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RAAOT-ACARO

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Dear Colleagues,

I am writing to you as President of the Asociación Argentina de Cadera y Rodilla (ACARO) through this editorial letter in the prestigious journal of the Asociación Argentina de Ortopedia y Traumatología (AAOT). First of all, I would like to express my gratitude to the journal for giving us the opportunity to publish this issue together, which demonstrates the collaborative spirit that characterizes us as a scientific society.

One of the pillars of ACARO is teamwork. We firmly believe that a multidisciplinary approach is essential to provide comprehensive and quality care to our patients. We promote collaboration between orthopedists, traumatologists, physiotherapists, radiologists and other related professionals, sharing knowledge and experience to achieve better results in the treatment of hip and knee pathologies.

We also believe that continuing education and subspecialization are critical for staying current in a discipline as dynamic as orthopedics and traumatology. We encourage our members to continue their education through conferences, courses, and training programs in order to deliver exceptional care and stay on the cutting edge of scientific and technological breakthroughs in our field.

Another fundamental aspect in our society is the promotion of scientific publications. We recognize the importance of research and the dissemination of knowledge as drivers of progress in our discipline. Therefore, we encourage our members to publish their work in specialized journals, such as this one, which provide us with a platform to share our studies and clinical experiences, promoting the exchange of ideas and academic debate.

In our daily work, it is essential to maintain high ethical standards. We must remember that our colleagues and our patients trust us and our professional integrity. We must act with respect, honesty and transparency, maintaining the confidentiality of information and respecting the ethical principles of medical practice. Only in this way will we be able to strengthen our bonds with one another and with society as a whole.

In conclusion, on behalf of the ACARO Board of Directors, I would like to express my gratitude to the AAOT journal for its collaboration and support. We recognize its contribution to the advancement of orthopedics and traumatology in Argentina and the region. We appreciate the opportunity to publish in this renowned journal, which allows us to disseminate our work and share our knowledge with the medical community.

I invite all ACARO members to continue working together towards our common goals. Let us keep promoting collaboration, postgraduate education, scientific publications, and professional ethics. Together we can achieve more and contribute to the well-being of our patients.

Sincerely,

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Use of Endoprosthesis for the Treatment of Non-Neoplastic Pathologies of the Knee

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ABSTRACT

Introduction: Endoprosthesis is the gold standard for reconstruction after oncological resections. The advances regarding its materials and designs allowed for the expansion of the indications to non-neoplastic pathologies. Its simple and fast intraoperative assembly and its immediate mechanical stability allow for early rehabilitation and functional recovery. However, the failure rate is high, although it is different from oncological pathologies. The predominant causes are varied. **Objectives:** To analyze our experience in the use of knee endoprosthesis and compare it with the literature, evaluating functional outcomes, radiographic outcomes, implant survival and causes of eventual failure. **Materials and Methods:** Patients with complex non-neoplastic knee pathology that required reconstruction with endoprosthesis were selected. Clinical history, anamnesis, physical examination, and radiographs were reviewed. For clinical examination and functional evaluation, the MusculoSkeletal Tumor Society Score (MSTS Score) was used. For implant failures, the modified Henderson et al. classification was used. **Results:** 12 endoprostheses were studied, with an average follow-up of 3.8 years. Failures were recorded in 2 (18%), with a mean time to failure of 47.5 months. One type 2 failure (aseptic loosening) and one type 4 failure (infection) were recorded. No other complications were noted. For the functional evaluation, the mean final score was 76.6%. **Conclusion:** Our results support the use of endoprostheses for complex non-neoplastic knee diseases in carefully selected patients, despite being a complex surgical procedure with many complications.
Keywords: Endoprosthesis; knee; infection; complications.
Level of Evidence: IV

Uso de endoprótesis para el tratamiento de enfermedades no neoplásicas de la rodilla

RESUMEN

Introducción: Las endoprótesis son el método de elección para la reconstrucción luego de las resecciones oncológicas. Los avances en los materiales y diseños permitieron expandir las indicaciones a enfermedades no neoplásicas. Su montaje intraoperatorio simple y rápido, y su estabilidad mecánica inmediata permiten una rehabilitación y una recuperación funcional tempranas. Sin embargo, la tasa de fallas es elevada, aunque distinta de la de las enfermedades oncológicas. Las causas predominantes son diferentes. **Objetivos:** Analizar nuestra experiencia con el uso de endoprótesis de rodilla y compararla con los estudios publicados, evaluando los resultados funcional y radiográfico, la supervivencia del implante y las causas de su eventual falla. **Materiales y Métodos:** Se seleccionaron pacientes con enfermedad no neoplásica compleja de rodilla que requirieran una reconstrucción con endoprótesis. Para el examen clínico y la evaluación funcional se utilizó el puntaje de la *Musculoskeletal Tumor Society,* y para las fallas de los implantes, la clasificación de Henderson y cols. modificada. **Resultados:** Se estudiaron 12 endoprótesis, con un seguimiento promedio de 3.8 años. Se registraron 2 fallas (18%), con un tiempo promedio hasta la falla de 47.5 meses. Una fue tipo 2 (aflojamiento aséptico) y la otra, tipo 4 (infección). No hubo otras complicaciones. En la evaluación funcional, el puntaje final medio fue del 76,6%. **Conclusión:** Nuestros resultados respaldan el uso de endoprótesis para enfermedades complejas no neoplásicas de rodilla en pacientes cuidadosamente seleccionados, pese a ser un procedimiento quirúrgico complejo y con muchas complicaciones.
Palabras clave: Endoprótesis; rodilla; infección; complicaciones.
Nivel de Evidencia: IV

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INTRODUCTION

Since the late 1980s, improvements in the quality and design of orthopedic implants, advances in imaging methods and surgical techniques, and the introduction of chemotherapy made limb-sparing surgery possible for patients with musculoskeletal tumors.[1] As a result, segmental resections of long bones and joints and their subsequent reconstruction became the procedure of choice.

Modular endoprosthesis has been the most widely used system in the last three decades and the method of choice for reconstruction after these segmental resections due to tumor bone disease. This is due to its availability, its relatively simple and fast intraoperative set-up, and the immediate mechanical stability that makes early rehabilitation and functional recovery possible.[1-3]

In recent years, great advances in endoprosthetic materials and designs have gradually expanded the indications for their use in the treatment of non-neoplastic diseases, such as acute trauma with severe bone loss and poor bone quality, post-traumatic failures (nonunion and infection sequelae), large complex bone defects in prosthetic revisions or periprosthetic fractures with loosening of the components and scarce bone stock.[4-8] Endoprosthetic treatment of these conditions has grown in popularity in recent years, particularly for the distal femur and proximal tibia with knee joint involvement.[6]

When used for the treatment of bone tumors, these systems have a high rate of complications and failures due to various factors, which makes revision surgery relatively frequent.[2,3,8-11] In the case of non-neoplastic conditions, the failure rate of endoprostheses is also high, although different from oncologic diseases, and the predominant causes may be different.[6]

The purpose of this study was to evaluate our experience with the use of endoprostheses for the treatment of non-neoplastic conditions affecting the knee joint. The objective was to evaluate the functional, clinical and radiographic outcomes, implant survival, and the causes of eventual failure, comparing them with those reported in the literature.

MATERIALS AND METHODS

A retrospective, analytical and descriptive study was carried out, in addition to an analysis of the literature on the subject. We selected patients who had undergone knee endoprosthesis placement in our hospital for the treatment of non-neoplastic or post-neoplastic conditions (i.e., patients whose initial disease was a bone tumor but who needed a knee endoprosthesis for reasons other than the disease). The period from January 2012 to December 2019 was taken into account. The minimum accepted follow-up was six months.

The inclusion criteria were: patients of both sexes, without age restriction, with a diagnosis of non-tumor disease (fractures, pseudarthrosis, infections, etc.) or post-neoplastic disease (infection, implant rupture, aseptic loosening, etc.) that compromised the knee joint and required reconstruction with a non-conventional knee prosthesis (endoprosthesis) or its revision. Exclusion criteria were: patients with similarly treated primary or metastatic oncologic disease. The termination criterion was: patients who desired to withdraw from the research protocol of their own free will, as stated in writing on the informed consent withdrawal form.

Sixteen unconventional knee prostheses were evaluated in 14 patients. Three patients (4 prostheses) were excluded because they suffered from oncologic conditions. None discontinued the study. Finally, 12 prostheses were analyzed in 11 patients: nine with non-neoplastic disease and three with post-neoplastic disease (Table 1).

Patient evaluation

In addition to a thorough assessment of their medical records, all patients were scheduled for an anamnesis and physical examination by the same specialist to objectively assess their functional status.

The patient's medical record was reviewed to establish the date of surgery, the patient's age at the time of surgery, the diagnosis, the location of the disease, the type of implant utilized, the date of revision surgery, if applicable, and any other possible complications.

Table 1. Patient characteristics

Patient	Date of surgery	Follow-up (months)	Sex	Age	Diagnosis	Location (Bone)	Side
1	14 Mar 2009	73	F	87	Fracture	Distal femur	Right
2	31 Jan 2014	74	M	72	Prosthetic infection	Distal femur	Right
3	16 Sept 2014	68	M	78	Prosthetic infection	Distal femur	Right
4	06 Nov 2014	66	F	56	Tibial plate fracture	Proximal tibia	Right
5	20 Sept 2010	55	F	65	Prosthetic infection	Distal femur + Proximal tibia	Right
6*	07 Jan 2015	64	F	41	Osteosarcoma	Distal femur	Left
7	30 Apr 2015	61	M	67	Periprosthetic fracture	Distal femur	Right
8‡	15 Nov 2016	42	F	77	Aseptic loosening, bone lymphoma	Distal femur	Right
9#	28 Mar 2016	40	M	77	Nonunion	Distal femur	Left
9	15 Jul 2019	10	M	80	Aseptic loosening, nonunion	Distal femur	Left
10	22 Nov 2016	25	M	25	Tibial mucormycosis of the anterior cruciate ligament	Proximal tibia	Left
11*	17 Nov 2017	30	M	15	Fibrosarcoma	Distal femur	Left
12*	16 Nov 2018	18	M	72	Chondrosarcoma	Distal femur	Right
13‡	20 Nov 2018	18	M	16	Bone graft nonunion, osteosarcoma	Distal femur	Left
14‡	04 Jun 2019	11	F	37	Prosthesis breakage, osteosarcoma	Distal femur	Left

F = female; M = male.
*Patients with post-neoplastic conditions.
#Patient 9 is included twice, because a non-conventional prosthesis was placed twice.
‡Excluded from the study for having a tumor disease.

Revision surgeries were defined as any operation related to total or partial failure of the prosthesis. All failures were classified according to Henderson[10,12] (Table 2). This system was previously modified for use in non-neoplastic cases and was divided as follows: soft tissue complications (type 1), aseptic loosening (type 2), structural complications (type 3), and periprosthetic infections (type 4).

The clinical examination and functional assessment were performed using the *Musculoskeletal Tumor Society* (MSTS) score.[13] Although it is a score initially designed for tumor disease, given the similarity of treatment (non-conventional prostheses), we believe it is adequate for the evaluation of our patients (Table 3).

All had radiographs taken to assess the condition of the prosthesis at the time of the study as well as the presence of signs or symptoms of implant failure (loosening, rupture, etc.) that were not included in the clinical record.

Table 2. Henderson et al. classification for failures in limb-sparing surgery after endoprosthetic reconstruction

General category	Type	Cause	Subtype
Mechanics	1	Soft tissue failure	A - Functional
			B - Coverage
	2	Aseptic loosening	A - Early (<2 years)
			B - Late (>2 years)
	3	Structural failure	A - Implant
			B - Graft
Non-mechanical	4	Infection	A - Early (<2 years)
			B - Late (>2 years)
	5	Tumor progression	A - Soft tissue
			B - Bone
Pediatric patients	6	Pediatric failures	A - Growth arrest
			B- Joint dysplasia

Table 3. *Musculoskeletal Tumor Society* score for evaluating patients with segmental long bone resections and unconventional prosthetic reconstruction.

Score of the *Musculoskeletal Tumor Society*	
Pain	0-5
Range of motion	0-5
Strength	0-5
Stability	0-5
Deformity	0-5
Function	0-5
Acceptance	0-5
Total	0-35
Result (%)	0-100

RESULTS

Twelve prostheses were analyzed in 11 patients (9 primary and 3 revisions). Six patients were male and five were female. The average age was 60 years (range 16-87). Follow-up ranged from 6.2 years to 11 months (mean 3.8 years). Table 1 lists the diagnoses. In total, nine prostheses had been placed for non-neoplastic conditions and three for post-neoplastic conditions (one aseptic loosening, one pseudarthrosis of the bone graft and one implant rupture) (Figures 1-3).

Figure 1. Revision for aseptic loosening in a patient with distal femoral bone lymphoma. **A and B.** Initial anteroposterior right knee radiograph and right knee MRI. **C and D.** Postoperative anteroposterior radiographs of the right femur and knee. **E.** Anteroposterior radiograph of the right femur 13 months after surgery. Signs of aseptic endoprosthetic loosening can be observed. **F.** Anteroposterior radiograph of the right femur after the revision.

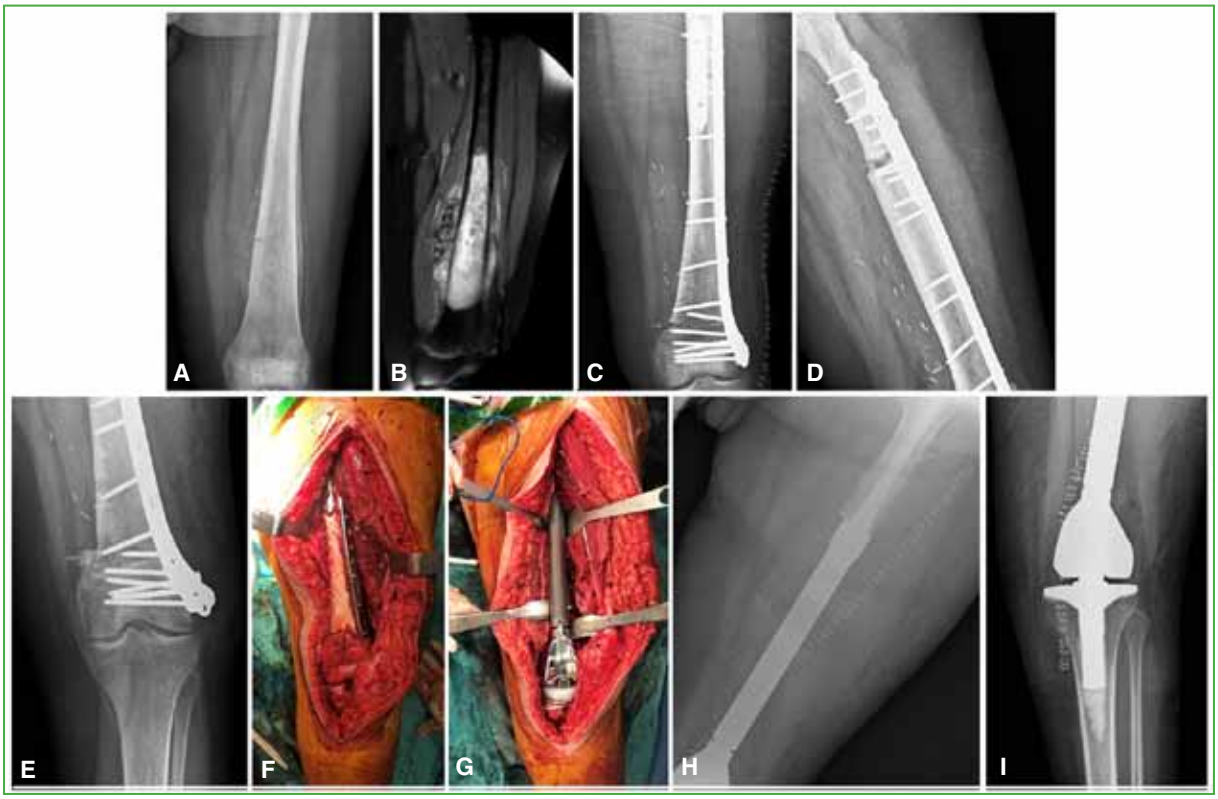

Figure 2. Graft nonunion in a patient with osteosarcoma of the distal femur. The evolution is observed. **A and B.** Initial preoperative anteroposterior left femur radiograph and MRI. **C.** Anteroposterior radiograph of the femur and left knee in the immediate postoperative period. **D and E.** Anteroposterior radiographs of the femur and left knee 12 months after surgery. Signs of prosthetic loosening can be observed. **F and G.** Intraoperative images of the revision. **H e I.** Anteroposterior radiographs of the left femur and knee after the revision.

