identified a 3-times higher prevalence of these findings in patients with borderline hips compared with healthy subjects. Furthermore, studies showed that patients with hip hypermobility often have higher Tönnis angles, potentially helping surgical decision-making.[17,18]

Table 1 Parameters for diagnosing borderline dysplasia or frank dysplasia

Parameter	Borderline dysplasia	Frank dysplasia
LCEA	20–25°	$< 20°$
Iliofemoral line	15–22%	$> 22\%$
Anterior center-edge angle	20–25°	$< 20°$
Tönnis angle	$> 13°$	$> 13°$
Sharp angle	39–42°	$> 42°$

Abbreviation: LCEA, lateral central-edge angle.

A third measurement of interest is the Sharp angle, measured between a horizontal line drawn at the middle of the bilateral tears (projection of the lower end of the acetabular fossa) and an additional line to the lateral acetabular roof. Studies indicate that Sharp angles between 33 and 38° are normal, while those ranging from 39 to 42° indicate borderline dysplasia, and values above 42° show established dysplasia.[19]

A fourth measurement of interest is the iliofemoral line (IFL). Values ranging from 15 to 22% indicate borderline DDH. For measurement, draw a line extending from the apex of the concavity of the lateral femoral neck to the internal cortical margin of the ilium, as well as a horizontal line from the medial to the lateral portion of the femoral head. Then, check how much the vertical line has advanced over the horizontal line as follows: A = size of the horizontal line from the medial edge of the femoral head to the vertical line, and B = size of the horizontal line from the lateral edge of the femoral head up to the vertical line. Then, calculate $B/(A + B)$. In hips with acetabular overcoverage, the IFL is tangential to the femoral head or may be completely lateral to the femoral head. If lateral coverage is lower or the center of the hip presents a superolateral displacement (as in varying degrees of dysplasia), the IFL increasingly intersects the femoral head.[20]

The femoroepiphyseal acetabular roof (FEAR) index (►**Fig. 1G**) can identify the presence of instability in patients with borderline DDH. To measure it, draw a line over the central portion of the physeal scar and a second line from the medial to the lateral part of the sourcil. An angle inclination in the lateral direction is positive; in this case, values above 5° indicate instability in borderline dysplasia.[4,21]

Another angle potentially important in decision-making is the alpha angle (►**Fig. 1H**). The alpha angle may guide the surgeon regarding the presence of cam deformities if it is higher than 50°; moreover, studies showed that patients with alpha angles above 78° are at a significantly higher risk of developing advanced-stage osteoarthritis.[22,23] The measurement of this angle occurs in the Dunn and Ducroquet view by drawing a circle around the femoral head and calculating its radius.[24] Mark the point where the distance from the femoral head center exceeds the radius of the femoral head. The alpha angle derives from a line connecting the femoral head center to the point where the distance from this center exceeds the radius and the axis of the femoral neck. Higher alpha angle values may indicate a risk of femoral impingement and the presence of cartilage injuries.[4,23,25]

The authors also reported the importance of the femoral neck angle (►**Fig. 1F**). To calculate it, draw a line along the center of the femoral shaft and a second line along the center of the femoral neck. These two lines form the femoral neck angle, with reference values ranging from 125 to 135°.[18]

Another two useful measurements to assess hip morphology and femoral coverage include the anterior and posterior wall indices. To obtain the anterior wall index (AWI), divide the distance between the center of the femoral head and the

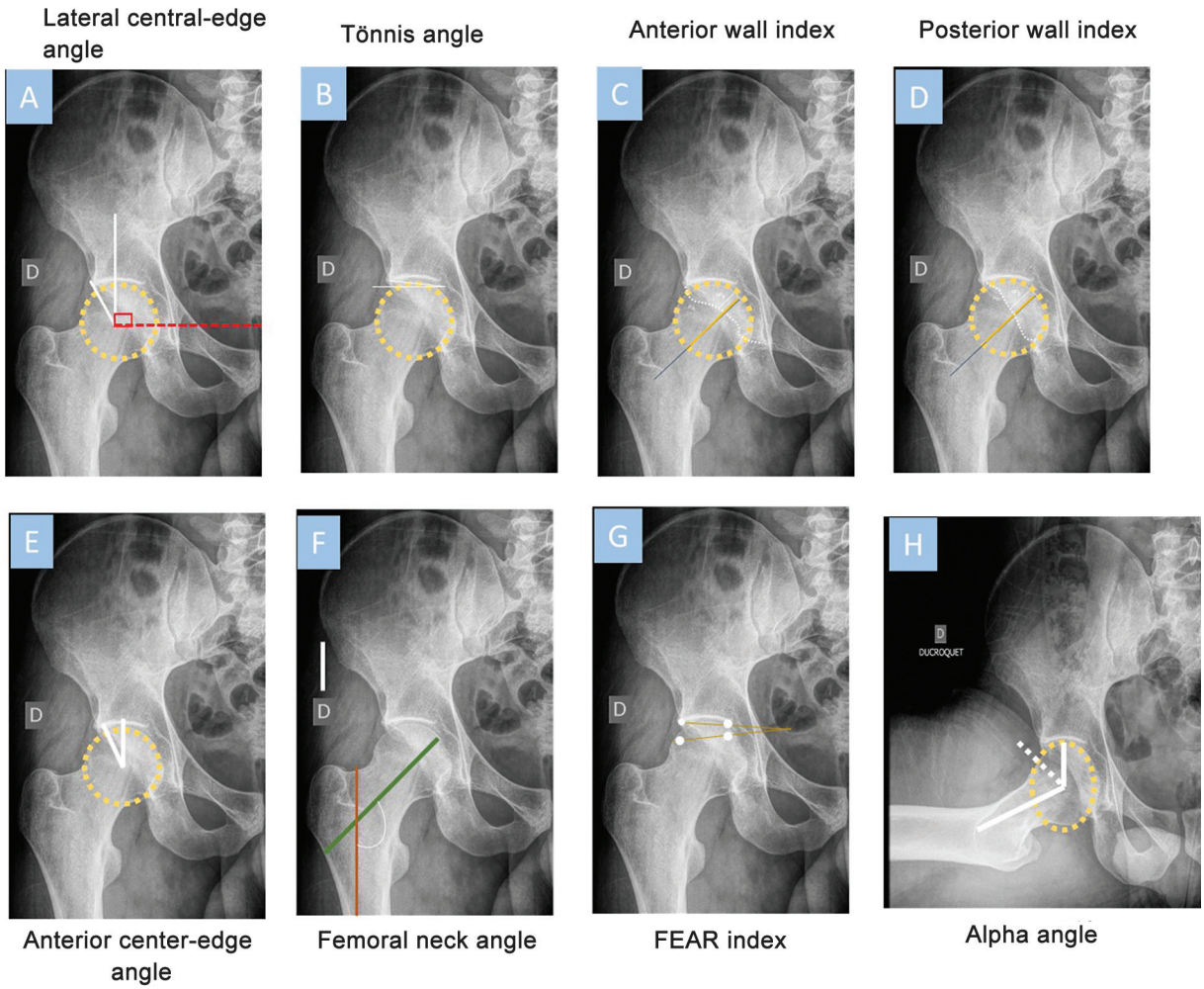


Fig. 1 Radiographic measurements to identify borderline hip dysplasia and secondary factors, including hip coverage and instability.

anterior wall by the femoral head radius (►**Fig. 1C**). Similarly, calculate the posterior wall index (PWI) by dividing the distance from the center of the femoral head to the posterior wall divided by the femoral head radius (►**Fig. 1D**). According to Siebenrock et al.,[26] AWI values lower than 0.30 or PWI values lower than 0.81 may indicate hip dysplasia.

Another measurement to check hip instability is the anterior center-edge angle (►**Fig. 1E**). To calculate it, draw a line from the center of the femoral head to the acetabular sourcil and a line perpendicular to the ground coming from the center of the femoral head.[27] Studies indicate that patients with anterior center-edge angles lower than 20° are more prone to present hip instability.[2]

Dornarcher et al.[28] proposed using three indices plus the LCEA to identify different types of borderline dysplasia, as follows: AWI > 0.30 and PWI > 0.80 (laterally dysplastic hip); AWI < 0.30 and PWI < 0.80 (anterolateral dysplastic hip); and AWI > 0.30 and PWI < 0.80 (posterolateral dysplastic hip).

Magnetic resonance imaging exams can identify labral hypertrophy. In patients with no hip conditions, the labrum is around 7.68 mm, whereas in patients with borderline dysplasia, the labrum is closer to 9.44 mm.[4]

As for computed tomography, it can provide several measurements to identify the presence of borderline DDH and other factors to assist in decision-making.[15]

In axial sections, the acetabular version is the angle between a line perpendicular to the horizontal axis of the posterior acetabulum and a line between the posterior and anterior edges of the acetabulum. This angle usually ranges from 12 to 20°.[29] Studies indicate that values higher than 25° degrees may indicate reduced acetabular coverage and greater instability risk. Low values, indicating acetabular retroversion, may increase the risk of acetabular impact due to excessive anterior acetabular coverage.[15,26,27]

The torsion angle of the femur can identify hip instability. Studies demonstrated that the higher this value, the greater the risk of instability. However, multiple methods can measure this angle; as a result, its reference values vary significantly but those ranging from 7 to 24° are normal.[4,30,31] The study by Han et al.[32] demonstrated that subjects without hip dysplasia had lower femoral torsion values than patients

with hip dysplasia (21.2 vs. 27.5°, $p < 0.05$). Furthermore, these authors pointed out that the higher the Hartofilakidis grade, the higher the femoral torsion (GI: 24, GII: 29, GIII: 39°).

Finally, in their study, Saks et al.[33] reported that patients with borderline DDH most likely are not a single/homogeneous group, but rather several subgroups with distinct characteristics. Their study investigated the difference between male and female patients with borderline DDH, demonstrating that male patients tend to present larger alpha angles (69.7 vs. 58.1°) than female patients. Male patients also had higher rates of labral injury (62.4 vs. 19.3%) and grade 3 and 4 cartilage injuries (50 vs. 30%). Female patients underwent more capsular plication to treat hip instability (78.5 vs. 45.9%) than males. Furthermore, more females presented painful internal pain requiring fractional iliopsoas stretching than males (60 vs. 32.1%). These data demonstrate that although both groups suffer from the same condition, the differences between radiological parameters and surgical findings are so striking that they could form two different pathological entities.[33]

Treatment of Borderline Developmental Dysplasia of the Hip

There is great debate in the literature about the ideal treatment for patients with borderline DDH since the most used procedures (arthroscopy or periacetabular osteotomy) result in effective outcomes. However, in both techniques, some patients present complications and require a new surgical approach.[3]

Swarup et al.[34] studied a retrospective cohort with 33 patients, reporting that the periacetabular osteotomy technique can significantly improve the patient's quality of life and clinical condition in 90% of subjects within one year after the procedure.

Evans et al.,[35] in a retrospective analysis of 17 patients with borderline DDH, paired 1:1 with subjects without hip dysplasia, analyzed the impact of hip arthroscopy. These authors reported both groups achieved significant improvement in clinical outcomes, showing that arthroscopy can be an effective treatment for borderline DDH.

Nawabi et al.[36] presented the 2-year clinical outcomes from 55 cases of borderline DDH treated with arthroscopy and compared with a control group (subjects with hips undergoing arthroscopy, but with LCEA $> 25°$ and $< 40°$). The authors demonstrated that both groups showed significant improvement in the postoperative quality of life questionnaires, with no difference between the improvement of one group over the other, and similar hip movement outcomes. Furthermore, the authors investigated the procedures performed in each group, and the most frequent in patients with borderline DDH was round ligament debridement.

Similarly, Beck et al.[37] performed a retrospective cohort study pairing patients with borderline dysplasia and patients without borderline dysplasia undergoing arthroscopy. The study indicated that both groups showed significant improvement in numerous quality of life questionnaires, significant clinical improvement, and a patient-acceptable symptom state (PASS). Moreover, the study showed that the smaller the alpha angle and the larger the preoperative LCEA, the greater the chance of the patient reaching PASS in 2 years.

Owens et al.,[38] in a paired study with a follow-up period of 5 years, reported that high-level athletes with borderline dysplasia undergoing hip arthroscopy presented clinical outcome improvement and returned to sports similarly to athletes with normal hip coverage.

In a study with 56 patients, Domb et al.[39] analyzed the 10-year clinical outcomes of patients with borderline dysplasia who underwent arthroscopy and capsular plication with labral preservation. The authors revealed that these subjects, on average, had a 76% rate of significant clinical improvement in some quality of life questionnaires and a 10-year arthroplasty-free survival rate of 82%. The study also demonstrated that patients with borderline DDH had a similar clinical evolution to patients with normal coverage undergoing the same procedure. However, the survival rate of patients without dysplasia was 92.4%. At last, the authors reported that in the group with borderline DDH, the factors most associated with the need for conversion to arthroplasty were older age and higher body mass index (BMI).[39]

Beals et al.,[40] in a retrospective cohort study with a minimum follow-up period of 10 years, investigated the clinical outcomes of patients with borderline DDH and FAI. The study demonstrated that patients undergoing arthroscopy showed significant improvement in multiple quality-of-life questionnaires. Additionally, it revealed that the risk factors for conversion to hip arthroplasty were advanced age, presence of advanced chondral lesions, and Tönnis angles higher than 15°.

Several authors investigated the potential risk factors for failed arthroscopies in subjects with borderline dysplasia. Maldonado et al.[41] identified that patients over 35 have a 2.35-fold greater risk of failing capsular plication surgery when compared with patients under 35-years-old. Hatakeyama et al.[42] demonstrated that patients with borderline DDH receiving arthroscopy with labral preservation, capsular plication, and cam osteoplasty had a higher risk of procedure failure if older than 42, with the Shenton line breaking and the Tönnis angles higher than 15°. Maldonado et al.[43] performed a paired study with patients with borderline dysplasia undergoing arthroscopy, revealing that those with an intact/healthy round ligament tended to present better outcomes than patients with round ligament injuries.

A new study by Maldonado et al.[44] investigated the clinical outcomes of patients undergoing revision hip arthroscopy through a second arthroscopy. The authors reported that patients with borderline DDH achieved similar clinical improvements to subjects without dysplasia. Nevertheless, the dysplastic group tended to have a higher risk of requiring a secondary procedure.

McClincy et al.,[25] in a study with 49 patients with borderline DDH, identified that they showed and sustained significant clinical improvement two years after undergoing periacetabular osteotomy. Moreover, these authors revealed that the 2-year survival rate without revision in patients undergoing osteotomy was 94%.

Nepple et al.,[45] presented a retrospective cohort of 178 patients (186 hips) with borderline DDH who underwent periacetabular osteotomy. Their study demonstrated that these patients showed significant clinical improvement in multiple quality of life questionnaires. Furthermore, the authors revealed that patients who underwent previous arthroscopies had worse clinical outcomes in the last follow-up than those without previous procedures. The authors also investigated the impact of adding concomitant osteoplasties or arthroscopies to periacetabular osteotomy, demonstrating that those who received these additional procedures did not present better clinical outcomes in the last follow-up than subjects who did not receive them. Finally, the authors significantly associated the low LCEA angle correction with treatment failures (failure: 6.6°; and success: 11.1°).[45]

Barton et al.,[46] in a systematic review, revealed that patients undergoing hip arthroscopy for borderline DDH treatment had a 7.5% rate of revision arthroscopies, approximately 4% of conversion to arthroplasty, and a 13.7% rate of requiring an overall revision.

In another systematic review of medium- and long-term clinical outcomes in patients with borderline DDH, Lee et al.[47] demonstrated that at least 70% of patients achieved important clinical improvement in one or more quality of life questionnaires. Furthermore, the authors reported that the rate of revision arthroscopies ranged from 0 to 7%, a rate of conversions to hip arthroplasties from 0 to 24%, a medium-term revision-free survival rate of 98.2%, and a long-term survival rate of 76.3%. Finally, the study revealed that a Tönnis grade higher than 2, a Tönnis angle higher than 15°, and an Outerbridge grade IV were the main factors associated with the need for conversion to arthroplasty in this group of patients.[47]

Murata et al.[48] performed a systematic review to compare the outcomes of periacetabular osteotomy and hip arthroscopy in patients with borderline hip dysplasia. The scarcity of literature comparing these techniques hindered their review. However, both procedures resulted in significant clinical improvements and similar complication rates, ranging from 0 to 22%.

Finally, Andronic et al.[49] compared patients with borderline DDH undergoing periacetabular osteotomy or hip arthroscopy matched by age, gender, and radiological data. The study demonstrated that both groups showed significant improvements in clinical outcomes and a similar rate of minimum important clinical difference (MCID) and PASS. The authors demonstrated that patients undergoing periacetabular osteotomy had a higher risk of future surgery than arthroplasty ones (mainly due to implant reaction). Additionally, there was evidence that three patients from their arthroplasty group required revision and underwent periacetabular osteotomy because of persistent pain, and one required a hip arthroplasty. Meanwhile, a single patient from the periacetabular osteotomy group required arthroscopy to treat intra-articular adhesions.[49]

Final Considerations

Borderline DDH generates much debate in the literature regarding its parameters and best approach methods. Therefore, supplementary tests are essential to identify different patterns of presentation, which can help the surgical decision-making process.

Lastly, there is still no consensus regarding the best approach for borderline DDH, with reviews pointing out the lack of clinical differences between arthroscopies and osteotomies.

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

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Closed Reduction and Percutaneous Pinning versus Open Reduction and Internal Fixation in Pediatric Supracondylar Humeral Fractures: A Systematic Review

Redução fechada e fixação percutânea versus redução aberta e fixação interna em fraturas pediátricas supracondilares do úmero: Uma revisão sistemática

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Abstract

Objective To compare the treatment approaches of closed reduction and percutaneous pinning (CRPP) and open reduction and internal fixation (ORIF) in pediatric supracondylar humeral fractures through a systematic review of cohort and case-control studies.

Methods The CRPP and ORIF treatment modalities were evaluated using Flynn's functional criteria and Baumann angle as outcome measures.

Results The results support the clinical equivalence of CRPP ORIF regarding functional outcomes. Despite the limited number of studies and the low level of evidence of the included articles, the present study consistently reported no significant differences, which is in line with the overall results. Limited Baumann Angle data prevented conclusive comparisons in this regard. Factors such as length of hospital stay and cosmetic outcomes influence treatment decisions in pediatric supracondylar humerus fractures. A holistic approach is essential, considering clinical efficacy and patient comfort. Future research should expand the evidence base and standardize outcome assessments.

Conclusion Both CRPP and ORIF are viable treatments for pediatric supracondylar humerus fractures, particularly those classified as Gartland type III.

Keywords
- bone nails
- bone wires
- elbow joint
- humeral fractures, distal
- meta-analysis

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Resumo

Objetivo Comparar as abordagens terapêuticas de redução fechada com fixação percutânea (*closed reduction and percutaneous pinning*, CRPP, em inglês) e redução aberta com fixação interna (*open reduction and internal fixation*, ORIF, em inglês) em fraturas supracondilares do úmero em pacientes pediátricos por meio de uma revisão sistemática de estudos de coorte e caso-controle.

Métodos As modalidades de tratamento CRPP e ORIF foram avaliadas usando os critérios funcionais de Flynn e o ângulo de Baumann como medidas de desfechos.

Resultados Os resultados deste estudo apoiam a equivalência clínica da CRPP e da ORIF em relação aos desfechos funcionais. Apesar do número limitado de estudos e do baixo nível de evidência dos artigos incluídos, este estudo não relatou diferenças significativas, o que condiz com os resultados gerais. Dados limitados sobre o ângulo de Baumann impediram comparações conclusivas a este respeito. Fatores como duração da internação hospitalar e resultados estéticos influenciaram as decisões de tratamento em fraturas supracondilares do úmero em pacientes pediátricos. Uma abordagem holística é essencial, considerando tanto a eficácia clínica quanto o conforto do paciente. Pesquisas futuras devem expandir a base de evidências e padronizar as avaliações de desfechos.

Conclusão A CRPP e a ORIF são tratamentos viáveis para fraturas supracondilares do úmero em pacientes pediátricos, particularmente as classificadas como tipo III de Gartland.

Palavras-chave

- articulação do cotovelo
- fios ortopédicos
- fraturas distais do úmero
- metanálise
- pinos ortopédicos

Introduction

Supracondylar humerus fractures represent a common and clinically-significant pediatric orthopedic injury; however, ita incidence has increased in the last decades, accounting for 3% to 15% of all fractures in children. Moreover, it is the fracture that most requires surgical treatment in the pediatric population.[1,2] These fractures typically occur in children aged between 5 and 7 years, and they result from accidents such as falls on an outstretched hand.[3,4] Given the unique anatomical characteristics of pediatric bone and the potential for complications, selecting the most appropriate treatment strategy is paramount to achieve favorable outcomes.

The choice between two primary surgical techniques, closed reduction and percutaneous pinning (CRPP) and open reduction and internal fixation (ORIF), has long been a subject of debate and clinical interest. Several Brazilian authors prefer various methods of CRPP, which involves the reduction of fractured bone fragments without the need for a large incision as an advantage, followed by the insertion of percutaneous pins to maintain alignment.[1,5,6] In contrast, ORIF requires open exposure of the fracture site (a disadvantage), direct visualization, and fixation with screws or plates. Nevertheless, ORIF offers the advantage of precise anatomical reduction and potentially stronger fixation, but it comes with the drawbacks of increased surgical morbidity and extended hospitalization.[7]

The decision-making process regarding the optimal treatment approach for pediatric supracondylar humerus fractures is multifaceted. It requires a comprehensive assessment of patient-specific factors, fracture characteristics, and the available evidence. Moreover, the selection of appropriate outcome measures to evaluate treatment success plays a crucial role in guiding clinical decisions.[8] Among these outcome measures, two primary parameters stand out as central to the assessment of treatment efficacy: Flynn's functional criteria and the Baumann angle.[8,9]

Flynn's functional criteria provide a comprehensive evaluation of functional recovery, encompassing factors such as pain, range of motion, and strength. These criteria are particularly relevant for pediatric patients, as they reflect the restoration of elbow function, which is essential for activities of daily living and overall quality of life.[10] And the Baumann angle is a radiological measure used to assess the anatomical alignment of the elbow joint postfracture. Proper anatomical alignment is essential to minimize long-term complications, such as cubitus varus or valgus deformities.[11]

While previous research has attempted to address the CRPP versus ORIF debate, inconsistencies in study designs, patient populations, and outcome measures have contributed to a lack of consensus in the field. Therefore, conducting a systematic review and meta-analysis to synthesize the existing evidence, with a specific focus on Flynn's functional criteria and the Baumann angle, is crucial. The present study aims to provide a comprehensive overview of the comparative effectiveness of CRPP and ORIF in the management of pediatric supracondylar humerus fractures. By consolidating the available data, we aim to inform clinical decision-making and contribute to the optimization of care for this prevalent and clinically-significant pediatric orthopedic condition.

Materials and Methods

Trial Registration

The current study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) on February 14, 2024 (registration number: CRD42024506147; available from: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=506147)

The present review employed a meta-analytic approach and adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, which encompass preparation, execution, and reporting stages.

Search Strategy

We conducted a comprehensive literature search in electronic databases (PubMed/MEDLINE, ProQuest, and Cochrane Library) to identify qualified studies published between 2013 and 2013. Search terms were combined using the OR operator and linked with the AND operator. The initial search included terms such as *supracondylar humerus fractures*, *CRPP*, and *ORIF*. The subsequent search included terms such as *pediatric*, *operative*, *Flynn's criteria*, and *Baumann angle*. We also expanded the research by reviewing references, reviews, and meta-analyses; after that, we conducted a Google Scholar search to explore the citations. Then, two of the authors (MAM and FF) also screened the reference lists of the eligible articles for more potential papers. After removing duplicates, the titles and abstracts of the studies were evaluated against predetermined inclusion/exclusion criteria. Discrepancies were resolved through discussion with a third reviewer (NGGNU).

Selection Criteria

The study focused on children with radiographically-confirmed supracondyle fractures who had undergone either ORIF or CRPP. The inclusion criteria were clinical trials conducted between 2013 and 2023 that compared ORIF and CRPP in children under 18 years of age with supracondylar humeral fractures. These trials were required to include original data on various factors such as operative time, infection, avascular necrosis, and non-union. The exclusion criteria were cases of supracondylar humeral fractures combined with other fractures, pathological fractures, as well as case reports, cadaver or model studies, and biomechanical studies. One of the authors (FF) also excluded all review studies.

Risk of Bias Assessment

Two of the authors (MAM and FF) followed established methods using the Risk of Bias in Non-Randomized Studies – of Interventions[12] (ROBINS-I) tool to assess the risk of bias due to confounding factors, selection of participants or animals used in the study, classification of interventions, missing data, measurement of outcomes, and selection of the reported results. The tool also considers the management of incomplete outcome data, selective reporting of outcomes, and it also spots other potential biases.

For each area examined, the authors classified the risk of bias as "low," "high," or "unclear," based on the available information. "Low" means there is a minimal chance that bias could affect the study's results; "high" suggests a significant chance of bias influencing the findings; and "unclear" indicates that there is not enough information to decide the level of risk of bias.[13] The authors used this approach to comprehensively assess the quality of the reviewed studies, enhancing the analyses and research conclusions by ensuring the consistent and transparent application of the ROBINS-I tool.

Data Extraction

Two of the authors (MAM and FF) meticulously extracted pertinent data from the included articles, referencing the full-text versions. Data extraction for the current study involved a systematic approach. Pertinent data was meticulously collected from the included articles. This encompassed key characteristics of the study population, including age distribution, gender ratio (male:female), the total number of subjects, and the duration of follow-up (in months). Additionally, the Gartland classification of the patients submitted to CRPP and ORIF was extracted to assess injury severity and treatment approaches.

Regarding the outcome measures of the studies included, the authors extracted data related to Flynn's criteria, specifically evaluating the satisfactory outcomes for CRPP and ORIF. The Baumann angle, a critical indicator in the assessment of fracture reduction, was also recorded for both treatment groups. Furthermore, *p*-values were extracted to quantify the statistical significance of the differences observed between CRPP and ORIF outcomes. This meticulous data extraction process facilitated a comprehensive analysis of the study's findings and contributed to the study's overall robustness. Subsequently, the articles selected were managed using the Review Manager (RevMan, The Cochrane Collaboration, London, United Kingdom) software, version 5.4.

Results

The initial literature search yielded 52 studies that could be suitable for assessment. Following a comprehensive review of titles and abstracts, 28 of these studies were excluded. Subsequently, the full-text versions of the remaining 24 studies were obtained; out of these, 18 were later disqualified. In the end, 6 studies,[14–19] involving a total of 405 subjects, satisfied the inclusion criteria for the present systematic review (►**Fig. 1**).

The authors gathered data from the selected studies to compare the functional outcomes of supracondylar humerus fractures in children after CRPP or ORIF. These studies were categorized by their level of evidence (►**Table 1**); most were cohort studies,[15–19] and only one was a case-control study.[14]

The authors assessed the bias in the selected studies using the ROBINS-I tool. The method to generate random sequences was well described and presented minimal bias risk, while allocation concealment was thoroughly explained and presented a low bias risk. Blinding of the participants and

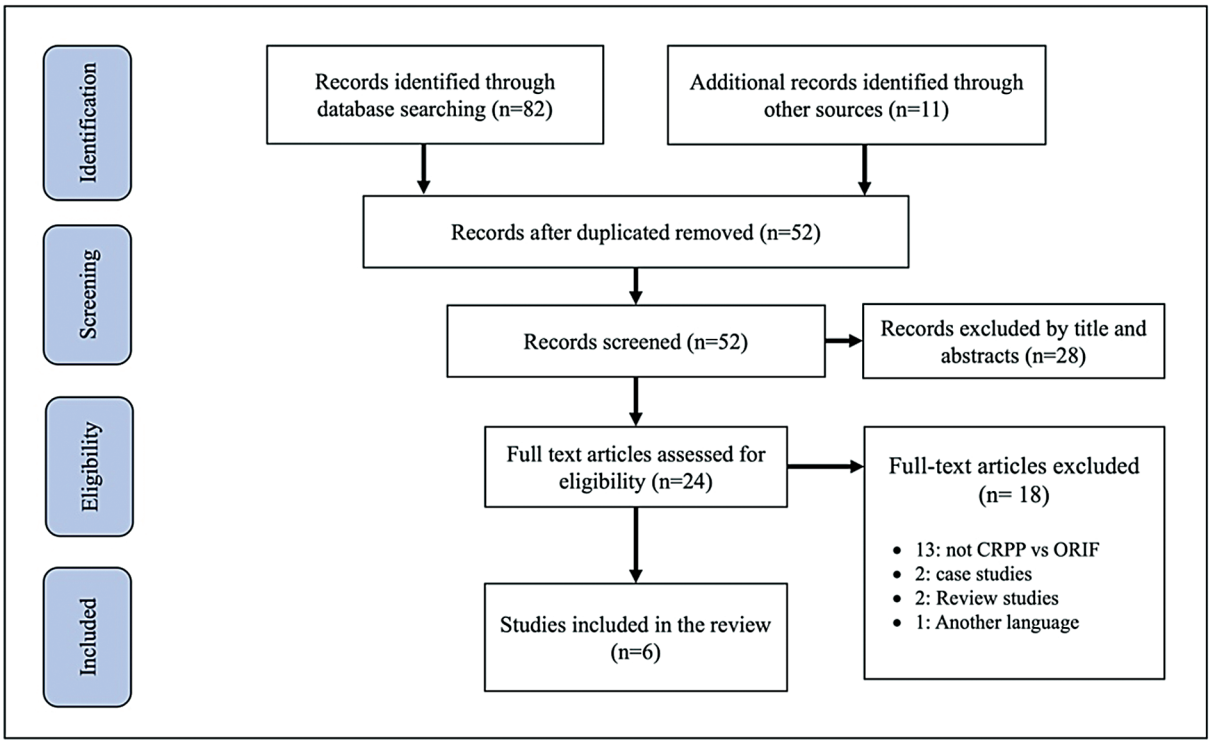


Fig. 1 Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) flow diagram.

personnel was not possible due to the nature of the intervention, leading to a higher bias risk. However, the outcome assessors remained unaware of the treatments, resulting in a low bias risk. Low dropout rates and reporting prespecified outcomes without selective reporting signs maintained the low bias risk. No additional bias sources were found, resulting in a low risk of bias in other areas. Overall, the current study presented a low bias risk, except for the blinding of the participants and personnel due to the intervention's nature (►**Table 2**).

►**Table 1** summarizes key characteristics from the selected studies involving a total of 405 patients. Tomori et al.[14] (2018) divided 34 patients into CRPP and ORIF groups, with follow-up durations of around 5.4 and 5.3 months respectively. Gartland classifications revealed differences between the groups. Abousaleh et al.[15] (2022) enrolled 60 patients in these groups, with CRPP having a shorter mean follow-up, of 5.21 months, and a balanced gender distribution. Ayub et al.[16] (2021) studied 60 patients in each group for 6 months, observing differences in Gartland classifications. Dučić et al.[17] (2016) included 71 patients in the same groups, with similar follow-up durations and varied Gartland classifications. Hossain et al.[18] (2023) examined 80 patients with varying follow-up durations, focusing on type-III fractures. Keskin and Sen.[19] (2014) studied 100 patients but did not report age and gender data, with the CRPP group followed up for 7.04 months. These studies collectively provide insights into treatment approaches and patient characteristics in this context.

►**Table 1** summarizes the outcomes of the treatment of several pediatric supracondylar humerus fractures in the studies[14–19] using Flynn's criteria and Baumann angle measurements. The CRPP and ORIF procedures generally resulted in high rates of satisfactory outcomes based on Flynn's criteria. Baumann angle measurements were comparable between the two methods across most studies, without statistically significant differences. This suggests the effectiveness of both approaches for pediatric supracondylar humerus fractures. However, variations in factors such as age, sex distribution, sample size, and follow-up duration among the studies should be considered when interpreting the results.

The forest plot analysis of Flynn's functional criteria in ►**Fig. 2** suggests that there was no statistically significant difference in functional outcome between CRPP and ORIF for supracondylar humerus fractures in children. The pooled effect estimates, represented by the diamond-shaped marker, are located to the left of the line of no effect, indicating a slightly higher proportion of satisfactory outcomes in the CRPP group. However, the confidence interval for the pooled effect includes the line of no effect, indicating that the difference is not statistically significant.

Flynn's functional criteria were used as one of the primary outcome measures. ►**Fig. 3** shows that there was no statistically significant difference in terms of the Baumann angle between CRPP and ORIF ($p > 0.05$). This suggests that both treatment approaches are viable options for supracondylar humerus fractures in children, particularly in cases of Gartland type-III fractures. The Baumann angle was also considered as a primary outcome measure. However, the limited data availability (only two studies) on the Baumann angle precluded a conclusive comparison. Therefore, no definitive conclusions regarding this measure can be drawn. Therefore, both CRPP and ORIF can be considered viable treatment options for these fractures in children.

Table 1 Summary of the data of the included studies

No.	Study	Journal	Study design/ level of evidence	Mean age (years)		Sex (M:F)		Number of Subjects	Mean follow-up duration (months)		Gartland classification		Flynn's criteria (satisfactory)			Mean Baumann angle	
				CRPP	ORIF	CRPP	ORIF		CRPP	ORIF	CRPP	ORIF	CRPP	ORIF	*p*-value	CRPP	ORIF
1	Tomori et al., 2018[14]	*Medicine* (Baltimore)	Case-control/IV	5.4 ± 3.5	5.3 ± 2.1	10:11	6:7	CRPP: 21; ORIF: 13	7.9 ± 5.7	10.2 ± 5.3	II: 12 ; III: 9	II: 4 ; III: 9	20 (95.2%)	13 (100%)	0.83	74.9 ± 6.2	69.8 ± 3.7
2	Abousaleh et al., 2022[15]	*Cureus*	Retrospective cohort/III	5.21 ± 2.17	6.69 ± 4.08	14:14	1.9:1	CRPP: 28; ORIF: 32	3.64 ± 2.61	8.13 ± 11.16	–	–	26 (92.8%)	32 (100%)	0.214	68.02 ± 9.83	70.75 ± 7.17
3	Ayub et al., 2021[16]	*Journal of Pakistan Orthopaedic Association*	Retrospective cohort/III	6 ± 1.1	6.9 ± 3.83	21:9	18:12	CRPP: 30; ORIF: 30	12	12	III: 30	III: 30	30 (100%)	23 (76.6%)	<0.05	–	–
4	Dučić et al., 2016[17]	*Serbian Archives of Medicine*	Cohort/III	6.7 + 1.7	6.8 + 2	29:8	23:11	CRPP: 37; ORIF: 34	–	–	II: 13 ; IV: 24	II: 17 ; III: 17	37 (100%)	31 (91.1%)	0.02	–	–
5	Hossain et al., 2023[18]	*Saudi Journal of Medical and Pharmaceutical Sciences*	Cohort/III	6.5	5.9	29:14	26:11	CRPP: 43; ORIF:37	32.9 ± 12.5	29.5 ± 10.75	III: 43	III: 43	42 (97.6%)	36 (97.2%)	>0.05	–	–
6	Keskin and Sen, 2014[19]	*Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca*	Cohort/II	7.04		69: 31		CRPP: 50; ORIF:50	49.2 ± 20.5	14.12 ± 12.75	–	–	47 (94%)	45 (90%)	0.774	–	–

Abbreviations: CRPP, closed reduction and percutaneous pinning; F, female; M, male; ORIF, open reduction and internal fixation.

Table 2 Risk of bias in the included studies

Study	Random sequence generation	Allocation concealment	Binding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Other source of bias
Tomori et al., 2018[14]	Low	Low	High	Low	Low	Low	Low
Abousaleh et al., 2022[15]	Low	Low	High	Low	Low	Low	Low
Ayub et al., 2021[16]	Low	Low	High	Low	Low	Low	Low
Dučić et al., 2016[17]	Low	Low	High	Low	Low	Low	Low
Hossain et al., 2023[18]	Low	Low	High	Low	Low	Low	Low
Keskin and Sen, 2014[19]	Low	Low	High	Low	Low	Low	Low

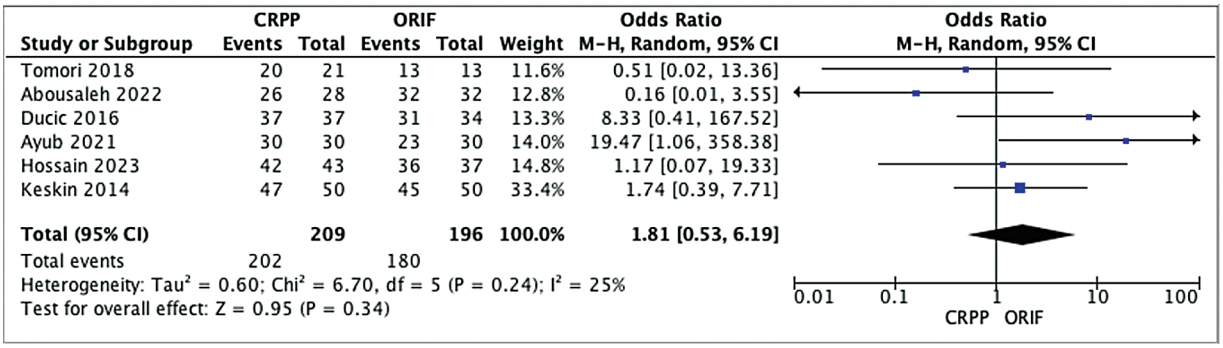


Fig. 2 Forest plot analysis Flynn's functional criteria.

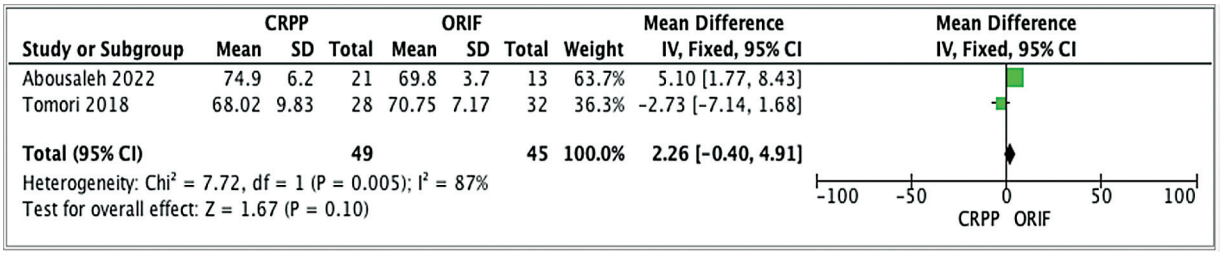


Fig. 3 Forest plot analysis of the Baumann angle.

Discussion

Supracondylar humerus fractures pose a substantial challenge in pediatric orthopedics, demanding a nuanced approach for optimal patient outcomes. The choice between CRPP and ORIF has long been a subject of debate within the field. In this discussion, we will delve deeper into our analysis, focusing on Flynn's functional criteria while also considering Baumann angle measurements (►**Figs. 2**–**3**) provided by individual studies to offer a more comprehensive understanding of the comparative efficacy of these treatments.[20,21]

Our analysis revealed no statistically significant difference in the outcomes according to Flynn's functional criteria between CRPP and ORIF for supracondylar humerus fractures in children ($p > 0.05$). The findings suggest that both treatments offer comparable functional recovery, rendering them viable options, particularly for Gartland type-III fractures. The forest plot analysis visually reinforces this finding, with the pooled effect estimate slightly favoring CRPP, but within a confidence interval encompassing the line of no effect. The consistency of these results across multiple studies underscores the clinical equipoise between CRPP and ORIF concerning functional outcomes. Zhu et al.[1] reported no statistical difference in clinical outcomes between CRPP and ORIF for supracondylar fractures ($p > 0.05$). Furthermore, ►**Figs. 2**–**3** shed light on patient demographics and characteristics within each treatment group. These data underscore the diversity of our dataset, with variations in patient age, follow-up duration, and the distribution of the fractures according ot the Gartland classification. Despite these variations, the individual studies consistently report no significant disparities in functional outcomes between CRPP and ORIF, aligning harmoniously with the overall meta-analysis results.

While the Baumann angle serves as a critical radiological parameter to assess the anatomical alignment of the elbow, the limited data available on it (only two studies,[14,15]) in the present meta-analysis hinders us from drawing definitive conclusions regarding the comparative effectiveness of CRPP and ORIF based on this parameter. Acknowledging the constraints imposed by the limited data on the Baumann angle is essential, emphasizing the need for future research with larger samples to comprehensively address this gap.

The lack of significant differences in functional outcomes between CRPP and ORIF can be attributed to several key factors, such as careful patient selection, standardized outcome assessment, surgical expertise, postoperative care, and advancements in surgical techniques.[22,23] By focusing on a relatively-homogenous group of patients with type-III fractures and employing Flynn's functional criteria as a standardized assessment tool, most of the selected studies minimized potential confounding variables and measurement bias. Additionally, the surgical teams' proficiency in both techniques likely contributed to the consistent positive outcomes in the two treatment groups.[24,25] Advances in surgical instruments, imaging, and perioperative care further improved the functional outcomes.

Besides Flynn's functional criteria and the Baumann angle, other factors warrant consideration when making treatment decisions in pediatric supracondylar humerus fractures, as seen in ►**Figs. 2**–**3**. Notably, the length of hospital stay and cosmetic outcomes are aspects that can significantly influence the overall patient experience. A minimally invasive

procedure, CRPP often results in shorter hospital stays than the more extensive ORIF procedure. Additionally, the limited surgical exposure and smaller incisions in CRPP may contribute to potentially superior cosmetic outcomes, a crucial consideration in the pediatric patient population.[25–27]

In the current clinical practice, these findings empower clinicians to make treatment decisions based on individual patient characteristics and preferences. Younger children with less severe fractures may benefit from CRPP's minimally-invasive nature and shorter hospitalization, while ORIF may be preferred for cases requiring precise anatomical reduction or stronger fixation. This patient-centered approach reflects the evolving landscape of the pediatric orthopedic practice, ensuring tailored care optimizes patient outcomes and overall well-being while considering unique circumstances.

The current study presents several limitations. Firstly, the low quality of the bias of the study, which may have affected the reliability of the results. Moreover, the small number of studies included in the meta-analysis limits the statistical power to detect meaningful differences and increases the likelihood of publication bias. This restricted sample size may have led to an overestimation or underestimation of effect sizes, particularly in the presence of selective reporting or small-study effects. Further high-quality, large-scale randomized controlled trials are needed to validate these findings and provide more definitive evidence on the subject.

Conclusion

Both CRPP and ORIF are viable treatments for pediatric supracondylar humerus fractures, particularly those classified as Gartland type-III, but further research is needed to address Baumann angle data, standardize outcome assessments, and guide treatment decisions based on functional, radiological, and cosmetic outcomes.

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

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Methodological Quality of Systematic Reviews on Platelet-Rich Plasma Therapy for Osteoarthritis: A Meta-Research Study

Qualidade metodológica das revisões sistemáticas sobre o tratamento de osteoartrite com plasma rico em plaquetas: Um estudo de metapesquisa

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Abstract

Objective To assess the methodological quality of systematic reviews on the benefits and disadvantages of platelet-rich plasma (PRP) to treat osteoarthritis.

Methods We conducted a comprehensive literature search, and the methodological quality of the included reviews was assessed using the tool A Measurement Tool to Assess Systematic Reviews, Version 2 (AMSTAR-2). In addition, the assessment of the certainty of evidence using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was investigated. A total of 31 systematic reviews met the inclusion criteria.

Results Almost 84% of the articles received an overall rating of critically-low quality, and 16.1%, of low quality. The methodological criteria most frequently reported in an inadequate manner were related to search strategies, with 77.3% of "no" or "partially yes" responses, and the reasons to exclude studies, which were not described in 100% of the reviews. Furthermore, 42% did not mention the registration of their protocols, 13% did not use the appropriate methodological quality tool to assess the risk of bias of the included clinical trials, 45.2% did not consider the risk of bias in the discussion of the results, and 32.26% did not report or planned to report publication bias. The GRADE approach was only used in 19.3% of the reviews.

Keywords
- osteoarthritis
- platelet-rich plasma
- systematic review

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Conclusion Despite the high number of systematic reviews on PRP for osteoarthritis, in the present meta-research study, we identified that most are not conducted adequately, presenting methodological flaws that may affect the reliability of clinical findings.

Resumo

Objetivo Avaliar a qualidade metodológica das revisões sistemáticas acerca dos benefícios e malefícios do plasma rico em plaquetas (PRP) no tratamento da osteoartrite.

Métodos Realizou-se uma busca abrangente na literatura, e a qualidade metodológica das revisões incluídas foi avaliada usando a ferramenta A Measurement Tool to Assess Systematic Reviews, Version 2 (AMSTAR-2). Além disso, a avaliação da certeza da evidência usando a abordagem Grading of Recommendations Assessment, Development, and Evaluation (GRADE) foi investigada. Ao todo, 31 revisões sistemáticas atenderam aos critérios de inclusão.

Resultados A classificação geral de qualidade foi criticamente baixa em quase 84% dos artigos, e baixa em 16,1%. Os critérios metodológicos relatados de forma inadequada com mais frequência estavam relacionados às estratégias de busca, com 77,3% das respostas "não" ou "parcialmente sim", e os motivos para a exclusão de estudos, que não foram descritos em 100% das revisões. Além disso, 42% não mencionaram o cadastro de seus protocolos, 13% não usaram a ferramenta de qualidade metodológica apropriada para a avaliação do risco de viés dos estudos clínicos incluídos, 45,2% não consideraram o risco de viés na discussão dos resultados, e 32,26% não relataram ou planejaram relatar o viés de publicação. A abordagem GRADE somente foi usada em 19,3% das revisões.

Conclusão Apesar do alto número de revisões sistemáticas sobre o tratamento de osteoartrite com PRP, neste estudo de metapesquisa, identificou-se que a maioria não é conduzida adequadamente, e apresenta falhas metodológicas que podem afetar a confiabilidade dos achados clínicos.

Palavras-chave
- osteoartrite
- plasma rico em plaquetas
- revisão sistemática

Introduction

Health interventions often gain popularity and become the focus of widespread scientific investigation. This is often the ideal scenario for the proliferation of evidence syntheses derived from the results of the numerous clinical trials published on the efficacy and safety of these interventions. A notable example is platelet-rich plasma (PRP) therapy,[1] which involves injecting a solution with a high concentration of an individual's platelets, which is considered promising due to its potential to release growth factors, cytokines, and various substances that induce analgesia, anti-inflammatory, and tissue anabolic effects at the site of application, resulting in a possible renewal of damaged tissue.[2–4] In addition, it is a minimally-invasive and easily-accessible technique which has received significant attention in recent years due to the potential benefit of adjuvant treatment for various clinical conditions. In particular, the growing interest in the use of PRP in the treatment of osteoarthritis is highlighted by the importance of synovial inflammation in the pathophysiology and its high prevalence worldwide.[4,5]

Given the significant increase in scientific publications on this topic, as expected, the number of systematic reviews on the effects of PRP for osteoarthritis has increased progressively in the last ten years, resulting in a mass of evidence synthesis that often disregards methodological standards and recommendations, compromising the results.[6,7] Given this scenario, meta-research studies emerge as an important tool to establish a connection between good science and its applicability in the clinical practice.[8,9] By gathering and evaluating methodological appropriateness in planning, conducting, and reporting different study designs, meta-research provide information about how common and harmful are certain biases to a research field.[10] In addition to identifying methodological flaws produced and reproduced in the numerous systematic reviews on PRP for osteoarthritis, a meta-research study can direct future efforts toward developing more pertinent and high-quality reviews in this field, increasing the transparency and reproducibility of their findings.[11,12]

Thus, the current meta-research study aimed to evaluate the methodological quality of systematic reviews on the benefits and disadvantages of PRP compared to placebo, to other interventions, or to no intervention in the treatment of patients with osteoarthritis.

Materials and Methods

The present study followed the methodological guidance recommended for meta-research studies.[13] To improve reporting quality, the relevant items from the Preferred

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[14] were used. The study protocol was registered on the Open Science Framework (available at: https://doi.org/10.17605/OSF.IO/NZXT9).

Criteria to Include Systematic Reviews

Studies identified as systematic reviews on the effects of PRP in the treatment of any type of osteoarthritis were eligible for inclusion. Only those explicitly labelled as "systematic reviews" were considered, while review protocols and systematic reviews incorporating observational study designs were excluded. Additionally, systematic reviews available only as abstracts or in incomplete formats were excluded.

Information Sources

To identify eligible systematic reviews, we conducted a comprehensive search on January 31, 2024, on the following electronic databases: Medical Literature Analysis and Retrieval System Online (MEDLINE, via Pubmed), The Cochrane Library (Cochrane Database of Systematic Reviews, CDSR), Excerpta Medica Database (Embase, via Elsevier), and Epistemonikos. No restrictions on publication date or language were applied. The detailed search strategies are presented in ►**Table 1**.

Study Selection

A pair of reviewers (MEO and MLA) analyzed the title and abstract of the references obtained with the search strategy. This initial screening was performed through the Rayyan (Qatar Computing Research Institute, Doha, Qatar) application,[15] which enabled the evaluation process to occur independently. After that first stage, the full text of the studies classified as potentially included was thoroughly examined. Any conflicts in both stages were resolved through a third reviewer. The excluded studies were recorded in the table of excluded studies, accompanied by the respective reasons for exclusion (►**Table 2**). Two independent reviewers used a pre-established data extraction form to collect data from the included studies. Following this process, a third reviewer (ALCM) resolved potential inconsistencies.

Data Extraction

For eligible systematic reviews, we extracted the following information: year of publication, number of included studies, aspects of the intervention and comparators, review protocol, tool used to assess methodological quality, outcomes, if meta-analyses were conducted, and funding sources. The authors evaluated several systematic reviews that assessed the certainty of the body of the evidence using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach[16] and the adequacy of the protocol registration regarding selective reporting bias.

Methodological Quality Evaluation of the Included Studies

We used A Measurement Tool to Assess Systematic Reviews, Version 2 (AMSTAR-2) tool[17] to critically assess the methodological quality of the systematic reviews. The tool has 16 items, and after an overall assessment of the systematic reviews, the study was categorized into four quality levels: critically-low, low, moderate, and high, depending on the weaknesses detected in critical and non-critical items. Two independent reviewers (KMMS and MES) conducted the AMSTAR-2 assessment; a third reviewer (EMS) was consulted in case of disagreements.

Synthesis of the Results

The methodological characteristics of the included systematic reviews were tabulated and summarized descriptively using a Microsoft Excel (Microsoft Corp., Redmond, WA, United States) spreadsheet. Data were expressed as absolute and relative frequencies.

Results

Search Results

With the search strategies, we initially retrieved 485 references. After eliminating 166 duplicates, 319 references underwent title and abstract screening. Thus, 31 systematic reviews met the eligibility criteria and were included in the present meta-research study (►**Fig. 1**).

Baseline Characteristics

►**Table 3** presents the detailed characteristics of the included systematic reviews, which assessed between 3 and 40 randomized clinical trials (RCTs) on the effects of PRP compared to placebo or other therapies. These reviews were published from 2015 to 2023, with the highest number of study publications in 2020.[18–24]

Almost half of the reviews registered their protocol on the International Prospective Register of Systematic Reviews (PROSPERO), although two did not report the registration number. Meta-analyses were conducted in 87% (27/31) of the reviews. The RCT methodological quality tool most used was the Cochrane Risk of Bias Tool (RoB) (68%; 21/31). Regarding financial support, 80.64% (25/31) of the included reviews stated that there were no funding sources nor conflicts of interest.

Methodological Quality of the Included Systematic Reviews

In the assessment of methodological quality using the AMSTAR-2 tool, 83.8% (26/31) of the systematic reviews were classified as having critically-low quality, followed by 16.13% (5/31) classified as low quality. Details of this assessment are presented in ►**Table 4**, and ►**Fig. 2** shows the frequency of adherence to each AMSTAR-2 item.

The current study revealed a significant increase in the number of systematic reviews over the years, with most exhibiting critically-low quality, except for 2017 (►**Fig. 3**).

Among the critical items assessed in the AMSTAR-2, items 4 and 7 emerged as particularly significant in the present evaluation:

- Item 4: 48.3% (15/31) received a "no" response, and 29% (9/31) received a "partially yes" response regarding the

Table 1 Search strategies

Database	Search strategies	Results
Medical Literature Analysis and Retrieval System Online (MEDLINE, via Pubmed)	#1 "Osteoarthritis" [Mesh] OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses #2 "Platelet-Rich Plasma" [Mesh] OR (Plasma, Platelet-Rich) OR (Platelet Rich Plasma) OR PRP #3 systematic[sb] #4 #1 AND #2 AND #3	221
The Cochrane Library (Cochrane Database of Systematic Reviews, CDSR)	#1 MeSH descriptor: [Osteoarthritis] explode all trees #2 Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses #3 MeSH descriptor: [Platelet-Rich Plasma] explode all trees #4 (Plasma, Platelet-Rich) OR (Platelet Rich Plasma) OR PRP #5 #1 OR #2 #6 #3 OR #4 #7 #5 AND #6 In Cochrane Reviews	7
Excerpta Medica Database (Embase, via Elsevier)	#1 'osteoarthritis'/exp OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR 'Arthritis, Degenerative' OR 'Arthritides, Degenerative' OR 'Degenerative Arthritides' OR 'Degenerative Arthritis' OR Arthrosis OR Arthroses #2 'platelet-rich plasma cell'/exp OR 'Plasma, Platelet-Rich' OR 'Platelet Rich Plasma' OR PRP #3 ('systematic review' OR 'meta-analysis') AND [review]/lim OR 'meta analysis'/exp OR 'meta analysis' OR 'systematic review'/exp OR 'systematic review' OR 'systematic review (topic)'/exp OR 'systematic review (topic)' OR 'meta analysis (topic)'/exp OR 'meta analysis (topic)' OR 'biomedical technology assessment'/exp OR 'biomedical technology assessment' OR 'network meta-analysis'/exp OR 'network meta-analysis' OR ((systematic* NEAR/3 (review* OR overview*)):ti,ab,kw) OR ((methodologic* NEAR/3 (review* OR overview*)):ti,ab,kw) OR ((quantitative NEAR/3 (review* OR overview* OR synthes*)):ti,ab,kw) OR ((research NEAR/3 (integrati* OR overview*)):ti,ab,kw) OR ((integrative NEAR/3 (review* OR overview*)):ti,ab,kw) OR ((collaborative NEAR/3 (review* OR overview*)):ti,ab,kw) OR ((pool* NEAR/3 analy*):ti,ab,kw) OR 'data synthes*':ti,ab,kw OR 'data extraction*':ti,ab,kw OR 'data abstraction*':ti,ab,kw OR 'handsearch*':ti,ab,kw OR 'hand search*':ti,ab,kw OR 'mantel haenszel':ti,ab,kw OR 'peto':ti,ab,kw OR 'der simonian':ti,ab,kw OR 'dersimonian':ti,ab,kw OR 'fixed effect*':ti,ab,kw OR 'latin square*':ti,ab,kw OR 'met analy*':ti,ab,kw OR 'metanaly*':ti,ab,kw OR 'technology assessment*':ti,ab,kw OR 'hta':ti,ab,kw OR 'htas':ti,ab,kw OR 'technology overview*':ti,ab,kw OR 'technology appraisal*':ti,ab,kw OR 'meta regression*':ti,ab,kw OR 'metaregression*':ti,ab,kw OR 'meta-analy*':ti,ab,kw,ok OR 'metaanaly*':ti,ab,kw,ok OR 'systematic review*':ti,ab,kw,ok OR 'biomedical technology assessment*':ti,ab,kw,ok OR 'bio-medical technology assessment*':ti,ab,kw,ok OR medline:ti,ab,ok OR cochrane:ti,ab,ok OR pubmed:ti,ab,ok OR medlars:ti,ab,ok OR embase:ti,ab,ok OR cinahl:ti,ab,ok OR cochrane OR 'health near/2 technology assessment' OR 'evidence report' OR ((comparative NEAR/3 (efficacy OR effectiveness)):ti,ab,kw,ok) OR 'outcomes research':ti,ab,kw,ok OR 'relative effectiveness':ti,ab,kw,ok OR ((('indirect' OR 'indirect treatment' OR 'mixed-treatment' OR 'bayesian') NEAR/3 comparison*):ti,ab,kw,ok) OR 'meta-analysis'/dm OR 'systematic review'/dm OR ((multi* NEAR/3 treatment NEAR/3 comparison*):ti,ab,kw,ok) OR ((mixed NEAR/3 treatment NEAR/3 ('meta analy*' OR meta-analy*)):ti,ab,kw,ok) OR (umbrella:ti,ab,kw,ok AND review*:ti,ab,kw,ok) OR ((multi* NEAR/2 paramet* NEAR/2 evidence NEAR/2 synthesis):ti,ab,kw,ok) OR ((multiparamet* NEAR/2 evidence NEAR/2 synthesis):ti,ab,kw,ok) OR (('multi paramet*' NEAR/2 evidence NEAR/2 synthesis):ti,ab,kw,ok) #4 #1 AND #2 AND #3 AND [embase]/lim NOT ([embase]/lim AND [medline]/lim)	135
Epistemonikos	((title:(Osteoarthritis OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses) OR abstract:(Osteoarthritis OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses))) OR abstract:((title:(Osteoarthritis OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses) OR abstract:(Osteoarthritis OR Osteoarthritides OR Osteoarthrosis OR Osteoarthroses OR (Arthritis, Degenerative) OR (Arthritides, Degenerative) OR (Degenerative Arthritides) OR (Degenerative Arthritis) OR Arthrosis OR Arthroses)))) AND (title:((Plasma, Platelet-Rich) OR (Platelet Rich Plasma) OR PRP) OR abstract:((Plasma, Platelet-Rich) OR (Platelet Rich Plasma) OR PRP))	122

Table 2 List of excluded studies and reasons for exclusion

Systematic Review	Justification
Belk, 2023	Associated PRP with another intervention (BMAC)
Chou, 2021	Included retrospective studies
Derwich, 2021	Associated PRP with another intervention
Evans, 2020	Included case series
Hegazy, 2019	Included cohort studies
Howlader, 2023	Included cohort studies
Kim, 2021	Included cohort studies
McLarnon, 2021	Included cohort studies
Paget, 2023	Trials without PRP
Patel, 2022	Included prospectives and retrospectives studies
Tietze, 2015	Included case series

Abbreviations: BMAC, bone marrow aspirate concentrate; PRP, platelet-rich plasma.

performance of a comprehensive and adequate literature search. No systematic review classified as presenting low methodological quality received a negative score in this item, and 57.7% of those classified as "critically low" received "no" (15/31) answers. Reviews that exhibited deficiencies in the literature search were primarily hindered by language restrictions, as evidenced by 38% (12/31) that limited their search only to RCTs written in English. Additionally, 11 reviews that received a poor score on this criterion failed to use trial registry platforms such as ClinicalTrials.gov in their search strategy.

- Item 7: 100% (31/31) did not inform the reasons for excluding RCTs during the study selection process.

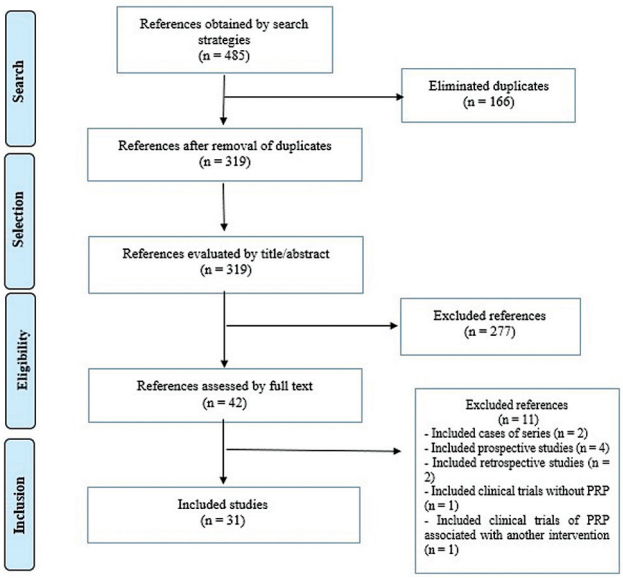


Fig. 1 Flowchart of the study selection process.

Systematic Reviews that Assessed the Certainty of the Evidence (GRADE approach)

Upon reviewing the AMSTAR-2 tool, we found no mention of assessmets of the certainty of evidence. However, we extracted additional data and found that only 19.35% (6/31) of the included systematic reviews conducted this assessment according to the GRADE approach; however, the complete assessment of each GRADE domain was not fully reported.

Discussion

Given the significant impact of systematic reviews on clinical recommendations and the development of medical guidelines, they must be conducted using methods that transparently minimize errors and biases.[25] However, despite the widespread dissemination of tools, such as the *Cochrane Handbook of Systematic Reviews* and the PRISMA statement,[14,26–28] and the increasing production of systematic reviews over the years, many reviews are still poorly conducted and exhibit a high risk of bias.[29] This finding aligns with the results of the current meta-research study, which observed an increase in reviews on PRP since 2015 but no improvement in their methodological and reporting quality.

As previously mentioned, 83.8% (26/31) of the included systematic reviews received an overall classification of critically-low quality and 16.13% (5/31) were classified as low-quality according to the AMSTAR-2 tool criteria. Considering the critical items, those most inadequately reported are related to search strategies (item 4), with 77,3% of "no" or "partially yes" responses, and the reasons for the exclusion of studies during the selection process (item 7), which was not described in 100% (31/31) of the reviews. Additionally, 42% did not mention the review protocol registry (item 2), 13% did not use the adequate methodological quality tool to assess the risk of bias in RCTs (item 9), 3.5% did not use appropriate statistical methods (item 11), 35.7% did not assess the impact of the RCT's risk of bias on the results (item 12), and 45.2% did not consider the risk of bias in interpreting the data obtained in the discussion section (item 13). Therefore, 32.26% did not meet the item 15 criteria, which involved a plan to investigate publication bias and discuss its impact on the systematic review results. It is important to mention that 100% (31/31) of the included reviews did not report reasons for choosing only RCT to be included in the review (item 3), and 93.5% did not mention the funding sources of their respective included RCTs (item 10). Also, the GRADE approach was used in only 19.3% of the reviews.

Despite methodological recommendations encouraging pre-established protocols for systematic reviews,[29] half of the PRP reviews examined in the present study did not register their protocols beforehand. Without this registration, it is not possible to compare the results obtained with those intended, which compromises the evaluation of possible protocol deviations,[30] and also hinders the to identification of redundancy of systematic reviews on a similar topic without additional contributions.[31]

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Table 3 Main characteristics of the included systematic reviews.

First author, year	Included RCTs (n)	Interventions versus (vs.) comparators	Systematic review protocol	Methodological quality assessment	Outcomes	Meta-analysis	Funding sources
Ali, 2018	3	PRP vs. HA; PRP vs. PRP + HA	Not registered	Jadad[18]	Pain and function	No	No funding
Belk, 2020	18	PRP vs. HA	Not registered	Cochrane RoB tool[19] and Modified Coleman Methodology Score[20]	Pain, function, and LP-PRP vs. LR-PRP adverse events	Yes	No funding
Cavazos, 2019	5	Single injection of PRP vs. multiple injections of PRP	Registered on PROSPERO (CRD42018106429)	Cochrane RoB tool[19]	Pain and Function	Yes	No funding
Chen, 2020	14	PRP vs. HA	Not registered	Cochrane RoB tool[19]	Pain, function, and adverse events	Yes	No funding
Chung, 2018	5	PRP vs. placebo; PRP vs. HA; PRP vs. saline solution	PROSPERO register (number not reported)	Cochrane RoB tool[19]	Pain and function	Yes	No funding
Costa, 2022	40	PRP vs. HA; PRP vs. corticosteroid; PRP vs. saline solution; PRP vs. exercise; PRP vs. oral pharmacological agents; PRP vs. ozone therapy; PRP vs. placebo	Registered on PROSPERO (CRD42018093247)	Cochrane RoB tool[19]	Pain, function, failure of treatment, and adverse events	Yes	No funding
Dai, 2017	10	PRP vs. HA; PRP vs. saline solution; PRP vs. corticosteroid; PRP vs. exercise; PRP vs. no treatment	Not registered	Cochrane RoB tool[19]	Pain, function, and adverse effects	Yes	No funding
Di, 2018	7	PRP vs. HA	Registered on PROSPERO (CRD42016048394)	Cochrane RoB tool[19]	Pain and function	No	No funding
Filardo, 2020	34	PRP vs. placebo; PRP vs. HA; PRP vs. saline solution; PRP vs. CS; PRP vs. ozone	Registered on PROSPERO (CRD42019145409)	Cochrane RoB tool 2.0[21]	Pain, function, and stiffness	Yes	No funding

Table 3 (*Continued*)

First author, year	Included RCTs (n)	Interventions versus (vs.) comparators	Systematic review protocol	Methodological quality assessment	Outcomes	Meta-analysis	Funding sources
Garcia, 2020	7	PRP vs. HA; PRP vs. PRP + HA; PRP vs. saline solution; PRP vs. bupivacaine; PRP vs. no injection	Registered on PROSPERO (CRD42020159802)	Coleman Methodology Score[20]	Pain, function, and return to daily activities and sports	Yes	No funding
Gong, 2021	6	PRP vs. HA	Registered on PROSPERO (CRD42020182571)	Cochrane RoB tool[19]	Pain, function, and adverse events	Yes	National Natural Science Foundation of China; Scientific Research Project of Chinese Academy of Traditional Chinese Medicine
Hohmann, 2020	12	PRP vs. HA	Not registered	Cochrane RoB tool 1[19]	Pain and function	Yes	No funding
Hong, 2021	23	PRP vs. placebo; PRP vs. HA; PRP vs. CS; PRP vs. oral NSAIDs	Not registered	Modified version of the Jadad Scale[22]	Pain, function, and adverse events	Yes	Beijing Municipal Science and Technology Commission, the National Natural Science Foundation of China, the National Key Research and Development Program of China, the Capital Health Research and

(*Continued*)

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Table 3 (*Continued*)

First author, year	Included RCTs (n)	Interventions versus (vs.) comparators	Systematic review protocol	Methodological quality assessment	Outcomes	Meta-analysis	Funding sources
							Development of Special
Idres, 2023	9	PRP vs. corticosteroids	Not registered	Cochrane RoB tool[19]	Pain, function, and stiffness	No	No funding
Kanchanatawan, 2015	9	PRP vs. HA; PRP vs placebo	Not registered	PRISMA[14]	Pain, function, stiffness, and adverse events	Yes	No funding
Kim, 2023	21	PRP vs. HA	PROSPERO (register number not reported)	Cochrane RoB tool[19] and Modified Coleman Methodology Score[20]	Pain, function, stiffness, and adverse events	Yes	No funding
Meheux, 2016	6	PRP vs. corticosteroids; PRP vs. HA; PRP vs. placebo	Registered on PROSPERO (CRD42014013032)	Modified Coleman Methodology Score[23]	Pain, function, and stiffness	No	No funding
Nie, 2021	21	PRP vs. corticosteroids; PRP vs. HA; PRP vs. placebo	Registered on PROSPERO (CRD42019122002)	Cochrane RoB tool[19]	Pain, adverse events, and complications	Yes	No funding
Peng, 2021	14	PRP vs. HA	Registered on PROSPERO (CRD42022347244)	Cochrane RoB tool[19]	Pain, function, and adverse events	Yes	No funding
Porqueres, 2020	4	PRP vs. HA	Registered on PROSPERO (CRD42014010210)	Cochrane RoB tool[19]	Pain, function, growth factors, and adverse events	Yes	No funding
Sadabad, 2016	6	PRP vs. HA	Not registered	Cochrane RoB tool[19] and Jadad[18]	Pain	Yes	Health Technology Assessment Department at Shahid Sadoughi University of Medical Sciences, Yazd

Table 3 (*Continued*)

First author, year	Included RCTs (n)	Interventions versus (vs.) comparators	Systematic review protocol	Methodological quality assessment	Outcomes	Meta-analysis	Funding sources
Sambe, 2023	7	PRP vs. HA	Not registered	Cochrane RoB tool 2.0[21]	Pain, function, and adverse events	Yes	No funding
Sax, 2022	24	PRP vs. CS; PRP vs. HA; PRP vs. saline solution and exercise therapy	Registered on PROSPERO (CRD42022296909)	Modified Coleman Methodology Score[23]	Pain	Yes	No funding
Shang, 2023	14	PRP vs. HA	Not registered	Jadad[18]	Pain	Yes	No funding
Shen, 2017	14	PRP vs. HA; PRP vs. ozone; PRP vs. placebo	Registered on PROSPERO (CRD42016045410)	Cochrane RoB tool[19]	Pain, function, and adverse events	Yes	National Natural Science Foundation of China and Shanghai Youth Science and Technology start-up grants
Simental, 2023	14	PRP vs. placebo	Registered on PROSPERO (CRD42022320169)	Cochrane RoB tool 2.0[21]	Pain and function	Yes	No funding
Tan, 2020	26	PRP vs. HA	Not registered	Modification of the tool used by the Cochrane bone, joint, and muscle trauma group[24]	Pain, function, adverse events, reintervention rate, C-reactive protein levels, quality of life, satisfaction rate, and return to activities of daily living and sports	Yes	No funding
Tao, 2023	7	Single injection of PRP vs. Multiple injections of PRP	Not registered	Cochrane RoB tool[19]	Pain and adverse events	Yes	No funding

(*Continued*)

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Table 3 (*Continued*)

First author, year	Included RCTs (n)	Interventions versus (vs.) comparators	Systematic review protocol	Methodological quality assessment	Outcomes	Meta-analysis	Funding sources
Vilchez, 2022	31	PRP vs. HA; PRP vs. corticosteroids; PRP vs. peptide	Registered on PROSPERO (CRD42020202048)	Cochrane RoB tool 2.0[21]	Pain and function	Yes	No funding
Xiong, 2023	24	PRP vs. saline solution; PRP vs. HA	Registered on PROSPERO (CRD42022362066)	Cochrane RoB tool[19]	Pain, function, and adverse events	Yes	Science and Technology Research Project of Jiangxi Provincial Education
Zhao, 2020	30	PRP vs. saline solution; PRP vs. HA; PRP vs. corticosteroids; PRP vs. acetaminophen; PRP vs. no injection	Registered on PROSPERO (CRD42018100067)	Cochrane RoB tool[19]	Pain and function	Yes	National Key Research and Development Program of China; the National Natural Science Foundation of China

Abbreviations: CS: Corticosteroid; HA, hyaluronic acid; NSAIDs, non-steroidal anti-inflammatory drugs; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, International Prospective Register of Systematic Reviews; PRP: Platelet-rich plasma; RCT, randomized clinical trial; RoB, Risk of Bias tool.

Table 4 Methodological quality of included systematic reviews (scores on the items of A Measurement Tool to Assess Systematic Reviews [AMSTAR-2] score)

First author, year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Overall quality
Ali, 2018	Y	N	N	PY	Y	N	N	Y	PY	N	N	N	N	N	N	Y	Critically low
Belk, 2020	Y	N	N	N	Y	Y	N	Y	Y	N	Y	N	N	Y	N	Y	Critically low
Cavazos, 2019	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	N	Y	Critically low
Chen, 2020	Y	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Chung, 2018	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	Y	Critically low
Costa, 2022	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Dai, 2017	Y	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Di, 2018	Y	Y	N	N	Y	Y	N	Y	Y	Y	NA	NA	N	N	NA	Y	Critically low
Filardo, 2020	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Low
Garcia, 2020	Y	Y	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	Y	Critically low
Gong, 2021	Y	Y	N	PY	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Low
Hohmann, 2020	Y	N	N	N	Y	Y	N	Y	Y	N	Y	N	N	Y	Y	Y	Critically low
Hong ,2021	Y	N	N	N	N	Y	N	Y	PY	N	Y	N	Y	Y	Y	Y	Critically low
Idres, 2023	Y	N	N	N	Y	Y	N	Y	Y	N	NA	NA	Y	Y	NA	Y	Critically low
Kanchanatawan, 2015	Y	N	N	N	Y	Y	N	Y	N	N	Y	N	Y	Y	Y	Y	Critially low
Kim, 2023	Y	Y	N	PY	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Critically low
Meheux, 2016	Y	Y	N	N	PY	N	N	Y	N	N	NA	NA	Y	N	NA	Y	Critically low
Nie, 2021	Y	Y	N	N	N	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Peng, 2021	Y	Y	N	N	N	N	N	Y	Y	N	Y	Y	N	Y	N	Y	Critically low
Porqueres, 2020	Y	Y	N	N	Y	N	N	Y	Y	N	Y	N	Y	Y	N	Y	Critically low
Sadabad, 2016	Y	N	N	PY	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	Y	Critically low
Sambe, 2023	Y	N	N	N	N	N	N	Y	Y	N	Y	Y	Y	Y	N	Y	Critically low
Sax, 2022	Y	Y	N	PY	N	N	N	PY	N	N	Y	N	N	Y	N	Y	Critically low
Shang, 2023	Y	N	N	N	Y	Y	N	Y	PY	N	Y	Y	N	Y	N	Y	Critically low
Shen, 2017	Y	Y	N	PY	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Low
Simental, 2023	Y	Y	N	PY	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Low
Tan, 2020	Y	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Tao, 2023	Y	N	N	PY	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Critically low
Vilchez, 2022	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Low
Xiong, 2023	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	N	N	Y	Y	Y	Critically low
Zhao, 2020	Y	Y	N	PY	N	Y	N	Y	Y	N	Y	N	N	Y	N	Y	Critically low

Abbreviations: NA, not applicable; Y, yes; N, no; PY, partially yes; Q: question.
Notes: Q1–about the Patient, Intervention, Comparison, Outcome (PICO) strategy; Q2–about protocol a priori; Q3–about study design for inclusion; Q4–about search strategy; Q5–about study selection; Q6–about data extraction; Q7–about list of excluded studies; Q8–about description of the the included studies; Q9–about method to assessing the risk of bias; Q10–about funding of included studies; Q11–about methods for statistical combination; Q12–about impact of risk of bias in individual studies on meta-analysis; Q13–about discussion of risk of bias in individual studies; Q14–about heterogeneity; Q15–about publication bias; and Q16–about conflict of interest.