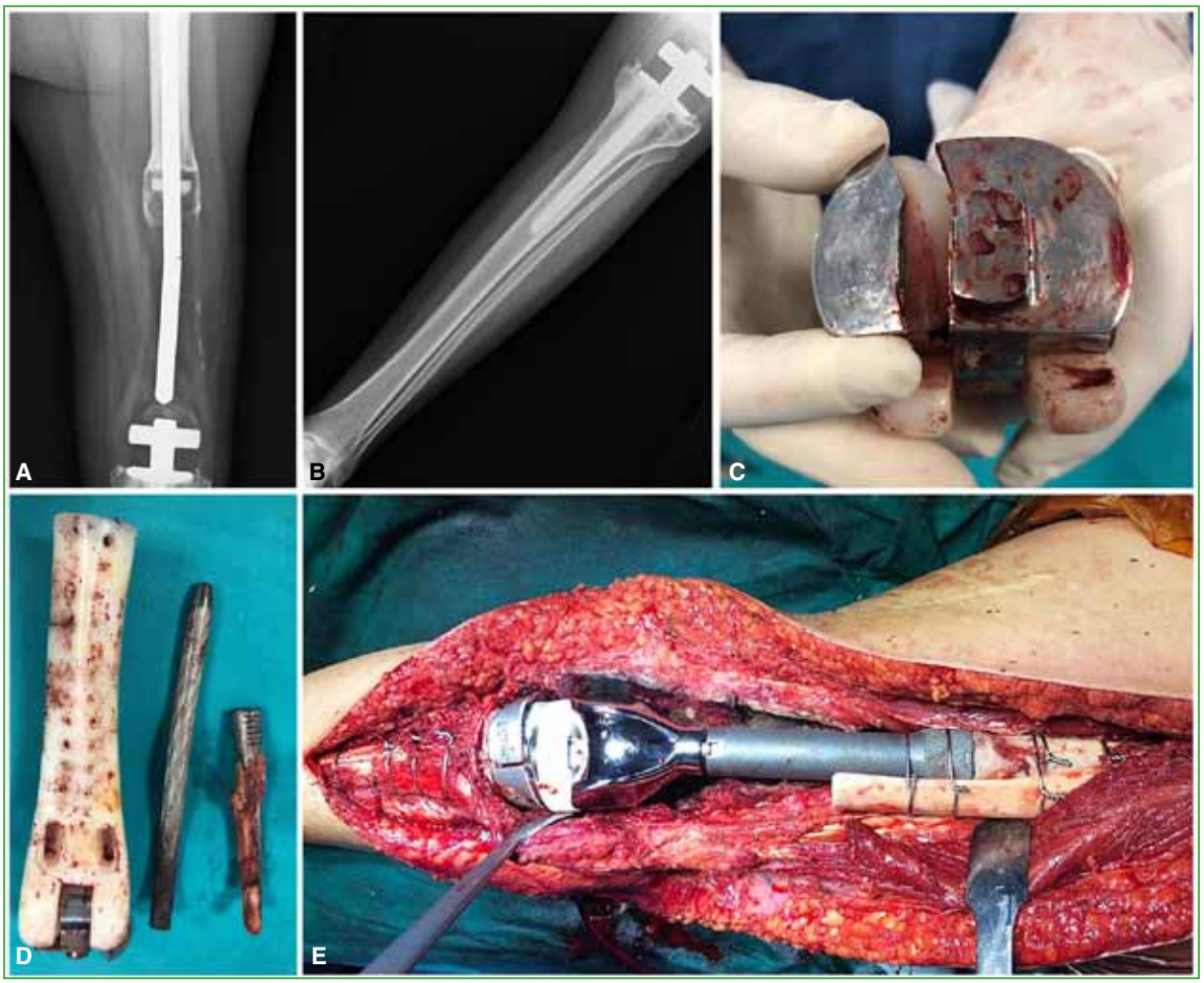

Figure 3. Revision of non-conventional distal femur prosthesis due to implant breakage. **A and B**. Preoperative anteroposterior radiographs of the left femur, knee and tibia. **C and D.** Intraoperative images of the ruptured implant. **E.** Intraoperative image of the final result.

The types of prostheses used for reconstruction had some variation and were: seven IOT-HCFMUSP Modular System prostheses (MDT Implantes, Rio Claro, SP, Brazil), three Megasystem-C prostheses (Waldemar Link GmbH & Co, Hamburg, Germany) and two OSS™ Orthopedic Salvage System (Biomet, Warsaw, IN, USA).

In detail, nine endoprostheses were implanted in the distal femur (75%), two in the proximal tibia (16.7%) and one each in the distal femur and proximal tibia (8.3%). When a proximal tibial prosthesis was implanted, the extensor mechanism was reconstructed by suturing the patellar tendon to the tibial component, which provides fixation holes in its proximal part, and creating a gastrocnemius rotational flap to enhance tendon reattachment. No patellar osteotomies were performed. Cemented stems were always used in both femur and tibia. Hinged prostheses (MDT) were placed in seven cases and a rotating hinge (Waldemar Link GmbH & Co and Biomet) in five.

The average time from primary surgery to implant failure was 47.5 months and ranged from 55 to 40 months.

The implant failed in two patients (18%) and the causes were: infection and aseptic loosening. The first case (patient 5) was a patient who suffered a surgical site infection following primary total knee arthroplasty, and required knee endoprosthesis reconstruction after treating the infection. Finally, due to another infection, the endoprosthesis was removed and an antibiotic-infused spacer was implanted. After this, the patient was lost to follow-up. The

second case (patient 9) was a patient who suffered a distal femur fracture that progressed to pseudarthrosis and had a knee endoprosthesis placed. After 40 months, he underwent revision surgery for aseptic loosening of the prosthesis.

Using Henderson's classification,[10] the types of endoprosthesis failure in our series were: type 2 mechanical failure, i.e., aseptic loosening (n = 1; 50%) and type 4 infection or failure (n = 1; 50%). There were no cases of soft tissue or structural failure, such as implant rupture or periprosthetic fracture.

At the time of this study, one of the 11 patients had died of other causes unrelated to knee disease (patient 1). Nine of the remaining 10 were available for clinical and radiographic evaluation.

Functional assessment was performed in nine patients. Mean scores for individual parameters were: pain 4.3 (range 0-5), range of motion 3.4 (range 0-5), strength 3.6 (range 0-5), stability 3.8 (range 0-5), deformity 4.1 (range 0-5), function 3.4 (range 0-5), and emotional acceptance 4.1 (range 1-5). The mean score was 26.8 (range 19-35), representing a mean final score of 76.6% (Table 4).

Table 4. Functional outcome according to the *Musculoskeletal Tumor Society* (MSTS Score)

MSTS SCORE									
Patient	**Pain**	**Range of motion**	**Strength**	**Stability**	**Deformity**	**Function**	**Acceptance**	**Total**	**Result (%)**
1	-	-	-	-	-	-	-	-	-
2	4	3	3	4	4	3	4	25	71.40%
3	5	3	4	4	4	4	4	28	80%
4	5	3	3	3	3	3	5	25	71.40%
5	-	-	-	-	-	-	-	-	-
7	3	3	3	3	4	3	2	21	60%
8	3	2	3	3	3	2	3	19	54.30%
9	5	5	4	4	5	4	5	32	91.40%
10	4	3	3	3	4	3	4	24	68.60%
13	5	5	5	5	5	5	5	35	100%
14	5	4	4	5	5	4	5	32	91.40%

According to the radiographs, no patient had signs of infection, loosening of the material, prosthesis breakage, periprosthetic fracture, or any other signs of implant failure at the time of analysis. It should be noted that, in patient 9, the radiographs prior to the revision were also evaluated, where signs of aseptic loosening were observed (Figures 4 and 5).

Tables 1 and 4 summarize the data, evolution and MSTS of each patient included in the study.

DISCUSSION

Endoprostheses or unconventional prostheses have become the method of choice for onco-orthopedic surgeons after major oncologic resections because they provide a very good option for the reconstruction and replacement of skeletal segments.[1] Currently, endoprostheses are also gaining momentum as a useful and effective reconstructive strategy when bone loss is significant after non-neoplastic diseases, such as acute trauma with severe bone loss, nonunion, infections, loss of bone stock in prosthetic revisions, periprosthetic fractures, etc.[4-8]

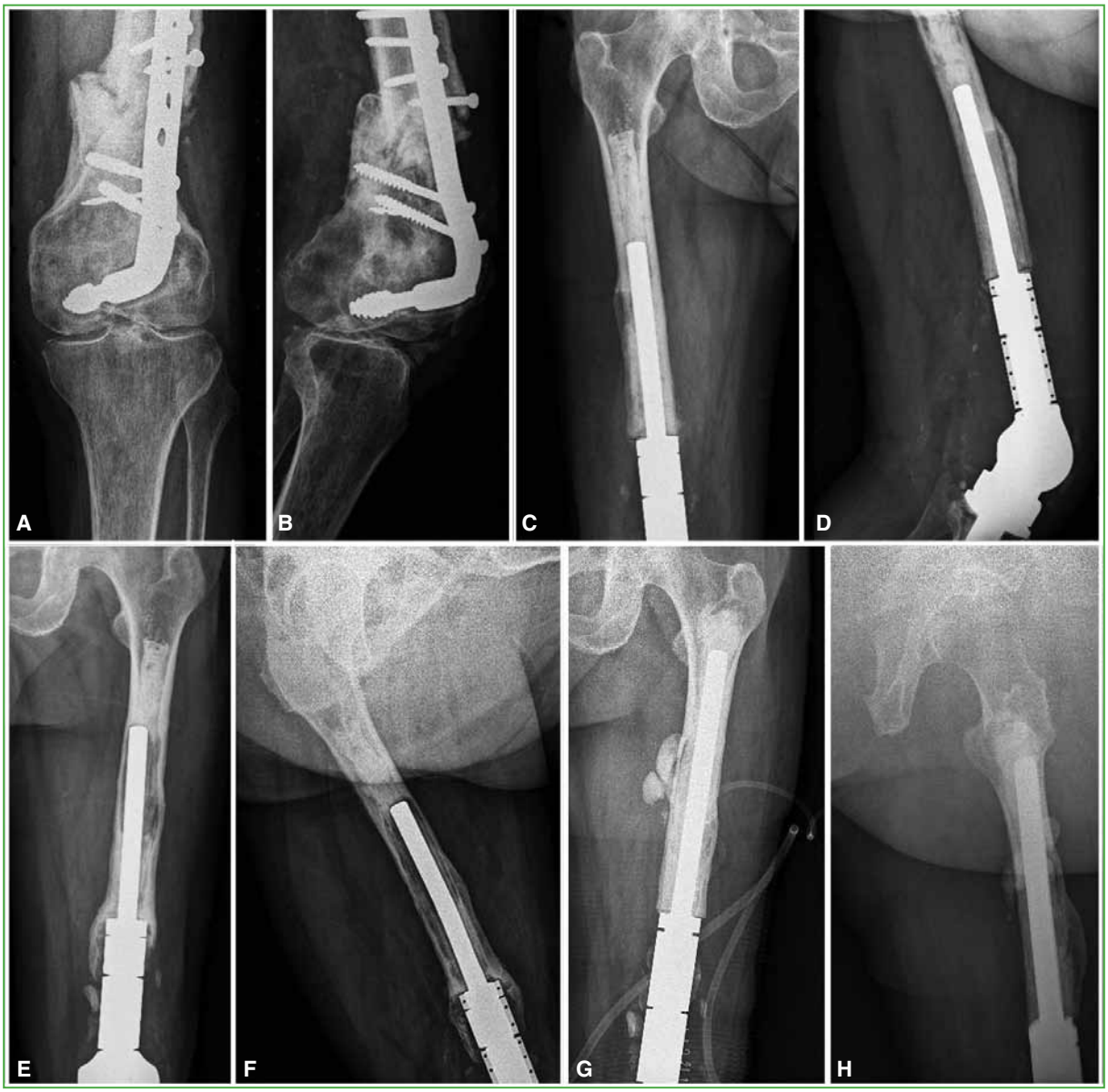

Figure 4. Distal femur nonunion and subsequent aseptic loosening. The patient's evolution is observed. **A and B.** Initial anteroposterior and lateral radiographs of the left knee. Nonunion of a distal femur fracture. **C and D.** Anteroposterior and lateral radiographs of the left femur in the immediate postoperative period. **E and F.** Anteroposterior and lateral adiographs of the left femur showing signs of aseptic loosening of the endoprosthesis. **G and H.** Anteroposterior and lateral radiographs of the left femur after the revision.

It has been shown that the implant survival rate of endoprostheses does not differ significantly between individuals with post-neoplastic disease and those with non-neoplastic conditions.[14]

In this study, we evaluated patients with non-neoplastic and post-neoplastic conditions who had been treated with knee endoprostheses.

Aside from the increased use and popularity of endoprostheses, implant survival remains the primary concern that may limit the routine use of endoprostheses to manage non-neoplastic conditions.[2,3,6,8-11] In this regard, it should be noted that patients with non-neoplastic conditions such as post-traumatic, infectious, and periprosthetic

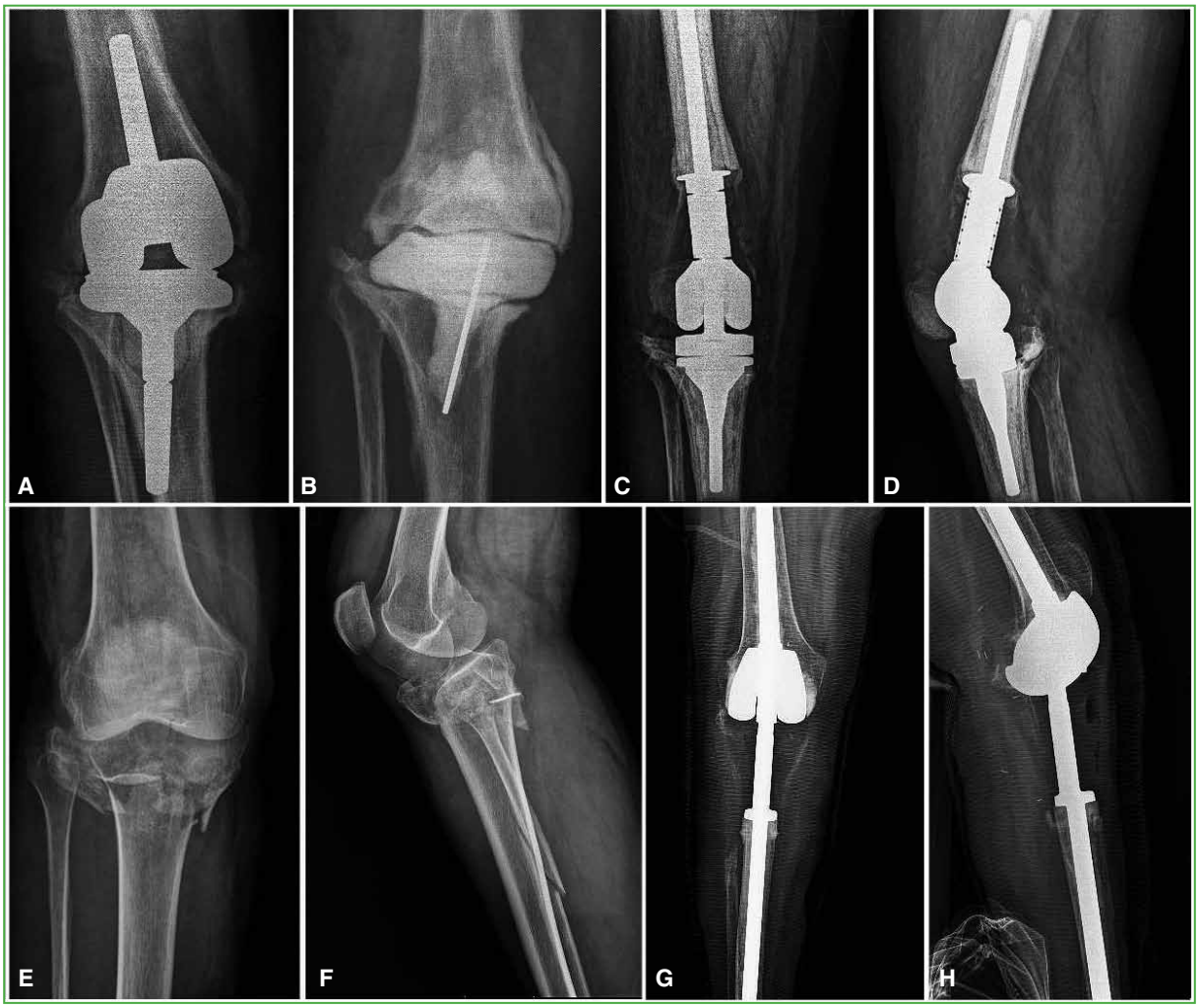

Figure 5. Examples of knee reconstruction with non-conventional prosthesis. **A-D.** Distal femur. **E-H.** Proximal tibia.

conditions exhibit characteristics that are distinct and different from those of oncologic patients. General condition and comorbidities, soft tissue status, lesion characteristics, previous surgeries, presence of adhesions, and previous infections are factors that should be carefully considered when using the endoprosthesis in these cases. These factors are very important in determining whether or not the prosthesis will fail.[5]

Highly variable and contrasting results have been published on implant survival in these patients. For example, Berend and Lombardi[7] reported an overall reoperation-free survival rate of 97% after 1 year, 95% after 2 years and 83% after 5 years for distal femoral and knee endoprostheses. In contrast, the systematic review by Korim et al. yielded a mean failure rate of 83% after 3.3 years for distal femoral prostheses.[6]

In our study, with a mean follow-up of 3.8 years, the failure rate was 18%. Although the results published on this subject vary widely, our results are encouraging and fall within the range mentioned in the literature.