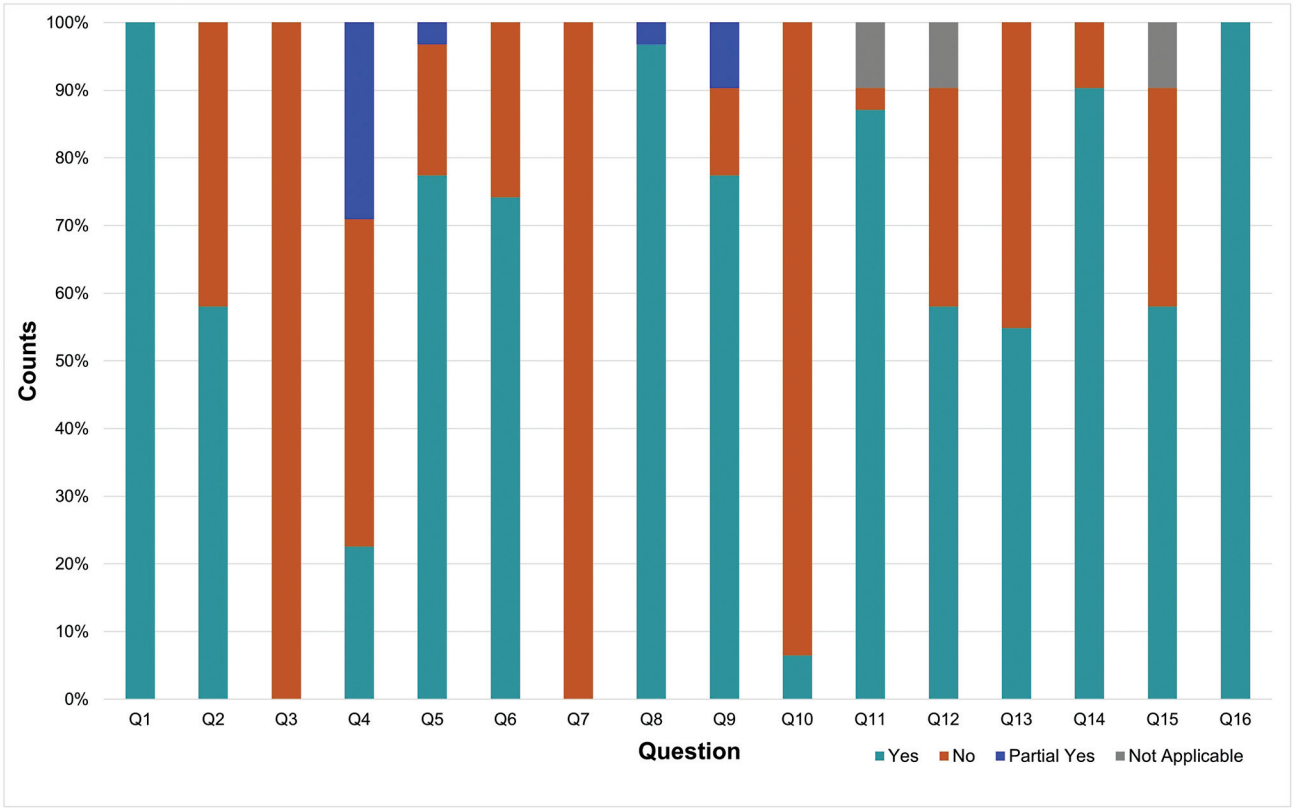


Fig. 2 Proportion of categories of methodological quality according to the A Measurement Tool to Assess Systematic Reviews, Version 2 (AMSTAR-2) tool. **Abbreviation:** Q: question. **Notes:** Q1–about the Patient, Intervention, Comparison, Outcome (PICO) strategy; Q2–about protocol a priori; Q3–about study design for inclusion; Q4–about search strategy; Q5–about study selection; Q6–about data extraction; Q7–about list of excluded studies; Q8–about description of the the included studies; Q9–about method to assessing the risk of bias; Q10–about funding of included studies; Q11–about methods for statistical combination; Q12–about impact of risk of bias in individual studies on meta-analysis; Q13–about discussion of risk of bias in individual studies; Q14–about heterogeneity; Q15–about publication bias; and Q16–about conflict of interest.

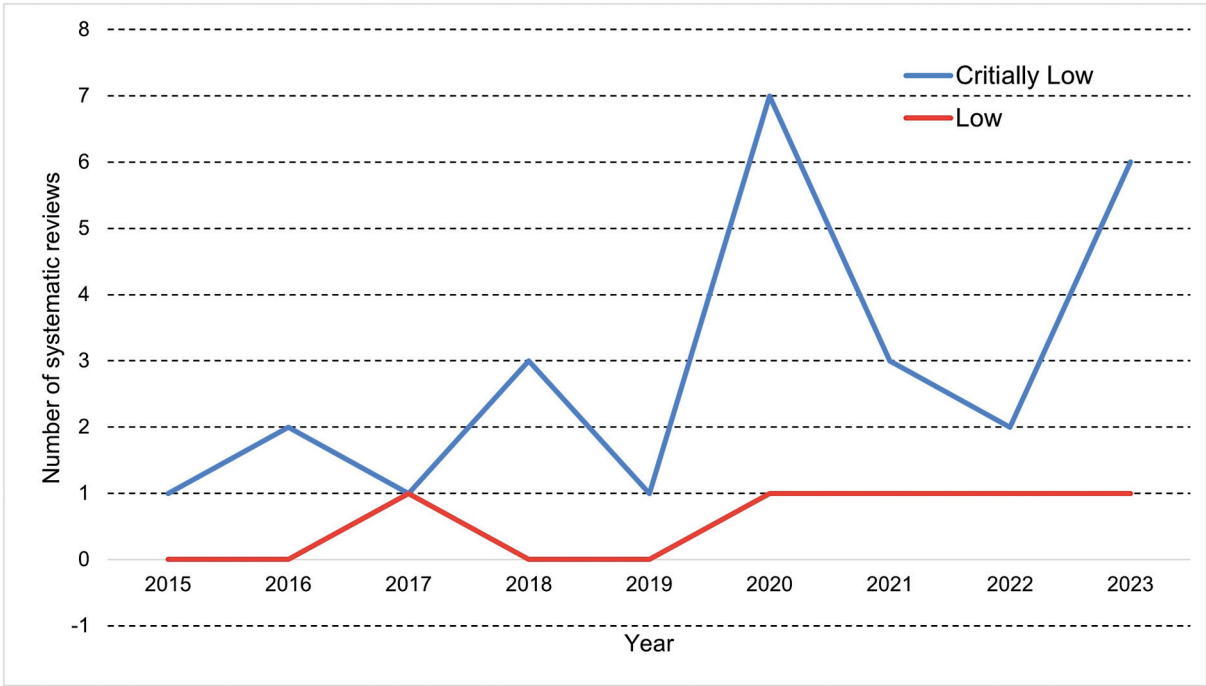


Fig. 3 Number of systematic reviews classified as having low and critically-low quality by year.

Another topic observed was the absence of a list of excluded references and detailed justifications in all analyzed systematic reviews. This indicates a potential transparency failure in the study selection process.[17] Due to this omission, the interpretation of the results can be underestimated or overestimated.[32]

Regarding the design of the studies included in the evaluated systematic reviews (AMSTAR-2, item 3), 100% (31/31) of the reviews did not clarify in the article that this is the best study design to answer research questions. As it is well established, RCTs are considered the gold-standard type of study and the most reliable to test interventions.[33] Therefore, it is assumed that this information is already a consensus, and the authors do not mention it in the text of their reviews.

Almost half of the reviews also conducted search strategies incompletely. In systematic reviews, search strategies involve multiple stages that must be transparent to the reader. Limiting language, mainly selecting only studies written in English, leads to monolingual bias and the potential loss of relevant studies.[32–35]

Even though adherence to the risk of bias tool was high among the systematic reviews on PRP investigated, some studies did not consider the RCTs' risk of bias results in the meta-analysis and discussion, making their conclusions weak. A cross-sectional study[36] showed that efficacy studies with a high risk of bias tend to present higher effect estimates than those with low bias.

No meta-research studies on PRP to treat osteoarthritis were identified. However, a study[37] assessed the methodological quality of systematic reviews in the orthopedic field across the top five impact factor journals between 2006 and 2010. This study[37] revealed that the main areas of deviation were the protocol registry and the assessment of publication bias likelihood, with only 54% of methodological components being fulfilled.

In addition, most reviews (80.6%) did not employ the GRADE approach to assess the certainty of the evidence. Failure to acknowledge evidence certainty and the strength of recommendation through the GRADE approach can lead to misguided guidelines and recommendations, negatively impacting patient health.[38] Due to its critical importance, we suggest that GRADE assessment be included as an item in a future version of the AMSTAR tool.

For the present study, a comprehensive literature search was conducted without date and language restrictions. However, it is possible that eligible reviews were eventually missed. Nevertheless, the decision to include systematic reviews involving only RCTs was due to the excessive number of clinical trials on the topic in question, considering the best primary study to assess the effects of therapeutic interventions. It is important to emphasize that, as meta-research, a sample of studies on the topic was analyzed to generate an overview of the current methodological situation of the published articles.

Conclusion

The methodological quality of the systematic reviews on the effects of PRP in the treatment of osteoarthritis was classified as having low and critically-low quality through the AMSTAR-2 assessment. Furthermore, most of them did not assess the certainty of the evidence using the GRADE approach. Despite the numerous systematic reviews conducted on this topic over the years, the current study identified that most of these reviews are not rigorously planned and conducted, presenting methodological flaws that could affect the reliability of the clinical findings.

Authors' Contributions

Each author contributed individually and significantly to the development of this article. MEOO, KMMS, MLS, MES, EMS, and ALCM contributed in terms of validation, visualization, research, data curation, writing – original draft, and writing – review and editing. MEOO, KMMS, and MES: conceptualization. ALCM and EMS: formal analysis and methodology.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Organization of a Pediatric Scoliosis Surgery Task Force and Analysis of Clinical and Radiographic Outcomes

Organização de um mutirão de cirurgia de escoliose pediátrica e análise dos resultados clínicos e radiográficos

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Abstract

Objective To demonstrate how a surgical task force can help provide access to surgical procedures for many patients waiting for surgery in the Brazilian Unified Health System (Sistema Único de Saúde - SUS, in Portuguese) waiting list.

Methods This is a retrospective cohort study involving 28 patients on the SUS waiting list included in a pediatric scoliosis surgery task force. We analyzed medical records, epidemiological data, and clinical and radiographic outcomes.

Results The data showed that the postoperative outcomes of curve correction and complications, such as infections, surgical wounds, pain, or other events, were consistent with the literature on the subject.

Conclusion Therefore, we believe a task force is critical for facilitating access to surgical procedures and restoring the quality of life of hundreds of patients.

Keywords
- scoliosis
- spine diseases
- surgery task force

Resumo

Objetivo Mostrar como o mutirão de cirurgias pode auxiliar no acesso ao procedimento cirúrgico para muitos pacientes que aguardam para realizar cirurgia na fila de espera do Sistema Único de Saúde (SUS).

Métodos Trata-se de um estudo retrospectivo de coorte que contou com 28 pacientes da lista de espera do SUS, incluídos em um mutirão de cirurgia de escoliose pediátrica, no qual foram realizadas revisão de prontuário, análise epidemiológica e de resultados clínicos e radiográficos.

Palavras-chave
- doenças da coluna vertebral
- escoliose
- mutirão de cirurgia

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Resultados Os dados mostraram que os resultados pós-cirúrgicos de correção das curvas e o nível de complicações observadas nos pacientes, tais como o acometimento de infecções, feridas cirúrgicas, dor ou outros tipos de eventos, são compatíveis com a literatura sobre tema.

Conclusão Sendo assim, entende-se que o mutirão é importante para facilitar o acesso ao procedimento cirúrgico e devolver a qualidade de vida a centenas de pacientes.

Introduction

Although scoliosis is defined as a spinal deformity in the coronal plane greater than 10°, it consists of a rotational vertebral deformity.[1] Idiopathic scoliosis is a structural disease in children at or near puberty[2] It can have different etiologies, including genetic syndromes, congenital spinal malformations, skeletal dysplasias, connective tissue conditions, and neuromuscular diseases.[1]

Most cases present a low curvature magnitude per the Cobb angle,[3] with no significant clinical repercussions. The prevalence of curvatures with a magnitude large enough to consider surgical treatment is extremely low, ranging from 0.04 to 0.4%.[1,4]

Most scoliosis cases present non-progressive deformity and do not require surgical treatment. However, some cases present rapid curvature progression requiring surgery due to the complex deformities associated with pediatric scoliosis, leading to the idea of organizing surgical task forces.[5]

Tasks forces aim to speed up the processing of elective surgeries. Regarding the topic addressed in the present study, the Scoliosis Research Society (SRS) pioneered the development of programs to organize training actions for reference centers in the surgical treatment of pediatric scoliosis, culminating in surgical task forces, as recently described in the literature.[6,7]

In the current paper, we describe a task force for scoliosis treatment and its epidemiological, logistical, radiographic, and clinical data to encourage similar initiatives.

Materials and Methods

This study was retrospective, with an observational cohort. Participants were selected from the Brazilian Unified Health System's (Sistema Único de Saúde [SUS], in Portuguese) waiting list in Maranhão, Brazil, who underwent outpatient reassessment by the group and outpatient anesthesia evaluation. The exclusion criteria were previous surgeries, active infection, and lack of anesthesia for surgery.

We informed all selected patients about the study and invited them to participate after signing the informed consent form and the underage assent form approved by the research ethics committee. The task force occurred at Hospital Universitário from Universidade Federal do Maranhão (HU-UFMA). Twenty-eight patients who underwent surgical procedures between February 1 and 4, 2021, participated in the study.

We collected and recorded demographic data, including gender, age, weight, etiology of the deformity, and time between inclusion on the waiting list and surgery. We calculated the mean, median, and standard deviation values for variables and the frequency of each scoliosis etiology.

We evaluated and tabulated surgical data, including intraoperative bleeding, neurophysiological changes, implant type, and number of implants. In addition, we assessed drainage volume, blood transfusions, and the presence or absence of infections in the postoperative period.

We determined the deformity magnitude per the Cobb angle from all patients in the preoperative and immediate postoperative periods using the SurgiMap (Nemaris Inc., Methuen, MA, USA) application.

Moreover, we collected data from the professionals involved in the task force, such as their area of medical specialty and the Brazilian region in which they operate, through interviews. We recorded logistical data, including the number of operating rooms and intensive care unit (ICU) bed reserves as well as specific needs subjectively observed at each process stage.

Results

Demographic and Preoperative Clinical Data

The participants were 10 to 17 years old, including 24 were females and 4 males. Idiopathic (childhood, adolescent, and juvenile) scoliosis was the most common condition, (observed in 20 subjects; 71%), followed by congenital (4 patients; 14%), neuromuscular (3 subjects; 11%), and diplomyelia (1 patient; 4%) etiologies (►**Table 1**).

The mean age at diagnosis/surgical indication was 10.2 years; the age at surgery was 15.1 years, and the mean time from the diagnosis to the procedure was 4.7 years.

Intraoperative Results

Regarding surgical data (►**Table 2**), the mean blood loss was 768.61 ml, and 3 patients required blood transfusion. The mean surgical time was 200.74 minutes. Five subjects presented transient neurophysiological changes but no postoperative neurological deficits.

Seventeen patients underwent traction procedures and type 2 osteotomies; five, intraoperative traction; three,

Table 1 Sociodemographic data

Patient	Scoliosis etiology	Pre-procedural height (m)	Weight (kg)	Gender
M1	Adolescent idiopathic	1.65	46	Female
M2	Neuromuscular	1.43	30	Female
M3	Congenital	1.39	35	Female
M4	Adolescent idiopathic	1.56	48	Female
M5	Adolescent idiopathic	1.54	46	Female
M6	Adolescent idiopathic	1.57	44	Female
M7	Child idiopathic	1.48	60	Female
M8	Adolescent idiopathic	1.62	43	Female
M9	Diplomyelia	1.35	28	Female
M10	Adolescent idiopathic	1.66	55	Female
M11	Adolescent idiopathic	1.55	54	Female
M12	Juvenile idiopathic	1.72	59	Female
M13	Child idiopathic	1.59	43	Female
M14	Adolescent idiopathic	1.65	52.5	Female
M15	Adolescent idiopathic	1.59	47	Female
M16	Neuromuscular	1.30	30	Male
M17	Juvenile idiopathic	1.42	41	Male
M18	Congenital	1.64	60	Male
M19	Juvenile idiopathic	1.53	37.2	Male
M20	Adolescent idiopathic	1.61	47	Female
M21	Neuromuscular	1.30	22	Female
M22	Congenital	1.61	46	Female
M23	Juvenile idiopathic	1.68	55	Male
M24	Adolescent idiopathic	1.66	50	Female
M25	Adolescent idiopathic	1.62	56	Female
M26	Congenital	1.27	23	Female
M27	Adolescent idiopathic	1.64	46	Female
M28	Adolescent idiopathic	1.52	38	Female

Note: Specification of scoliosis type, height, weight, and gender.
Source: Authors (2023).

intraoperative traction combined with the bipolar technique; three, intraoperative traction and osteotomies; one, intraoperative traction combined with costoplasty; and three patients underwent osteotomies alone.

Other surgical procedures included asymmetric pedicle subtraction osteotomy (PSO) of T10, laminectomy, and transforaminal lumbar interbody fusion (TLIF).

Regarding arthrodesis, the proximal level of screw insertion was the thoracic region, mainly in the T4 vertebra; in 1 patient, it occurred in the cervical region (C7) and, in another subject, in the lumbar region (L4). The distal level concentrated in the lumbar region; in four patients, it occurred in the thoracic region (T12), in the sacrum region (S1) in one patient, and, in three subjects, the procedure occurred in the hip region (ilium).

All patients received implants. In total, we used 457 implants, including screws, rods, hooks, and sublaminar bands.

Clinical Postoperative Outcomes and Complications

The clinical postoperative data (►**Table 3**) show that the average time to discharge was 6.92 days. All patients presented secretions or blood in the drain on the 1st day after surgery (average volume, 370.05 mL), 27 (96%) subjects on the 2nd day (average volume, 252.59 mL), 9 (32%) on the 3rd day (average volume, 144.66 mL), and only 1 (4%) on the 4th day (280 mL).

Twelve patients (43%) required blood bags postoperatively. Six received two, three received three, two received one, and one received four bags.

Among complications, two subjects presented infection; one had urinary tract infection (UTI) by *Enterobacter cloacae*, and the other had a surgical site infection by *Klebsiella pneumoniae*. In percentage terms, by etiology, we observed 5% of surgical site infections in idiopathic cases, with no other surgical site infections. Sixteen patients (57%)

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Table 2 Surgical data

Patient	Blood loss (mL)	Neurophysiological abnormality	Episode description	Techniques	Proximal level included in arthrodesis	Distal level included in arthrodesis	Surgical time (min)
M1	790	Yes	Motor potential drop at derotation. Signals normalized after bar removal. Surgery was completed without further complications.	NA	T8	L3	180
M2	870	No	NA	Intraoperative traction: bipolar	T1	Ilium	310
M3	110	No	NA	Laminectomy; transforaminal lumbar interbody fusion	L4	S1	180
M4	580	No	NA	NA	T4	L2	200
M5	1115	No	NA	NA	T4	T12	180
M6	470	Yes	Motor potential drop on the left side. The potential returned after mean blood pressure and room temperature increase.	Intraoperative traction	T4	L1	220
M7	970	Yes	Potential drop on the left side with normalization after traction removal	Intraoperative traction.	T2	L2	180
M8	650	No	NA	NA	T11	L3	100
M9	1140	No	NA	Intraoperative traction; costoplasty	T3	L3	240
M10	550	No	NA	Intraoperative traction	T4	L3	300
M11	960	No	NA	NA	T4	L4	200
M12	1400	No	NA	Osteotomies (3)	T4	L4	300
M13	1010	No	NA	Intraoperative traction	T4	L2	200
M14	610	No	NA	NA	T4	T12	145
M15	900	No	NA	NA	T6	L3	135
M16	350	No	NA	Intraoperative traction; bipolar	T1	Ilium	250
M17	1500	No	NA	Intraoperative traction; osteotomies (3)	T2	L2	220
M18	560	No	NA	Osteotomies (3)	T2	L2	280
M19	980	No	NA	Osteotomies (3); intraoperative traction	T4	L3	120
M20	690	No	NA	NA	T10	L4	120
M21	840	No	NA	Intraoperative traction; bipolar	T1	Ilium	220
M22	1,250	Yes	Motor and sensory potential drop during osteotomy. The potential normalized after decompression and osteotomy completion.	Asymmetric pedicle subtraction osteotomy in T10	T6	L3	270

Table 2 (*Continued*)

Patient	Blood loss (mL)	Neurophysiological abnormality	Episode description	Techniques	Proximal level included in arthrodesis	Distal level included in arthrodesis	Surgical time (min)
M23	740	No	NA	NA	T3	T12	200
M24	950	No	NA	Osteotomies (3)	T3	L2	200
M25	300	No	NA	NA	T4	T12	100
M26	330	Yes	Potential drop in the left leg with normalization after traction decrease	intraoperative traction	C7	L1	240
M27	820	No	NA	Proximal level translation	T4	L3	200
M28	590	No	NA	NA	T11	L4	150

Note: Specification of intraoperative bleeding, neurophysiological abnormalities, procedures performed, arthrodesis levels, and surgical time.
Source: Authors (2023).

presented some complication, including eight with nausea and vomiting, two with intense pain, one with moderate pain, two with metabolic acidosis, one with acidosis and urinary alterations (bladder globe), one with a sacral stasis ulcer, one required surgical debridement, one presented dyspnea on moderate exertion, and one presented functional obstruction, seizures, and hypokalemia.

Pre- and Postoperative Radiographic Results

Regarding the radiographic data, the preoperative mean Cobb angles were 29.3 degrees (range, 0–68) for the upper thoracic curve, 3.6 degrees (range, 0–120) for the lower thoracic curve, 42.2 degrees (range, 16–79) for the lumbar curve, 36.6 degrees (range, 5 to 75) of thoracic kyphosis, and 55.6 degrees (range, 8–86) of lumbar lordosis (►**Table 4**).

In the immediate postoperative period, the average correction was 28% for the upper thoracic curve, 47% for the lower thoracic curve, and 50% for the lumbar curve (postoperative mean values of 21 degrees, 34.2 degrees, and 21.5 degrees, respectively).

Addressing non-idiopathic scoliosis separately, the correction percentage of the main curve was 28% in neuromuscular scoliosis and 30% in congenital scoliosis.

Organizational and logistical results

The hospital structure included an outpatient clinic, a radiology department, 5 dedicated surgical rooms available for 4 days, and approximately 10 to 15 ICU beds for routine postoperative care. The surgical team included volunteer doctors and doctors from the hospital staff. The implants were donated, so we could not assess their costs with precision.

Although the surgeries occurred over 4 days in February 2021, the task force organization began in 2020 (►**Fig. 1**).

Discussion

Most patients were female, including 24 (86%) of the 28 subjects. This data is consistent with another study with 169 patients, including 121 (71.6%) females.[7] Another study on the incidence of adolescent idiopathic scoliosis (AIS) in several countries noted that the prevalence and severity of scoliosis were higher in girls.[8]

The present study also found a higher prevalence of idiopathic scoliosis, accounting for 20 cases (71%). In the current literature, the overall prevalence of AIS ranges from 0.47 to 5.2%.[8] A review from Pereira and Gomes[9] mentions studies corroborating our results: in a sample of 358 subjects, 16 had AIS (prevalence, 4.8%);[10] in a sample of 3,105 subjects, 38 had AIS (prevalence, 5.3%);[11] among 418 subjects, 18 adolescents had AIS (prevalence, 4.3%);[12] among 2,562 adolescents, 37 had AIS (prevalence, 1.5%).[13] These data demonstrate that our study is consistent with the epidemiological literature.

Regarding postoperative complications, discomforts are frequent, including nausea and vomiting in the first hours after surgery due to oral refeeding or anesthesia, dyspnea, oliguria,[14] odynophagia, pain at the intravenous injection

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Table 3 Postoperative outcomes

Patient	Time to discharge	Right drain 1 output (mL)	Right drain 2 output (mL)	Right drain 3 output (mL)	Right drain 4 output (mL)	Transfused blood bags	Number	Hemoglobin, PO1	Hemoglobin, PO3	Infections	Infection description	Other complications	Complication description
M1	5 days	225	175	150		Yes	2	8.2	9.8	No		Yes	Nausea and vomiting
M2	12 days	680	350			Yes	3	12.6	12.8	No		No	
M3	4 days	300	200			No		11.1	11.0	No		No	
M4	4 days	370	250			No		10.6	10.1	No		No	
M5	6 days	317	150			No		10.2	9.9	No		No	
M6	8 days	454	300			No		9.4	9.1	No		No	
M7	7 days	144	180			Yes	2	8.2	10.2	No		Yes	Nausea and vomiting
M8	5 days	300	150	86		No		9.0	8.1	No		Yes	Nausea and vomiting
M9	5 days	480	200			Yes	2	8.1	12.2	No		Yes	Intense pain
M10	6 days	290	278			No		10.1	10.7	No		Yes	Dyspnea at moderate exertion
M11	6 days	450	140			Yes	4	8.4	12.3	No		Yes	Nausea and vomiting
M12	18 days	250	500	500		Yes	3	7.5	9.3	Yes	Surgical site infection with *Klebsiella pneumoniae*	Yes	Secretive surgical wound, debridement on Feb 12
M13	7 days	155	45			No		9.7	8.1	No		Yes	Nausea and vomiting
M14	6 days	300	188			Yes	1	8.5	10.7	No		Yes	Moderate pain
M15	5 days	390	380	120		No		9.5	9.6	No		No	
M16	14 days	630	450			No		11.2	10.3	Yes	UTI by *Enterobacter cloacae*	Yes	Sacral stasis ulcer
M17	5 days	550	190			Yes	3	7.6	10.5	No		Yes	Metabolic acidosis
M18	5 days	250	450	53		No		13.6	11.3	No		No	
M19	6 days	500	150			Yes	1	9.7	11.0	No		Yes	Metabolic acidosis
M20	18 days	370	500	115	280	Yes	2	9.1	9.4	No		Yes	Functional obstruction, seizures, hypokalemia.
M21	8 days	400	344			No		10.9	11.1	No		No	
M22	5 days	725	400	118		No		9.0	8.4	No		Yes	Intense pain
M23	5 days	400	200			No		11.4	11.0	No		No	
M24	6 days	303	100			No		9.4	8.4	No		Yes	Bladder globe, metabolic acidosis
M25	4 days	350	170	100		No		8.9	8.9	No		No	
M26	5 days	358	180			Yes	2	8.0	11.2	No		No	
M27	5 days	200				Yes	2	8.0	10.9	No		Yes	Nausea and vomiting
M28	4 days	220	200	60		No		10.3	10.4	No		No	

Abbreviations: PO, postoperative day; UTI, urinary tract infection.
Note: Specification of postoperative variables and complications.
Source: Authors (2023).

Table 4 Radiographic outcomes

Patient	Preoperative proximal thoracic Cobb angle (degrees)	Preoperative distal thoracic Cobb angle (degrees)	Preoperative lumbar Cobb angle (degrees)	Preoperative kyphosis Cobb angle (degrees)	Preoperative lordosis Cobb angle (degrees)	Postoperative proximal thoracic Cobb angle (degrees)	Postoperative distal thoracic Cobb angle (degrees)	Postoperative lumbar Cobb angle (degrees)	Postoperative kyphosis Cobb angle (degrees)	Postoperative lordosis Cobb angle (degrees)
M1	22	49	35	43	60	20	29	21	2	36
M2	50	86	36	17	46	34	61	25	4	56
M3	0	0	55	38	66	0	0	50	38	46
M4	35	72	38	16	58	16	23	9	27	47
M5	30	48	36	27	57	3	27	31	20	50
M6	33	106	55	47	50	22	29	34	36	45
M7	49	83	44	58	86	38	44	25	49	68
M8	15	36	45	5	30	24	33	16	13	34
M9	68	120	20	75	56	20	56	0	40	52
M10	27	56	68	5	48	5	23	48	33	45
M11	66	103	40	41	55	56	54	21	15	49
M12	0	50	79	5	8	0	26	23	19	33
M13	49	78	43	28	57	35	44	20	39	55
M14	9	54	40	18	65	15	25	7	32	20
M15	16	49	48	38	71	15	37	31	30	52
M16	12	22	50	28	72	20	14	34	28	80
M17	30	97	37	70	45	27	65	25	50	50
M18	40	74	47	56	58	33	54	27	41	36
M19	30	94	38	58	53	35	38	17	38	40
M20	6	36	47	36	52	6	10	20	40	50
M21	45	101	16	62	68	40	78	2	3	45
M22	51	89	44	70	76	28	53	21	55	55
M23	23	60	34	25	43	26	30	26	28	35
M24	43	57	30	42	56	29	35	16	38	50
M25	19	40	20	10	71	5	0	0	12	60
M26	45	87	31	65	57	37	48	10	33	24
M27	6	0	40	23	48	0	0	16	40	40
M28	2	34	66	19	45	0	24	27	30	37
	29.32142857	63.60714286	42.21428571	36.60714286	55.60714286	21.03571429	34.28571429	21.5	29.75	46.55555556
Percentage of curve correction			High thoracic: 28%	Low thoracic: 47%	Lumbar: 50%					

Note: Radiographic results calculated by the Cobb method pre and postoperatively.
Source: Authors (2023).

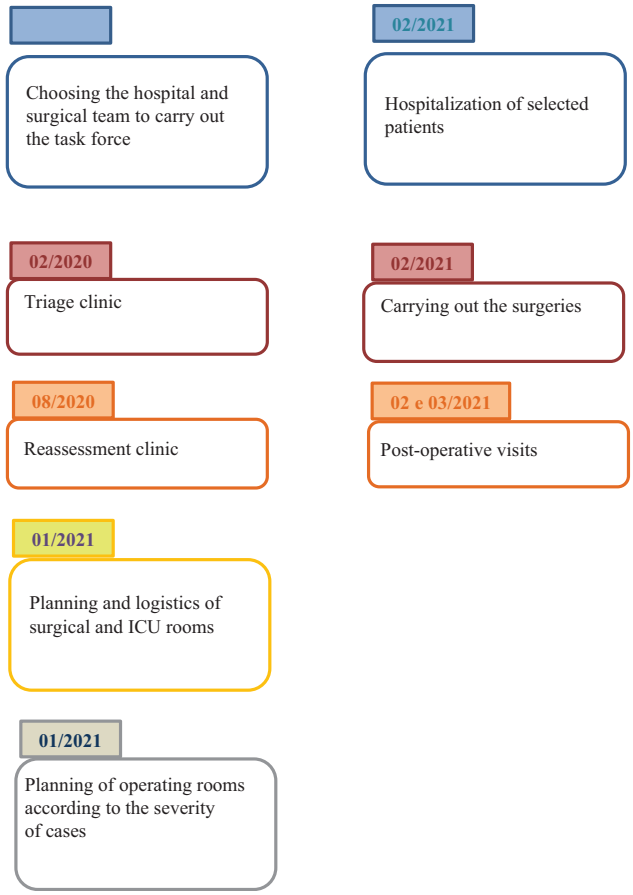


Fig. 1 Task force schedule.

sites, insomnia, and constipation.[15,16] Eight patients presented nausea and vomiting, one had dyspnea with moderate exertion, and one had functional obstruction; these are common reactions in postoperative patients.

As for pain, a citation highlights that "[...] the surgical wound is not spontaneously painful after 48 hours of the surgical procedure"[14]. Therefore, it is critical to ascertain the pain level and perform the required procedures. Among the 28 patients, only 2 presented intense pain, while 1 had moderate pain, with no other complications.

Other more painful occurrences may occur in the postoperative period of surgical procedures in general, including bleeding, wound infection, venous thrombosis, respiratory failure, pulmonary thromboembolism, pulmonary atelectasis, and UTI.[15,16]

Other studies on postoperative infections in patients treated for spinal deformities report UTIs, sphincter control loss, contamination, wound infections, gastrointestinal disorders, and pulmonary complications[17] They also reported a higher infection risk in patients with neuromuscular scoliosis than those with AIS. In the present study, complications and infections were common in postoperative patients[18]

Sensitivity loss in the extremities may cause loss of bowel or bladder control, especially in patients with neuromuscular scoliosis.[18] The complications observed in patient M16 (with neuromuscular scoliosis) may be related to the scoliosis type as they could not walk and had a UTI and a sacral ulcer.

The most severe complication occurred in patient M12 (AIS), who developed a surgical wound infection, a complication also observed in other studies.[15–18] The treatment was surgical debridement mentioned as the usual therapy,[18] with surgical site irrigation. In the literature, the infection rate in surgery for AIS ranged from 0.9 to 3%, and, for neuromuscular scoliosis, it ranged from 4.2 to 20%. In our study, the prevalence of surgical wound infection was approximately 3.5% in the general analysis and 5% among idiopathic cases.

Regarding other complications, the data depends on the consulted databases, ranging from 5 to 23% in AIS. More recent data from the SRS database, from 2011, cited a complication rate of 6.3% for all cases of idiopathic scoliosis (IS). In our study, 16 patients (57%) presented complications; those associated with the specific type of surgery affected 6 out of the 28 patients, that is, a prevalence rate of 21%, with only one major complication (which led to reoperation), a surgical site infection.

Since the complication and infection rates are consistent with the literature, the short time of surgery has no relationship with complications.

Radiographically, the overall average correction was 28% for the high thoracic curve, 47% for the low thoracic curve, and 50% for the lumbar curve (postoperative averages of 21 degrees, 34.2 degrees, and 21.5 degrees, respectively). After stratification by non-idiopathic etiologies, the main curve correction was 28% in neuromuscular scoliosis and 30% in congenital scoliosis. In a study[19] analyzing several postoperative outcomes, an article published in 1973, with 71 participants using Harrington rods, Risser plaster, and early ambulation, reported a mean preoperative curve of 56°, with 54% correction on the day of surgery and 46% correction at follow-up. In 1989, a study with 352 patients undergoing posterior spinal fusion reported a mean preoperative curve of 54° and a mean correction of preoperative active supine tilt of 48%. The average correction at surgery was 52% and 40% at the 2-year follow-up[19]

In 2004, a comparative study of 4 different instrumentations (double rod, multi-hook systems) involving 127 patients and using the C-D Horizon, Moss-Miami, TSRH, and Isola systems showed an average correction of 63% for the C-D Horizon and Moss-Miami and 58% for the TSRH and Isola.[19]

The curve correction over the years remained similar, and the values achieved in our study are consistent with the literature. As such, although the curve correction was not complete, the outcomes were satisfactory.[19] ►**Figs. 2–5** visually demonstrate the correction level achieved in some patients.

Regarding logistics, we had some difficulties during the task force, but no similar studies addressed them. In the preoperative period, we faced challenges in publicizing the triage clinic and contacting several patients. In addition, we needed to train radiology technicians to perform spinal panoramic radiographs in orthostasis. We also required large

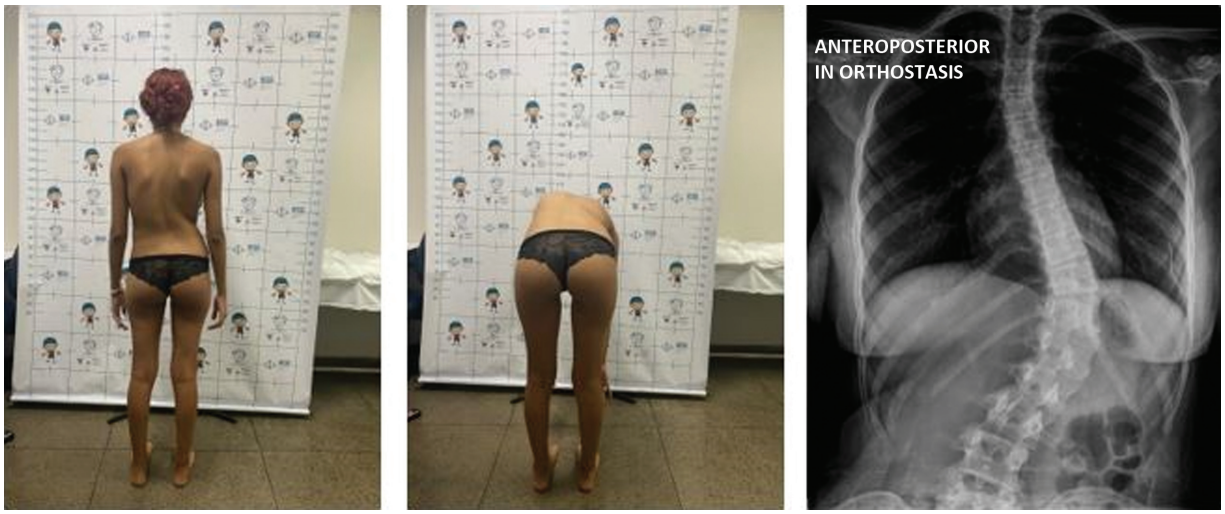


Fig. 2 Preoperative image of patient M21. Source: Authors (2023).

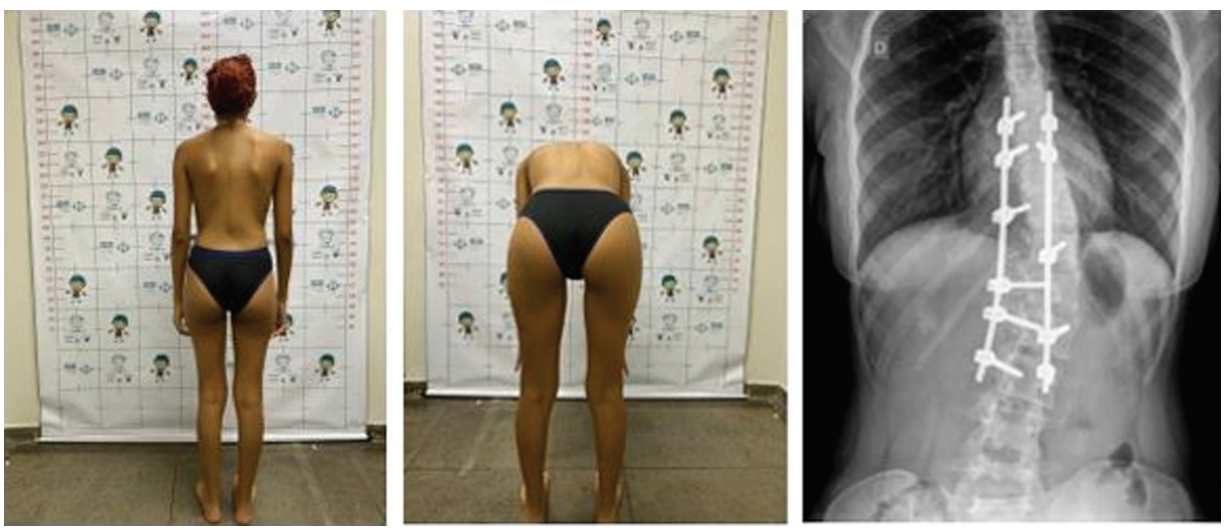


Fig. 3 Postoperative outcomes in patient M1. Source: Authors (2023).



Fig. 4 Preoperative image of patient M16. Source: Authors (2023).



Fig. 5 Postoperative outcomes in patient M16. Source: Authors (2023).

treatment rooms to take photographs and clinically evaluate the patients in the triage clinic. For the preoperative evaluation, we needed an anesthesiology clinic to assess and prepare patients for the procedure.

The logistical difficulties during surgery included gathering staff and resources for the stipulated task force time. The task force required a team of professionals from various areas of expertise and different Brazilian states with experience in scoliosis surgery and availability.

In the postoperative period, the challenges included ICU room availability. We required approximately 10 to 15 beds at the same time because sometimes more severe patients could not be discharged from the ICU on the first postoperative day. In addition, we needed nursing and physical therapy teams trained in scoliosis treatment procedures to maintain drains, change dressings, or ensure early ambulation.

The literature about surgical task forces[5,7] for correcting scoliosis curves provided no data on logistical difficulties or reported complications potentially warranted by these joint efforts. However, some news reports provided data on task forces and highlighted critical points.

The Regional Medical Council of the State of Bahia (CREMEB, for its acronym in Portuguese),[20] in 2018, warned about some issues in task forces, including problems resulting from the scenarios in which these surgeries occur and complication risks from surgical procedures, especially because of the potential lack of qualified personnel for intraoperative and postoperative monitoring.

Despite the news reports on complications in task forces, none deals with scoliosis surgery, and the cases with problems are low compared to the number of benefited people.

In December 2022, Centro Estadual de Reabilitação e Readaptação Dr. Henrique Santillo (CRER), a rehabilitation center from the Health Department of Goiás, Brazil, performed elective scoliosis surgeries in patients on the SUS list. Twenty patients underwent treatment; some had been on the waiting list for about 5 years, and the surgery improved their quality of life.[21]

In Pernambuco, Brazil, the traumatology and orthopedics team at Hospital Otávio de Freitas performed a surgical series for scoliosis treatment in 18 patients to minimize the SUS waiting list. This team did 4 procedures per day in 3 dedicated surgical rooms and used 16 beds from the adult and pediatric wards, trauma surgical center, ICU, and recovery room.[22]

In our study, the average age at diagnosis was 10.2 years, and surgery occurred at 15.1 years old, with a waiting time for the procedure of 4.7 years. In Brazil, a study[23] with 51 patients, all diagnosed from ages 10 to 17 years old, and the average waiting time for surgery was 25.41 months (ranging from 2–180 months). However, some patients waited for the surgery for up to 15 years. This waiting time can compromise the patient's quality of life, self-image, satisfaction, and functionality.[24]

We did not analyze the quality of life or personal satisfaction questionnaires because of logistical issues.

Conclusion

Despite the difficulties in organizing similar actions and some complications, it seems feasible to encourage the multiplication of these task forces in more hospitals due to the high number of patients on waiting lists for scoliosis surgery. However, it is fundamental to emphasize the need for more actions using this model to assess accurately its safety and applicability, especially in severe and non-idiopathic cases.

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

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Distal Femur Morphology in a Brazilian Population: Challenging the Universal Use of 3° of External Rotation

Morfologia do fêmur distal em uma população brasileira: Desafiando o uso universal de 3° de rotação externa

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Abstract

Objective To evaluate the external rotation angle between the transepicondylar axis (TEA) and the posterior condylar axis (PCA) in a Brazilian population to determine whether the universal use of 3° of external rotation of the femoral component is appropriate in these patients undergoing total knee arthroplasty (TKA).

Methods We measured the angle of external rotation in 167 magnetic resonance imaging (MRI) scans using 4 different methods for the PCA according to the posterior landmarks: measurement A – chondral prominences; measurement B – bony prominences; measurement C – lateral bony prominence and medial chondral prominence; and measurement D – lateral chondral prominence and medial bony prominence. We statistically compared these measurements with the traditional 3° of external rotation used in TKA.

Results The mean angles of external rotation in measurements A, B, C, and D were of $5.44° \pm 2.39°$, $4.94° \pm 2.10°$, $8.56° \pm 2°$, and $2.33° \pm 2°$ respectively. All measurement methods resulted in significant differences regarding the universal value of 3° ($p > 0.0001$). All intergroup comparisons showed statistical differences among the measurement methods ($p > 0.0001$), except for the comparison between measurements A and B ($p = 0.1614$).

Conclusion Using a chondral or bony reference point for the PCA, the TEA in the Brazilian population studied presented approximately 5° of external rotation. The

Keywords
- arthroplasty, replacement, knee
- knee joint
- magnetic resonance imaging
- rotation

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traditional rotation of the femoral component of 3° regarding the PCA may be insufficient in the Brazilian population, especially in valgus knees. Therefore, we emphasize the significance of an individualized approach to achieve the ideal rotational alignment of TKA components.

Resumo

Objetivo Avaliar, em uma população brasileira, o ângulo de rotação externa entre o eixo transepicondilar (ETE) e o eixo condilar posterior (ECP), a fim de estipular se o uso universal de 3° de rotação externa do componente femoral é apropriado neste grupo de pacientes na artroplastia total do joelho (ATJ).

Métodos O ângulo de rotação externa foi medido em 167 imagens de ressonância magnéticas utilizando-se 4 métodos diferentes para o ECP, de acordo com os pontos de referências posteriores: medida A – proeminências condrais; medida B – proeminências ósseas; medida C – proeminências óssea lateral e condral medial; e medida D – proeminências condral lateral e óssea medial. As medidas obtidas foram comparadas estatisticamente com os valores tradicionais de rotação externa de 3° empregados na ATJ.

Resultados As médias do ângulo de rotação externa para as medidas A,B,C,D foram de $5{,}44° \pm 2{,}39°$, $4{,}94° \pm 2{,}10°$, $8{,}56° \pm 2°$ e $2{,}33° \pm 2°$, respectivamente. Todos os métodos de medição resultaram em diferenças significativas em relação ao valor universal de 3° ($p > 0{,}0001$). Diferenças estatísticas foram encontradas em todas as comparações intergrupos entre os métodos de medição ($p > 0{,}0001$), exceto na comparação entre as medidas A e B ($p = 0{,}1614$).

Conclusão Utilizando um ponto de referência condral ou ósseo para o ECP, o ETE na população brasileira estudada apresentou aproximadamente 5° de rotação externa. A rotação tradicional do componente femoral de 3° em relação ao ECP pode ser insuficiente na população brasileira, sobretudo no joelho valgo. Assim, enfatizamos a importância de uma abordagem individualizada para alcançar o alinhamento rotacional ideal dos componentes na ATJ.

Palavras-chave
- articulação do joelho
- artroplastia do joelho
- imageamento por ressonância magnética
- rotação

Introduction

Total knee arthroplasty (TKA) is the gold-standard surgical procedure for advanced tricompartmental knee osteoarthritis, with satisfactory pain and function improvement.[1] Multiple factors determine the survival and successful functional outcomes of TKA, including correct component alignment.[1–5]

In the axial plane, rotational alignment of the femoral component greatly influences postoperative knee kinematics, particularly patellar tracking. To define femoral rotational alignment, several anatomical parameters are discussed, including the transepicondylar axis (TEE), the trochlear groove line (Whiteside line), the posterior condylar axis (PCA) or, even, according to the balanced extension gap.[2] In an arthroplasty following the principle of mechanical alignment based on measured resection, the literature widely accepts the femoral component positioning parallel to the surgical TEA.[3–5] Therefore, to achieve the final parallelism of the TEA component, the standard instrumentation of commercially-available prostheses is typically designed for a section at 3° of external rotation regarding the PCA, since the femoral condylar posterior surface supports the guide.

However, the bone morphology of the distal third of the femur may differ in populations or ethnic groups, as previously reported in Eastern populations.[5–8] With this context in mind, it is possible that the universal application of 3° of external rotation regarding the PCA is not adequate for all populational groups.

The main objective of the present study was to evaluate the angular relationship between the femoral TEA and femoral PCA in a Brazilian population to identify whether the empirical application of 3° of external rotation of the femoral component is appropriate for this population.

Materials and Methods

Sample and eligibility criteria

We retrospectively analyzed magnetic resonance imaging (MRI) scans from the Radiology Department of a quaternary hospital after approval by the Institutional Ethics Committee. The study included previously-collected images of patients

older than 60 years of age (a clinically-relevant age range for TKA indication) complaining of knee pain and without osteoarthritis greater than grade 2 on the Kellgren-Lawrence classification or intra- or extra-articular deformities. We excluded patients with a history of lower limb surgery, fractures, or pre-existing systemic inflammatory disease.

Sample size determination considered a 5% significance level. The correlation between the analyzed variables was deemed moderate, and the statistical test power was of 80%. Thus, the minimum number of patients was of 55 for each sex, considering the significant anthropometric differences between male and female subjects.

Radiological analysis

We analyzed axial T2-weighted MRI scans in a single section containing the topographies of the medial and lateral epicondyles and posterior femoral condyles. The TEA definition relied on the apices of the medial and lateral epicondylar prominences, and the PCA definition relied on a line tangent to the most posterior extension of the femoral condyles. The primary study outcome was the angular relationships between the TEA and the PCA. To identify the potential influence of the posterior condylar cartilage on PCA measurement, we used four methods with different anatomical landmarks:

- Measurement A – defided by the most posterior chondral prominences of the posterior medial and lateral femoral condyles (►**Fig. 1A**).
- Measurement B – defided by the most posterior bony prominences of the posterior medial and lateral femoral condyles (►**Fig. 1B**).
- Measurement C – defided by the medial femoral condylar chondral prominence and lateral femoral condylar bony prominence (►**Fig. 1C**).
- Measurement D – defided by the medial femoral condylar bony prominence and lateral femoral condylar chondral prominence (►**Fig. 1D**).

The same orthopedist performed all angular measurements using a specific software (Synapse Radiology PACS, Fujifilm, Minato, Tokyo, Japan).

Statistical analysis

To assess whether the angular measurements of external rotation between the TEA and the PCA presented statistically significant differences from the universal value of 3° of

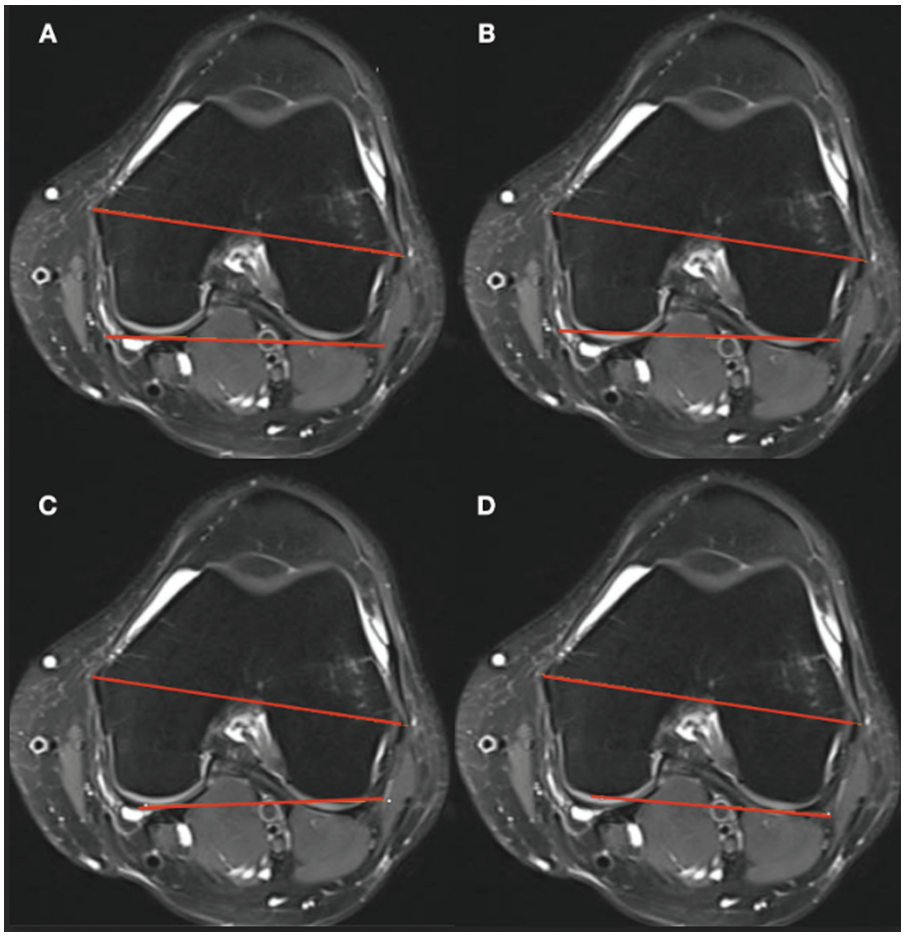


Fig. 1 Measurement of the posterior condylar axis (PCA) according to several anatomical references. (**A**) PCA defined by the most posterior chondral prominences of the medial and lateral femoral condyles; (**B**) PCA defined by the most posterior bony prominences of the medial and lateral femoral condyles; (**C**) PCA defined by the medial femoral condylar chondral prominence and lateral femoral condylar bony prominence; and (**D**) PCA defined by the medial femoral condylar bony prominence and lateral femoral condylar chondral prominence.

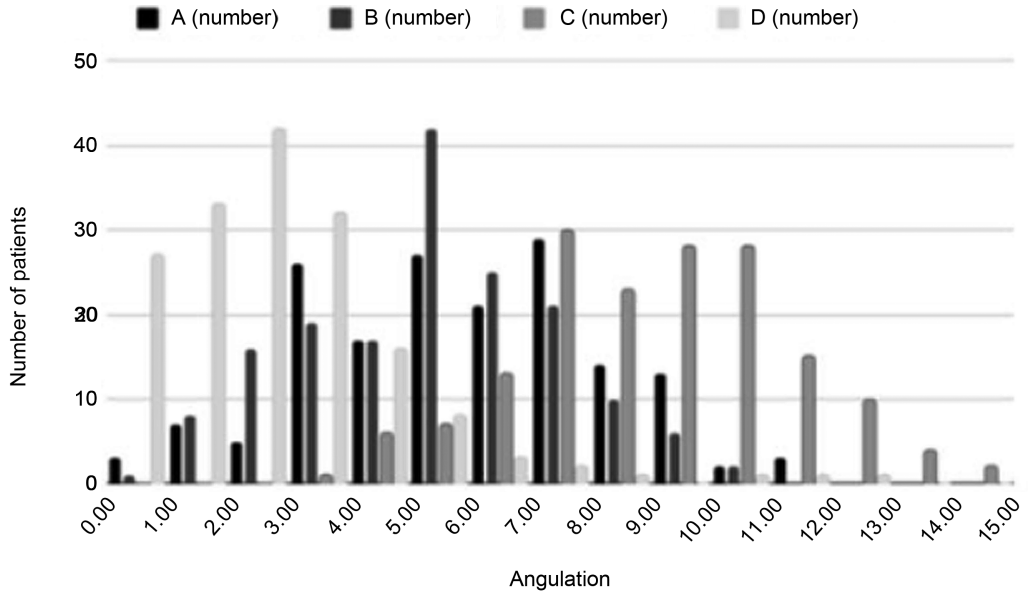


Fig. 2 Graph of the distribution of the rotation angles of the transepicondylar axis regarding each posterior condylar axis measurement (A, B, C, and D).

external rotation used in traditional TKA instrumentation, we used the Student's *t*-test for a single sample, which is suitable for comparing means between a sample and an established target value. The significance level was of 5% ($p < 0.05$).

We performed analysis of variance (ANOVA) to detect whether there was any difference between the different forms of rotation of the TEA regarding the PCA. When the ANOVA revealed statistically significant differences, the Tukey test was used for post-hoc comparisons between the groups to identify actual differences comparing each pair of measurements (A-B, A-C, A-D, B-C etc.).

Results

The present study included 167 knees, 106 from female and 61 from male patients, with 95 left and 72 right knees. The mean age of the final sample was of 67.57 ± 6.22 (range|: 60–85) years. ►**Figs. 2**–**4** show the distribution of the measurements for the total sample, and for the male and female patients respectively.

The mean angular values of external rotation of the TEA regarding the PCA, according to measurements A, B, C, and D, were of 5.44°, 4.94°, 8.57°, and 2.33° respectively. These

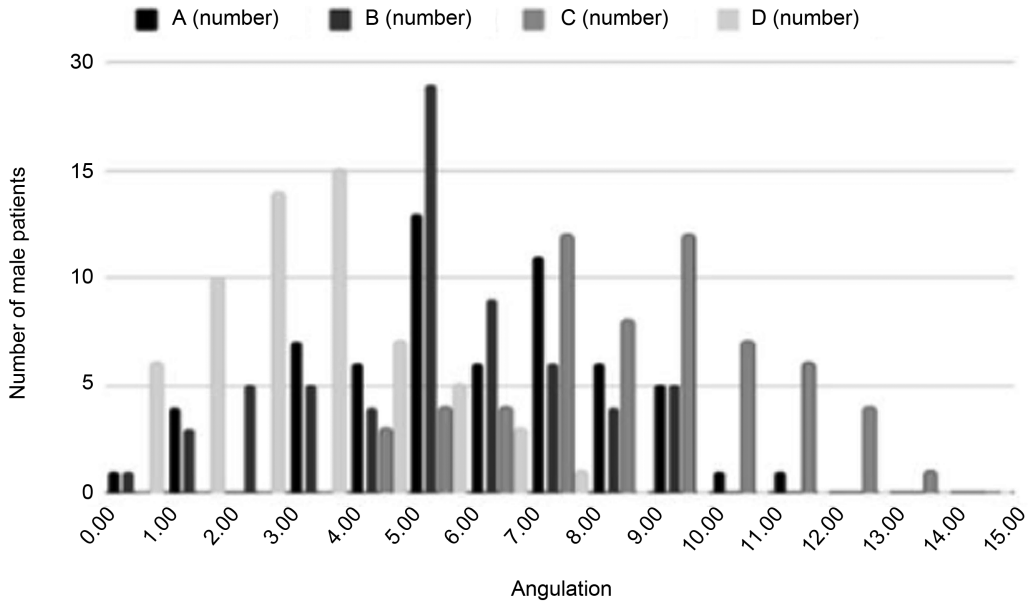


Fig. 3 Graph of the distribution of the rotation angles of the transepicondylar axis regarding each posterior condylar axis measurement (A, B, C, and D) in male patients.

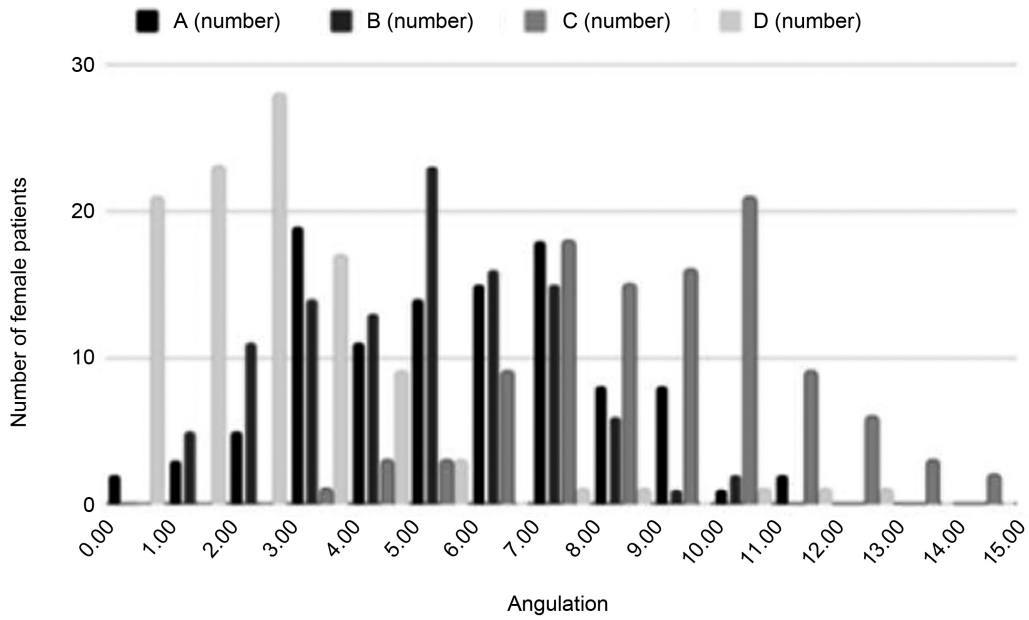


Fig. 4 Graph of the distribution of the rotation angles of the transepicondylar axis regarding each posterior condylar axis measurement (A, B, C, and D) in female patients.

values, in all forms of rotation measurement (A, B, C, D), presented statistically significant differences ($p < 0.0001$) from the universal value of 3° of external rotation used in the standard TKA instrumentation (►**Table 1**). There was no statistically significant difference between male and female patients in any measurement ($p > 0.05$).

Table 1 Angular measurements of external rotation (ER) of the transepicondylar axis (TEA) regarding the posterior condylar axis (PCA) and statistical comparison with the universal value of 3° in total knee arthroplasty

	TEA-PCA external rotation: mean ± standard deviation	*p* versus universal value of 3° of external rotation
Measurement A		
Male sex	5.590° ± 2.404°	
Female sex	5.358° ± 2.391°	
Total	5.443° ± 2.384°	$p < 0.0001$
Measurement B		
Male sex	5.115° ± 2.119°	
Female sex	4.846° ± 2.051°	
Total	4.946° ± 2.097°	$p < 0.0001$
Measurement C		
Male sex	8.334° ± 2.190°	
Female sex	8.698° ± 2.132°	
Total	8.347° ± 2.273°	$p < 0.0001$
Measurement D		
Male sex	2.639° ± 1.684°	
Female sex	2.263° ± 2.213°	
Total	2.335° ± 2.002°	$p < 0.0001$

Among the different measurement methods, based on combinations of bone or chondral limits of the condyles, ANOVA revealed statistically significant differences between the groups ($p < 0.0001$), with a large effect size ($f = 1.02$). Next, we compared each group using the Tukey's (Honest Significant Difference, HSD) test. This test detected statistically significant differences ($p < 0.0001$) for all measurement pairs (A-C, A-D, B-C, B-D, C-D), except for A and B ($p = 0.161$; ►**Table 2**).

Discussion

The most significant finding of the present study is the external rotation profile of the TEA regarding PCA specifically for a Brazilian population, which presents a significant difference to the universal value of 3°. Our results show that using the parameters previously established in the literature, such as 3° of external rotation for the axial positioning of the femoral component, may not be an accurate method for the Brazilian population.

In a pivotal study, Berger et al.[7] demonstrated, in the axial plane, the requirement of approximately 3° of external rotation of the femoral component regarding the plane of the posterior condyles as a landmark. However, the results from this American population do not necessarily reflect the reality of populations with different ethnic compositions. Using similar measurements, Murgier et al.[8] described angles of 6.4° of external rotation in the Asian population. In another study, Pun et al.[9] found 4.6° of rotation for the Indian population. Therefore, given the discrepancy in values presented in the literature according to the ethnic group studied, the surgeon should question whether using

Table 2 Statistical intergroup comparison of different ways of measuring the external rotation of the transepicondylar axis regarding the posterior condylar axis

Comparison	Difference	Standard error	Confidence interval	*p*-value
A-B	0.497	0.1691	−0.119–1.13	0.1614
A-C	3.1257	0.1691	2.5097–3.7418	< 0.0001
A-D	3.1078	0.1691	2.4918–3.7238	< 0.0001
B-C	3.6228	0.1691	3.0067–4.2388	< 0.0001
B-D	2.6108	0.1691	1.9947–3.2268	< 0.0001

anatomical references based on other populations may interfere with the planning for their patients.

In the present study, when the reference for the measurements was the intact chondral and bicondylar bone structures (groups A and B), there were no significant differences between the mean angles of 5.44° and 4.94°. Given the conditions of equal posterior condylar wear, the chance of error in rotational positioning is lower if the surgeon applies an external rotation greater than that traditionally stipulated in the cutting guides, using an approximate value of 5° of external rotation empirically. The results of a previous study by Loures et al.[10] corroborate the need for higher external rotation of the femoral component in the Brazilian population, for they identified a mean value of 6.89°. However, the authors[10] analyzed the PCA with a single measurement.

Specifically regarding the rotational positioning of the femoral component using the PCA and considering the anatomical parameters of the lateral and medial chondral bony prominence of the posterior femoral condyles (group C), we found relevant results for the difference in mean measurements of 8.56°. Thus, one must pay attention to the chondral profile of the posterior femoral condyles for rotational planning of the femoral component when using the condylar support guide. It is worth noting that the findings of the present study may be valuable in lateral posterior chondral wear, which was more prevalent in knees with valgus overload and resembled measurement C in the current study. In this scenario, the approximate mean divergence would be an additional 5° of external rotation regarding the universal empirical value of 3°. This fact would result in the positioning of the femoral component in internal rotation, which would contribute to an increase in lateral patellofemoral conflict and increase retinacular tension and patellar tilt, conditions that favor post-arthroplasty patellofemoral syndrome.[11–14] The resulting non-physiological knee kinematics entails the potential for worse clinical outcomes and postoperative anterior pain.[3–5]

Nam et al.[15] showed that the average thickness of the lateral posterior femoral condyle cartilage is greater than the cartilage thickness of the medial posterior femoral condyle, with an average difference of 0.4 mm. This discrepancy may justify the significant difference in the angular values between the different forms of PCA measurements. In addition, the inequality in the chondral thickness of the femoral condyles in knee osteoarthritis may vary according to limb axis deviations and contribute as a causal factor for the error in determining the PCA.[16] Tashiro et al.[17] and Yang et al.[18], when comparing the chondral thickness in the posterior aspect of the lateral and medial condyles, demonstrated that a thinning of just 2 mm of the cartilage in the lateral condyle can generate divergences of approximately 2° in the rotational alignment of the femoral implant.

The results of the present study provide additional support for the recommendation to use more than one method to measure the rotational positioning of the femoral component to reduce potential alignment errors due to anatomical variations, in addition to potential interobserver differences when defining the anatomical parameters used as landmarks.[19,20]

The current study has some limitations. Limbs with valgus may present hypoplasia of the lateral femoral condyle, and we did not analyze the mechanical axes of the lower limbs, introducing a potential bias. Another limitation is that the group of the Brazilian population studied, in terms of number and age, may not reflect anatomically the entire Brazilian population due to the great ethnic diversity found in Brazil.

Conclusion

Considering exclusively chondral or exclusively bony posterior references, the TEA in the Brazilian population studied presents approximately 5° of external rotation regarding the PCA. Therefore, the empirical application of 3° of external rotation in the femoral component may be insufficient for adequate rotational alignment in the Brazilian population, which may be even more pronounced in genu valgum. Thus, it is critical to consider the need for individualized techniques for optimal rotational positioning of the femoral component to obtain better accuracy.

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

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The Top 100 Most Cited Articles on Anterolateral Ligament: A Bibliometric Analysis and Review

Os 100 artigos mais citados sobre o ligamento anterolateral: Uma análise bibliométrica e revisão

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Abstract

Objectives To conduct a bibliometric analysis aimed at evaluating the 100 most frequently cited articles concerning the anterolateral ligament (ALL).

Methods A thorough search was executed using the Scopus database with the keyword "Anterolateral Ligament." The analysis incorporated technical notes, systematic reviews focusing on clinical outcomes and/or complications, clinical studies, and foundational scientific articles (both cadaveric and biomechanical). Case reports or personal opinion articles were omitted from the review. The 100 articles with the highest citation counts were examined using the Bibliometrix R-package software, which evaluated total citations, study type, country of origin, journal of publication, affiliated institution, and most prolific authors.

Results The 100 articles accumulated 11,192 citations, ranging from 44 to 703 per article. Most articles (69) were published between 2015 and 2017, predominantly focusing on anatomical and biomechanical studies. The United States was the leading country of publication (29%), followed by the United Kingdom (15%), Brazil (14%), France (13%), and Belgium (8%). The top five journals were the American Journal of Sports Medicine (31%), Arthroscopy (17%), Knee Surgery, Sports Traumatology, Arthroscopy (17%), Arthroscopy Techniques (5%), and Skeletal Radiology (4%). The most prolific authors were Sonnery-

Keywords
- bibliometric analysis
- knee
- ligaments, articular
- publications

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Cottet (21), Helito (17), with Musahl, Saithna, and Thaunat each contributing 11 articles. Sonnery-Cottet had the highest citation count, with 2,421.

Conclusion The analysis reveals that research on the ALL is growing, with significant contributions in anatomy and biomechanics. However, further studies are needed to establish the best indications for reconstruction and optimal surgical techniques.

Resumo

Objetivos Este objetivo deste estudo foi realizar uma análise bibliométrica visando avaliar os 100 artigos mais citados sobre o ligamento anterolateral (LAL).

Métodos Uma busca completa foi executada usando o banco de dados Scopus com a palavra-chave "*Anterolateral Ligament*" ("Ligamento Anterolateral"). A análise incorporou notas técnicas, revisões sistemáticas com foco em desfechos clínicos e/ou complicações, estudos clínicos e artigos científicos fundamentais (cadavéricos e biomecânicos). Relatos de caso ou opiniões pessoais foram omitidos da revisão. Os 100 artigos com os maiores números de citações foram examinados com o programa Bibliometrix R-package, que avaliou citações totais, tipo de estudo, país de origem, periódico de publicação, instituição afiliada e autores mais prolíficos.

Resultados Os 100 artigos acumularam 11.192 citações, variando de 44 a 703 por artigo. A maioria dos artigos (69) foi publicada entre 2015 e 2017, com foco predominante em estudos anatômicos e biomecânicos. Os Estados Unidos foram o principal país de publicação (29%), seguidos por Reino Unido (15%), Brasil (14%), França (13%) e Bélgica (8%). Os cinco principais periódicos foram o *American Journal of Sports Medicine* (31%), *Arthroscopy* (17%), *Knee Surgery, Sports Traumatology, Arthroscopy* (17%), *Arthroscopy Techniques* (5%) e *Skeletal Radiology* (4%). Os autores mais prolíficos foram Sonnery-Cottet (21), Helito (17), com Musahl, Saithna e Thaunat contribuíram com 11 artigos cada. Sonnery-Cottet teve o maior número de citações, com 2.421.

Conclusão A análise revela que a pesquisa sobre o LAL está crescendo, com contribuições significativas em anatomia e biomecânica. No entanto, estudos adicionais são necessários para estabelecer as melhores indicações para a reconstrução e as técnicas cirúrgicas ideais.

Palavras-chave
- análise bibliométrica
- joelho
- ligamentos articulares
- publicações

Introduction

The anterolateral ligament (ALL) is a structure that has recently garnered significant attention due to its critical role in knee biomechanics, especially concerning anterolateral rotational stability. Positioned in the anterolateral region of the knee (►**Fig. 1**), the ALL is vital for rotational stability and contributes to limiting anterior tibial translation relative to the femur, albeit to a lesser extent.[1] Its importance becomes particularly evident in the context of anterior cruciate ligament (ACL) injuries, where rotational stability may remain compromised even after successful ACL reconstruction.[2] An injury to the ALL might contribute to the failure of ACL reconstruction, given its crucial role in maintaining knee rotational stability. Therefore, evaluating its integrity is essential in diagnosing and managing knee injuries, especially in patients who experience persistent rotational instability following ACL reconstruction.[3]

Since the first detailed descriptions of the ALL by Helito et al.,[4] Claes et al.,[5] and Vincent et al.[6] in 2012 and 2013, there has been a notable increase in publications focusing on the ligament's anatomy, biomechanical characteristics, radiological markers, clinical outcomes, and complications related to its reconstruction.[1] Bibliometric analyses have emerged as valuable tools to delineate areas of consensus, identify controversial topics, explore research frontiers, and track current trends across various subjects, thereby providing readers with a comprehensive and up-to-date reference. A review of prior bibliometric studies indexed in the Scopus and PubMed databases revealed several analyses related to the reconstruction of tge anterior cruciate,[7] medial patellofemoral (MPFL),[8] and posterior cruciate (PCL) ligaments,[9] as well as of patellar instability.[10] However, to date, no bibliometric analysis has specifically addressed ALL.

Given the growing acceptance of ALL reconstruction as a standard procedure, this study was conducted to identify the 100 most cited articles published. The aim was to conduct a detailed bibliometric analysis aimed at evaluating the 100 most frequently cited articles concerning the ALL.

Materials and Methods

Data Collection and Allocation

A comprehensive search was performed using the Scopus database, which is recognized for its extensive repository of

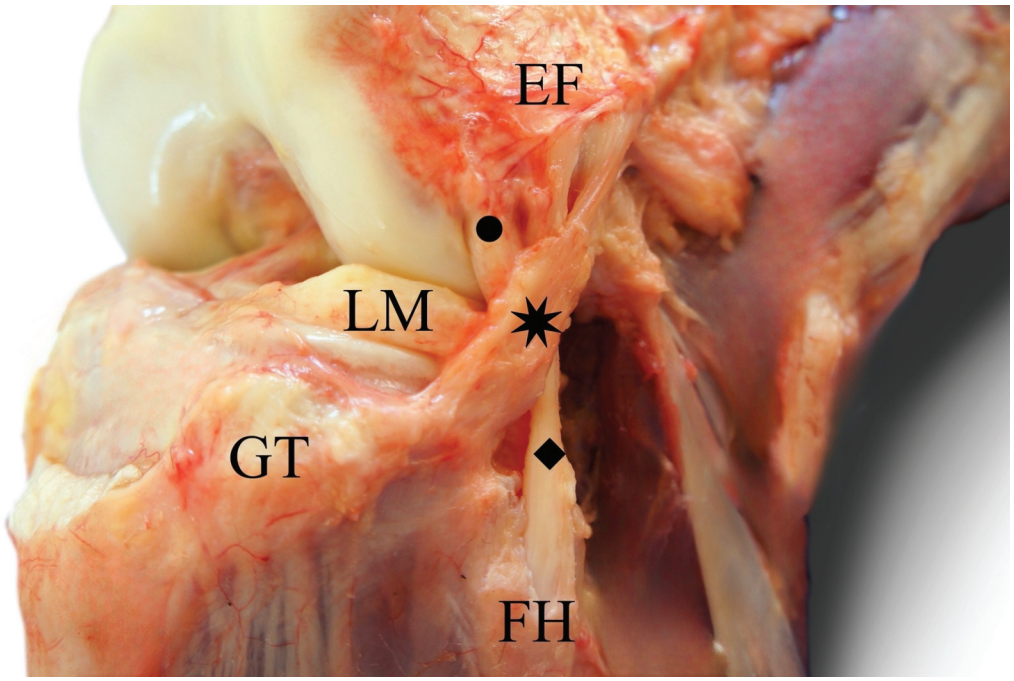


Fig. 1 Anterolateral aspect of the knee, highlighting the relationship between the ALL, Lateral Collateral Ligament, and Popliteus Tendon. **Abbreviations:** FH, fibular head; GT, Gerdy tubercle; LM, lateral meniscus. Source: Ariel de Lima et al.[21]

peer-reviewed scientific articles and detailed citation data, to support this literature review. The search utilized the term "Anterolateral Ligament" across all fields, with the results restricted to English-language publications and no limitations on publication dates. The search included technical notes, systematic reviews focused on clinical outcomes and/or complications, clinical studies, and foundational scientific articles (cadaveric and biomechanical). Case reports and personal opinions were excluded. To enhance accuracy, two of the authors independently selected articles for inclusion. The search was completed in July 2024, yielding 748 articles published since 2000.

These articles were ranked according to citation count, and after excluding those with fewer than 30 citations, 146 articles were retained for further analysis. Titles and abstracts were thoroughly reviewed, and each article was categorized into one of five study types: cadaveric (anatomical and/or biomechanical), clinical, computational/robotic, radiological, and systematic reviews. After excluding irrelevant articles and resolving any disagreements regarding inclusion, a total of 132 articles were retained. The articles defined as "irrelevant/controversial" were those with more than 30 citations but escaped the first filter of exclusion criteria (non-English language, case reports, and personal opinions). The top 100 most cited articles were then organized by citation count for the final analysis (►**Fig. 2**).

Data Extraction

For data analysis, the Bibliometrix R-package software (https://www.bibliometrix.org) was utilized. In July 2024, a file with the ".bib" extension was extracted from Scopus. The full text of all selected articles was reviewed, and data were extracted, including title, author names, journal, year of publication, total number of citations, geographical origin, primary institution involved, and study type. Statistical analyses and data visualization were conducted using R and RStudio (R Foundation for Statistical Computing, Vienna, Austria), both of which are widely recognized open-source statistical software platforms.

Results

The 100 most cited articles on the ALL are detailed in ►**Table 1**. Research on this topic is relatively recent, as evidenced by the publication dates of the earliest articles in 2012[6] and 2013,[5,11] and the small total number of articles identified in our extensive search (748 results). In comparison, a PubMed search for "ACL" yielded over 38,000 results.

The majority (69) of the top 100 articles were published between 2015 and 2017, as shown in ►**Fig. 3**. The total number of citations for these articles was 11,192, with individual citations ranging from 44 to 703. The reduction in the number of top 100 most cited articles after 2017 suggests that citations are concentrated in these earlier publications. Despite an increase in recent ALL research, citations remain predominantly focused on earlier works. Just the first three articles, published in 2012[6] and 2013,[5,11] account for 1,265 citations (11.3%).

Categorizing the articles by study type (clinical, cadaveric, radiological, reviews, and computational studies), cadaveric studies accounted for 33% of the top 100 most cited articles. Of these, 12 were purely anatomical studies, while the remainder were biomechanical. Clinical studies were the second most common category (22%), followed by radiological studies (21%), literature reviews (18%), and computational studies (6%).

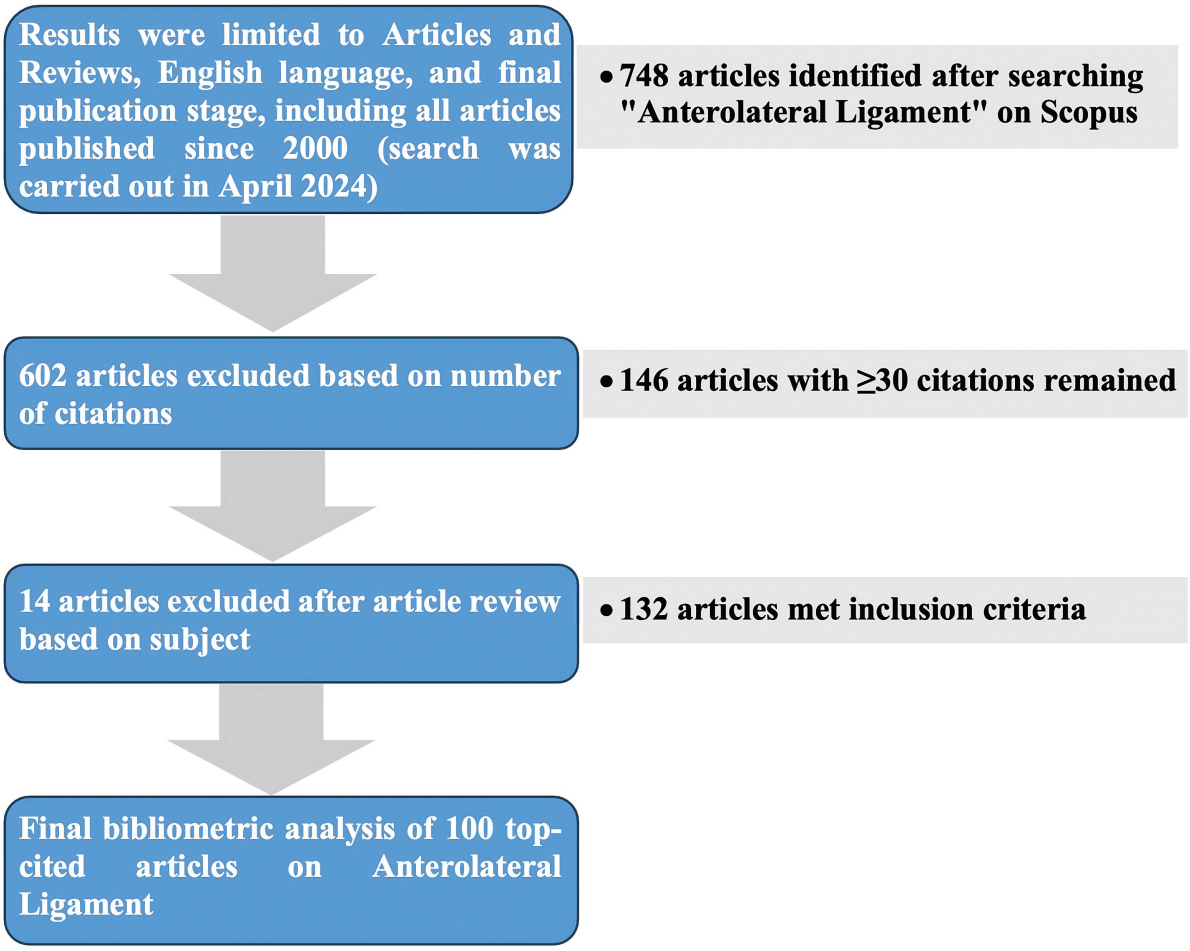


Fig. 2 Flowchart illustrating the article selection procedure for the top 100 most cited articles on ALL.

Table 1 The 100 most cited articles on the ALL

Rank	AU	PY	TI	SO	TC
1	Claes et al.	2013	Anatomy of the Anterolateral Ligament of the Knee	Journal of Anatomy	703
2	Sonnery-Cottet et al.	2015	Outcome of a Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction Technique with a Minimum 2-Year Follow-Up	American Journal of Sports Medicine	360
3	Dodds et al.	2014	The Anterolateral Ligament: Anatomy, Length Changes and Association with the Segond Fracture	Bone and Joint Journal	341
4	Vincent et al.	2012	The Anterolateral Ligament of the Human Knee: An Anatomic and Histologic Study	Knee Surgery, Sports Traumatology, Arthroscopy	337
5	Sonnery-Cottet et al.	2017	Anterolateral Ligament Reconstruction is Associated with Significantly Reduced ACL Graft Rupture Rates at a Minimum Follow-Up of 2 Years: A Prospective Comparative Study of 502 Patients from the Santi Study Group	American Journal of Sports Medicine	332
6	Kennedy et al.	2015	The Anterolateral Ligament: An Anatomic, Radiographic, and Biomechanical Analysis	American Journal of Sports Medicine	297
7	Kittl et al.	2016	The Role of the Anterolateral Structures and the ACL in Controlling Laxity of the Intact and ACL-Deficient Knee	American Journal of Sports Medicine	263

Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
8	Parsons et al.	2015	The Biomechanical Function of the Anterolateral Ligament of the Knee	American Journal of Sports Medicine	257
9	Caterine et al.	2015	A Cadaveric Study of the Anterolateral Ligament: Reintroducing the Lateral Capsular Ligament	Knee Surgery, Sports Traumatology, Arthroscopy	246
10	Helito et al.	2013	Anatomy and Histology of the Knee Anterolateral Ligament	Orthopedic Journal of Sports Medicine	225
11	Getgood et al.	2019	The Anterolateral Complex of the Knee: Results from the International ALC Consensus Group Meeting	Knee Surgery, Sports Traumatology, Arthroscopy	224
12	Rasmussen et al.	2016	An In Vitro Robotic Assessment of the Anterolateral Ligament, Part 1	American Journal of Sports Medicine	218
13	Spencer et al.	2015	Biomechanical Analysis of Simulated Clinical Testing and Reconstruction of the Anterolateral Ligament of the Knee	American Journal of Sports Medicine	198
14	Inderhaug et al.	2017	Biomechanical Comparison of Anterolateral Procedures Combined with Anterior Cruciate Ligament Reconstruction	American Journal of Sports Medicine	195
15	Sonnery-Cottet et al.	2017	Anterolateral Ligament Expert Group Consensus Paper on the Management of Internal Rotation and Instability of the Anterior Cruciate Ligament – Deficient Knee	Journal of Orthopedics and Traumatology	188
16	Sonnery-Cottet et al.	2016	The Involvement of the Anterolateral Ligament in Rotational Cntrol of the Knee	American Journal of Sports Medicine	184
17	Claes et al.	2014	The Segond Fracture: A Bony Injury of the Anterolateral Ligament of the Knee	Arthroscopy – Journal of Arthroscopic and Related Surgery	169
18	Nitri et al.	2016	An In Vitro Robotic Assessment of the Anterolateral Ligament, Part 2	American Journal of Sports Medicine	166
19	Claes et al.	2014	High Prevalence of Anterolateral Ligament Abnormalities in Magnetic Resonance Images of Anterior Cruciate Ligament-Injured Knees	Acta Orthopaedica Belgica	154
20	Kittl et al.	2015	Length Change Patterns in the Lateral Extra-articular Structures of the Knee and Related Reconstructions	American Journal of Sports Medicine	153
21	Schon et al.	2016	Anatomic Anterolateral Ligament Reconstruction of the Knee Leads to Overconstraint at any Fixation Angle	American Journal of Sports Medicine	152
22	Ferretti et al.	2017	Prevalence and Classification of Injuries of Anterolateral Complex In Acute Anterior Cruciate Ligament Tears	Arthroscopy – Journal of Arthroscopic and Related Surgery	152
23	Musahl et al.	2016	The Influence of Meniscal and Anterolateral Capsular Injury on Knee Laxity in Patients with Anterior Cruciate Ligament Injuries	American Journal of Sports Medicine	146
24	Helito et al.	2014	MRI Evaluation of the Anterolateral Ligament of the Knee: Assessment in Routine 1.5-T Scans	Skeletal Radiology	137
25	Daggett et al.	2016	Femoral Origin of the Anterolateral Ligament: An Anatomic Analysis	Arthroscopy – Journal of Arthroscopic and Related Surgery	134
26	Geeslin et al.	2018	Anterolateral Knee Extra-Articular Stabilizers: A Robotic Study Comparing Anterolateral Ligament Reconstruction and Modified Lemaire Lateral Extra-Articular Tenodesis	American Journal of Sports Medicine	130

(*Continued*)

Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
27	Inderhaug et al.	2017	Anterolateral Tenodesis or Anterolateral Ligament Complex Reconstruction: Effect of Flexion Angle at Graft Fixation When Combined with ACL Reconstruction	American Journal of Sports Medicine	126
28	Thein et al.	2016	Biomechanical Assessment of the Anterolateral Ligament of the Knee: A Secondary Restraint in Simulated Tests of the Pivot Shift and of Anterior Stability	Jurnal of Bone and Joint Surgery – American Volume	114
29	Porrino et al.	2015	The Anterolateral Ligament of the Knee: MRI Appearance, Association with the Segond Fracture, and Historical Perspective	American Journal of Roentgenology	113
30	Mackay et al.	2015	A Review of Ligament Augmentation with the Internalbrace™: The Surgical Principle is Described for the Lateral Ankle Ligament and ACL Repair in Particular, and a Comprehensive Review of Other Surgical Applications and Techniques is Presented	Surgical Technology International	103
31	Sonnery-Cottet et al.	2018	Epidemiological Evaluation of Meniscal Ramp Lesions in 3,214 Anterior Cruciate Ligament-Injured Knees from the Santi Study Group Database: A Rist Factor Analysis and Study of Secondary Meniscectomy Rates Following 769 Ramp Repairs	American Journal of Sports Medicine	100
32	Taneja et al.	2015	MRI Features of the Anterolateral Ligament of the Knee	Skeletal Radiology	100
33	Van Der Watt et al.	2015	The Structure and Function of the Anterolateral Ligament of the Knee: A Systematic Review	Arthroscopy – Journal of Arthroscopic and Related Surgery	99
34	Lee et al.	2019	Clinical Outcomes of Isolated Revision Anterior Cruciate Ligament Reconstruction or in Combination with Anatomic Anterolateral Ligament Reconstruction	American Journal of Sports Medicine	99
35	Helito et al.	2017	Assessment of the Anterolateral Ligament of the Knee by Magnetic Resonance Imaging in Acute Injuries of the Anterior Cruciate Ligament	Arthroscopy – Journal of Arthroscopic and Related Surgery	97
36	Helito et al.	2018	Combined Reconstruction of the Anterolateral Ligament in Chronic ACL Injuries Leads to Better Clinical Outcomes than Isolated ACL Reconstruction	Knee Surgery, Sports Traumatology, Arthroscopy	93
37	Helito et al.	2014	Radiographic Landmarks for Locating the Femoral Origin and Tibial Insertion of the Knee Anterolateral Ligament	American Journal of Sports Medicine	91
38	Ibrahim et al.	2017	Anatomic Reconstruction of the Anterior Cruciate Ligament of the Knee with or without Reconstruction of the Anterolateral Ligament: A Randomized Clinical Trial	American Journal of Sports Medicine	91
39	Sonnery-Cottet et al.	2018	Anterolateral Ligament Reconstruction Protects the Repaired Medial Meniscus: A Comparative Study of 383 Anterior Cruciate Ligament Reconstructions From The Santi Study Group with a Minimum Follow-Up of 2 Years	American Journal of Sports Medicine	90
40	Noyes et al.	2017	Is an Anterolateral Ligament Reconstruction Required in ACL-Reconstructed Knees With Associated Injury to the Anterolateral Structures? A Robotic Analysis of Rotational Knee Stability	American Journal of Sports Medicine	89
41	Van Dyck et al.	2016	Anterolateral Ligament Abnormalities in Patients with Acute Anterior Cruciate Ligament Rupture are Associated with Lateral Meniscal and Osseus Injuries	European Radiology	89

Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
42	Helito et al.	2019	Combined Reconstruction of the Anterolateral Ligament in Patients with Anterior Cruciate Ligament Injury and Ligamentous Hyperlaxity Leads to Better Clinical Stability and a Lower Failure Rate than Isolated Anterior Cruciate Ligament Reconstruction	Arthroscopy – Journal of Arthroscopic and Related Surgery	87
43	Helito et al.	2015	Combined Intra- and Extra-Articular Reconstruction of the Anterior Cruciate Ligament: The Reconstruction of the Knee Anterolateral Ligament	Arthroscopy Techniques	86
44	Pomajzl et al.	2015	A Review of the Anterolateral Ligament of the Knee: Current Knowledge Regarding its Incidence, Anatomy, Biomechanics, and Surgical Dissection	Arthroscopy – Journal of Arthroscopic and Related Surgery	83
45	Thaunat et al.	2017	Reoperation Rates After Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction: A Series of 548 Patients from the Santi Study Group with a Minimum Follow-Up of 2 Years	American Journal of Sports Medicine	80
46	Kraeutler et al.	2018	Current Concepts of the Anterolateral Ligament of the Knee: Anatomy, Biomechanics, and Reconstruction	American Journal of Sports Medicine	79
47	Tavlo et al.	2016	The Role of the Anterolateral Ligament in ACL Insufficient and Reconstructed Knees on Rotatory Stability: A Biomechanical Study on Human Cadavers	Scandinavian Journal of Medicine & Science in Sports	79
48	Lutz et al.	2015	Behavior of the Anterolateral Structures of the Knee During Internal Rotation	Orthopedics and Traumatology: Surgery and Research	78
49	Stijak et al.	2016	Anatomic Description of the Anterolateral Ligament of the Knee	Knee Surgery, Sports Traumatology, Arthroscopy	77
50	Musahl et al.	2017	Contributions of the Anterolateral Complex and the Anterolateral Ligament to Rotatory Knee Stability in the Setting of ACL Injury: A Roundtable Discussion	Knee Surgery, Sports Traumatology, Arthroscopy	75
51	Smith et al.	2015	Combined Anterolateral Ligament and Anatomic Anterior Cruciate Ligament Reconstruction of the Knee	Knee Surgery, Sports Traumatology, Arthroscopy	75
52	Imbert et al.	2016	Isometric Characteristics of the Anterolateral Ligament of the Knee: A Cadaveric Navigation Study	Arthroscopy – Journal of Arthroscopic and Related Surgery	74
53	Sonnery-Cottet et al.	2016	Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction	Arthroscopy Techniques	74
54	Rahnemai-Azar et al.	2016	Structural Properties of the Anterolateral Capsule and Iliotibial Band of the Knee	American Journal of Sports Medicine	74
55	Noyes et al.	2017	Rotational Knee Instability in ACL-Deficient Knees: Role of the Anterolateral Ligament and Iliotibial Band as Defined by Tibiofemoral Compartment Translations and Rotations	Journal of Bone and Joint Surgery – American Volume	73
56	Zens et al.	2015	Length Changes of the Anterolateral Ligament During Passive Knee Motion	American Journal of Medicine	72
57	Dephillipo et al.	2017	Anterolateral Ligament Reconstruction Techniques, Biomechanics, and Clinical Outcomes: A Systematic Review	Arthroscopy – Journal of Arthroscopic and Related Surgery	71
58	Chahla et al.	2016	Anterolateral Ligament Reconstruction Technique: An Anatomic-Based Approach	Arthroscopy Techniques	70

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Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
59	Runer et al.	2016	The Anterolateral Ligament of the Knee: A Dissection Study	Knee	69
60	Grassi et al.	2020	Good Midterm Outcomes and Low Rates of Residual Rotatory Laxity, Complications and Failures After Revision Anterior Cruciate Ligament Reconstruction (ACL) and Lateral Extra-Articular Tenodesis (LET)	Knee Surgery, Sports Traumatology, Arthroscopy	69
61	Kosy et al.	2015	Characterization of the Anatomy of the Anterolateral Ligament of the Knee Using Magnetic Resonance Imaging	Skeletal Radiology	67
62	De Maeseneer et al.	2015	Segond Fracture: Involvement of the Iliotibial Band, Anterolateral Ligament, and Anterior Arm of the Biceps Femoris in Knee Trauma	Skeletal Radiology	67
63	Song et al.	2016	Bone Contusions After Acute Noncontact Anterior Cruciate Ligament Injury Are Associated With Knee Joint Laxity, Concomitant Meniscal Lesions, and Anterolateral Ligament Abnormality	Arthroscopy – Journal of Arthroscopic and Related Surgery	66
64	Saiegh et al.	2017	Sectioning the Anterolateral Ligament did not Increase Tibiofemoral Translation or Rotation in an ACL-Deficient Cadaveric Model	Knee Surgery, Sports Traumatology, Arthroscopy	66
65	Herbst et al.	2017	The Anterolateral Complex of the Knee: A Pictorial Essay	Knee Surgery, Sports Traumatology, Arthroscopy	65
66	Rosenstiel et al.	2019	Combined Anterior Cruciate and Anterolateral Ligament Reconstruction in the Professional Athlete: Clinicals Outcomes from the Scientific Anterior Cruciate Ligament Network International Study Group in a Series of 70 Patients with a Minimum Follow-Up of 2 Years	Arthroscopy – Journal of Arthroscopic and Related Surgery	64
67	Inderhaug et al.	2017	The Effects of Anterolateral Tenodesis on Tibiofemoral Contact Pressures and Kinematics	American Journal of Sports Medicine	64
68	Geeslin et al.	2018	Anterolateral Knee Extra-Articular Stabilizers: A Robotic Sectioning Study of the Anterolateral Ligament and Distal Iliotibial Band Kaplan Fibers	American Journal of Sports Medicine	63
69	Cavaignac et al.	2016	Ultrasonographic Identification of the Anterolateral Ligament of the Knee	Arthroscopy – Journal of Arthroscopic and Related Surgery	62
70	Aariel de Lima et al.	2019	Anatomy of the Anterolateral Ligament of the Knee: A Systematic Review	Arthroscopy – Journal of Arthroscopic and Related Surgery	62
71	Delaloye et al.	2020	Anterolateral Ligament Reconstruction and Modified Lemaire Lateral Extra-Articular Tenodesis Similarly Improve Knee Stability After Anterior Cruciate Ligament Reconstruction: A Biomechanical Study	Arthroscopy – Journal of Arthroscopic and Related Surgery	61
72	Williams et al.	2017	The Scientific Rationale for Lateral Tenodesis Augmentation of Intra-Articular ACL Reconstruction Using a Modified 'Lemaire' Procedure	Knee Surgery, Sports Traumatology, Arthroscopy	60
73	Cavaignac et al.	2017	Ultrasonographic Evaluation of Anterolateral Ligament Injuries: Correlation with Magnetic Resonance Imaging and Pivot-Shift Testing	Arthroscopy – Journal of Arthroscopic and Related Surgery	59
74	Sonnery-Cottet et al.	2021	Long-Term Graft Rupture Rates After Combined ACL and Anterolateral Ligament Reconstruction Versus Isolated ACL Reconstruction: A Matched-Pair Analysis from the Santi Study Group	American Journal of Sports Medicine	58

Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
75	Marom et al.	2020	Lateral Extra-Articular Tenodesis Reduces Anterior Cruciate Ligament Graft Force and Anterior Tibial Translation in Response to Applied Pivoting and Anterior Drawer Loads	American Journal of Sports Medicine	58
76	Rezansoff et al.	2015	Radiographic Landmarks for Surgical Reconstruction of the Anterolateral Ligament of the Knee	Knee Surgery, Sports Traumatology, Arthroscopy	57
77	Saithna et al.	2018	Subspecialty Procedures: Combined ACL and Anterolateral Ligament Reconstruction	JBJS Essential Surgical Techniques	57
78	James et al.	2015	Anatomy and Biomechanics of the Lateral Side of the Knee and Surgical Implications	Sports Medicine and Arthroscopy Review	57
79	Musahl et al.	2016	Anterolateral Ligament of the Knee, Fact or Fiction?	Knee Surgery, Sports Traumatology, Arthroscopy	56
80	Sonnery-Cottet et al.	2016	Minimally Invasive Anterolateral Ligament Reconstruction in the Setting of Anterior Cruciate Ligament Injury	Arthroscopy Techniques	56
81	Daggett et al.	2016	Surgical Dissection of the Anterolateral Ligament	Arthroscopy Techniques	54
82	Dombrowski et al.	2016	Macroscopic Anatomical, Histological and Magnetic Resonance Imaging Correlation of the Lateral Capsule of the Knee	Knee Surgery, Sports Traumatology, Arthroscopy	53
83	Helito et al.	2015	Evaluation of the Anterolateral Ligament of the Knee by Means of Magnetic Resonance Examination [Avaliação do ligamento anterolateral do joelho por meio de exame de ressonância magnética]	Revista Brasileira de Ortopedia	53
84	Hartigan et al.	2016	Visibility of Anterolateral Ligament Tears in Anterior Cruciate Ligament-Deficient Knees with Standard 1.5-Tesla Magnetic Resonance Imaging	Arthroscopy – Journal of Arthroscopic and Related Surgery	52
85	Roessler et al.	2016	The Anterolateral Ligament (ALL) and its Role in Rotational Extra-Articular Stability of the Knee Joint: A Review of Anatomy and Surgical Concepts	Archives of Orthopedic and Trauma Surgery	52
86	Bonanzinga et al.	2017	Kinematics of ACL and Anterolateral Ligament. Part I: Combined Lesion	Knee Surgery, Sports Traumatology, Arthroscopy	51
87	Monaco et al.	2019	Correlation Between Magnetic Resonance Imaging and Surgical Exploration of the Anterolateral Structures of the Acute Anterior Cruciate Ligament-Injured Knee	American Journal of Sports Medicine	49
88	Wytrykowski et al.	2016	Cadaveric Study Comparing the Biomechanical Properties of Grafts Used for Knee Anterolateral Ligament Reconstruction	Arthroscopy – Journal of Arthroscopic and Related SurgeryY	48
89	Herbst et al.	2017	The Anterolateral Complex of the Knee	Orthopedic Journal of Sports Medicine	48
90	Helito et al.	2017	Anterolateral Ligament Abnormalities Are Associated with Peripheral Ligament and Osseous Injuries in Acute Ruptures of the Anterior Cruciate Ligament	Knee Surgery, Sports Traumatology, Arthroscopy	48
91	Thaunat et al.	2014	The Arcuate Ligament Revisited: Role of the Posterolateral Structures in Providing Static Stability in the Knee Joint	Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA	48
92	Zens et al.	2015	Mechanical Tensile Properties of the Anterolateral Ligament	Journal of Experimental Orthopedics	48

(*Continued*)

Table 1 (*Continued*)

Rank	AU	PY	TI	SO	TC
93	Sonnery-Cottet et al.	2018	Clinical Outcomes of Extra-Articular Tenodesis/Anterolateral Reconstruction in the ACL Injured Knee	Knee Surgery, Sports Traumatology, Arthroscopy	47
94	Lording et al.	2017	Rotational Laxity Control by the Anterolateral Ligament and the Lateral Meniscus is Dependent on Knee Flexion Angle: A Cadaveric Biomechanical Study	Clinical Orthopedics and Related Research	47
95	McDonald et al.	2017	Passive Anterior Tibial Subluxation in the Setting of Anterior Cruciate Ligament Injuries: A Comparative Analysis of Ligament-Deficient States	American Journal of Sports Medicine	46
96	Cianca et al.	2014	Musculoskeletal Ultrasound Imaging of the Recently Described Anterolateral Ligament of the Knee	American Journal of Physical Medicine and Rehabilitation	45
97	Helito et al.	2016	The Meniscal Insertion of the Knee Anterolateral Ligament	Surgical and Radiological Anatomy	45
98	Musahl et al.	2018	The Anterolateral Complex and Anterolateral Ligament of the Knee	Journal of the American Academy of Orthopedic Surgeons	45
99	Ferretti et al.	2019	High Prevalence of Anterolateral Ligament Abnormalities on MRI in Knees with Acute Anterior Cruciate Ligament Injuries: A Case-Control Series from the Santi Study Group	Orthopedic Journal of Sports Medicine	44
100	Thaunat et al.	2019	Hamstring Tendons or Bone-Patellar Tendon-Bone Graft for Anterior Cruciate Ligament Reconstruction?	Orthopedics and Traumatology: Surgery and Research	44

Abbreviations: AU, authors; PY, year of article publication; Rank, classification in descending order according to the number of citations; SO, journal; TC, total citations; TI, title.

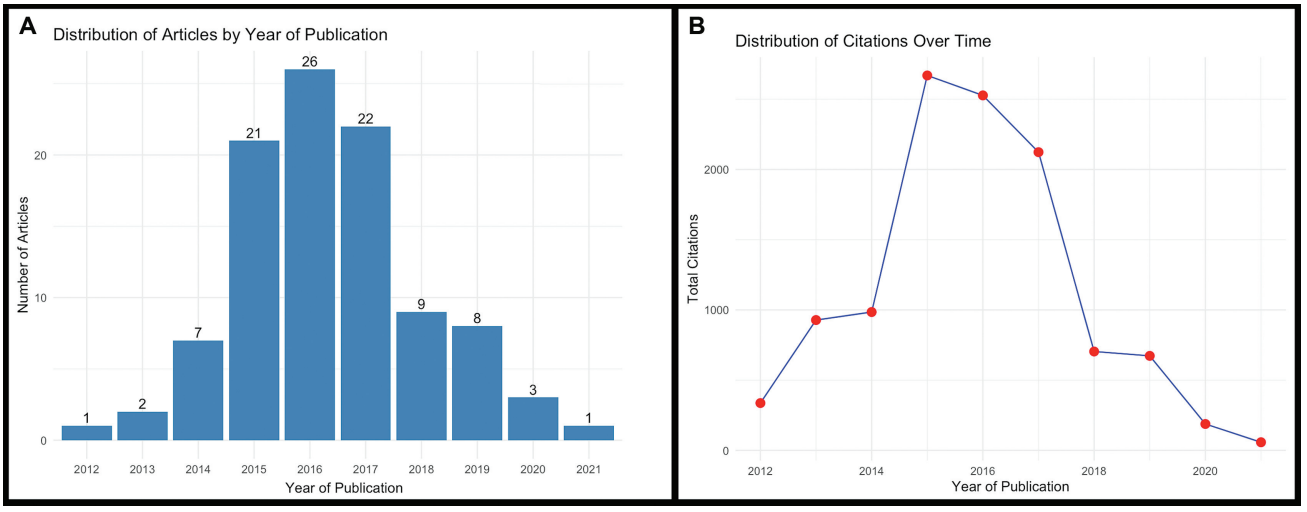


Fig. 3 Distribution of the top 100 most cited articles on the ALL over the years. (**A**) All articles were published between 2012 and 2021. (**B**) Distribution of citations over the years.

An analysis of the articles by country revealed that the United States was the most common country of publication (29%), followed by the United Kingdom (15%), Brazil (14%), France (13%), and Belgium (8%), as shown in ►**Fig. 4**.

Institutions with the most cited articles among the top 100 on ALL include:

- Centre Orthopedique Paul Santy, Lyon, France;
- Institute of Orthopedics and Traumatology, University of São Paulo (IOT-HCFMUSP), São Paulo, Brazil;
- Steadman Philippon Research Institute, Vail, Colorado, United States;
- Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, USA;
- Kansas City University, Kansas City, USA;

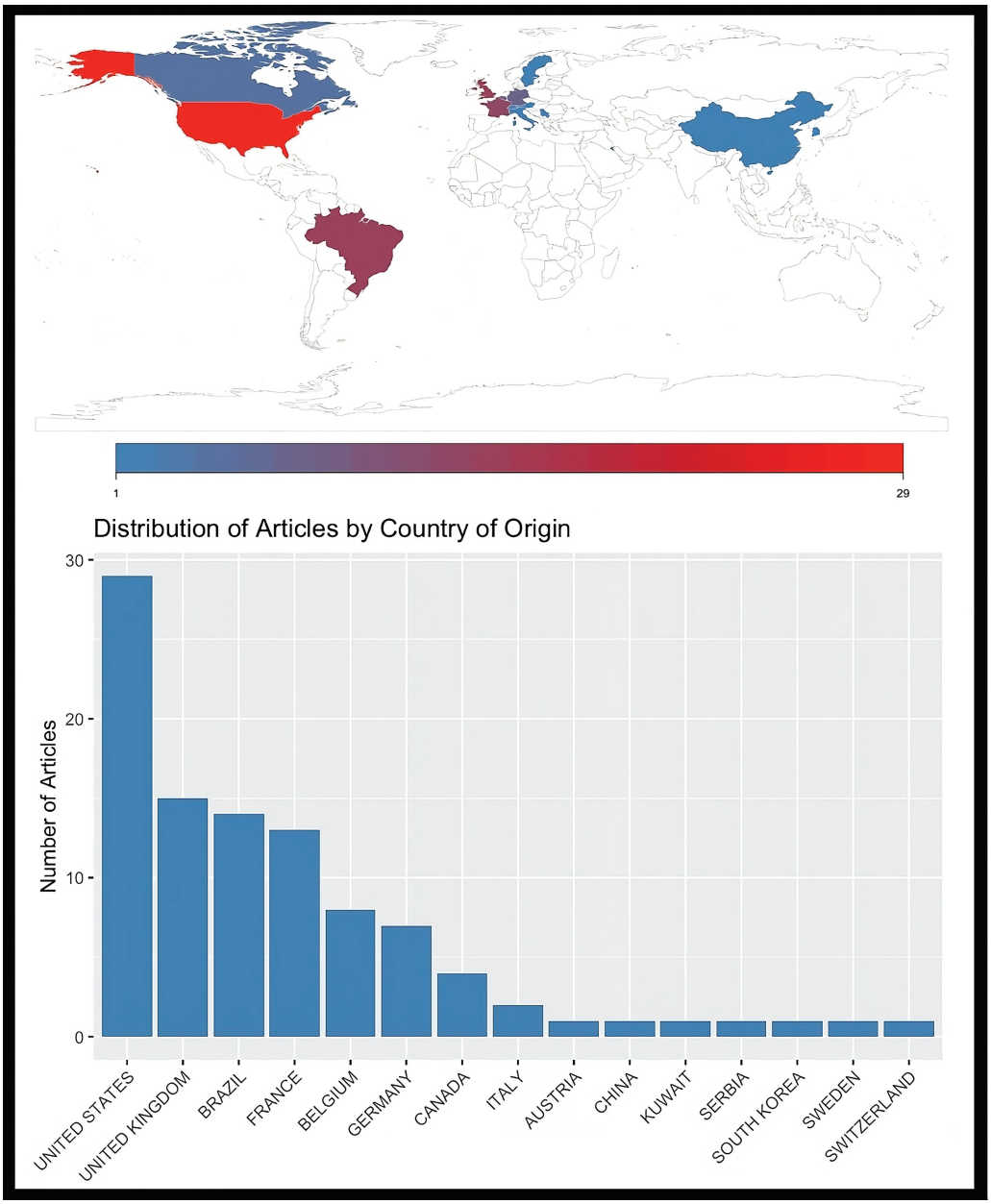


Fig. 4 Distribution of the top 100 most cited articles on ALL according to the country of origin.

- Biomechanics Group, Mechanical Engineering Department, Imperial College London, United Kingdom;
- Ormskirk Hospital, Ormskirk, Lancashire, United Kingdom;
- Department of Orthopedic Surgery & Traumatology, University Hospitals Leuven, Leuven, Belgium;
- Orthopaedic Unit and Kirk Kilgour Sports Injury Center, Sant'Andrea University Hospital, "Sapienza" University of Rome, Rome, Italy;
- Hospital Sírio Libanês, São Paulo, Brazil.

Articles and citations per journal were also analyzed. Regarding the number of top 100 most cited articles, the five journals with the most top 100 published were: American Journal of Sports Medicine (31%), Arthroscopy – Journal of Arthroscopic and Related Surgery (17%), Knee Surgery, Sports Traumatology, Arthroscopy (17%), Arthroscopy Techniques (5%), and Skeletal Radiology (4%).

However, when we analyzed the journals by the number of citations, the order of the journals changed slightly: American Journal of Sports Medicine (4,380 citations), Knee Surgery, Sports Traumatology, Arthroscopy (1,699 citations), Arthroscopy – Journal of Arthroscopic and Related Surgery (1,440 citations), Journal of Anatomy (703 citations), and Skeletal Radiology (471 citations).

Regarding the authors of the top 100 most cited articles on ALL, in terms of the number of articles, we have Sonnery-Cottet (21), followed by Helito (17), and tied in third place with 11 each, Musahl, Saithna, and Thaunat. When considering the number of citations, we have Sonnery-Cottet with

2,421; Claes with 2,170; Helito with 1,935 citations; Williams with 1,501 citations; and closing the top 5 authors with the most citations, Daggett with 1,410 citations (►**Fig. 5**).

Discussion

The research surrounding the ALL has considerable potential, especially in light of the significant advances made since 2012. The top 100 most cited articles on this topic have collectively received 11,192 citations, surpassing the 7,908 citations garnered by the top 50 most cited articles on the PCL since 1975. This count is approximately ⅓ of the 29,629 citations accumulated by the top cited articles on the ACL since 1975, being closely comparable to the 16,358 citations related to the MPFL.[8]

The American Journal of Sports Medicine continues to be the leading journal in terms of the number of highly cited articles, consistent with findings from bibliometric studies on the ACL, PCL, and MPFL. The United States remains at the forefront of ALL research, with significant contributions also coming from the United Kingdom, Brazil, France, and Belgium.

An interesting case is that of the Journal of Anatomy, where its single entry on the list placed this journal among the top 5 most cited, that being Claes et al.[5] with 703 citations, which demonstrates how a single article can have a significant impact and relevance.

Regarding authorship, as depicted in ►**Fig. 5**, the top 10 authors responsible for the most cited articles on the ALL collectively account for 118 publications. This reflects a high level of collaboration among these researchers, underscoring a strong cooperative environment, which is particularly notable given the relatively recent focus on this topic.

In reviewing the latest publications, we identified several key areas of controversy within ALL research, including measurements; trajectory and insertions; function and biomechanics; histology; vascularization; innervation; ultrasound; magnetic resonance imaging; combined reconstruction of the ALL and the ACL.

Measurements of the ALL

Most studies report that the ALL measures between 33.0 and 42.0 mm in length, with this dimension increasing during knee flexion and internal rotation of the tibia. The ligament's width is typically found to be between 4.0 and 7.0 mm, while its thickness ranges from 1.0 to 2.0 mm.[1,4] Daggett et al.,[12] in a comprehensive study involving over 160 specimens, observed that the average thickness of the ALL in men is approximately twice that observed in women.

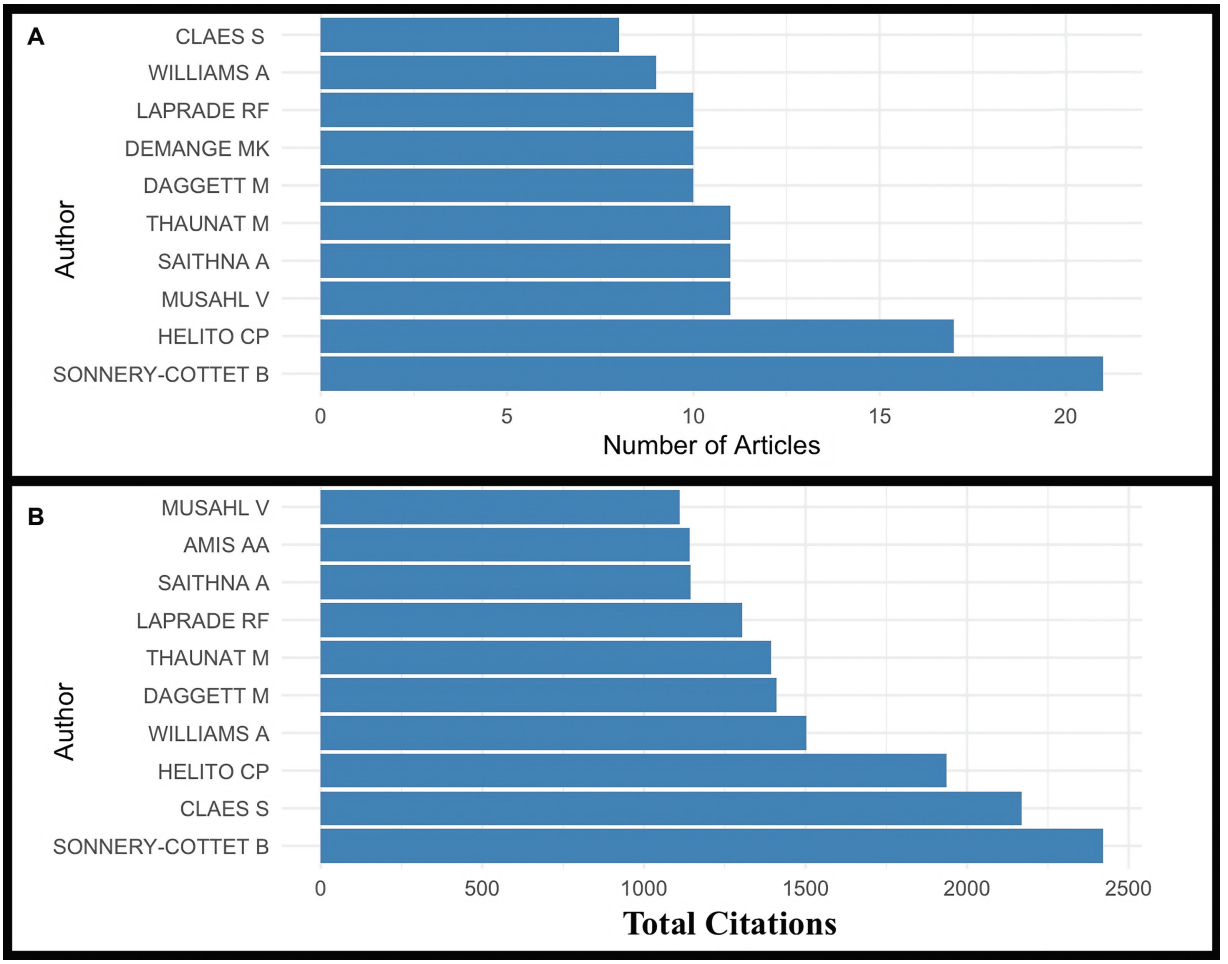


Fig. 5 Distribution of the top 100 most cited articles on ALL. (**A**) Top 10 authors with the most articles on the list. (**B**) Top 10 authors with the most citations.

Trajectory and Insertions of the ALL

The ALL is characterized by three primary attachment points: femoral, tibial, and meniscal. It originates from the femur, near the lateral epicondyle, and follows an anteroinferior path toward the anterolateral aspect of the tibia.[1] The meniscal attachment is positioned between the body and the anterior horn of the lateral meniscus. Before connecting with the meniscus, the ALL fans out, increasing the insertion area.[13,14]

The tibial attachment is located midway between the fibular head and the Gerdy tubercle, approximately 4.0 to 7.0 mm distal to the tibial plateau.[15]

The femoral origin of the ALL shows the most variability among studies, with anatomical landmarks often including the lateral epicondyle of the femur and the origin of the lateral collateral ligament (LCL). Most studies describe the ALL as originating posterior and proximal to the lateral epicondyle.[1]

Function and Biomechanics of the ALL

The primary function of the ALL is to provide anterolateral stability to the knee, helping to prevent anterior and lateral subluxation of the tibia relative to the distal femur.[2] This stabilizing effect is partly attributed to the relatively posterior and proximal insertion of the ALL compared with the LCL.[16]

Histology of the ALL

Histological analysis of the ALL has revealed dense, well-organized collagen fibers, predominantly composed of type I collagen, with an average density of 121 fibroblasts/mm^2 in adults and 1,631 in fetuses, along with vascular tissue consistent with typical ligament morphology.[1]

Macchi et al.[17] described the ALL as being primarily composed of type I collagen (90%), with smaller amounts of III (5%), VI (3%), and minimal elastic fibers (1%). The type I collagen was arranged in parallel, with wavy fibrils surrounded by type VI.

Vascularization of the ALL

Situated within the third layer of the anterolateral aspect of the knee, the ALL is closely associated with the lateral inferior genicular vessels, which are separated by a thin layer of adipose tissue.[17] These vessels are situated between the ALL and the lateral meniscus, serving as an anatomical landmark for identification.[18,19]

Innervation of the ALL

Caterine et al.[20] identified the presence of neurofilament protein within the ALL, suggesting that it is innervated by peripheral nerves. Their research uncovered circular structures that likely correspond to small peripheral nerves or mechanoreceptors. Ariel de Lima et al.,[21] through an immunofluorescence study using protein gene product 9.5, determined that this ligament contains peripheral nerve structures, primarily type I and IV mechanoreceptors. These findings imply that the ALL plays a significant role in proprioception and contributes to the anterolateral stabilization of the knee.

Ultrasonography of the ALL

Cianca et al.[22] and both studies by Cavaignac et al.,[23,24] utilizing ultrasonography, reported a 100% success rate in visualizing the ALL. Oshima et al.[25] found that most segments could be clearly identified, establishing ultrasonography as a valuable tool for diagnosing related injuries. Conversely, Capo et al.,[26] who achieved a 75% visualization rate, noted that ultrasound was not consistently effective in reliably identifying the ligament's tibial and femoral origins.

Magnetic Resonance Imaging of the ALL

The ALL can be visualized on conventional 1.5T magnetic resonance imaging (MRI) scans, particularly on coronal sections and T2-weighted images with fat saturation. The visualization rate can reach up to 97.8%, with the meniscal portion being the most frequently observed (94.8%).[19] Caterine et al.,[20] in a study using 3.0T MRI on cadavers, achieved 100% visualization. However, in many cases, the femoral origin was not distinctly visible on coronal plane images, primarily due to the close association of the ALL with other ligamentous structures. Nevertheless, the tibial and meniscal insertions were identifiable.

Kosy et al.[27] and Helito et al.,[28] in 1.5T MRI studies, reported good results in identifying the meniscal portion of the ALL. Taneja et al.,[29] in contrast, in studies involving both 1.5 and 3.0T MRI, were unable to identify the meniscal insertion.

Combined Reconstruction of the Anterolateral and Anterior Cruciate Ligaments

In a review study, Ariel de Lima et al.,[3] concluded that the main surgical indications for combined reconstruction of the ACL and ALL are: revision surgery, a physical examination with pivot shift grade 2 or 3, participation in sports with a pivot mechanism and/or high levels of activity, ligamentous laxity, and presence of a Segond fracture. Secondary indications may include those aged under 25 years, chronic ACL injury, and radiological signs of lateral femoral condyle depression.

Limitations

Our research included only articles published in English, which means that high-quality studies in other languages may have been overlooked. Furthermore, data collection was limited to the Scopus database, as it is known for its accuracy and extensive coverage, and it allowed us to export citation data; other databases, such as PubMed or the Cochrane Library, were not included in our search. Additionally, our research was restricted to the ligament specifically described as "Anterolateral," potentially excluding relevant studies that refer to it by other names, such as the "Lateral Capsular Ligament" or the "Anterior Oblique Band."

Another limitation arises from the nature of bibliometric research itself, as the articles included may not fully represent the current standard of care and evidence. Despite this, the bibliometric analysis of the top 100 most cited articles on ALL offers a valuable foundation for identifying research

trends and highlighting key research centers. It also provides a curated list of influential articles, serving as essential reading material for researchers and new residents aiming to build upon the existing body of literature on this subject.

Conclusion

This analysis reveals that research on ALL is growing, with significant contributions in anatomy and biomechanics. However, further studies are needed to establish the best indications for ALL reconstruction and optimal surgical techniques.

Authors' Contributions

Each author contributed individually and significantly to the development of the present article: DAL and CPH designed and performed the research and analyzed the data. VPA and SMGC collected the data and contributed equally to the write-up of the manuscript. PBJ and VBCP supervised the write-up of this manuscript. All authors read and approved of the final manuscript.

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Conflict of Interests

The authors have no conflict of interests to declare.

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A Comparative Study of the Medial Parapatellar and Midvastus Surgical Approaches for Total Knee Arthroplasty

Estudo comparativo das abordagens cirúrgicas parapatelar medial e midvasto para artroplastia total do joelho

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Abstract

Objective To compare the postoperative recovery outcomes of total knee arthroplasty (TKA) between the medial parapatellar (MP) and midvastus (MV) surgical approaches, focusing on quadriceps strength, knee motion range, and pain.

Methods This retrospective study included 82 patients with degenerative knee arthropathy who underwent primary TKA. Patients were divided into two groups: one underwent MP and the other MV. Data were collected on quadriceps strength, knee flexion and extension, pain using the visual analog scale (VAS), and the ability to perform functional tasks like walking and stair climbing. Outcomes were assessed at multiple postoperative intervals.

Results Both groups showed improvements in all measured parameters from baseline to the last follow-up, with no significant differences between them in terms of pain and the ability to walk and climb stairs. However, the MV group exhibited statistically significant greater quadriceps strength at the final follow-up.

Conclusion While both surgical approaches provided similar overall recovery outcomes, MV led to greater improvements in quadriceps strength and knee extension, suggesting a potentially quicker functional recovery in the early postoperative period.

Keywords
- arthroplasty, replacement, knee
- knee
- quadriceps muscle
- range of motion, articular

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Resumo

Objetivo Comparar os resultados da recuperação pós-operatória da artroplastia total do joelho (ATJ) entre as abordagens cirúrgicas parapatelar medial (PPM) e midvasto (MV), focando na força do quadríceps, amplitude de movimento do joelho e dor.

Métodos Este estudo retrospectivo incluiu 82 pacientes com artropatia degenerativa do joelho que foram submetidos à ATJ primária. Os pacientes foram divididos em dois grupos: um submetido à PPM e o outro à MV. Foram coletados dados sobre a força do quadríceps, flexão e extensão do joelho, dor utilizando a escala visual analógica (EVA), e a capacidade de realizar tarefas funcionais como caminhar e subir escadas. Os resultados foram avaliados em vários intervalos pós-operatórios.

Resultados Ambos os grupos mostraram melhorias em todos os parâmetros medidos desde a linha de base até o último acompanhamento, sem diferenças significativas entre eles em termos de dor e a capacidade de caminhar e subir escadas. No entanto, o grupo MV exibiu uma força do quadríceps significativamente maior na última avaliação.

Conclusão Embora ambas as abordagens cirúrgicas tenham fornecido resultados de recuperação geral semelhantes, a MV levou a maiores melhorias na força do quadríceps e extensão do joelho, sugerindo uma recuperação funcional mais rápida no período pós-operatório inicial.

Palavras-chave

- amplitude de movimento articular
- artroplastia do joelho
- joelho
- músculo quadríceps

Introduction

Total knee arthroplasty (TKA) is typically performed using the classic medial parapatellar (MP) approach described by Von Langenbeck[1,2] and modified by Insall.[3] This surgical access involves sectioning the quadriceps tendon along the direction of its fibers to gain access to deeper tissues (►**Fig. 1**). Despite the ease and excellent surgical exposure of all structures to be instrumented, a significant blood supply to the patella is interrupted;[2] postoperative recovery is referred to as difficult and often painful, and moreover, the gain in knee flexion is a slow and laborious task in rehabilitation.[4,5]

The MP access, despite its great utility, can function as an important factor in the difficulties encountered during the postoperative rehabilitation period. Thus, the gain in muscle strength, recovery of range of motion, and postoperative pain may be consequences of the choice of surgical access used in TKA.[1,6]

Other surgical approaches, such as the midvastus (MV), described by Engh,[7,8] have been proposed with the aim of reducing postoperative pain, allowing greater preservation of vascularization, improving patellar stability, quadriceps strength, and facilitating rehabilitation (►**Fig. 1**). This surgical approach is performed by splitting the medial vastus from the superior pole of the patella in the direction of its fibers, allowing a theoretically less aggressive approach to the extensor mechanism of the knee by maintaining the integrity of the quadriceps tendon.[2,9] Although some studies have shown that the MV approach is associated with better outcomes regarding pain, functional recovery, and quadriceps strength,[10,11] others have shown limited benefits and no clinical significance.[12,13]

The aim of the present study was to compare the postoperative recovery outcomes of TKA between the MP and MV surgical approaches, focusing on quadriceps strength, knee motion range, and pain.

Materials and Methods

The study commenced following approval by the Research Ethics Committee. There were no conflicts of interest. This was a retrospective study that evaluated 82 patients who underwent primary TKA due to gonarthrosis. The sample excluded cases of prosthesis revision, cases with extreme preoperative deformities (flexion $>20°$, varus $>20°$, and valgus $>25°$), and those who had undergone previous knee surgeries, such as fracture treatments, osteotomies, or patellectomies. Patients with any neurological or muscular pathology, those with systemic diseases that could interfere with the data results, or obese patients (body mass index >40) were excluded.

Pre- and postoperative patient data were used, including sociodemographic, clinical, and functional data. The following information was cataloged:

1) Pain grading using the visual analog scale (VAS);
2) The ability for active leg elevation was assessed at 1, 2, 5 (hospital discharge), and 15 days postoperatively, recorded as a binary variable (Yes or No). The elevation capacity of the operated limb was assessed using the Kendall muscle strength grading scale, converted into percentages through the Likert scale;[14]
3) Knee flexion and extension range of motion was measured using goniometry, presented in degrees, where full knee extension was considered 0°, any extension

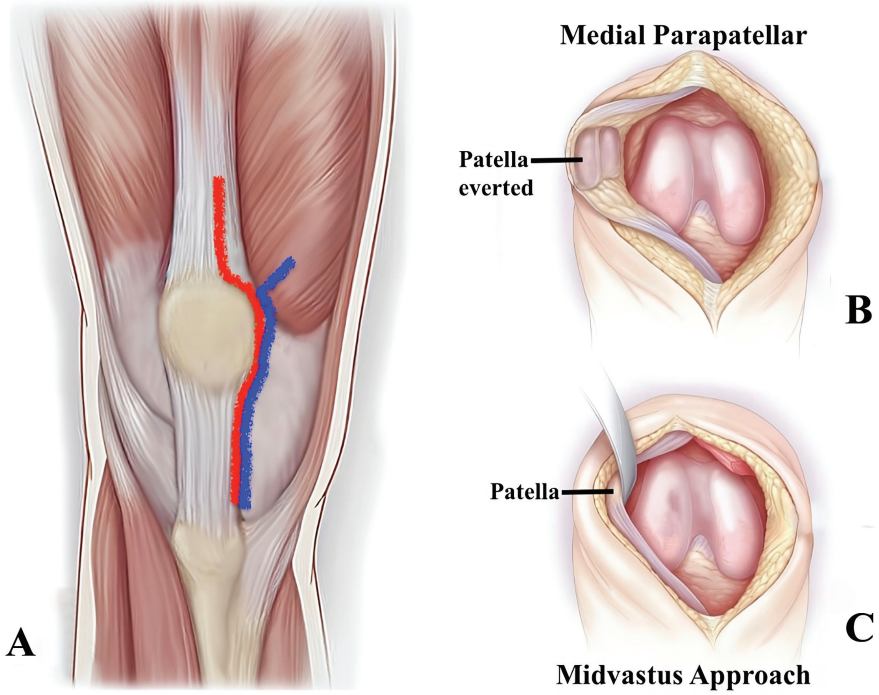


Fig. 1 Medial parapatellar and midvastus surgical approaches for total knee arthroplasty. (**A**) Medial parapatellar (red line) and midvastus (blue line) surgical approaches for total knee arthroplasty. (**B**) Medial parapatellar approach. (**C**) Midvastus approach.

deficit was recorded as a negative value, and hyperextension was recorded as a positive value;

4) Walking ability was considered dichotomously, depending on whether the patient was able or unable to walk with support (crutches or walker);
5) The ability to climb a stair step was assessed at 15, 30, 45, and 60 days postoperatively. It was recorded as a binary variable, based on whether the patient could climb at least one 18 cm step using the strength of the operated limb without assistance from the contralateral limb.

All surgeries were performed in the same hospital by the same surgeon and his team. All patients underwent spinal anesthesia (spinal block) and used a tourniquet for bleeding control. In the postoperative period, all patients followed the same analgesia protocol, underwent physiotherapy, and were discharged around the 5th postoperative day.

The selected TKA patients were divided into two groups: the first group through the MP approach as described by Von Langenbeck,[1–3] and the second through the MV approach as described by Engh.[7,8]

Data were presented in the form of descriptive statistics with mean and standard deviation for continuous variables, or absolute and percentage values for categorical variables. For the statistical analysis of this study, the chi-squared or Fisher's exact tests were used when the assessed variable was nominal. For continuous variables, Student's *t*-test was used, and the nonparametric Mann-Whitney test was employed when necessary. We adopted 0.05 as the significance level. Models were also constructed for the serial comparison of variables: knee extension, muscle strength of the operated limb, and the VAS for pain among the groups. For this analysis, repeated measures analysis of variance (ANOVA) was used.

Results

The sample of this study consisted of 82 patients, divided into the PPM (42 subjects) and MV (40 subjects) groups. The analysis of demographic data was homogeneous between the groups, without any statistically significant difference, except for age, with the MV group patients being slightly older. The other demographic data are found in ►**Table 1**. Over 80% of the data obtained from medical records were considered consistent and reliable and could be used for the purpose of the study.

The ability to elevate the extended limb, to walk, and to climb a step increased progressively in both groups from baseline to the last assessment, with no statistically significant differences in the comparison (►**Table 2**). There was no difference between the groups regarding pain, which showed a trend of improvement ($p < 0.100$) when comparing the last (15 days) and first assessments (►**Table 2**).

Muscle strength gradually increased in both groups during the assessment period, however, initially, there was a trend for greater strength in the MV group ($p < 0.100$) and at the last assessment moment (60 days postoperatively), the MV group had significantly greater strength than the PPM group ($p = 0.006$), as shown in ►**Table 3**. The ANOVA between the groups for quadriceps muscle strength in elevating the operated limb showed a

Table 1 Demographic data

	MP	MV	*p*-value
Gender			0.265
Female	36 (85.7%)	38 (95%)	
Age	65 ± 8.08	69 ± 8.4	
Diagnosis			0.025
Osteoarthritis	41 (97.6%)	37 (92.5%)	
Rheumatoid arthritis	1 (2.4%)	2 (5.0%)	
Osteonecrosis	0	1 (2.5%)	0.475
Side			
Left	22 (52.4%)	20 (50%)	
Right	20 (47.6%)	20 (50%)	0.829
Total	42	40	

Abbreviations: MP, medial parapatellar; MV, midvastus.

slight difference in the graphical analysis in favor of the MV approach. In both groups, there was an improvement in the range of motion, with the deficit in extension tending to be smaller in the MV group at the last assessment (►**Table 3**).

We also used combined outcome analysis to assess the potential for patients from each group to present similar results. For this, we selected the following combined effects at the time of the last assessment: mild pain (VAS $\leq$ 3); being able to climb steps; being able to walk; having knee flexion

Table 2 Postoperative clinical parameters of patients who underwent TKA in the PPM and MV surgical approach groups

Clinical parameter	MP (N = 42)	MV (N = 40)	*p*-value
Elevation			
1 day	16 (38.1%)	20 (50%)	0.497
2 days	26 (61.9%)	28 (70%)	0.726
5 days (hospital discharge)	38 (90.5%)	38 (95%)	0.878
15 days	34 (94%)	35 (97%)	0.999
p-value*	0.042	0.117	
Walking			
2 days	27 (64.3%)	30 (75%)	0.292
5 days (hospital discharge)	42 (100%)	39 (97.5%)	0.488
15 days	35 (97%)	36 (100%)	0.999
p-value*	< 0.001	< 0.001	
Climbing steps			
15 days	1 (3%)	2 (6%)	0.999
30 days	6 (17%)	9 (25%)	0.562
45 days	14 (39%)	15 (42%)	0.999
60 days	23 (64%)	28 (78%)	0.299
p-value*	< 0.001	< 0.001	
Pain (VAS)			
1 day	4.05 ± 2.45	4.18 ± 2.65	1.000
5 days (hospital discharge)	1.90 ± 1.44	2.10 ± 1.90	0.522
15 days	2.72 ± 1.86	2.81 ± 1.52	0.837
p-value*	0.052	0.082	

Abbreviations: MP, medial parapatellar; MV, midvastus; TKA, total knee arthroplasty; VAS, visual analogue scale.
Note: **p*-value within-group, considering the initial moment versus the last assessment.

Table 3 Serial evaluation of postoperative muscle strength and range of motion in the operated limb for the PPM and MV surgical approach groups

Clinical parameter	MP N = 42	MV N = 40	*p*-value
Muscle strength			
1 day	29.44 ± 12.17	35.55 ± 15.94	0.072
2 days	35,56 ± 14.43	38.33 ± 13.83	0.407
5 days (hospital discharge)	47.78 ± 11.98	48.89 ± 12.14	0.697
60 days	68.33 ± 12.07	78.67 ± 13.09	0.006
p-value*	< 0.001	< 0.001	
Range of motion			
Flexion			
1st day	59.83 ± 22.22°	62.78 ± 22.31°	0.579
5 days (hospital discharge)	84.43 ± 13.27°	87.58 ± 9.86°	0.259
30 days	98.80 ± 14.84°	102.69 ± 10.46°	0.205
p-value*	< 0.001	< 0.001	
Extension			
1st day	−10.57 ± 9.45°	−8.11 ± 7.94°	0.239
5 days (hospital discharge)	−3.71 ± 5.81°	−3.31 ± 4.58°	0.743
30 days	−4.69 ± 6.30°	−2.61 ± 3.61°	0.092
p-value*	< 0.001	< 0.001	

Abbreviations: MP, medial parapatellar; MV, midvastus.
Note: * *p*-value within-group, considering the initial moment versus the last assessment.

greater than 90°. Muscle strength was excluded from the combination to avoid bias in favor of one approach, considering that this parameter was significantly better in the MV group. This analysis showed that 11 (26.2%) of the patients in the PPM group presented the combined outcomes versus 20 (50%) in the MV group, with this difference being statistically significant with a *p*-value of 0.026.

The adjusted relative risk (RR) of limb elevation on day-1 postoperatively was 1.31 (confidence interval [CI]: 0.80–2.15), representing a 31% higher probability of elevation on the first postoperative day for patients with MV access. At the time of discharge, this probability (adjusted RR) was 1.05 (CI: 0.93–1.18), representing an effect of 0.5% in favor of the MV access.

Discussion

This study aimed to compare two patient groups undergoing TKA through the MP and MV surgical approaches, assessing parameters such as pain, early quadriceps strength recovery, extended limb elevation capability, and range of knee motion in the immediate postoperative period. Improvement or a trend toward improvement was noted in all measured parameters across both groups, with no statistically significant differences except for a few instances. Notably, the MV group demonstrated significant muscle strength improvement at the final evaluation. These findings suggest that this approach yields comparable results to the MP approach, with added benefits in quadriceps strength.

Although half of the patients in the MV group were able to elevate the extended limb on the 1st postoperative day with a RR of 31%, no significant difference was observed between the two groups at the time of hospital discharge. The ability to walk and climb stairs was similarly comparable between the groups. However, a significant difference was noted in the combined outcomes analysis, favoring the MV group, which showed better levels of pain, knee flexion, walking ability, and stair climbing capability. This suggests that improved combined variable levels might translate into noticeable benefits for basic daily activities involving the lower limb in the early postoperative phase.

Over the past 30 years, various surgical approaches have been proposed for TKA, including the MP, MV, and subvastus approaches.[1] The MV approach, as described by Engh et al.,[7] was introduced as an alternative to the MP approach, with several theoretical advantages such as reduced damage to the extensor mechanism by preserving the quadriceps tendon.[15]

In assessing muscle strength in the operated limb, the ability to elevate the leg with an extended knee was used as a marker of early functional quadriceps recovery. This test's capability immediately postoperative has also been utilized by other authors as an indicator of the return of quadricep function.[4] White et al.[16] reported that patients

undergoing the MV approach had a better ability to elevate the extended leg after eight days postsurgery. A similar observation was made in a prospective study that analyzed outcomes from 24 bilateral TKAs, noting that patients who underwent the MV approach could elevate the extended leg in 1.7 days postoperatively as opposed to 5.2 days in the PPM group.[10]

Bäthis et al.,[11] using an isokinetic dynamometer for late quadriceps strength evaluation, observed better and quicker recovery with the MV approach. Another prospective, randomized, double-blind study utilizing isokinetic evaluation found that quadriceps extension strength was higher in the MV group than in the PPM group three weeks postsurgery; this difference became statistically insignificant after 6 weeks.[12]

The combination of limb elevation capability, quadriceps muscle strength, and improved motion range may collectively facilitate the lower limb function recovery after surgery. Nutton et al.[17] observed earlier recovery of extended limb elevation and crutch-assisted walking in patients undergoing the MV approach, with walking ability enhanced by dynamic balance and quadriceps strength. Maestro et al.,[9] despite noting more preoperative flexion deformities in knees undergoing the MV approach, found better range of motion and greater active extension in these patients postsurgery. The overall improvement in range of motion during the initial weeks postsurgery was confirmed in meta-analyses by Liu et al.[18] and Alcelik et al.,[19] highlighting the primary advantages of the MV over the PPM approach for TKA. Similarly, Aslam et al.[20] needed fewer retinacular releases, could perform the limb elevation test earlier, and observed less extension deficit in the first postoperative week. These literature findings corroborate the results from the combined analysis of this study, reinforcing the hypothesis of potentially earlier functional recovery in the group operated through the MV approach.

Limitations

This study's retrospective nature implies some reliability loss in data obtained from medical records that, in our case, were not digitized. Therefore, any record with erasures, missing pages, or even missing sheets was excluded. As a result, we obtained 80% reliable records. The absence of randomization might have introduced some bias, despite the apparent homogeneity between the groups. Another limitation of the present study was that the comparison of prosthetic component positioning was not performed, as the MV approach generally does not allow the same exposure and ease for positioning guides and making bone cuts. Objective assessments, such as dynamometry or gait analysis, might offer more accurate estimations than subjective clinical evaluations (walking ability, stair-climbing capability, or VAS-graded strength). However, the assessment type used in this study is more applicable in real clinical settings than more complex tests, which might not be routinely feasible in most clinics and hospitals.

Conclusion

While both surgical approaches provided similar overall recovery outcomes, MV led to greater improvements in quadriceps strength and knee extension, suggesting a potentially quicker functional recovery in the early postoperative period.

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

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Closed-Incision Negative-Pressure Wound Therapy in Proximal and Distal Femur Megaprosthetic Reconstructions after Bone Tumor Resections

Terapia de pressão negativa com a ferida encerrada em reconstruções do fémur proximal e distal com megapróteses após ressecções de tumores ósseos

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Abstract

Objective Surgical management for bone tumors is aggressive in nature and frequently followed by wound-related complications (WRCs). To minimize these events, different strategies have been employed, with closed-incision negative-pressure wound therapy (ciNPWT) emerging as a potential adjuvant. With this study we intend to assess the impact of this technique in minimizing WRCs in patients with proximal and distal femur tumors treated with megaprosthesis.

Methods This was an observational retrospective study including 41 participants diagnosed with proximal or distal femur tumors treated with wide resection and reconstruction using a megaprosthesis. Patients were divided into two groups based on the postoperative surgical dressing applied: the vacuum-assisted closure group (VAC) received ciNPWT; and the non-VAC group that received conventional dressings. Data regarding postoperative WRCs and other potential variables of interest were recorded. Statistical analysis was carried out using the IBM SPSS Statistics, version 24.0.

Results There were 20 patients included in the VAC and 21 in the non-VAC group. The majority of patients presented no complications and there were no differences

Keywords
- negative-pressure wound therapy
- neoplasms
- prosthesis
- sarcoma
- surgical wound infection

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between groups in terms of WRCs, including infection. Nonetheless, wound dehiscence and persistent fluid leakage had a positive correlation with the diagnosis of infection, which all together presented correlation with the need for surgical revision.
Conclusion Despite the absence of statistical significance, ciNPWT seems to help minimize wound dehiscence, persistent wound leakage and surgical site infections in patients with proximal and distal femur bone tumors treated with megaprosthesis. Also, wound dehiscence and persistent wound leakage correlate well with surgical site infection, and those three parameters correlate with the need for surgical revision.

Resumo

Objetivo O tratamento cirúrgico de tumores ósseos é agressivo por natureza e frequentemente seguido por complicações relacionadas com a ferida (CRFs). Para minimizar esses eventos, diferentes estratégias foram empregadas e o penso de pressão negativa (*closed-incision negative-pressure wound therapy*, ciNPWT, em inglês) emergiu como possível adjuvante. Neste estudo, pretendemos avaliar o impacto dessa técnica na minimização de CRFs em pacientes com tumores de fêmur proximal e distal tratados com megapróteses.
Métodos Este estudo retrospectivo observacional incluiu 41 participantes diagnosticados com tumores de fêmur proximal ou distal tratados com ressecção alargada e reconstrução com megaprótese. Os pacientes foram divididos em dois grupos com base no penso cirúrgico pós-operatório aplicado: grupo de encerramento assistido por vácuo (VAC), onde foi aplicado ciNPWT; e grupo não-VAC, que recebeu pensos convencionais. Dados sobre CRFs pós-operatórias e outras possíveis variáveis de interesse foram registados. A análise estatística foi realizada recorrendo ao programa IBM SPSS Statistics, versão 24.0.
Resultados Foram 20 pacientes incluídos no grupo VAC e 21 no grupo não-VAC. A maioria dos pacientes não apresentou complicações e não houve diferenças entre os grupos em termos de CRFs, incluindo infecção. No entanto, deiscência da ferida e extravasamento persistente de fluido tiveram correlação positiva com o diagnóstico de infecção que, juntos, apresentaram correlação com a necessidade de revisão cirúrgica.
Conclusão Apesar da ausência de significância estatística, a ciNPWT parece ajudar a minimizar a deiscência da ferida, o extravasamento persistente da ferida e as infecções da ferida operatória em pacientes com tumores ósseos do fêmur proximal e distal tratados com megaprótese. Além disso, a deiscência da ferida e o extravasamento persistente da ferida foram bem correlacionados com a infecção de ferida operatória, e os três parâmetros estão correlacionados com a necessidade de revisão cirúrgica.

Palavras-chave
- infecção da ferida cirúrgica
- neoplasias
- próteses
- sarcoma
- tratamento de ferimentos com pressão negativa

Introduction

Bone reconstruction with megaprosthesis is a common approach after tumor resection or even in trauma or revision surgeries with severe bone loss.[1–4] This is mainly true for juxta-articular primary bone tumors or metastasis affecting the proximal and distal femur, since these are two of the most common places for sarcomas or metastases to arise.[3] Furthermore, for patients presenting significant bone loss in the revision or trauma scenarios, modular megaprosthesis became a valuable way to manage these complex situations.[5,6] They provide the major advantage of modularity, which allows tailoring (to a certain extent) of the implant to the bone defect and patients' need. Additionally, long-term follow-up from these megaprosthesis already proved a reasonable implant survivorship with acceptable function.[7–9]

Despite the notorious improvements regarding patients' preoperative clinical optimization, implants quality, surgical technique, and overall medical support in the perioperative period, surgical approach to resect bone tumors will always imply an aggressive nature, which coupled with patient's clinical complexity and extensive prosthetic reconstruction will increase wound-related complications, including surgical site infections (SSIs) and prosthetic joint infections (PJIs).[10–12]

For primary oncologic implants, the general assumption is that the risk for prosthetic joint infection is around 5 to 10% based on studies with mid-term follow-up.[10,13] However, these numbers can be substantially higher, as highlighted in

the PARITY randomized clinical trial, which reported a SSIs rate of 15 to 16.7%, for patients with bone tumors who underwent reconstruction with megaprosthesis.[14] To aggravate this scenario, infections occurring after bone tumor resection and reconstruction are particularly difficult to eradicate and carry a high risk of amputation, which has been reported to be around 36%.[13,15]

Given all these facts, different strategies are employed in order to minimize infections in musculoskeletal oncology surgery, however, improvements are still needed. In this regard, our working group recently published results from the implementation of close incision negative-pressure wound therapy (ciNPWT) as a postoperative adjuvant method to minimize wound-related complications, in primary or metastatic bone tumors resections.[16] This study demonstrated lesser wound complications, in particular SSIs, for those patients where ciNPWT was used. However, one of the main criticism arrived from the heterogeneity within the cohort, which included several different diagnosis, and most importantly, different reconstructive techniques in a wide range of anatomic locations.[16] In order to better understand the preliminary findings elsewhere published, we promoted a study to assess the impact of ciNPWT as an adjuvant to minimize wound related complications, in patients with primary or metastatic bone tumors, exclusively located in the proximal or distal femur, and exclusively managed with wide resection and reconstruction with megaprosthesis.

Materials and and Methods

Patients

This observational retrospective study included a group of 41 patients diagnosed with localized primary bone sarcomas, bone giant cell tumors (GCT), or solitary metastatic bone disease exclusively located in the proximal or distal femur, with clinical indication for wide resection, between 2012 and 2021. A minimum 24-months postoperative follow-up was applied. All patients were identified from the Orthopedic Department database, and all underwent bone tumor wide surgical resection and reconstruction with modular megaprosthesis (proximal or distal femur) which were performed by one of two orthopedic oncology consultants (JSB or JP).

Patients were divided into two groups based on the postoperative surgical dressing applied: Group A (vacuum-assisted closure, VAC) received ciNPWT, and Group B (non-VAC) conventional dressings. The rational to use ciNPWT was based on the recent data showing that ciNPWT is helpful at reducing risk of wound complications after complex arthroplasty surgery.[17,18]

No case within this cohort received preoperative radiotherapy in the surgical bed, however, patients with some bone sarcomas (in particular osteosarcoma) received pre- and postoperative chemotherapy. Patients with bone metastases received postoperative radiotherapy in the surgical bed, as well as standard medical therapy according to the subtype histology.