Infection remains one of the most challenging complications after joint replacement and a major cause of early implant failure.[15] While the overall infection rate is relatively low (about 1% after primary hip and knee arthroplasties),[16] this rate increases dramatically if certain risk factors are present, such as poor health status, extensive soft tissue resection, prolonged surgery times, and the need for multiple blood transfusions.[9,17] In addition, a history of surgical site infection is also considered one of the main risk factors for reinfection after

endoprosthetic reconstruction.[18] All of these factors come into play when performing treatment with a knee endoprosthesis.

A deep infection after knee endoprosthetic replacement can be a devastating complication that increases the need for further surgical procedures and leads to endoprosthesis failure.

The infection rate of endoprostheses following tumor resections or their use in non-tumor conditions is high in both cases but does not differ significantly. In patients with tumor disease, Jeys et al.[11] reported infection rates of 11%, with a high incidence of infection in the first two years. Pala et al.[2] and Mavrogenis et al.[19] published infection rates of 9.3% and 8.6%, respectively. In a systematic review by Racano et al.,[20] the mean periprosthetic infection rate was 10%.

For non-neoplastic conditions, De Gori et al.[14] reported an infection rate of 11.5%, while Korim et al. found a mean rate of 15% for distal femoral prostheses.[6]

In our study, there was only one case of periprosthetic infection (case 5), which represented 9.1% of the total. This corresponds to what has been published in the literature.

In the treatment of non-neoplastic conditions, rates of aseptic loosening of endoprostheses range from 0% to 9.5%.[4] In our series, there was only one case (patient 9) (9.1%).

There is no clear consensus on one fixation method versus another, nor is it clear whether cemented and cementless endoprostheses have comparable survival and complications.[3,21] Regarding aseptic loosening, in some studies, the risk was lower with cementless prostheses,[1,19] while other authors, such as Houdek et al.,[8] did not observe such a difference. In our study, cemented stem endoprostheses were always used in both femur and tibia.

The hinge mechanism is also considered an important factor that could increase the risk of aseptic loosening in knee endoprostheses. Hinge designs in knee endoprostheses cause stress between the prosthesis-cement or prosthesis-bone interface, which increases the incidence of loosening.[22] The addition of the rotating hinge is an important design modification that helps to reduce these mechanical stresses at the implant-bone interface.[23]

In our series, a hinged prosthesis was used in seven patients and a rotating hinge prosthesis in five others. The only case of aseptic loosening (patient 9) occurred with a hinged endoprosthesis.

Another factor to consider is that the long lengths of these prostheses create large bending stresses at the prosthesis-bone interface that can contribute to loosening and periprosthetic fracture or fracture of the prosthesis itself.[22] In our series, there were no structural failures, such as prosthesis breakage or periprosthetic fractures.

Regarding the postoperative assessment of function and quality of life, several studies have shown that treatment with knee endoprostheses results in good function and pain relief, and also significantly improves patients' quality of life.[7,24]

Although it is a score initially designed for tumor disease, given the similarity of the treatment (non-conventional prostheses), we used the MSTS[13] for functional assessment.

According to the literature, the overall mean outcome in MSTS in patients with endoprosthetic reconstructions varies from 78% to 86%,[2] but most studies include patients with tumor disease.

In our series, the average MSTS was 76.6%, comparable to other findings in the literature.[25]

The joint range of motion and function scores were the lowest of all, with an average score of 3.4 (range 2-5). Similarly, Tun et al. and McGoveran et al. also found lower function scores.[25]

We note that there is a correlation between low overall functional scores and low scores in function, joint range of motion and strength, while pain-related and emotional acceptance scores are better.

Our study has certain limitations that must be considered. This is a retrospective, non-randomized study with a small number of patients, which exposes it to biases of various types. Differences in diagnosis and the fact that the prostheses are from different manufacturers and with different implant designs are also factors that can affect the results. Other weaknesses of the study are that the follow-up time was not long enough in all cases and a great diversity of age groups was analyzed.As strengths, we can mention that it is a single-site study with only a few surgeons responsible for the placement of all endoprostheses.

CONCLUSIONS

Despite the fact that it is a demanding surgical procedure with many complications, our findings support the use of modular endoprostheses as a solution to manage complex non-neoplastic conditions. It is possible to state that our complication rate, such as infection and aseptic loosening, as well as implant survival and functional outcome, are similar to those published.

Endoprostheses deserve to be explored as a limb salvage option in carefully selected patients when other surgical treatments are not feasible, considering the favorable results in published studies.

We recommend this reconstruction method for the treatment of the aforementioned diseases.

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

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The Use of Semi-Constrained Knee Prostheses

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ABSTRACT
Introduction: Semi-constrained implants in TKA are indicated in cases where knee stability is compromised, either in primary or revision surgeries. **Materials and Methods:** 43 patients were evaluated at the same institution, treated by the same surgical team between 2015-2022, with Sigma TC3 (Johnson & Johnson™) implants. **Results:** the WOMAC, KSS function and Oxford functionality scales had good/very good results. The scores were lower in patients over 75 years of age if they used gait assistance and if they had previous pathologies (statistically significant). 86% had no pain, 91% were satisfied, 11% had complications. There were no infections or revision surgeries. **Conclusions:** TKAs with Sigma TC3 present good outcomes in the short and medium term with a low rate of complications in this series, with no statistical differences in function between primary and revision surgeries.
Keywords: Knee arthroplasty; semi-constrained prosthesis; TC3.
Level of Evidence: III

Artroplastia total de rodilla con implante semiconstreñido. Análisis de serie de casos

RESUMEN
Introducción: Los implantes semiconstreñidos en la artroplastia total de rodilla están indicados cuando hay compromiso de la estabilidad de la rodilla, ya sea en cirugías primarias o de revisión. **Materiales y Métodos:** Se evaluó a 43 pacientes tratados con implantes de constricción condilar varo-valgo, en una misma institución, por el mismo equipo quirúrgico, entre 2015 y 2022. **Resultados:** Los resultados en las escalas de función WOMAC, KSS y Oxford fueron buenos/muy buenos. Los puntajes fueron menores en pacientes >75 años, si utilizaban asistencia para caminar y si tenían enfermedades previas (estadísticamente significativo). El 86% no tuvo dolor, el 91% estaba satisfecho y el 11% sufrió complicaciones. No hubo infecciones, ni cirugías de revisión. **Conclusiones:** Respetando las indicaciones y la técnica quirúrgica, las artroplastias totales de rodilla semiconstreñidas con constricción condilar varo-valgo logran buenos resultados a corto y mediano plazo, con una tasa baja de complicaciones, sin diferencias estadísticas en la función entre las cirugías primarias y de revisión.
Palabras clave: Artroplastia de rodilla; prótesis semiconstreñida; implante TC3.
Nivel de Evidencia: III

INTRODUCTION

The first total knee arthroplasties (TKA) date back to 1840, in Germany, where Glück treated patients with sequelae of tuberculous arthritis with an ivory prosthesis. Implant design and materials evolved and improved and, in 1940, metallic models appeared in the femur (Boyd and Campbell) and with tibial plates (Mckeever and Macintosh).[1,2] In 1976, Insall et al. introduced condylar prostheses with a structure and composition similar to the current ones. Emphasis was placed on implant design, ligament balance, symmetrical bone resection, and good alignment to ensure the lasting success of the implant.[3]

Implants have been improved in recent years, adapting to the needs of patients. Constrained and semi-constrained implants were developed to improve prosthesis stability when knee stability is compromised, which can occur due to significant bone deformity, bone defect, or ligament instability, either in primary or revision TKA surgeries.[3]

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In the United States, more than 900 thousand TKAs are performed every year;[4] in Uruguay, an average of 2,284 primary and 53.1 annual revisions (average 2015-2020) are performed.[5] In Uruguay, a single study has analyzed TKA replacements and their survival,[6] and it highlights that semi-constrained implants are used in 89.1% of cases. There are no studies evaluating the use of these implants in primary TKAs.

In this study, we analyze the epidemiology, outcomes and complications of the use of a semi-constrained implant in a series of patients operated on by the same surgical team, in the same institution, with a minimum follow-up of six months.

MATERIALS AND METHODS

The research protocol was approved by the Institutional Ethics Committee before starting the research.

All patients undergoing TKA with a semi-constrained implant with varus-valgus condylar constriction at the treating surgeon's (DM) institution were included. The implant placed was SIGMA® TC3 Knee System (DePuy Synthes/Johnson & Johnson, Warsaw, IN, USA) which is the only semi-constrained implant tendered in our country.

The institutional database was used, which includes patients operated on between September 18, 2015 (date on which the first TKA with TC3 prosthesis was performed at the institution) and March 30, 2022 (minimum date to have 6 months of follow-up).

Medical records were reviewed and all registered patients were assessed by telephone call, applying specific knee function instruments: the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Knee Society Score (KSS) and the Oxford Knee Score. Patients were asked about their satisfaction after surgery and the presence of complications.

Statistical Analysis

Tables are presented to describe the variables analyzed. The study of differences between means was performed with Student's t test for independent samples. A p-value of 0.05 was considered statistically significant. Statistical analysis was performed with Excel (Microsoft) v16.65.

We acted in accordance with the national regulations in force, following Decree 158/019 issued by the Executive Branch according to the National Research Ethics Commission. The study was approved by the CASMU Bioethics Commission, File No. 221518 (07 Sept 2022).

RESULTS

All patients who had undergone TKA with a TC3 implant between 2015 and 2022 were evaluated, taking as the start date the date of the first surgery performed with this implant and, as the last date, April 2022 to reach a minimum follow-up of six months.

The implant was cemented in the femur and tibia; in some occasions, stems and wedges were used as needed. Fifty-one TKAs were performed with a TC3 implant; 43 of these patients were fit for evaluation (3 were lost to follow-up, 1 died, 4 were no longer walking due to other conditions). 79% were female and 21% were male, and the mean age at the time of evaluation was 73.7 years (range 54-90). Follow-up ranged from 6 months to 7 years (average 27 months). 63% of the surgeries were primary (previous osteosynthesis or osteotomy); and 37% were replacements (aseptic and infected).

According to the WOMAC scale, pain and stiffness were minimal, functional capacity was moderate, and outcomes were good according to the KSS (Table 1).

Satisfaction was good or very good in 91% of patients. 7% reported poor satisfaction (3 patients), 2%, frank dissatisfaction (1 patient).

56% used some type of walking assistance: cane (17 patients), walker or two canes (7 patients). 56% had an associated disease that could alter gait, such as osteoarthritis in another territory (knee, hip or spine), another arthroplasty, lumbar canal stenosis, and rheumatoid arthritis.

Data from the scores separated by subgroups were compared to see if any variable affected the results. They were compared to the overall score as well as between scores (Table 1).

The score results are good/very good when each variable is separated.

No statistically significant differences were found in surgery (primary or revision) and follow-up time between the subgroups (Figures 1 and 2).

Table 1. Scores in each subgroup and statistical analysis

Variable	Subgroup	n	Score				
			WOMAC			Oxford	KSS Function
			Pain	Stiffness	Final score		
Global		43	1.5	0.6	13.5	36.3	59.9
Surgery	Primary	27	1.2	0.5	13.6	38	59.8
	Revision	16	2	0.8	13.2	33.5	60
	Student's t		-1.11	-0.89	0.10	1.81	0.02
	p		NS	NS	NS	NS	NS
Follow-up	<1 year	19	2.1	0.8	13.8	34.3	69.7
	>1 year	24	1	0.4	13.1	37.9	59.1
	Student's t		1.54	1.18	0.18	-1.47	0.20
	p		NS	NS	NS	NS	NS
Satisfaction	Satisfied	39	1.2	0.4	12.4	37.6	62.1
	Not satisfied	4	4.5	2.5	24.2	24.3	38.8
	Student's t		-2.79	-3.91	-2.02	3.54	1.76
	p		0.008	0.000	0.049	0.001	NS
Age	<75	25	1.9	1.9	9.9	38	70
	>75	18	1.1	0.4	19.1	34	44
	Student's t		1.11	2.12	2.67	1.63	3.74
	p		NS	0.04	0.01	NS	0.000
Assistance	No	19	1.9	0.4	7.8	39.4	76.8
	Yes	24	1.2	0.8	18	33.9	46.5
	Student's t		1.00	-1.18	-3.11	2.35	4.70
	p		NS	NS	0.003	0.024	0.000

WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; Oxford = Oxford Knee Score; KSS = Knee Society Score; NS = not significant.

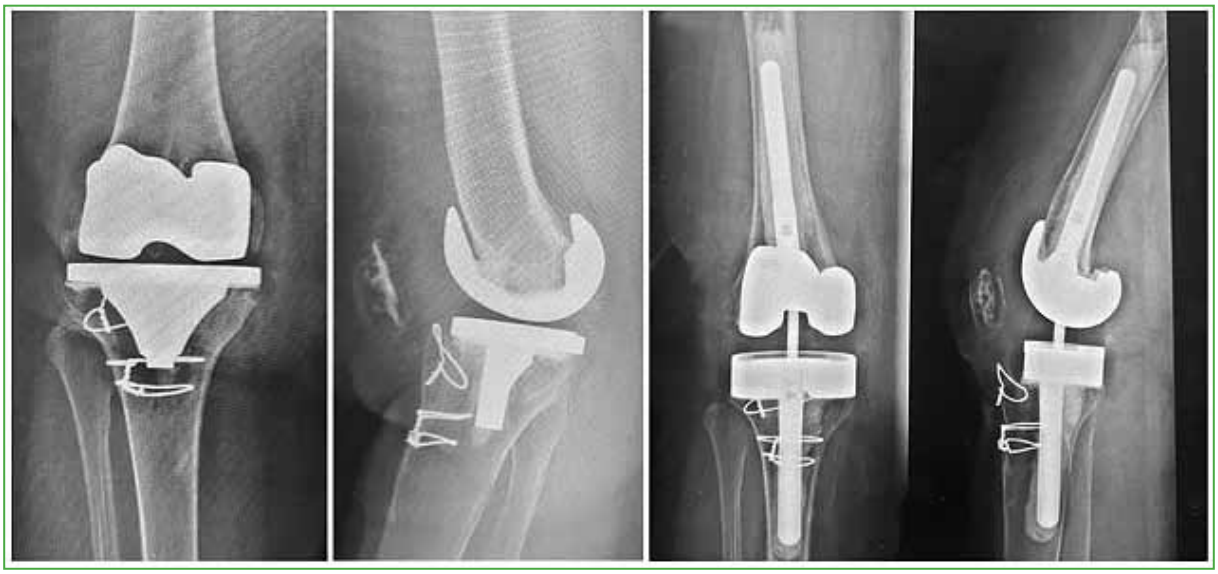

Figure 1. Revision total knee arthroplasty in a patient with aseptic loosening.

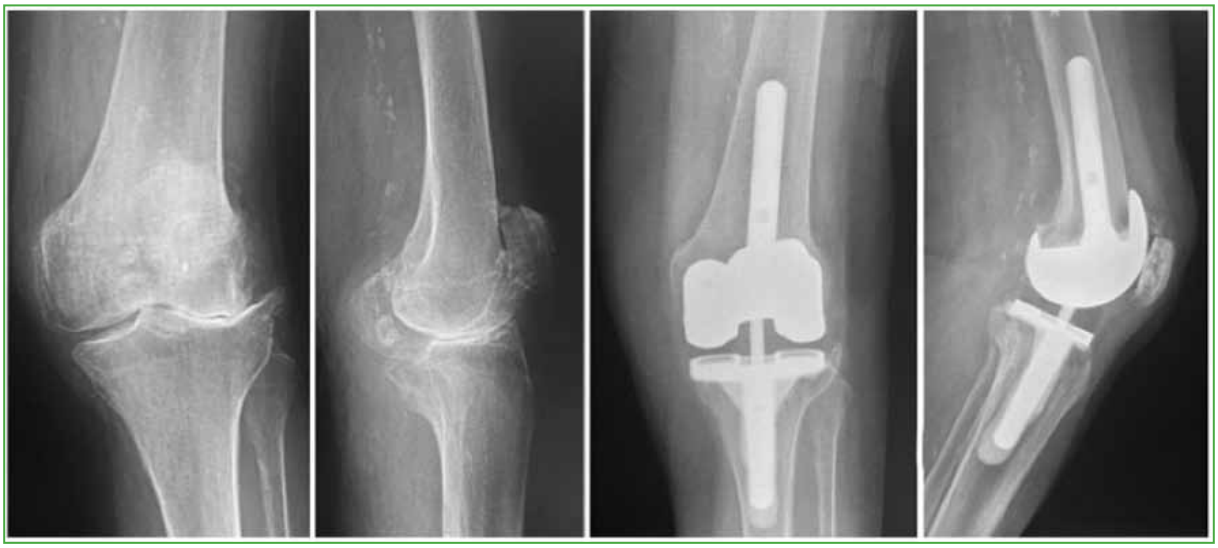

Figure 2. Primary total knee arthroplasty in a patient with unstable valgus.