Data regarding postoperative wound-related complications, including wound dehiscence, persistent wound leakage, and SSIs, as well as causes for surgical revision within the first 2 postoperative years, were retrieved from patients' medical records. Postoperative complications were described according to Henderson et al.[19]

In line with the standard protocol for musculoskeletal tumor surgery of our institution, surgical drains and perioperative intravenous antibiotics (cefazolin) were used in all patients, maintaining prophylactic antibiotherapy until drain removal, which means during 24 hours after surgery. Also, in order to study any other potential variables capable of promoting wound complications we included for further analysis pre- and postoperative hemoglobin levels and subsequent need for blood transfusion, preoperative total proteins count, preoperative glycemia, and surgical time for each case.

All data were subjected to anonymization in order to protect the privacy and confidentiality of participants. This study followed the ethical standards of the Declaration of Helsinki. Written and informed consent forms for surgical and clinical data collection for scientific purposes were obtained from all patients upon admission and before surgery, according to institutional protocol. A formal approval from our Institutional Review Board was also obtained for this study under number 132/24.

Closed-Incision Negative-Pressure Wound Therapy (ciNPWT) Technique

After tumor resection, skeletal reconstruction with megaprosthesis and adequate soft tissue coverage, a drain is used to minimize risk for seroma and subsequent infection. Afterwords, the skin is closed with individual stitches separated by one centimeter using Ethilon (Ethicon, Inc., Bridgewater, NJ, USA) nylon 2.0 sutures. Vacuum is then applied to the drain and a Mepitel (Mölnlycke Health Care AB, Gothenburg, Sweden) stripe is applied over the closed surgical wound. Then, the negative pressure wound system is initiated, with a pressure value of 120 mmHg (►**Figs. 1**, **2**). The drain is usually removed 24 hours after surgery and negative pressure therapy is maintained during the first postoperative week, being subsequently replaced by a conventional dressing for another week (►**Fig. 2**).

Statistical analysis

The statistical analysis was carried out using the commercial software package IBM SPSS Statistics for MAC OS X (IBM Corp., Armonk, NY, USA), version 24.0. All statistical tests were conducted for a significance level of 5%.

Results

Patients' demographic and clinical features are depicted in ►**Table 1**. For the cohort study of 41 patients, 20 (49%) were included in Group A, VAC; and 21 (51.0%) in Group B: non-VAC. The percentage of male gender was slightly higher for the VAC group, however, the small differences observed between genders were not significant ($p = 0.901$). Also, despite the higher mean age in the VAC group compared with the non-VAC, these differences were not significant ($p = 0.275$) (►**Table 2**).



Fig. 1 Immediate postoperative surgical wound with closed-incision negative-pressure wound therapy (ciNPWT) applied after a distal femur resection and reconstruction with megaprosthesis (**A**). We can also observe the drain in place together with the ciNPWT.



Fig. 2 Postoperative surgical wound of a proximal femur resection and reconstruction with megaprosthesis with ciNPWT applied (**A**), after its removal at 1 week postsurgery (**B**), and with a conventional dressing applied (**C**).

Table 1 Patient demographics and clinical data

		VAC group (N = 20)		Non-VAC group (N = 21)		χ^2 or F	*p*-value
		N	%	N	%		
Gender	Male	8	40	8	38.1	$\chi^2 = 0.016$	0.901
	Female	12	60	13	61.9		
Diagnosis	Bone sarcoma	6	30	8	38.1	F = 2.276	0.319
	Bone giant cell tumor	2	10	5	23.8		
	Bone metastasis	12	60	8	38.1		
Location	Proximal femur	13	65	10	47.6	$\chi^2 = 1.257$	0.262
	Distal femur	7	35	11	52.4		
Pathologic fracture	Yes	11	55	4	19	$\chi^2 = 5.707$	*0.017
	No	9	45	17	81		
Fracture type	Subcapital	1	5	2	9.5	F = 8.137	*0.028
	Supracondylar	3	15	1	4.8		
	Per and subtrochanteric	7	35	1	4.8		
Reconstruction type	Proximal femur megaprosthesis	13	65	10	47.6	$\chi^2 = 1.257$	0.262
	Distal femur megaprosthesis	7	35	11	52.4		
Cement	Yes	12	60	10	47.6	$\chi^2 = 0.631$	0.427
	No	8	40	11	52.4		
Resection	R0	12	60	13	61.9	F = 1.954	0.518
	R1	8	40	6	28.6		
	R2	0	0	2	9.5		

Abbreviations: χ^2, Chi squared; VAC, vacuum-assisted closure. **Note:** $^*p \leq 0.05$.

Table 2 Relation between patients' age and the VAC and non-VAC groups

	VAC group (N = 20)		Non-VAC group (N = 21)		$t_{(39)}$	*p*-value
	M	SD	M	SD		
Age	52.2	16.3	45.8	20.0	1.108	0.275

Abbreviations: M, mean; SD, standard deviation; VAC, vacuum-assisted closure.

Regarding diagnosis, the percentage of bone metastases was higher in the VAC group, with high percentages of bone sarcoma and giant cell tumor within the non-VAC group. Nonetheless, these differences were also not statistically significant ($p = 0.319$). Again, the differences regarding tumor location or reconstruction with megaprosthesis were not significant ($p = 0.262$). Similarly, the use of cemented or uncemented megaprosthesis revealed no significant differences ($p = 0.427$). The percentage of pathologic fractures was higher in the VAC group, presenting statistically significant differences when compared with the non-VAC group ($p = 0.017$).

Regarding the quality of bone tumor resection, the percentage of R0 was similar for both groups, while the percentage of R1 was higher for the VAC group and the percentage of R2 was higher for the non-VAC group. These differences were not statistically significant ($p = 0{,}518$).

Overall, the majority of the cohorts presented no postoperative complications (►**Table 3**). Acute infection, classified as a complication type IVA by Henderson et al.,[19] was observed in 4 cases (19%) within the non-VAC group, while only one case (5%) was recorded in the VAC group. Acute aseptic loosening (class IIA), chronic aseptic loosening (class IIB), mechanical failure of the implant (class IIIA) and local recurrence within the bone (class VA), all had one case each, with all these cases being within the non-VAC group. None of these complications presented significant differences between both groups ($p = 0.083$).

Wound dehiscence and persistent fluid leakage were higher for the non-VAC group, but without statistically significant differences. When analyzing specifically SSIs, which correspond to an acute infection, classified by Henderson et al.[19] as a type-IVA complication, this diagnosis

Table 3 Contingency cross table for the relation between complicationsand the VAC and non-VAC groups

		VAC group (N = 20)		Non-VAC group (N = 21)		F	*p*-value
		N	%	N	%		
Complications[19]	No	19	95.0	13	61.9	6.470	0.083
	Acute infection (IVA)	1	5.0	4	19.0		
	Acute aseptic loosening (IIA)	0	0	1	4.8		
	Chronic aseptic loosening (IIB)	0	0	1	4.8		
	Mechanical failure of the implant (IIIA)	0	0	1	4.8		
	Bone local recurrence (VA)	0	0	1	4.8		
Wound dehiscence	Yes	0	0	3	14.3	3.083	0.232
	No	20	100.0	18	85.7		
Persistent fluid leakage	Yes	0	0	3	14.3	3.083	0.232
	No	20	100.0	18	85.7		
Surgical site infection	Yes	1	5.0	4	19.0	1.888	0.343
	No	19	95.0	17	81.0		
Need for surgical revision	Yes	1	5.0	7	33.3	5.236	*0.045
	No	19	95.0	14	66.7		

Abbreviation: VAC, vacuum-assisted closure. **Note:** $^{*}p \leq 0.05$.

Table 4 Contingency cross table for the relationship between diagnosis of surgical site infection and need for surgical revision

		VAC group (N = 20)		Non-VAC group (N = 21)		F	*p*-value
		N	%	N	%		
Diagnosis of surgical site infection	Yes	1	5.0	4	19.0	1.888	0.343
	No	19	95.0	17	81.0		
Need for surgical revision	Yes	1	5.0	7	33.3	5236	*0.045
	No	19	95.0	14	66.7		

Abbreviation: VAC, vacuum-assisted closure. **Note:** $^{*}p \leq 0.05$.

occurred in 5% of the VAC and 19% of the non-VAC group. Although these differences were also not statistically significant ($p = 0.343$), as shown in ►**Table 4**.

The variable "need for surgical revision" took into consideration all causes for revision within our cohort, meaning that were considered not only wound-related complications, but also any other conditions requiring a new surgical procedure. In this particular setting, the VAC group (5.0%) presented a lower need for surgical revision when compared with the non-VAC group (33.3%), with these differences being statistically significant ($p = 0.045$), as shown in ►**Table 4**.

The analysis of pre- and postoperative chemotherapy, postoperative radiotherapy, pre- and postoperative hemoglobin levels, the need for blood transfusion, the preoperative total proteins count, the preoperative glycemia, and the surgical time, also performed between the VAC and non-VAC groups. In none of those cases statistically significant differences were found (►**Tables 5**–**6**).

A subsequent analysis of the cohort on the relation between all the variables failed to find any relation between the diagnosis of SSI and tumor subtype, anatomic location, presence of pathologic fracture, reconstruction type, the presence or not of cemented megaprosthesis, or quality of resection. However, the presence of wound dehiscence and persistent fluid leakage presented a clear positive correlation with the diagnosis of infection ($p \leq 0.05$), as shown in ►**Table 7**.

Again, the study of the relation between the variables and the need for surgical revision showed how the occurrence of complications, such as acute infection, chronic aseptic loosening, and local recurrence, together with the presence of wound dehiscence or persistent fluid leakage, indicate the need for a new surgical procedure (►**Table 8**).

Table 5 Contingency cross table for the relation between pre- and postoperative chemotherapy, and postoperative radiotherapy

		VAC group (N = 20)		Non-VAC group (N = 21)		χ^2	*p*-value
		N	%	N	%		
Preoperative Ct	Yes	6	30.0	8	38.1	0.299	0.585
	No	14	70.0	13	61.9		
Postoperative Ct	Yes	10	50.0	11	52.4	0.023	0.879
	No	10	50.0	10	47.6		
Postoperative RT	Yes	10	50.0	7	33.3	1.172	0.279
	No	10	50.0	14	66.7		

Abbreviations: χ^2, Chi squared; Ct, chemotherapy; RT, radiotherapy; VAC, vacuum-assisted closure.

Table 6 Contingency cross table for the relation between pre- and postoperative hemoglobin levels, the preoperative total proteins count, the preoperative and surgical time glycemia

	VAC group (N = 20)		Non-VAC group (N = 21)		$t_{(38)}$	*p*-value
	M	SD	M	SD		
Preoperative hemoglobin	12.15	1.76	12.29	1.64	−0.251	0.803
Postoperative hemoglobin	8.64	1.37	9.27	0.99	−1.655	0.106
Preoperative total protein count	6.89	0.62	6.89	0.79	0.022	0.982
Preoperative glycemia	100.55	17.86	103.2	21.03	−0.429	0.670
Surgical time (minutes)	309.0	80.05	285.0	97.47	0.851	0.400

Abbreviations: M, mean; SD, standard deviation; VAC, vacuum-assisted closure.

Table 7 Contingency cross table for the relation between wound dehiscence and persistent fluid leakage and the diagnosis of surgical site infection (SSI)

		SSI diagnosis				F	*p*-value
		Yes (N = 5)		No (N = 36)			
		N	%	N	%		
Wound dehiscence	Yes	3	60	0	0	23.305	*0.001
	No	2	40	36	100		
Persistent fluid leakage	Yes	3	60	0	0	23.305	*0.001
	No	2	40	36	100		

Note: $^*p \leq 0.05$.

Discussion

There is growing evidence for the advantages of using ciNPWT in hip and knee arthroplasties, in order to minimize wound-related complications. These advantages seem clearer for revision arthroplasties and for high-risk patients, when compared to conventional hip or knee prosthetic replacements.[20–23] Consequently, there is an increased use of ciNPWT in such clinical scenarios, whereas conventional dressings are still the standard procedure.

In bone tumor surgery, the evidence is less clear concerning the potential role of ciNPWT. A recent secondary analysis on the PARITY randomized clinical trial studied the impact of drain usage and negative pressure wound therapy as predictors for surgical site infection.[24] The conclusion highlighted that neither the use of postoperative drains nor the use of negative-pressure wound therapy was a predictor of surgical site infection. Batista et al.[25] published a recent study involving patients with malignant bone tumors, who underwent surgical resection and reconstruction with megaprosthesis using ciNPWT. These authors observed both lower rates of SSI and the absence of other complications such as dehiscence and fluid collections.[25]

In this study we observed a higher number of overall complications, wound dehiscence, persistent fluid leakage

Table 8 Contingency cross table for the relation between complications, wound dehiscence and persistent fluid leakage and the need for surgical revision

		Need for surgical revision				F	*p*-value
		Yes (N = 8)		No (N = 33)			
		N	%	N	%		
Complications	No	1	12.5	31	93.9	28.524	*0.000
	Acute infection	5	62.5	0	0		
	Acute aseptic loosening	0	0	1	3.0		
	Chronic aseptic loosening	1	12.5	0	0		
	Mechanical failure of the implant	0	0	1	3.0		
	Bone local recurrence	1	12.5	0	0		
Wound dehiscence	Yes	3	37.5	0	0	13.352	*0.005
	No	5	62.5	33	100		
Persistent fluid leakage	Yes	3	37.5	0	0	13.352	*0.005
	No	5	62.5	33	100		

Note: $^{*}p \leq 0.05$.

and surgical site infection within the non-VAC group, however, the difference towards the VAC group was not statistically significant. As for the need for surgical revision, we observed statistically significant differences between the groups, however, these findings were only possible due to nonwound-related complications reported within the non-VAC group, which included patients treated before 2018, with a higher follow-up and necessarily increased opportunity for mechanical complications to develop. We also found a relation between the diagnosis of surgical site infection and presence of wound dehiscence or persistent fluid leakage within the overall cohort. The same was noted in the need for surgical revision, meaning this could be a consequence due to wound dehiscence, persistent fluid leakage, or SSIs.

Despite the lack of statistical superiority regarding minimizing wound-related complications in this study for cases using ciNPWT, we still found a favorable trend to improve results with this strategy: SSI of 5% within the VAC and 19% in the non-VAC group. This trend reinforces our belief in the advantages of this technique for patients with bone tumors, despite our cohort being limited in size, and needing a higher number of patients to enhance statistical power. Additionally, the results reported from the use of ciNPWT in orthopedic trauma and revisions arthroplasty points it as a valuable adjuvant for reducing risk of surgical site infection, dehiscence or seroma formation.[26,27]

Musculoskeletal oncologic surgical procedures are particularly prone to infectious complications given the need for particularly wide dissections, complex bone and soft tissue reconstructions, significant blood loss, and prolonged surgical times.[28] To this day, the cornerstone for minimizing postoperative infections rate is perioperative antibiotic prophylaxis, but it seems insufficient given the high number of infections after tumor resections and reconstructive surgery.[15]

Furthermore, there is still a lack of consensus regarding antibiotic prophylaxis after tumor resection and reconstruction with megaprosthesis, with the PARITY randomized clinical trial failing to prove differences between surgical site infection rate using different antibiotic regimens.[14] Despite this gap in knowledge, there are still few studies exploring options to improve postsurgical infection rates in musculoskeletal oncology. While ciNPWT is a promising option, it still has a very limited number of studies comparing the outcomes. Herein, we failed to prove with statistical significance the advantage of this technique in minimizing wound-related complications and, in particular, surgical site infections. However, we observed how the presence of wound dehiscence and persistent fluid leakage correlates with infection, and how these three parameters indicate the need to promote a new surgical procedure.

The authors acknowledge this study presents some limitations, such as its retrospective nature, low number of patients included, and some heterogeneity regarding the types of malignancy affecting the bone, which can all generate relevant bias in interpretation of the results. It is of utmost importance to promote multicentric prospective studies capable of generating more robust evidence in a larger population. Our working group is pursuing that goal and with time, we hope to better clarify the role of ciNPWT in malignant bone tumor surgery.

Wound-related complications and SSIs in particular have a potential catastrophic impact on patients with megaprosthesis after bone tumor resections. As such, measures capable of reducing these complication rates are urgently needed and all opportunities to improve results should be considered. The ciNPWT have showed a relevant potential in different settings including for musculoskeletal oncology surgery.[29–31] In our opinion, the findings herein presented still favor this strategy as an adjuvant to prevent wound-

related complications and infection after proximal and distal femur bone tumor resection and reconstruction with megaprosthesis.

Conclusion

Despite the reduction in wound dehiscence, persistent wound leakage, and surgical site infections when ciNPWT is used, there is a lack of statistical significance within the differences observed. Nonetheless, it seems clear that the presence of wound dehiscence and persistent wound leakage correlates well with surgical site infection; while wound dehiscence, persistent wound leakage, and surgical site infection correlate with the need for surgical revision.

There is a need for further prospective, multicentric, randomized studies to clarify the role of ciNPWT in the management of this cohort, as well as to measure the impact in preventing wound-related complications.

Authors' Contributions

JSB contributed to study conception and design, data analysis and interpretation, writing, and tables organization. All the remaining authors also made substantial contributions to study conception, data analysis, and revision.

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Conflict of Interests

The authors have no conflict of interests to declare.

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The Impact of COVID-19 Social Isolation on Physical Activity and Sedentary Behavior in Brazilian Children and Adolescents

O impacto do isolamento social da Covid-19 na atividade física e no comportamento sedentário de crianças e adolescentes brasileiros

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Abstract

Objective To measure the impact of social isolation on physical activities and sedentary behavior in Brazilian children and adolescents. To assess whether factors such as age, gender, days of week, type of housing, and the population of the city also had an impact.

Methods The study was approved by the Medical Ethics Committee, and consent from parents was obtained. A Google Form (Google LLC, Mountain View, CA, USA) was sent to parents by email and WhatsApp (Meta Platforms Inc., Menlo Park, CA, USA). Parents answered the C-PAQ.PT questions for two different periods of time, one month before and during social isolation.

Results There was a statistically significant reduction in the mean physical activity ($p < 0.001$) and an increase in the mean sedentary activities ($p < 0.001$) on weekdays and weekends during social isolation. There was a greater reduction in basketball, handball, and running in the 10 to 14-year-old group, as well as playing in the playground in the 5-to-9-year-old group. There was a statistically significant decrease in the practice of tag and cycling, respectively, among females and males. We did not observe statistically significant differences between types of housing and the number of inhabitants in the city.

Conclusion The C-PAQ.PT allowed a quantitative assessment to identify the variations in physical activities and sedentary behaviors during social isolation. We have observed that only two physical activities were impacted by gender. The changes were not influenced by the number of inhabitants in the city or the type of housing.

Keywords

- adolescent
- children
- COVID-19
- exercise
- surveys and questionnaires

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Resumo

Objetivo Este estudo mediu o impacto do isolamento social nas atividades físicas e no comportamento sedentário de crianças e adolescentes brasileiros e avaliou a influência de fatores como idade, sexo, dias da semana, tipo de moradia e população da cidade.

Métodos O estudo foi aprovado pelo Comitê de Ética Médica e o consentimento dos pais dos participantes foi obtido. Um *Google Form* (Google LLC, Mountain View, CA, EUA) foi enviado aos pais por *e-mail* e WhatsApp (Meta Platforms Inc., Menlo Park, CA, EUA). Os pais responderam às perguntas do *Children's Physical Activity Questionnaire* em sua versão em português (C-PAQ.PT) duas vezes, um mês antes e durante o isolamento social.

Resultados Houve redução estatisticamente significativa na média de atividade física ($p < 0,001$) e aumento na média de atividades sedentárias ($p < 0,001$) nos dias úteis e finais de semana durante o isolamento social. Houve maior redução em basquete, handebol e corrida no grupo de 10 a 14 anos, assim como em brincar em parquinhos no grupo de 5 a 9 anos. Houve diminuição estatisticamente significativa na prática de pega-pega e ciclismo, respectivamente, entre meninas e meninos. Não observamos diferenças estatisticamente significativas entre os tipos de moradia e o número de habitantes na cidade.

Conclusão O C-PAQ.PT permitiu uma avaliação quantitativa para identificação das variações nas atividades físicas e comportamentos sedentários durante o isolamento social. Observamos que apenas duas atividades físicas foram impactadas pelo sexo dos participantes. As mudanças não foram influenciadas pelo número de habitantes da cidade ou pelo tipo de moradia.

Palavras-chave

- adolescente
- Covid-19
- criança
- exercício físico
- inquéritos e questionários

Introduction

On January 30, 2020, and March 11, 2020, respectively, the World Health Organization declared the coronavirus disease 2019 (COVID-19) infection a global public health emergency and pandemic. Many countries have implemented a series of control measures to prepare for and respond to COVID-19. To prevent the disease from spreading, complete or partial lockdowns were instituted. Social measures, including movement restrictions, the closure of schools and businesses, social isolation, and international travel restrictions, were implemented to prevent the introduction and limit the movement of the virus.[1]

One way to assess the level and frequency of physical activity in children outside the school environment is through the use of accelerometers, which act as movement sensors. This is a method that allows you to collect information immediately, at low cost, and with great applicability, considering different contexts and practices of physical activity.[2] In a situation of social isolation, the use of an accelerometer for this research was practically impossible. For this reason, we conducted a literature search to identify alternative methods that could enable the evaluation of the degree and frequency of physical activity among children outside the school setting without compromising social isolation. Self-report questionnaires may still be the only feasible way to assess physical activity in many situations and for aspects that are not easily measured objectively.[3] Questionnaires have been proposed for different age groups and have been validated by comparing questionnaires with the concomitant use of accelerometers.[4–6]

The proliferation of web-based epidemiological studies employing online recruitment techniques is increasing; however, the optimal approach to maximize recruitment rates remains uncertain.[7]

Although there are studies performed in Brazil[8] and systematic reviews,[9,10] there is a lack of quantitative assessments of the impact of social distancing on physical activity and sedentary behavior in children. The primary objective of this study was to identify and quantify whether physical activities and sedentary behavior underwent modifications in comparison to pre-pandemic levels in children and adolescents during the period of social isolation. Secondary objectives were to investigate whether changes were influenced by age, gender, type of day of the week or weekend, housing (vertical or horizontal), and the number of inhabitants in the city.

Materials and Methods

The cross-sectional observational study was approved by the Medical Ethics Committee under number CAAE: 31168920.6.0000.5505. It required the participation of volunteers, such as parents or guardians, who had personal relationships with the researchers and answered the questions. An informed consent form was included prior to the questionnaire to inform all parents or guardians that they would consent to participate in the research by clicking on an

"I want to participate" item. We included answers from parents or guardians who live with children of both genders, aged from 5 to 14 years old, and who live in a city and have experienced social isolation due to the COVID-19 pandemic. We included answers from parents or guardians who live with children of both genders. Questionnaires' answers were excluded if repeated.

Questionnaire

We used Google Forms (Google LLC., Mountain View, CA, USA) to specifically develop a questionnaire for the purpose of this investigation. We have employed a translation and cross-cultural adaptation of the children's physical activity questionnaire (C-PAQ)[11,12] to Portuguese.[13] This included 49 questions regarding physical activities and sedentary behaviors. The answers were straightforward and could be completed within a few minutes.

There were two situations where the parents or guardians were asked to participate. The first was based on the activities performed by children and adolescents about a month before social isolation. The second was based on the activities performed by children and adolescents upon receiving the form during social isolation. In addition to the questionnaire's answers, we also requested the children's identification data, the city of residence, and the type of housing. The survey was distributed to 350 parents or guardians through electronic mail and WhatsApp (Meta Platforms Inc., Menlo Park, CA, USA) between June 1st, 2020, and June 15, 2020.

To perform the analysis, the children were divided into two types of housing: apartment (vertical) or house (horizontal) and cities with more than or less than 500,000 inhabitants. The age range was chosen because it is the most common among Brazilian elementary and middle school students, and was divided into two age groups: 5 to 9 and 10 to 14-years-old.

Statistical Methodology

We used the Wilcoxon test to evaluate the differences between before and during the lockdown. The chi-squared test was used to determine whether or not the variables were dependent or associated with each other. Each comparison was associated with a *p*-value. For this statistical analysis, the following were used: the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, USA) version 20.0, Minitab 16 (Minitab Inc., State College, PA, USA), and the Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA).

Results

Among the 171 completed forms, 35 were excluded due to a lack of information that prevented data analysis. In total, 136 forms were analyzed. Regarding age, the groups were aged from 5 to 9 and 10 to 14-years-old, being comprised of 70 and 66 children, respectively. The groups of those living in apartments and houses were comprised of 52 and 84 children, respectively. Regarding gender, 66 children were female, 65 were male, and 5 were not identified by their parents. We received questionnaires from residents of 27 cities, distributed across eight states of Brazil. Regarding the size of the city, 102 children lived in cities with over 500,000 inhabitants, 32 with less than 500,000 inhabitants, and two children did not inform where they lived.

►**Fig. 1** shows the 45 activities that had a variation in the number of children and adolescents upon comparing before and during social isolation. Of which 17 and 28 were considered physical and sedentary activities, respectively. There was a significant reduction in the number of practitioners, total time, and frequency of activities such as basketball, dodgeball, soccer, handball, fights, capture-the-flag, running, swimming lessons, swimming for fun, riding a bicycle, playing in the playground, tag, physical education class, walking to school, and going by car or bus to school (►**Fig. 2**). Activities that were performed indoors had a significant increase in total time and frequency despite lacking a significant increase in the number of participants in drawing and painting activities, playing with toys indoors, board/card games, games on electronic devices, sitting and chatting, browsing the internet, and watching videos/television (►**Fig. 3**). Some activities were practiced only by a few children, which resulted in a high degree of uncertainty in the estimates.

The frequency and duration of each activity were categorized to determine the number of minutes each activity was practiced throughout the weekdays and weekends, before and during the pandemic. The categorization of his behavior was based on the average frequency (number of times per week) and average intensity (period), as shown in ►**Table 1**. We obtained the mean time practiced by participants in all activities by multiplying frequency by intensity. Therefore, the time spent practicing activities before and during the pandemic on weekdays and weekends was compared. For this analysis, we will only consider responses from participants who cited practice both before and during the pandemic. Thus, we have the condition of paired data, that is, when the same participant is the researcher and controls themselves.

During periods of social isolation, there was a reduction in the duration of physical activity and a rise in sedentary behaviors, both on weekdays and weekends. During weekdays, the mean physical activity before and during social isolation was 197.0 and 153.4 minutes, respectively ($p < 0.001$). On weekends, the average physical activity before and during social isolation was 192.1 and 149.4 minutes, respectively ($p < 0.001$). On weekdays, the mean sedentary activities before and during social isolation were 268.1 and 393.3 minutes, respectively ($p < 0.001$); on weekend days, they were 251.8 and 346.2 minutes, respectively ($p < 0.001$), as shown in ►**Table 2**.

During social isolation, there was a reduction in activities that can be performed outdoors in groups or related to school activities and an increase in the frequency and amount of participation in sedentary activities that were performed indoors. In the 10 to 14-year-old group, there was a greater reduction in basketball, handball, and running; whereas in the 5 to 9-year-old group, there was a greater reduction in playing in the playground. There was a statistically significant decrease in tag and cycling practices among females and males, respectively. In most activities, there were no statistically significant differences between different types of

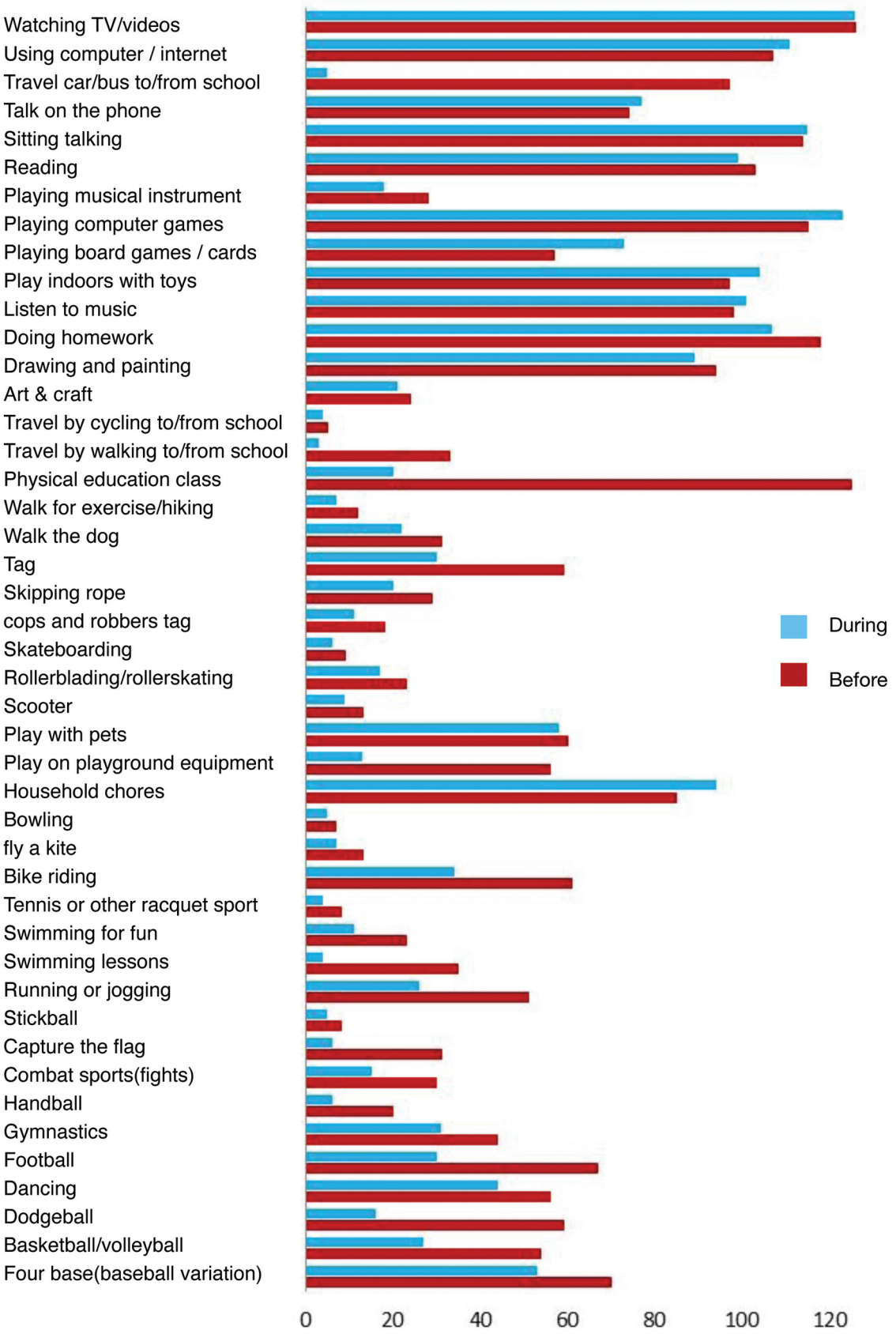


Fig. 1 The content of the graph depicts the number of children and adolescents engaged in each activity prior to and during social isolation.

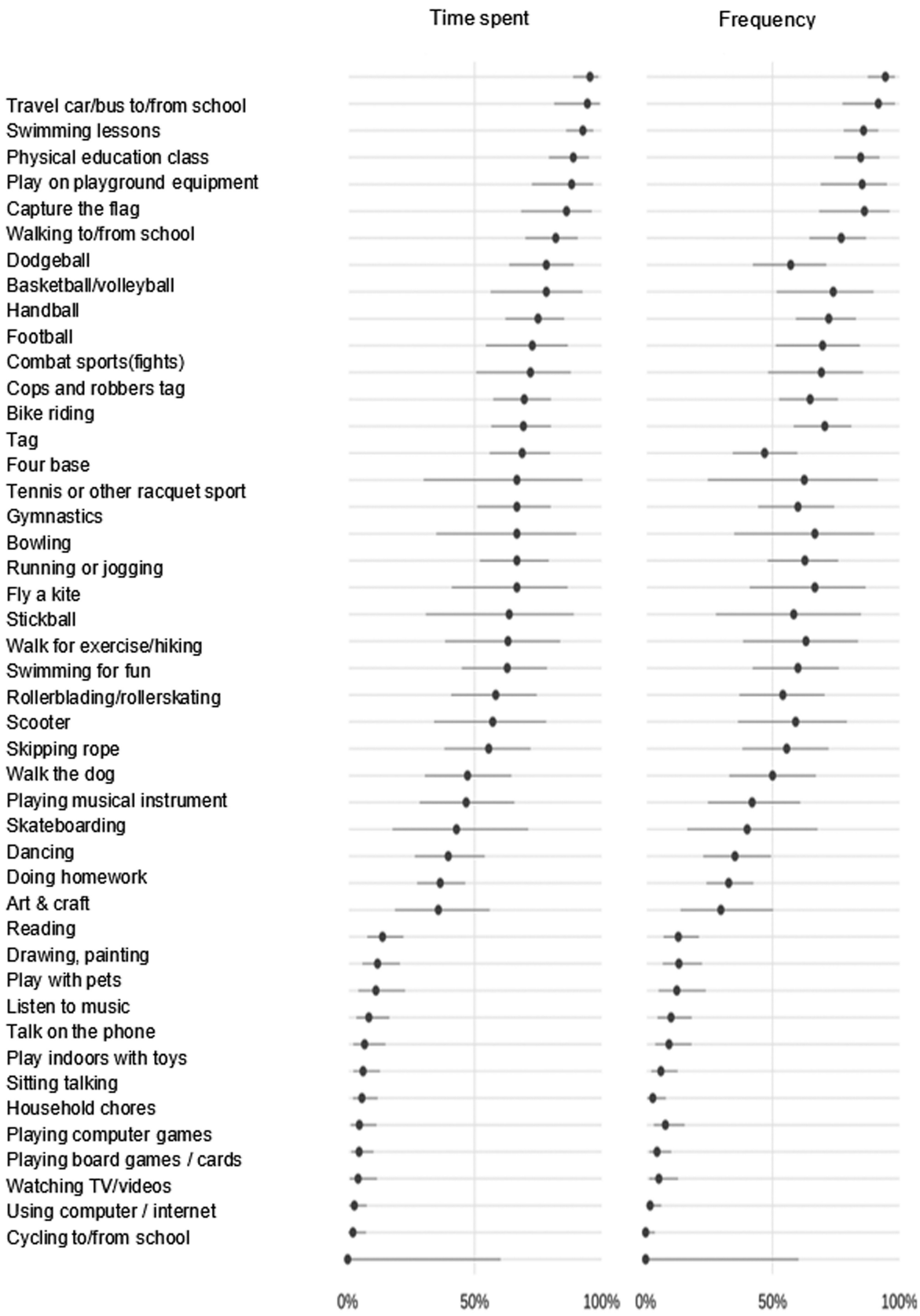


Fig. 2 The contents of the spreadsheet indicate the reduction rate of time spent and frequency of each activity.

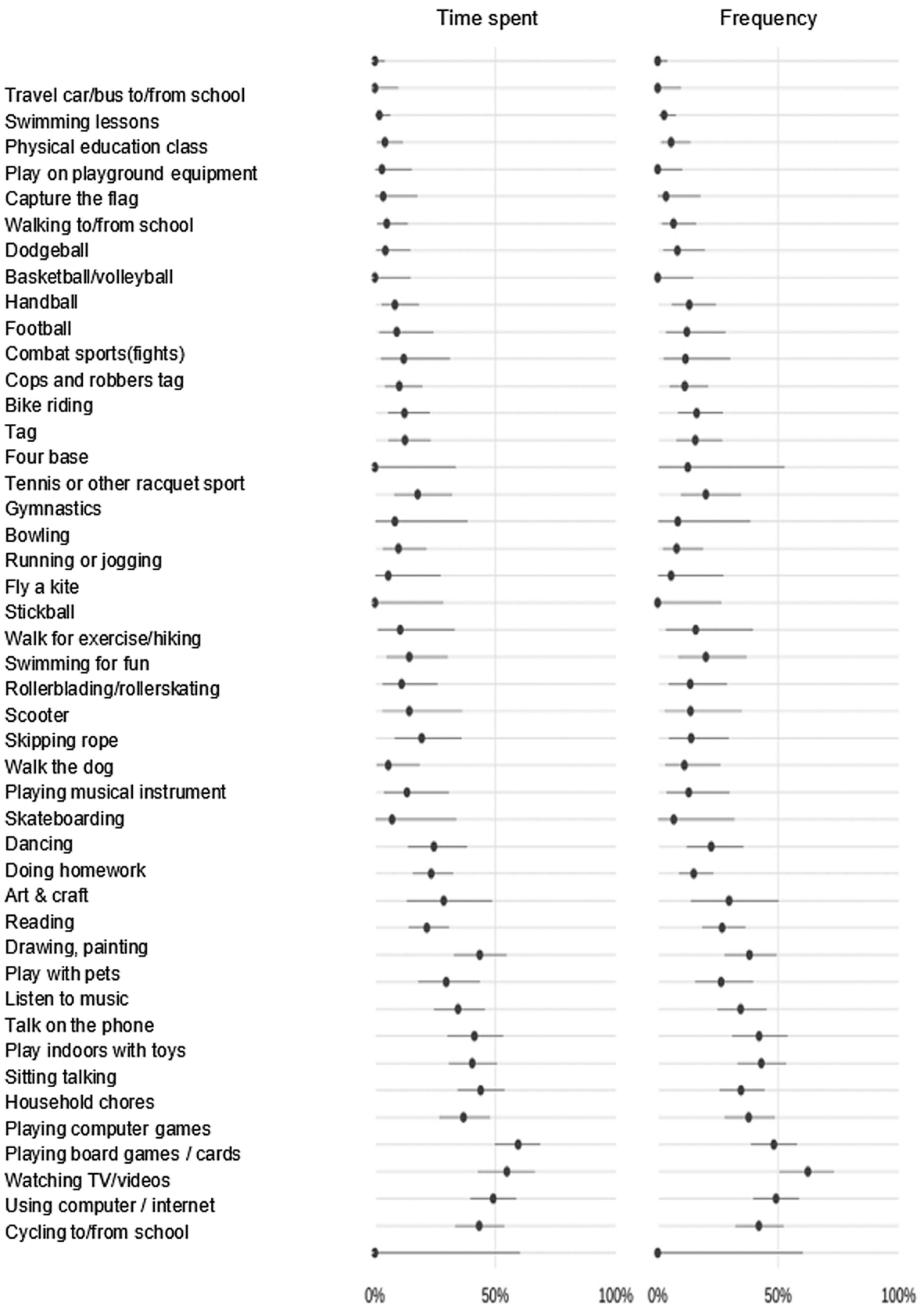


Fig. 3 The contents of the spreadsheet indicate an increase in the rate of time spent and frequency of each activity.

Table 1 The behaviors were categorized based on frequency (number of times per week) and intensity (period)

Frequency	Categorization
1–2 times	1.5
3–4 times	3.5
5 or more times	5
Intensity	
1–30 minutes	15
31–60 minutes	45
61–180 minutes	120
More than 180 minutes	240

housing. As for the frequency, only the activities of playing with toys indoors and watching television/videos had a difference between the groups. Although the difference in the reduction of these activities was statistically significant, their values are small, and the activities had relatively little reduction in the sample as a whole. The number of inhabitants of the city had no statistical significance, meaning that it did not influence changes in the activities of children and adolescents.

Discussion

The diminution in the frequency and intensity of physical and sedentary activities among children during social isolation resulting from the COVID-19 pandemic may have an impact on the habit of sustaining a healthy life, including the postural balance in children.[14]

Self-reported questionnaires were used on a large scale to evaluate and monitor physical activity in children and adolescents. The C-PAQ is a tool that can be downloaded from the website (https://www.mrc-epid.cam.ac.uk/wp-content/uploads/2014/08/CPAQ.pdf), and the questionnaire was previously validated.[12] Due to its characteristics, we considered it a good tool to evaluate the impact of social isolation due to the COVID-19 pandemic on the activities of children and adolescents living in Brazil. The translation and cultural adaptation of a self-assessment questionnaire enabled the use of instruments to compare groups with different languages and cultures, which is very useful in clinical practice.[15–17] The eight activities exchanged for Brazilian culture showed a high response rate. Due to the speed of the turnover and consistency of answers, we considered that the C-PAQ was easy to understand and complete by parents/legal guardians (►**Supplementary Appendix 1**, online).

A scoping review was conducted in 84 studies, and the main determinants of children's physical activity during the pandemic were age, gender, socioeconomic background, and outdoor environment.[18] Guam et al.[19] demonstrated the concern about sedentary lifestyles in children caused by the COVID-19 pandemic and proposed solutions for physical activities at home. Dunton et al.[20] studied the early effects of the pandemic on physical activity and sedentary behavior in children living in the United States. They provided alerts for increased risk of obesity, diabetes, and cardiovascular disease in children and suggested that programmatic and policy strategies should be geared toward promoting physical activities and reducing sedentary behaviors over the following 12 months.[20] Moore et al.[21] described the immediate collateral consequences of the COVID-19 outbreak, which demonstrated an adverse impact on the movement and play behaviors of Canadian children (5–17-years-old). The results indicated that families spent less time on physical activities and spent more time on sedentary behaviors. Some parents have reported adopting new hobbies or accessing new resources.[21] We found a decrease in physical activity and an increase in sedentary activity, which was similar to previous studies. However, after using C-PAQ-PT in our study, we were able to quantify the changes in the intensity and frequency of physical and sedentary activities.

The quantification of changes caused by social distancing in activities was considered a strong point of our study. We have also identified some weaknesses, such as the potential limitations of a survey conducted through the internet.[22] Although subjective or self-reported measures have proven to be a promising means of gathering information, they do have their limitations.[23] As compared with other studies, the number of children studied was relatively small.[24–26] Another factor that may have influenced the results was that all questionnaires were answered by parents with some relationship with the researchers.

Table 2 A comparison of the duration of physical activity prior to and during the pandemic (Wilcoxon test)

Social isolation			Mean	Median	SD	Q1	Q3	N	CI	*p*-value
Physical activity	Week	Before	197.0	67.5	262.4	22.5	180.0	273	31.1	< 0,001
		During	153.4	52.5	270.5	22.5	157.5	273	32.1	
	Weekend	Before	192.1	67.5	304.9	22.5	180.0	177	44.9	0,019
		During	149.9	22.5	282.2	22.5	157.5	177	41.6	
Sedentarism	Week	Before	268.1	157.5	352.5	22.5	420.0	1,378	18.6	< 0,001
		During	393.3	157.5	414.6	52.5	600.0	1,378	21.9	
	Weekend	Before	251.8	67.5	354.4	22.5	420.0	1,143	20.5	< 0,001
		During	346.2	157.5	412.6	22.5	600.0	1,143	23.9	

Abbreviations: CI, confidence interval; Q1, first quartile; Q3, third quartile; SD, standard deviation.

Regarding gender, Sá et al.[24] indicated that differences between sexes among 816 children were found with regards to screen play time (boys > girls) and playing without physical activity (girls > boys). In our study, we did not find significant differences, except in two activities, where we observed a decrease in the practice of tag and cycling among girls and boys, respectively.

Siegle et al.[8] described a decrease in the levels of physical activity, with no difference between the three age groups (3–5, 6–9, and 10–12 years) among Brazilian children during social isolation. In our study, the 10 to 14-year-old group had significantly greater participation in sports than the 5 to 9-year-old group. This difference may be related to the activity in physical education classes at school. Meanwhile, the group of 5 to 9-years-old can carry out activities in smaller spaces, with fewer children.

When analyzing the daily activities of children during restriction according to the type of house, Zagalaz-Sánchez et al.[26] found that the time dedicated to physical activity of those who live in a house with a garden and in apartments with more than 121 m^2 was greater than that of those living in flats less than 60 m^2. Pombo et al.[27] confirmed that children with outdoor spaces in the household were significantly more active. We were unable to reproduce these results in our study, and did not find a statistically significant difference between residents of different types of housing.

A systematic review and meta-analysis performed by Pfledderer et al.[28] provided evidence that disparities in physical activity and health outcomes existed between urban and rural youth. Another study demonstrated that the presence of a park with free space for physical activity near the local residence was associated with a lower BMI among adults.[29] Based on these studies, we believed that the children included in our study who lived in smaller cities (< 500,000 inhabitants) would be less impacted than children who live in big ones (> 500,000 inhabitants); however, no significant differences were found.

The social withdrawal due to the COVID-19 pandemic has caused a significant reduction in activities that can be performed outdoors, in groups, or related to school activity in children and adolescents. In addition to having fewer, less-demanding activities performed indoors, this may be a significant indicator of a reduction in the level of physical activity in children during the period of social isolation induced by COVID-19, which may have an impact on orthopedic practice. Raitio et al.[30] observed a significant decrease in surgical procedures due to injuries related to daily, school, and sports activities performed by children during the period of social isolation. In an Italian trauma center,[31] the number of pediatric patients decreased by 84.6% in this period; there were no observed cases of trauma related to injuries at school or high-energy lesions. A sedentary lifestyle in children is associated with obesity, which in turn is associated with orthopedic complications during growth and development.

As for the impact on sports medicine, recovery efforts will be necessary to ensure the survival and threats of youth sports in the future.

Physical activities in the elderly are important for reducing physiological changes taking place on the locomotor apparatus.[32] For these reasons, the authors believe that future studies should include both children and the elderly.

Conclusion

The use of C-PAQ-PT allowed a quantitative assessment to identify there was a reduction in the time for physical activities and an increase in the time for sedentary behaviors. During the week and on weekends, children and teenagers in Brazil are more isolated than they were before the pandemic.

Furthermore, only two physical activities were influenced by gender. The changes occurred in physical activities and sedentary behaviors, which were more common for each age group. The number of inhabitants in the city and type of housing did not influence changes.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Assessment of the Pennation Angle of the Medial Gastrocnemius Muscle in Road Runners and Non-runners

Avaliação do ângulo de penação do músculo gastrocnêmio medial em corredores de rua e não corredores

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Abstract

Objective To evaluate the pennation angle (PA) of the medial gastrocnemius muscle (MGM) in orthostasis and bilateral maximum plantar flexion (BMPF) in road runners and non-runners.

Methods We assessed 31 runners and 31 non-runners from both genders between January and April 2019. We measured the MGM's PA on both sides by ultrasound during orthostasis and BMPF.

Results The groups were homogeneous regarding the dominant side, gender, and age. During orthostasis, the mean right-sided PA was 19.46° in runners and 22.5° in non-runners ($p < 0.004$). On the left side, the mean PA was 20.79° in runners and 22.83° in non-runners ($p < 0.029$). During BMPF, the right-side PA was 40.06° in runners and 40.89° in non-runners, and, on the left side, the mean PA was 40.01° in runners and 40.52° in non-runners. The MGM's PA of the right limb from male runners was statistically significantly higher in orthostasis ($p < 0.029$) and BMPF ($p < 0.045$). The correlation between MGM in orthostasis and BMPF in the leg in each group was statistically significant in the right lower limb of non-runners.

Conclusion Road runners presented a significantly lower MGM's PA than non-runners in orthostasis.

Keywords
- motor activity
- muscle contraction
- muscle, skeletal
- sedentary behavior
- ultrasonography

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Resumo

Objetivo Avaliar o ângulo de penação (AP) do músculo gastrocnêmio medial (MGM) em ortostatismo e flexão plantar máxima bilateral (FPMB) em corredores de rua e não corredores.

Métodos Foram avaliados 31 corredores e 31 não corredores, de ambos os gêneros, entre janeiro e abril de 2019. O AP do MGM foi mensurado em ambos os lados por meio de ultrassom durante ortostatismo e apoio em flexão plantar máxima bilateral.

Resultados Os grupos foram considerados homogêneos quanto ao lado dominante, gênero e idade. Durante o ortostatismo, os corredores apresentaram no lado direito um AP médio de 19,46° em comparação a 22,5° dos não corredores ($p < 0,004$) e no lado esquerdo apresentaram um AP médio 20,79° para corredores versus 22,83° para não corredores ($p < 0,029$). Durante a FPMB, os corredores apresentaram no lado direito um AP médio de 40,06° em comparação a 40,89° dos não corredores e no lado esquerdo apresentaram um AP médio 40,01° para corredores versus 40,52° para não corredores. O AP do MGM do membro direito em corredores do gênero masculino foi estatisticamente significante maior, tanto em ortostatismo ($p < 0,029$) quanto em FPMB ($p < 0,045$). A correlação entre ortostatismo e FPMB do MGM da perna em cada um dos grupos demonstrou ser estatisticamente significante no grupo de não corredores para o membro inferior direito.

Conclusão Os corredores de rua apresentaram um valor significativamente menor do AP do MGM em relação aos não corredores em ortostatismo.

Palavras-chave

- atividade motora
- comportamento sedentário
- contração muscular
- músculo esquelético
- ultrassonografia

Introduction

Running started in prehistoric times when humans needed to move quickly to hunt or escape predators. Running, even for 5 to 10 minutes per day and at slow speeds (< 9.65 km/h), is associated with significantly reduced risk of death from all causes and, specifically, from cardiovascular disease. The present study may motivate healthy but sedentary subjects to start and continue running to achieve substantial mortality reduction benefits.[1]

Human muscle architecture has been studied in cadaveric specimens. However, scarce data are available on living human muscles.[2–4] Skeletal muscle tissue has properties that determine its characteristics and performance, such as excitability, contractility, extensibility, and elasticity.[5] The mechanical properties of skeletal muscle account for its performance, such as strength, length, speed, work, and power.[6]

The pennation angle (PA) of the muscle fiber is the angle between the muscle fascicle and the intramuscular tendon, that is, the vertical inclination of the muscle fibers from the long muscle-tendon axis.[5,7,8] The fiber PA is a crucial functional feature of the muscle and varies according to the muscle contraction intensity and fiber length.[9] Muscle contraction causes fibers to shorten, increasing the PA.[9,10] Ultrasound allows accurate measurements of the length or PA of a muscle fascicle.[10–12]

Muscle pain in the posterior region of the lower limb is a common complaint among runners.[13,14] Of all calf muscle injuries, 58 to 65% involve the medial gastrocnemius muscle (MGM), 8 to 38% affect the lateral head of the gastrocnemius, and 58 to 66% involve the soleus.[14] We believe that ultrasonographic studies of muscle architecture can support further research on the treatment and prevention of muscle injuries.

The objective of the current study was to compare the PA differences in the MGM in orthostasis and bilateral maximum plantar flexion (BMPF) in runners and non-runners.

Materials and Methods

The Research Ethics Committee approved the present study under CAAE 02582718.0.0000.5505, opinion number 3.115.229. This study was clinical, observational, cross-sectional, and comparative.

The study included volunteers aged 18 to 60 years old. The non-runner group included subjects who had not practiced physical activity for over a year. The road runner group included those who ran for more than a year at least twice a week and five kilometers per week. We did not include subjects with musculoskeletal injuries, neuromuscular diseases, prostheses, acute or chronic pain in the lower extremities, cognitive disabilities, malignant diseases, or pregnancy.

The study participants completed a questionnaire, and their body mass index (BMI) was calculated as the ratio between weight (in kilograms) and the square of their height (in meters).

A physician specialized in musculoskeletal imaging and an orthopedist supervised the ultrasound examinations.

Images were obtained with a real-time ultrasound, model HD 11(Philips Medical Systems, Amsterdam, Netherlands), with a 9-MHz linear transducer and an acoustic coupling gel.

To capture the image in the maximum cross-section area of MGM, the transducer was in a longitudinal position to the tibia, parallel to the muscle fascicles, and perpendicular to the skin in the upper third of an imaginary line from the flexion crease of the popliteal fossa to the center of the medial malleolus.[10,15] As described by Narici et al.,[11] for the orthostatic examination, the volunteers remained in orthostasis with their feet parallel to the sagittal axis and the hip and knee in maximum extension (►**Fig. 1A**).

We asked the study participants to stand up and actively and gradually increase the force until BMPF for image capture on one leg (►**Fig. 1B**), followed by a gradual relaxation for five seconds. Next, we instructed them to perform the same maneuver for image capture of the contralateral leg. Images were satisfactory when they allowed the delineation of multiple fascicles across the entire image without interruption.[10,16] Stored images underwent a subsequent analysis with the free open-source medical image viewer Horos (version 3.1.1) distributed under a Lesser General Public License (LGPL) at Horosproject.org. Pennation angle was the angle between the deep intramuscular aponeurosis and a visible muscle fascicle in orthostasis (►**Fig. 2A**) and BMPF (►**Fig. 2B**).[9,11,17,18] The same orthopedist obtained three PA measurements from each image, using different fibers. The data underwent statistical analysis.

Statistical analysis

The Kolmogorov-Smirnov test assessed the normality of quantitative variables. The Student's t-test, Chi-squared test, and Pearson's correlation were used for data evaluation. The result of each comparison presented a *p*-value, defined as a statistical significance, at 0.05 (5%). Statistical analysis employed the following software: IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA), Minitab version 16 (Minitab LLC, State College, PA, USA), and MS Excel 2010 (Microsoft Corp., Redmond, WA, USA).

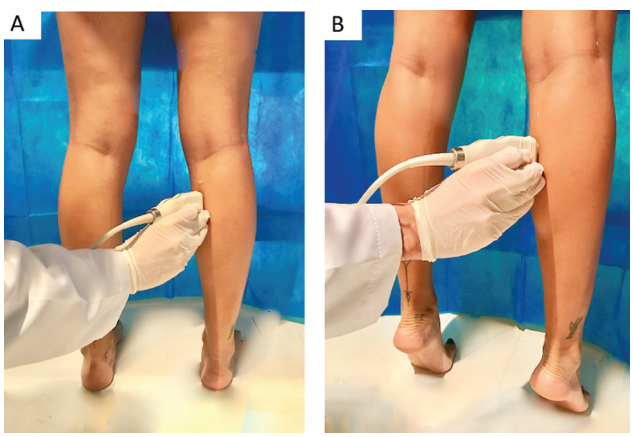


Fig. 1 Orthostatic position (**A**) and maximum bilateral plantar flexion (BMPF) position (**B**) position of the medial gastrocnemius muscle.

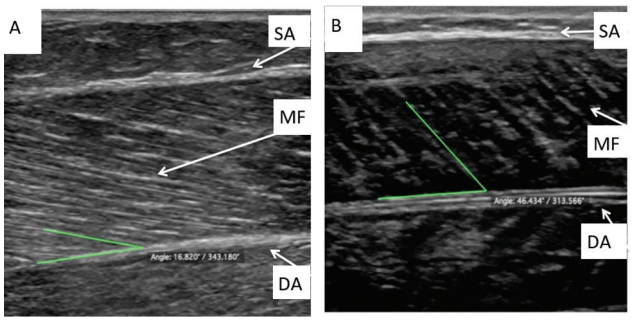


Fig. 2 The arrows indicate a superficial aponeurosis (SA), a muscle fiber (MF), and a deep aponeurosis (DA). (**A**) Pennation angle (PA) of the medial gastrocnemius muscle in orthostasis. (**B**) Pennation angle of the medial gastrocnemius muscle during BMPF.

Results

The present study consisted of 62 volunteers, including 31 runners and 31 non-runners. The runner group had 14 (45.2%) females and 17 (54.8%) males. The non-runner group had 18 (58.1%) females and 13 (41.9%) males.

The runner group had 25 (80.6%) subjects with right-side dominance and 6 (19.4%) participants with left-side dominance. The non-runner group had 28 participants (90.3%) with right-side dominance and 3 (9.7%) with left-side dominance.

The age in the runner group ranged from 23 to 51 years, with a mean age of 35.6 years, and a coefficient of variation (CV) of 19%. The age in the non-runner group ranged from 18 to 59 years, with a mean value of 34.5 years, and a CV of 24%. According to the Chi-squared test, the groups were homogeneous regarding the dominant side, gender, and age.

The mean BMI was higher in the non-runner group (26.6) than in the runner group (22.40) ($p < 0.001$).

►**Table 1** shows the descriptive statistical analysis of PA in orthostasis and BMPF of the right or left lower limbs from runners and non-runners.

The Pearson's correlation was used to assess the correlation between MGM in orthostasis and BMPF of each leg in each group (►**Table 2**). We found a positive correlation (higher than 0) in all comparisons, which was greater in the right lower limb of the non-runner group.

►**Table 3** shows the descriptive statistical analysis of MGM's PA in orthostasis and BMPF of both lower limbs and gender.

Discussion

Scientific research has demonstrated that muscle architecture, including PA, fascicle length, and fiber composition and arrangement, affects muscle functions.[17–20]

The first authors to describe PA were Gans and de Vree, in 1987,[21] when studying the external adductor muscle of a lizard's jaw. In 1992, Henriksson-Larsen et al.[22] evaluated the vastus lateralis muscle PA of 15 female volunteers. This was the first in vivo assessment of contraction and relaxation

Table 1 Pennation angle in the medial gastrocnemius muscle at ultrasound in road runners and non-runners

Inferior limb	*Condition*	*Group*	*PA (mean)*	*PA (median)*	*SD*	*CV*	*Min.*	*Max.*	*N*	*95%CI*	*p*
Right	*Orthostasis*	*Runners*	19.46	19.12	3.57	18	11.36	26.79	31	10.26	**00.004**
		Non-runners	22.25	22.04	3.77	17	13.23	30.23	31	10.33	
	BMPF	*Runners*	40.06	39.44	7.78	19	26.10	55.72	31	20.74	00.680
		Non-runners	40.89	40.47	8.07	20	25.42	56.25	31	20.84	
Left	*Orthostasis*	*Runners*	20.79	20.88	3.58	17	14.75	28.04	31	10.26	**00.029**
		Non-runners	22.83	22.45	3.61	16	15.12	29.45	31	10.27	
	BMPF	*Runners*	40.01	39.99	7.48	19	24.54	56.75	31	20.63	00.774
		Non-runners	40.52	39.95	6.38	16	27.56	59.26	31	20.25	

Abbreviations: PA, pennation angle; CV, coefficient of variation (in percentage); SD, standard deviation; BMPF, bilateral maximum plantar flexion; 95%CI, 95% confidence interval; Max., maximum; Min., minimum.

Table 2 Correlation between bilateral medial gastrocnemius muscle pennation angles in runners and non-runners

Group	*Inferior limb*	*r*	*p*
Runners	*Right*	34.4	0.058
	Left	37.8	**0.036**
Non-runners	*Right*	60.7	**0.001**
	Left	26.3	0.152

using an ultrasound device. The authors photographed the images for later PA analysis, being the first to demonstrate the feasibility of in vivo measurements and observing that the fiber angle in the relaxed position was smaller than in contraction. These results showed that the methodology for PA measurement using ultrasound images had high reliability. Our study evaluated PA in road runners compared with non-runners. We did not find any studies with this comparison in the literature.

The ultrasound method for capturing PA measurements from the MGM effectively determined muscle architecture parameters.[23] Its advantages included low relative cost, easy handling, portability, tissue contrast, good reproducibility, no radiation exposure, and real-time image analysis.[11,18,24–26]

Our sample consisted of 62 participants. Only four studies (Binzoni et al.,[27] Kubo et al.,[15,28] and Kawakami et al.[29]) presented a larger sample than ours. However, unlike us, these authors did not evaluate the PA during BMPF.

Regarding gender, the current study had a slight female predominance (51.61%; 32 out of 62), but without statistical significance. A paper on injuries in amateur runners demonstrated a male predominance.[30]

In the present study, the mean PA in males was higher compared with females, consistent with the findings of other authors.[16,28,29]

The mean age in years was 35.6 in runners and 34.5 in non-runners, contrasting with other authors, such as 22, according to Chow et al.,[16] 28.3, per Maganaris et al.,[12] 24, per Manal et al.,[31] and 38.8, per Narici et al.[11] The mean age in our study was higher than in some studies in the literature. Kubo et al.[15] noted a significant difference in PA between young and elderly subjects only in the vastus lateralis muscle of the thigh. The same authors described that MGM did not present a statistically significant value regarding PA and age. We did not analyze whether age was a factor in MGM's PA range.

Table 3 Measurement of the pennation angle of the medial gastrocnemius muscle by ultrasound examination in volunteer runners according to laterality and gender

Inferior limb	*Condition*	*Gender*	*PA (mean)*	*PA (median)*	*SD*	*CV*	*Min.*	*Max.*	*N*	*95%CI*	*p*
Right	*Orthostasis*	*F*	17.94	17.33	3.92	22	11.36	26.79	14	2.05	**0.029**
		M	20.71	21.64	2.78	13	13.60	24.24	17	1.32	
	BMPF	*F*	37.00	36.73	7.02	19	27.20	53.49	14	3.68	**0.045**
		M	42.57	43.21	7.66	18	26.10	55.72	17	3.64	
Left	*Orthostasis*	*F*	19.49	19.42	2.74	14	14.75	24.40	14	1.43	0.067
		M	21.85	21.10	3.90	18	16.93	28.04	17	1.85	
	BMPF	*F*	38.28	38.23	6.71	18	26.07	49.16	14	3.51	0.247
		M	41.45	42.36	7.98	19	24.54	56.75	17	3.79	

Abbreviations: PA, pennation angle; CV, coefficient of variation (in percentage); SD, standard deviation; F, female; BMPF, bilateral maximum plantar flexion; 95%CI, 95% confidence interval; M, male; Max., maximum; Min., minimum.

There are different methods for assessing muscle strength, including isometric, isokinetic, variable resistance, and free weight tests. The selection of a strength testing method involves specificities, ease of acquisition, cost, and safety.[32] Although runners perform monopodial support during their practice, we measured the PA during BMPF with the volunteer's body weight, as it is safe and easy to perform and analyze the data. We did not find any PA measurements in the literature using this method.

When comparing our PA data in the standing position with the literature,[11,12,15] we noted a non-significant difference of one or two degrees. Comparing road runners and non-runners, we found statistically significant values in the standing position and the BMPF.

Pearson's correlation was used to measure the degree of variable interconnection. We found a positive correlation of 60.7% when analyzing contraction in orthostasis and BMPF, indicating that the greater the angle in orthostasis, the greater the muscle contraction, consistent with the literature.[10–12,31]

The present study had some limitations, such as considering road runners' answers as reliable regarding the time spent running and the distance covered per week. In addition, some runners may perform other types of physical exercise, such as weight training, swimming, and ballet, potentially changing the leg muscles.

Another limiting factor of our study was measuring a single variable from the muscle architecture, the PA, hindering the comparison with other muscle components. Muscle architecture presents several parameters for analysis, such as muscle thickness, fiber length, physiological cross-sectional area, and PA, which impact a muscle's force production capacity. Although ultrasound quality depends on the operator and is subject to interpretation errors, measurements of muscle structure following a protocol performed by sonographers with different training and experience can achieve objective image measurements with few differences and little variation in results.[33]

Considering the great plasticity of the muscular system and the ability of skeletal muscles to adapt to different stimuli, such as disuse or training types, studies to elucidate the mechanisms by which muscle tissues adapt to these changes are relevant. For instance, we know that children with cerebral palsy have spastic muscles. We can evaluate the PA in contractures after surgical treatment for muscle stretching. In tendon transfers, we can choose muscles with similar PAs. In muscle injuries, we can monitor healing with serial PA assessments.

In sports medicine, we can study training variability by evaluating the PA in structural and functional muscle changes, especially in the force production capacity. A meta-analysis of Brazilian studies investigating the prevalence and risk factors for injury in amateur road runners detected a higher prevalence of injuries in men, most frequently muscle injuries (27.9%, 95% confidence interval [CI] 18.2–40.1%).[34] Timmins et al.[35] described a PA increase in the injured biceps femoris compared with the unaffected side. These findings encourage studies to help treat and prevent injuries early in road runners and other athletes.

Conclusion

Road runners presented a significantly lower PA in MGM than non-runners in orthostasis.

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

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Infiltration and Nerve Block in Painful Shoulder: Current Perspectives and Trends

Infiltração e bloqueio de nervo no ombro doloroso: Perspectivas e tendências atuais

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Abstract

Objective To investigate the use of infiltration and nerve block in shoulder pain treatment by shoulder surgery specialists and compared the results with previous research conducted by our group in 2017.

Methods The present study consisted of a cross-sectional analysis of shoulder surgery specialists to investigate the use of infiltration and nerve block in treating shoulder pain. The survey employed a structured questionnaire addressing the clinical practice regarding these procedures. We collected and analyzed the data using descriptive statistics and associated analyses between variables, such as patient age and type of procedure performed.

Results The results revealed a high rate of infiltrations and nerve blocks for shoulder pain treatment, especially in patients over 40. The use of steroids and hyaluronic acid in infiltrations was common, particularly in shoulder osteoarthritis and partial rotator cuff tears. However, ultrasound guidance during the procedures was not frequent. Two thirds of respondents performed nerve blocks, mainly of the suprascapular nerve, with a low complication rate.

Conclusion The present study highlighted the prevalence and trends in clinical practice regarding infiltrations and nerve blocks in shoulder pain treatment. Despite the gaps identified, such as the low use of ultrasound guidance, the results provide valuable insights to improve therapeutic approaches and to consider the adoption of imaging technologies in the field.

Keywords
- arthrosis
- infiltration
- nerve block
- shoulder
- tendinopathy

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Resumo

Objetivo Investigar o uso de infiltração e bloqueio de nervo no tratamento da dor no ombro por especialistas em cirurgia de ombro, incluindo a comparação dos resultados com os de um estudo anterior realizado por nosso grupo em 2017.

Métodos O estudo consistiu em uma análise transversal, envolvendo especialistas em cirurgia de ombro, para investigar o uso de infiltração e bloqueio de nervo no tratamento da dor no ombro. Foi conduzida uma pesquisa com questionários estruturados, abordando a prática clínica em relação a esses procedimentos. Os dados foram coletados e analisados por meio de estatísticas descritivas e análises de associação entre variáveis, como idade dos pacientes e tipo de procedimento realizado.

Resultados Os resultados revelaram uma alta taxa de adoção de infiltrações e bloqueios de nervo para o tratamento da dor no ombro, com predomínio de pacientes acima de 40 anos de idade. O uso de corticoides e ácido hialurônico foi comum nas infiltrações, especialmente nos casos de artrose do ombro e lesões parciais do manguito rotador. No entanto, a ultrassonografia não foi amplamente utilizada como guia durante os procedimentos. O bloqueio de nervo, principalmente do nervo supraescapular, foi realizado por dois terços dos entrevistados, com baixa incidência de complicações.

Conclusão Este estudo destacou a prevalência e as tendências na prática clínica em relação ao uso de infiltração e bloqueio de nervo no tratamento da dor no ombro. Apesar das lacunas identificadas, como a baixa utilização de ultrassonografia, os resultados fornecem insights valiosos para aprimorar as abordagens terapêuticas e considerar a adoção de tecnologias de imagem na área.

Palavras-chave

- artrose
- bloqueio nervoso
- infiltração
- ombro
- tendinopatia

Introduction

Shoulder pain complaints frequently affect adult patients, with a prevalence ranging from 7 to 34%, with the population over 40 being at the greatest risk.[1,2] It is estimated that 10 to 16% of the population will have more than one episode of painful shoulder throughout their lives.[1,3] The medical practice questions the treatment, monitoring, and recovery of this type of complaint, and factors such as age between 45 and 54 and pain lasting more than 3 months indicate a poor prognosis.[1,4] Refractoriness and recurrence of the complaint after 1 year are complications present in approximately 40 to 50% of patients.[4] When studying the pathophysiology of conditions related to painful shoulder, degenerative osteotendinous diseases and inflammatory changes, including tendonitis, with or without calcification, are essential.[5] It is worth noting that the degeneration stage and comorbidity severity are directly associated with the prognosis and outcome.[5,6]

Infiltration and nerve block are procedures with proven effectiveness in recent years for controlling shoulder pain symptoms, in addition to the several drugs that are part of the repertoire of physicians managing these complaints.[7–9] Infiltration sites, imaging guidance, and indications also vary.[9,10] The objective of the present study was to evaluate how shoulder specialists have used infiltration and nerve block in their daily practice.

Materials and Methods

This cross-sectional study, characterized as a single-time, intersectional survey research, adopted a non-probabilistic convenience sampling. The Ethics Committee of our institution approved the study under number 71476223.3.0000.5505.

We administered a questionnaire previously developed by the authors (►**Supplementary Appendix 1**) during the 8th Closed Meeting of the Brazilian Society of Shoulder and Elbow Surgery, held from August 17 to 19, 2023.

One hundred thirty-four orthopedists specialized in shoulder and elbow surgery answered the questionnaire out of a total of 300 registered participants, resulting in a response rate of 44%. To preserve confidentiality, we did not identify the orthopedists and asked them to answer the questionnaire only once. We distributed the questionnaires during the breaks of the three days of the congress and allowed responses virtually (through Google Forms) and in person.

We described the characteristics assessed in the questionnaire as absolute and relative frequencies; then, we analyzed the procedures of interest regarding the professionals' experience using likelihood-ratio tests. Finally, we related the use of steroids in different types of procedures with the administration of hyaluronic acid during infiltrations and assessed the association using Fisher exact tests.

Each survey had questions about the professionals' experience and the number of infiltrations performed, and we evaluated their association through Chi-squared tests, as recommended by Kirkwood and Sterne (2006).

Data statistical analysis employed the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, USA) software, version 22.0. We performed data tabulation in the Microsoft Excel 2013 (Microsoft Corp., Redmond, WA, USA) software. All tests considered a significance level of 5%.

Results

Among the respondents, 29.9% had over 10 years of experience in shoulder surgery; 20.1% had between 5 and 10 years; 37.3% had from 1 to 5 years; and 12.7% had less than 1 year of experience. In the study population, 48.5% reported 10 to 30 infiltration indications within the previous year.

Indications for subacromial and glenohumeral steroid infiltration accounted for 92.5% and 80.6% of the total infiltration indications, respectively. Regarding subacromial infiltration, 50.7% opted for lateral approaches, 26.9% for posterior approaches, and 3% for anterior approaches; 18.4% participants mentioned other approaches. For glenohumeral infiltration, 53.7% used anterior approaches, 29.1% used posterior approaches, and 17.2% used different approaches.

Most respondents (73.1%) did not use ultrasound guidance for infiltration, and 75.4% performed subacromial infiltration in the office. As for glenohumeral infiltration, 45.5% performed them in the office, while 19.4% did it in the surgical center.

Most respondents (86.6%) used hyaluronic acid for infiltrations, including 22% for treating shoulder osteoarthritis alone and 18.7% for treating partial rotator cuff tears/tendinopathies. The main complication reported by respondents was postinfiltration pain, accounting for 50% of the complications in the subacromial region and 44.8% in the articular region.

Regarding shoulder nerve block, 66.4% of respondents performed the procedure while 33.6% did not; 44.8% blocked the suprascapular nerve, and 29.9% added an axillary nerve block. Among the participants performing blocks, only 32.1% used ultrasound for guidance. Most respondents reported no post-procedure complications (36.6%). The most reported complication was local pain, corresponding to 24.6% of cases.

►**Table 1** shows that the higher number of infiltrations in the last year is associated with the professionals' greater experience ($p < 0.001$); professionals with less experience used fewer steroids in subacromial infiltrations and performed fewer infiltrations with hyaluronic acid ($p = 0.004$ and $p = 0.041$ respectively), while orthopedists with greater experience performed statistically less nerve blocks ($p = 0.001$).

►**Table 2** reveals no statistically significant association between steroid use in these procedures and the performance of hyaluronic acid infiltration ($p > 0.05$).

►**Table 3** reveals that respondents had statistically less experience than in the previous study ($p = 0.001$) and the number of infiltrations performed in the last 12 months by the professionals from the current survey was statistically higher than in the previous study ($p < 0.001$).

Discussion

The present study investigated the approach of shoulder surgery specialists in treating shoulder pain complaints, a prevalent condition with a significant impact on patients' quality of life.[11,12] The research aimed to analyze how specialized orthopedists have used infiltration and nerve block in their daily practice, offering a comprehensive view of trends and practices in the current medical community and comparing these results from 2020 up to now to those from the previous study by our group, which included a similar questionnaire.

The results revealed a diverse sample of orthopedists, covering different experience levels, which is crucial to understanding the variations in clinical practices. The predominance of patients over 40, as identified in the study, was consistent with the literature, highlighting the relevance of this condition in an older population.[13,14]

The study highlighted the prevalence of steroid use in subacromial and glenohumeral infiltrations, indicating a practice in line with the current literature.[15] Preferences regarding the lateral approach in subacromial infiltrations and anterior approach points in glenohumeral infiltrations reflected the diversity in techniques used by specialists. The incorporation of hyaluronic acid in infiltrations was notable, with a significant percentage of professionals adopting this approach, mainly for treating shoulder osteoarthritis and partial rotator cuff tears/tendinopathies.[16,17] This trend suggested a search for more comprehensive and conservative therapies in shoulder pain treatment.

Most respondents did not use ultrasound as a guide during the infiltration procedure, revealing a possible gap in incorporating imaging technologies in clinical practice. This finding raises discussions about the efficacy and need for imaging methods to improve procedural accuracy.[18,19] However, there was a significant 15% increase in the use of ultrasound as an auxiliary examination in shoulder infiltrations compared to the previous study carried out in 2020 by our group.

Shoulder nerve block is a common practice among specialists, and the suprascapular nerve is the most frequently blocked.[20] The preference for not using ultrasound to guide the procedure may indicate confidence in the conventional technique or the need for greater awareness of the benefits of ultrasound in this context.[21] The reported complication rate is relatively low, and local pain was the most common complication. This result suggests a safe approach to these procedures, but a detailed analysis of complications may provide valuable insights to improve techniques and reduce risks.[22,23]

The association between time of experience and the number of infiltrations performed is intriguing. This study had more specialists with a shorter time since training completion compared with the previous research. More experienced professionals statistically performed fewer nerve blocks, indicating a potential preference for other

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Table 1 Description of the professional conduct per experience and results of association tests

Variable	1) How many years of experience do you have in shoulder surgery?				Total	*p*
	< 1 year	1–5 years	5–10 years	> 10 years		
2) How many infiltrations did you perform in the last 12 months?						**< 0.001**
None	4 (23.5)	1 (2)	0 (0)	0 (0)	5 (3.7)	
1–10	9 (52.9)	27 (54)	0 (0)	4 (10)	40 (29.9)	
10–30	3 (17.6)	18 (36)	22 (81.5)	22 (55)	65 (48.5)	
> 40	1 (5.9)	4 (8)	5 (18.5)	14 (35)	24 (17.9)	
8) Do you perform ultrasound-guided infiltration?						0.079
No	9 (52.9)	42 (84)	19 (70.4)	28 (70)	98 (73.1)	
Yes	8 (47.1)	8 (16)	8 (29.6)	12 (30)	36 (26.9)	
12) Which medication(s) do you use for subacromial infiltration?						**0.004**
Without steroid	5 (29.4)	3 (6)	2 (7.4)	0 (0)	10 (7.5)	
With steroid	12 (70.6)	47 (94)	25 (92.6)	40 (100)	124 (92.5)	
13) Which medication(s) do you use for glenohumeral infiltration?						0.169
Without steroid	4 (23.5)	14 (28)	3 (11.1)	5 (12.5)	26 (19.4)	
With steroid	13 (76.5)	36 (72)	24 (88.9)	35 (87.5)	108 (80.6)	
14) Which medication(s) do you use for acromioclavicular infiltration?						0.542
Without steroid	2 (12.5)	2 (4)	1 (3.7)	1 (2.5)	6 (4.5)	
With steroid	14 (87.5)	48 (96)	26 (96.3)	39 (97.5)	127 (95.5)	
16) Do you perform hyaluronic acid infiltration?						**0.041**
No	6 (35.3)	6 (12)	1 (3.7)	5 (12.5)	18 (13.4)	
Yes	11 (64.7)	44 (88)	26 (96.3)	35 (87.5)	116 (86.6)	
20) Do you perform nerve block?						**0.001**
No	4 (23.5)	16 (32)	3 (11.1)	22 (55)	45 (33.6)	
Yes	13 (76.5)	34 (68)	24 (88.9)	18 (45)	89 (66.4)	
26) Do you perform ultrasound-guided nerve block?						0.666
No	10 (62.5)	32 (65.3)	16 (64)	11 (50)	69 (61.6)	
Yes	6 (37.5)	17 (34.7)	9 (36)	11 (50)	43 (38.4)	

Note: Likelihood-ratio test.

Table 2 Description of the performance of hyaluronic acid infiltration according to steroid use in each type of procedure and results of the association tests

Variable	16) Do you perform hyaluronic acid infiltration?		Total	*p*
	No	Yes		
12) Which medication(s) do you use for subacromial infiltration?				0.133
Without steroid	3 (16.7)	7 (6)	10 (7.5)	
With steroid	15 (83.3)	109 (94)	124 (92.5)	
13) Which medication(s) do you use for glenohumeral infiltration?				> 0.999
Without steroid	3 (16.7)	23 (19.8)	26 (19.4)	
With steroid	15 (83.3)	93 (80.2)	108 (80.6)	
14) Which medication(s) do you use for acromioclavicular infiltration?				0.590
Without steroid	1 (5.6)	5 (4.3)	6 (4.5)	
With steroid	17 (94.4)	110 (95.7)	127 (95.5)	

Note: Fisher exact test.

Table 3 Description of the experience and number of infiltrations in the last 12 months in the two surveys and results of the association tests

Variable	Previous study	Current study	*p*
1) How many years of experience do you have in shoulder surgery?			**0.001**
< 1 year	17 (9.5)	17 (12.7)	
1–5 years	35 (19.6)	50 (37.3)	
5–10 years	43 (24)	27 (20.1)	
> 10 years	84 (46.9)	40 (29.9)	
2) How many infiltrations did you perform in the last 12 months?			**< 0.001**
≤ 10	113 (63.1)	45 (33.6)	
> 10	66 (36.9)	89 (66.4)	

Note: Chi-squared test.

therapeutic options or greater effectiveness in treatment decisions. It is worth noting that the 44% response rate may introduce a selection bias in the sample, limiting the generalizability of the results. Furthermore, the conventional approach during conferences may have influenced participants' responses since they may have been more likely to discuss traditional practices.

We observed similarities and advances when comparing this study with previous research from 2017 during the 5th Closed Meeting of the Brazilian Shoulder and Elbow Society, in which 179 orthopedic shoulder and elbow specialists answered the questionnaire.[24]

These two studies highlighted the widespread adoption of infiltration and nerve block as effective therapies to mitigate shoulder pain symptoms. However, the present study expanded on this analysis by addressing the relationship between orthopedists' experience and their clinical practices. In addition, both studies highlighted the underutilization of ultrasound as an adjunct tool in infiltration procedures, indicating a potential failure to integrate imaging technologies into clinical routine.

The two studies concluded that both infiltration and nerve block of the shoulder are safe procedures, with a low rate of reported complications. However, this most recent study added a new perspective by exploring the incorporation of hyaluronic acid in infiltrations, suggesting a trend toward more comprehensive and conservative therapies. In addition, it adds prolotherapy and bone marrow aspirate (BMA) concentrate as treatment options, representing innovative therapies still under evaluation for their true relevance and efficacy in shoulder pain treatment.

Conclusion

The prevalence of steroid and hyaluronic acid infiltrations indicated a trend toward innovative and conservative approaches. The underutilization of ultrasound highlighted a potential gap in adopting imaging technologies, raising the need to evaluate the efficacy of these methods. Nerve blocks in the shoulder, especially the suprascapular nerve, were common and safe, with a low incidence of

complications. The association between experience and the infiltration number suggested an evolution throughout the career, with more experienced professionals opting for fewer nerve blocks. Despite limitations, such as the 44% response rate, the study provided valuable insights to improve clinical practices in the management of shoulder pain by orthopedists.

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

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Neurological Anatomy Applied to the Deltopectoral Surgical Approach: Safety Parameters in the Latarjet Procedure

Anatomia neurológica aplicada à abordagem cirúrgica deltopeitoral: Parâmetros de segurança no procedimento de Latarjet

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Abstract

Objective The present study aims to identify neurological safety parameters for performing the Latarjet procedure via the deltopectoral approach in a cross-sectional and prospective analysis of fresh cadavers.

Methods We dissected 12 shoulders from cadavers in good condition with no history of previous surgery or musculoskeletal dysfunction. Their mean age, height, weight, and body mass index (BMI) were the following: 75.33 (41–97) years, 168.81 (149–186) cm, 60.35 (26–77) kg, and 21.38 (11.71–34.22) kg/m^2, respectively. We identified the anatomical landmark of the deltopectoral approach (medial glenoid rim, MGR) and measured its distance from the axillary, musculocutaneous, and subscapular nerves.

Results We obtained the following measurements in neutral rotation and 40° external rotation, respectively: distance from the MGR to the axillary nerve (AN), 2.87 cm and 2.58 cm ($p = 0.29$); distance from the MGR to the musculocutaneous nerve (MCN), 2.70 cm and 2.54 cm ($p = 0.36$); distance from the MGR to the upper subscapular nerve (USSN), 3.83 cm and 4.00 cm ($p = 0.30$); distance from the MGR to the middle subscapular nerve (MSSN), 3.50 cm and 3.50 cm ($p = 1.00$); and distance from the MGR to the lower subscapular nerve (LSSN), 3.00 cm and 2.83 cm ($p = 0.36$).

Conclusion The deltopectoral approach is safe. However, in the Latarjet procedure, subscapularis muscle splitting and coracoid graft fixation require attention and caution

Keywords
- scapula/anatomy & histology
- scapula/surgery
- shoulder

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due to the small distance to the adjacent nerves. These precautions can avoid major postoperative complications.

Resumo

Objetivo Identificar parâmetros de segurança neurológica para a realização do procedimento de Latarjet através da via deltopeitoral por meio de um estudo transversal e prospectivo em cadáveres frescos.

Métodos Foram dissecados 12 ombros de cadáveres, sem história de cirurgia ou disfunção musculoesquelética prévia e em bom estado de conservação, com médias de idade, altura, peso e índice de massa corporal (IMC): 75,33 (41–97) anos; 168,81 (149–186) cm; 60,35 (26–77) kg e 21,38 (11,71–34,22) kg/m^2, respectivamente. Foi identificado o marco anatômico da via estudada (rebordo medial da glenoide - RMG) e sua distância para os nervos axilar, musculocutâneo e subescapular foi mensurada.

Resultados Obtivemos as seguintes medidas em rotação neutra e rotação externa de 40°, respectivamente: a distância entre o RMG e o nervo axilar (NA) = 2,87 cm e 2,58 cm ($p = 0,29$); a distância do RMG ao nervo musculocutâneo (NMC) = 2,70 cm e 2,54 cm ($p = 0,36$); a distância do RMG ao nervo subescapular superior (NSS) = 3,83 cm e 4,00 cm ($p = 0,30$); a distância do RMG ao nervo subescapular médio (NSM) = 3,50 cm e 3,50 cm ($p = 1,00$); e a distância do RMG ao nervo subescapular inferior (NSI) = 3,00 e 2,83 cm ($p = 0,36$).

Conclusão A via deltopeitoral é considerada segura; porém, é preciso atenção e cautela durante o *split* do músculo subescapular e na fixação do enxerto do coracoide no procedimento de Latarjet, devido à curta distância até os nervos adjacentes. Tais precauções podem evitar maiores complicações pós-operatórias.

Palavras-chave

- escápula/anatomia & histologia
- escápula/cirurgia
- ombro

Introduction

Latarjet surgery is a complex orthopedic procedure frequently used to treat recurrent shoulder instability. This procedure involves transferring the coracoid process to the glenoid cavity to stabilize the shoulder joint. Although effective in reducing instability, Latarjet surgery has risks and complications, including infection, nerve injury, joint stiffness, and graft nonunion. A careful approach and meticulous patient selection are essential to minimize these risks.[1]

Neurological injuries are a significant concern in Latarjet surgery, and studies indicate a variable incidence of these complications. The literature highlights that neurological injuries potentially result from several factors, such as direct trauma during the surgical procedure, nerve compression due to an altered anatomical position after coracoid process transfer, and iatrogenic damage during graft fixation. These complications can lead to symptoms such as persistent pain, muscle weakness, and sensory deficits, significantly impacting the postoperative quality of life. Therefore, a careful approach, including identification and preservation of periarticular nerves, is critical to reduce the risk of neurologic injury during Latarjet surgery.[2,3]

Yung et al.[4] specifically dissected the upper and lower subscapular nerves to study their role in innervating the subscapularis muscle. They described a safe zone for surgical dissection. These authors found that the palpable glenoid anterior rim, deep to the subscapularis, and the medial margin of the conjoint tendon could serve as landmarks because all neural branches were at least 1.5 cm medial to the conjoint tendon; in addition, all nerve branches to the subscapularis were on the anterior aspect of the muscular surface.[5–7]

The muscular attachment site of the lower subscapular nerve is close to the axillary nerve, and its branches are small. Thus, the location and protection of the axillary nerve could guide the attachment point of the lower subscapular nerve. Interestingly, the lower subscapular nerve has recently been reported to arise directly from the axillary nerve segment in 21% of cases.[5–7]

The Latarjet procedure, widely used for recurrent anterior glenohumeral joint dislocation, places the subscapular nerve at risk due to the sharp dissection of the subscapularis muscle for coracoid graft positioning, which can decrease adduction and the medial rotation strength of the arm.[8] The procedure also places the musculocutaneous nerve at risk during coracoid graft fixation with screws, potentially resulting in severe limitations to shoulder function.[9–11]

The primary objective of the present study was to determine a "safety zone" for the subscapular nerve by measuring its distance from the coracoid graft using the medial glenoid rim (MGR) as a parameter. The secondary objective was to

establish a "safety zone" for the axillary and musculocutaneous nerves by measuring their distance from the coracoid graft using MGR as a parameter.

Materials and Methods

We submitted the project to the Ethics Committee of our institution in September 2023 and received its approval under CAAE No. 74541723.3.0000.5463.

From October 2023 to January 2024, we dissected 12 shoulders (with no previous scars) from fresh adult cadavers. For dissections, we positioned the cadavers in dorsal decubitus with the shoulder in neutral rotation, the elbow flexed at 90°, and the forearm supinated at 45°. The dissection occurred through the deltopectoral groove. We performed juxtaosseous detachment and repair with high-resistance suture (Ethibond - Ethicon Inc., Raritan, NJ, USA) of the tendon of the conjoint tendon of the coracoid process. We divided the subscapularis muscle at the transition between the upper two thirds and the lower third of its muscular portion. Next, we fixated a plug measuring approximately 2.0 cm vertically at the MGR with two nails simulating the coracoid graft and fixation screws. We exposed the subscapularis muscle in its original anatomical position to measure three points on the internal surface of the muscle: the distance from the MGR to the course of the subscapular nerve (including the upper, middle, and lower branches); the distance from the MGR (at 3 o'clock considering the right shoulder) to the course of the axillary nerve; and the distance from the nails to the musculocutaneous nerve. All these measurements used a manual caliper graduated in millimeters (►**Figs. 1**–**3**). To measure the distance of the musculocutaneous nerve, we sutured the previously repaired conjoint tendon to the plug on the anterior glenoid rim, simulating the coracoid graft and maintaining the anatomical correlations of the surgery.

All measurements occurred with the arm in a neutral position, as this is the most frequent position for shoulder surgery using the anterior or anterolateral approach, and in 40° external rotation, the average range of motion achieved by the limb after the Latarjet procedure.

Sample description

We dissected 12 shoulders, with no previous scars, from 12 fresh adult cadavers from the Death Verification Service in our city. The cadavers included 4 females and 8 males, with a

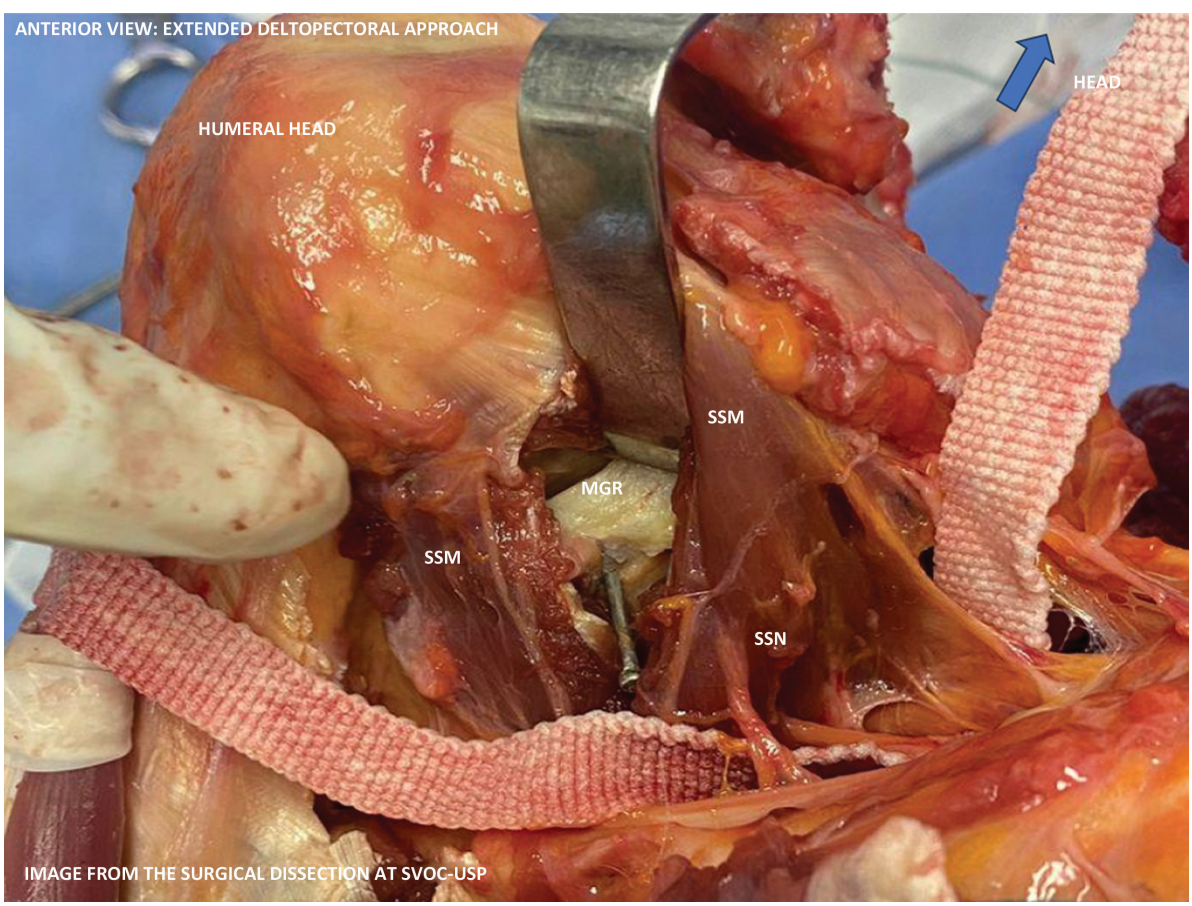


Fig. 1 Surgical dissection performed at the São Paulo State Capital Death Verification Service (Serviço de Verificação de Óbitos da Capital, in Portuguese) from Universidade de São Paulo (SVOC-USP) in 2023: extended deltopectoral approach. **Abbreviations:** MGR, medial glenoid rim (marked with a metal pin); SSM, subscapularis muscle; SSN, subscapular nerves (marked with a cotton suture thread).

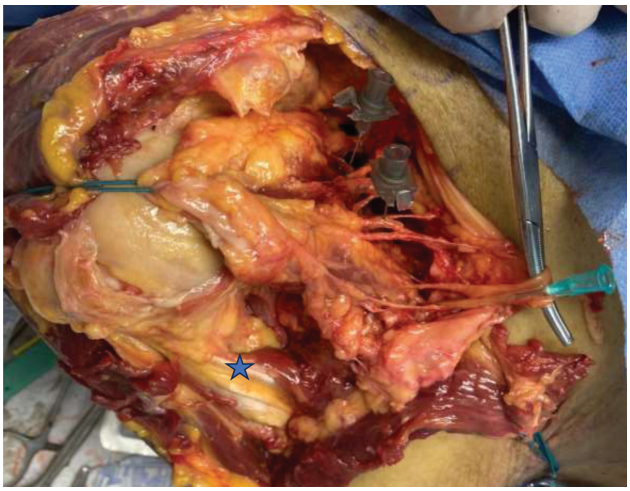


Fig. 2 Surgical dissection performed at the SVOC-USP in 2023: extended deltopectoral approach. **Caption:** Subscapularis muscle detached and repaired with high-resistance suture; a gray needle marks the upper and middle subscapular nerves, and a green needle indicates the lower subscapular nerve; **Notes:** *Axillary nerve; lower/right region: conjoined tendon repaired with a high-resistance suture.

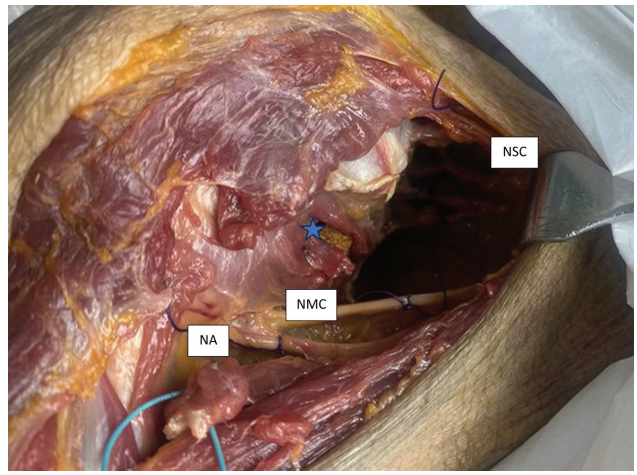


Fig. 3 Surgical dissection performed at the SVOC-USP in 2023: extended deltopectoral approach. **Abbreviations:** SCN, subscapular nerves; MCN, musculocutaneous nerve, AN, axillary nerve; **Notes:** *Subscapular muscle split with graft); lower region: conjoint tendon repaired with a high-resistance suture.

mean age of 75 years at the year of their death (95% confidence interval [95% CI]: 65–85), mean height of 168.9 cm (95% CI: 160–177), mean weight of 60.35 kg (95% CI: 48.9–71.7) and mean body mass index (BMI) of 21.38 (95% CI: 16.58–26.18) (►**Table 1**).

Results

We dissected 12 shoulders, including 7 (53.3%) right shoulders and 5 (41.6%) left shoulders to determine the neurological anatomical measurements. These measurements occurred in neutral rotation and 40° external rotation of the shoulder, using the MGR as a landmark to evaluate, in millimeters, the distances between the MGR and the axillary nerve (AN), the musculocutaneous nerve (MCN), and the upper (USSN), middle (MSSN), and lower subscapular nerves (LSSN). ►**Tables 2** and **3** show the mean measurements and the confidence intervals between the distances at the right and left shoulders in neutral and 40° rotation.

The Student's t-test for mean values verified whether there was no difference between the anatomical measurements, regarding side, rotation, and sex. Before performing this test, we confirmed the assumption of normality using the Shapiro-Wilk test (p-value > 0.05), which showed the measurement variables had a normal distribution between the right and left shoulders.

We detected no statistically significant differences (p-value > 0.05) between the left and right shoulders regarding the distances from MGR and neurological structures in neutral or 40° rotation.

As for rotation, there were no statistically significant differences in the mean distances between shoulders in neutral and 40° rotation (►**Tables 3** and **4**). Regarding sex, we found no statistically significant differences (►**Table 5**).

Discussion

Neurological injuries during Latarjet surgery are concerning, and several sources from the literature highlight the significance of anatomical and dissection aspects to prevent them. Authors such as Lafosse and Boyle[12] and Nam et al.[3] emphasize the need to fully understand the anatomy of periarticular nerves, including the suprascapular and the axillary nerves, to minimize the risk of injuries during the surgical procedure. Meticulous dissection techniques, as described by Maldonado et al.,[13] are crucial to preserve nerve integrity during coracoid process transfers. In addition, strategies such as nerve identification and adequate protection during graft fixation are recommended, as discussed by Gupta et al.,[14] Domos et al.,[15] Ferreira Filho et al.,[16] and da Silva et al.[17] These combined approaches help to effectively reduce the risk of neurological injuries and improve postsurgical outcomes.

The present study is consistent with the one by Coifman et al.,[18] who reported mean distances between the MGR and the upper, middle, and lower portions of the subscapular nerve in neutral rotation as 33 mm, 32.5 mm, and 20 mm, respectively. This study also agrees with that of La Prade et al.,[19] who described that the mean distances between the MGR and the musculocutaneous and axillary nerves were 24.4 mm and 19.8 mm, respectively. Most measurements were within the confidence interval of this study, except for the lower portion of the subscapular nerve reported by Coifman et al.[18] This difference may result from the fact that these authors made their measurements on formalized pieces, potentially reducing the course of the structures.

In contrast, the studies from other authors used smaller samples with different epidemiological characteristics. La Prade et al.[19] analyzed 14 shoulders of 7 North American

Table 1 Descriptive measures of the study sample

a) Measurement summary (total sample)			
Variable	Mean	Standard deviation	95% confidence interval
Age (years)	75.3	±15.7	65.3–85.3
Height (cm)	168.0	±12.8	160.0–177.0
Weight (kg)	60.3	±17.9	48.9–71.7
Body mass index (kg/m^2)	21.3	±7.5	16.58–26.18
b) Measurement summary (female sex)			
	n	Mean(±standard deviation)	Minimum–maximum
Age (years)	4	82.25 (±9.84)	77–97
Height (cm)	4	154.0(±8.67)	149–167
Weight (kg)	4	60(±24.04)	26–77
Body mass index (kg/m^2)	4	25.41(±10.92)	11.71–34.22
c) Measurement summary (male sex)			
	n	Mean(±standard deviation)	Minimum-maximum
Age (years)	8	71.88(±17.57)	41–95
Height (cm)	8	176.38(±6.19)	170–186
Weight (kg)	8	60.53(±16.15)	35.4–75
Body mass index (kg/m^2)	8	19.36(±4.95)	12.25–23.78
d) Side frequency			
Side	n (%)		
Right	7 (58.3%)		
Left	5 (41.6%)		
e) Gender frequency			
Gender	n (%)		
Female	4 (33.3%)		
Male	8 (66.6%)		

cadavers, all males, with an average age of 53. Coifman et al.[18] analyzed 12 shoulders of 6 Hispanic cadavers, with an average age of 74 years, including 4 females and 2 males. Our study brought innovations regarding rotational measurements and comparisons for side and sex, aspects disregarded by previous authors.

The neurological complication rate after the Latarjet procedure ranges from 8 to 10% in clinical studies; these complications mostly affect the axillary and musculocutaneous nerves.[2,9,20] It is believed that neurological injury after the bone block procedure results from traction, poor patient positioning, and inadvertent suturing. Most injuries were transient neuropraxia, with no long-term clinical repercussions. Furthermore, the authors believe that the neurological complication rate may be higher because of the lack of adequate recording.[2,20]

In the Latarjet procedure, in addition to filling the glenoid bone defect with the coracoid graft, the "sling" effect of the conjoint tendon transferred between a split in the subscapularis muscle is a critical "soft-tissue stabilizer" for the humeral head. However, it has been shown that the lower part of the subscapularis muscle tends to degenerate, leading to fatty infiltration of the muscle. In addition, exposure through subscapularis splitting is technically demanding and implies a risk of nerve damage due to the traction forces of the retractors during open surgery.[21]

The long-term structural and functional integrity of the subscapularis after the Latarjet procedure remains unknown.[22,23] In a mean follow-up period of 8 years after the Latarjet procedure, Azizi et al.[22] found a slight reduction in abduction strength, but no reduction in medial rotation strength. Furthermore, in ultrasound and magnetic resonance imaging studies, the subscapularis tendon remained intact in circumference compared with preoperative measurements. In contrast, Ernstbrunner et al.[23] found a significant decrease in active medial and lateral rotation and strength compared with the healthy contralateral shoulder. However, the clinical influence of these findings has not yet been defined. There was no increase in fatty degeneration of the subscapularis muscle but minimal hypertrophy on the operated side in the long-term follow-up.

The discussion about the integrity of the subscapularis muscle and its innervation in the Latarjet procedure is growing in the literature. Davey et al.[24] analyzed, in a

Table 2 Mean distances between the medial glenoid rim and neurological structures in the right and left shoulders in neutral rotation and 40° of lateral rotation

a) Assessment in neutral rotation						
	Right shoulder			Left shoulder		
	Mean	Standard deviation	95% confidence interval	Mean	Standard deviation	95% confidence interval
Neutral rotation						
MCN	2.57	±1.27	1.39–3.74	2.90	±1.24	1.35–4.45
AN	2.71	±0.48	1.29–3.41	3.10	±0.65	2.29–3.91
USSN	4.07	±1.23	2.92–5.21	3.50	±0.86	2.42–4.58
MSSN	3.78	±1.28	2.59–4.97	3.10	±0.41	2.58–3.62
LSSN	3.28	±0.99	2.36–4.20	2.60	±0.41	2.08–3.12
b) Assessment in 40° lateral rotation						
	Right shoulder			Left shoulder		
	Mean	Standard deviation	95% confidence interval	Mean	Standard deviation	95% confidence interval
40° of rotation						
MCN	2.42	±0.67	1.80–3.05	2.70	±1.44	0.91–4.49
AN	2.42	±1.20	1.31–3.54	2.80	±1.15	1.37–4.23
USSN	4.42	±1.01	3.48–5.36	3.40	±0.96	2.21–4.59
MSSN	3.71	±1.34	2.46–4.96	3.20	0.90	2.07–4.33
LSSN	3.28	±1.07	2.29–4.27	2.20	±0.57	1.49–2.91

Abbreviations: AN, axillary nerve; LSSN, lower suprascapular nerve in neutral rotation; MCN, musculocutaneous nerve; MSSN, middle suprascapular nerve; USSN, upper suprascapular nerve.

Table 3 Mean differences for left and right shoulders in neutral and 40° lateral rotation

	Right shoulder		Left shoulder		
	Mean	Standard deviation	Mean	Standard deviation	*p*-value
MCN1	2.57	± 1.2724	2.900	± 1.245	0.665926
AN1	2.714	± 0.488	3.100	± 0.6519	0.266182
USSN1	4.071	± 1.2392	3.500	± 0.866	0.397955
MSSN1	3.78	± 1.28	3.10	± 0.41	0.282479
LSSN1	3.28	± 0.99	2.60	± 0.41	0.180875
MCN2	2.42	± 0.67	2.70	± 1.44	0.668109
AN2	2.42	± 1.20	2.80	± 1.15	0.603784
USSN2	4.42	± 1.01	3.40	± 0.96	0.108165
MSSN2	3.71	± 1.34	3.20	± 0.90	0.478452
LSSN2	3.28	± 1.07	2.20	± 0.57	0.068181

Abbreviations: AN1, axillary nerve in neutral rotation; AN2, axillary nerve in 40° rotation; LSSN1, lower suprascapular nerve in neutral rotation; LSSN2, lower suprascapular nerve in 40° rotation; MCN1, musculocutaneous nerve in neutral rotation; MCN2, musculocutaneous nerve in 40° rotation; MSSN1, middle suprascapular nerve in neutral rotation; MSSN2, middle suprascapular nerve in 40° rotation; USSN1, upper suprascapular nerve in neutral rotation; USSN2, upper suprascapular nerve in 40° rotation.

systematic review, whether managing the subscapularis muscle with a split or "L" tenotomy would influence the clinical outcomes of the open Latarjet procedure through a deltopectoral approach. This systematic review established that the subscapularis splitting technique resulted in significantly better functional outcome measures and lower rates of subscapularis insufficiency compared with an "L" tenotomy technique in the medium-term follow-up.[24] Furthermore, Raiss et al.[21] described the procedure known as "Flipped Latarjet", that is, the transfer of the coracoid process to the deficient glenoid with no subscapularis muscle splitting, maintaining the benefits of a sling effect of the conjoint tendon. Although there are no long-term data available to prove any superiority of the method compared with the

Table 4 Mean differences in neutral and 40° lateral rotation

Variable	Mean	Standard deviation	N	Difference	t	*p*	95% CI	
MCN1	2.71	±1.21						
MCN2	2.54	±1.01	12	0.17	0.93808	0.368343	−0.22–0.56	
AN1	2.67	±1.01						
AN2	2.58	±1.14	12	0.08	0.48378	0.638029	−0.30–0.46	
USSN1	3.83	±1.09						
USSN2	4.00	±1.09	12	−0.17	−1.07606	0.304937	−0.51–0.17	
MSSN1	3.50	±1.04						
MSSN2	3.50	±1.17	12	−0.00	−0.00000	1.000000	−0.43–0.43	
LSSN1	3.00	±0.85						
LSSN2	2.83	±1.03	12	0.17	0.93808	0.368343	−0.22–0.56	

Abbreviations: 95% CI, 95% confidence interval; AN1, axillary nerve in neutral rotation; AN2, axillary nerve in 40° rotation; LSSN1, lower suprascapular nerve in neutral rotation; LSSN2, lower suprascapular nerve in 40° rotation; MCN1, musculocutaneous nerve in neutral rotation; MCN2, musculocutaneous nerve in 40° rotation; MSSN1, middle suprascapular nerve in neutral rotation; MSSN2, middle suprascapular nerve in 40° rotation; USSN1, upper suprascapular nerve in neutral rotation; USSN2, upper suprascapular nerve in 40° rotation.

Table 5 Measurement difference per sex

	Female sex		Male sex		
	Mean	Standard deviation	Mean	Standard deviation	*p*-value
MCN1	2.625	±1.1087	2.750	±1.3363	0.875731
AN1	2.75	±0.8660	2.938	±0.4173	0.614463
USSN1	3.875	±0.2500	3.813	±1.3611	0.930854
MSSN1	3.125	±0.2500	3.688	±1.2518	0.404879
LSSN1	2.625	±0.4787	3.188	±0.9613	0.303033
MCN2	2.75	±0.9574	2.438	±1.0836	0.636582
AN2	2.875	±1.2500	2.438	±1.1476	0.558121
USSN2	4.000	±0.4082	4.000	±1.3363	1.00000
MSSN2	2.875	±1.0308	3.813	±1.1630	0.203447
LSSN2	2.125	±0.6292	3.188	±1.0329	0.091778

Abbreviations: AN1, axillary nerve in neutral rotation; AN2, axillary nerve in 40° rotation; LSSN1, lower suprascapular nerve in neutral rotation; LSSN2, lower suprascapular nerve in 40° rotation; MCN1, musculocutaneous nerve in neutral rotation; MCN2, musculocutaneous nerve in 40° rotation; MSSN1, middle suprascapular nerve in neutral rotation; MSSN2, middle suprascapular nerve in 40° rotation; USSN1, upper suprascapular nerve in neutral rotation; USSN2, upper suprascapular nerve in 40° rotation.

traditional open or arthroscopic Latarjet procedure, this technique would be an alternative to avoid neuromuscular injuries to the subscapularis.

The limitations of this study are sample size due to the inherent difficulty of cadaveric studies, anatomical variations in the brachial plexus, and loss of tension in neurological structures since we used fresh cadavers with no fixation techniques for the shoulder girdle and humerus. Furthermore, the average age of the cadavers is far from the target age for the Latarjet technique, potentially modifying muscle quality and volume.

Finally, this is a pilot study whose main purpose was to verify average neurological distances, and the same observer performed all measurements more than once to ensure data reliability. A supplementary analysis is under development, with a larger sample size and another design type to assess the interobserver measurement reliability using the Kappa coefficient.

Conclusion

The deltopectoral approach is safe. However, in the Latarjet procedure, subscapularis muscle splitting, and coracoid graft fixation require attention and caution due to the small distance to the adjacent nerves. These precautions can avoid major postoperative complications.

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

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Critical Predictors of the Outcomes of Rotator Cuff Arthroscopic Repair

Principais fatores preditivos dos desfechos do reparo artroscópico do manguito rotador

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Abstract

Objective To evaluate the functional outcomes after rotator cuff arthroscopic repair in an adult population and to establish risk factors for poor prognosis in this procedure.

Methods This retrospective cohort study analyzed medical records of 302 shoulders that underwent arthroscopy for rotator cuff repair between October 1, 2014, and December 31, 2017. Patients were included if they had a complete rotator cuff injury and met other specific criteria. Surgical procedures were performed consistently, and postoperative care involved a structured rehabilitation protocol. The primary outcome measure was the need for further surgery or a University of California, Los Angeles (UCLA) shoulder score < 28 at 2 years postsurgery. Statistical analyses included descriptive, inferential, and logistic regression methods.

Results Treatment success was observed in 234 shoulders (77.5%), while 68 shoulders (22.5%) were classified as treatment failures. Factors significantly associated with treatment failure included having more than 2 affected tendons (OR: 2.8, 95%CI: 1.5–5.0) and lesion sizes greater than 25 mm (OR: 2.9; 95%CI: 1.6–5.3). Patients aged 75 years or older had a failure rate of 54.5%, compared to 21.3% in younger patients ($p = 0.019$). The Goutallier classification for fatty degeneration was significantly worse in older patients ($p = 0.001$). Critical patients, defined as those aged ≥ 75 years with a Goutallier classification > 2 and lesion sizes > 25 mm, had a treatment failure rate of 75.0% (OR: 11.2; 95%CI: 2.2–57.0).

Conclusion Rotator cuff arthroscopy showed no worse prognosis based solely on age until 75 years. However, patients older than 75 years with significant muscle degeneration and large lesions had substantially increased chances of poor outcomes. Alternative treatments should be considered for these critical patients to improve their quality of life and upper limb functionality.

Keywords
- arthroscopy
- elderly
- retrospective studies
- rotator cuff injuries
- shoulder pain

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Resumo

Objetivo Avaliar os desfechos funcionais após o reparo artroscópico do manguito rotador em uma população adulta e estabelecer os fatores de risco para o mau prognóstico deste procedimento.

Métodos Este estudo de coorte retrospectiva analisou os prontuários médicos de 302 ombros submetidos à artroscopia para reparo do manguito rotador entre 1° de outubro de 2014 e 31 de dezembro de 2017. Os pacientes foram incluídos se tivessem uma lesão completa do manguito rotador e atendessem a outros critérios específicos. Os procedimentos cirúrgicos foram realizados de forma consistente e o tratamento pós-operatório envolveu um protocolo de reabilitação estruturado. A principal medida de desfecho foi a necessidade de cirurgia adicional ou um escore de ombro da University of California, Los Angeles (UCLA) < 28 em 2 anos após a cirurgia. As análises estatísticas incluíram métodos descritivos, inferenciais e de regressão logística.

Resultados O sucesso do tratamento foi observado em 234 ombros (77,5%), enquanto 68 ombros (22,5%) foram classificados como falhas de tratamento. Fatores significativamente associados à falha do tratamento incluíram o acometimento de mais de 2 tendões (razão de chances [RC]: 2,8; intervalo de confiança de 95% [IC95%]: 1,5–5,0) e lesão com mais de 25 mm de tamanho (RC: 2,9; IC95%: 1,6–5,3). Pacientes com 75 anos ou mais apresentaram taxa de falha de 54,5% em comparação a 21,3% em pacientes mais jovens ($p = 0{,}019$). A classificação de Goutallier de degeneração gordurosa foi significativamente pior em pacientes mais velhos ($p = 0{,}001$). Pacientes críticos, definidos como aqueles com idade ≥ 75 anos, classificação de Goutallier > 2 e tamanho de lesão > 25 mm, apresentaram taxa de falha do tratamento de 75,0% (RC: 11,2; IC95%: 2,2–57,0).

Conclusão A artroscopia do manguito rotador não mostrou pior prognóstico com base somente na idade até os 75 anos. No entanto, nos pacientes com mais de 75 anos, degeneração muscular significativa e lesões grandes tiveram chances substancialmente maiores de desfechos ruins. Tratamentos alternativos devem ser considerados para melhorar a qualidade de vida e a funcionalidade dos membros superiores desses pacientes críticos.

Palavras-chave

- artroscopia
- dor de ombro
- estudos retrospectivos
- idoso
- lesões do manguito rotador

Introduction

The increase in life expectancy and the desire to maintain healthy conditions in the labor market have prompted orthopedists to reconsider the conservative treatment of complete rotator cuff lesions in adults. Approximately 50% of patients over 70 years old have asymptomatic full-thickness rotator cuff tears, with about half becoming symptomatic within 2.8 years and seeking tendon repair to regain normal function.[1] Despite the established correlation between tendon degeneration, tear size, and patient age with postoperative outcomes, more comprehensive data is needed to guide treatment decisions effectively.

Rotator cuff injuries are a common cause of shoulder pain and disability, particularly among the elderly. Previous studies have shown that factors such as tear size, tendon degeneration, and patient age significantly influence the outcomes of rotator cuff repair surgeries.[2–4] Studies by Gasbarro et al.[4] and Wu et al.[2] have demonstrated that larger tears and greater tendon degeneration are associated with higher rates of surgical failure. Similarly, patient age has been identified as a critical factor, with older patients often experiencing poorer outcomes due to reduced healing capacity and increased comorbidities.[3]

However, there is a lack of consensus on the specific age threshold beyond which the prognosis significantly worsens. Additionally, the combined effect of age, tear size, and tendon degeneration on functional outcomes has not been thoroughly investigated in a large cohort. This gap underscores the need for further research to identify critical predictors of surgical success and failure in rotator cuff repair.

The present study aims to evaluate the impact of age, tendon degeneration, and tear size on functional outcomes after rotator cuff arthroscopic repair. We were also able to determine a critical age threshold associated with a worse prognosis and identify key predictors of treatment failure in this patient population. By providing a nuanced understanding of these factors, we hope to assist surgeons in making more informed decisions regarding the suitability of rotator cuff repair for their patients.

Materials and Methods

Study Design

The current retrospective cohort study followed the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines[5] and the Declaration of Helsinki. We analyzed our hospital medical records of all consecutive shoulder arthroscopy surgeries to repair complete rotator cuff injuries from October 1, 2014, to December 31, 2017, resulting in an eligible sample of 302 shoulders.

The inclusion criteria were all patients with rotator cuff injuries admitted for arthroscopy surgery for rotator cuff tendon repair. The exclusion criteria included patients younger than 18, those with unavailable clinical evaluations or imaging in medical records, individuals with previous shoulder surgery, those with irreparable cuff injuries, and patients whose contralateral shoulder was already included.

Surgical Procedures

All surgeries were performed at a single hospital by the same two shoulder surgeons. Patients were positioned in a lateral decubitus position with the arm held by a traction device at 15 degrees of forward flexion and 45 degrees of abduction with up to 3 kg of traction.

Three portals (posterior, anterior, and lateral) were used to inspect the labrum, biceps tendon, and rotator cuff tendons. Lesions were repaired using 1 to 4 absorbable suture anchors until proper closure was achieved. The surgical technique included acromioplasty and, if necessary, biceps tenotomy or tenodesis. Specific repair techniques, such as single- or double-row sutures, were employed based on tendon quality and tear size.

Postoperative Care

Postoperative care involved a sling, and abduction pads for 6 weeks.

Strengthening exercises began 12 weeks postsurgery. Patients were evaluated using clinical examinations and functional scales at regular intervals, with a final assessment at 2 years.

Outcome Measures

The primary outcome measure was the need for further surgery or a University of California, Los Angeles (UCLA) shoulder score < 28 at 2 years post-surgery, indicating treatment failure.[6] Degeneration of cuff muscles was assessed using MRI and classified by the Goutallier classification.[7,8] Lesion sizes were measured intraoperatively with a 5-mm probe and categorized as smaller than 25 mm or 25 mm and larger.[9]

Statistical Analysis

We conducted descriptive and inferential analyses to profile patients in 2 groups based on prognosis (with and without failure) and UCLA scores before and 2 years after surgery. Variability in the quantitative variable distribution was considered low for coefficient of variation (CV) < 0.20, moderate for $0.20 \leq CV < 0.40$, and high for $CV \geq 0.40$. Inferential statistical analysis evaluated the significance of differences in independent groups, UCLA scores pre- and postoperatively, and variable correlations.

To evaluate correlations between two qualitative variables, we used Chi-squared or Fisher test. If a significant correlation was found, the odds ratio (OR) estimated the risk of treatment failure, evaluated by the 95% confidence interval (95%CI).

For inferential analysis of quantitative variables, we compared distributions of quantitative or ordinal variables in two independent groups using the Mann-Whitney test. For comparisons involving more than two independent groups, the Kruskal-Wallis test was used. The Wilcoxon test compared UCLA scores before and after arthroscopy.

In the Wilcoxon signed-rank, the effect of the intervention received on the UCLA score was evaluated using Glass's Δ effect size measure: in which m_1 denotes the mean of the variable in the first evaluation (pre-intervention), m_2 denotes the mean of the variable of the second evaluation (postintervention), and s_1 is the standard deviation of the variable in the preintervention. This index is used in clinical trials[7] and comprises the sample value of the standardized mean difference through the standard deviation of the control group without failure, which more closely reflects the population's standard deviation.[10–12]

The classification of Glass's Δ proposed by Rosenthal (10) was used as follows: insignificant: $\Delta \leq 019$; small: $020 \leq \Delta \leq 049$; medium: $050 \leq \Delta \leq 079$; large: $080 \leq \Delta \leq 129$; and very large: $\Delta \geq 130$. The effect size using Wilcoxon nonparametric tests (r) was also calculated by the quotient between the z-value (from the Mann–Whitney test) and the square root of the total sample number. The classification adopted for the effect size of non-parametric tests was the one proposed by Pallant: very small for $r < 01$; small for $01 < r \leq 03$; medium for $03 < r < 05$; and great for $r > 05$.[13]

The association between two quantitative variables was investigated using Spearman's rank correlation coefficient. Correlation was considered strong if the absolute value was greater than 0.7 and moderate if between 0.65 and 0.7. The Forward Wald method was used for variable selection in logistic regression analysis with a cutoff point equal to the proportion of failures in the sample. Model quality was assessed by the significance of the final model's parameters, OR, and measures of accuracy, sensitivity, and specificity. All significance tests were conducted with a maximum significance level of 5% ($p < 0.05$), rejecting the null hypothesis if the p-value was less than 0.05.[11,14–16]

Results

The study initially included 332 shoulders. Based on the exclusion criteria, 6 shoulders with irreparable lesions identified during surgery, 5 shoulders with insufficient medical data, and 19 shoulders from the opposite side of patients already included were removed. Consequently, the results are based on an eligible sample of 302 shoulders that underwent arthroscopy for rotator cuff repair.

Surgical Procedures Characteristics

In summary, patients undergoing arthroscopy for tendon suture typically had right-sided lesions (72.5%). The majority of lesions were degenerative (93.4%), and the "single-row" technique was used in 92.1% of cases. Lesion sizes were predominantly smaller than 25 cm (56.6%), and 2 tendons were most commonly affected (49.7%). In 52.0% of cases, there were no alterations in the long head of the biceps, while biceps tenodesis was performed in 37.7% of patients. The most common type of acromion was type II (49.7%), and the incidence of instability associated with tendon rupture was 20%.

Treatment Outcomes

Treatment success was observed in 234 shoulders (77.5%), while 68 shoulders (22.5%) were classified as treatment failures. Treatment failure was defined by the need for further surgery or a UCLA shoulder score < 28 at 2 years postsurgery. Among the failures, 67 cases (22.2%) were due to a UCLA score indicating poor function, and 15 cases required additional surgery (►**Fig. 1**).

The Kruskal-Wallis test showed no significant difference between groups in pre and postoperative UCLA scores, nor in improvement between patients with an intact long head of the biceps or those who underwent tenodesis or tenotomy.

Improvement in UCLA scores was not correlated with acromion type or shoulder critical angle (SCA), indicating that these variables did not significantly affect outcomes.

Influence of Tendon Involvement

When analyzing the frequency of the lesion characteristics of the patients in the sample, it was observed that the distribution of the number of affected tendons was significantly different in the groups with and without failure ($p = 0.009$). When we dichotomized this variable into "more than 2 affected tendons" (yes or no), an association with a worse prognosis was evident among those who fit this classification (17.8% versus 37.5%; $p < 0.001$). The OR was 2.8 (95%CI: 1.5–5.0).

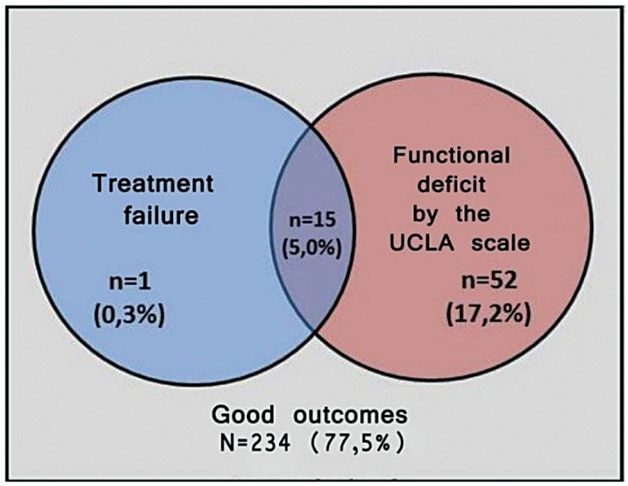


Fig. 1 Distribution of cases by outcomes observed within 2 years after arthroscopy.

Lesion Size

Lesions were categorized as < 25 mm or ≥ 25 mm.

In patients with lesions ≥ 25 mm, the OR for treatment failure was 2.9 (95%CI: 1.6–5.3), indicating a significant increase in poor outcomes.

We also examined the effect of lesion size and more than two affected tendons on prognosis. Our findings showed that 23.2% of cases had both more than 2 affected tendons and lesions ≥ 25 mm. Within the favorable prognosis group, only 18.4% had these combined characteristics. Conversely, in the poor prognosis group, 39.7% had both more than 2 affected tendons and lesions ≥ 25 mm ($p < 0.001$). The OR for poor prognosis in patients with these combined factors was 2.9, indicating that these patients were nearly 3 times more likely to experience poor outcomes. This OR was significant, with a CI of 1.6 to 5.3, meaning the result is statistically robust and the CI does not include 1.

Age as a Predictor

Age significantly predicted treatment outcomes. Patients younger than 75 years had a failure rate of 21.3%, while those aged 75 years or older had a failure rate of 54.5% ($p = 0.019$). However, there was no significant difference in the improvement of UCLA shoulder scores between these age groups ($p = 0.068$).

Goutallier Classification

The Goutallier classification for fatty degeneration of the infraspinatus muscle was significantly worse in patients aged 75 years or older compared to younger patients ($p = 0.001$). This classification assessed the degree of muscle degeneration and its impact on surgical outcomes (►**Table 1** and ►**Fig. 2**).

Critical Group Analysis

Critical patients, defined as those aged ≥ 75 years with a Goutallier classification of the infraspinatus muscle > 2 and lesion sizes ≥ 25 mm, represented 2.6% of the sample (8 patients). The incidence of poor prognosis in this group was 75.0% compared to 21.1% in non-critical patients ($p < 0.001$), as shown in ►**Fig. 3**. The OR for treatment failure in the critical group was 11.2 (95%CI: 2.2–57.0).

Logistic Regression Analysis

All significant factors identified were proposed as predictors for failure in a multivariate logistic regression analysis. ►**Table 2** shows the critical group results. The forward Wald method was employed for variable selection, using a cutoff point equal to the proportion of failures in the sample (0.23). The results of the final model are presented in ►**Table 3**.

The multivariate analysis identified "the number of tendons $>$ than 2" and "belonging to the critical group" as the primary factors associated with treatment failure. This means that when the multivariate analysis was performed, adjusting for all significant factors, the influence of other variables associated with failure in the univariate analysis was excluded.

Table 1 Main nonparametric statistics of the Goutallier classification in the subgroups defined according to the age group for the cutoff points of 70 and 75 years

Goutallier classification	Age < 70 years ($n = 270$)	Age ≥ 70 years and < 75 years ($n = 21$)	Age ≥ 75 years ($n = 11$)	Kruskal-Wallis *p*-value test
SUPRASPINATUS				
Minimal	0.0	0.0	1.0	**0.007**
Maximum	4.0	4.0	4.0	
Quartile 1	**1.0**	**1.0**	**2.0**	
Median	2.0	2.0	3.0	
Quartile 3	3.0	3.0	3.0	
INFRASPINATUS				**0.001**
Minimal	0.0	0.0	0.0	
Maximum	4.0	3.0	4.0	
Quartile 1	0.0	1.0	2.0	
Median	1.0	1.0	2.0	
Quartile 3	1.0	2.0	2.5	
SUBSCAPULARIS				0.189
Minimal	0.0	0.0	0.0	
Maximum	3.0	3.0	2.0	
Quartile 1	**0.0**	**0.0**	**0.5**	
Median	1.0	1.0	1.0	
Quartile 3	1.0	1.0	1.0	

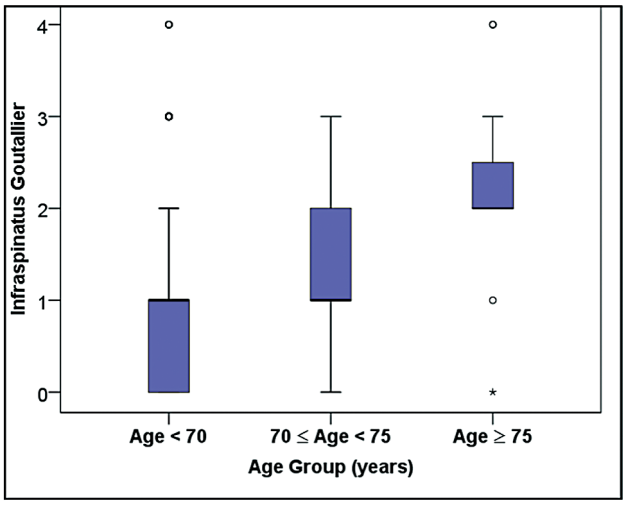


Fig. 2 Boxplots of distributions of infraspinatus Goutallier classification according to age group.

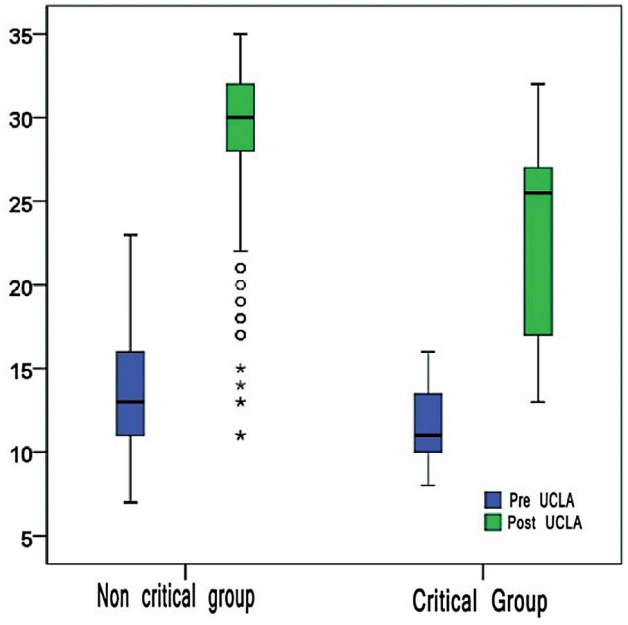


Fig. 3 Boxplots of UCLA measurements before and after surgery in the critical and noncritical groups.

The model exhibited significant coefficients and a substantial OR, with an accuracy of 72.0%, a sensitivity of 45.2%, and a specificity of 80.3%. In practical terms, this indicates that the proposed model correctly classified 72.0% of the sample, accurately identified 45.2% of the failure cases, and correctly recognized 80.3% of the non-failure cases.

Discussion

Gasbarro et al.[4] showed that larger lesions significantly correlate with the failure of rotator cuff repairs compared

Table 2 Analysis of factors associated with failure

Factor	Fault				*p*-value*	OR (95%CI)
	No		Yes			
Critical group = age > 75 years old + Goutalier IS >2 + lesion > 2.5 cm						
No	232	78.9%	62	21.1%	< **0.001****	**11.2 (2,2–57.0)**
Yes	2	25.0%	6	75.0%		

Abbreviations: 95%CI, 95% confidence interval; IS, infraspinatus; OR, odds ratio.
Notes: *Chi-squared test. **Fisher's exact test was used.

Table 3 Logistic regression model for the occurrence of failure

Factor	Coefficient B	Standard error	Wald data	Degree of freedom	*p*-value	OR = Exp (B)	lower limit of the 95% CI for Exp. (B)	95%CI for Exp (B) upper limit
Number of tendons > 2	1.075	0.296	13.193	1	0.0 00	2.92 9	1.64 0	5.230
Being of the critical group	1.896	0.854	4.926	1	0.0 26	6.66 0	1.24 8	35.531
Constant	-1.553	0.174	80.011	1	0.0 00	0.21 2		

Abbreviations: 95%CI, 95% confidence interval; OR, odds ratio.

to smaller or medium-sized lesions. Similarly, Wu et al.[2] emphasized that lesion size is a significant predictor of re-rupture among various intra-operative factors. Le et al.[3] found a correlation between lesion size, muscle quality, and early tendon re-rupture (up to 6 months postprocedure).

In our study, lesion size and the number of affected tendons were critical factors influencing outcomes. The failure rate among patients with up to 2 affected tendons was 17.8%, increasing to 37.5% for those with more than 2 affected tendons, with an OR of 2.8. This aligns with existing literature. Additionally, our study confirmed that lesions larger than 25 mm presented a higher OR for poor prognosis, especially when associated with more than 2 affected tendons. The risk of surgical failure for patients with more than 2 affected tendons and lesions larger than 25 mm was 2.89 times higher than for those outside this group.

Kim et al.[12] and our analysis both demonstrated that lesion sizes with more than 2.2 cm of retraction and muscle atrophy are highly predictive of non-healing repairs. A prolonged wait for suture correlates with increased failure risk due to lesion size progression and tendon atrophy. Our study found significant distinctions in the Goutallier classification of the infraspinatus muscle, especially in patients aged 75 or older, with higher fatty degeneration levels. This was less pronounced in younger age groups.

According to Yoon et al.[17] and Zhao et al.[18] infraspinatus infiltration with more than grade 2 fatty degeneration is directly related to re-rupture, with a sensitivity of 98% and specificity of 83.6%. This characteristic was prominent in the group aged over 75 years in our study. We concluded that patients up to 75 years old do not show age as an isolated factor of poor prognosis and are suitable candidates for surgical treatment to maintain better upper limb functionality.

In 2.6% of our sample, we identified a critical group based on the combination of age (over 75 years), muscle degeneration (Goutallier classification of the infraspinatus muscle greater than 2), and lesion diameter (greater than 25 mm). These patients had a high incidence of poor prognosis, with a treatment failure rate exceeding 75.0% and an OR of 11.2. We suggest that arthroscopic rotator cuff repair may not be the best option for these critical patients and that alternative treatments should be considered to enhance their quality of life and upper limb functionality.

This study has several limitations. Its retrospective nature introduces biases, such as selection and recall bias, affecting the generalizability of the findings. The absence of postoperative MRI data is significant, as MRI assesses the integrity of rotator cuff repairs and tendon healing. Without this data, our analysis relies solely on clinical and functional outcomes, which may not fully capture anatomical success. Future studies with postoperative MRI could provide a more comprehensive understanding and validate our findings. Furthermore, our sample was limited to patients treated at a single hospital by one surgical team, which may limit external validity. Despite rigorous statistical methods, unmeasured confounding variables may still influence outcomes, so caution is needed when interpreting the results.

Conclusion

Rotator cuff arthroscopic repair did not show a worse prognosis for patients based on age alone up to the age of 75 years.

However, the critical group identified (age > 75 years, Goutallier classification > 2 for the infraspinatus muscle, and lesion size > 25 mm) had significantly increased chances of suboptimal functional outcomes following rotator cuff repair.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by MCP, CLSF, PCM and RACC The first draft of the manuscript was written by MCP and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Correlation of the Neutrophil-to-lymphocyte and Platelet-to-lymphocyte Ratios with Postoperative Complications and Survival in Surgery for Bone Metastasis of the Appendicular Skeleton

Correlação das razões neutrófilo-linfócito e plaqueta-linfócito com complicações e sobrevida pós-operatórias na cirurgia para metástase óssea do esqueleto apendicular

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Abstract

Objective To analyze, in cases of long-bone metastases, the incidence of postoperative complications and survival of up to 1 year, correlating them with the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR).

Methods Review of 160 medical records of patients who underwent surgery for bone metastases in the appendicular skeleton. We determined epidemiological characteristics and NLR and PLR values, which were correlated with survival and complications.

Results Women represented 64.5% of the sample, and 62.6% presented primary breast tumor. The proximal femur was the most affected bone. The median survival was of 13.2 months, and the 1-year survival rate, of 34.7%. Tumor resection with endoprosthesis was the most common surgery. The postoperative complication rate was of 10%, and the mean time until occurrence was of 27.9 (range: 0–140) days. We observed a significant association between neutrophil levels and postoperative complications ($p = 0.04$): for every increase of 100 neutrophils, the risk of postoperative complications increased by 1%. The mean NLR and PLR values were of 5.3 (range: 0.2–30.7) and 199.7 (range: 32.1–676.7) respectively. Patients with NLR ≥ 2 ($p < 0{,}001$) showed a decrease in survival from 92,3 to 62,5% in the third month, and from 61,5 to 31,3% in the first year. Those with PLR ≥ 209 ($p < 0.001$) showed a decrease in survival from 69 to 59.3% in the third month, and from 40.2 to 25.9% in the first year.

Keywords
- blood platelets
- lymphocytes
- neoplasm metastasis
- neutrophils
- operative surgical procedures
- postoperative complications

* *Study developed at Hospital Erasto Gaertner in partnership with Faculdade Evangélica Mackenzie do Paraná, Curitiba, PR, Brazil.*

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Conclusion There was no positive association regarding the NLR and PLR and postoperative complications. However, we noted a strong correlation involving elevated NLR and PLR levels and reduced life expectancy starting from the third postoperative month.

Resumo

Objetivo Analisar, em metástases de ossos longos, a incidência de complicações e sobrevida pós-operatórias até um ano, e correlacioná-las com a razão neutrófilo-linfócito (RNL) e a razão plaqueta-linfócito (RPL).

Métodos Revisão de 160 prontuários de pacientes submetidos a cirurgias por metástases ósseas no esqueleto apendicular. Além das características epidemiológicas, foram determinados os valores da RNL e da RPL, que foram correlacionados com sobrevida e complicações.

Resultados Mulheres representaram 64,5% da amostra, com tumor primário na mama em 62,6%. O fêmur proximal foi o osso mais acometido. A sobrevida média foi de 13,2 meses, e a taxa de sobrevida em 1 ano, de 34,7%. Ressecção tumoral com endoprótese foi o procedimento mais comum. A taxa de complicação pós-operatória foi de 10%, e o tempo médio para a ocorrência de complicações pós-operatórias foi de 27,9 (variação: 0–140) dias. Foi identificada uma associação da variável neutrófilos com as complicações pós-operatórias ($p = 0,04$): a cada 100 unidades a mais de neutrófilos, houve aumento de 1% nas chances de complicações pós-cirúrgicas. Os valores médios da RNL e da RPL foram, respectivamente, de 5,3 (variação: 0,2–30,7) e de 199,7 (variação: 32,1–676,7). Os pacientes com RNL ≥ 2 ($p < 0,001$) apresentaram diminuição na sobrevida de 92,3 para 62,5% no terceiro mês, e de 61,5 para 31,3% em 1 ano. Aqueles com RPL ≥ 209 ($p < 0,001$) apresentaram diminuição na sobrevida de 69 para 59,3% no terceiro mês, e de 40,2 para 25,9% em 1 ano.

Conclusão Não houve associação positiva entre RNL e RPL com complicações pós-operatórias, mas houve uma forte correlação da RNL e da RPL elevadas com a redução da expectativa de vida dos pacientes a partir do terceiro mês de pós-operatório.

Palavras-chave
- complicações pós-operatórias
- linfócitos
- metástase neoplásica
- neutrófilos
- plaquetas
- procedimentos cirúrgicos operatórios

Introduction

Cancer is a public health problem, with approximately 626 thousand new cases in Brazil in 2020.[1] Bone metastases (BMs) are the most common malignant neoplasm of the skeleton, ranking third in the spread of adenocarcinomas after the lung and the liver.[2,3] Bone metastasis occurs mainly in the axial skeleton (80%), pelvis, and femur, especially affecting women after the fourth decade of life.[4,5] Most BMs originate from breast, prostate, or lung cancers.[4,5]

Bone metastasis is the main cause of morbidity in patients with advanced cancer,[6] and its control is essential to improve the patient's quality of life, pain, and independence.[2] Treatment is multidisciplinary, including clinical or surgical measures.

Surgery aims to stabilize imminent or pathological fractures, promote pain reduction, improve limb function, provide early ambulation, and avoid complications of prolonged decubitus.[2] The surgical decision must consider metastasis location and extension, the response to adjuvant therapies, the clinical condition, and the life expectancy.[6] The complication rate in BM treatment correlates with advanced age, clinical comorbidities, immunodeficiency, malnutrition, prolonged hospitalization, and local irradiation.[7]

Inflammation is a hallmark of cancer. In some tumors, it precedes malignancy; in others, the tumor induces an inflammatory response, favoring its growth.[8] Inflammatory biomarkers, such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR), are prognostic in several cancer types.[9] Increased NLR correlate with lower survival in multiple myeloma and gastric, colorectal, lung, breast, and endometrial neoplasms.[10] Therefore, the NLR and PLR may be used to predict survival and postoperative complications in patients with BM.[2]

The present study aimed to identify the epidemiological profile of patients with metastasis in long bones, the complication rate, the postoperative survival rate, and the correlation of the NLR and PLR with complications and survival up to 1 year postoperatively.

Materials and Methods

For the current retrospective, longitudinal, analytical, and descriptive observational study, we selected patients from the surgical registry book of the Orthopedic Oncology Service of Hospital Erasto Gaertner and extracted data by reviewing the Tasy (Philips Healthcare, Best, Netherlands)

electronic medical records per the Brazilian General Personal Data Protection Law (Lei Geral de Proteção de Dados Pessoais, LGPD, in Portuguese; law no. 13,709/2018). The data was collected from patients who underwent surgery from January 1, 2010, to December 31, 2019.

The epidemiological profile included age, gender, primary tumor site, BM location, surgical procedure, presence of other metastases, comorbidity, and previous radiotherapy (RT). We determined the NLR and PLR and their correlation with survival and postoperative complications.

The inclusion criteria were patients who underwent surgery for appendicular skeleton BM with confirmed diagnosis of metastatic malignant bone neoplasm by histological or immunohistochemical examination. The exclusion criteria were incomplete medical records, patients submitted to revision surgery in another institution, and absence of preoperative blood count.

We obtained the NLR and PLR from the preoperative blood count performed in the hospital laboratory up to 72 hours before surgery. We considered data from the first surgical procedure alone for patients undergoing multiple orthopedic surgeries due to BM.

Statistical Analysis

We organized the data in an Excel (Microsoft Corp., Redmond, WA, United States) spreadsheet and analyzed it using the Stata/SE software (StataCorp L LC, College Station, TX, United States), version 14.1. The quantitative variables were expressed as mean, standard deviation, median, minimum, maximum, and interquartile range (IQR) values. The categorical variables were expressed as absolute frequencies and percentages. Adjusted logistic regression models were used to analyze the factors associated with postoperative complications. The Wald test was applied to assess the significance of each variable. The estimated measure of association was the odds ratio (OR) with 95% confidence intervals (95%CIs).

The Cutoff Finder software,[11] which identifies the cutoff values generating significant differences in the log-rank tests, determined the cutoff points for NLR and PLR. This process ensured that the selected cutoff points corresponded to the NLR and PLR levels most related to the selected clinical outcomes. Statistical significance was set at $p < 0.05$.

Results

Epidemiological Profile

We evaluated a total of 160 medical records from 2010 to 2019. Of these, we excluded 16 due to lack of data or loss to follow-up, 2 due to lack of metastasis confirmation in the anatomopathological examination, and 1 due to surgery in another service. We included a total of 154 surgeries, and 12 patients presented multiple metastases. For data analysis, we considered only the first surgery, totaling 141 procedures.

The mean age of the patients was of 61.5 (range: 25–89) years, and the mean survival time was of 13.2 (range: 0–99.6) months. The mean laboratory parameters were within normal limits per blood count reference values.[12] The NLR was of 5.3 (range: 0.2–30.7), and the PLR, of 199.7 (range: 32.1–676.7; ►**Table 1**).

Regarding gender, 64.5% (n = 91) of the subjects were women. The femur was the most affected bone (n = 112), followed by the humerus (n = 21). As for the surgical procedure, 67% of the patients underwent tumor resection with hip endoprosthesis replacement. Most subjects (80.1%) presented multiple BMs, and 51.1% presented visceral metastases. ►**Table 2** summarizes the remaining data.

►**Table 3** shows the distribution and categorization of the primary tumor. In female patients, the most common primary site was the breast, with 62.6% (n = 57); in male subjects, the most common primary tumor was the prostate, with 38% (n = 19). In both genders, the second most common neoplasm was lung cancer.

Postoperative Complications

►**Table 4** shows that the mean time until the development of postoperative complications was of 27.9 (range: 0–140) days. The complication rate was of 31.2% (n = 44). ►**Table 5** shows that the most common complications were pneumonia (n = 10) and surgical wound infection (n = 5). A total of 4 patients presented deep infection, including 2 with

Table 1 Quantitative epidemiological variables

Variable	n	Mean	Standard deviation	Median	Minimum	Maximum	Interquartile range
Age (years)	141	61.5	12	62	25	89	54–69
Survival (months)	141	13.2	18.8	5	0	99.6	1.9–16.9
Neutrophils	141	6,451	3,094	5,762	137	19,272	4,276–8,398
Lymphocytes	141	1,542	779	1,315	301	4,518	999–1,958
Leukocytes	141	8,657	3,486	8,100	980	21,900	6,340–10,800
Platelets	141	252,579	104,642	241,000	63,000	596,000	174,000–308,000
Neutrophil-to-lymphocyte ratio	141	5.3	4.5	4.2	0.2	30.7	2.7–6.3
Platelet-to-lymphocyte ratio	141	199.7	118.8	171.6	32.1	676.7	114.9–248

Table 2 Categorical epidemiological variables

Variable	Classification	n	%
Gender	Female	91	64.50%
	Male	50	35.50%
Anatomy	Diaphyseal femur	3	2.10%
	Distal femur	10	7.10%
	Proximal femur	99	70.20%
	Radius	2	1.40%
	Diaphyseal tibia	1	0.70%
	Proximal tibia	5	3.50%
	Diaphyseal humerus	8	5.70%
	Distal humerus	2	1.40%
	Proximal humerus	11	7.80%
Surgery	Hip endoprosthesis	95	67.40%
	Knee endoprosthesis	15	10.60%
	Shoulder endoprosthesis	10	7.10%
	Fracture fixation	6	4.30%
	Arthroplasty resection	4	2.80%
	Diaphyseal femoral endoprosthesis	3	2.10%
	Elbow endoprosthesis	2	1.40%
	Amputation	1	0.70%
	Disarticulation	1	0.70%
	Total femoral endoprosthesis	1	0.70%
	Diaphyseal humeral endoprosthesis	1	0.70%
	Proximal radial resection	1	0.70%
	Intralesional resection	1	0.70%
Presence of other visceral metastasis	No	72	51.10%
	Yes	69	48.90%
Presence of other bone metastasis	No	28	19.90%
	Yes	113	80.10%
Diabetes	No	110	78.00%
	Yes	31	22.00%
Previous radiotherapy	No	136	96.50%
	Yes	5	3.50%

prosthesis dislocation. All underwent surgical cleaning and debridement, and two were submitted to a new surgery for implant replacement.

Assessment of the Association between Factors and Postoperative Complications

For each variable, we tested the null hypothesis of association with the probability of postoperative complications versus the alternative hypothesis of the existence of an association. ►**Table 6** presents the demographic and clinical factors and the postoperative complications.

There was no correlation of hemoglobin levels, diabetes, and previous RT with complications. Neither did the presence of other metastases, visceral or bone, correlate with complications. For neutrophils alone, there was a significant association with the probability of complications ($p = 0.040$): for every 100 additional neutrophils, the chance of complications increased by 1%. The NLR and PLR were not risk factors for complications.

Death

Descriptive Analysis of Survival Time

►**Fig. 1** presents the Kaplan-Meier curve for the survival time and the median survival time, which was of 5 months, with a 1-year survival rate of 34.7% (n = 49).

Table 3 Gender and primary diagnosis

Primary diagnosis	Gender				Total	
	Female		Male			
	n	%	n	%	n	%
Breast cancer	57	62.60%			57	40.40%
Prostate cancer			19	38.00%	19	13.50%
Lung and adnexa cancer	9	9.8	9	18.00%	18	12.70%
Kidney cancer	5	5.50%	9	18.00%	14	9.90%
Unknown primary diagnosis	7	7.70%	1	2.00%	8	5.70%
Colon cancer	1	1.10%	2	4.00%	3	2.10%
Endometrium cancer	3	3.30%			3	2.10%
Gastric cancer	2	2.20%	1	2.00%	3	2.10%
Bladder cancer	2	2.20%			2	1.40%
Esophagus cancer			2	4.00%	2	1.40%
Skin cancer			2	4.00%	2	1.40%
Pharynx cancer			1	2.00%	1	0.70%
Gastrointestinal cancer	1	1.10%			1	0.70%
Intracranial hemangiopericytoma	1	1.10%			1	0.70%
Liver cancer			1	2.00%	1	0.70%
Larynx cancer			1	2.00%	1	0.70%
Melanoma	1	1.10%			1	0.70%
Oropharynx cancer			1	2.00%	1	0.70%
Pancreas cancer	1	1.10%			1	0.70%
Thyroid cancer			1	2.00%	1	0.70%
Uterus and adnexa cancer	1	1.10%			1	0.70%
Total	91	100%	50	100%	141	100%

Table 4 Time until postoperative complication

Variable	n	Mean	Standard deviation	Median	Minimum	Maximum	Interquartile range
Time until postoperative complication (days)	44	27.9	31.7	15	0	140	3–42

The most significant cutoff values were NLR = 2 and PLR = 209. ►**Table 7** and ►**Fig. 2** show the survival rates and Kaplan-Meier curves considering the cutoff point of NLR = 2. We tested the null hypothesis that the survival curves were the same for NLR < 2 and NLR ≥ 2 against the alternative hypothesis that they differed. From the third postoperative month onwards, the survival of patients with NLR ≥ 2 ($p < 0.001$) decreased from 92.3 to 62.5% and, at 12 months, from 61.5 to 31.3% (►**Table 8**).

For the PLR, we tested the null hypothesis that the survival curves were the same for cases with PLR < 209 and PLR ≥ 209 versus the alternative hypothesis that they were different. Similarly to the NLR, patients with PLR ≥ 209 ($p < 0.001$) presented a lower survival rate, decreasing from 69 to 59.3% in the third month, and from 40.2 to 25.9% 1 year postoperatively (►**Table 9**). ►**Table 10** and ►**Fig. 3** show the results and Kaplan-Meier survival curves considering the cutoff point of PLR = 209.

Discussion

More than 18 million cases of cancer are registered annually worldwide, and approximately 50% of these subjects will develop advanced metastatic disease.[13,14] Advances in oncological treatment increased patient survival and, at the same time, the number of BM cases. According to estimates, the prevalence of BM in the United States will reach 600 thousand by 2030.[4]

The present study included 141 patients undergoing surgical treatment for BM, with a mean age of 61.5 (range: 25 to 89) years and a predominance of women (64.5%; n = 91). Meohas et al.[15] and Li et al.[16] observed a higher incidence in women over 40 years of age.