Patients of advanced age (>75 years), those who were dissatisfied, and those who used some type of assistance had statistical differences with the control group, but still remained in good/very good values.

The risk of using assistance was higher if the patient had concomitant diseases affecting gait (osteoarthritis in other territories, rheumatoid arthritis, and lumbar canal stenosis) (odds ratio= 8.4; relative risk = 3).

Five patients suffered complications: two had pulmonary thromboembolic events in the immediate postoperative period; one had deep vein thrombosis; two reported dysmetria requiring shoe enhancement; one reported pain that made walking difficult. There were no infectious complications or reoperations during the study.

14% reported that pain was a regular symptom; 16% reported that it was occasional; and 70% reported no pain. One patient reported that pain was a daily and persistent problem.

DISCUSSION

The use of augmented stability implants always represents a challenging scenario. These implants are used in revision and complex primary surgeries due to poor bone stock or ligament instability.[7]

Semi-constrained implants include a number of features that improve stability and balance gaps in flexion and extension,[8] such as larger femoral and tibial components, tibial and femoral stems, tibial metaphyseal steps and wedges to complement bone defects, deeper sockets and larger inserts.[9]

Few articles have been published analyzing semi-constrained TKAs and their outcomes (Table 2). In our study, 43 patients were evaluated at the same institution and operated on by the same surgeon. All obtained good/very good scores on the Oxford and KSS function and pain scales. In dissatisfied patients, those over 75 years old, and those who require assistance walking, the results worsen (with a significant difference), but remain at good/moderate values. These function and functional capacity scores seem obvious in patients who are older and require walking assistance, but the high percentage of satisfaction despite functional outcomes is noteworthy.

Table 2. Published studies on semi-constrained total knee arthroplasty and their outcomes.

Authors, year	Quantity	Indication	Implant	KSS	Complications
Baier et al., 2013	78	Revision	TC3	61	28%
Wilke et al., 2014.	234	Revision	TC3	49	17%
Sabatini et al, 2017	18	Primary	TC3 and CCK	92	NR
Vedoya et al., 2018	40	Primary	TC3, Optetrak, PFC®, hinges	79	4%
Pintos et al., 2021	156	Revision	TC3, hinges	-	25%
Zhao et al., 2021	50	Primary	TC3	85	25%
This study	43	Revision, primary	TC3	59.9	11%

KSS = Knee Society Score; TC3 = TC3 implant; CCK = Constrained Condylar Knee.

Scores show minimal pain in all groups, except in dissatisfied patients, with a statistically significant difference. Zhao et al.[10] found pain in 10% of patients; Vedoya et al.[11], in 16%, both in primary surgeries; in our study, 14% usually had pain.

A complete medical record, complementary tests, imaging studies, and microbiological analysis are all required for successful pain management; in general, pain is multifactorial, and the approach should be multidisciplinary.[8]

The patients' functional survival was 89.5%. At the end of the study, all retained the implant, but actual survival was not evaluated, because follow-up was highly variable. Actual survival in 10-year replacements in the authors reviewed was 86%[6] and 85%.[9]

The intraoperative and postoperative complications that have been published are similar to those that occurred in the patients in our study, i.e., thromboembolic events, habitual pain, extensor apparatus tears, dysmetria.

No infectious complications occurred during follow-up. Sabatini et al.[12] also reported no complications in primary surgeries, while Zhao et al.[10] reported 10%. Reported complication rates are 14%,[6] 8%,[9] 4%[13] in revision surgeries with TC3, and 6%[14] and 7%[15] with other semi-constrained implants.

There are no specific studies evaluating the use of assistance after TKA or predisposing factors. Vedoya et al.[11] report an 11% rate of cane use with various semi-constrained implants. In our series, 56% required canes or a walker; this affected function scores significantly, but not pain (Table 1). The risk of using assistance triples if the patient already suffers from a disease that affects gait (odds ratio = 8.4; relative risk = 3).

It is considered that 20-30% of patients are not satisfied after TKA and that only 40% live without pain.[8] These are general values and do not differentiate the type of TKA. Satisfaction is subjective and depends on the patient's own perception. We rated patients as dissatisfied if they reported little or no satisfaction (9% of the total).

A systematic review showed that, in revision surgeries, complications vary from 5% to 50% and that the success of the surgery and the results of the scores depend on several factors, such as gender, systemic diseases and age.[16]

In our field, semi-constrained TKA continues to play an important role, especially when primary TKA fails and when there are bone defects that can hardly be compensated with soft tissue releases or larger inserts. Hinged arthroplasty is reserved for the most challenging cases with instability and major bone defects.

The limitations of this study are those of a retrospective design, the evaluation was not face-to-face, and the follow-up of the series was insufficient to evaluate prosthesis survival and the prevalence of long-term complications. The dissatisfaction group has an n=4 which could generate a type B error as it is a small sample. Patients who required stems or wedges were not analyzed in a differentiated manner, which may generate an information bias when presenting with more severe disease.

The strengths are the number of patients operated on by the same surgical team, in the same institution, the use of several rating scales and the statistical analysis.

CONCLUSIONS

The use of the Sigma TC3 semi-constrained implant with varus-valgus condylar constriction achieved good or very good functional outcomes in all the patients analyzed, with a statistical difference in elderly patients (>75 years), those with previous diseases, and those who use walking assistance. There are no statistical differences in the results according to the type of surgery (primary or revision). Pain scores are very low, with high satisfaction rates. At present, good outcomes are obtained with this implant, and it is necessary to continue evaluating its survival and the appearance of complications in the coming years.

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

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Basicervical Fractures Treated with Single-Screw Cephalomedullary Nail. Case Series and Review of the Literature

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ABSTRACT

Background: Given the rotational instability of basicervical fractures, recent studies suggest using a spiral blade, a second screw or compression screws instead of single-screw cephalomedullary nail fixation. **Objective:** The aim of our study is to analyze the outcomes of basicervical fractures treated with single-screw cephalomedullary nails. **Materials and Methods:** This is a retrospective study based on a case series identified from all extracapsular femoral fractures treated with single-screw cephalomedullary nails in our hospital from 2016 to 2020. Clinical records and radiographs from 269 patients were reviewed; only 12 (6.4%) subjects met inclusion criteria (two-part non-pathologic fractures with at least a 9-month follow-up). Different factors were evaluated, including: tip-apex distance, cephalic screw position, reduction quality, surgical time, complications and re-operations; differences between patients who experienced complications and those who did not were also assessed. **Results:** Four subjects out of the 12 included patients experienced fixation failure and implant cut-out. There were no statistically significant differences between subjects with and without cut-out regarding the analyzed variables. **Conclusions:** The high cut-out rate observed in our sample suggests considering the hypothesis that single-screw cephalomedullary nail fixation should not be used in basicervical fractures. Alternative fixation devices capable of controlling the high rotational instability of these fractures may be preferable.

Keywords: Basicervical fracture; cut-out; single-screw; cephalomedullary nail.

Level of Evidence: IV

Fracturas basicervicales tratadas con clavo intramedular con tornillo cefálico único. Serie de casos y revisión bibliográfica

RESUMEN

Introducción: Debido a la inestabilidad rotatoria de las fracturas basicervicales, en estudios recientes, se sugiere el uso de una hoja espiral, doble tornillo o tornillos de compresión en lugar del tornillo cefálico único. **Objetivo:** Analizar los resultados de las fracturas basicervicales tratadas con tornillo cefálico único en nuestro centro. **Materiales y Métodos:** Estudio retrospectivo de una serie de casos formada a partir de la revisión de todas las fracturas extracapsulares de fémur proximal tratadas con clavo intramedular con tornillo cefálico único entre 2016 y 2020. Se revisaron las historias clínicas y las radiografías de 269 pacientes, y solo 12 (6,4%) de ellos cumplieron los criterios de inclusión (fracturas en dos fragmentos no patológicas y con seguimiento mínimo de 9 meses). Se evaluaron diferentes factores, como distancia punta-ápex, posición del tornillo cefálico, calidad de la reducción, tiempo quirúrgico, complicaciones y reintervención, y se analizaron las posibles diferencias entre los pacientes que sufrieron complicaciones y los que no. **Resultados:** Cuatro de los 12 pacientes tuvieron una falla de la fijación que evolucionó a *cut-out* (única complicación identificada en la muestra). No hubo diferencias estadísticamente significativas entre pacientes con *cut-out* o sin *cut-out* respecto al resto de variables analizadas. **Conclusiones:** La elevada proporción de pacientes que desarrollaron *cut-out* sugiere considerar la hipótesis de que debería evitarse fijar las fracturas basicervicales con tornillo cefálico único. Dada su alta tasa de inestabilidad rotatoria, podría ser más apropiado el uso de implantes que la contrarresten.

Palabras clave: Fracturas basicervicales; *cut-out*; tornillo cefálico único; clavo intramedular.

Nivel de Evidencia: IV

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INTRODUCTION

The frequency of hip fractures has been increasing in recent years due to the increasing age of the population.[1] These fractures have a high morbidity and mortality rate, cause great limitations and difficulties in regaining walking, and can lead to serious complications, such as venous thromboembolic disease**,** pneumonia, or pressure ulcers.[2] This is why early surgical intervention and early initiation of walking are essential in most of these patients.

A subtype of hip fractures are basicervical fractures, which are considered to be transitional fractures between the intracapsular and extracapsular zones. They are typically characterized as two-fragment fractures with a line at the base of the femoral neck, medial to the intertrochanteric line, above the lesser trochanter (Figure 1).[1,2] They are infrequent, with a prevalence ranging from 1.8% to 7.7%.[3,4] Their treatment is complex, because their intermediate situation between intracapsular and extracapsular fractures causes high axial biomechanical instability (their line, more vertical and lateral than that of pertrochanteric fractures, is subjected to greater shearing and varus forces) and rotational instability, since the proximal fragment lacks muscular insertions to fix it, which leads to a high rate of complications (up to 54%), among which the cut-out phenomenon stands out.[4-6] For this reason, several authors consider that its management should differ from that of other extracapsular fractures.[4-7]

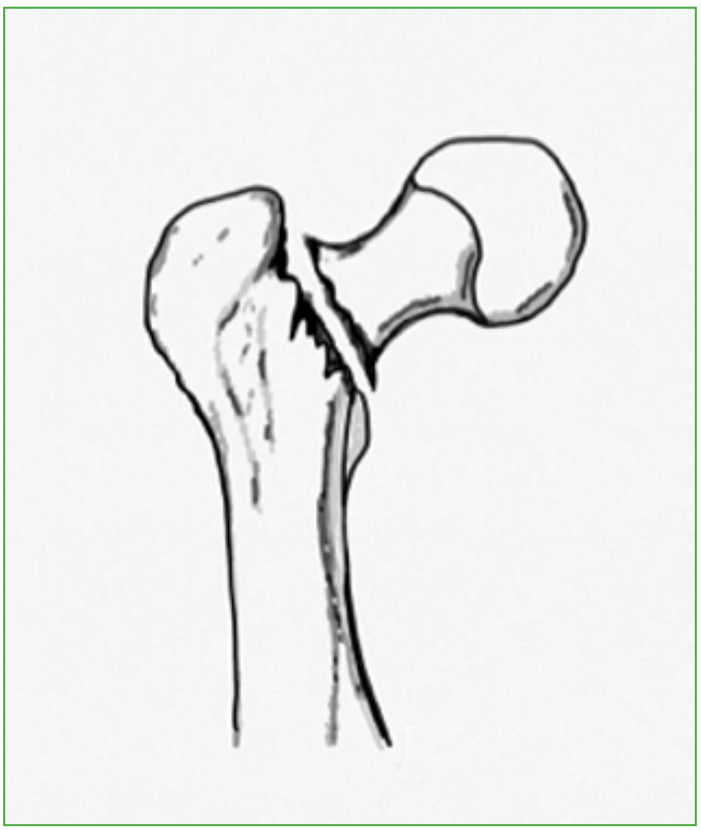

Figure 1. Schematic representation of the basicervical fracture.

Although the most frequent treatment, as in peritrochanteric fractures, is intramedullary nailing with a single cephalic screw,[8] recent studies suggest that, due to their rotational instability, basicervical fractures should be considered a specific risk factor for secondary displacement or failure of intramedullary nail fixation.[4,5,9] As a result, femoral head fixation other than a single cephalic screw is required, and spiral blade, double screw, or compression screws are recommended.[4,7]

The purpose of this study was to analyze the results obtained with intramedullary nailing treatment with a single cephalic screw in basicervical fractures in our site. In addition, a non-systematic literature review was performed to try to achieve a better understanding of the reasons that may lead to failure of surgery in this type of fracture.

MATERIALS AND METHODS

A descriptive, observational, retrospective, cross-sectional study was conducted on a case series formed from the review of all patients with extracapsular fractures of the proximal femur operated on at our site between 2016 and 2020.

Based on clinical history and radiographs (anteroposterior and lateral), patients with a basicervical fracture were included, defined radiographically as a two-fragment fracture with a line at the base of the femoral neck, medial to the intertrochanteric line, above the lesser trochanter, but more lateral than the transcervical fracture (AO type 31B2.1). To achieve a more homogeneous sample, those with 'equivalent basicervical' fractures (AO 31A1.1, A2.1, A2.1, A2.2, A2.3) were excluded, as were those with disease secondary to tumors; follow-up <9 months or who had not undergone surgery with a Gamma-3 model single cephalic screw intramedullary nail (Stryker®, Kiel, Germany). Two of the authors independently reviewed the patients to identify those who met the inclusion criteria; in case of disagreement, a third reviewer not involved in the study design was consulted.

Sociodemographic (age and sex), clinical (fracture laterality and time of admission), surgery-related (time to surgery, duration of surgery, cephalic screw angle, and requirement for open reduction), and postoperative (early weight bearing in the first 48 hours following surgery) attributes were all analyzed.

In the postoperative control radiograph, the tip-apex distance (TAD) was determined according to the formula of Baumgaertner et al.[10] The position of the cephalic screw was classified as good, acceptable, or poor, according to Gardenbroek.[11] The quality of the reduction was evaluated according to the criteria proposed by Fogagnolo.[12] These variables were evaluated jointly by two of the authors.

Surgical complications included fixation failure, defined as fracture collapse and migration of the cephalic screw in the femoral head (cut-out), absence of clinical-radiological consolidation after six months, and the need for reintervention.

This study was approved by the Clinical Research Ethics Committee of our institution.

Statistical Analysis

Quantitative variables are described as median (interquartile range, IQR), while qualitative variables are expressed as absolute numbers. The data were analyzed with the Mann-Whitney U test for quantitative variables and the chi-squared test or Fisher's exact test for qualitative variables. A bilateral significance level of 0.05 was established. All calculations were performed with the SPSS program version 25.

RESULTS

Of the 269 extracapsular femoral fractures treated in our site, 12 patients (6.4%) had a basicervical fracture and met the inclusion criteria, with no discrepancies between the two evaluating authors. All were adults and the fracture had been produced by low-energy mechanisms.

The median age was 78 years (IQR 66.8-89.0), 75% were women. In eight cases, the fracture was on the left side. The most commonly used nail angle was 125° (8 patients), the median TAD was 15.6 mm (IQR 11.3-22.4) and 11 reductions were considered anatomic, open reduction was not necessary in any of the cases (Table 1). All patients started with early weight bearing during admission.

When data were collected, 11 of the 12 patients were alive. One had died of *Staphylococcus aureus* bacteremia secondary to a skin infection unrelated to the osteosynthesis process.

In eight cases, fracture healing was achieved without implant mobilization or collapse. In the other four cases, there was a fixation failure that evolved to cut-out, three of them were operated again (Figure 2); the fourth patient was offered a new surgery, but refused it. The median TAD in these four cases was 23.9 mm, compared to 13.8 mm in patients without this complication (p = 0.09); however, as can be seen in Table 1, the only two patients in

the entire sample with a TAD >25 mm presented cut-out. In three of the cases with cut-out, the position of the cephalic screw according to the Gardenbroek classification was "acceptable" and only one had a "poor" position; in three of them, the reduction was "good" according to Fogagnolo (Table 1).