Table 5 Incidence of postoperative complications

Variable	Classification	n	%
Postoperative complications	No	97	68.8%
	Yes	44	31.2%
Type of postoperative complication (n = 44)	Pneumonia	10	22.7%
	Surgical wound infection	5	11.3%
	Gastrointestinal tract bleeding	4	9.1%
	Prosthesis infection	4	9.1%
	Prosthesis dislocation	4	9.1%
	Acute arterial occlusion in lower limb	2	4.5%
	Surgical wound bleeding	2	4.5%
	Pulmonary thromboembolism	2	4.5%
	Hemodynamic shock	2	4.5%
	Local recurrence	2	4.5%
	Hypercalcemia	2	4.5%
	Dehiscence with material exposure	1	2.3%
	Urinary tract infection	1	2.3%
	Systemic inflammatory response syndrome	1	2.3%
	Deep vein thrombosis	1	2.3%

Hernández et al.[17] analyzed 382,733 patients with primary solid tumors. The incidence of BM was of 6.9% (n = 26,250), and the mean age of the patients was of 64 years. The most prevalent tumors and those with the highest susceptibility to BM were breast, prostate, and lung cancer.[17] In another study[18] with 85,296 patients with BM, the prevalence was of 64.2% for breast tumors, of 59.89% for prostate tumors, of 52.85% for nasopharynx cancers, of 35.82% for lung cancers, and of 35.10% for kidney cancers. Consistent with the literature, in the present study, 66% of BMs originated from breast, prostate, and lung tumors.

More than 80% of BM cases are in the axial skeleton, especially in the vertebrae, ribs, and hips.[19] In the appendicular skeleton, BM frequently involves the proximal regions of the limbs. Lesions below the knee and elbow are rare and associated with lung, kidney, and thyroid neoplasms.[20] In a study[21] with 171 patients, 58 presented appendicular lesions, including 73.8% in the proximal femur, 58.3% in the proximal humerus, and only 4 cases in the tibia. In the current analysis, the most affected bone was the femur, with 112 cases, followed by the humerus, with 21 cases. There were only three cases of BM occurred in the extremities, two in the radius and one in the tibial diaphysis. This dissemination pattern reflects the red bone marrow vascularization, facilitating the implantation and growth of tumor cells.[14]

Ideally, patients with BM should undergo a single procedure to enable early full weight-bearing and lasting the patient's life expectancy.[22] Patients with a life expectancy lower than 3 months can undergo non-surgical or less invasive treatments, while those with a longer life expectancy may benefit from more complex surgical procedures for tumor control and functional improvement.[23]

In the current study, 88% of the patients (n = 124) underwent bone reconstruction with endoprosthesis. Postoperative complications occurred in 44 subjects, including 68% clinical and 10% surgical complications. A total of 4 patients presented prosthesis infections, with 2 requiring implant exchanges. Teixeira et al.[2] evaluated 64 patients undergoing surgery for BM. Of these, 17 (26.6%) presented complications, including 10 surgical, 4 clinical, and 3 combined complications.[2] Kumar et al.[24] reported 4 infections, 2 dislocations, and 2 aseptic loosening cases in 32 patients undergoing proximal femoral endoprosthesis procedures.

Approximately 60% of the patients with BM present comorbidities, especially cardiovascular, respiratory, and metabolic disorders.[5] Bindels et al.[25] associated early postoperative complications with factors such as fast-growing tumors, multiple BMs, pathological fractures, lower limb surgeries, hypoalbuminemia, hyponatremia, and leukocytosis.[25] Preoperative RT increases the risk of postoperative complications, predominantly when performed up to 2 months before surgery.[26] Although diabetes and RT were deemed risk factors, they had no association with complications.

Anemia negatively affects cancer patient survival regardless of the primary tumor.[9,10] However, in the present study we did not observe an association between hemoglobin levels and postoperative complications. Neither did leukocytosis from infections and inflammations show any correlation with complications. Nonetheless, there was an association between increased neutrophil counts and the risk of postoperative complications: for every 100 additional neutrophils, there was a 1% increase in the chance of complications.

Table 6 Demographic and clinical factors and postoperative complications

Variable	Classification	Total	Postoperative complications		p^*	OR (95%CI)
			No	Yes		
Age (years)	Mean ± SD	141	60.7 ± 12.5	63.3 ± 10.9	0.238	1.02 (0.99–1.05)
Gender	Male	50	39 (78.0%)	11 (22.0%)		
	Female	91	58 (63.7%)	33 (36.3%)	0.083	2.02 (0.91–4.46)
Presence of other visceral metastases	No	72	46 (63.9%)	26 (36.1%)		
	Yes	69	51 (73.9%)	18 (26.1%)	0.201	1.60 (0.78–3.29)
Presence of other bone metastases	No	28	19 (67.9%)	9 (32.1%)		
	Yes	113	78 (69%)	35 (31.0%)	0.905	1.06 (0.44–2.57)
Diabetes	No	110	76 (69.1%)	34 (30.9%)		
	Yes	31	21 (67.7%)	10 (32.3%)	0.886	0.94 (0.40–2.21)
Previous radiotherapy	No	136	94 (69.1%)	42 (30.9%)		
	Yes	5	3 (60.0%)	2 (40.0%)	0.668	0.67 (0.11–4.16)
Neutrophils (every 100)	Median (IQR)	141	5,550 (3,760–7,900)	6,941 (4,933–8,689)	0.040	1.01 (1.001–1.02)
Lymphocytes (every 100)	Median (IQR)	141	1,280 (974–1,940)	1,361 (1,058–2,005)	0.925	1.00 (0.96–1.05)
Leukocytes (every 100)	Mean ± SD	141	8,280 ± 3,246	9,487 ± 3,876	0.062	1.01 (1.00–1.02)
Platelets (every 10,000)	Median (IQR)	141	237,000 (181,000–304,000)	243,500 (154,000–310,000)	0.797	1.00 (0.96–1.03)
Hemoglobin	Mean ± SD	141	11.9 ± 2.0	11.3 ± 1.8	0.145	0.87 (0.72–1.05)
Neutrophil-to-lymphocyte ratio	**Median (IQR)**	**141**	**4.1 (2.5–5.8)**	**4.5 (3.2–6.9)**	**0.534**	**1.03 (0.95–1.11)**
Platelet-to-lymphocyte ratio	**Median (IQR)**	**141**	**167 (116–269)**	**177 (105–242)**	**0.534**	**0.999 (0.996–1.002)**

Abbreviations: 95%CI, 95% confidence interval; OR, odds ratio; IQR, interquartile range; SD, standard deviation.
Note: *Logistic regression model and Wald test; $p < 0.05$

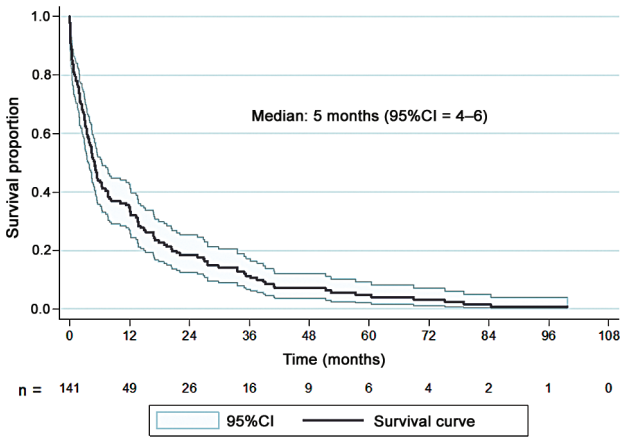


Fig. 1 Kaplan-Meier curve with patient survival time (95% confidence interval [95%CI]). Definition of neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) cutoff points associated with survival time.

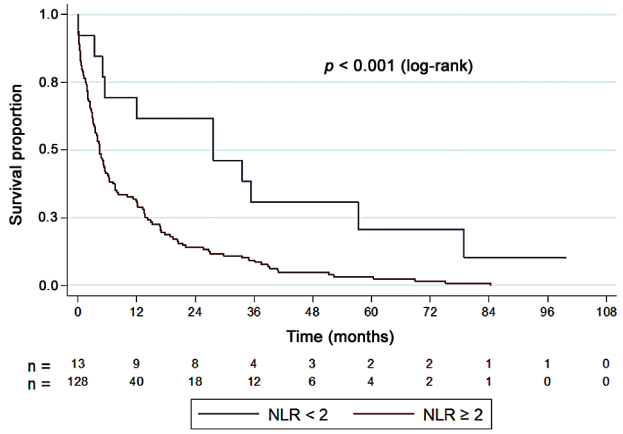


Fig. 2 Survival curve considering an NLR cutoff point of 2.

Table 7 Survival rate considering the neutrophil-to-lymphocyte ratio cutoff point of 2

Variable	Classification	Total	Death				p^*
			No		Yes		
			n	%	n	%	
Neutrophil-to-lymphocyte ratio	< 2	13	2	15.4%	11	84.6%	< 0.001
	≥ 2	128	0	0%	128	100%	

Note: *Log-rank test; $p < 0.05$.

Table 8 Survival percentages estimated by the Kaplan-Meier curve for NLR <2 and ≥ 2

Time	Survival (%)	
	NLR < 2	NLR ≥ 2
0 = surgery	100%	100%
1 month	92.3%	92.2%
3 months	92.3%	62.5%
6 months	69.2%	41.4%
12 months	61.5%	31.3%

Abbreviation: NLR, neutrophil-to-lymphocyte ratio.

The overall 1-year survival rate was of 34.7% (n = 49), with a median survival rate of 5 months. In patients with NLR ≥ 2 ($p < 0.001$), survival decreased from 92.3 to 62.5% at 3 months, and from 61.5 to 31.3% after 1 year. Although the mechanisms of interaction between cancer and inflammatory factors require elucidation, studies[9,10] show that elevated NLR has an association with poor survival in several neoplasms, such as multiple myeloma and gastric, colorectal, lung, breast, and endometrial cancers. A meta-analysis of 40,559 patients with malignant tumors found that an elevated NLR, that is, higher than 4, results in worse overall survival.

Wang et al.[27] selected 497 patients with BM from different carcinomas, including 225 subjects who underwent surgical treatment, and evaluated the prognostic implications of NLR. These authors divided NLR into ≤ 3.0 and > 3.0, and they observed that a high NLR was associated with a worse prognosis, especially in surgical patients.[27] In an analysis of 1,012 patients with BM, Thio et al.[28] defined the NLR and PLR cutoff points as 4 and 408 respectively. Subjects with high NLR and PLR presented lower survival at 3 months; 84.0% of those with low NLR were alive compared with 61.3%

Table 9 Survival rate considering the platelet-to-lymphocyte ratio cutoff point of 209

Variable	Classification	Total	Death				p^*
			No		Yes		
			n	%	n	%	
Platelet-to-lymphocyte ratio	< 209	87	2	2.3%	85	97.7%	0.019
	≥ 209	54	0	0%	54	100%	

Note: *Log-rank test; $p < 0.05$.

Table 10 Survival percentages estimated by the Kaplan-Meier curve for PLR < 209 and ≥ 209

Time	Survival (%)	
	PLR < 209	PLR ≥ 209
0 = surgery	100%	100%
1 month	81.6%	79.6%
3 months	69.0%	59.3%
6 months	49.4%	35.2%
12 months	40.2%	25.9%

Abbreviation: PLR, platelet-to-lymphocyte ratio.

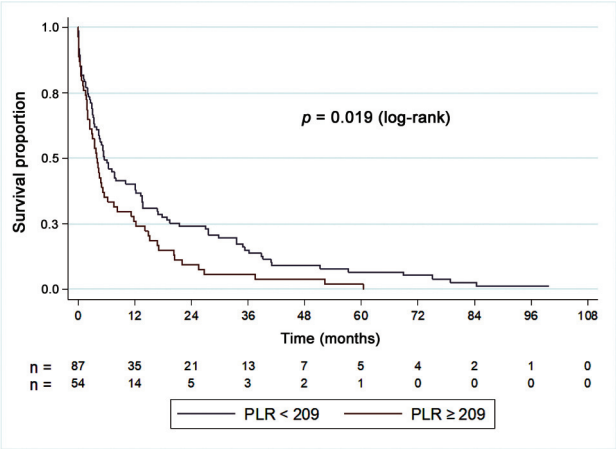


Fig. 3 Survival curve considering a PLR cutoff point of 209.

of those with high NLR, and 75.8% of those with low PLR were alive compared with 55.6% of those with high PLR.[28]

The prognostic value of PLR has been extensively studied in recent years. However, the mechanisms linking high PLR to poor prognosis in cancer patients remains unknown. A meta-analysis[10] of 12,754 patients from 20 studies on PLR in solid tumors showed that cutoff values ranged from 150 to 300 and revealed a significant association between high PLR and lower overall survival, especially in patients with metastatic disease. In the present study, patients with PLR ≥ 209 presented reduced survival, from 69 to 59.3% at 3 months and from 40.2 to 25.9% after 1 year.

The use of different cutoffs for NLR and PLR is controversial. Advanced disease stages, with higher inflammation levels, may result in increased NLR or PLR, indicating that the cutoff points may be higher. Furthermore, the prognostic values of NLR and PLR and their optimal cutoffs may vary among tumors; therefore, specific analyses are required.

The current study has limitations, including a statistical approach to define the optimal cutoff values for NLR and PLR based on data rather than hypotheses. The retrospective nature of the study did not enable the determination of uniform criteria for treatment or surgery, leading to the exclusion of patients not submitted to surgery, with BM in the axial skeleton, or with multiple myeloma. Thus, our conclusions apply to patients with BM in long bones and surgical candidates.

Certain factors, such as age, gender, ethnicity, chemotherapy, antibiotic therapy, transfusions, and infection may affect neutrophil, lymphocyte, or platelet counts. However, since the prognostic value of NLR and PLR is unclear, we believe that pretreatment counts reflect the patient's immune and inflammatory response without identifying the individual factors influencing them.

Conclusion

In the current study, we did not observe a positive association regarding NLR, PLR and postoperative complication rates. However, we detected a strong correlation of increased NLR and PLR values with life expectancy reduction from the third month postoperatively.

Authors' Contributions

Each author contributed individually and significantly to the development of the present article: MST and AVRT: conceptualization and investigation; CAPMR: methodology; FIT: project administration; and all authors: writing – review and editing.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Ottawa Ankle Rules: A Reliable Clinical Instrument to Detect Fractures in Children and Adolescents

Regras do tornozelo de Ottawa: Um instrumento clínico confiável na detecção de fraturas na população infantojuvenil

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Abstract

Objective To evaluate the accuracy of the Ottawa Ankle Rules (OARs) applied to the medical records of a high-complexity hospital and a private clinic and to analyze their clinical utility in subjects aged 16 or younger.

Methods The present is a cross-sectional, analytical observational study with secondary data collected from an orthopedic emergency department and a private orthopedic clinic. The sample consisted of 144 subjects, including all patients with ankle torsion episodes who underwent ankle and/or foot radiographs upon admission. We adopted the OARs as the diagnostic test to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and positive and negative likelihood ratios using the radiographic examination finding as the gold standard.

Results A total of 191 patients were selected, 144 of whom were included after the application of the inclusion criteria. The sensitivity and NPV of the OARs for fracture identification were of 100%, with the most sensitive test and highest NPV being the inability to walk four steps. We identified a potential reduction of 43.8% in the total number of radiographs requested if only patients with positive OARs underwent the examination.

Conclusions The OARs seem to be a reliable clinical tool in ankle sprain management and a useful clinical protocol to exclude fractures in pediatric patients. Their use demonstrated their ability to reduce unnecessary radiograph requests, minimizing radiation exposure and healthcare system costs.

Keywords
- ankle
- foot
- pediatrics
- radiography
- sprains and strains
- wounds and injuries

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Resumo

Objetivo Avaliar a acurácia das regras do tornozelo de Ottawa (RTOs) aplicadas em prontuários de um hospital de alta complexidade e em uma clínica privada, assim como sua utilidade clínica em indivíduos com idade menor ou igual a 16 anos.

Métodos Trata-se de estudo observacional analítico transversal, com coleta de dados secundários de um departamento de emergência ortopédica e uma clínica ortopédica privada. A amostra foi representada por 144 pacientes, incluindo todos os pacientes com episódio torcional de tornozelo submetidos a radiografias de tornozelo e/ou pé quando da admissão. As RTOs foram adotadas como teste diagnóstico para o cálculo da sensibilidade, da especificidade, do valor preditivo positivo (VPP), do valor preditivo negativo (VPN) e das razões de verossimilhança positivas e negativas, e o resultado do exame radiográfico foi considerado o pardão-ouro.

Resultados Foram selecionados 191 pacientes, 144 dos quais foram incluídos após a aplicação dos critérios de inclusão. A sensibilidade e o VPN das RTOs na identificação de fraturas foram de 100%, sendo que o teste mais sensível e com o maior VPN foi a incapacidade de caminhar quatro passos. Identificou-se um potencial de redução de 43,8% no número total de radiografias solicitadas, caso apenas os pacientes com RTOs positivas fossem radiografados.

Conclusões As RTOs parecem ser um instrumento clínico confiável no manejo das entorses de tornozelo, e são um protocolo clínico útil na exclusão de fraturas em pacientes pediátricos. A utilização das regras evidenciou a sua capacidade de diminuir as solicitações desnecessárias de radiografias, o que minimiza a exposição à radiação e reduz os custos para o sistema de saúde.

Palavras-chave

- entorses e distensões
- ferimentos e lesões
- pé
- pediatria
- radiografia
- tornozelo

Introduction

Ankle injuries are common in emergency departments, accounting for 6 to 12% of visits.[1] Ankle fractures account for approximately 5% of all fractures in pediatric patients.[2] The peak incidence of these injuries occurs from 8 to 15 years of age, affecting 2-fold more boys.[3] Most patients with foot and ankle trauma undergo radiography in the emergency department because of potential fractures, although their frequency is lower than 15%. This conservative approach results in many unnecessary requests for radiography, which leads to avoidable radiation exposure, additional costs to the healthcare system, and prolonged waiting times for patients.[4]

To standardize diagnostic methods and reduce unnecessary radiography requests, a research group introduced the Ottawa Ankle Rules (OARs) in 1992, which enable the prediction of fracture occurrence in acute ankle injuries through a targeted physical examination.[5] The protocol states that radiographic evaluation is only essential when the patient reports malleolar pain associated with lateral or medial malleolar pain on bone palpation (both 6 cm distal in the posterior region) or inability to support the limb (immediately after the injury and walking four steps in the emergency room). Another indication consists of cases of ankle trauma with referred pain in the midfoot with one or more of the following criteria: pain on bone palpation at the base of the fifth metatarsal, pain on navicular bone palpation, and inability to support the limb (immediately after the injury and walking four steps in the emergency room).[6] At first, radiography alone is required when the clinical criteria are met.[7] Other supplementary tests, such as computed tomography (CT), magnetic resonance imaging (MRI), and blood tests, are reserved for specific situations, such as assessments of joint congruence, intra-articular lesions, and surgical planning.[8] The protocol is contraindicated in patients with altered mental status, drug intoxication, language barriers, or significant edema limiting bone palpation.[6]

The sensitivity of the OARs reaches virtually 100% in studies involving the adult population.[9] However, international authors[10–13] have identified an opportunity to use the OARs in the pediatric population. Application of the OARs to pediatric patients is scarce, possibly due to the challenge of obtaining a reliable verbal history and performing a proper physical examination in some children compared with adults. Furthermore, the OARs can only be applied to children who could walk independently before the episode.[12]

The OARs have already been validated in adults, but there is a lack of studies involving the pediatric population regarding the potential use of the rules as a diagnostic screening tool. In the present study, we aimed to evaluate their applicability in pediatric patients treated in a high-complexity hospital and a private clinic.

Materials and Methods

The present is an observational, cross-sectional, and analytical study with a quantitative approach. The institutional

Ethics Committee approved and supervised the project (CAAE: 60851622.1.0000.0119).

The sample included 144 patients aged 16 or younger, treated from January 2019 to December 2022, who underwent radiographs after an episode of ankle sprain. The study sites include a public hospital and a private orthopedic clinic: the clinic has an orthopedic on-call service from Monday to Saturdays, and its vast facility includes an X-ray machine; and the hospital is a reference in highly-complex services and has an orthopedic on-call service 24 hours a day, 7 days a week.

The data collection instrument contained ten qualitative and quantitative variables: presence of ankle and/or foot fracture – the radiological finding; sex; age; skin color; history of ankle torsional trauma; affected side; time since injury; fracture site; surgery requirement; and the presence of at least one Ottawa criteria. Physicians available upon admission evaluated and treated all patients, with no interference from the researchers. The inclusion criteria were a history of ankle sprain and the request for ankle and/or foot radiographs, in addition to the examination. We excluded medical records without sufficient information for the OAR application. A radiologist analyzed all radiographs, and the report was attached to the medical records, enabling the retrospective analysis. A pediatric orthopedist monitored data collection and had the technical ability to interpret the radiographs without prior knowledge of the results or of the presence or absence of OARs in the patients' records. The image analysis by the radiologist and the pediatric orthopedist was fully concordant in terms of the identification of fractures. After the identification or not of the OARs in the patients' medical records and considering the agreement in the radiographic interpretations, we compared the radiographic findings with the OARs. As such, we calculated the clinical accuracy, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the positive and negative likelihood ratios of the OARs. To rule out fractures, a test must present high sensitivity, low negative likelihood ratio, and high NPV. This means that the test should yield few false negatives, being highly accurate in excluding fractures when the result is negative.

We analyzed the data collected using the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States) software, version 21.0. The quantitative variables were expressed as mean and standard deviation values. The statistical tests considered a significance level of $\alpha = 0.05$, indicating a 95% confidence level. The Kolmogorov-Smirnov test was used to verify the normality of the quantitative variables. Through the Pearson's Chi-squared test, followed by residual analysis when there was a statistical significance, we investigated the existence of associations involving the qualitative variables. We calculated the sensitivity, specificity, accuracy, PPV, NPV, and positive and negative likelihood ratios. The result of the radiological examination was considered the gold standard, and the presence of at least one Ottawa criterion, the diagnostic method being tested.

Table 1 Characteristics of the sample

		95% confidence interval
	n = 144	
Age (years): mean ± standard deviation	10.36 ± 3.45‡	9.81–10.96
Sex: n (%)		
Male	77 (53.5)	–
Female	67 (46.5)	–
Skin color: n (%)		
White	142 (98.6)	–
Brown	1 (0.7)	–
Black	1 (0.7)	–

Notes: ‡Non-normal distribution per the Kolmogorov-Smirnov test ($p < 0.001$); median (interquartile range): 11.0 (8.0–13.0).

Results

In total, 144 patients were eligible, and we excluded 47 patients from the sample due to the absence of torsional trauma or incomplete records, which prevented OAR application. ►**Table 1** shows that the mean age of the sample was of 10.36 years, with a minimum age of 2 and a maximum of 16 years. Among the patients, 53.5% were male, and 98.6% were White.

►**Table 2** shows that 51.4% of the injuries were on the right side. Regarding the time of injury, 87.5% presented for consultation within ≤ 48 hours after the sprain. In addition, 20.1% of the patients had ankle and/or foot fractures according to the radiographic examination performed upon admission. There was a total of 35 fractures in 6 different regions: the distal tibia was the most common site (34.3%), followed by the fibula and lateral malleolus (with 22.9% each). Most patients (95.8%) underwent the conservative treatment.

►**Table 3** shows that 81 patients presented at least 1 Ottawa criterion in their first visit. Lateral malleolar pain and inability to walk four steps occurred in 35.4% and 34.7% of the patients, respectively. Among the additional criteria evaluated in patients with at least one positive criterion, 7.6% presented medial malleolar pain, 5.6%, pain at the base of the fifth metatarsal, and 2.1%, navicular pain.

►**Table 4** describes the association between fractures and the Ottawa criteria. There was a statistically significant association between the presence of at least 1 OAR and fractures ($p < 0.001$).

►**Table 5** shows the distribution of the Ottawa criteria among the sample. The sensitivity and NPV of the rules in the sample were of 100.0% (sensitivity: 95% confidence interval [95%CI] = 96.2–100.0%; NPV: 95%CI = 95.7–100.0%) in detecting fractures, with a negative likelihood ratio of 0.00% (95% CI = 0.00–0.00%). The criteria for medial malleolar pain, pain at the base of the fifth metatarsal, and navicular pain showed high specificity in detecting fractures, reaching values greater than 90% in all cases. In addition, the

Table 2 Clinical and diagnostic features and treatment of ankle lesions

	n = 144
Affected side: n (%)	
Right	74 (51.4)
Left	70 (48.6)
Lesion time: n (%)	
≤ 48 hours	126 (87.5)
> 48 hours	18 (12.5)
Presence of ankle and/or foot fractures (radiological result): n (%)	
Yes	29 (20.1)
No	115 (79.9)
Fracture site ($n = 29$)* – n (%)	
Distal tibia	12 (34.3)
Fibula	8 (22.9)
Lateral malleolus	8 (22.9)
Base of the fifth metatarsal bone	4 (11.4)
Medial malleolus	2 (5.7)
Third metatarsal bone	1 (2.9)
Treatment: n (%)	
Conservative	138 (95.8)
Surgical	6 (4.2)

Notes: *Subjects can present fractures in more than one site.

Table 3 Ottawa protocol variables

	n = 144
Presence of at least one Ottawa criteria: n (%)	
Yes	81 (56.3)
No	63 (43.8)
Lateral malleolar pain on palpation: n (%)	
Yes	51 (35.4)
No	93 (64.3)
Medial malleolar pain on palpation: n (%)	
Yes	11 (7.6)
No	133 (92.4)
Inability to walk four steps: n (%)	
Yes	50 (34.7)
No	94 (65.3)
Pain at the base of the fifth metatarsal on palpation: n (%)	
Yes	8 (5.6)
No	136 (94.4)
Navicular pain on palpation: n (%)	
Yes	3 (2.1)
No	141 (97.9)

Table 4 Association between the presence of at least one Ottawa criteria and a fracture

	Fracture		*p*-value†
	Yes	No	
	n = 29	n = 115	
Presence of at least one Ottawa criteria: n (%)			
Yes	29 (100.0)[b]	52 (45.2)	< 0.001
No	0 (0.0)	63 (54.8)[b]	

Notes: †Value obtained after applying the Pearson's Chi-squared test; [b] tatistically significant value after the residual analysis ($p < 0.05$).

criteria for lateral malleolar pain on palpation and inability to walk four steps presented NPVs of 91.4% and 94.7%, respectively.

►**Table 6** shows the relationship between the patients diagnosed with fractures through radiological examination and the presence of Ottawa criteria upon admission, revealing that 75.9% of the subjects presented 2 Ottawa criteria before radiography.

Discussion

Torsional injuries are common in orthopedic emergency and urgent care services, resulting in fractures in 12% to 15% of cases.[11] In a meta-analysis of the OARs in 3,130 pediatric patients, Dowling et al.[12] identified fractures in 671 patients, with a prevalence of 21.4%. In the present study, the rate of fracture occurrence was similar, that is, 20.1% of the patients included, with 75.9% presenting 2 Ottawa criteria upon admission.

The most common childhood fracture occurs at the distal tibial physis, accounting for 9% to 18% of physeal injuries, surpassed only by fractures of the phalanges and distal radius.[14] In line with the literature, we observed that, of the 6 distinct fracture sites identified, the distal tibia region presented the highest frequency, with a rate of 34.3% of the fractures. The peak of these pediatric ankle fractures occurs from the ages of 8 to 15 years and the incidence rate is 2-fold higher in boys compared to girls.[2] Similarly, we observed that the average age for fracture presentation was of 10.36 years. In addition, there was a predominance (53.5%) of male subjects, which is consistent with the higher frequency in boys, although the incidence was not two-fold higher than in girls.

The initial management of these patients often involves routine foot and ankle radiographs. These are the second most frequently performed radiographs in the emergency department after spine radiographs. However, this cautious approach results in many unnecessary radiological

Table 5 Distribution of the Ottawa criteria among the sample

	n = 144
Presence of at least one Ottawa criterion: % (95%CI)	
Sensitivity	100.0 (96.2–100.0)
Specificity	54.8 (47.3–62.0)
Accuracy	63.9 (55.7–72.0)
Positive predictive value	35.8 (27.5–46.5)
Negative predictive value	100.0 (95.7–100.0)
Positive likelihood ratio	2.21 (1.73–4.97)
Negative likelihood ratio	0.00 (0.00–0.00)
Medial malleolar pain on palpation: % (95%CI)	
Sensitivity	10.3 (0.0–21.4)
Specificity	93.0 (88.4–97.7)
Accuracy	76.4 (69.5–83.3)
Positive predictive value	27.3 (1.0–53.6)
Negative predictive value	80.5 (73.7–87.2)
Positive likelihood ratio	1.47 (0.00–9.30)
Negative likelihood ratio	0.96 (0.8–1.13)
Lateral malleolar pain on palpation: % (95%CI)	
Sensitivity	72.4 (56.1–88.7)
Specificity	73.9 (65.9–81.9)
Accuracy	73.6 (66.4–80.8)
Positive predictive value	41.2 (27.7–54.7)
Negative predictive value	91.4 (85.7–97.1)
Positive likelihood ratio	2.77 (1.65–4.90)
Negative likelihood ratio	0.37 (0.14–0.67)
Inability to walk four steps: % (95%CI)	
Sensitivity	82.8 (69.0–96.5)
Specificity	77.4 (69.7–85.0)
Accuracy	78.5 (71.8–85.2)
Positive predictive value	48.0 (34.2–61.8)
Negative predictive value	94.7 (90.1–99.2)
Positive likelihood ratio	3.66 (2.28–6.43)
Negative likelihood ratio	0.22 (0.04–0.44)
Pain at the base of the fifth metatarsal on palpation: % (95%CI)	
Sensitivity	17.2 (3.5–31.0)
Specificity	97.4 (94. –100.0)
Accuracy	81.3 (74.9–87.6)
Positive predictive value	62.5 (29.0–96.0)
Negative predictive value	82.4 (75.9–88.8)
Positive likelihood ratio	6.62 (0.64–310.0)
Negative likelihood ratio	0.85 (0.69–1.02)
Navicular pain on palpation: % (95%CI)	
Sensitivity	6.9 (0.0–16.1)
Specificity	99.1 (97.4–100.0)
Accuracy	80.6 (74.1–87.0)
Positive predictive value	66.7 (13.3–100.00)
Negative predictive value	80.9 (74.4–87.3)
Positive likelihood ratio	7.67 (0.00–161.0)
Negative likelihood ratio	0.94 (0.84–1.03)

Abbreviation: 95%CI, 95% confidence interval

Table 6 Fracture description and presence of Ottawa criteria upon admission

	n = 29
One criterion: n (%)	5 (17.2)
Two criteria: n (%)	22 (75.9)
Three criteria: n (%)	2 (6.9%)

examinations, leading to higher costs, longer treatment times, and avoidable radiation exposure. This led Stiell et al.[6] to develop and validate the OARs, which have become an extremely beneficial tool in managing ankle trauma, reducing the need for exam requests.[11]

Yavas et al.[15] estimated a 28.4% reduction in radiograph requests by not performing them in patients with negative OARs. This results from the high sensitivity and moderate specificity of the method, which enables faster care and fewer exams. Similarly, in a meta-analysis including 15,581 patients from 27 studies, Bachmann et al.[10] confirmed that the OARs are a reliable clinical tool to exclude ankle and midfoot fractures. Furthermore, statistical calculations showed a possible reduction rate of 30% to 40% in unnecessary radiograph requests.[10] In the current study, we retrospectively observed that, if only patients with positive OARs underwent radiographic examinations, there would be a 43.8% (95%CI) reduction in the radiographs requested, which is in agreement with the available literature on the applicability of the test.

Plint et al.[13] found that the OARs reach 100% of sensitivity in detecting ankle and midfoot fractures in pediatric patients. The 667 patients studied by them[13] had 12 to 16 years of age and reported a previous episode of ankle trauma within 48 hours. The present study corroborates these findings, showing that 87.5% of patients sought care within 48 hours after the trauma and had similar minimum and maximum ages. Their statistical analysis showed the same sensitivity of 100.0%, NPV of 100.0%, and a negative likelihood ratio of 0.00%. Therefore, this demonstrates the

greater probability of the child or adolescent not suffering a fracture if the AORs are negative, due to the high precision of the test in excluding fractures. The specificity levels were high for pain in the fifth metatarsal and on navicular palpation, with values of 97.4% and 99.1%, respectively. The NPV was high for pain on medial and lateral malleolus palpation, with values of 80.5% and 91.4%, respectively.

Conclusion

The OARs appear to be a reliable clinical tool in the initial management of ankle sprains in pediatric patients, and they can be applied without concerns of missing significant fractures. We also observed a reduction in radiograph requests, which yields benefits such as reduced radiation exposure for children and adolescents, lower costs for the healthcare system, and shorter waiting times in the emergency department. Few international studies have analyzed the OARs in the pediatric population, and, to date, there are no Brazilian studies, reinforcing the need for further research to consolidate this clinical tool. Therefore, the results of the present study can serve as a basis for the formulation and implementation of government measures and guidelines aimed at improving the detection and treatment of ankle sprains.

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

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Calcaneo-Stop: An Effective Surgical Technique to Correct Symptomatic Flexible Flatfoot in Children

Calcâneo-stop: Uma técnica cirúrgica eficaz para a correção do pé plano valgo flexível sintomático em crianças

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Abstract

Objective Flexible juvenile valgus flatfoot is a prevalent condition that typically resolves spontaneously but requires surgical treatment if associated with discomfort, pain, and physical limitation. However, certain surgical procedures are associated with higher morbidity, as they involve osteotomies and arthrodesis. In this context, extra-articular talocalcaneal arthroereisis is an option, because it is a cost-effective, low-morbidity, and efficient method of treatment. The aim of the present study is to report the outcomes of the treatment of flexible juvenile valgus flatfoot using the calcaneo-stop technique.

Methods Pre-adolescent patients with severe or symptomatic flexible juvenile valgus flatfoot were surgically treated using the calcaneo-stop technique (talocalcaneal arthroereisis). The outcomes were evaluated clinically and radiographically, assessing Meary angles, talonavicular coverage, talus-metatarsal alignment, Moreau-Costa-Bertani angle, calcaneal pitch, and the percentage of talus head coverage by the navicular.

Results A total of 23 individuals (44 feet) were evaluated and operated on, with ages ranging from 7 to 13 years (mean: 11) and a mean follow-up of 28 months. There was marked improvement or disappearance of symptoms in 90% of the patients. The complication rate was of 13.6%, primarily associated with localized pain at the surgical

Keywords
- adolescent
- flatfoot
- subtalar joint

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site. All radiographic parameters improved significantly ($p < 0.001$), with values approaching normality in most cases.
Conclusion Improvements in both clinical and radiographic parameters suggest that talocalcaneal arthroereisis corrects deformities with a low complication rate.

Resumo

Objetivo O pé plano valgo juvenil flexível é uma doença prevalente que, de modo geral, se resolve de forma espontânea. No entanto, requer tratamento cirúrgico se associado a desconforto, dor e limitação física. Alguns procedimentos cirúrgicos, porém, são associados a maior morbidade, pois envolvem osteotomias e artrodese. Nesse contexto, a artrorrise talocalcânea extra-articular é uma opção por ser um método de tratamento barato, de baixa morbidade e eficaz. O objetivo deste estudo é relatar os resultados do tratamento do pé plano valgo infantil flexível usando a técnica calcâneo-stop.
Métodos Pacientes pré-adolescentes com pé plano valgo flexível grave ou sintomático foram submetidos ao tratamento cirúrgico usando a técnica calcâneo-Stop (artrorrise talocalcaneana). Os resultados foram avaliados clínica e radiograficamente, incluindo os ângulos de Meary, a cobertura talonavicular, o alinhamento tálus-metatarso, o ângulo de Moreau-Costa-Bertani, o *pitch* calcâneo e a porcentagem de cobertura da cabeça do tálus pelo navicular.
Resultados No total, 23 pacientes (44 pés) foram avaliados e operados. A idade dos pacientes variou de 7 a 13 anos (média: 11), com acompanhamento médio de 28 meses. Houve melhora acentuada ou desaparecimento dos sintomas em 90% dos pacientes. A taxa de complicação foi de 13,6%, associada principalmente à dor localizada no sítio cirúrgico. Todos os parâmetros radiográficos melhoraram significativamente ($p < 0,001$), com valores próximos da normalidade na maioria dos casos.
Conclusão Melhoras nos parâmetros clínicos e radiográficos sugerem que a artrorrise talocalcânea corrige deformidades com baixa taxa de complicações.

Palavras-chave
- adolescente
- articulação talocalcânea
- pé chato

Introduction

Flexible flatfoot is characterized by the absence of or significant reduction in the medial longitudinal arch, associated with an increased valgus of the ankle during weight bearing. It is a common condition in children, but it is self-limiting and has a strong tendency for spontaneous regression.[1] However, a minority of individuals may experience complete failure in the development of the medial plantar arch, resulting in permanent flatfoot throughout life. In adulthood, if the condition is severe, there may be functional limitations, pain, and an increased risk of developing osteoarthritis.[2]

In the juvenile age group, flatfoot can be associated with symptoms such as fatigue after usual efforts, cramps, pain, and discomfort when attempting to fit the unconventional foot shape into standard footwear.[3] These complaints tend to be exacerbated with excess weight, ligament laxity, or Achilles tendon shortening.[4]

Conservative interventions, such as the use of insoles, despite their widespread use, lack scientific evidence supporting their effectiveness.[5,6] As a result, several surgical procedures have been developed to correct symptomatic flexible flatfoot in immature individuals. These techniques can be grouped into soft-tissue procedures,[7] osteotomies,[8–10] or localized arthrodesis.[4] Approaches that exclusively target musculotendinous and ligamentous structures provide temporary corrective effects due to tissue compliance. Osteotomies yield favorable outcomes, but they require longer periods of immobilization and recovery. Arthrodesis has limited indications, as it requires joint destruction to achieve correction.[11]

Another surgical option is arthroereisis (from the Greek *arthroereisis*, in which *arthros* means joint, and *ereisis*, the action of supporting or sustaining). These procedures aim to preserve the joint providing mechanical stabilization without limiting functional movements. They are interesting for their potential in correcting and preventing severe deformities.[12] When applied to flatfoot, such techniques show simplicity, efficiency, low morbidity, and prompt recovery, making them suitable for young and healthy patients.[13]

The origins of arthroereisis in the foot can be attributed to Grice,[14] in 1952, who devised an extra-articular arthrodesis procedure by inserting a bone graft into the tarsal sinus, attempting to correct valgus deformities in children affected by poliomyelitis sequelae. In 1990, Crawford et al.[12] employed temporary metal staples in the subtalar joint to correct valgus feet in individuals with spastic cerebral palsy. The primary objective was to restore the medial plantar arch by partially restricting subtalar joint motion, rather than

completely blocking it. Later, the arthroereisis effect was achieved through the insertion of implants into the tarsal sinus, or by blocking excessive calcaneal eversion using a screw placed laterally to the tarsal sinus, under the lateral process of the talus.[15]

Subtalar implants within the tarsal sinus were initially introduced in 1977, utilizing a silicone elastomer block to maintain the optimal position of the joint.[16] Since then, a wide variety of implants have been developed for this purpose, encompassing various shapes such as plugs, spacers, cones, screws, and cylinders. The materials include elastomer, polyethylene, titanium, and bioabsorbable poly-L-lactic acid.[3]

According to De Pellegrin,[15] the insertion of an extra-articular screw into the calcaneus, adjacent to the lateral process of the talus, was initially described by Álvarez[17] to achieve the effect of arthroereisis, and later modified by Pisani.[18] The technique temporarily blocks excessive pronation of the subtalar joint, enabling the lateral column to grow and occupy the space without pressure.

Currently, this technique is widely used in Europe.[13,15,18–20] In Brazil, arthroereisis with a screw in the calcaneus remains, to some extent, unfamiliar to most of the orthopedists, and the publications are on the treatment of neuropathic flatfoot.[21]

The objectives of the present study were to analyze the results of correcting severe symptomatic flexible valgus flatfoot in the preadolescent age group using the calcaneo-stop technique, and to contribute to a wider dissemination of this method.

Materials and Methods

The current retrospective study was designed to evaluate the outcomes of the surgical treatment in preadolescent patients with symptomatic flexible valgus flatfoot. The study was approved by the institutional Ethics Committee (CAAE: 77119524.8.0000.5440). The sample included individuals of both sexes presenting severe, flexible, idiopathic valgus flatfoot submitted to the calcaneo-stop technique at our institution. The flexibility of the foot was assessed based on reversibility of the deformity with and without weight bearing, the tiptoe standing test (►**Fig. 1**), and on the result of the Jack test.

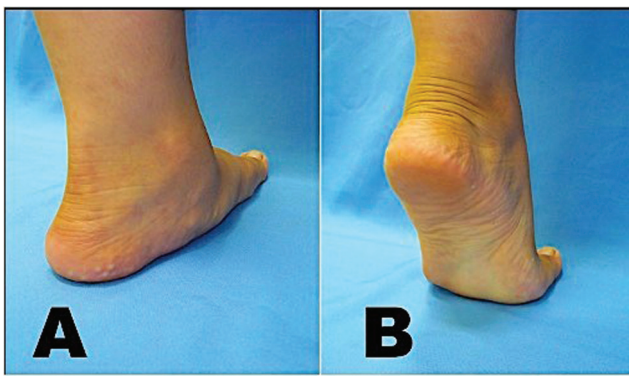


Fig. 1 Tiptoe standing test to demonstrate foot flexibility. (**A**) On weight bearing, the medial arch collapses. (**B**) The heel turns into varus and the medial arch reappears.

Data were collected from medical records, and the assessment included the resolution of the symptoms, the satisfaction of the patients and their families, as well as pre- and postoperative radiographic parameters. The study included cases with complete documentation and informed consent, involving surgeries performed between 2017 and 2022, with an average follow up of 28 months (range: 12-65). We excluded cases of lower limb mechanical axis deviation, concurrent foot deformities or stiffness, prior foot surgery or fractures, or underlying local or systemic diseases (Down syndrome, Ehlers-Danlos syndrome, etc.).

Operative Procedure

Under anesthesia, with the knee extended, the foot was forced into dorsiflexion to assess the degree of heel valgus and to check for associated equinus. Palpation was used to identify the sinus tarsi, and a skin incision measuring approximately 2.0 cm in length was made over it (►**Fig. 2A**). Careful blunt dissection was performed to expose the fat pad and the short extensor muscle, ensuring the sensory branch of the fibular nerve remained undamaged. Under fluoroscopy, the foot was forced into supination, enabling the identification and exposure of the flat surface in the lateral region of the calcaneus, serving as the entry point to the sinus tarsi. A Kirschner wire (K wire) with 2.0 mm in diameter was perpendicularly inserted into the calcaneus bone surface, outside of the sinus tarsi, and its position was confirmed using fluoroscopy (►**Fig. 2B**). Subsequently, the K wire was removed, but the hindfoot was maintained in varus position. The entry point of the wire was identified, the hole was enlarged using a 3.2-mm drill bit, and a partially threaded 6.5-mm cancellous stainless-steel screw (DePuy Synthes, Raynham, MA, United States) with 30 to 40 mm in length was inserted (►**Fig. 2C,D**). The depth of the screw was adjusted to ensure its head was positioned beneath the lateral process of the talus, thereby correcting the malalignment in valgus of the hindfoot. If under- or overcorrection occurred, the screw was respectively advanced or retracted until the desired alignment was achieved. In certain cases, alternative implants, such as those of 7.0-mm cannulated cortical screws (DePuy Synthes), or fully-threaded screws were used. It should be noted that the available literature does not indicate any significant impact of these implant variations on the outcomes of the procedure. If residual equinus was present, a Hoke-type lengthening of the Achilles tendon was carried out, followed by the application of a long leg plaster cast splint.

Postoperative Care

Postoperatively, all patients were immobilized for 7 days, after which weight bearing was gradually reintroduced. In cases requiring equinus correction, patients wore a walking cast for an additional two weeks before transitioning to regular footwear.

A standardized physiotherapy protocol was not implemented, nor was the use of orthotics or modified footwear recommended. Around three weeks after surgery, once the scars had fully healed, the patients were advised to gradually

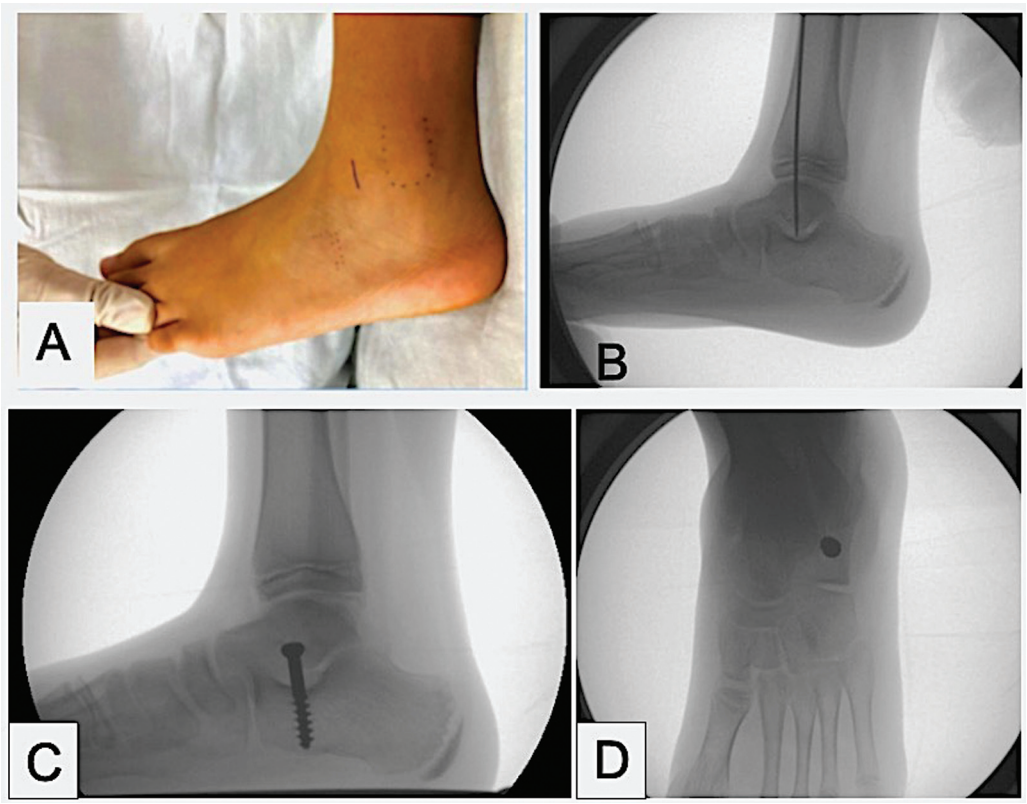


Fig. 2 Surgical steps for calcaneal screw insertion. (**A**) Cutaneous demarcation of the surgical incision over the sinus tarsi. (**B**) After blunt dissection, the entrance of the sinus tarsi was exposed, and a guide K wire was vertically inserted into the calcaneus (**C**) Screw positioning in lateral view. (**D**) Screw positioning in anteroposterior view.

resume physical activities and sports, provided postoperative pain had subsided.

Clinical Evaluation

The patient's medical record was accessed to compare the pre- and postoperative findings. Complications resulting from the surgical procedure, along with symptoms observed postoperatively that were not present preoperatively, were taken into consideration, such as pain, discomfort, and esthetic improvement.[22]

Radiographic Evaluation

The pre and the latest postoperative images were evaluated in anteroposterior and lateral views, under weight bearing. The following angles and measurements were assessed: Meary's, calcaneal pitch, Moreau-Costa-Bertani's, alignment between the long axis of the talus with the first metatarsal, talonavicular angular coverage, and talonavicular percentual coverage.[23,24] ►**Fig. 3** shows the angles used, how to trace them, and their normal ranges. All collected data were grouped and presented in ►**Table 1**.

Statistical Analysis

The Shapiro-Wilk test was used to evaluate the normality of the sample distribution and determine a parametric distribution, with statistical significance set at $p < 0.05$. The paired *t*-test was used to assess the significance of the surgical intervention and improvement in radiological outcomes, with p set at < 0.001. Analyses were conducted using the RStudio Desktop Pro (Posit, PBC, Boston, MA, United States) software, version 2023.03.0.

Results

A total of 23 patients (44 feet), aged between 7 and 13 (mean: 11) years, were considered eligible for the study. The minimum follow-up was 12 months, and the maximum was 5 years (65 months), with a mean of 28 months.

The clinical outcomes were satisfactory, addressing both esthetic concerns and alleviating pain. In total, 90% of the patients reported improvement or complete resolution of symptoms and pain relief compared to their preoperative condition. The rate of complications was of 13.6%, and they occurred in 6 cases: 3 with chronic pain at the surgical site, and 3 with incomplete correction of the deformity. In two cases, the pain was resolved with local corticosteroid injections, while, in the other case, the screw was removed, resulting in reduced pain – though not fully resolved. Implant removal was not necessary for the other patients. There were no occurrences of infection, wound healing issues, or implant breakage. All radiographic parameters exhibited significant postoperative improvement (►**Fig. 4**).

The calcaneal pitch showed a significant increase of 87%, with a preoperative mean value of 6.61° (standard deviation [SD]: 0.65°) and a postoperative value of 12.41° (SD: 0.60°)



Fig. 3 X-Ray evaluation of the foot deformities. (**A**) Meary's angle: measured in lateral view, it represents the angle formed between the long axis of the talus and the long axis of the first metatarsal (normal range: 5°–15°). (**B**) Calcaneal pitch: measured in lateral view, it represents the angle formed between the inferior surface of the plantar cortex of the calcaneus and the ground (normal range: 15°–25°). (**C**) Moreau-Costa-Bertani's angle: determined by tracing a line from the inferior surface of the medial sesamoid to the inferior surface of the talonavicular joint. Another line is traced from this point to the posterior tuberosity of the calcaneus (normal range: 115°–125°). (**D**) Talus-metatarsal angle: measured in anteroposterior view, it represents the angle between the long axis of the talus and the long axis of the first metatarsal (normal values range: 0°–5°). (**E**) Coverage angle of the talonavicular joint: measured in anteroposterior view, it represents the angle formed by the medial and lateral articular surfaces of the talus and the articular surface of the navicular bone (normal range: 0°–7°). (**F**) Percentual coverage of the talus head is the percentage of the articular surface of the talus head that is covered by the navicular (normal: $\geq$ 90%).

(►**Fig. 5**). The talonavicular coverage exhibited a significant improvement, of 136%, as evidenced by the *t*-test ($p < 0.001$). The final mean values of 15.43° (SD: $\pm$ 1.15°) remained slightly higher than the reference values (►**Fig. 6**). The Meary's angle showed a strong correlation in the *t*-test ($p < 000.1$) (►**Fig. 7**), with a significant improvement of 383%, in the talonavicular alignment of the sagittal axis. However, the mean final value of -3.64° (SD: $\pm$ 1.01°) was still not within the normal range.

The alignment of the long axis of the talus with the first metatarsal in the coronal plane showed improvement of 141%, a significant difference in the *t*-test ($p < 0.001$) (►**Fig. 8**). The mean preoperative value was of 18.12° (SD: $\pm$ 1.22°) and, postoperatively, it was of 7.5° (SD: $\pm$ 0.78°).

The Moreau-Costa-Bertani's angle showed improvement in the measured parameters ($p < 0.001$). Although the values did not reach normality, with a preoperative mean of 143.8° (SD: $\pm$ 1.22°) and a postoperative mean of and 131.21° (SD: $\pm$ 1.19°), an improvement of 9% in the formation of the plantar arch was observed (►**Fig. 9**). The talonavicular coverage percentage showed significant improvement of 38% as evidenced by the *t*-test analysis ($p < 0.001$). The preoperative mean value of 59.7% (SD: $\pm$ 1.54%) increased to 82.8% (SD: $\pm$ 1.28%), with a significant improvement in the relationship between the hindfoot and midfoot (►**Fig. 10**).

Discussion

In the present case series, the treatment of the severe idiopathic pediatric flatfoot using the calcaneo-stop technique demonstrated effective correction of the deformity with minimal complications. The surgical procedure is technically straightforward and yields positive clinical and radiographic outcomes.

Although the exact cause of flatfoot remains a topic of debate,[7,25] if left untreated, it can lead to functional limitations in adulthood. Progressive subluxation and excessive loading of the triple joint complex and the spring ligament may occur, ultimately leading to late articular degeneration. This overloading is clinically responsible for fatigue, pain, and mechanical insufficiency.

The extra-articular technique known as calcaneo-stop involves the insertion of a screw into the calcaneus, effectively blocking excessive talus-calcaneus pronation and subsequent subluxations.[17] Moreover, research[15,26,27] suggests that, besides joint restriction, proprioceptive mechanisms influence gait kinetics. Unlike osteotomies, which immediately alter joint relationships and load distribution, arthroereisis induces an early correction of the deformities, followed by a late gradual three-dimensional articular reorganization over several months, leading to articular remodeling.

Table 1 Study sample data

Identification	Age	Follow-up	Calcaneal pitch		Talonavicular angle coverage		Talonavicular percentual coverage		Meary's angle		Talus-first metatarsal angle		Moreau-Costa-Bertani's angle		Pain		Complications
	(years)	(month)	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
F1	9	20	4.5	11.8	45.6	22.4	50.6	24.8	-32.6	-5.5	25.3	2.7	159	140.8	Yes	No	No
F2	9	20	7.7	14	44.8	21.8	47.7	24.2	-23	-5.6	14.3	7.4	148.2	135.3	Yes	No	No
F3	13	34	6	16.7	36.6	16.5	40.6	18.3	-24	-13.7	12.4	3.4	142.4	132.4	SIM	No	No
F4	13	28	8.6	17.3	23.9	11.6	26.5	12.8	-22	-8.6	13.3	1.4	142.8	127.8	Yes	No	No
F5	9	34	2	4	56.1	24.7	62.3	27.4	-18.1	1.7	18.6	9.7	143.4	135	Yes	No	No
F6	9	34	-4	1.5	45.9	25	51	27.7	-18	-4.6	20.3	1.2	147.6	135.8	Yes	No	No
F7	11	40	2.6	10.5	45.8	18.7	50.8	20.7	-17.2	-0.8	17.1	5.5	146.1	133.1	Yes	No	Chronic pain
F8	11	40	1	8.7	44.1	15.1	49	16.7	-22	-1.5	16.4	5	141.6	134.9	Yes	Yes	Chronic pain
F9	12	30	0.5	4.3	41.3	1	45.8	1.1	-17.8	-12.8	16.8	5.2	144.2	134	Yes	No	No
F10	12	30	0.5	6	50.4	23.3	56	25.8	-23.2	-9.8	36.1	17.3	151.5	135.3	Yes	No	No
F11	12	37	10.5	13.8	16	11.3	17.7	12.5	-6.7	6.3	25	14.3	130.3	115.6	Yes	No	No
F12	12	37	10.8	12.1	39.5	16.8	43.8	18.6	-14.6	1.6	36.2	19	134.7	119.5	Yes	No	No
F13	11	21	6.3	9.5	39	21.5	43.3	23.8	-30.6	-12.5	23.5	3	151.7	142.5	Yes	No	No
F14	11	21	9	7.8	11.9	9.8	13.2	10.8	-12.5	-7.7	6	7.8	141.6	137.7	Yes	No	No
F15	11	39	11	18	40.2	1.1	44.6	1.2	-10.7	13.3	24.1	6.5	138.7	118.6	Yes	No	No
F16	11	39	11.6	18.4	42.9	2.3	47.6	2.5	-12.5	-3.5	29.4	3.5	140	127	Yes	No	No
F17	12	17	4.7	5.1	32.9	20.2	36.5	22.4	-22.1	-13.5	12	12.7	152.6	144.2	Yes	No	Undercorrection
F18	12	17	3.3	9.6	43	27.6	47.7	30.6	-28	-4.5	25.5	1.9	153.4	131.2	Yes	No	No
F19	11	47	9.6	15	38.8	12.8	43.1	14.3	-19	-5.3	19.2	9.3	151.2	129.5	Yes	No	No
F20	11	47	6.5	16.8	32	11.9	35.5	13.2	-19.7	-2	22.4	12.9	148.1	129.9	Yes	No	No
F21	9	65	3.9	17.3	42.8	15.5	47.5	17.2	-20.6	-4.4	16.8	8.6	144.8	130.4	Yes	No	No
F22	9	65	3.3	13.3	46.9	22.7	52.1	25.2	-30	-7.1	20.1	8.1	158	137.2	Yes	No	No
F23	9	6	3.6	7.9	26	20.4	28.8	22.6	-22.4	-12.2	4.4	2.3	148.4	141	Yes	Yes	Chronic pain
F24	16	33	10.1	12.2	35.6	31.7	39.5	35.2	-9.5	-6	14.8	13	131.4	132	Yes	No	No
F25	16	33	8.1	14.1	30.1	24.8	33.4	27.5	-14.6	-5.2	16	11	136.9	128.1	Yes	No	No
F26	11	32	7.9	15.6	41.6	15.1	46.2	16.7	-18.7	-5.7	13.6	1.1	142.9	137.6	Yes	No	No

Table 1 (*Continued*)

Identification	Age	Follow-up	Calcaneal pitch		Talonavicular angle coverage		Talonavicular percentual coverage		Meary's angle		Talus-first metatarsal angle		Moreau-Costa-Bertani's angle		Pain		Complications
	(years)	(month)	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
F27	11	32	10.6	14.8	39.6	6.9	44	7.6	-13.4	-6.5	13.5	1.6	140.3	137.4	Yes	No	No
F28	7	11	7	12.7	41.6	7.1	46.2	7.8	-9.5	10.6	12.5	9.2	140.9	124.6	Yes	No	No
F29	7	11	6.7	8.2	33.8	4.5	37.5	5	-10.5	10.1	14.1	14.4	138.7	128	Yes	No	No
F30	13	26	13.4	20.1	32.5	12.1	36.1	13.4	-12.9	4.8	36.6	16	134.8	121.8	Yes	No	No
F31	13	26	19.3	20.6	36.4	16.6	40.4	18.4	-11.4	4.1	35.3	12.7	124.7	117.2	Yes	No	No
F32	10	6	9.7	16.2	26.4	14.7	29.3	16.3	-9.6	0.8	13.7	11.2	133.5	122.1	Yes	No	No
F33	10	6	14.4	17.3	20.8	2.3	23.1	2.5	-10.1	1.5	10.2	5	127.6	118	Yes	No	No
F34	11	47	5.7	8.1	27.7	23.4	30.7	26	-17.7	3.5	16	11.8	142.2	128.7	Yes	No	No
F35	11	47	7.1	8.7	23.8	18	26.4	20	-18.7	3.9	14	7	143.8	127.1	Yes	No	No
F36	13	20	10.4	17.4	25.2	9.9	28	11	-11.2	-1	4.2	4.7	133.2	119.1	Yes	No	No
F37	13	20	11.8	18.2	25.8	15.5	28.6	17.2	-13.6	-2.5	3.2	0.1	136.8	124.3	Yes	No	No
F38	12	12	3	12.7	43	23.9	47.7	26.5	-24	-3.5	22	9.8	158	126.5	Yes	No	No
F40	14	12	4.3	7.5	32.1	4.4	35.6	4.8	-21.7	-14.3	19.1	6.8	154.2	147.5	Yes	No	Undercorrection
F41	14	12	5.5	11.1	36.7	5	40.7	5.5	-19.2	-10.4	23.2	9.8	150.1	143.2	Yes	No	Undercorrection
F42	7	26	3.3	9.2	42	16.2	46.6	18	-13.3	-7.1	14.4	4.4	144.3	134.4	Yes	No	No
F43	7	26	4.1	10.1	40.7	13.3	45.2	14.7	-11.9	-6.6	13.2	3.9	142.1	129.1	Yes	No	No
F44	12	34	2.2	16.4	41.2	20.2	45.7	22.4	-23.1	-9.4	16.8	4.4	151.1	139.1	Yes	No	No

Abbreviations: Pre, preoperative; Post, postoperative.

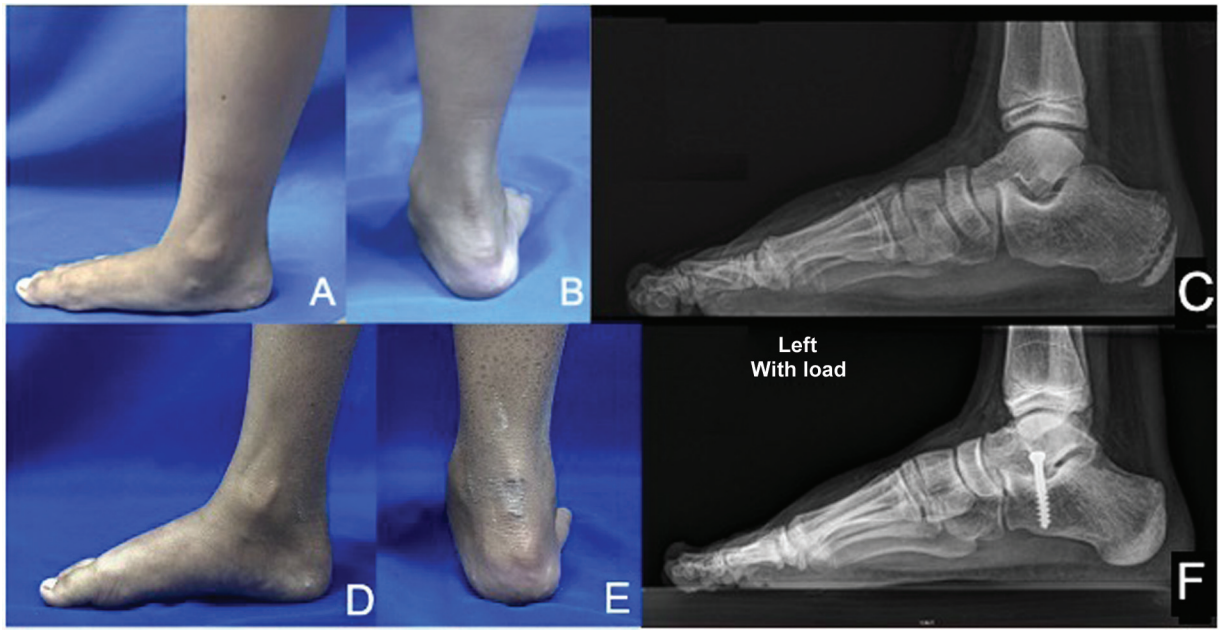


Fig. 4 Pre (**A**,**B**) and postoperative (**C**,**D**) clinical appearance of a 10-year-old boy who underwent surgery to correct a severe valgus flat foot. Significant improvement was observed in both the ankle alignment and foot arch. In this case, in addition to the calcaneo-stop procedure, a percutaneous lengthening of the Achilles tendon was performed to correct the equinus. (**E**) Preoperative X-ray in lateral view performed in 2019. (**F**) Postoperative X-ray in lateral view performed in 2022.

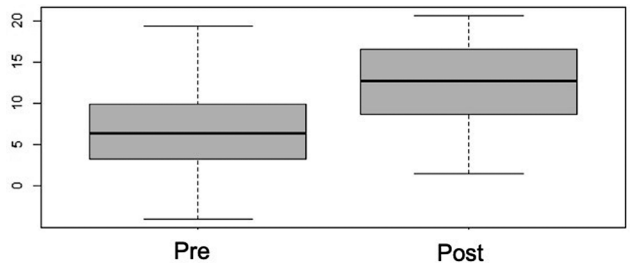


Fig. 5 Box plot distribution for the pre and postoperative calcaneal pitch angle. There was a significant postoperative increase, and the angle reached normal ranges ($p < 0.001$).

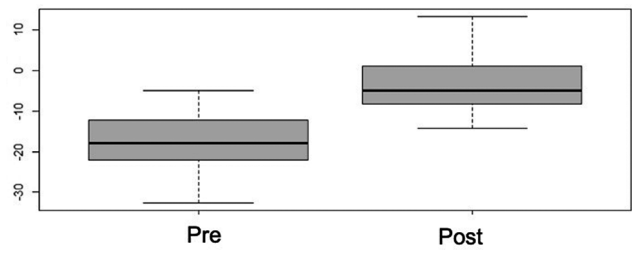


Fig. 7 Box plot distribution for the pre and postoperative Meary's angle. There was significant postoperative improvement, and the angle was slightly below normal parameters ($p < 0.001$).

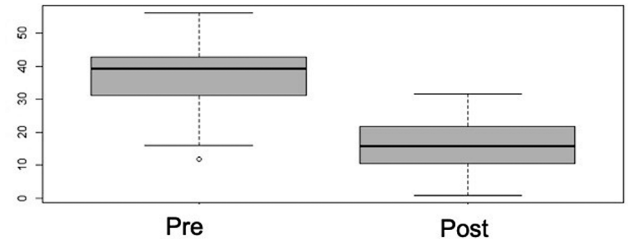


Fig. 6 Box plot distribution for pre and postoperative talonavicular angle. There was significant postoperative improvement, and the angle almost reached normal ranges ($p < 0.001$).

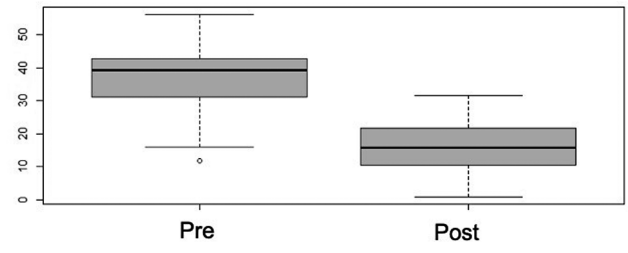


Fig. 8 Box plot distribution for the pre and postoperative talus-metatarsal angle. There was significant postoperative improvement, and the angle almost reached normal ranges ($p < 0.001$).

Lateral column lengthening osteotomies and medialization of the calcaneus are accepted treatments for symptomatic flexible flatfoot in the immature foot, with reported satisfactory results of approximately 90%.[8–10] However, these procedures are more invasive, require longer recovery time, and impose activity restrictions for weeks. In contrast, arthroereisis results in a fast rehabilitation, enabling the patient to walk shortly after surgery.[13,17,27,28] Nevertheless, in the present series, 42% of the patients underwent Achilles tendon lengthening and required plaster immobilization for up to 21 days. For the remaining patients, weight bearing was allowed on the seventh postoperative day. Conversely, some

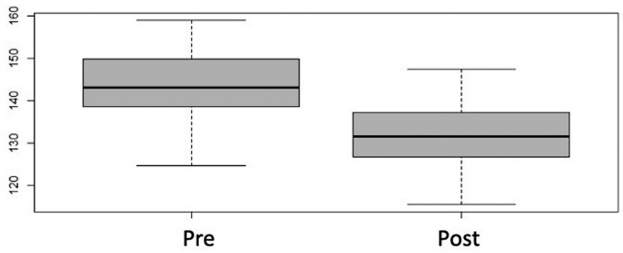


Fig. 9 Box plot distribution for the pre and postoperative Moreau-Costa-Bertani's angle. There was a significant postoperative increase, and the angle reached normal ranges ($p < 0.001$).

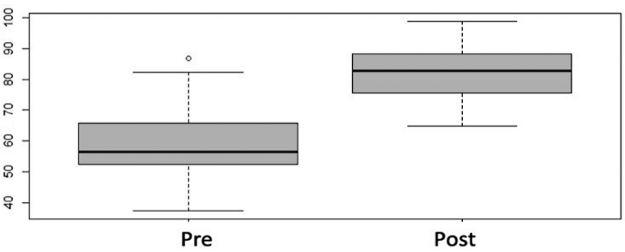


Fig. 10 Box plot distribution for the pre and post-operative talonavicular coverage percentage. There was significant postoperative improvement, and the coverage almost reached normal ranges ($p < 0.001$).

authors[15] do not routinely release the triceps surae, even in the presence of equinus, arguing that the postoperative equinus can be reversed with physiotherapy.

While clinico-radiographic dissociation exists, we employed angular parameters to evaluate and enhance the objectivity and reproducibility of the results. Nonetheless, these variables may not directly correlate with the symptoms and severity of the foot. Moreover, establishing the most significant signals for the diagnosis and determining the precise threshold to define a foot as a flat remains challenging. The relevance of radiographic measures and flatfoot diagnosis is still under debate.[23]

Our radiographic assessments revealed improvement in hindfoot and midfoot parameters over a mean follow-up period of 28 months, which is consistent with the findings of previous studies.[19,27,28] The clinical outcomes were deemed satisfactory, with 90% of the patients reporting no pain. The complication rate was 13.6%, but they were minor complications, primarily attributed to pain that showed improvement following analgesic treatment. Our data and complication rates are similar to those reported in other studies.[19,20,27]

Determining the optimal time for implant removal without compromising correction remains uncertain in the calcaneo-stop technique. Some authors[11,29] suggest removal after 2 years, during which joint remodeling and proprioceptive reflex incorporation occur. However, establishing a removal protocol in the present study was challenging due to high hospital service demands. As a result, most of the patients retained the implant for up to 5 years without experiencing overcorrection, pain, or breakage. The radiographic images showed no evidence of any impression on the talus secondary to prolonged contact at the implant interface. However, we did not precisely evaluate this parameter due to limited symptoms.

The current study has limitations, including a restricted sample size. Moreover, we faced challenges in quantifying the subjective and variable nature of pain and discomfort in a pediatric population and in establishing a correlation between the radiographic parameters and the clinical findings of the flatfoot.

Overall, our impression is that the calcaneo-stop technique seems to be an adequate option to treat symptomatic flexible flatfoot in juvenile patients, according to major studies.[30,31] It offers potential correction of the initial deformity and consistent improvement in clinical and radiographic parameters. Furthermore, the technique can be reversed through screw removal if necessary, and it does not compromise the use of other techniques in cases of failure. There are still questions regarding joint remodeling and possible long-term repercussions; however, the technique seems promising.

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

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Description of Hip Deformities in 5-Year-Old Patients with Congenital Zika Virus Syndrome: A Cross-Sectional Study

Descrição das deformidades do quadril em pacientes com síndrome congênita do Zika vírus aos 5 anos de vida: Um estudo transversal

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Abstract

Objective To report on the most prevalent hip alterations in children older than 5 with congenital Zika virus syndrome (CZS) per clinical and radiographic examinations.

Methods Cross-sectional and retrospective study of 62 patients older than 5 with CZS. We extracted clinical data, including maximum abduction values, hip flexion contracture, gross motor function classification system (GMFCS) level, and radiographical data, including Reimers index (RI), femoral neck-shaft angle (FNSA), and acetabular index (AI), from medical records and radiographs and statistically evaluated them.

Results The mean age of children was 65.6 ± 4.1 months. Most patients (95.2%) presented GMFCS scores of IV and V. Slow hip abduction was 41.2 ± 19.5°. The Thomas test revealed a mean deviation of 16.1 ± 14.9°. The mean values of RI, FNSA, and AI were 54.1 ± 34.1%, 158 ± 11.9°, and 26.0 ± 8.12°, respectively. Patients with GMFCS III and IV had lower RI and AI than those with a score of V. Regarding FNSA, there was no statistical difference between groups. Patients who underwent tenotomy of the hip adductor muscles presented greater abduction but no relevant radiographic differences.

Conclusion There was a higher incidence of patients with hip luxation and more compromised functional degrees (GMFCS IV and V), and increased RI and AI in V.

Keywords
- child
- deformities
- developmental dysplasia of the hip
- Zika virus

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Operated patients presented abduction gain abduction but no radiographic improvement. Long-term studies are required to evaluate hip deformities in these subjects.

Resumo

Objetivo Informar as alterações mais prevalentes no quadril em crianças com síndrome congênita do Zika vírus (SCZ) acima de 5 anos de idade por meio de exames clínicos e radiográficos.

Métodos Estudo transversal e retrospectivo em 62 pacientes com SCZ, com mais de 5 anos de idade durante o estudo. Os dados clínicos como valores de abdução máxima, contratura em flexão do quadril e nível do sistema de classificação da função motora grossa (SCFMG), assim como os dados radiográficos índice de Reimers (IR), ângulo colodiafisário (ACD) e índice acetabular (IA), foram extraídos de prontuários e radiografias e avaliados estatisticamente.

Resultados Idade média de 65,6 ± 4,1 meses. Prevalência de SCFMG IV e V foi 95,2%. A abdução lenta do quadril foi 41,2 ± 19,5°. O teste de Thomas revelou média de 16,1 ± 14,9°. Os valores médios do IR, ACD e IA, foram 54,1 ± 34,1%, 158 ± 11,9° e 26,0 ± 8,12°, respectivamente. Pacientes com SCFMG III e IV apresentaram IR e IA menores do que aqueles com V. Quanto ao ACD, não foi observada diferença estatística entre os grupos. Pacientes submetidos à tenotomia dos músculos adutores do quadril apresentaram abdução maior, mas sem diferença radiográfica relevante.

Conclusão Observa-se maior incidência de pacientes com luxação dos quadris e graus funcionais mais comprometidos (SCFMG IV e V), aumento do IR e IA no V. Pacientes operados tiveram ganho de abdução, porém sem melhora radiográfica. Estudos de longo prazo são necessários para a real avaliação das deformidades do quadril.