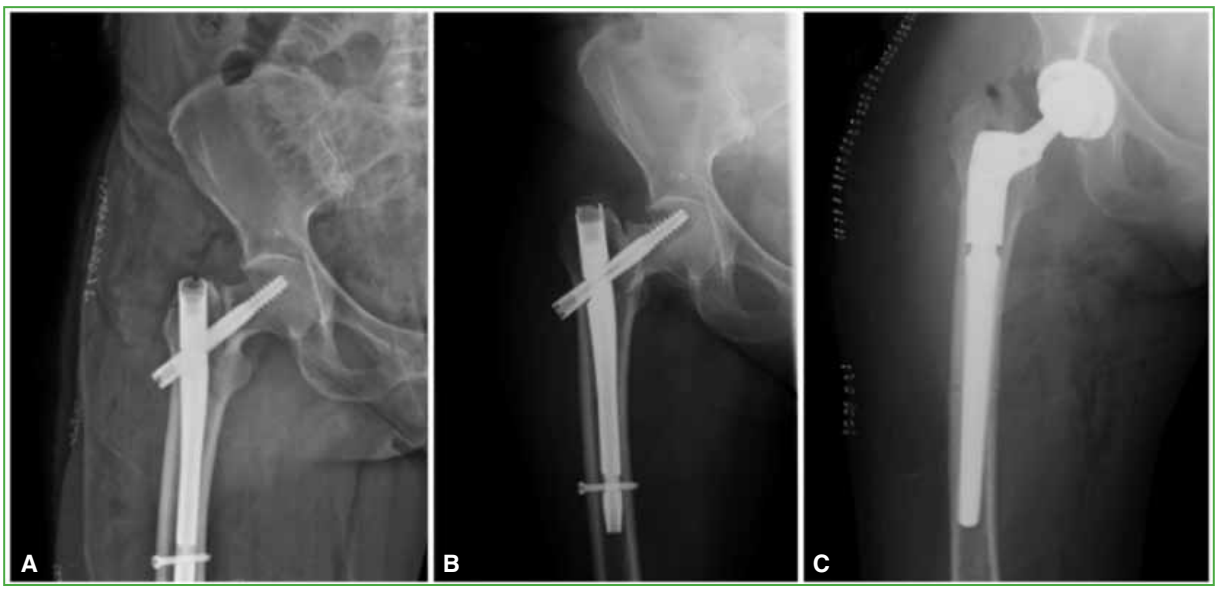

Figure 2. Anteroposterior hip radiographs of case number 10. **A.** Immediate postoperative period: a varus reduction is observed; the cephalic screw is in a superior position and has an increased tip-apex distance. **B.** Two months after surgery: cut-out implant failure is observed. **C.** After reintervention with total hip prosthesis.

Table 1. Clinical, radiographic, and surgical characteristics and complications of patients with basicervical fractures.

Patient	Sex	Age (years)	Laterality	TAD (mm)	Cephalic screw angle	Cephalic screw position (Gardenbroek)	Type of reduction (Fogagnolo)	Surgery time (min)	Complications	Reintervention
1	F	46	Right	8.8	125º	Acceptable	Good	93	No	-
2	F	95	Left	11.4	125º	Good	Good	55	No	-
3	F	88	Left	11.1	125º	Acceptable	Acceptable	80	No	-
4	F	89	Left	15.4	130º	Acceptable	Good	40	No	-
5	F	73	Right	15.8	125º	Acceptable	Good	45	No	-
6	M	43	Left	35.7	130º	Acceptable	Good	125	Cut-out	Yes
7	F	83	Left	16.5	130º	Good	Good	58	No	-
8	M	72	Left	21.8	125º	Good	Good	25	No	-
9	F	73	Left	11.3	125º	Acceptable	Good	35	Cut-out	No
10	F	65	Right	22.7	125º	Poor	Acceptable	65	Cut-out	Yes
11	M	89	Left	25.2	125º	Acceptable	Good	68	Cut-out	Yes
12	F	91	Right	12.3	130º	Acceptable	Good	115	No	-

F = female; M = male; TAD = tip-apex distance.

The median surgery time was 66.5 min in patients with cut-out and 56.2 min in the rest (p = 0.61). Patients without cut-out tended to remain hospitalized longer (Table 2), because, in this group, three requested an intermediate care facility for discharge, so they could not be discharged until it was granted.

Table 2. Description and analysis of different variables in cut-out and non-cut-out patients.

	Group with cut-out	Group without cut-out	p
Age (years)	69.0 (48.5-85.0)	85.5 (72.3-90.5)	0.23
TAD (mm)	23.9 (14.2-33.1)	13.8 (11.2-16.3)	0.09
Time until surgery (days)	2.0 (0.3-3.8)	2.5 (1.3-4.8)	034
Surgery time (min)	66.5 (42.5-110.8)	56.2 (41.3-89.8)	0.61
Hospital stay (days)	6.0 (4.3-10.0)	12,5 (8.5-15.5)	0.05
Cephalic screw position (Gardenbroek)			
Good	0	3	
Acceptable	3	5	
Poor	1	0	
Reduction type (Fogagnolo)			
Good	3	7	
Acceptable	1	1	

Data are expressed as median (interquartile range) for quantitative variables and as absolute number for qualitative variables. TAD = tip-apex distance.

The cut-out was observed in all individuals within three months of the intervention; no trauma or triggering falls were identified in any of them. There were no other intraoperative complications in the 12 cases. Fracture healing had not occurred in any case of cut-out before the complication was detected. At the third month follow-up, sufficient consolidation was visible in the control radiographs of the other patients. Only one case (number 3) showed femoral neck varization on a control radiograph one month after surgery.

DISCUSSION

Hip fractures with a basicervical line are rare; their definition is complex and not always unanimous, which explains why their prevalence is highly variable in studies (1.8%-7.6% of hip fractures).[4,5,7,13,14] In fact, it is considered that up to two thirds of basicervical fractures are misclassified by an incorrect axial hip radiograph.[7,13]

To avoid confusion and homogenize the sample in our study, we only included fractures in two single-line fragments at the base of the femoral neck, medial to the intertrochanteric line, and above the lesser trochanter, as defined by Blair et al.[3] No other fracture lines or equivalent fractures have been included;[14] thus, we have obtained a prevalence of 6.4%, very similar to that of similar studies.[4,5,7]

Given their low frequency and their intermediate intra/extracapsular location, treatment is controversial, as they have characteristics of both types of fractures. They have rotational instability due to the lack of muscle insertions that stabilize the proximal fragment (as seen in subcapital fractures) and axial instability due to the highly vertical line (as seen in extracapsular fractures).[2,6,7] This combination of instabilities determines high complication rates (9-54%);[4,5,7] in our study, it was 33%.

Over time, basicervical fractures have been treated in different ways: as intracapsular fractures or as extracapsular fractures. These fractures have less lateral bone support and are more susceptible to varus forces because they are more vertical and lateral than a typical subcapital line. According to various studies,[3,6,7,15] cannulated screws (the standard therapy for subcapital fractures) produce more complications (19-50%) than other devices, such as the DHS-type sliding screw-plate (8-10%).[7,13] Therefore, it is possible that treating unstable fractures like basicervical fractures as extracapsular, using intramedullary nailing, yields better outcomes than employing a sliding screw plate.[2]

In our series, the complication rate (cut-out) was 33%, in agreement with studies whose surgical management was similar.[4,5] Furthermore, it should be taken into account that, unlike other authors (Hu et al.[8]), we have selected only those simple basicervical line; if more complex fractures with associated basicervical lines had been included, it is likely that even higher complication rates would have been obtained.[7,14]

Although there are studies reporting favorable outcomes in terms of postsurgical complications with the implants already discussed (DHS or intramedullary nails),[3,15,16] other therapeutic options have been proposed for basicervical fractures, including cephalic spiral blades. These differ from screws in their biomechanical and clinical behavior because, unlike screws, which require reaming of the bone for placement, the spiral blade is introduced by compacting the cancellous bone. This improves the stability of the microtrabecular system around the implant, which is very significant because microtrabecular fracture is thought to be one of the triggering elements in the process that causes cut-out. According to studies such as that of Lenich et al.,[17] cut-out starts with microtrabecular fracture, followed by rotation of the femoral head around the implant, migration of the implant and varus collapse of the fracture. Thus, fracture fixation with a spiral blade has been reported as better than the single cephalic screw in several studies.[5,7,8,18-22] However, cut-out can also occur with the spiral blade; moreover, it has a paradoxical behavior: although its resistance to cut-out initiating forces is superior than that of the cephalic screw, once implant migration has begun, the development of this complication is more rapid.[7] Likewise, this type of blade has been associated with other complications such as cut-through, which consists of perforation of the femoral head by the spiral, which is introduced into the hip joint, without fracture displacement.[23]

Another widely used technique is to add an anti-rotation screw outside the implant to block rotational instability.[6,14,18] However, the additional screw has been used more with DHS sliding screw-plate systems, but the clinical and biomechanical results have been mixed.[6,14,18,24] Other ways to compensate for rotational instability may include cementing the cephalic implant or using implants with two integrated screws in association.[7,25]

It is important to note that the correct choice of implant does not exempt from the proper surgical technique. Thus, the location of the cephalic implant must have a correct TAD (<25 mm) and a center-to-center location in both radiographic projections.[4,7,11] In our results, there was a difference in the median TAD, which was higher in patients with cut-out; although this difference was not statistically significant, there was a tendency to significance ($p = 0.08$). Additionally, the only two cases in which the TAD was >25 mm had cut-out. The position of the cephalic screw was satisfactory or acceptable in the majority of the patients; there was just one case (number 10) where the screw was situated in a central-superior position and developed cut-out. Therefore, it is possible that these errors in surgical technique may have influenced the development of this complication.

It is also important to remember that surgical planning is fundamental in these cases, both the correct identification of the basicervical fracture and the correct selection of the cephalic screw angle.

The limitations of this study are its retrospective design, the lack of a control group, and the small sample size due to the low frequency of strict basicervical fractures (the only ones included in this study in order to ensure as homogeneous a sample as possible).

In view of our results and the literature review, we consider that basicervical fractures should be treated with special care, with proper implant selection and correct surgical technique. In this regard, the choice of devices that counteract the rotational instability inherent to this type of fracture, either by means of spiral blades, anti-rotational screws outside the nail, nails with two integrated screws or implants augmented with cement, could be useful.

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

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Morbidity and Mortality in Intertrochanteric Hip Fractures Treated With Cephalo-medullary Nailing. Predictive Value of the Parker Mobility Score

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ABSTRACT

Introduction: Hip fracture represents an independent predictor of morbidity and mortality. The aim of this retrospective study was to assess the morbidity and mortality associated with intertrochanteric hip fractures fixed with cephalomedullary nails. **Materials and Methods:** We analyzed all patients treated between 2018 and 2021 with a cephalomedullary nail for an intertrochanteric hip fracture, with a minimum follow-up of 12 months. We evaluated the demographic data, comorbidities, functional level through the Parker Mobility Score (PMS), complications, and mortality (12 months and at the end of follow-up). Variables related to post-operative complications or death were identified by bivariate and multivariate regression analyses. **Results:** 68 patients were included. The mean follow-up was 23 (range 12-40) months. The rate of complications was 8.8% (n=6), 1 urinary tract infection, 1 pneumonia, 1 deep vein thrombosis, and 3 (4.4%) cephalic screw fixation losses. Patients who had complications presented significant differences in age at the time of fracture. Mortality at 12 months and at the end of the study was 2.9% (n=2) and 29.4% (n=20) respectively. Those patients who died presented significant differences in the incidence of kidney comorbidities, dementia, a Charlson Comorbidity Index > 4, and a PMS < 5. PMS < 5 was the only independent variable related to mortality. **Conclusions:** Cephalomedullary nailing in unstable intertrochanteric hip fractures in elderly patients represents a treatment option that offers an acceptable complication rate and a low 12-month mortality rate. The risk of death is significantly increased in patients with low functional scores (Parker < 5) pre-fracture.

Keywords: Intertrochanteric hip fracture; morbidity; mortality; cephalo-medullary nailing; Parker Mobility Score.
Level of Evidence: IV

Morbimortalidad en pacientes con fracturas intertrocantéricas de cadera tratadas con clavos cefalomedulares. Valor predictivo del Índice de Movilidad de Parker

RESUMEN

Introducción: La fractura de cadera es un factor independiente que aumenta la morbimortalidad. El objetivo de este estudio retrospectivo fue determinar la morbimortalidad en ancianos con fracturas intertrocantéricas de cadera tratadas con clavos cefalomedulares. **Materiales y Métodos:** Se analizó a pacientes tratados con clavo cefalomedular por fractura intertrocantérica de cadera, entre 2018 y 2021, y un seguimiento mínimo de 12 meses. Se registraron: datos demográficos, comorbilidades, capacidad funcional con el Índice de Movilidad de Parker, complicaciones y tasa de mortalidad a los 12 meses y al final del seguimiento. Se identificaron las variables independientes relacionadas con complicaciones o muerte. **Resultados:** Se incluyó a 68 pacientes (seguimiento medio 23 meses). La tasa de complicaciones fue del 8,8%: infección urinaria, neumonía, trombosis venosa profunda y tres pérdidas de fijación del tornillo cefálico. Al comparar pacientes con complicaciones o sin ellas, hubo diferencias significativas en la edad cuando se produjo la fractura. Las tasas de mortalidad anual y al concluir el estudio fueron del 2,9% y 29,4%, respectivamente. Las diferencias fueron significativas en la incidencia de comorbilidades renales, demencia, el Índice de Comorbilidad de Charlson >4 y el puntaje de Parker <5 en quienes fallecieron. El puntaje de Parker <5 fue la variable indepen-

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diente relacionada con muerte. **Conclusiones:** Las tasas de complicaciones y de mortalidad a los 12 meses del tratamiento de las fracturas intertrocantéricas inestables de cadera con clavos cefalomedulares es aceptable en ancianos. El riesgo de muerte aumenta significativamente si el puntaje de Parker es <5 antes de la fractura.

Palabras clave: Fractura intertrocantérica; morbilidad; mortalidad; clavo cefalomedular; índice de movilidad de Parker.
Nivel de Evidencia: IV

INTRODUCTION

Hip fractures in older adults represent a public health problem worldwide and generate a considerable impact on morbidity and mortality.[1] Up to 90% of these fractures occur in patients >65 years of age, predominantly in women, after a fall from their own height.[1-3] The mortality rate ranges between 2% and 7% during the hospital stay, while, after one year, it is 17-33%.[4,5] It is considered that the mortality rate in these patients doubles or triples that of the population of the same sex and age who did not suffer a hip fracture.[6-9]

This impact on morbidity and mortality has been related to different factors, such as age, comorbidities (analyzed individually, or using the Charlson Comorbidity Index [CCI], or the American Society of Anesthesiologists [ASA] score), type of of treatment and functional status before the fracture.[10,11] The Parker Mobility Score is an instrument to assess pre-fracture mobility that has also been related to death after surgical treatment of a hip fracture.[12]

The objective of this retrospective study was to evaluate the factors related to morbidity and mortality in patients with intertrochanteric hip fracture treated with a cephalomedullary nail.

MATERIALS AND METHODS

The database of our Center was retrospectively analyzed to identify all patients with an intertrochanteric hip fracture treated with a cephalomedullary nail between 2018 and 2021.

The inclusion criteria were: patients >65 years old, with an unstable intertrochanteric hip fracture treated with cephalomedullary nailing, and with a minimum follow-up of 12 months. Patients whose fractures were caused by an oncological disease or high-energy trauma, as well as those who were unable to walk, were excluded.

For pre-surgical optimization, a multidisciplinary team of clinical medicine, orthogeriatrics, cardiology, endocrinology, kinesiology, and orthopedics specialists treated all patients from hospital admission.

The surgery was performed on a traction table, under fluoroscopy. Anesthesia was general or spinal, according to the anesthesiologist's indication. Cephalomedullary nails were always used, with one or two cephalic screws and one or two static distal bolts. From the first day following surgery, postoperative therapy consisted of standing and walking with a walker, as tolerated. The use of two canes was indicated for the first four weeks, followed by three weeks with only one cane. Clinical and radiographic controls (anteroposterior radiographs of both hips and lateral radiographs of the operated hip) were done at 3, 6, and 12 months, and then annually.

Variables analyzed

Demographic data, such as sex and age, and comorbidities were recorded according to the affected system, classifying them as cardiac, pulmonary, hepatic, rheumatic, and renal. The presence of dementia, osteoporosis, diabetes, and anticoagulation was also recorded. With these data, the CCI at admission and the ASA score were calculated. The Parker Mobility Score was used to assess patients' pre-fracture walking abilities, which ranges from 0 (non-ambulatory) to 9 (independent mobility) based on gait type, ability to go shopping, need for assistance, and difficulties (Table 1).[12] In addition, the days elapsed until surgery and the total days of hospitalization were recorded.

In the radiographic analysis, the cervico-diaphyseal angle, the position of the cephalic screw according to the areas described by Cleveland,[13] the tip-apex distance and the quality of the reduction were determined using the method described by Baumgaertner.[14] Union, failure, complication and mortality rates were analyzed at one year and at the end of the study.

Table 1. Parker Mobility Score Description

Walking ability	No difficulty	Alone with an assistive device	With help from another person	Not at all
Able to walk inside house	3	2	1	0
Able to walk outside house	3	2	1	0
Able to go shopping	3	2	1	0

Bone consolidation was defined as the presence of a callus in three of the four cortices in the radiographic analysis, and failure was defined as the loss of fixation of the cephalic screw in the femoral head or the presence of nonunion (absence of bone consolidation 9 months after surgery, without radiographic progression of healing in the last three months).