Palavras-chave
- criança
- deformidades
- displasia do desenvolvimento do quadril
- Zika vírus

Introduction

In 2015, Brazil faced an alarming increase in cases of microcephaly and a series of clinical alterations later known as the congenital Zika virus syndrome (CZS),[1] with 22,251 suspected and 3,742 confirmed cases by 2023. The infection persists, representing a continuous risk to pregnancy, and more than 2,000 affected children require multidisciplinary care and monitoring.[2]

The neurological alterations from CZS increase muscle tone and spasticity, similar to upper motor neuron syndrome, leading to progressive musculoskeletal problems.[3] The hip is among the most affected joints, potentially presenting contractures, subluxations, and luxations resulting from muscle spasticity. These abnormalities cause debilitating functional effects, pain, and difficulties in hygiene, increasing the risk of infections and compromising quality of life.[4]

Since the progression of deformity is fast, it is essential to maintain vigilance for early detection and immediate intervention.[5] Therapies for preventing hip luxation, similar to those used for spastic hips in cerebral palsy (CP), rely on physical and imaging examinations.[6] However, studies on the effectiveness of preventive measures in patients with CZS remain scarce.

Because of the lack of studies describing changes in hip development in CZS patients over time, the present aimed to inform the scientific community about the most prevalent changes in hips from children older than 5, correlating them with findings described in children with CP and using clinical and radiographic data.

Materials and Methods

This cross-sectional, retrospective, descriptive study included children with CZS diagnosed by a neuropediatrician and followed up at the *Associação Pernambucana de Apoio à Criança com Deficiência* (AACD/PE) from August 2020 to January 2022. The study followed bioethical principles and received approval from the AACD/SP Research Ethics Committee (CAAE: 56150816.8.0000.0085).

This study included patients with CZS, born from June 2015 to May 2016, and older than 5 years of age during the research period. We excluded patients with ultrasound records of luxation at birth and multiple congenital joint contracture syndrome (arthrogryposis).

We collected data from medical records containing clinical examinations. Two orthopedists, including one specialist in pediatric orthopedics, analyzed these children's radiographs and recorded the following values: maximum slow hip abduction with flexed knees and hip flexion contracture, per the Thomas test. We also assessed the patients' treatment, considering those undergoing tenotomy of the hip adductors as surgical and those undergoing physical therapy as nonsurgical. We recorded the Gross Motor Function Classification System (GMFCS) scores, and data from anteroposterior radiographs, including the acetabular index (AI; angles > 30° suggested dysplasia), femoral neck-shaft angle (FNSA), and Reimers index (RI; values > 90%, from 33 to 90%, and < 33% respectively indicated luxation, subluxation, and proper positioning), as shown in ►**Fig. 1**.

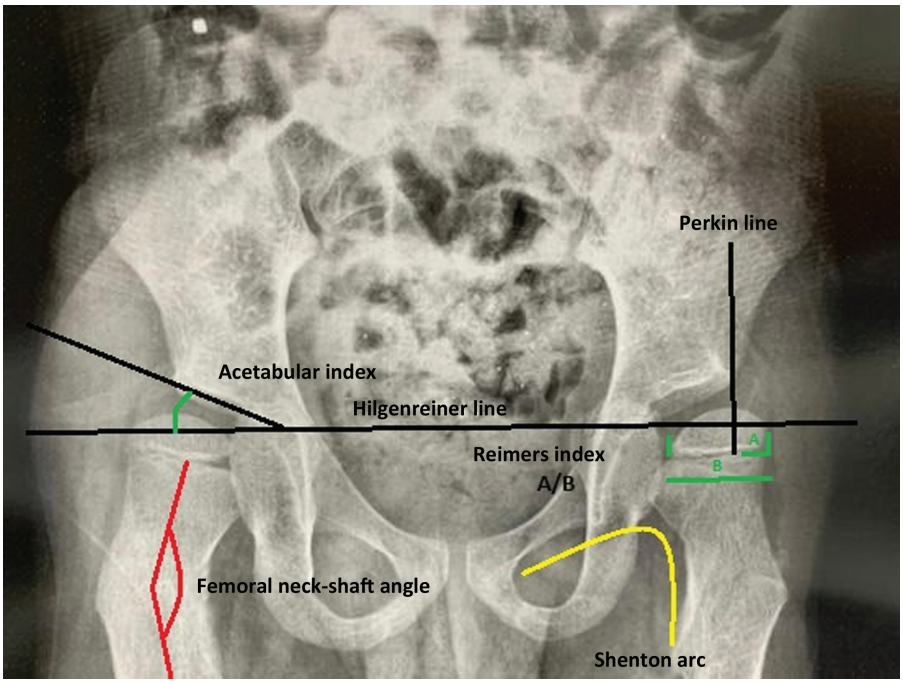


Fig. 1 Anteroposterior pelvic radiograph with radiographic measurements.

For the statistical analysis, the categorical variables were expressed as frequencies and percentages, and the quantitative variables, as mean, standard deviation (SD), median, and interquartile range (IQR) values. The Shapiro-Wilk and Levene's tests for homogeneity of variances determined normality. The prevalence ratio compared categories based on nominal variables. We used the following tests for numerical variables: Student's *t* or Mann-Whitney tests for two categories, and analysis of variance (ANOVA) or nonparametric Kruskal-Wallis test for more than two categories. Spearman's correlation coefficient was used to perform an inductive analysis of dependent variables with nonnormal distribution. The significance level to reject or accept the null hypothesis was 5%.

Results

►**Table 1** presents the demographic data of 62 children included in this study.

Most patients did not undergo surgical treatment until age 5, corresponding to 72.59% of the sample. Regarding the positioning status of the 124 hips evaluated, 52 (41.93%) were proper, as shown in ►**Table 1**.

The physical examination revealed a mean slow hip abduction of approximately $41.2 \pm 19.5°$, and a quarter of the sample presented $< 30°$ abduction. The Thomas test showed a mean value of $16.1 \pm 14.9°$ with distribution between the first and third interquartile ranges. The mean RI, FNSA, and AI were $54.1 \pm 34.1\%$, $158 \pm 11.9°$, and $26.0 \pm 8.12°$, respectively (►**Table 2**).

The FNSA and AI analysis relied on the deformity present (subluxation or luxation). There was no statistically significant correlation between FNSA and the deformities. However, AI was lower in properly positioned hips than in dislocated (subluxated and luxated) hips, as shown in ►**Table 3** and ►**Figs. 2**–**3**.

Dividing the sample by their GMFCS score, we observed a statistical correlation in RI among patients from the three GMFCS groups. Considering hip subluxation ($RI \geq 33\%$) and GMFCS scores, hips with V had a subluxation prevalence 1.39-fold higher compared with IV ($p = 0.029$; 95% confidence interval [CI]: 1.02–1.91). Patients with GMFCS III and IV had lower AI than those with V. There was no statistical difference between FNSA and the GMFCS groups (►**Table 4** and ►**Figs. 4**–**5**)

There were 17 patients who underwent tenotomy of the hip adductor muscles (adductor longus, adductor brevis, and gracilis muscle) because they had $RI > 33\%$ and $AI > 30°$. Their mean age at surgery was 28.41 ± 9.04 months. These patients used an abduction orthosis for the first 2 months after the procedure and their mean follow-up time was 35.57 months. These patients presented no relevant difference in pre- and postoperative radiographic data. However, their physical examination indicated greater hip abduction among the operated patients.

Considering only surgically treated patients, we investigated GMFCS correlation with hip positioning, RI, AI, and FNSA but found no statistical correlation 2.96 years after surgery (►**Table 5**).

Discussion

The CZS cases in Northeast Brazil accounted for more than half of those reported (53.1%), with the state of Pernambuco having the highest number.[2] The AACD-PE played an important role as a service provider for these patients. However,

Table 1 Sample characterization

Variable	n	%
Children	62	100
Age (months)[a]	65.6 ± 4.1	–
Gender		
Male	28	45.2
Female	34	54.8
Gestational age at infection (weeks)[a]	14.07 ± 6.89	
Head circumference at birth[a]	28.57 ± 2.13	–
Gross motor function classification system		
I	0	–
II	0	–
III	3	4.8
IV	26	42.0
V	33	53.2
Treatment method		
Physical therapy, abduction orthosis, and/or botulinum toxin	45	72.6
Adductor tenotomy	17	27.4
Age at surgery (months)[a]	28.41 ± 9.04	
Hip status	n (124)	
Proper positioning	52	41.9
Subluxation	35	28.2
Luxation	37	29.9

Note: [a]Mean ± standard deviation.

with the loss of follow-up over time, obtaining data 5 years after the initial contact was difficult.

The mean age of the 62 patients was 5.46 ± 0.34 years, a critical time frame since Wagner e Hägglund[7] reported that, at around 6-years-old, CP patients without previous surgeries present a tendency toward stabilization of the lateral migration velocity of the femoral head (increased RI). In contrast, at the same age, muscle contracture increases, potentially causing severe bone deformities.[8]

Severe nervous system involvement and associated abnormalities impair neurodevelopment, preventing the acquisition of functional skills, as in CP. The GMFCS assesses a child's functional capacity and limitations, helping to determine motor prognosis and providing a better understanding of the severity of neurological impairment.[9] Ribeiro et al.[10] reported a prevalence of 88% of GMFCS IV and V in patients with CZS and a mean age of 13.9 months.

Similarly, Carvalho et al.,[11] in 2019, evaluated children in the first year of life and reported a prevalence of 86.5%, and Cavalvante et al.,[12] in 2021, followed children with the syndrome up to 36 months and reported a prevalence of 95% in the 110 patients with GMFCS IV and V. The present study corroborates this high prevalence by presenting a total of 59 patients (95.2%) with GMFCS IV and V. At the same time, Terjesen[13] investigated 335 children with CP and observed a prevalence of nondeambulatory children (GMFCS IV and V) of only 34%, which is consistent with Soo et al.[14] and Connely et al.,[15] who reported 34 and 31%, respectively. This reflects the severity of neurological involvement and its influence on neurodevelopment in children with the syndrome.

Nervous system abnormalities, such as increased spasticity and delayed motor development, compromise hip development. Previous studies have described two mechanisms explaining the occurrence of hip deformities: muscle imbalance resulting from hip flexor and adductor spasticity outweighing the extensor and abductor muscles, increasing the force vector directing the femoral head away from the hip joint; and abductor muscle weakness due to delayed weight-bearing as determinants of the proximal femur anatomy.[16,17]

In 2012, Terjesen[13] determined the velocity of lateral migration of the femoral head in children with CP but no CZS and demonstrated that complete hip dislocation occurred before age 6 in 11.3% of cases. Poirot et al.[18] reported that 53 of 218 hips (24.3%) of patients with CP had an RI > 40, and > 67% of them did not progress over 2.6 years. In the present study, 29.8% of the hips presented complete dislocation at age 5, raising the possibility of a more frequent unfavorable occurrence than in CP patients. The prevalence of proper positioning hips with RI < 33% was of 41.9%, contradicting Matos et al.[19] who reported 47 children with CZS and a prevalence of well-positioned hips of up to 90.4%. However, these authors did not include the age of the participants in their study.

Table 2 Clinical and radiographic measurements

	ABD (degrees)	Thomas test (degrees)	RI (%)	FNSA (degrees)	AI (degrees)
N	124	124	124	108	112
Mean	41.2	16.1	54.1	158	26.0
Median	40.0	15.0	45.0	160	24.0
Standard deviation	19.5	14.9	34.1	11.9	8.12
25thpercentile	30.0	0.00	26.5	150	20.0
75thpercentile	50.0	25.0	92.0	168	32.0

Abbreviations: ABD, abduction; AI, acetabular index; FNSA, femoral neck-shaft angle; RI, Reimers index.

Table 3 Femoral neck-shaft angle and acetabular index relationship with the hip status

		Proper positioning	Subluxation	Luxation
Femoral neck-shaft angle (degrees)				
Proper positioning	Difference between mean values	—	1.670	1.654
	p-value	—	0.909[a]	0.945[a]
Subluxation	Difference between mean values		—	−0.012
	p-value		—	0.987[a]
Luxation	Difference between mean values			—
	p-value			—
Acetabular Index (degrees)				
Proper positioning	Difference between mean values	—	−9.25	−11.21
	p-value	—	< 0.001[b,*]	< 0.001[b,*]
Subluxation	Difference between mean values		—	−1.96
	p-value		—	0.528[b]
Luxation	Difference between mean values			—
	p-value			—

Notes: [a]Per the Kruskal-Wallis test with paired comparison by Dwass-Stell-Critchlow-Fligner. [b]Per the analysis of variance test with Welch correction and Games-Howell post-hoc test. *Significant different at the 5% level.

As a monitoring recommendation, as in CP, hips with a maximum abduction of 30° and residual flexion in the Thomas test of 20° are at risk of developing subluxation or luxation.[5] In our sample, slow hip abduction with flexed knees had a mean angle of 41.2 ± 19.5°), and the Thomas test revealed a mean angle of 16.1 ± 14.9°. Excluding dislocated hips, 17 hips were considered at risk.

Despite a high FNSA, there was no statistical correlation between its increase and the presence or absence of subluxation or luxation. However, it is known that the presence of coxa valga alters the force vector acting on the hip, resulting in loss of joint congruence.[16] The lack of correlation in our study can result from age, as this interference is more prevalent in patients with CP older than 8.[20]

Considering the ability to walk, Bobroff et al.[21] found a significantly elevated FNSA in 5-year-old patients who do not walk and a low FNSA among children with CP who do, which is consistent with observations from our sample regarding GMFCS IV and V patients compared to III, but without statistical significance. The increased FNSA in nondeambulatory subjects may result from the lack of vertical force in the proximal femur during development or a decreased traction force of the hip abductors on the greater trochanter.[21]

Regarding AI, it was lower in properly positioned hips compared to subluxated or dislocated hips, with a difference between means of −9.25 ($p < 0.001$) and −11.21° ($p < 0.001$), respectively. This result is justified by the lack of adequate contact between the femur and acetabulum in the subluxation and luxation.[22] The GMFCS score also influenced AI since patients with V had a higher AI than those with III ($p = 0.014$) and IV ($p = 0.008$), consistent with Chung et al.,[23] who studied spastic hips in patients without CZS.

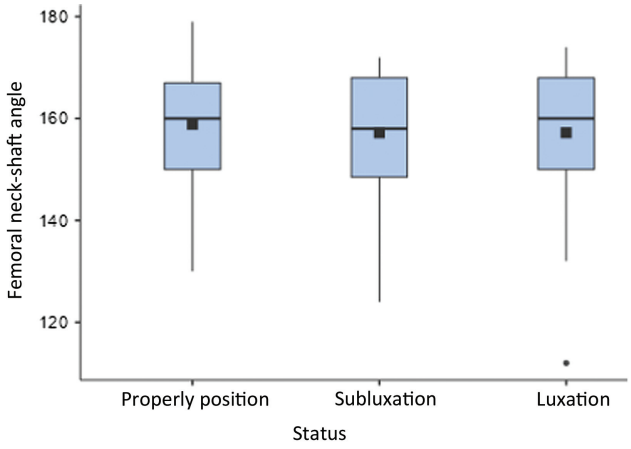


Fig. 2 Femoral neck-shaft angle (degrees) versus hip status.

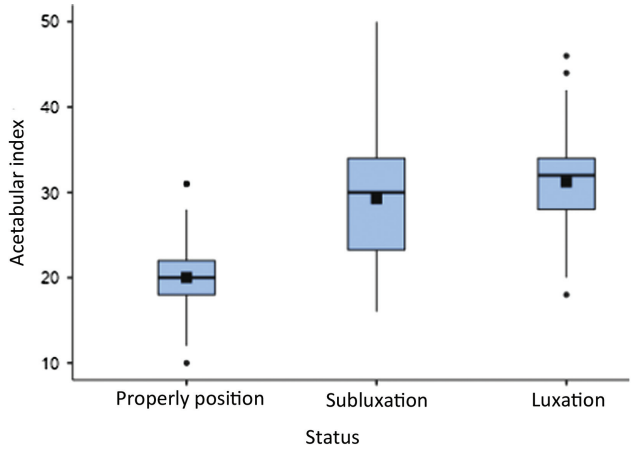


Fig. 3 Acetabular index (degrees) versus hip status.

Table 4 Relationship of the RI, FNSA, and AI with the GMFCS

	GMFCS	N	Median	Percentile		MC	*p*-value[a]
				25th	75th		
RI	3	6	25.0	7.75	25.0	3 - 4	0.107
	4	52	31.5	23.50	70.0	3 - 5	0.003*
	5	66	67.5	33.00	100.0	4 - 5	0.011*
FNSA	3	6	146.5	145.25	153.0	3 - 4	0.052
	4	46	164.0	152.50	168.0	3 - 5	0.053
	5	56	160.0	150.00	168.0	4 - 5	0.790
AI	3	6	19.0	13.50	23.0	3 - 4	0.242
	4	46	22.0	18.00	30.0	3 - 5	0.014*
	5	60	28.5	22.00	34.0	4 - 5	0.008*

Abbreviations: AI, acetabular index; FNSA, femoral neck-shaft angle; GMFCS, gross motor function classification system; MC, multiple comparison; RI, Reimers index.
Notes: [a]Per the Kruskal-Wallis test with paired comparison by Dwass-Stell-Critchlow-Fligner. *Significant different at the 5% level.

In addition to more dysplastic hips (increased AI), children with GMFCS V also presented a higher tendency to lateralize the femur (increased RI) than those with lower motor levels. Aroojis et al.[16] reported in their study with spastic hips that the incidence of hip luxation (RI > 33%) was 2.5, 7.7, 50, 61, and 66% in GMFCS I, II, III, IV, and V, respectively. Barik et al.,[24] in their systematic review, also observed an increase in lateralization velocity in CP patients with GMFCS of I–III, IV, and V by 0.3, 1.9, and 6.2% per year, respectively. In their study of patients with CP, Soo et al.[14] reported that the incidence of hip luxation was 69% in patients with GMFCS IV, with a relative risk 4.6 times higher for luxation than in those with II and worsening in V, with an incidence of 90% and a relative risk 5.9 times higher than in II. This corroborates the relationship found in our study, which shows a 1.39 times higher prevalence of hip luxation in children with GMFCS V compared to those with IV ($p = 0.029$; 95% CI: 1.02–1.91). Likewise, the RI in patients with V was higher than in those with III ($p = 0.003$) and IV ($p = 0.011$).

To date, the treatment or prevention of hip deformities in children with CZS has followed the same indication patterns for children with CP, both surgical and nonsurgical.[25] Gordon and Simkiss[26] indicate surgery (tenotomy of the hip adductors) for patients with RI > 33% and AI > 30°. Ha et al.[27] considered a preoperative AI < 34° of the hip joints as an indicator of a better probability of success in preventing subluxation.

In the present study, all patients who underwent surgery had GMFCS IV or V. Although a study involving adductor tenotomy in 55 hips of children with CZS demonstrated a decrease in RI 12 months after the procedure,[28] patients who underwent surgical treatment did not present statistically significant improvements in radiographic measurements after virtually 3 years of surgery. While, by eliminating the force vector originated by the adductor muscles, operated subjects presented higher abduction ($p = 0.018$) and less flexion contracture, there was no without statistical significance.

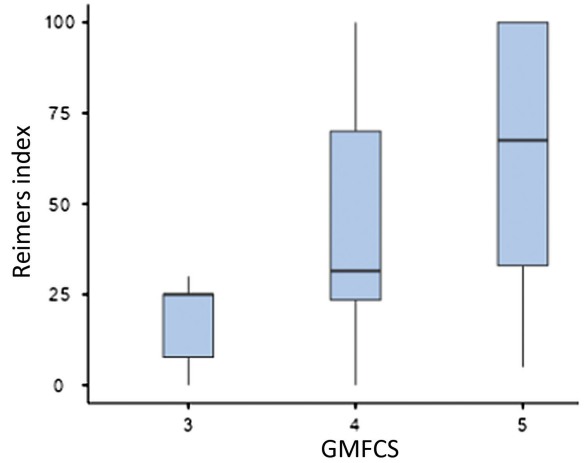


Fig. 4 Reimers index versus gross motor function classification system (GMFCS).

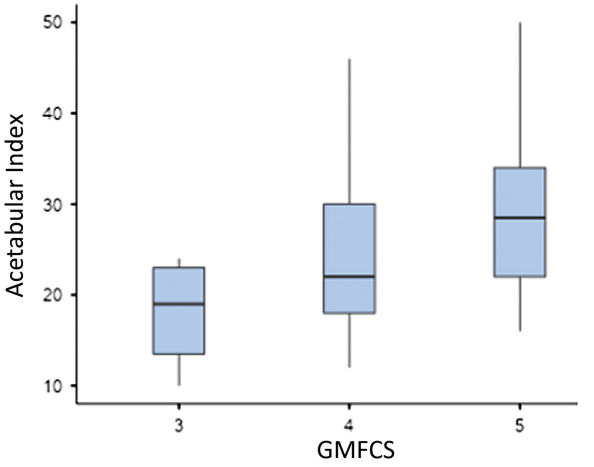


Fig. 5 Acetabular index versus GMFCS.

Table 5 Relationship between radiographic measurements and the type of treatment

	Treatment	N	Mean	Median	SD	Percentile		*p*-value[a]
						25th	75th	
RI (%)	Surgical	34	58.8	55	34.35	27.3	100	0.825
	Non-surgical	90	52.3	38.5	34.06	25.0	90.8	
AI (degrees)	Surgical	24	29	30	5.97	24	34.0	0.992
	Non-surgical	88	25.2	24	8.46	20.0	30.3	
FNSA (degrees)	Surgical	20	157.7	162	15.39	151.5	168.0	0.680
	Non-surgical	88	157.9	160	11.09	150	168.0	
Hip abduction (degrees)	Surgical	34	47.6	45	19.5	30	67.5	0.018*
	Non-surgical	90	38.8	40	19	30	45	
Thomas test (degrees)	Surgical	34	14.6	15	12	2.5	20	0.348
	Non-surgical	90	16.6	15	15.9	0.5	25	

Abbreviations: AI, acetabular index; FNSA, femoral neck-shaft angle; RI, Reimers index; SD, standard deviation.
Notes: [a]Per the Mann-Whitney test. *Significant different at the 5% level.

Regarding GMFCS, Shore et al.[29] observed progressively unfavorable tenotomy outcomes in patients with CP and abduction $< 40°$ and RI $> 30\%$, with success rates of 27 and 14% in subjects with IV and V, respectively. We attempted to perform the same correlation (GMFCS and RI) among our patients but found no statistical relationship ($p = 0.835$).

Conclusion

Children with CZS had a high incidence of hip dislocation and more severe neurological impairment (GMFCS IV and V). As in CP, children with GMFCS V had higher RI and AI, requiring greater surveillance. Surgery increases abduction capacity; however, studies with longer follow-ups are needed to address the natural history of hip deformities and the outcome of treatments performed in these patients.

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

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Hip Hemiarthroplasty in Patients with Multiple Myeloma: A Retrospective Case Series and Review of the Literature

Hemiartroplastia de quadril em pacientes com mieloma múltiplo: Uma série de casos retrospectivos e revisão da literatura

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Abstract

Objectives Femoral neck fractures in multiple myeloma patients are usually managed with hemiarthroplasty or total hip arthroplasty, depending on the presence of acetabular infiltration. Due to the paucity of dedicated studies, the aim of the present study is to review the clinical outcomes of hip hemiarthroplasty in patients with multiple myeloma and to review the literature regarding the outcomes and survival in these patients' subset.

Methods There were 15 patients (16 cases), with a mean age of 71.7 years, who had myeloma and received hip hemiarthroplasty for displaced femoral neck fractures had their radiographs and clinical data assessed for this study. From those, 13 cases received bipolar and 3 unipolar hemiarthroplasty.

Results After a mean follow-up of 18.2 months since the time of surgery, 3 cases suffered periprosthetic fractures (18.75%), 4 cases (25%) had heterotopic ossification, and 1 case (6.25%) had acetabular erosion. The 1- and 5-year patient mortality rates for the study cohort were 53.3 and 73.3%, respectively.

Conclusion Hip hemiarthroplasty remains a viable treatment option in myeloma patients; however, the potentially high morbidity and mortality in these patients should be sensibly understood before the surgery to achieve satisfactory expectations.

Keywords
- femoral neck
- hemiarthroplasty
- hip fractures
- multiple myeloma

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Resumo

Objetivos As fraturas do colo femoral em pacientes com mieloma múltiplo são geralmente tratadas com hemiartroplastia ou artroplastia total do quadril de acordo com a presença de infiltração acetabular. Devido à escassez de relatos nesta área, o objetivo deste estudo é revisar os desfechos clínicos da hemiartroplastia do quadril em pacientes com mieloma múltiplo e os resultados e a sobrevida neste subconjunto de pacientes.

Métodos Um total de 15 pacientes (16 casos), com idade média de 71,7 anos e portadores de mieloma, foram submetidos à hemiartroplastia de quadril para tratamento de fraturas de colo femoral com luxação. Suas radiografias e dados clínicos foram avaliados. Destes casos, 13 passaram pela hemiartroplastia bipolar e três pela unipolar.

Resultados Após um acompanhamento médio de 18,2 meses desde o momento da cirurgia, 3 casos sofreram fraturas periprotéticas (18,75%), 4 casos (25%) tiveram ossificação heterotópica e 1 caso (6,25%) apresentou erosão acetabular. A mortalidade dos pacientes em 1 e 5 anos foi de 53,3 e 73,3%, respectivamente.

Conclusão A hemiartroplastia de quadril ainda é uma opção terapêutica viável em pacientes com mieloma. No entanto, a morbidade e a mortalidade podem ser altas nesses pacientes e devem ser compreendidas com sensatez antes da cirurgia para atingir bons resultados.

Palavras-chave

- colo do femur
- fraturas do quadril
- hemiartroplastia
- mieloma múltiplo

Introduction

Plasma cell dyscrasias represent a wide range of conditions, including monoclonal gammopathy of undetermined significance (MGUS; Kyle disease), solitary plasmacytoma of bone, and multiple myeloma.[1] Multiple myeloma is the most common primary bone malignancy and typically presents with fatigue, musculoskeletal pain, pathologic fractures, or recurrent infection.[1–3] The pelvis and proximal femur are common sites of osteolytic infiltrations caused by solitary or multiple myeloma lesions. These lesions usually present with pain and impending or pathological fractures.[4,5] Surgical management of femoral neck fractures in myeloma patients includes either hemiarthroplasty or total hip arthroplasty, depending mainly on the presence of acetabular involvement.[3,4,6]

The outcomes of prosthetic replacement in metastatic bone disease have been well studied in previous literature. However, no study has specifically evaluated the outcomes of hemiarthroplasty in myeloma fracture cases. The available studies have either reported collectively on the results of two or more of the treatment options, being open reduction and internal fixation (ORIF), hemiarthroplasty (HA) and total hip arthroplasty (THA) in myeloma,[4,6] or reported on a cohort that included myeloma and other non-myeloma causes of bone infiltration.[7–15] The aim of the present study is to report our outcomes in a series of hemiarthroplasty cases in patients with myeloma performed at a level-1 trauma center in an effort to add to the existing scarce evidence. Our main study question was whether myeloma patients would have high incidence of complications, particularly fractures and acetabular wear after HA. We also aim to provide a literature review that includes all reported hemiarthroplasty case series in myeloma patients that have been reported in the literature.

Materials and Methods

After Institutional Review Board approval, a retrospective study was performed to evaluate all hemiarthroplasty patients, using the Current Procedural Terminology (CPT - American Medical Association, Chicago, IL, USA) codes. Between January 1988 and June 2023, a total of 2,488 HA cases were identified. All the cases were reviewed against our inclusion and exclusion criteria to extract the cases and data relevant for this study. The data collected included patients' demographics, clinical information, and radiographic evaluation. Detailed information about the follow-up and postoperative clinical course were collected for all cases.

Inclusion Criteria

1 - Patients who underwent HA for a hip fracture, either primarily after trauma or for management of femoral neck fracture nonunion.
2 - Patients who had a diagnosis of multiple myeloma or plasmacytoma of bone.

Exclusion Criteria

1 - Patients without clinical follow-up notes after HA surgery.

Results

A total of 18 cases (17 patients) of plasma cell dyscrasias that underwent HA for femoral neck fractures have been retrieved from our database. Two patients have been excluded due to having non-progressive MGUS, leaving 16 cases (15 patients) for inclusion in this study.

Of these patients, 9 were female and 6 were male, with a mean age of 71.7 years (range: 39.2–89.6) at the time of primary HA surgery. One female had bilateral femoral neck fractures, which occurred 2 months apart and received bilateral cemented unipolar HA. Fourteen patients (15 cases) had multiple myeloma, and 1 patient had a solitary bone plasmacytoma at the time of fracture that progressed to multiple myeloma later. Apart from plasma cell dyscrasias, 10 patients (11 cases) had additional significant, frequently combined medical comorbidities as shown in ►**Table 1**. The mean body mass index (BMI) for 12 patients was 32.9 (range: 22–52.2), while in 3 other patients, data regarding BMI was not available in their records.

All of the cases had been diagnosed with femoral neck fractures secondary to low-energy trauma (fall while walking). Nine patients had been diagnosed with multiple myeloma prior to presentation with femoral neck fractures and have received active chemotherapy, and four patients presented with femoral neck fractures as their first presenting symptom of myeloma. For those cases who had been diagnosed with myeloma prior to fracture, the average duration of the disease was 32 months (range: 1–78).

At presentation, all cases had pelvis radiographs and/ or computed tomography (CT) scans, along with long film femoral radiographs for exclusion of acetabular and skip femoral shaft osteolytic lesions. Eight out of the 16 cases had been identified as pathologic fractures secondary to myeloma lesion, in which osteolytic lesions could be recognized in the preoperative radiographs.

Fourteen different surgeons performed surgery. Thirteen cases were treated with bipolar HA, and 3 cases were treated with unipolar HA. Surgery was performed through the posterolateral approach in 10 cases while the direct lateral approach was utilized in 6 cases. Fourteen cases received cemented and two received cementless stems. Ten cases received conventional arthroplasty stems, and 6 cases received long stems to bypass skip lesions in the femoral shaft. The average follow-up was 18.2 months (range: 1.3–79.3; ►**Fig. 1**). None of the cases developed cement implantation syndrome, dislocations, periprosthetic infections, aseptic loosening, or neurovascular injury.

Table 1 Medical comorbidities in the study patients

Chronic kidney disease	4 (1 ESRD)
Diabetes mellitus	2
Heart failure	2
Severe or morbid obesity (BMI $\geq$ 35)	3
Hypothyroidism	1
Parkinson disease	1

Abbreviations: BMI, body mass index; ESRD, end-stage renal disease.

Complications

Intraoperative Blood Loss

The average estimated blood loss in all cases was 710 ml (range: 150–2,500 ml). Four cases required intra or postoperative blood transfusion (packed red blood cells/ platelets) without further consequences.

Periprosthetic Fractures

Three cases (18.75%) were complicated by periprosthetic fractures. Of these three cases, one involved intraoperative fracture of the greater trochanter and was managed with a trochanteric hook plate and cerclage wires. The second case sustained a postoperative greater trochanteric fracture that was evident 3 weeks after surgery and managed nonoperatively. The third case involved a Vancouver type-B distal femur fracture that occurred 3 weeks after surgery due to another low energy fall; this was managed with ORIF with locking plate and cerclage wires. All the fractures occurred in association with cemented stems. To note, the surgical approaches that were utilized during the index HA surgery in the first and third cases was the posterolateral approach, while the second case had the index surgery performed through the direct lateral approach.

Heterotopic Ossification

Four cases (25%) had grade 2 or 3 heterotopic ossification (HO) involving the acetabulum and/or the trochanteric or subtrochanteric area. All 4 cases were performed through the posterolateral approach. Heterotopic ossification was radiologically evident as early as 6 weeks postoperatively and was managed nonoperatively in both cases.

Mortality

Thirteen patients (86.6%) died at a mean of 18.5 months (range: 1.3–79.1) after the primary HA surgery. Of them, 3 patients died within the first 3 months of the HA surgery (►**Table 2**). For the patients that passed within 3 months of surgery, the cause of death was acute respiratory failure in 2 patients and septicemia secondary to gastrointestinal infection in one case. The median survival for all cases at the last follow-up or the date of death was 8.4 months.

Acetabular Erosion

Despite the presence of variable degrees of osteopenia in all of the cases, only 1 case (6.25% of cases), an 82-year-old female (►**Fig. 2**), presented 16 months with mild hip pain with weight bearing after the HA surgery. Plain radiographs suggested mild acetabular erosion. The patient was managed conservatively, and she is alive and under regular follow-up (21 months after the HA surgery).

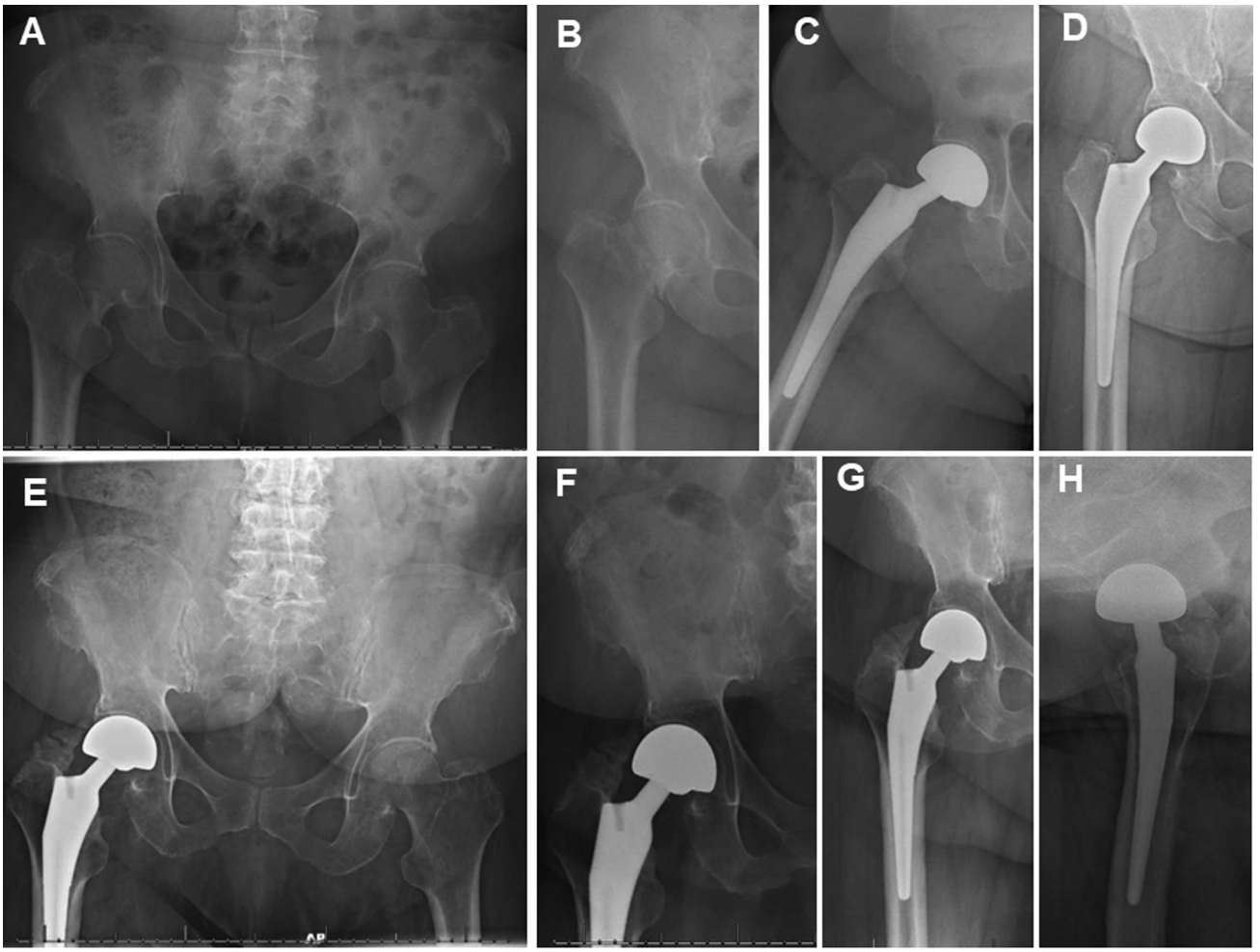


Fig. 1 (A, B) Plain pelvic and hip radiographs of a 79.2-year-old female with multiple myeloma showing right sub capital femoral neck fracture. (C) Immediate (same day) postoperative left hip plain X-ray showing cementless bipolar hemiarthroplasty. (D) 6 weeks and (E, F) 56-month, and (G, H) 70-month follow-up plain left hip radiographs showing stable, well-fixed components without evidence of acetabular erosion. Note the presence of grade-III heterotopic ossification.

Discussion

This is a retrospective series of 16 hip HAs in cases with multiple myeloma. After a mean follow-up of 18 months, 1 case had acetabular wear, 4 cases had radiographically significant heterotopic ossification, and 3 cases had periprosthetic fractures. The 3-month, 1-year, and 5-year mortality rates for this series were 20, 53.3, and 73.3%, respectively.

Patients with pathological fractures secondary to malignant infiltration have a higher risk of perioperative medical complications.[2,13–15] When it comes to orthopedic complications, the existing evidence showed conflicting results, since the available literature compared different surgical techniques, for example ORIF, HA, or THA, for different causes of bone infiltration, including primary bone malignancies and metastatic bone infiltration.[4,6,16–23] For example, the life expectancy and the existing comorbidities differ between myeloma and other causes of bony infiltration such as lymphoma, metastatic breast, prostate, or lung cancers. Again, the indications and outcomes of HA differ from the outcomes of ORIF and THA, and the surgical settings are different.[24]

Excluding case reports and studies that reported on sporadic cases, the available studies in the literature that reported on hip replacement in myeloma showed different outcomes for different diagnoses and mostly compared several interventions (►**Table 3**). Of them, only two retrospective studies reported solely on a series of myeloma patients.[4,6] Papagelopoulos et al.[4] reported on 53 cases of myeloma who were managed with HA (33 cases) or THA (20 cases). The authors enumerated several complications, including deep infection, dislocation (1.8% each), and a 1-month mortality of 5.6%. The authors did not distinguish whether the complications occurred in HA or THA cases, which are different entities that may be affected by factors such as patients' age, medical comorbidities, activity level, and surgery duration. These factors may be translated to the reported difference in the incidence of periprosthetic infections between HA and THA in the literature, being 1.6 to 10% vs 0.2 to 0.7%, respectively.[25,26] In another study, Park et al.[6] reported on the in-hospital outcomes in 4,011 myeloma

Table 2 Mortality rate in the study group

Mortality at	Number of patients, %
3 months	3; 20%
1 year (+5 patients)	8; 53.3%
5 years (+3 patients)	11; 73.3%

cases who received surgery for femoral fractures, extracting the data from a national medical database. In their study, 1,288 patients received HA, 2,555 patients received ORIF, and 168 received THA. When comparing their total outcomes with non-myeloma cases, the authors found that multiple myeloma cases had a higher risk of in-hospital pneumonia, sepsis, surgical site infection, and acute renal failure as well as a lower risk of myocardial infarction. The authors, however, did not distinguish which complications occurred in HA, and which occurred in ORIF and THA.

Other studies included myeloma and non-myeloma cases, reporting on the incidence of complications amongst the total study cohorts (►**Table 3**). To the best of our knowledge, the current study is the first to report solely on the outcomes of hip hemiarthroplasty in patients with myeloma. Despite the small series, the most interesting findings are the high mortality (20% for the 3-month mortality), high incidence of periprosthetic fractures (18.75%), and the relatively low incidence of clinical or radiological acetabular erosion, given the associated osteopenia and osteoporosis that are usually present in myeloma patients.[1–3]

In patients with multiple myeloma, the reported 1- and 5-year survival rate is about 85 and 58%, respectively.[27,28] When hip fracture occurs, these numbers seem to significantly decline. In our study, only 46.7% of patients survived past 1 year, and 26.7% survived past 5 years from the surgery, while the median survival of all the cases was 8.4 months. Comparatively, Papagelopoulos et al.[4] reported a median survival of 18 months and a 2- and 5-year survival of 43 and 13%. These figures highlight the high mortality of hip fracture in myeloma patients. In the literature, the most common causes of mortality in myeloma patients are adult respiratory failure, septicemia and renal failure.[28] For the 1-month and in-hospital mortality, the incidence in myeloma and non-myeloma patients tends to be similar.[6] In our study, there was no in-hospital mortality, and the first patient died 1.3 months postoperatively, after discharge from the hospital.

Patients with multiple myeloma have weak and osteoporotic bones.[1–3,29,30] This may explain the higher incidence of periprosthetic fractures following prosthetic replacement in our study (3 patients; 18.75%). This agrees with the results of Peterson et al.,[18] who reported one periprosthetic fracture (PPF) (20%) in 5 HA myeloma cases and required revision. Despite this, Papagelopoulos et al.[4] did not report any PPF in their series of 53 HA and THA myeloma cases. In our study, all the fractures occurred in association with cemented stems. Since the current study has only 2 cases who received uncemented stems, we could not make a recommendation regarding the impact of stem type on the occurrence of periprosthetic fractures in myeloma patients.

Regarding heterotopic ossification (HO), this complication has been rarely reported in patients with multiple myeloma, most likely since it is a less serious complication. Seraj et al.[31] reported it in one patient with multiple myeloma who underwent right hip internal fixation. Due to the small number and the non-comparative nature of the current study, we could not conclude whether the HO cases in our study were related to myeloma or the HA surgery itself. The incidence of radiologically significant HO in our study is 25%, which is less than the reported incidence of HO in HA in general, which reached 27% in one study.[32]

Osteoporosis and osteomalacia are known risk factors for acetabular protrusion in native hips.[33,34] When it comes to acetabular wear after hip arthroplasty, the effect of preexisting osteoporosis is controversial.[35–37] The incidence of

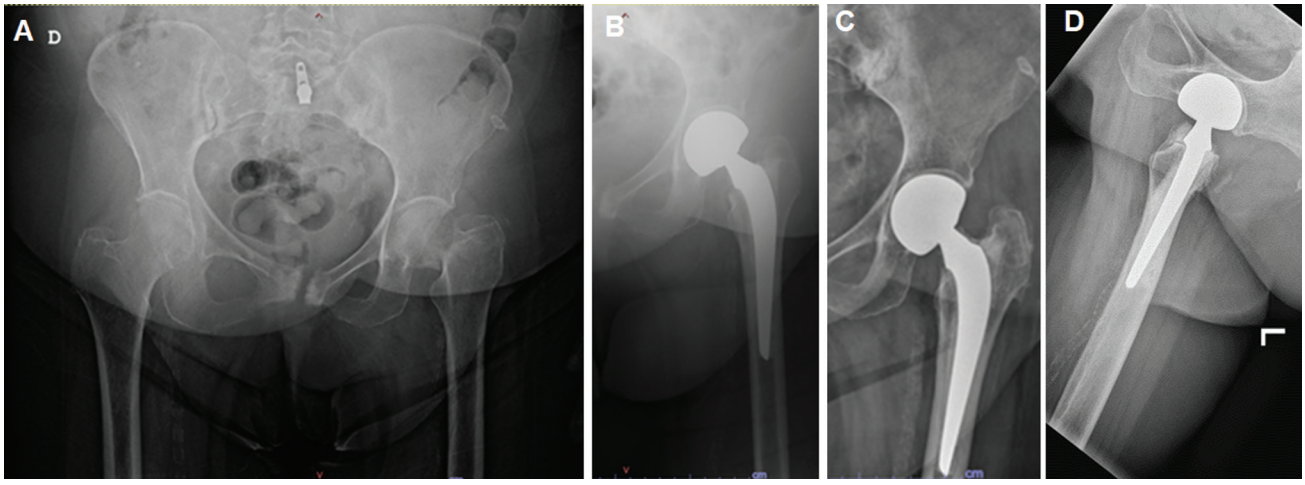


Fig. 2 (A) Plain pelvic radiographs of an 82-year-old female showing left displaced femoral neck fracture. (B) Immediate postoperative left hip plain X-ray showing cemented bipolar hemiarthroplasty. (C, D) 16-month postoperative plain left hip radiographs showing acetabular erosion. The patient complained of groin pain with movement and was managed conservatively.

Table 3 Review of the literature regarding the studies that reported about the outcomes of prosthetic replacement in a series of myeloma patients (excluding case reports)

Study/Year	Diagnosis (number of cases)	Intervention (number of cases)	Complications in myeloma cases (number of cases)	Notes
Papagelopoulos et al. 1997[4]	Multiple myeloma (53)	HA (33) THA (20)	Intraoperative severe blood loss (1) Intraoperative pulmonary distress (1) 1-month mortality (3) Aseptic loosening (1) Dislocation (1) Deep Infection (1) Superficial infection (1) Persistent wound drainage (4)	Two revisions, resection arthroplasty for infection or dislocation (1 each) The authors did not distinguish whether the complications occurred in HA or THA cases.
Schneiderbauer et al. 2005[7]	Multiple myeloma (31) Other tumors (298)	Hemiarthroplasty	Patients who underwent HA for tumor lesions had a significantly higher incidence of dislocation compared to other indications.	The authors did not mention the number of complications in myeloma cases.
Parker et al., 2011[8]	Multiple myeloma (9) Other tumors (136)	HA, THA, or ORIF	Patients with Myeloma had the longest mean survival, compared to lymphoma, breast, lung and prostate metastatic lesions.	The authors did not mention the number of complications in myeloma cases, nor the types of interventions.
Alvi et al., 2013[9]	Multiple myeloma (17) Other tumors (79)	Shoulder Arthroplasty, ORIF, THA and HA (not mentioned)	One case, managed with cemented long stem calcar replacement HA had radiological myeloma disease progression noticed 4 months after the index surgery.	The authors have not mentioned how many of the patients received which implant.
Park et al., 2016[6]	Multiple myeloma (4,011), comparing in hospital complications with non-myeloma cases.	ORIF (2,555) Hemiarthroplasty (1,288) THA (168)	Patients with multiple myeloma had a higher risk of in-hospital pneumonia (5.4%), sepsis (1.4%), surgical site infection (2.8%), and acute renal failure (9.6%). While there was no difference in DVT, pulmonary embolism, respiratory failure, and in-hospital mortality, multiple myeloma patients had less incidence of myocardial infarction.	The authors did not distinguish which complications occurred in HA and which occurred in ORIF and THA.
Peterson et al., 2016[10]	Myeloma (5) Other metastatic lesions (17)	Long stem hemiarthroplasty	Sciatic nerve injury (1) Stroke (1) Periprosthetic fracture (1) 1-month mortality (1) 1-year mortality (2)	1 revision for peri prosthetic fracture
Stevenson et al., 2018[11]	Myeloma (6) Other tumors (94)	Proximal femoral replacement HA (6)	No dislocations, No revisions for pain or acetabular erosion.	The series reported four infections and three revisions; however, the authors did not distinguish whether the complications occurred in myeloma or other cases.
Seglam et al., 2019[12]	Multiple myeloma (19) Other tumors (114)	Proximal femoral replacement HA (18) Proximal femoral replacement HA (1)	15 patients expired at a mean follow up of 35.11 ± 22.38 months. 12 patients had class 1 or 2 radiological acetabular erosion.	Two revisions, for aseptic loosening and for dislocation (1 each).

Table 3 (*Continued*)

Study/Year	Diagnosis (number of cases)	Intervention (number of cases)	Complications in myeloma cases (number of cases)	Notes
Schwarzkopf et al., 2019[13]	Myeloma (15) Other cases (359 cases)	HA and THA	11/15 myeloma cases had bone cement implantation syndrome, without intraoperative death.	The authors did not distinguish whether complications occurred in HA or THA cases.
Hayden et al., 2021[14]	Multiple myeloma (25) Other tumors (139)	HA (15) THA (10)	The authors did not find significant differences in the incidence of complications between THA and HA.	The authors did not mention the number of complications in Myeloma cases.

Abbreviations: DVT, deep vein thrombosis; HA, hemiarthroplasty; ORIF, open reduction and internal fixation; THA, total hip arthroplasty.

acetabular wear in the current study (6.25%) is comparable to the reported incidence after hip HA in general, which ranges between 0.7 and 17.2%.[38–40] Considering these results, HA remains a viable option for management of proximal femoral fractures in myeloma patients. However, patients' expectations regarding the associated morbidities and mortality should be clearly presented as regard to the presented evidence. The lower survival rates in myeloma patients and in this study could potentially have affected the incidence of acetabular erosion in myeloma patients with such osteoporotic bone.

In myeloma patients undergoing hip HA, surgeons should be aware of the incidence of specific complications, especially the potential risk of increased intraoperative blood loss and perioperative PPFs. It is imperative also for the surgeon to properly assess the acetabulum and the entire femur for the presence of osteolytic lesions using CT scans, long film femur radiographs, and even magnetic resonance imaging,[41] to detect the presence of skip myeloma lesions and, hence, allow the surgeon to choose the suitable implant.

The current study has several limitations. This is a small series and is limited by the non-comparative and retrospective study design. A large multicenter study may be required to better evaluate the outcomes of prosthetic replacement in myeloma patients when compared to the general population.

Conclusion

Hip HA is a reasonable option for the management of femoral neck fractures in patients with multiple myeloma. Provided that the acetabulum is free from tumor invasion, the incidence of acetabular erosion is relatively small. The surgeons should be aware of the associated high morbidity and mortality in such patients.

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

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Anatomical Study of the Ultrasound-guided Percutaneous Tenotomy of the Iliopsoas Muscle Tendon in Cadavers: A Feasible Technique?

Estudo anatômico da tenotomia percutânea do tendão do músculo iliopsoas guiada por ultrassonografia em cadáveres: Técnica viável?

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Abstract

Objective To evaluate the efficacy and safety of percutaneous tenotomy of the iliopsoas muscle tendon guided by ultrasound (US) in cadavers.

Methods We conducted an anatomical and descriptive study of the US-guided percutaneous tenotomy technique for the iliopsoas muscle tendon to review our experience performing it and its reproducibility in the clinical practice.

Results Of the 20 tenotomies, 17 were total, at the level of the upper edge of the acetabulum, while 3 were partial. One procedure resulted in a partial injury to the femoral nerve. We measured the distance between the place of blade introduction and the femoral nerve, a noble structure potentially at a higher risk during the procedure; the mean distance was of 8.4 mm.

Conclusion Iliopsoas tendon release procedures guided by US in a cadaveric model are feasible and consistently result in the total release of the tendon, except in cases of obesity, with minimal repercussions on adjacent structures, and their completion requires approximately 4 minutes.

Keywords
- cadaver
- hip
- hip joint
- tenotomy
- ultrasonography

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Resumo

Objetivo Avaliar a eficácia e a segurança da tenotomia percutânea do tendão do músculo iliopsoas guiada por ultrassonografia (USG) em cadáveres.

Métodos Realizamos um estudo anatômico e descritivo da técnica de tenotomia percutânea do tendão do músculo iliopsoas guiada por USG para repassar nossa experiência ao realizá-la e a reprodutibilidade na prática clínica.

Resultados Das 20 tenotomias, 17 foram totais, realizadas no nível da borda superior do acetábulo, e 3 foram parciais. Durante um dos procedimentos, houve uma lesão parcial do nervo femoral. Foram realizadas as medições da distância entre o local onde a lâmina foi introduzida e o nervo femoral, uma estrutura nobre que estaria em maior risco durante o procedimento, e a distância média foi de 8,4 mm.

Conclusão Os procedimentos de liberação do tendão do iliopsoas guiados por USG podem ser executados em um modelo cadavérico, pois obtém-se de forma consistente a liberação total do tendão, exceto em casos de obesidade, com mínimas repercussões em estruturas adjacentes; os procedimentos demandam aproximadamente 4 minutos para serem concluídos.

Palavras-chave

- articulação do quadril
- cadáver
- quadril
- tenotomia
- ultrassonografia

Introduction

Total hip arthroplasty (THA) is a widely used intervention to restore function and alleviate pain in patients with several hip joint conditions. However, even with THA success, some patients remain with persistent postoperative pain, often related to friction of the iliopsoas muscle tendon against the anterior edge of the acetabular component.[1,2] This friction, known as psoas impingement, results in inflammation, discomfort, and significant functional limitation for the patient, including going up or down stairs, getting in and out of cars, or in situations requiring hip extension.[3] An alternative before reviewing the acetabular component is an arthroscopy with an intra-articular approach and capsule opening to access the iliopsoas muscle tendon and perform a tenotomy.

The percutaneous technique may present additional advantages, such as shorter procedure time and a single incision compared with the techniques currently described, which range from arthroscopic approaches to open surgeries.[4,5]

We devised an even less invasive technical variant, locating the iliopsoas muscle tendon by ultrasound (US) imaging at the impingement point and performing guided tenotomy as previously described by Sampson et al.[6] This technique is an alternative to arthroscopic surgery, which is minimally invasive but may pose more risks, including technique-related complications or irrigation fluid leakage into the iliopsoas muscle sheath.[5]

We analyzed the approach, potential risk for noble structures, and the effectiveness of tenotomy in cadavers. The investigations included a meticulous evaluation of the interventional technique with a special focus on minimizing damage to surrounding noble structures.

The present study aimed to assess the efficacy and safety of percutaneous US-guided tenotomy of the iliopsoas muscle tendon in cadavers.

Materials and Methods

This anatomical and descriptive study was developed at the Orthopedics and Traumatology Department of Faculdade de Ciências Médicas Santa Casa de Misericórdia de São Paulo and performed at the São Paulo Capital Death Verification Service (Serviço de Verificação de Óbitos da Capital, SVOC, in Portuguese) of Universidade de São Paulo (USP), with duly registration of the study team under letter number 18/2024 per its regulations and approval from the institutional Ethics Committee (CAAE number 76524523.4.0000.5479). Those responsible signed a free and informed consent form.

The study included a sample of 10 cadavers, with 20 hips not embalmed with formaldehyde.

Tenotomy Technique

We placed the subject in the horizontal supine position, with no traction, with the hip in a neutral position. We performed the tenotomy using an ultrasound device (Sonosite Edge II, FUJIFILM Sonosite, Inc., Bothell, WA, United States) with a low-frequency convex probe (5–2 MHz) per the following technique:

- We identified the anterior superior iliac spine (ASIS) by palpation. We measured a point 4 cm distal to the ASIS and 1 cm medial to it using a 150-mm/6", 0.05-mm, universal analog caliper (Mitutoyo Corporation, Kawasaki, Kanagawa, Japan) to determine the incision site (►**Fig. 1**).
- We positioned the probe transversely to the frontal plane. Next, we rotated the probe at 90° seeking the longitudinal positioning on the upper edge of the hip joint. This enabled the visualization of the iliopsoas muscle tendon, the upper edge of the acetabulum, and the femoral head, projecting an image called "stacking sign" (►**Figs. 2**–**3**).

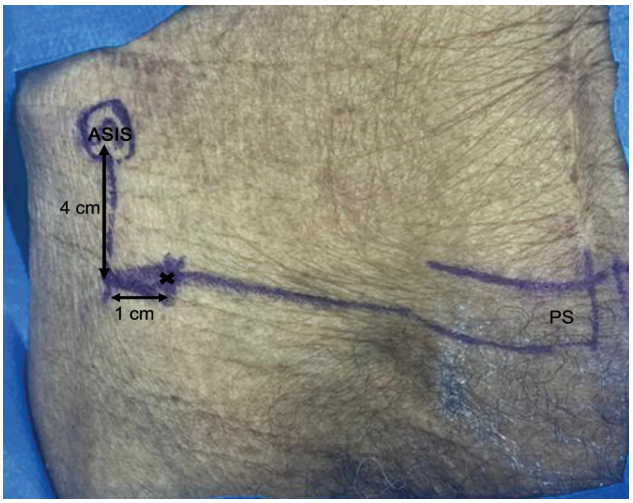


Fig. 1 Location of the incision location, 4 cm distal and 1 cm medial from the anterosuperior iliac spine (ASIS). **Abbreviation:** PS, pubic symphysis.

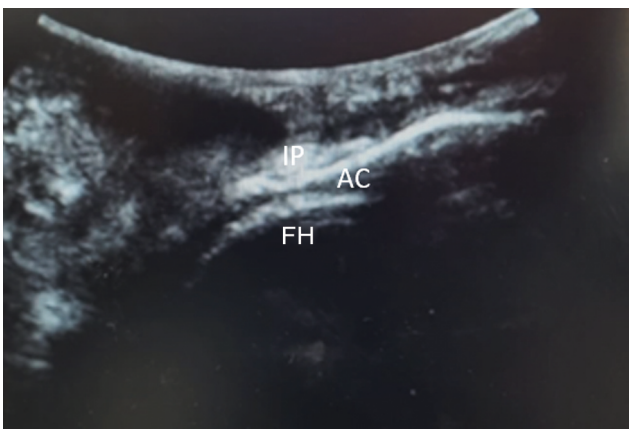


Fig. 2 Ultrasound view of the "stacking sign" with the transducer transverse to the frontal plane showing the femoral head, the superior acetabular rim, and the iliopsoas tendon. **Abbreviations:** IP, iliopsoas tendon; AC, acetabulum; FH, femoral head.

- We proceeded to the US-guided infiltration of 0.5 mL of methylene blue. We introduced a disposable needle for regional anesthesia (of 0.7 × 88 mm/22 G × 3.5", Spinocan, B. Braun Melsungen SE, Melsungen, Germany) at 40° of angulation, parallel and adjacent to the probe in a transverse position to the frontal plane on the upper edge of the acetabulum. This enabled the visualization of the psoas tendon and the staining of the tenotomy site alone.
- We used a 27-cm long-handled scalpel with a 5-mm thick and 3-cm long blade to make a 1-cm incision parallel and adjacent to the transducer to perform the technique (►**Fig. 4**).
- With real-time US visualization of the tenotomy site and femoral artery, vein, and nerve, we introduced the scalpel at the approach created, trying to position the blade inferior to the tendon. The tenotomy occurred with subtle movements from medial to lateral (►**Fig. 5**).

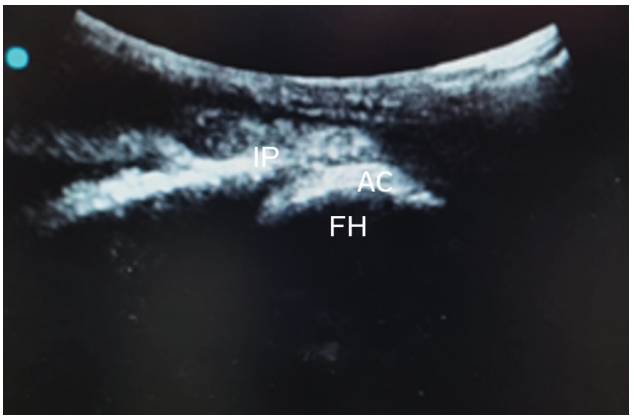


Fig. 3 Ultrasound view of the "stacking sign" with the transducer longitudinal to the frontal plane. **Abbreviations:** IP, iliopsoas tendon; AC, acetabulum; FH, femoral head.

- After the percutaneous tenotomy, we performed a quadrangular flap and dissected it in planes around the scalpel to check for injured structures, structures at risk, and the technical outcome (►**Fig. 6**).
- We visually inspected and took detailed measurements of the anatomical structures adjacent to the psoas tendon and in the scalpel path, including muscles, vessels, and nerves (►**Figs. 7**–**8**).

Tenotomy Analysis

To dissect the anterior region of the hip, we created a quadrangular skin flap with its apex in the middle of the medial aspect of the thigh and its base between the ASIS and the inferior gluteal fold. After dissection, we identified the ASIS, the anterior inferior iliac spine (AIIS), the inguinal ligament, the femoral neurovascular bundle, the joint capsule, the sartorius muscle, the rectus femoris muscle, and the iliopsoas muscle.

After identifying these anatomical structures, we assessed their correlations with the scalpel path, the potential injuries, and the effectiveness of the tenotomy. In addition, we measured the distance between the tenotomy site and the femoral neurovascular bundle using the same analog caliper.

Results

We performed 20 iliopsoas tenotomies on 10 (6 male and 4 female) cadavers with ages ranging from 55 to 94 (mean: 75.2) years. Their body mass index (BMI) ranged from 12.4 to 28.7 (mean: 22.5) Kg/m^2. We excluded one subject who presented an extruded bilateral inguinal hernia, which prevented the technique's performance (►**Table 1**).

Of the 20 tenotomies, 17 were total, at the level of the upper edge of the acetabulum, while 3 were partial. Among these partial tenotomies, two were performed on the subject with the highest BMI, and one, on the cadaver with the second highest BMI (►**Figs. 9**–**10**).

One of the tenotomies resulted in a partial injury to the femoral nerve of the subject with the highest BMI. We

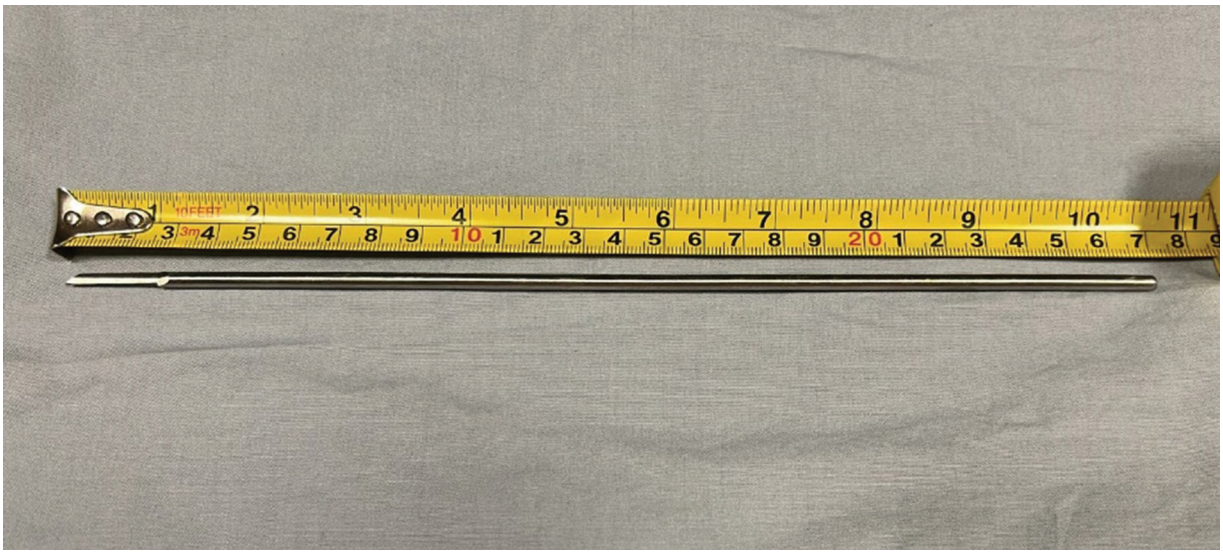


Fig. 4 Scalpel used to perform the technique.

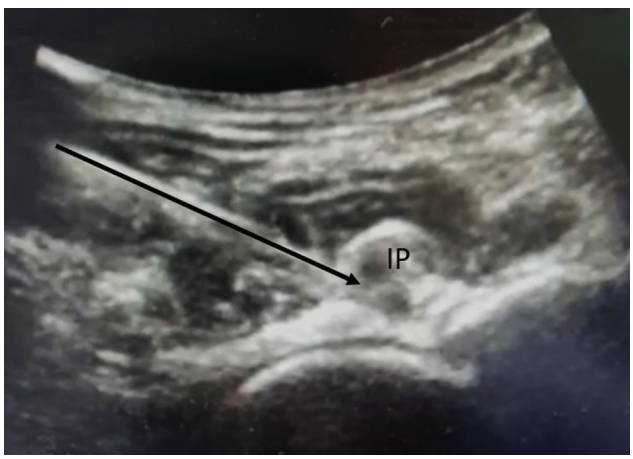


Fig. 5 Ultrasound image of the blade path during guided iliopsoas tenotomy. **Abbreviation:** IP, iliopsoas tendon.

observed that all tenotomies were close to the myotendinous portion and, in 14 of the 20 procedures, the blade caused a partial transfixing injury of the sartorius muscle. We evaluated the joint capsule, which showed no injuries in any procedure (►**Table 2**).

We measured the distance between the site where the blade was introduced and the femoral nerve, a noble structure potentially at greater risk during the procedure. The average distance was of 8.4 (range: 5–12) mm. We noted that high BMIs increased the difficulty and duration of the procedure.

Discussion

One of the causes of anterior hip pain and difficulty in daily activities, such as climbing stairs or getting into cars, is the internal protrusion of the hip caused by the iliopsoas muscle.[2] Initially, the treatment can be conservative, with success

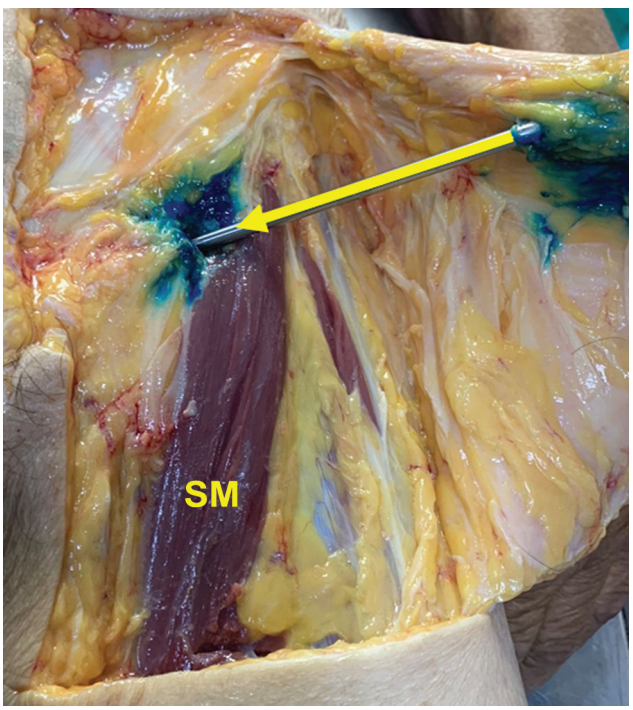


Fig. 6 Quadrangular flap and visual inspection of the scalpel path transfixing the sartorius muscle. **Abbreviation:** SM, sartorius muscle.

rates of up to 50% depending on the degree of anterior extrusion of the acetabular component. When the conservative treatment fails, it may be necessary to release the iliopsoas tendon before reviewing the acetabular component.[7]

The release of the iliopsoas tendon usually occurs arthroscopically, presenting good outcomes and lower risks than those of open surgeries.[7–9] However, this procedure requires general anesthesia and addressing a previously operated joint, which can lead to complications such as infection,

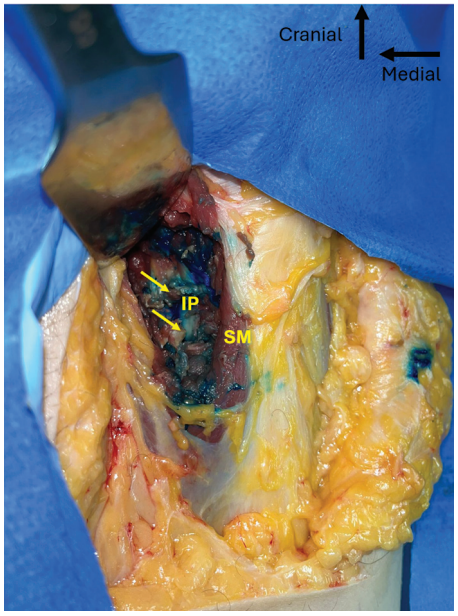


Fig. 7 Dissection and deep inspection of the iliopsoas tenotomy. The arrows indicate the proximal and distal stumps of the tendon. **Abbreviations:** IP, iliopsoas tendon; SM, sartorius muscle.

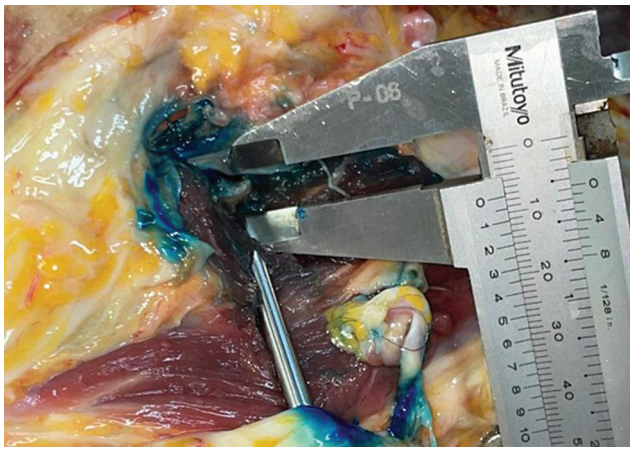


Fig. 8 Measurement of the distance between the tenotomy site and the femoral neurovascular bundle.

leakage of the fluid infused through the tendon sheath, and other risks inherent to the technique. In addition, it is a more expensive procedure.[5,8,10,11]

Seeking a less-invasive, faster, and equally-effective way to perform this release, Sampson et al.[6] were the first to report the US-guided technique.[6] Next, Johnson et al.[12] used this technique and performed the release on ten hips, without damaging noble structures. The tenotomy was incomplete in five cases. Although these authors[12] also conducted an anatomical study of the region, they did not measure the distances between the tenotomy site and the noble structures for a better assessment of the risks of this procedure.

In the present study, using a long blade instead of a needle, we achieved complete release in 17 of the 20 hips, with only 3 incomplete releases. Of these, two occurred in the cadaver with the highest BMI; this same subject suffered an incomplete injury of 4 mm to the femoral nerve. Our measurements revealed that the mean distance from the tenotomy site to the femoral nerve was of 8.4 mm. The femoral nerve injury in this single case can be attributed to an anatomical variation of the nerve,[13] and it could be avoided by direct US visualization and releasing the tendon from lateral to medial. Other than that, we observed less significant findings, such as sartorius transfixation and proximal injury to the psoas muscle.

This technique is promising, as the use of US avoids injuries to adjacent structures, such as the femoral plexus and joint capsule. In clinical studies, this technique may prove cheaper than arthroscopy, with a shorter time until the return to daily activities, and fewer complications related to anesthesia and surgical wounds.

The present study has its limitations. Since it employed cadavers, it is impossible to follow up the progression and resolution of symptoms. A single surgeon with extensive experience in US performed the releases, and the procedure may be more complex for less experienced professionals. All procedures used a scalpel with a long handle and a 3-cm

Table 1 Anthropometric data of the study sample

Identification	Sex	Age (years)	BMI (Kg/m^2)
C1	Male	61	24.2
C2	Male	67	25.7
C3	Male	71	26.2
C4	Female	85	25.9
C5	Female	89	28.7
C6	Female	55	19.3
C7	Male	58	22.1
C8	Male	88	16.4
C9	Female	94	12.4
C10	Male	84	19.2

Abbreviations: C, cadaver; BMI, body mass index.

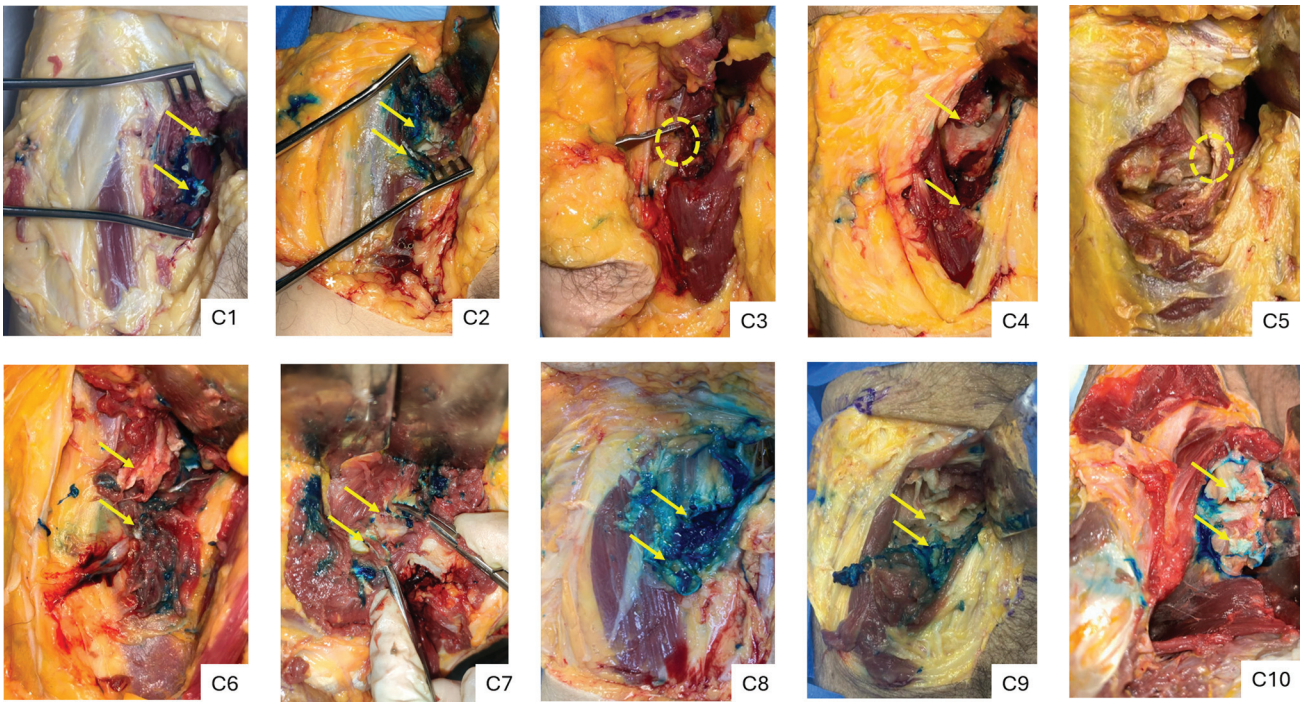


Fig. 9 Right hips undergoing ultrasound-guided percutaneous tenotomy. The arrows indicate the distal and proximal stumps of the iliopsoas tendon, and the dotted circles show incomplete tenotomies.