Statistical Analysis

The variables are expressed as mean and range, median and standard deviation, or frequency and percentage, depending on their distribution and nature. To establish differences, the Mann-Whitney or Fisher tests were used, as necessary. With the significant results ($p < 0.05$), a multivariate analysis was performed in order to identify the risk variables. The SPSS, IBM program was used for the analysis.

RESULTS

73 patients were identified, five of them were excluded (one for fracture secondary to oncological disease, another for fracture in the context of multiple trauma, three for not complying with the minimum follow-up). The study population consisted of 68 patients with 68 fractures. The characteristics of the included patients are detailed in Table 2.

Complications

The complication rate was 8.8% (n = 6): a urinary infection, pneumonia, and deep vein thrombosis, which were cured with specific medical treatment. The remaining ones corresponded to three (4.4%) cephalic screw fixation losses that were treated by total hip arthroplasty (Figure). When comparing patients with complications and without complications, only significant differences were observed in the age when the fracture occurred (Table 3). However, this variable could not be identified as an independent risk variable (odds ratio, OR, 1.29; 95% confidence interval, 0.8-1.60).

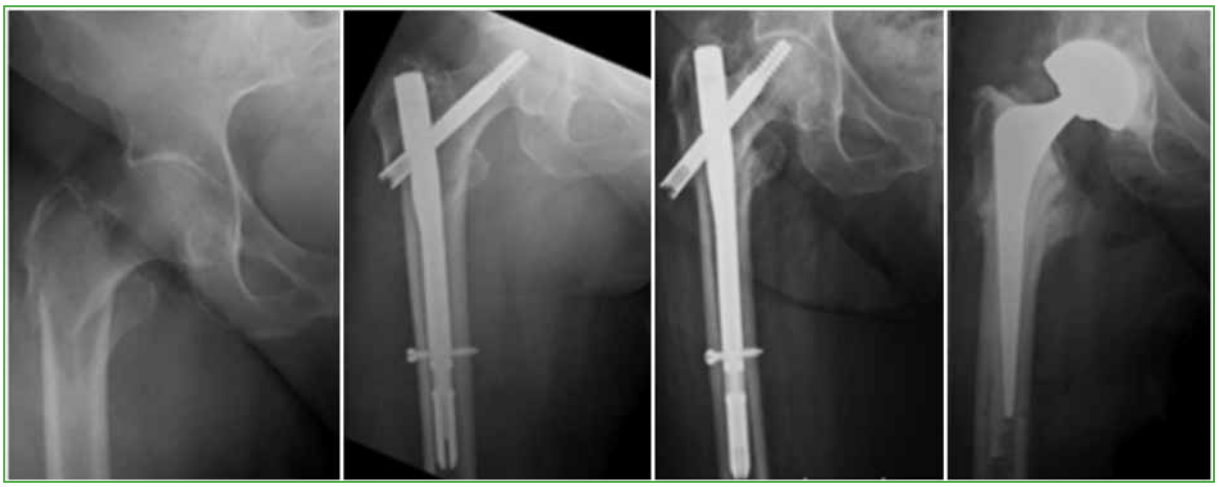

Figure. Patient treated with intramedullary nailing for an intertrochanteric hip fracture. During the follow-up period, there was a loss of cephalic screw fixation, which was treated with total hip arthroplasty.

Table 2. Description of the patients in the series

Variable	
Male sex, n (%)	16 (23.5)
Age, median SD	76.1 ± 10.8
Heart disease, n (%)	18 (26.5)
Lung disease, n (%)	6 (8.8)
Renal disease, n (%)	6 (8.8)
Dementia, n (%)	14 (20.6)
Osteoporosis, n (%)	6 (8.8)
Diabetes, n (%)	6 (8.8)
Anticoagulation, n (%)	6 (8.8)
CCI, median SD	4.6 ± 1.7
ASA score, median SD	2.7 ± 0.5
Parker score, median SD	7.2 ± -2.7
Days until surgery, median SD	3.8 ± 1.8
Total days of hospitalization, median SD	9.9 ± 3.3
CDA, median SD	132 ± 7.0
Position of the cephalic screw, n (%) Anteroposterior 1 2 3 Lateral 1 2 3	 9 (13.2) 51 (75) 8 (11.8) 6 (8.8) 53 (78) 9 (13.2)
TAD, median SD	12 ± 2.4
Reduction quality, n (%) Good Acceptable Poor	 52 (76.4) 12 (17.6) 4 (5.8)
Consolidation, n (%)	65 (95.6)

SD = standard deviation; CCI = Charlson Comorbidity Index; ASA = American Society of Anesthesiologists; CDA = cervico-diaphyseal angle; TAD = tip-apex distance.

Table 3. Comparative analysis between patients with complications and without complications

Variable	Complications (n = 62)	With complications (n = 6)	p
Male sex, n (%)	15 (24.2)	1 (16.7)	0.68
Age, median SD	75.2 ± 10.9	84.2 ± 4.6	0.04
Comorbidity, n (%)			
Heart disease	17 (27)	1 (17)	0.9
Renal disease	6 (9.6)	0	1
Anticoagulation	5 (8)	1 (17)	0.48
Hypertension	9 (14.5)	1 (17)	0.9
Dementia	14 (22.5)	0	0.3
Lung disease	5 (8)	1 (17)	0.48
Osteoporosis	4 (6.4)	2 (33.3)	0.08
Diabetes	5 (8)	1 (17)	0.48
ASA score, n (%)			
I-II	22 (35.5)	0	0.16
III-IV	40 (64.5)	6 (100)	
CCI >4, n (%)	32 (51.6)	1 (16.7)	0.31
Parker score, n (%)			
<5	16 (25.8)	2 (33.3)	0.93
>5	46 (74.2)	4 (66.7)	
Reduction, n (%)			
Good	50 (80.6)	2 (33.3)	0.09
Acceptable	9 (14.5)	3 (50)	0.29
Poor	3 (4.9)	1 (16.7)	0.24
CDA <130°, n (%)	10 (16.1)	0	0.58
Position of the cephalic screw, n (%)			
Anteroposterior			
1	7 (11.3)	2 (3.3)	0.13
2	48 (77.4)	3 (50)	0.14
3	7 (11.3)	1 (16.7)	0.69
Lateral			
1	6 (9.7)	0	0.99
2	47 (75.8)	6 (100)	0.32
3	9 (14.5)	0	0.99
TAD >2 5 mm, n (%)	14 (22.6)	3 (50)	0.14
Waiting days, median SD	3.7 ± 1.8	4.5 ± 1.4	0.32
Hospitalization days, median SD	9.7 ± 3.3	11.5 ± 3.1	0.21
Death, n (%)	18 (29)	2 (33.3)	0.82

SD = standard deviation; CCI = Charlson Comorbidity Index; ASA = American Society of Anesthesiologists; CDA = cervico-diaphyseal angle; TAD = tip-apex distance.

Mortality

The mortality rate 12 months after the fracture was 2.9% (n = 2) and 29.4% (n = 20) at the end of the study. When comparing patients who died and those who did not, significant differences were observed in the incidence of renal comorbidities, dementia, CCI >4, and Parker score <5 (Table 4).

Table 4. Comparative analysis between patients who died and those who did not, at the end of the study

	Deceased (n = 20)	Alive (n = 48)	p
Male sex, n (%)	4 (20)	11 (22.9)	0.79
Age, median SD	75.8 ±11.8	76.6 ± 10.7	0.78
Comorbidity, n (%)			
Heart disease	10 (50)	8 (16.6)	0.13
Renal disease	6 (30)	0	0.0004
Anticoagulation	0	6 (12.5)	0.17
Hypertension	10 (50)	11 (23)	0.06
Dementia	8 (40)	6 (12.5)	0.02
Lung disease	2 (10)	4 (8.33)	0.9
Osteoporosis	0	6 (12.5)	0.17
Diabetes	0	6 (12.5)	0.17
ASA score, n (%)			
I-II	4 (20)	18 (37.5)	0.16
III-IV	16 (80)	30 (62.5)	
CCI, n (%)			
>4	14 (70)	31 (64.6)	0.002
Parker score, n (%)			
>5	8 (40)	46 (95.8)	<0.00001
<5	12 (60)	2 (4.2)	
Complication, n (%)	2 (10)	4 (8.3)	0.91

SD = standard deviation; ASA = American Society of Anesthesiologists; CCI = Charlson Comorbidity Index.

Multivariate analysis

With the variables of interest related to mortality, a multivariate analysis was performed. The final adjusted model showed a Parker score <5 as an independent variable related to mortality (Table 5).

Table 5. Multivariate analysis

	Odds ratio	95% confidence interval	p
Renal disease	0.77	0.11-5.04	0.78
Dementia	1.91	0.57-9.37	0.38
CCI >4	1.20	0.91-1.99	0.05
Parker score <5	1.31	1.02-1.98	0.02

CCI = Charlson Comorbidity Index.

DISCUSSION

One of the main findings of our study was that cephalomedullary nail treatment was associated with a complication rate of 8.8%, resulting from three medical complications and three mechanical failures.

When analyzing preoperative comorbidities, significant differences were only found in age between patients who suffered complications and those who did not. Patients who had complications were almost 10 years older than those who did not. We understand that this could be due to the fact that, at an older age, patients may suffer more comorbidities.

The three complications were: urinary infection, pneumonia, and deep vein thrombosis, conditions that have been widely reported as frequent complications after a hip fracture.[15] The incidence of postoperative complications has been shown to be a variable that affects mortality after surgery for a hip fracture.[16-18] In our analysis, this variable was not identified as significant, possibly due to the low number and the relatively low impact on mortality with respect to urinary tract infections and deep vein thrombosis.[15-18]

Regarding mechanical complications, there were three losses of cephalic screw fixation in the femoral head, resulting in a failure rate of 4.4%. This rate was similar to that published by Kashigar et al. in 2014[19] and Ibrahim et al. in 2019.[20] When analyzing the variables related to these failures, neither the quality of the reduction nor the position of the implant were correlated with the failures. We understand that these are more frequent in patients with poor reduction, a cephalic screw in the upper area in the anteroposterior radiograph, and anterior in the lateral radiograph, and a tip-apex distance >25 mm as reported by Garabano et al. in 2022.[21] Perhaps the lack of statistical significance in our analysis is related to the low number of failures evaluated.

The other relevant finding was that the mortality rate one year after the fracture was 2.9%, a figure lower than the 10-33% published.[5,12,16,20,22] This could be a consequence of the interdisciplinary management of patients and correct preoperative optimization.

When variables related to death were analyzed, it was observed that patients who died had significant differences in the incidence of comorbidities, such as dementia, kidney disease, a CCI >4, and a Parker score <5. Dementia and kidney disease have been associated with death after a hip fracture.[22,23] In 2015, Pérez-Sáez et al.[22] found that hip fracture and mortality rates increase in patients with chronic kidney disease. Likewise, according to a 2021 meta-analysis, patients with dementia have worse functional outcomes and higher rates of infection, dislocations, respiratory complications, and mortality after a hip fracture.[23]

The CCI has been shown to be a useful tool for assessing preoperative comorbidities.[11] Regarding mortality, its predictive value after a hip fracture has been proven in several studies.[15,16,24] Although we found significant differences in this score between patients who died and those who did not, it was not possible to identify it as an independent risk variable related to death.

Parker et al.[12] reported that the Parker score was directly correlated with death, that the risk of death after a hip fracture increases if the Parker score is <5, a finding similar to that obtained in our study.

The relationship between pre-fracture functional activity and death after hip fracture surgery has been widely studied. Multiple types of scales and scores have been developed that have highlighted this relationship;[12,25,26] In addition to the Parker Mobility Score, we can mention the Koval score[25] and the score that evaluates the performance of daily activities,[26] among others. Regarding functional activity, it has been published that only 40-50% of elderly people who suffer a hip fracture will recover the level of activity they had before.[15] This demonstrates another aspect of the impact of the fracture in these patients. In this study, it was observed that those patients with lower Parker scores, in other words, those with lower functional capacity, were those who had an increased risk of death.

The limitations of this study are those of a retrospective study that included a small number of patients. The latter could have generated a lack of statistical significance in some of the variables related to mortality, generating type 2 or beta errors.

CONCLUSIONS

The treatment of unstable intertrochanteric hip fractures with cephalomedullary nails in the elderly represents an option that offers a relatively low number of complications. The associated annual mortality rate was 2.9%, and close to 30% at the end of follow-up. This rate was associated with the level of functional activity before the fracture, represented by a Parker score <5.

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

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Early Complications in Direct Transgluteal Anterolateral Total Hip Arthroplasty: A Comparative Study

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ABSTRACT

Introduction: In recent years, the advent of new procedures, surgical instruments, and surgeon skills has contributed to a reduction in the number of early complications that can arise after hip arthroplasty. Among the most frequent are femoral loosening, deep vein thrombosis, and dislocation. **Objective:** To evaluate the rate of intraoperative complications and complications within the first 12 months after a hip arthroplasty performed utilizing the direct anterolateral approach; and to compare the results to a series published in 2007. **Materials and Methods:** Retrospective cohort study, which included patients who underwent surgery for primary hip osteoarthritis at two institutions, divided into: group I (468 patients who were operated between June 1999 and June 2003) and group II (344 patients who were operated between January 2018 and January 2020). **Results:** The global rate of complications in group II was 4.7%. Deep vein thrombosis was the most frequent event, and there were no episodes of dislocation. The use of 22 mm diameter heads was associated with a higher risk of dislocation compared to surgeries in which larger heads were used (OR= 6.7 – 95% CI 1.2 – 78.2). **Conclusions:** Total hip replacement through a direct transgluteal anterolateral approach had a low global rate of complications within the first postoperative year. Complications were reduced by almost half in surgeries performed between 2018 and 2020, compared to the previous series, mainly in regards to dislocation.

Keywords: Total hip arthroplasty; anterolateral approach; hip replacement; complications; direct anterolateral approach.
Level of Evidence: IV

Complicaciones tempranas de la artroplastia total de cadera por vía anterolateral transglútea directa: estudio comparativo

RESUMEN

Introducción: En los últimos años, la introducción de diversas técnicas, el instrumental quirúrgico y las competencias del cirujano han contribuido a disminuir las complicaciones tempranas que pueden sobrevenir luego de una artroplastia de cadera. Las complicaciones más frecuentes son: el aflojamiento femoral, la trombosis venosa profunda y la luxación. **Objetivos:** Evaluar la tasa de complicaciones intraoperatorias y durante los primeros 12 meses luego de una artroplastia de cadera por vía anterolateral directa; y comparar los resultados con la serie publicada en 2006. **Materiales y Métodos:** Estudio de cohorte retrospectivo que incluyó a pacientes operados por artrosis primaria de cadera en 2 instituciones, divididos en: grupo I (468 pacientes operados entre junio de 1999 y junio de 2003) y grupo II (344 pacientes operados entre enero de 2018 y enero de 2020). **Resultados:** La tasa global de complicaciones en la nueva serie fue del 4,7%. La trombosis venosa profunda fue la complicación que más se repitió, no hubo episodios de luxación. El empleo de cabezas de 22 mm de diámetro se asoció con un riesgo de luxación más alto que con cabezas más grandes (OR = 6,7; IC95% 1,2-78,2). **Conclusiones:** La artroplastia total de cadera con abordaje anterolateral transglúteo directo causó una baja tasa global de complicaciones dentro del primer año de la cirugía. Las complicaciones se redujeron casi a la mitad en las cirugías realizadas entre 2018 y 2020, con respecto a la serie anterior, fundamentalmente a expensas de la luxación.

Palabras clave: Artroplastia total de cadera; abordaje anterolateral; reemplazo de cadera; complicaciones; abordaje anterolateral directo.
Nivel de Evidencia: IV

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INTRODUCTION

In recent decades, the number of primary hip arthroplasties has increased[1] and, in many studies, successful outcomes have been obtained in terms of clinical, functional and survival evaluations.[2-4] However, there are numerous potential complications that the orthopedic surgeon must face during the initial stage after primary arthroplasty, some of them are: loosening, infection, fractures (including protrusion), neurovascular injuries and dislocation.[5-7]

In 2007, the author of this article took part in a study in which a series of 468 hip arthroplasties were analyzed. The overall complication rate was 8.5% during the first year after surgery, and the three most frequent complications were: femoral loosening, deep vein thrombosis, and dislocation.[8]

Since then, in the last 20 years, improved designs of femoral stems and cementless prostheses and cementing techniques, as well as the advent of tranexamic acid, the introduction of highly cross-linked polyethylene together with the use of larger diameter femoral heads, and the experience gained in the approach, have contributed to a decrease in complications.[9-12]

The aim of this study was to evaluate the rate of complications intraoperatively and during the first 12 months after direct anterolateral hip arthroplasty, and to compare the results with those of the series published in 2007.

The hypothesis was that the number of overall complications had decreased between the two periods.

MATERIALS AND METHODS

A retrospective cohort study was conducted involving patients operated on for primary hip osteoarthritis at two institutions. Patients were divided into: group I (468 operated between June 1999 and June 2003)[8] and group II (344 operated between January 2018 and January 2020). All surgeries were performed by the same surgeon and the rate of complications during surgery and the first 12 months after surgery was recorded in both groups.