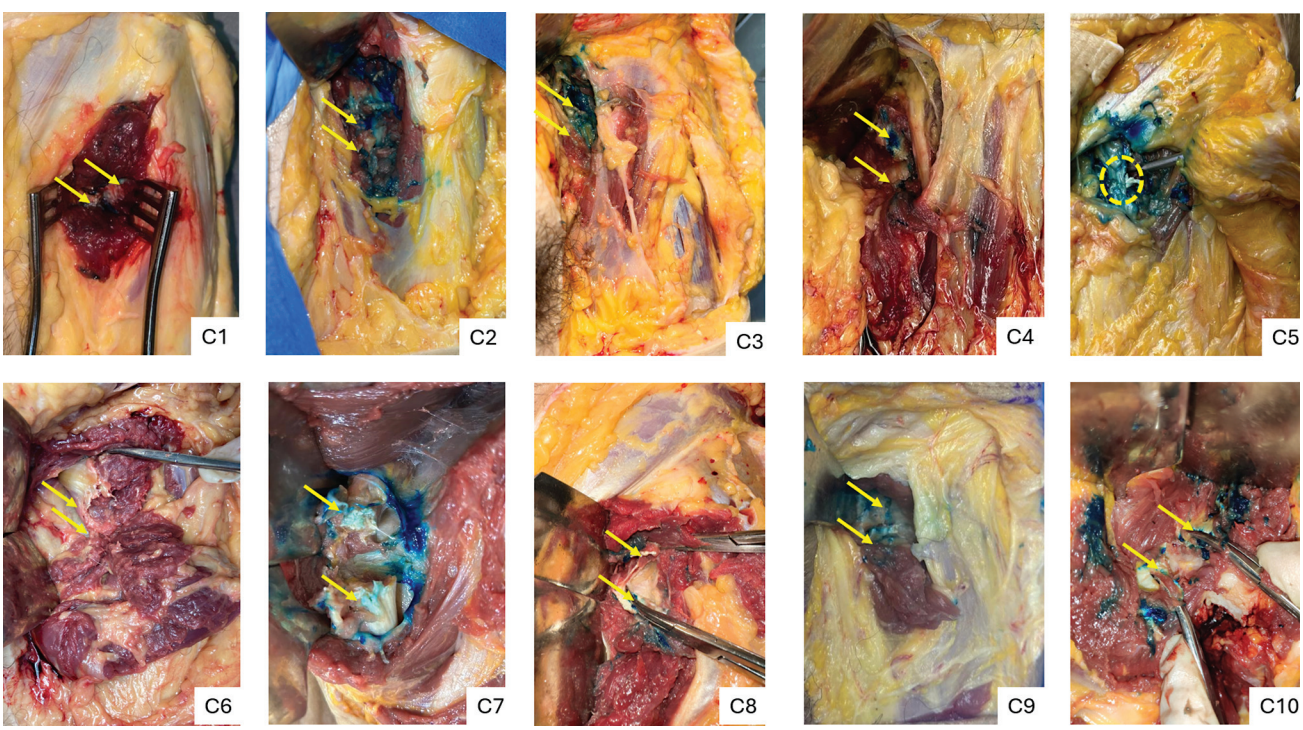


Fig. 10 Left hips undergoing ultrasound-guided percutaneous tenotomy. The arrows indicate the distal and proximal stumps of the iliopsoas tendon, and the dotted circle shows an incomplete tenotomy.

blade, and we noted a greater difficulty in cadavers with higher BMIs. It is impossible to know the progression of cases with incomplete tenotomy and how devastating the femoral nerve injury would be.

Although the results cannot be completely reliable for a clinical setting due to the minimally-invasive approach, it is plausible that this technique can be safely performed with local anesthesia. Moreover, it presents lower costs than those of arthroscopy and provides a faster recovery to return to activities compared with traditional surgical procedures. Further research is required to evaluate its safety and efficacy in clinical applications.

Table 2 Tenotomy data and analysis

Identification	Complete right-sided tenotomy	Right neurovascular bundle injury	Complete left-sided tenotomy	Left neurovascular bundle injury
C1	Yes	No	Yes	No
C2	Yes	No	Yes	No
C3	No	No	Yes	No
C4	Yes	No	Yes	No
C5	No	Yes	No	No
C6	Yes	No	Yes	No
C7	Yes	No	Yes	No
C8	Yes	No	Yes	No
C9	Yes	No	Yes	No
C10	Yes	No	Yes	No

Abbreviation: C, cadaver.

Conclusion

The US-guided iliopsoas muscle tendon tenotomy procedure is feasible in a cadaveric model, consistently obtaining total tendon release, except in cases of obesity, and with minimal repercussions on adjacent structures.

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

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Transiliac-transsacral Screws: What is the Required Implant Length for Adequate Percutaneous Fixation of the Posterior Pelvic Ring?

Parafusos transilíaco-transacrais: Qual o comprimento necessário dos implantes para uma adequada fixação percutânea do anel pélvico posterior?

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Abstract

Objective Brazilian orthopedic surgeons experience the unavailability of long screws allowing percutaneous fixation of the posterior pelvic ring in transiliac-transsacral (TI-TS) configuration. The objective of the present study is to measure the lenght of the osseous fixation pathways available for TI-TS fixation in a population sample to infer the required implant length.

Methods We retrospectively assessed patients undergoing computed tomography (CT), initially identifying the existence of a potential osseous fixation pathway (POFP) in S1, S2 and S3. Each POFP was measured from the external cortex of the iliac bone to the external cortex of the contralateral iliac bone on axial CT images.

Results The analysis comprised a sample of 180 cases. A POFP was identified in S1 in 116 (64.4%) cases, in S2 in 178 (98.9%) cases, and in S3 in 16 (8.9%) cases. The median (interquartile range – IQR) POFP measurement in S1 was 153 (148–161) mm, ranging from 135 mm to 179 mm. In S2, the median (IQR) POFP measurement was 136 (131–144) mm, ranging from 114 to 160 mm. In S3, the median (IQR) POFP measurement was 120.5 (115–126) mm, ranging from 110 to 131 mm.

Conclusions We demonstrated that the maximum lengths of the osseous fixation pathways identified in our sample would require screws up to 180 mm in length, with a clear dissociation between the values measured and the longer screws currently commercialized in our setting.

Keywords
- bone screws
- fracture fixation, internal
- fractures, bone
- pelvic bones

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Resumo

Objetivo Cirurgiões ortopédicos brasileiros vivenciam a indisponibilidade de parafusos longos que permitam a fixação percutânea do anel pélvico posterior na configuração transilíaco-transacral (TI-TS). O objetivo do presente estudo é mensurar o comprimento dos corredores ósseos de fixação disponíveis para fixação TI-TS em uma amostra populacional para inferir o comprimento necessário do implante.

Métodos Foram avaliados retrospectivamente pacientes que realizaram tomografia computadorizada (TC), identificando inicialmente a existência de um potencial corredor ósseo de fixação (PCOF) em S1, S2 e S3. Cada PCOF foi medido a partir da cortical externa de um ilíaco até a cortical externa do ilíaco contralateral em imagens axiais de TC.

Resultado A análise compreendeu uma amostra de 180 casos. PCOF em S1 foi identificado em 116 (64,4%) casos, PCOF em S2 foi identificado em 178 (98,9%) casos e PCOF em S3 foi identificado em 16 (8,9%) casos. A mediana (intervalo interquartílico - IIQ) da aferição do PCOF de S1 foi de 153 (148–161) mm, variando de 135 a 179 mm. Em S2, a mediana (IIQ) foi de 136 (131–144) mm, com uma variação de 114 a 160 mm. Em S3, a mediana (IIQ) da medição do PCOF foi de 120,5 (115–126) mm, com uma variação de 110 a 131 mm.

Conclusões Demonstramos que os comprimentos máximos dos corredores ósseos de fixação identificados exigiriam parafusos de até 180 mm de comprimento, com uma clara dissociação entre os valores medidos e os parafusos mais longos atualmente comercializados em nosso meio.

Palavras-chave

- fixação interna de fraturas
- fraturas ósseas
- ossos pélvicos
- parafusos ósseos

Introduction

From its first descriptions,[1,2] percutaneous fixation of traumatic posterior pelvic ring injuries using cannulated screws has been established as a safe, reproducible, effective, and versatile method, which can be used to treat a wide variety of fractures, dislocations, and fracture-dislocations affecting the posterior ilium, sacroiliac joint, and sacrum.[3–5] Current indications include more unstable injury patterns[4,6] and subjects with poor bone quality.[7,8] The method requires extensive knowledge of the anatomy, neurovascular structures at risk, and the osseous fixation pathways (OFP) available in each patient.[8] Sacral dysmorphism recognition is essential and guides the fixation strategy.[9]

Depending on individual features and the purpose of implant use, implants can be positioned in the iliosacral (IS) or transiliac-transsacral (TI-TS) configuration. Screws in the traditional IS configuration are inserted from the iliac bone external cortex towards the sacral vertebral body. This configuration has proven insufficient, especially in situations of major instability, comminution, and osteoporosis.[10,11] The TI-TS configuration, i.e the insertion of a screw crossing the sacral segment and reaching the external cortex of the contralateral iliac bone, became possible only after the production of longer implants in the early 2000s.[12] Since then, a better understanding of OFPs and bone density-related particularities of the posterior ring have demonstrated clinical and biomechanical advantages of using screws in the TI-TS configuration.[13–15]

Brazilian orthopedic surgeons experience the unavailability of cannulated screws with lengths that allow implant application in TI-TS configuration, preventing optimal OFP use and, in many cases, compromising the ability to offer sufficiently rigid and stable fixation.

The main objective of the present study was to perform the tomographic measurement of the length of OFPs used in the TI-TS fixation in a population sample.

Materials and Methods

After obtaining Intitucional Review Board approval (CAAE: 78038724.5.0000.5330), we assessed retrospectively patients admitted in the emergency department between January 2nd and 10th, 2024, using the picture archiving and communication system (PACS) version 12 (Philips Medical Systems Nederland B.V., Best, The Netherlands) available at the institution.

Patients aged between 18 and 85 years who were evaluated in the hospital emergency department and underwent computed tomography (CT) of the abdomen/pelvis with serial axial images of up to 2 mm were included. Patients with traumatic injuries (acute or chronic) or malignancy-related anatomical deformities were excluded.

The presence of a potential osseous fixation pathway (POFP) for a safe insertion of a TI-TS screw in the first (S1), second (S2), and third (S3) sacral segments was inittialy evaluated on axial CT images. The presence of POFP in S1 was defined by the existence of a wide bone corridor allowing for a safe insertion of a TI-TS screw according to previously described criteria;[16] these patients have been considered non-dysmorphic (►**Figure 1A**). According to the same criteria, the presence of sacral dysmorphism is represented by the

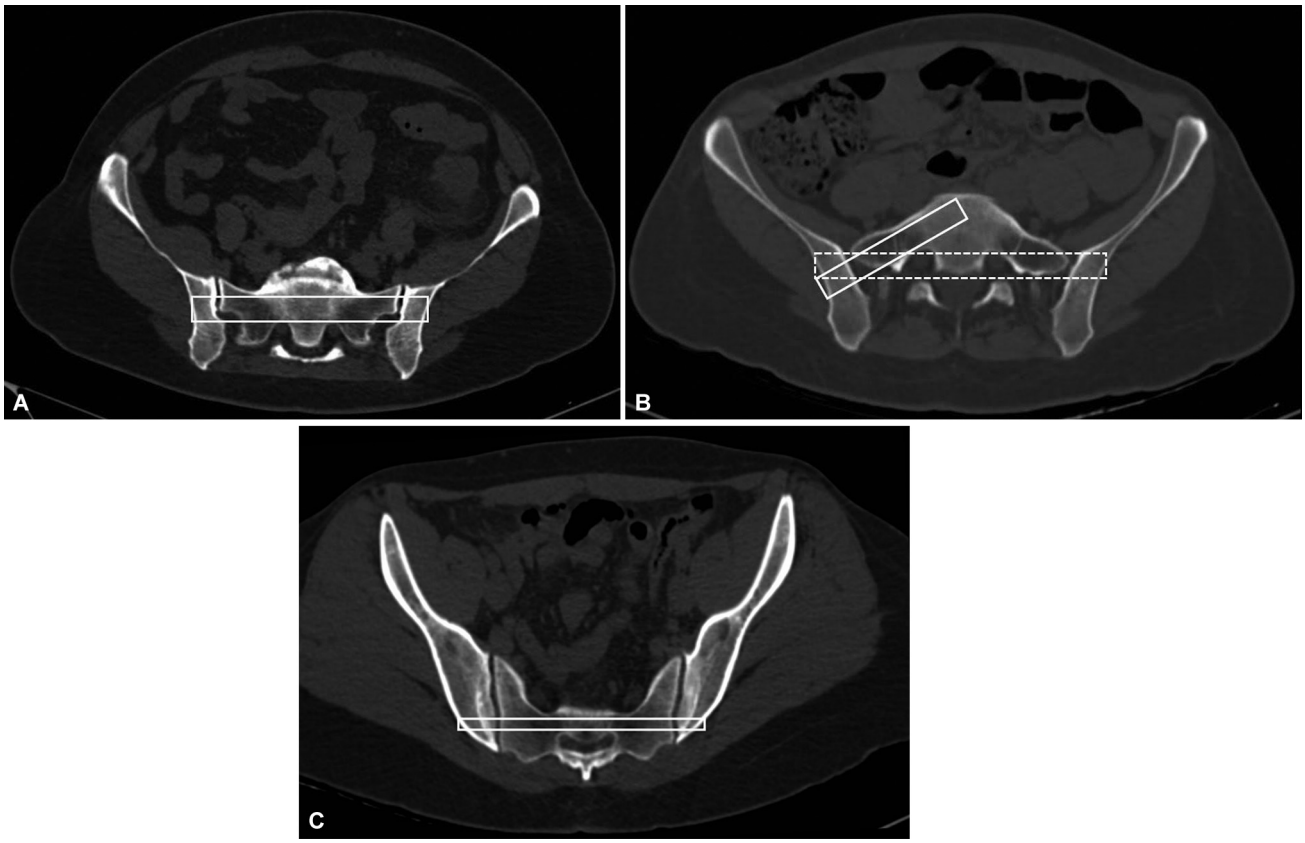


Fig. 1 Definition of a transiliac-transsacral (TI-TS) potential osseous fixation pathway (POFP) in S1 and S3. (A) Presence of TI-TS POFP in S1 (absence of sacral dysmorphism). (B) The absence of TI-TS POFP in S1 (presence of sacral dysmorphism), with a narrow and oblique OFP at this level, only allows for implant application in the iliosacral (IS) configuration. (C) Patient with a TI-TS POFP in S3 presenting a bilateral complete articulation between the caudal portion of the iliac bone and the third sacral vertebra.

absence of a POFP in S1 that would allow the application of a TI-TS screw (►**Figure 1B**). Only patients with a complete bilateral articulation between the caudal portion of the ilium and the third sacral vertebra were considered to have a POFP in S3 according to previous definition[17] (►**Figure 1C**). POFPs identified in S1, S2, and S3 were measured (in millimeters *[mm]*) from the external cortex of the posterior iliac bone to the external cortex of the contralateral posterior iliac to infer the minimum TI-TS configuration implant length (►**Figure 2**). The same evaluator (an orthopedic surgeon experienced in treating pelvic ring injuries) performed the measurements using the tool provided by the software.

All sample size calculations used the WinPEPI program (Programs for Epidemiologists for Windows) version 11.65 (Jerusalem, Israel) based on data from a pilot survey analyzing 20 patients and referring to subjects from both genders and the presence of PBCFs at each level. Considering the quantitative data for S1, the standard deviation for men (8.81) and women (7.10), an 80% analysis power, a 5% significance level, and a 10% potential loss margin, the minimum sample size required to detect a difference of five units between the groups was 63 participants from each gender, totaling 126 subjects.

Data processing, double entry into the database, review, and analysis used IBM SPSS Statistics for Windows (IBM Corp., version 21.0, Armonk, NY, USA) software. Descriptive analyses expressed quantitative data as mean ± standard deviation of the mean (± SD) or median and interquartile range (IQR) (25^{th}–75^{th} percentiles) per the Shapiro-Wilk distribution test. Qualitative variables were described as absolute frequencies (n) and relative frequencies (%). The Chi-squared ($\chi 2$) test with adjusted residual analysis assessed potential associations between qualitative variables. The Student's t-test for independent samples (t) compared means (± SD), and the Mann-Whitney (MW) test compared medians (IQR). For all analyses, the significance level was set at 5%.

Results

The analysis comprised a sample of 180 patients admitted to the emergency department who underwent abdominal/pelvic CT between January 2nd and 10th, 2024. The sample had 115 women (63.9%) and 65 men (36.1%). The median (IQR) age was 43.5 years (34–62), ranging from 19 to 82. Of the total 180 cases included in the analysis, we identified a POFP in S1 in 116 (64.4%) cases, a POFP in S2 in 178 (98.9%) cases, and a POFP in S3 in 16 (8.9%) cases.

►**Table 1** shows the presence of POFP at each sacral level evaluated. We noted the absence of POFP at S1, i.e, the presence of sacral dysmorphism, in 64 (35.5%) of the 180 patients evaluated.

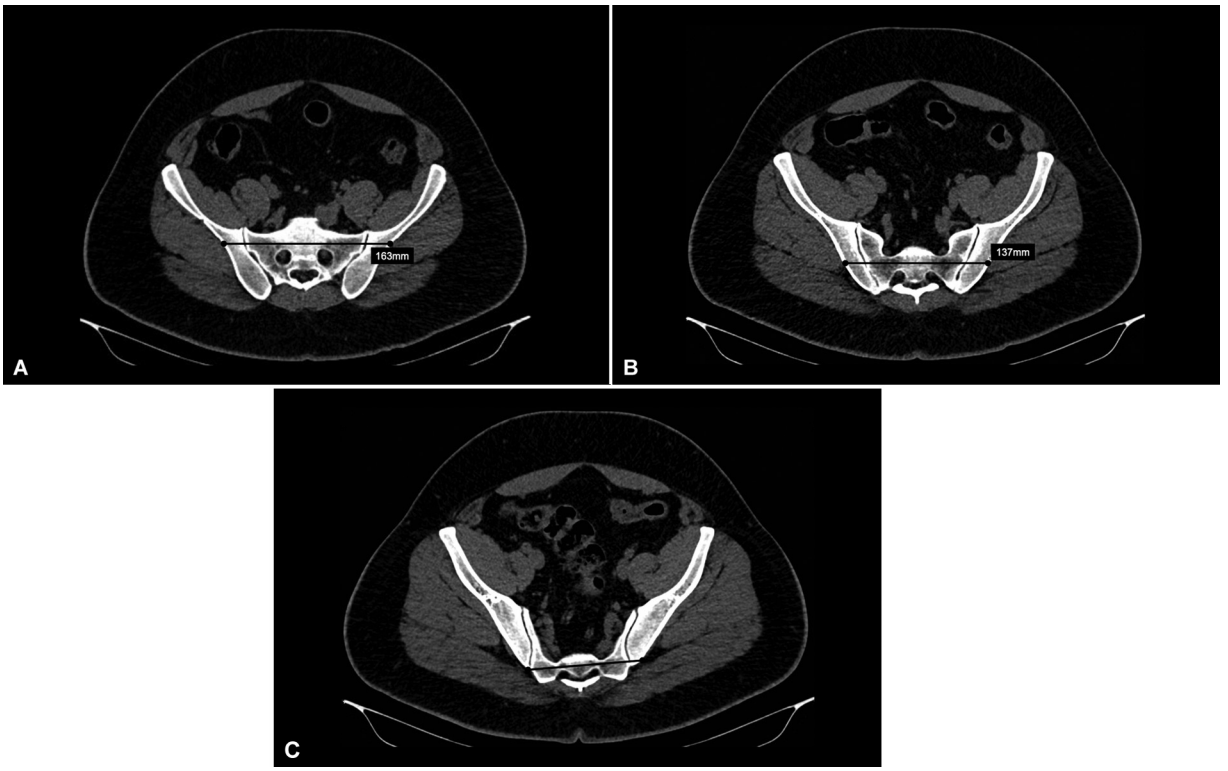


Fig. 2 Technique for measuring the length of the potential osseous fixation pathway (POFP) in each patient. The patient has POFP in the first (A) and second (B) sacral segments, with lengths of 163 mm and 137 mm, respectively. There is no POFP in the third sacral segment (C).

Table 1 Presence of a potential osseous fixation pathway at each sacral level evaluated

Sacral level	Total presence of POFP ($N = 180$)
S1	116 (64.4)
S2	178 (98.9)
S3	16 (8.9)

Abbreviation: POFP, patients with a potential osseous fixation pathway.
Note: Data presented as absolute (n) and relative (%) frequencies.

►**Table 2** shows the length of each POFP in millimeters (mm) for each sacral level. The median [IQR] of the POFP at S1 was 153 (148–161) mm, ranging from 135 mm to 179 mm. At S2, the median (IQR) was 136 (131–144) mm, ranging from 114 to 160 mm. At S3, the median (IQR) POFP was 120.5 (115–126) mm, ranging from 110 to 131 mm.

►**Table 3** presents the differences between patients with and without sacral dysmorphism. Among those without sacral dysmorphism ($N = 116$), the mean (± SD) of POFP length in S2 was 135.68 ± 8.54 mm, while, in those with sacral dysmorphism ($N = 64$), the mean (± SD) POFP length in S2 was slightly higher, of 139.50 (± 9.30) mm (t, $p = 0.006$). There was a significant contrast between groups regarding the presence of POFP at S3. Among patients with sacral dysmorphism, 21.9% presented a POFP at S3, whereas only 1.7% of those without sacral dysmorphism did so (χ^2, $p \leq 0.001$).

Table 2 Lenght of the potencial osseous fixation pathways at each sacral level evaluated

Sacral level		POFP measurement (mm) ($N = 180$)
S1[a]	(minimum–maximum)	153 [148–160] (135–179)
S2[b]	(minimum–maximum)	137.05 ± 8.98 (114–160)
S3[c]	(minimum–maximum)	121.81 ± 6.92 (111–131)

Abbreviations: mm, millimeter; POFP, patients with a potential osseous fixation pathway.
Notes: Data presented as mean ± SD, median (IQR], minimum and maximum.
[a]$n = 116$ (64.4%).
[b]$n = 178$ (98.9%).
[c]$n = 16$ (8.9%).

►**Table 4** shows gender-related differences for each POFP at each sacral level evaluated. In S1, women exhibited a mean (± SD) length of 151.64 (± 9.19) mm, whereas men showed a mean (± SD) length of 157.14 (± 9.70) mm (t, $p = 0.003$). In S2, there was no significant difference between genders, with women presenting a mean (± SD) length of 137.21 (± 9.00) mm and men, 136.77 (± 9.01) mm (t, $p = 0.752$). In S3, although not statistically significant (MW, $p = 0.055$), there was a trend towards a difference, with women presenting a

Table 3 Differences between patients without and with sacral dysmorphism

	Without sacral dysmorphism (N = 116)	With sacral dysmorphism (N = 64)	*p-value
S2 measurement[a]	135.68 ± 8.54	139.50 ± 9.30	0.006
PCOF present in S3	2 (1.7)	14 (21.9)	≤ 0.001

Notes: Data presented as mean ± SD, absolute frequencies (n), and relative frequencies (%). Abbreviation: p – statistical significance index.
*Student's t-test for independent samples or Chi-squared test for adjusted residual analysis. Significance was set at 5% for all analyses.
[a]with sacral dysmorphism, *n* = 64 (100.0%); without sacral dysmorphism, *n* = 116 (98.3%).

Table 4 Measurement of the potential osseous fixation pathways at each sacral level according to gender

Sacral level	POFP measurement in females (*N* = 115)	POFP measurement in males (*N* = 65)	*p-value
S1	151.64 ± 9.19	157.14 ± 9.70	0.003
S2	137.21 ± 9.00	136.77 ± 9.01	0.752
S3	130 [121.5–130.5]	119 [116–123]	0.055

Abbreviations: *p*-value, statistical significance level; PBCF, patients with a potential osseous fixation pathway.
Notes: *Student's t-test for independent samples or Mann-Whitney test (MW).
Data presented as mean ± SD, or median (IQR).
Significance was set at 5% for all analyses.

Table 5 Patients with a potential osseous fixation pathways in S3

Variable		POFP in S3 (*n* = 16)
Gender	Female Male	7 (43.8) 9 (56.3)
Sacral dysmorphism	Yes No	14 (87.5) 2 (12.5)

Abbreviation: PBCF, patients with a potential bone corridor for fixation.
Note: Data presented as absolute (n) and relative (%) frequencies.

median (IQR) POFP length of 130 (121.5–130.5) mm and men 119 (116–123) mm.

►**Table 5** presents data on patients with POFP in S3. We identified 16 (8.9%) cases of POFP in S3, including 7 women (43.8%) and 9 men (56.3%). In addition, we noted morphology consistent with sacral dysmorphism in 14 cases (87.5%) and 2 cases (12.5%) had no sacral dysmorphism.

Discussion

Screws in TI-TS configuration offer better fixation than in the IS configuration, and their insertion is preferred whenever possible according to the OFPs available in each patient.[13–16] Biomechanical studies comparing different posterior pelvic ring injuries fixation methods favor the use of TI-TS screws;[18–23] however, their use depends on the availability of implants of sufficient length. Long screws provide better load distribution, reducing stress at the tip of the implant and preventing secondary displacement.[12] TI-TS screws have higher pullout resistance,[15] allowing anchorage of up to six cortices; moreover, their higher lever arm increases shear resistance.[17] In addition to the absolute measurement of the implant length, fully threaded long screws may offer the possibility of anchoring the highest number of threads, contributing to their effectiveness in maintaining posterior ring stability.[12] Furthermore, the insertion of two TI-TS screws at the same sacral level has been described and is advantageous as long as it is carefully planned according to the published technique.[24]

Recognition of sacral dysmorphism has fundamental practical implications for planning and executing percutaneous posterior ring fixation. Sacral dysmorphism is characterized by several radiographic peculiarities, such as noncircular sacral foramina and an acute alar slope.[25] However, in a more practical approach and with wider clinical applicability, a binary delineation is currently performed regarding the presence or absence of sacral dysmorphism.[13,16] The patient is defined as dysmorphic whenever the first sacral segment allows an intraosseous screw in the IS configuration but does not allow the safe intraosseous application of a TI-TS screw. In dysmorphic patients, the first sacral segment has a smaller and more obliquely oriented safe zone, allowing only the insertion of short screws in an oblique direction. In these subjects, S2 has a safety zone with a transverse orientation and a larger area[26,27] compared to the same segment in nondysmorphic patients. The identification of sacral dysmorphism in 35.5% (64/180) of the patients analyzed is compatible with previously published data and, in this group, the impossibility of TI-TS fixation in S1 due to the lack of a safe OFP increases the significance of using S2 OFP.

Studies have shown that S3 may be a viable and safe option for TI-TS fixation in approximately 15% of patients, with dysmorphic patients being more likely to have a OFP at this level.[17,28] Our sample demonstrated the existence of POFP at S3 in only 16/180 (8.9%) cases and corroborated that most of these patients (87.5%) have a morphology consistent with sacral dysmorphism. When advanced intraoperative imaging techniques are available,[29,30] S3 offers an additional fixation site when a more stable construct is required.

Although previously described, the insertion of TI-TS screws in S3 is compromised by the unavailability of a viable OFP in most of the population and the small number of studies defining its safety and indications. Furthermore, due to the high technical demand and precision required, as well as the structures at risk, percutaneous placement of screws in S3 presupposes the use of advanced intraoperative imaging techniques (such as three-dimensional fluoroscopy), which are rarely available in our setting.

Posterior pelvic ring percutaneous fixation requires a complete set of fully and partially threaded cannulated screws.[2] Although it is possible to apply implants with diameters ranging from 6.5 to 7.3 mm, 7.0-mm implants are the most widely available and studied. The production and commercialization of longer implants allowing TI-TS fixation occurred in major international centers only from the first decade of the 21st century onwards.[12]

Few scientific studies about this topic provide data specifically on screw lengths. Before the existence of longer screws and the popularization of the TI-TS fixation concept, Routt et al.[2] stated that screws up to 140 mm in length would be necessary to reach the contralateral sacral asa. In a study on percutaneous stabilization of "U"-shaped sacral fractures, Nork et al.[4] reported using screws of up to 150 mm. In a specific publication on TI-TS fixation, Gardner et al.[12] used implants of lengths ranging from 160 to 180 mm for S1 fixation and from 120 to 160 mm for S2 fixation.

To the authors' knowledge, in the Brazilian federation unit where this study occurred, the longest 7.0-mm cannulated screws currently on the market are 150-mm long (partially threaded only). In the same federation unit, the most significant orthopedic trauma public institutions, which account for managing most patients with pelvic fractures, provided, at the time of this study, only partially threaded implants with a maximum length of 120 mm. We believe this reality extends to the rest of the country. Considering minimum and maximum lengths of S1 and S2 POFPs identified in our sample (from 135–179 mm for S1 and 114–160 mm for S2), we noticed the unavailability of implants allowing TI-TS fixation in most patients. In our practice, we have exceptionally identified patients with small dimensions allowing TI-TS fixation in S2. In the case presented ►**Figures 3**–**7** (images from author's archive), preoperative planning indicated no sacral dysmorphism, with a wide OFP in S1, measuring 141 mm, and representing a length higher than the longer implant offered by the institution at that time. On the other hand, S2 OFP measured 118 mm, which allowed for planning and safe insertion of a 120 mm TI-TS screw without a washer.

Limitations of this study include the fact that planning TI-TS screw requires additional sagittal plane evaluation.[16]



Fig. 3 Case example (preoperative radiographs). Anteroposterior (AP) (A), inlet (B), and outlet (C) radiographs of a female patient presenting a mechanically unstable pelvic ring injury, including a complete and nondisplaced sacral fracture on the right side, incomplete injury of the left sacroiliac joint, and a pubic symphysis injury.

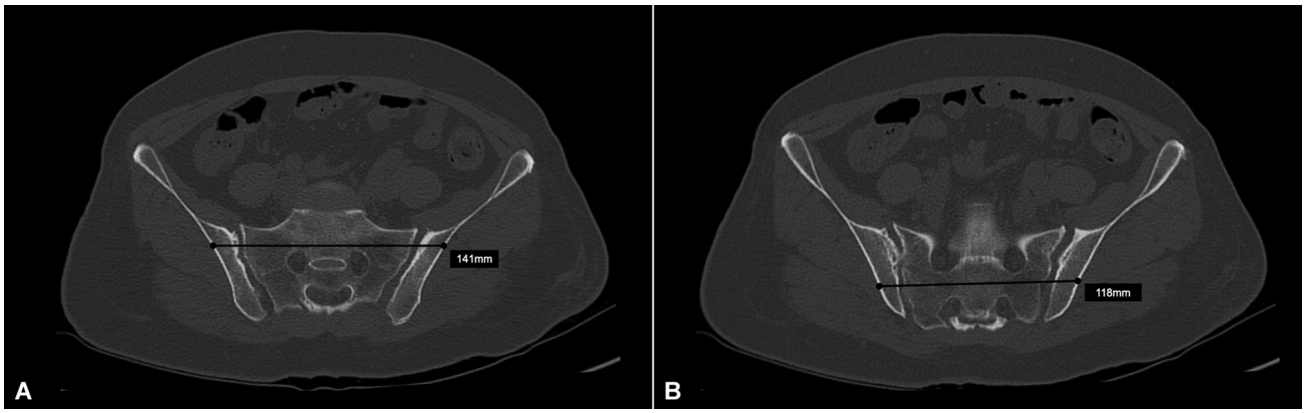


Fig. 4 Case example (preoperative planning). Axial computed tomography scans demonstrating the measurement of the length of the bone corridors for fixation in the first (A) and second (B) sacral segments during preoperative planning.

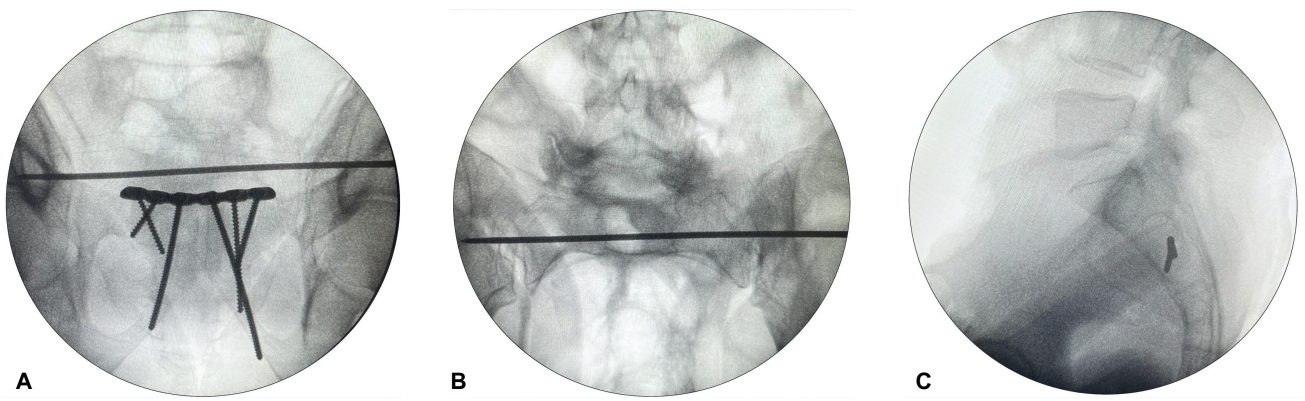


Fig. 5 Case example (intraoperative images). Fluoroscopic (A) outlet, (B) inlet, and (C) lateral views of the sacrum acquired intraoperatively.

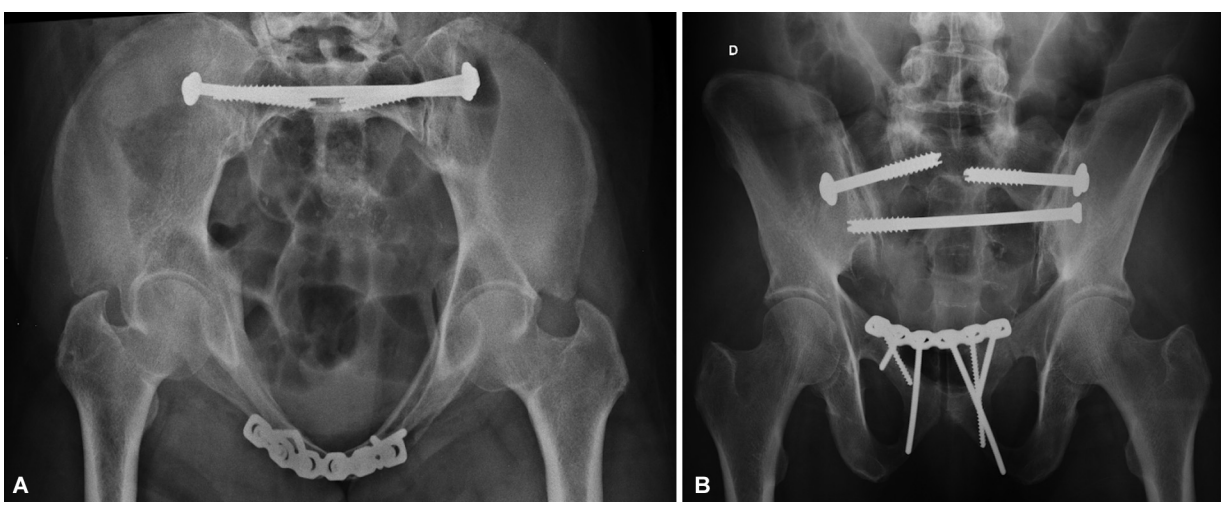


Fig. 6 Case example (postoperative radiographs). Postoperative images in inlet (A) and outlet (B) views demonstrating the iliosacral fixation in S1 bilaterally and transiliac-transsacral fixation in S2.

The proposed measurement (between the external cortices of the posterior iliac as a way of determining the implant length) occurred in axial images alone and, therefore, we preferred the term "potential" OFP. It is worth mentioning that the measurement technique used in this study does not consider that, conceptually, an implant should exceed one or two threads the opposite cortex. In addition, there is a preference for using washers, which would increase the real implant length in a clinical situation by around 2 or 3 mm.

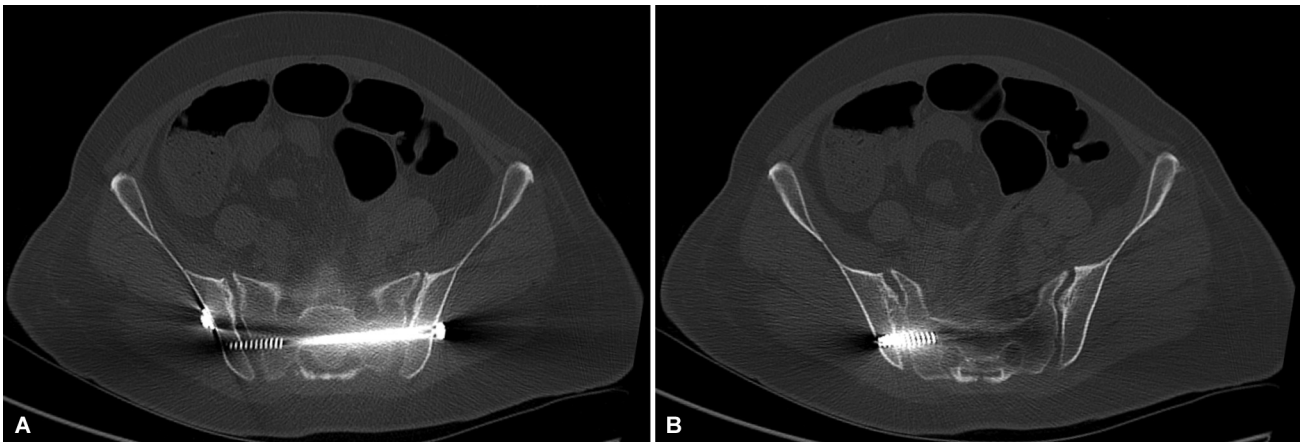


Fig. 7 Case example (postoperative computed tomography [CT] scans). CT images demonstrating the safe and intraosseous positioning of the previously planned implant in S2.

Conclusion

Percutaneous posterior pelvic ring fixation is a traditional, well-established method widely validated by clinical and biomechanical studies. From a historical perspective, it is clear that the production of longer implants for screw application in TI-TS configuration allowed the method to establish itself as the main method of treatment for traumatic injuries affecting the posterior iliac, sacroiliac joint, and sacrum.

In our sample, we demonstrated that the OFP lenghts are dissociated from the longer screws currently commercialized in our country, and an adequate percutaneous posterior pelvic ring fixation requires a complete set of cannulated screws with lengths of up to 180 mm.

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

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Adjustment of Acetabular Cup Inclination Assisted by Smartphone during Revision Total Hip Arthroplasty: Surgical Technique and Report of Four Cases

Ajuste de inclinação do acetábulo assistido por smartphone durante revisão de artroplastia total de quadril: Técnica cirúrgica e relato de quatro casos

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Abstract

We herein present a smartphone-assisted technique for acetabular cup placement during revision total hip arthroplasty (rTHA). Four patients were operated on: three were submitted to second-stage rTHA after infection, and one underwent surgery due to aseptic loosening. The technique entails three main steps: evaluation of the amount of lateral pelvic tilt (either clinically or radiographically); setting a supracetabular rod using the smartphone app as a reference for inclination adjustment; and acetabulum preparation and final cup placement using the smartphone to guide the inclination angle after considering the amount of pelvic tilt. Cup anteversion was adjusted according to the transverse acetabulum ligament. All 4 cases underwent a follow-up that ranged from 17 to 24 months. None of the patients required further revision, and no complications (intraoperative, early, or late postoperative) were observed. All cups were within the Lewinnek safe zone for inclination (42°, 43°, 47°, and 41°). The functional outcome per the Harris Hip Score was excellent for all patients. Smartphones are cheap tools that can assist physicians in the adjustment of acetabular cup inclination during rTHA; however, assessing the possible lateral pelvic tilt and considering it while placing the cup are crucial.

Keywords
- acetabulum
- arthroplasty, replacement, hip
- smartphone

Resumo

Apresentamos uma técnica assistida por *smartphone* para a colocação de cúpula acetabular durante a revisão de artroplastia total de quadril (rATQ). Quatro pacientes foram submetidos à cirurgia; três à rATQ de segundo estágio após infecção e um devido

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a afrouxamento asséptico. A técnica tem três etapas principais: avaliação (clínica ou radiográfica) da inclinação pélvica lateral; colocação de uma haste supra-acetabular usando o aplicativo do *smartphone* como referência para o ajuste da inclinação; e preparação do acetábulo e colocação final da cúpula utilizando o *smartphone* para a orientação do ângulo de inclinação após considerar a inclinação pélvica. A anteversão da cúpula foi ajustada de acordo com o ligamento acetabular transverso. Todos os quatro casos foram acompanhados por 17 a 24 meses; nenhum paciente precisou de outra cirurgia de revisão ou apresentou complicações (intraoperatórias pós-operatórias precoces ou tardias). Todas as cúpulas estavam dentro da zona segura de Lewinnek de inclinação (42° 43° 47° e 41°). O resultado funcional de acordo com o Harris Hip Score foi excelente em todos os pacientes. Os *smartphones* são ferramentas baratas que podem auxiliar os médicos no ajuste da inclinação da cúpula acetabular durante a rATQ; no entanto é crucial avaliar a possível inclinação pélvica lateral e considerá-la ao posicionar a cúpula.

Palavras-chave
- ► acetábulo
- ► artroplastia do quadril
- ► smartphone

Introduction

Proper implant positioning during primary total hip arthroplasty (THA) is one crucial factor for short- and long-term outcomes and survival;[1,2] this becomes more demanding during revision THA (rTHA), especially if there are bone defects or distorted anatomical landmarks.[2,3]

The economic burden of rTHA is increasing, and instability and aseptic loosening are the leading causes of revision; therefore, various strategies have been employed to reduce the risk of revision, including improving implant designs, bearing materials, and newer technologies such as computer navigation and robotic-assisted surgeries; however, most of these are expensive and unavailable at every institution.[1,4,5]

Smartphone-assisted acetabular cup placement has been investigated in primary THA with promising results both in cadaveric and clinical settings, which showed acceptable accuracy, ease of sue by young surgeons, and cheap application, especially in institutions with economic constraints that limit the introduction of the aforementioned newer technologies.[6–8]

We herein present a simple and economical technique entailing the use of smartphone applications (apps) to adjust acetabular cup inclination in three steps during rTHA and report the early results of the first four cases.

Surgical Technique and Description of the Cases

Approval was obtained from our local ethical committee (IRB No.:17300762), and written informed consent was obtained from all patients before surgery.

The erioperative protocol for all patients was as follows: 1) detailed medical and surgical history, 2) preoperative clinical evaluation; 3) laboratory investigations as part of the regular preoperative assessment and to exclude infection (complete blood count [CBC] with differential white blood cell [WBC] count, erythrocyte sedimentation rate [ESR], and levels of C-reactive protein [CRP]); and 4) imaging studies: plain preoperative radiographs of the pelvis in anteroposterior (AP) view (including both hips; ►**Figs. 1A,B** and **2A,B**), of the affected hip in AP and lateral views (►**Fig. 2A**), and of the pelvis in AP view while the patient was in the lateral decubitus position (as described in the literature;[9,10] ►**Figs. 3B** and **4C**); and computer tomography (CT) scans to assess the amount of bone defect, if suspected (►**Fig. 1C**).

The same surgeon operated on all cases (patient details are described in ►**Table 1** and in ►**Figs. 1**–**4**) under spinal anesthesia, with the patient in the lateral decubitus position (after ensuring that the table was parallel to the floor) through a modified direct lateral approach (incorporating the previous surgical incision); after adequate exposure, implant removal, and debridement, at least five tissue samples were obtained and sent for bacterial culture and sensitivity assessment. We aimed at inserting the cup within the Lewinnek safe zone ($40° \pm 10°$ for inclination and $15° \pm 10°$ for anteversion).

The three main steps of smartphone-assisted adjustment of acetabular cup inclination during rTHA are as follows:

1) Radiological or clinical calculation of the possible lateral pelvic tilt; radiological: in the pelvis AP radiograph with the patient in the lateral decubitus position, as the angle between a transverse pelvis axis (interteardrop or interischial lines) and the level of the radiology table (►**Figs. 3B** and **4C**); if it cannot be obtained preoperatively, it can be obtained using fluoroscopy after final positioning of the patient on the operative table. The pelvis could be in a neutral position (0°) if the angle is of 90°, abducted (positive value) if the angle is $> 90°$, and adducted (negative value) if the angle is $< 90°$;[8–10] clinical: as an angle between a line connecting marks placed on the anterosuperior iliac spines (ASISs) bilaterally and the level of the operative table.[6,8]
2) Setting the intraoperative reference for cup inclination: we followed steps described previously in the literature,[6,8] entailing the use of a sterile plastic bag as a protector for the smartphone after turning on the Spirit Level app with a built-in compass on an iPhone XR smartphone (Apple Inc.,

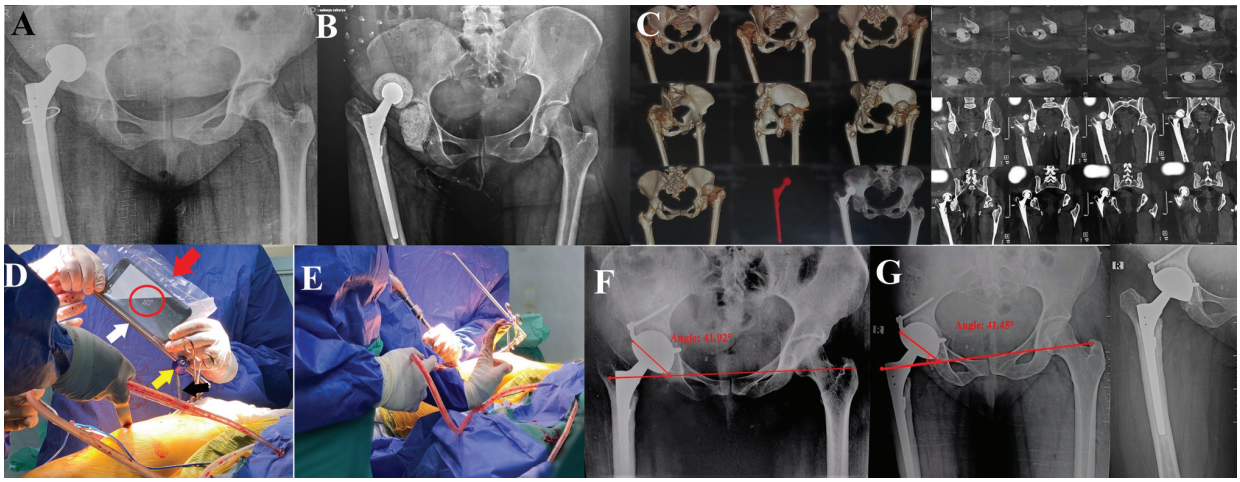


Fig. 1 Case 1. (**A**) A cementless bipolar hemiarthroplasty with dislocation and infection. (**B**) First -stage total hip arthroplasty (THA), with the application of a cement spacer loaded with antibiotics (the stem was retained, as it was solidly ingrown). (**C**) Computed tomography (CT) scan to assess the amount of bone defect. (**D**) Intraoperative smartphone app-assisted adjustment of the supracetabular rod (white arrow) as a reference for cup inclination (red arrow: smartphone in a sterile plastic bag; red circle: the adjusted angle measured by the Spirit Level app; black arrow: the supraacetabular Schanz screw; and yellow arrow: a clamp). (**E**) Acetabular reaming performed parallel to the supraacetabular rod. (**F**) Immediate postoperative anteroposterior (AP) radiograph of the pelvis showing cementless dual mobility cup and an inclination angle of 41.9°. (**G**) The last follow-up visit (at 24 months), showing maintained cup position.

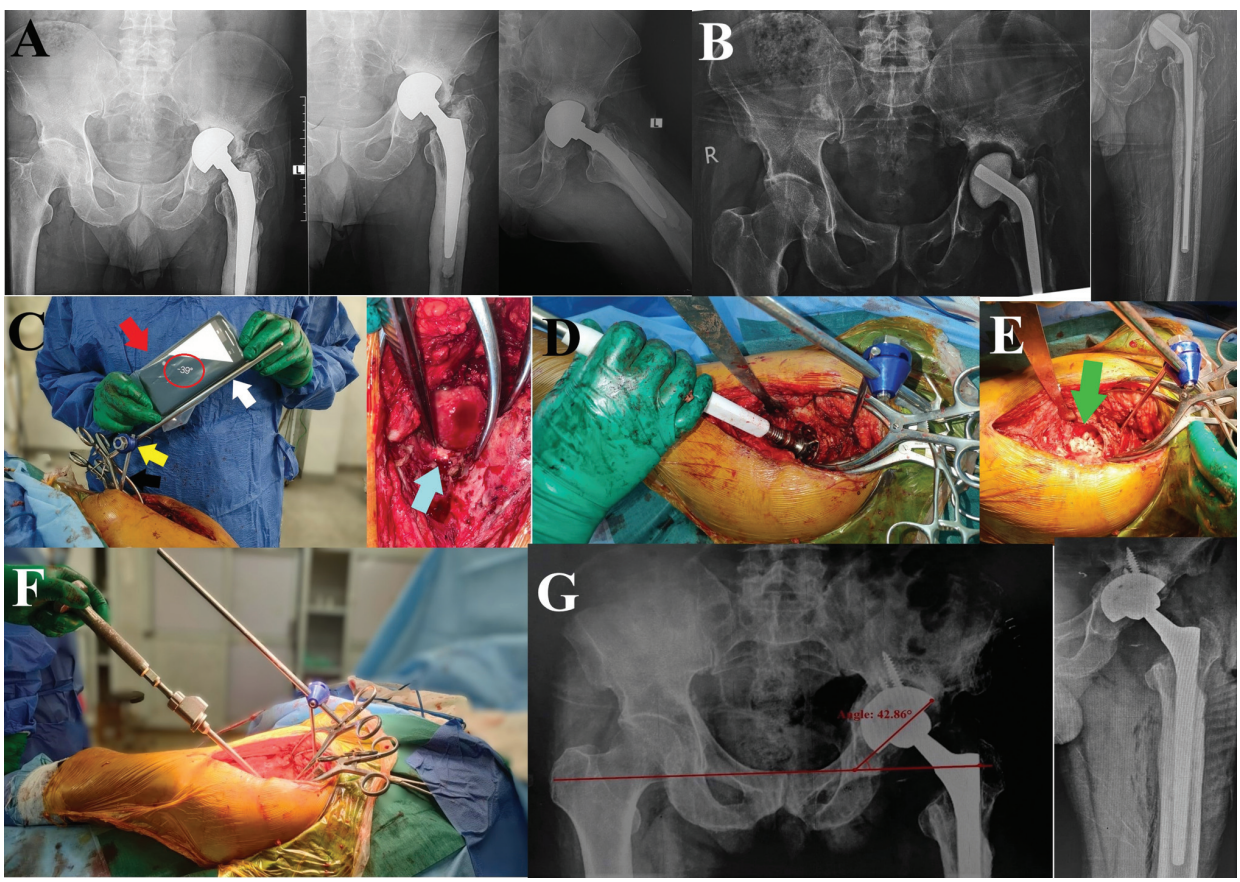


Fig. 2 Case 2. (**A**) A cemented bipolar hemiarthroplasty with infection after failure of the fixation of a neck of the femur fracture. (**B**) First-stage THA with the application of an articulating cement spacer loaded with antibiotics. (**C**) Intraoperative smartphone app-assisted adjustment of the supracetabular rod (white arrow) as a reference for cup inclination (red arrow: smartphone in a sterile plastic bag; red circle: the adjusted angle measured by the Spirit Level app; black arrow: the supraacetabular Schanz screw; yellow arrow: a clamp; and blue arrow: transverse acetabular ligament for anteversion adjustment). (**D**) Acetabular reaming performed parallel to the supraacetabular rod. (**E**) Green arrow showing the allografts used for impaction bone grafting to reconstruct the bone defect. (**F**) Final acetabular cup insertion performed while the handle is parallel to the supracetabular rod. (**G**) immediate postoperative AP radiographs of the pelvis showing cementless cup and an inclination angle of 42.9°.

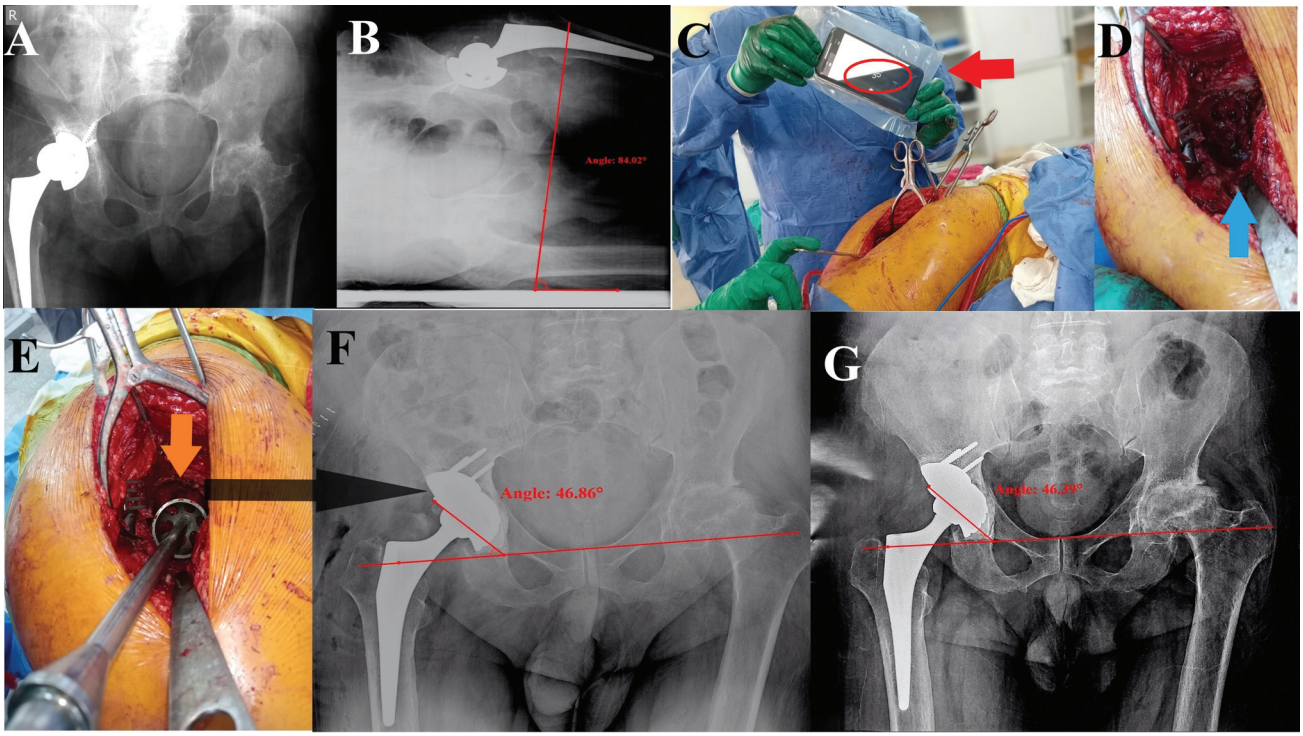


Fig. 3 Case 3. (**A**) A malpositioned cementless acetabular cup with aseptic loosening. (**B**) An AP radiograph of the pelvis with the patient in the lateral decubitus position showing a lateral pelvic tilt (adduction) of -6°. (**C**) Intraoperative smartphone app-assisted adjustment of the supracetabular rod as a reference for cup inclination (red arrow: smartphone in a sterile plastic bag; red circle: the adjusted angle measured by the Spirit Level app). (**D**) Blue arrow showing the transverse acetabular ligament for anteversion adjustment. (**E**) After acetabular reaming and insertion of a trial cup, the amount of acetabular bone defect could be assessed (orange arrow). (**F**) Immediate postoperative AP radiograph of the pelvis view showing cemented dual mobility cup with An inclination angle of 46.9°, and bone defect reconstruction using a metal augment. (**G**) The last follow-up visit (at 17 months), showing maintained implant position.

Cupertino, CA, United States), or other similar, free, and downloadable apps (for Android platform-based smartphones). A supra-acetabular Schanz screw was inserted from within the surgical approach to which a rod was connected using an adjustable clamp. The rod acts as the reference to adjust the cup inclination after considering the value of the pelvic tilt measured. For a target final inclination angle of 45° and if the pelvic tilt is of -10°, for example, we adjust the rod at 35°, and vice versa for pelvic abduction (►**Figs. 1D, –2C, 3C**, and **4D**).

3) Acetabulum reaming and final acetabular cup insertion: acetabulum reaming in a progressed manner was performed by adjusting the reamer handle parallel to the supraacetabular rod for inclination adjustment (►**Figs. 1E, –2D**, and **4E**). For the anteversion, we rely mainly on the transverse acetabular ligament (TAL; ►**Figs. 2C** and **3D**), a consistent anatomical landmark in nearly most revision cases.[11,12] After reaching a proper fit, a trial acetabular component is used to assess the final cup size, the stability, and the need to reconstruct the present acetabular defect (►**Fig. 3E**). The final cup insertion (cemented or cementless) is performed while the inserter handle is parallel to the supraacetabular rod (►**Figs. 2F** and **4F**).

Postoperative Assessment and Follow-up

Postoperatively and at the last follow-up visit, AP radiographs of the pelvis were obtained to evaluate the inclination (abduction) angle of the acetabular cup, measured between the interteardrop or interischial lines and a line along the axis of the cup eclipse formed by the superolateral edge and inferomedial edge as reference points (►**Figs. 1F, –2G, 3F**, and **4G**). The functional outcomes at the last follow-up visit were assessed according to the Harris Hip Score (HHS), and complications at any point of the follow-up were reported. The outcomes are shown in ►**Table 1**.

Discussion

Most surgeons agree that optimum acetabular cup positioning is crucial for long-term results and to reduce the incidence of instability after primary and revision THA.[2,5,11]

The use of computer navigation and robotics in rTHA showed satisfactory results regarding the decrease in the risk of instability due to proper placement of the implants and the reduction in dislocation rates after rTHA of up to 0%.[13] However, these technologies are expensive, unavailable in every institution, and require specific training and preparation.[4,5]

To overcome these obstacles, we have applied smartphone apps that successfully assisted acetabular cup adjustment in four rTHA surgeries. We believe that the technique is simple and surgeon-friendly without the need for complex preparation or special preoperative imaging studies apart from AP radiographs of the pelvis with the patient in the lateral

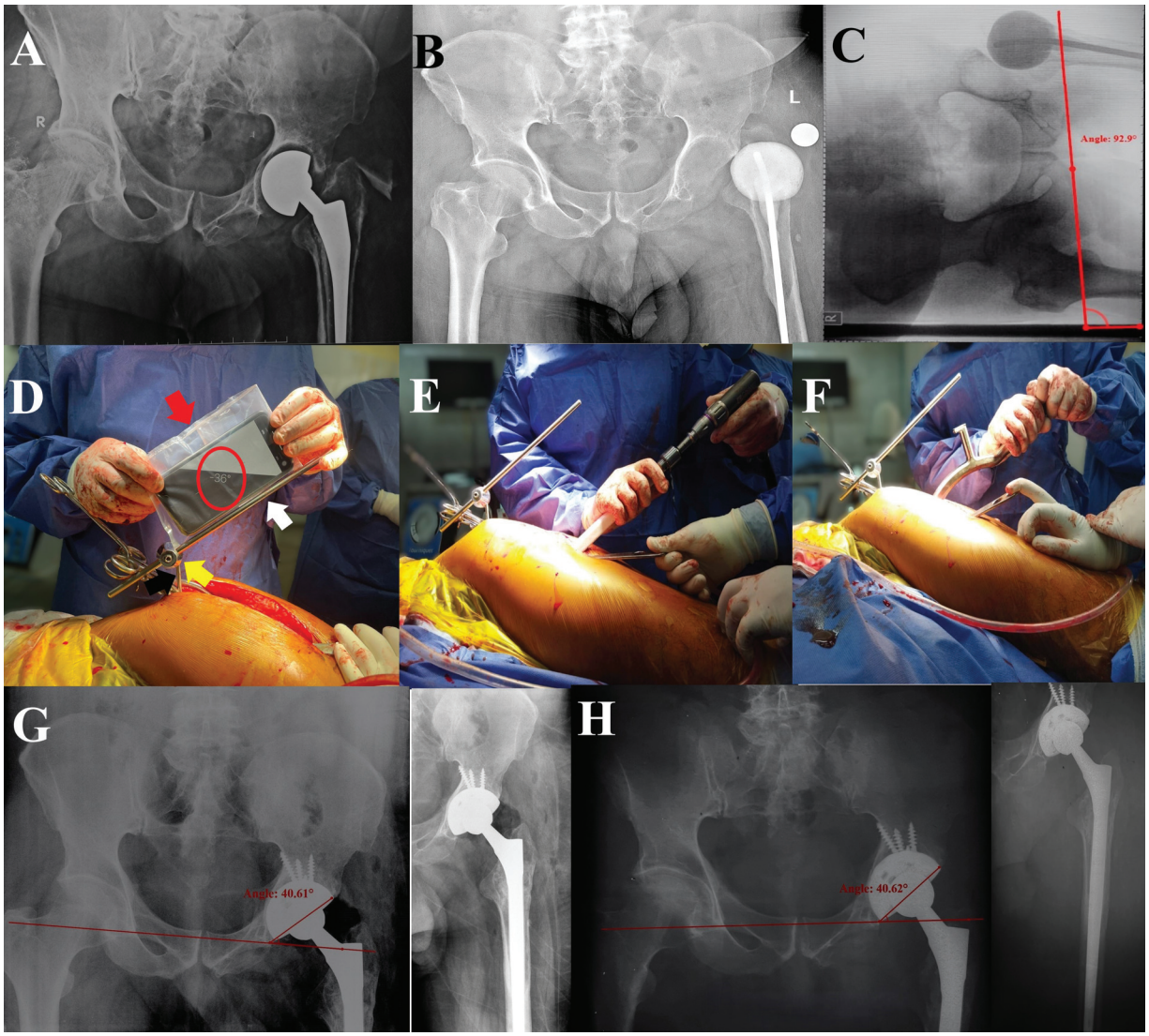


Fig. 4 Case 4. (**A**) A cemented bipolar hemiarthroplasty with loosening and infection. (**B**) First-stage THA with a dislocated cement spacer loaded with antibiotics. (**C**) An AP radiograph of the pelvis with the patient in the lateral decubitus position showing a lateral pelvic tilt (abduction) of 3°. (**D**) Intraoperative smartphone app-assisted adjustment of the supracetabular rod (white arrow) as a reference for cup inclination (red arrow: smartphone in a sterile plastic bag; red circle: the adjusted angle measured by the Spirit Level app; black arrow: the supraacetabular Schanz screw; and yellow arrow: a clamp). (**E**,**F**) Acetabular reaming and final cup insertion performed parallel to the supraacetabular rod. (**G**) Immediate postoperative AP radiograph of the pelvis showing cementless cup and an inclination angle of 40.6°. (H) The last follow-up visit (at 19 months), showing maintained cup position.

decubitus position to calculate the lateral pelvic tilt, and helped in achieving the acetabular cup inclination angle within the safe zone; furthermore, no complications or infections were reported in any of the cases.

The smartphone-assisted cup placement technique has described in primary THA, and it showed promising results in terms of helping young, less experienced surgeons obtain optimum acetabular cup placement comparable to their senior peers, with further improvement in cup placement accuracy compared with visual methods; this was proven in clinical studies,[8] as well as in an invitro and cadaveric models.[7]

In the current technique, we employed the same manual instruments used routinely during THAs, without the need for a complex setup. The time spent using the smartphone app and adjusting the angles was of approximately 5 minutes, without external assistance. We admit that the smartphone-assisted technique cannot compete with the accuracy of computer navigation or robotic-assisted cup placement; however, we believe it is more economical and time-saving than these technologies.

In a systematic review on the role of an inclinometer (including smartphone apps) in the adjustment of acetabular cup positioning during THA, van Duren et al.[3] reported that, in the inclinometer group, the cup inclination angle was significantly more within the target zone compared with the freehand or mechanical guide-assisted techniques. They[3] also reported that using an inclinometer increased the operative time by 2 to 7 minutes compared with other techniques based on the results of 3 clinical studies.

The amount of lateral pelvic tilt was reported to reach $\pm 10°$ in the literature, with up to 45% of the patients having

Table 1 Demographic, surgical, and outcome data of the study sample

	Case 1 (►Fig. 1)	Case 2 (►Fig. 2)	Case 3 (►Fig. 3)	Case 4 (►Fig. 4)
Age (years)	35	61	58	60
Gender	Female	Male	Male	Male
Side	Right	Left	Right	Left
Preoperative diagnosis	PJI requiring second-stage rTHA	PJI requiring second-stage rTHA	Malpositioned cup with aseptic loosening	PJI requiring second-stage rTHA
Number of previous surgeries	3	4	1	3
Follow-up (months)	24	23	17	19
Acetabular bone defect	Yes	Yes	Yes	Yes
Bone defect per the Paprosky classification	2A	2C	3A	2A
Preoperative lateral pelvic tilt (degrees)	0	0	-6	+3
Implants used	Cementless dual mobility cup, the femoral side was not revised	Cementless primary cup and cementless stem (Wagner)	Cemented dual mobility cup, the femoral side was not revised	Cementless primary cup and cementless stem (Wagner)
Bone defect reconstruction	Not required	Impaction bone grafting using allograft	Metal (tantalum) augment	Not required
Postoperative cup inclination (degrees)	41.9	42.9	46.9	40.6
Cup inclination at the last follow-up (degrees)	41.5	Not acquired	46.4	40.6
Complications	Mild, occasional pain and limping gait	Mild, occasional pain	None	None
Harris Hip Score (at the last follow-up)	95	Not acquired*	92	90

Abbreviations: PJI, periprosthetic joint infection; rTHA, revision total hip arthroplasty.
Note: *The patient could not come for follow-up; we contacted him by phone, and he reported returning to his daily activities, occasional pain, sporadic use of a cane while walking, but no symptoms suggestive of infection.

an absolute tilt of 5°.[8,9,14] Therefore, one crucial preoperative step we recommend is to anticipate the amount of lateral pelvic tilt, which could pass unnoticed by the surgeon and get obscured after draping, especially in overweight patients or when there is a fixed hip joint deformity.[9,10,14]

We obtained acetabular cup inclination within the safe zones in all patients, and no instability was reported during the follow-up. Kurosaka et al.[7] compared the accuracy of iPhone-assisted acetabular cup placement to computer navigation in five cadaveric hips in procedures performed by 7 surgeons (4 first-year residents and 3 senior hip surgeons); they reported a mean difference between both techniques of $2.1° \pm 1.6°$ (range: 0°–6°), no significant difference between residents or senior surgeons in inclination adjustment ($p = 0.74$), and that all acetabular cups placed using the iPhone technique were within the Lewinnek safe zone.[7]

One limitation of the smartphone technique is the difficulty in assessing anteversion, as reported in previous studies.[7] To overcome this obstacle, we relied on the TAL in all cases as a consistent patient-specific anatomical landmark.[12]

Conclusion

Smartphones can assist young surgeons or those who do not have access to newer technologies in the adjustment of acetabular cup inclination when placing the cup in rTHA; however, assessing the possible lateral pelvic tilt and considering it while placing the cup are crucial.

Authors' Contributions

Each author contributed individually and significantly to the development of the present article. AAK conceived the case report, performed the surgeries, and drafted the manuscript. MFA and MAM performed data acquisition, patient assessment, literature search, and prepared the images. A.A.K. and M.A.M. performed the critical revision. All authors read, discussed, and approved the final manuscript.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Letter to the Editor regarding the Article: Glenosphere Size Does Not Matter in Reverse Total Shoulder Arthroplasty. Rev Bras Ortop. 2024;59(2):254–259

Carta ao editor sobre o artigo: O tamanho da glenosfera não importa na artroplastia total reversa de ombro. Rev Bras Ortop. 2024;59(2):254–259

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With great interest, I read the article: "Glenosphere Size Does Not Matter in Reverse Total Shoulder Arthroplasty" published by Patel et al.[1] Studies focusing on the clinical outcomes of reverse total shoulder arthroplasty (RTSA) are always important given the linear growth and "popularization" of this procedure. Given the conclusion of the published study (which was the basis for its title), it is necessary to scrutinize the details of the applied methodology, due to the impact and significance of its repercussions. Some details could help us understand the outcomes obtained in such research, especially regarding the surgical technique, rehabilitation, and chronology of the applied methodology.

Surgical Technique and Rehabilitation

Considering the wide range of configurations available for the design of RTSA (such as inlay versus onlay, lateralization of the glenosphere, neck-shaft angle, tilt, among others) and their respective influences on functional outcomes,[2,3] a detailed understanding of the specific type of implant used in the study under analysis is crucial. The precise identification of the prosthesis used is fundamental for replicating the results, allowing for a more accurate assessment of the efficacy of the applied technique.

The reinsertion or not of the subscapularis tendon in RTSA is a widely discussed factor that has significant impacts, especially regarding the range of motion. The elucidation of these data in the article will provide readers with a solid foundation to assess the methodologies and outcomes of the study.[4]

Regarding the rehabilitation process: there is a lack of precise information about which protocol was adopted postsurgery, as well as the immobilization period with a sling, which type of sling was used, and when physiotherapeutic rehabilitation was initiated. The rehabilitation protocols after reverse arthroplasty are often discussed and have a significant impact on the final degree of mobility.[5]

Chronology

The study, developed at the Department of Orthopedic Surgery, Icahn School of Medicine at Mount Sinai, New York, United States, mentions that 35 patients were included who underwent reverse shoulder arthroplasty since 1987. However, such a procedure was approved by the Food and Drug Administration 16 years later, in November 2003 (Delta Shoulder K021478; DePuy Inc., Raynham, MA, USA).[6] I believe that clarifying this chronological

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discrepancy is essential for a proper understanding of the study's methodology.

The range of motion—which is the most important aspect of the study in question—was measured by being divided, pre- and postoperatively. However, in the study, it is not clear at what point the postoperative measurement was taken. The precise determination of this interval is crucial, as it directly influences the interpretation of the results and the validity of the study.

The simple shoulder test (SST) score was applied for pre- and postoperative evaluation of patients. However, there is a methodological gap regarding the data collection of patients who underwent surgery before 1993, the year in which the SST was formally described.[7]

In summary, it is imperative to emphasize that the detailed deepening of the information presented is crucial, considering the substantial relevance of the findings reported in this study and the significant potential impact of this publication in the scientific field.

Conflict of Interests

The author has no conflict of interests to declare.

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Letter in Response to the Article "Glenosphere Size Does Not Matter in Reverse Total Shoulder Arthroplasty"

Carta em resposta ao artigo "O tamanho da glenosfera não importa na artroplastia total reversa de ombro"

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To the Editor,

My co-authors and I thank Dr. Bonadiman for taking the time to respond to our manuscript, "Glenosphere Size Does Not Matter in Reverse Total Shoulder Arthroplasty."[1] We have prepared a reply addressing the comments he has raised.

The work in question represents a single-surgeon, single-implant study. The capacity to have a single implant and single surgeon removes many variables, and we believe this is a great strength of the dataset. All patients in the study received a Trabecular Metal Reverse Shoulder System (Zimmer Biomet, Warsaw, IN, United States). Additionally, the subscapularis was repaired in all of our patients. The choice to repair was a preference of the operative surgeon. This choice predated many of the published papers demonstrating the impact of choosing to repair or to not repair the subscapularis. As such, a protocol for why to repair was not possible.

Regarding the postoperative protocol, the study was not a randomized controlled trial. As such, a standardized methodology of postoperative treatment was not established a priori. As a rule, all patients were asked to wear a sling for six weeks, and active motion did not begin until the sling was removed.

At the time this paper was written, our institutional shoulder arthroplasty registry included patients from 1987 to 2019 who had undergone hemiarthroplasty or anatomic or reverse TSA. However, the patients in the study had undergone a reverse TSA between 2005 and 2014. This is illustrated in the reported follow-up periods.

The postoperative measurements were reported until the final follow-up visit. Each patient had a minimum of 2.0 years of follow-up. The mean follow-up in each group was of 6.7 ± 3.3 years for the 36-mm cohort and of 4.8 ± 3.1 years for the 40-mm cohort.

Similarly, all patients in the study underwent reverse TSA after the invention of the Simple Shoulder Test in 1993. Thus, the test was applied to all patients pre- and postoperatively.

We thank the journal for publishing our manuscript and for this opportunity to comment on it in further detail.

Conflict of Interests

PJC: consultant for Stryker, Johnson & Johnson, and Zimmer Biomet; BOP: consultant for Arthrex; ELF: member of the board or committee of the American Shoulder

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and Elbow Surgeons and Health Association of NY, and recipient of intellectual property royalties from Innomed and Zimmer Biomet, and of publishing royalties and financial or material support from Springer.

Reference

1 Patel AV, White CA, Li T, Parsons BO, Flatow EL, Cagle PJ. Glenosphere Size Does Not Matter in Reverse Total Shoulder Arthroplasty. Rev Bras Ortop 2024;59(02):e254–e259

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