The following data were extracted from the medical records of the institutions: age, sex, diagnosis, follow-up, femoral or acetabular loosening, deep vein thrombosis, dislocation, heterotopic calcifications, and neurovascular injuries.

The radiographic evaluation was performed on anteroposterior radiographs of both hips with 10° of internal and lateral rotation of the operated hip using Synapse® software (Fujifilm, USA). Patients were routinely monitored in the immediate postoperative period, and 30 days, 3 months, 6 months, and 1 year after surgery (Figure). The Trendelenburg test and the ability to perform abduction against gravity in lateral decubitus were used to measure gluteal insufficiency in the clinical control.

A fellow trained in hip arthroplasty surgery documented all data.

Patients undergoing primary hip arthroplasty for osteoarthritis or avascular necrosis were included. Patients undergoing hip arthroplasty for fracture or fracture sequelae, septic arthritis sequelae, osteotomy sequelae, or high congenital hip dislocation were excluded.

Surgical technique

All patients were operated on in dorsal decubitus, under hypotensive spinal anesthesia. Antibiotic prophylaxis included 1 g of cefazolin (2 g if the patient weighed >80 kg) administered 30 minutes before the skin incision. All were given an initial dose of tranexamic acid during anesthetic induction.

The surgery was performed through a direct transgluteal anterolateral approach and, unlike the operations from 1999 to 2003 in which 22 mm diameter heads were used with conventional polyethylene (high-molecular weight polyethylene, HMWPE), since 2018, 28, 32 and 36 mm diameter heads were used depending on the prosthetic acetabular size, with ultra-high-molecular weight polyethylene (UHMWPE).

Prophylaxis for venous thrombosis included low molecular weight heparin administered subcutaneously for 21 days after surgery. In May 2019, patients without risk of thrombosis began receiving 325 mg of aspirin daily.[13]

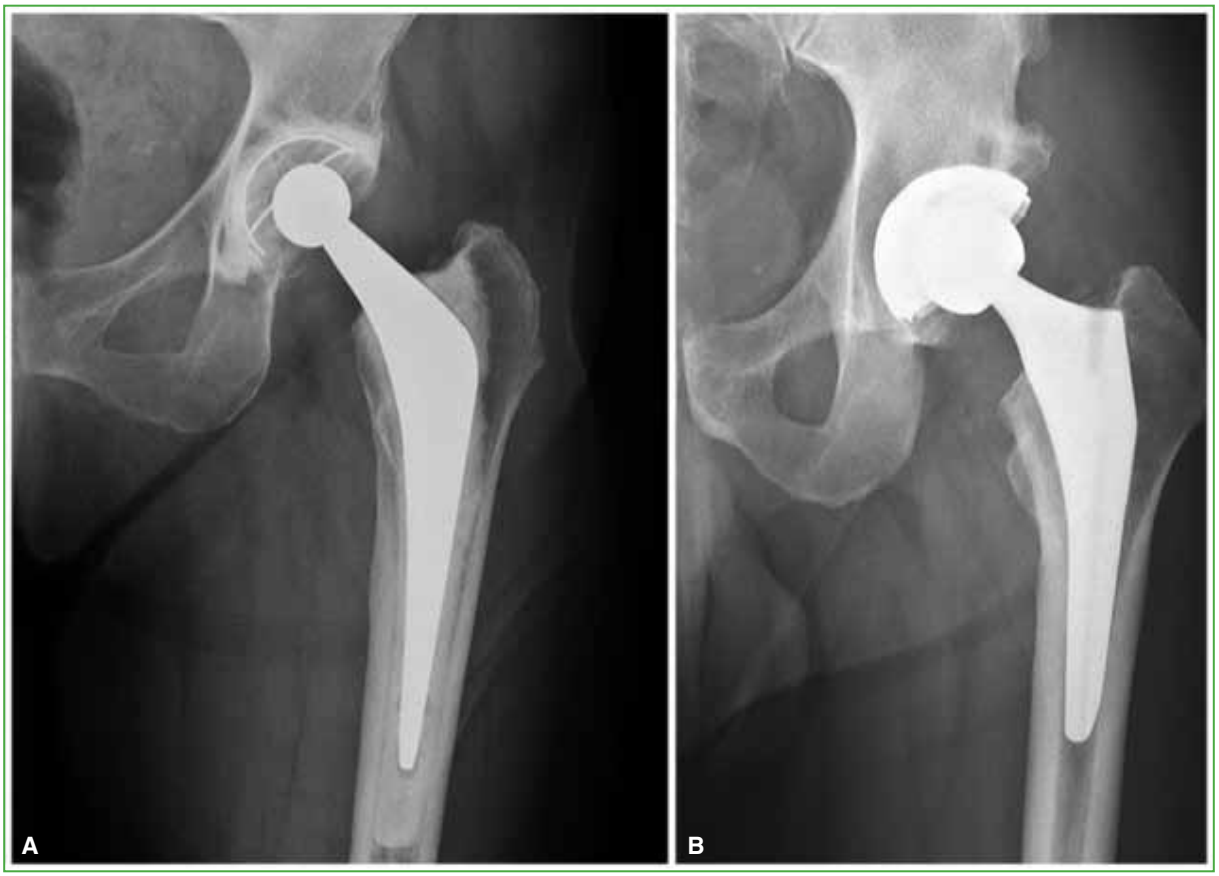

Figure. Anteroposterior control radiographs of the hip one year after surgery. **A.** Patient in group I, where cemented prostheses with a 22 mm head predominated. **B.** Patient in group II, where cementless prostheses with a 32 mm head prevailed.

Rehabilitation protocol

All patients followed the same rehabilitation protocol. They were allowed to sit on the edge of the bed with their knees flexed up to 90º and to stand upright during the first day. They began walking with the assistance of a walker on the second day, followed by two Canadian crutches for a period of 3 to 6 weeks, depending on tolerance.

Statistical Analysis

Qualitative variables are described as frequency or percentages, and numerical variables as mean and standard deviation. Categorical and continuous variables were compared between the two groups with chi-squared (or Fischer exact method, if necessary) and Student's t-tests. A univariate analysis was performed to determine the association between dislocation and femoral head diameter. Similarly, the relationship between the use of cemented stems and femoral loosening was evaluated. A p value <0.05 was considered significant.

All data were entered into an Excel® spreadsheet (Redmond, USA) and the GraphPad Prism® 8.0 program (LaJoya, CA, USA) was used for statistical calculations.

RESULTS

The first series covered the period from June 1999 to June 2003. In this case, 478 primary total hip arthroplasties with direct anterolateral Charnley prosthesis were analyzed in 409 patients, with a minimum follow-up of one year. Eleven patients were lost to follow-up, one of whom died six weeks after surgery. Therefore, the analysis was performed on 468 hips corresponding to 398 patients, of which 79 were bilateral and non-simultaneous.

Subsequently, between January 2018 and January 2020 (group II), the second series of 356 primary hip arthroplasties was evaluated; 12 patients were excluded because they did not have complete records. The series of this group finally consisted of 344 patients, 50.6% were men and the mean age was 70.8 ± 11.5 years.

The prostheses used in this series were: 271 (78.8%) Trident-Accolade II (Stryker Inc. Mahwah, NJ, USA), 52 (15.1%) Trident-Exeter (Stryker Inc, Mahwah, NJ, USA), 10 (2.9%) UII Motion- UTF Stem (United Orthopaedic Corporation, Taiwan) and 11 (3.2%) Trilogy-ML Taper (Zimmer, Warsaw, IN, USA).

All of the uncemented stems had metaphyseal fixation. The 52 cemented stems were highly-polished, double-tapered Exeter stems (Stryker Inc, Mahwah, NJ, USA). The rest of the population characteristics are described in Table 1.

Table 1. Characteristics of patients operated on between January 2018 and January 2020.

Variables	n = 344
Age, mean, SD	70.8 ± 11.5
Sex, n (%)	
Male	174 (50.6)
Female	170 (49.4)
Femoral head diameter, n (%)	
28 mm	46 (13.4)
32 mm	223 (64.8)
36 mm	75 (21.8)
Femoral stems, n (%)	
Cemented	52 (15.1)
Uncemented	292 (84.9)
Complications, n (%)	
Deep vein thrombosis	6 (1.7)
Trochanteric fracture	3 (0.9)
Periprosthetic infection	3 (0.9)
Protrusion	1 (0.3)
Gluteal insufficiency	1 (0.3)
Neurovascular injury	1 (0.3)
Acetabular loosening	1 (0.3)
Femoral loosening	0 (0)
Dislocation	0 (0)
Heterotopic calcification	0 (0)

The overall complication rate was 4.7%. The highest percentage was represented by six patients who developed deep vein thrombosis in the lower limb ipsilateral to the operated hip. Five of them evolved favorably and one suffered a pulmonary thromboembolism for which he was admitted to the Intensive Care Unit where he received specific treatment and anticoagulant therapy, and had no other complications.

Secondly, there were three patients with fractures of the greater trochanter produced during surgery, which were treated with high-strength suture. None had pain or gait disturbances at the end of the study.

Three periprosthetic infections were also detected: two women, 22 and 30 days after surgery, respectively, came to the office with pain and signs of phlogosis and persistent serohemorrhagic discharge through the wound. Both were treated with surgical lavage, debridement, and polyethylene replacement. In the samples taken during surgery, the following microorganisms were isolated: Methicillin-sensitive *Staphylococcus aureus* and *Staphylococcus epidermidis*. Both evolved satisfactorily with specific antibiotic therapy.

The remaining case was a man with chronic infection four months after arthroplasty. Initially, an arthrocentesis was performed and methicillin-resistant *S. epidermidis* was isolated, so a two-stage revision with an antibiotic-loaded cement spacer and adjusted antibiotic therapy was performed. Eleven weeks later, reconversion to distal fixation prosthesis was performed, with no recurrences at the end of the study.

In addition, in one case, a femoral protrusion was observed in the immediate postoperative radiographic control, so the stem was repositioned that same day. Furthermore, radiographic acetabular loosening was detected in one woman in the sixth month control, which did not progress in subsequent controls. The patient never reported symptoms; therefore, conservative treatment was chosen.

In addition, one man had gluteal insufficiency that healed 11 weeks after surgery.

Finally, one patient evolved with steppage gait during the postoperative period, was treated with electrostimulation and orthoses, and partial recovery was achieved.

There were no cases of dislocation, femoral loosening, or heterotopic calcification.

When comparing variables between group I and group II, there was a statistically significant decrease with respect to the rate of femoral loosening ($p = 0.01$) and dislocation ($p = 0.02$). The rest of the variables compared are detailed in Table 2.

In the univariate analysis, it was observed that, when heads with a diameter of 22 mm were used, the risk of dislocation was 6.7 times higher than with larger heads (odds ratio= 6.7; 95%CI 1.2-78.2). On the other hand, no significant association was found between femoral loosening and the use of cemented stems (odds ratio = 0.91; 95%CI 0.15-10.07).

Table 2. Comparison of the variables between group I and group II

Variables	Group I (n = 468)	Group II (n = 344)	p
Age	69.0	70.8 ± 11.5	0.89
Sex			
Male	183 (46.0)	174 (50.6)	0.21
Female	215 (54.0%)	170 (49.4%)	
Femoral head diameter			
22 mm	468 (100%)	0 (0%)	
28 mm	0 (0%)	46 (13.4%)	
32 mm	0 (0%)	223 (64.8%)	
36 mm	0 (0%)	75 (21.8%)	
Stems			
Cemented	468 (100%)	52 (15.1%)	<0.01
Uncemented	(0%)	292 (84.9%)	
Complicaciones, n (%)			
Acetabular loosening	1 (0.2%)	1 (0.3%)	0.99
Femoral loosening	10 (2.1%)	0 (0%)	0.01
Deep vein thrombosis	9 (1.9%)	6 (1.7%)	0.99
Periprosthetic infection	3 (0.6%)	3 (0.9%)	0.46
Dislocation	8 (1.7%)	0 (0%)	0.02
Heterotopic calcification	4 (0.8%)	0 (0%)	0.14
Trochanteric fracture	4 (0.8%)	3 (0.9%)	0.99
Protrusion	1 (0.2%)	1 (0.3%)	0.99
Gluteal insufficiency	0 (0%)	1 (0.3%)	0.42
Neurovascular injury	0 (0%)	1 (0.3%)	0.42

DISCUSSION

One of the most important findings of our study was the overall low rate of early complications during the first year after arthroplasty compared to that published in 2007 (4.7% vs. 8.5%).[8]

In a prospective randomized study by Martin et al.,[14] the complication rate was 5.1% at 12 months after anterolateral hip arthroplasty. The main complications described were: psoas tendinopathy and deep vein thrombosis.

We believe that the decreased complication rate in our study may be due, in part, to improved femoral stem designs, increased use of cementless components, and the use of larger diameter femoral heads (32 and 36 mm). The latter was directly related to a significant decrease in dislocation rates with respect to the series published by Lopreite et al. in 2007 (0% vs. 1.7%; p = 0.02).[8]

All patients were operated by the same surgeon and with the same surgical technique, but, in group I, 22 mm diameter femoral heads were used.

When comparing both groups, the risk of dislocation decreased 6.7-fold (odds ratio = 6.7; 95%CI 1.2-78.2) in favor of group II.

In 1970, the use of 22 mm diameter heads decreased and the use of 28 and 32 mm diameter heads steadily increased, due to multiple reports that this resulted in lower dislocation rates.[15,16] The placement of uncemented cups generated controversy, because some authors published higher wear rates of polyethylene with larger diameter heads.[17] It was also established that the minimum thickness of conventional polyethylene (HMWPE) in uncemented cups should not be less than 8 mm, since a thickness <8 mm was associated with early wear and breakage. This led to the more frequent use of 22 mm diameter heads for cups of 50 mm or less, and 28 mm heads for cups of a larger diameter.

With the advent of highly cross-linked inserts (UHMWPE), it was shown that wear does not vary significantly with 32 and 36 mm heads.[18,19] Since a minimum polyethylene thickness of 6 mm can be used, 32 mm heads can used for uncemented cup diameters of 48 mm and up. The use of larger diameter heads and the improved design of the femoral necks allow an increase in the femoral head/neck ratio with a greater range of motion and a lower risk of impingement, thus decreasing the risk of instability. In this study, all the inserts included in the analysis were made of highly cross-linked polyethylene.

Another major cause of failure after hip arthroplasty is the loosening of the femoral stems.[20] Bozic et al.[21] conducted an epidemiological study in the United States, and observed that loosening represented the second leading cause of revision. Decades ago, loosening rates with cemented stems were high;[22,23] however, with advances in cementing designs and techniques, more promising series were published with better results in terms of loosening and survival rates.[24]

In the group of patients operated on between January 2018 and January 2020, there were no cases of femoral loosening during the first year after surgery, which represented a statistically significant difference from the 2007 series (0% vs. 2.13%). We consider that this could be due to a correct cementation technique and to the lower proportion of cemented stems in group II (10.8%), due to the improved designs of the cementless femoral stems with respect to their fixation surfaces that allow better osseointegration.

In the first published series, the femoral stems were cemented. In that study, it was clarified that the technique of cementing a femoral stem, as well as the difficulties of neutral orientation while avoiding varus placement, could predispose to early loosening.[8] However, in a different study by the same author on the coronal orientation of uncemented stems, it was shown that varus orientation did not alter osseointegration and long-term survival.[25]

This study has some limitations, such as its retrospective design and the variability of the prosthetic components placed. Likewise, we believe that the period established as a cut-off point to study some of the complications listed is insufficient, particularly for loosening, periprosthetic infection, and late dislocation.

It should also be noted that these are two non-consecutive cohorts of patients, operated on at different time periods and that the variables analyzed, both dislocation and loosening, are influenced not only by the approach used, but also by other technical details, such as the number of the head used and the type of femoral stem fixation.

As strengths, all patients were operated by the same surgeon and with the same surgical technique.

CONCLUSIONS

Total hip arthroplasty by a direct transgluteal anterolateral approach resulted in a low overall complication rate within the first postoperative year. Complications were nearly halved in surgeries performed between 2018 and 2020 compared to those in the previous publication, at the expense of a lower rate of early femoral loosening and a significant decrease in the dislocation rate.

The use of cementless metaphyseal fixation stems decreased the rate of early loosening when compared to cemented stems in the direct transgluteal anterolateral approach. The risk of dislocation was 6.7 times lower with the larger diameter heads than with the 22 mm heads for this approach.

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

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Treatment of Paprosky Type IIIA-B Acetabular Defects and Pelvic Discontinuity With Custom 3D Implants: Medium-Term Results

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ABSTRACT

Introduction: Acetabular revision is a particularly challenging surgery when there is loss of bone stock and extensive acetabular defects. 3D implants can make up for these defects and adapt to each circumstance. The objective of this study was to evaluate clinical and radiographic outcomes in patients with severe acetabular defects treated with 3D-printed implants and determine the appropriate cup constraint for each patient. **Materials and Methods:** A retrospective study was carried out on 10 patients with severe acetabular defects classified as Paprosky type IIIA-B and pelvic discontinuity who underwent surgery with a custom 3D-printed acetabular prosthesis, carried out by the same surgery team between 2016 and 2022. **Results:** The average follow-up was 40.5 months. The Harris hip score improved significantly from an average of 24.2 to 63.5 at the last follow-up. No signs of loosening or migration of the 3D cup in terms of inclination and anteversion were observed in any case, at the last control. **Conclusion:** Custom-made acetabular implants represent a valid solution to treat severe acetabular bone defects and pelvic discontinuity.

Keywords: Acetabular defect; 3D cup; custom implant; reconstruction.

Level of Evidence: IV

Tratamiento de defectos acetabulares tipo IIIA-B de Paprosky y discontinuidad pélvica con implantes 3D a medida: resultados a mediano plazo

RESUMEN

Introducción: La revisión acetabular es una cirugía particularmente desafiante cuando hay pérdida de stock óseo y defectos acetabulares extensos. Los implantes 3D pueden suplir estos defectos y adaptarse a cada circunstancia. El objetivo de este estudio fue evaluar los resultados clínicos y radiográficos en pacientes con defectos acetabulares severos tratados con implantes impresos en 3D y determinar el constreñimiento adecuado del cotilo para cada paciente. **Materiales y Métodos:** Se realizó un estudio retrospectivo de 10 pacientes con defectos acetabulares severos clasificados como tipo IIIA-B de Paprosky y discontinuidad pélvica que se sometieron a una cirugía con prótesis acetabular a medida impresa en 3D, a cargo del mismo equipo quirúrgico, entre 2016 y 2022. **Resultados:** El seguimiento medio fue de 40.5 meses. El puntaje de cadera de Harris mejoró significativamente de un promedio de 24,2 a 63,5 en el último control. No se observaron signos de aflojamiento ni migración del cotilo 3D en cuanto a la inclinación y anteversión en ningún caso, en el último control. **Conclusión:** Los implantes acetabulares a medida representan una solución válida para tratar defectos óseos acetabulares severos y la discontinuidad pélvica.

Palabras clave: Defecto acetabular; cotilo 3D; implante a medida; reconstrucción acetabular.

Nivel de Evidencia: IV

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INTRODUCTION

In recent years, the number of primary arthroplasties has increased exponentially, so the absolute number of revisions will have a directly proportional increase.[1] Acetabular revision is a challenging surgery, particularly when there is loss of bone stock with extensive acetabular defects, poor bone quality, and implant migration. Successful acetabular reconstruction with fixation of prosthetic components requires sufficient primary stability for subsequent secondary osseointegration.[2,3] Reasons for revision are attributable to various causes: dislocation, instability, mechanical loosening, infection, among others.[4]

A wide range of surgical strategies are available for the resolution of this condition, such as acetabular support rings, trabecular metal cups with wedges, etcetera. However, it has not yet been defined which one should be used as a reference. While many contained defects can be managed with the use of standard cups, extensive uncontained defects may require custom-made implants given the complexity of the bone defect.[5] 3D implants can treat acetabular defects and be tailored to each situation by printing images from a preoperative computed tomography (CT) scan, giving the surgeon the option of adding precision metal sockets to the implant based on the hemipelvis defects, as well as fixation adjustments to the remaining bone stock by designing and locating precisely oriented screw holes for the bones: ilium, ischium, and pubis, taking into account the bone quality for optimal fixation and planning the reconstruction of the hip center of rotation.[6,7]

Custom-made implants are costly in terms of both money and time; yet, they are a viable therapeutic alternative for extensive bone defects that cannot be treated with standard implants. Although this method is quite costly compared to the use of standard implants, it can often be the only possible solution for revision total hip arthroplasty (THA). Custom implants were developed to achieve implant stability and restore hip biomechanics when there is significant loss of bone stock.[7]

The aim of this study was to evaluate the clinical and radiological outcomes in patients with severe Paprosky type IIIA-B acetabular defects and pelvic discontinuity after treatment with custom 3D-printed implants using CT for revision surgery and to determine the appropriate cup constraint for each patient based on individual patient needs.

MATERIALS AND METHODS

A retrospective evaluation of patients who underwent surgery with a custom 3D-printed acetabular prosthesis for the treatment of severe Paprosky type IIIA-B acetabular defects and pelvic discontinuity between 2016 and 2022 was performed.

Ten patients (7 females and 3 males) underwent revision THA using a custom 3D-designed acetabular component to reconstruct severe acetabular defects. Patient information, including the indication for initial THA and the number of previous operations or revision procedures, was collected from hospital medical records and entered into an Excel spreadsheet (Table 1).

Acetabular involvement was determined according to the Paprosky classification[8] and the American Academy of Orthopaedic Surgeons classification. At admission and at the final control, the Harris Hip Score (HHS), the Oxford Hip Score (OHS), and the Short Form-36 Health Survey (SF-36) were employed.

All patients were operated on by the same surgical team. Inclusion criteria were: patients with severe Paprosky type IIIA or type IIIB acetabular defects and pelvic discontinuity who had been authorized by the infectious diseases team to undergo the second revision stage. Exclusion criteria were: patients with Paprosky types I and II acetabular defects or minor acetabular defects, and active infection.

Although there were no malnourished or morbidly obese patients, we usually tried to correct the clinical condition by setting a BMI between 18 and 30 by protocol.

Preoperative planning and development of the customized 3D acetabular component

All patients underwent revision THA with a customized 3D acetabular component to reconstruct extensive acetabular defects. Prior to surgery, CT images with a metal artifact reduction algorithm were taken of each patient in the supine position, with the lower limbs aligned in anatomical position and neutral rotation. The tomographic slices were 1 mm over the entire pelvis and the data were saved in standard DICOM format (Digital Imaging and Communications in Medicine).

Table 1. Patient characteristics

Patients	Follow-up (months)	Sex	Age	BMI	Indication for primary THA	Reason for the revision	Paprosky type	Revision surgery
1	28	F	82	25	Rheumatoid arthritis	Septic loosening	IIIB	2
2	63	F	73	23	Osteoarthritis	Recurrent dislocation	IIIA	1
3	60	F	68	18	Osteoarthritis	Aseptic loosening	IIIA	1
4	13	F	70	22	Osteoarthritis	Septic loosening	IIIB	3
5	24	F	81	29	Rheumatoid arthritis	Septic loosening	IIIB	2
6	20	F	79	27	Osteoarthritis	Septic loosening	IIIB	2
7	29	F	63	21	Residual hip dysplasia	Septic loosening	IIIB Discontinuity	5
8	72	M	73	23	Rheumatoid arthritis	Aseptic loosening	IIIB	1
9	31	M	80	27	Osteoarthritis	Aseptic loosening	IIIA	2
10	65	M	68	26	Osteoarthritis	Septic loosening	IIIB	2

BMI = body mass index; THA = total hip arthroplasty.

The area of the acetabular bone defect was estimated with a specific image processing program (Mimics, Materialise).

Total radial acetabular bone loss was measured following the method described by Gelaude et al.[9] Bone quality was evaluated by the program in all cases and quantified in Hounsfield units (Figure 1) and, with this information, a precision calculation was made to place the screws in a divergent manner in areas where good bone quality was available so that they would have an optimal grip and, in this way, obtain the maximum possible stability.

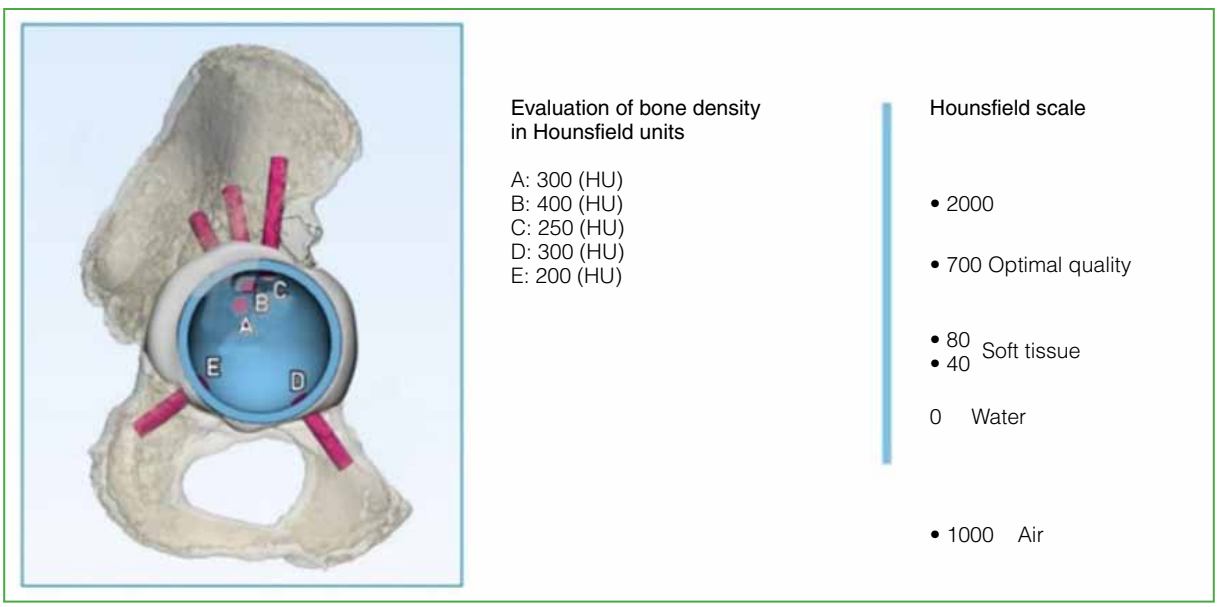

Figure 1. Evaluation of bone density in Hounsfield units (HU).

Prior to the final manufacture of the 3D implant, the technicians and design engineers and the surgeon communicated constantly to optimize the inclination, anteversion and center of rotation of the implant. This communication between the bioengineer and the surgeon is critical for achieving the highest precision in implant development. Thus, two implants are manufactured; first, a plastic prototype of the implant and the affected hemipelvis, which is sterilized and used during surgery to reduce the margin of error. Secondly, the implant is custom made in definitive trabecular titanium.

Selection of the cemented implant

The degree of cup constraint was determined on a patient-by-patient basis. Dual-mobility cups were indicated for patients without comorbidities, increasing the degree of constraint according to the personal risk of dislocation, one of the most common complications of this technique. Patients with extensive abductor mechanism involvement were assessed using MRI, which was requested with a CT scan prior to surgery, to establish their risk of instability.

Before each surgery, synovial fluid was aspirated by arthrocentesis to rule out prosthesis-related infection. Patients with a diagnosis of periprosthetic infection underwent a two-stage revision and definitive surgery was performed with the authorization of the Infectious Diseases Department after complete targeted antibiotic treatment and a recorded decrease in serological markers.

Surgical technique

Preoperative antibiotic prophylaxis was indicated, in addition to tranexamic acid at the time of anesthetic induction and at wound closure.

All surgeries were performed by the same surgical team. The patient was placed in the lateral decubitus position with conventional preparation. An extended posterolateral hip approach was performed in all cases, which was deepened to the articular plane with subsequent tissue debridement to expose the acetabular defect and achieve adequate exposure of the ilium, ischium, and pubis. Osteophytes were removed as determined by preoperative planning.

During surgery, the surgeon relied on the anatomical plastic prototype of the hemipelvis and the trial implant as a guide to identify the defect calculated in the previous CT scan analysis.

First, the trial implant was placed according to the planned setting and the function and stability were evaluated. Subsequently, the trial prototype was removed and the definitive 3D cup was implanted in the acetabular defect and fixed with screws using the placement guides; three screws were placed in the ilium, one in the pubis and two crossed screws in the ischium, which provides greater stability to the implant. Finally, a cup with a varying degree of constraint was cemented into the custom-made implant, depending on the requirements of each patient. It should be highlighted that the 3D implant offers versatility in the selection of numerous cup choices with varying degrees of constraint that can be cemented into the implant to meet the patient's circumstances and lessen the risk of instability. In addition, it allows to improve the component orientation, if necessary. In other words, the cemented cup selected has an anteversion and inclination that are independent of the 3D implant, resulting in acceptable stability and a lower dislocation rate.

A joint drain was left in all cases (for 48 h) and the wound was closed in layers.

Postoperative protocol

Postoperative analgesia began with ropivacaine wound infiltration during closure and was maintained with intravenous ketorolac combined with oral paracetamol. This multimodal pain management, together with the administration of enoxaparin for 30 days, facilitates physical and rehabilitation therapy, expediting hospital discharge and decreasing the risk of deep vein thrombosis.

Patients were mobilized early, allowing them to stand on the first day following surgery. Partial weight-bearing was indicated for the first three weeks, followed by a progression to full weight-bearing 6 to 8 weeks after surgery.

Serial radiographs of the pelvis (anteroposterior, axial, alar, and obturator views) were taken in the immediate postoperative period, and after one week, one month, and three months, where osseointegration of all implants was observed (Figure 2). Annual control radiographs were then taken. A follow-up CT scan was also requested after three months.

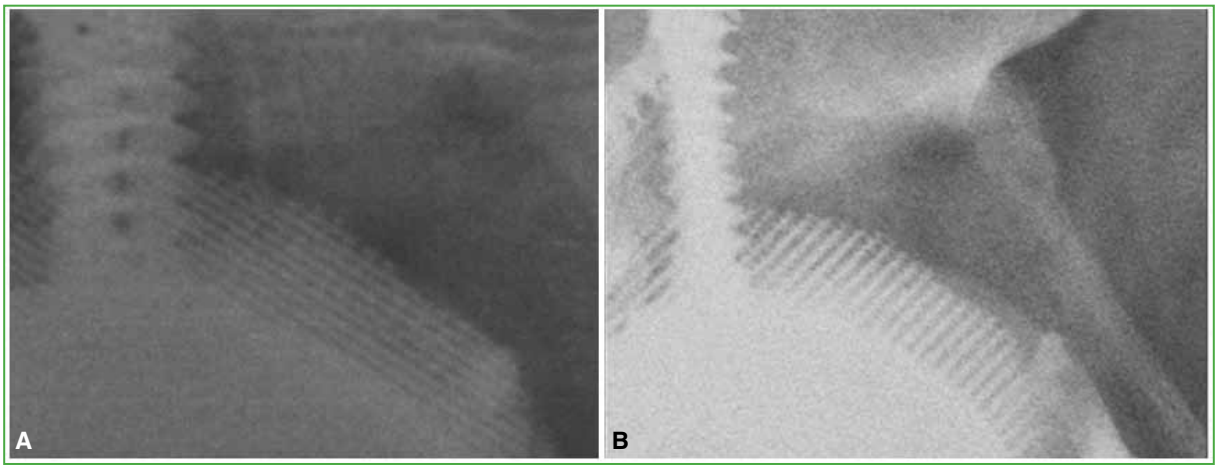

Figure 2. A. Magnified radiograph of the right hip, AP view, in the immediate postoperative period. The trabecular metal of the 3D implant is observed. **B.** Magnified radiograph of the right hip, AP view, 3 months after surgery. Signs of osseointegration are detected around the trabecular metal.

RESULTS

In the final analysis, 10 patients were included (Table 1), the mean follow-up was 40.5 months (range 13-72). Seven patients were female and three were male, with a mean age of 73.7 years (range 63-82). The mean body mass index was 24.1 kg/m^2 (range 18-29). Indications for primary THA were diagnoses of hip dysplasia (n = 1), rheumatoid arthritis (n = 3) and osteoarthritis (n = 6).

Patients had undergone an average of 2.1 revision surgeries (range 1-5).

All had a poor functional score prior to surgery. HHS improved from 24.2 (range 10-40) at admission to 63.5 (range 35-92) in the last control. The mean OHS was 34.5 (range 15-46) and the mean SF-36 was 68.8 (range 58-95) (Table 2). In the final control, the patient's range of motion, pain relief, and independence improved after surgery when compared to pre-surgical values, as evidenced by the aforementioned functional scores.

Table 2. Comparison of preoperative and postoperative functional scores.

Patients		Preoperative evaluation			Postoperative evaluation	
	HHS	OHS	SF-36	HHS	OHS	SF-36
1	40	18	48	65	40	70
2	25	15	32	70	36	72
3	38	18	42	92	46	95
4	10	16	20	35	35	40
5	21	19	35	82	39	80
6	24	17	36	60	36	69
7	15	21	25	58	32	65
8	20	18	29	50	24	58
9	28	10	35	52	15	58
10	21	19	32	71	42	81
Average	24,2	17,1	33,4	63,5	34,5	68,8

HHS = Hip Harris Score; OHS = Oxford Hip Score; SF-36 = Short Form-36 Health Survey.

Anteroposterior radiographs of the pelvis, and alar and obturator radiographs of the affected hip were taken one week, one month, and three months after surgery and then annually. Following Manaster's criteria,[10] no signs of loosening or migration of the 3D cup in terms of inclination and anteversion were observed in any case in the last control (Figure 3), so that the medium-term implant survival, according to the Kaplan-Meier method, is 100% (Table 3). A control CT scan was performed three months after surgery where the osseointegration of all implants was confirmed.

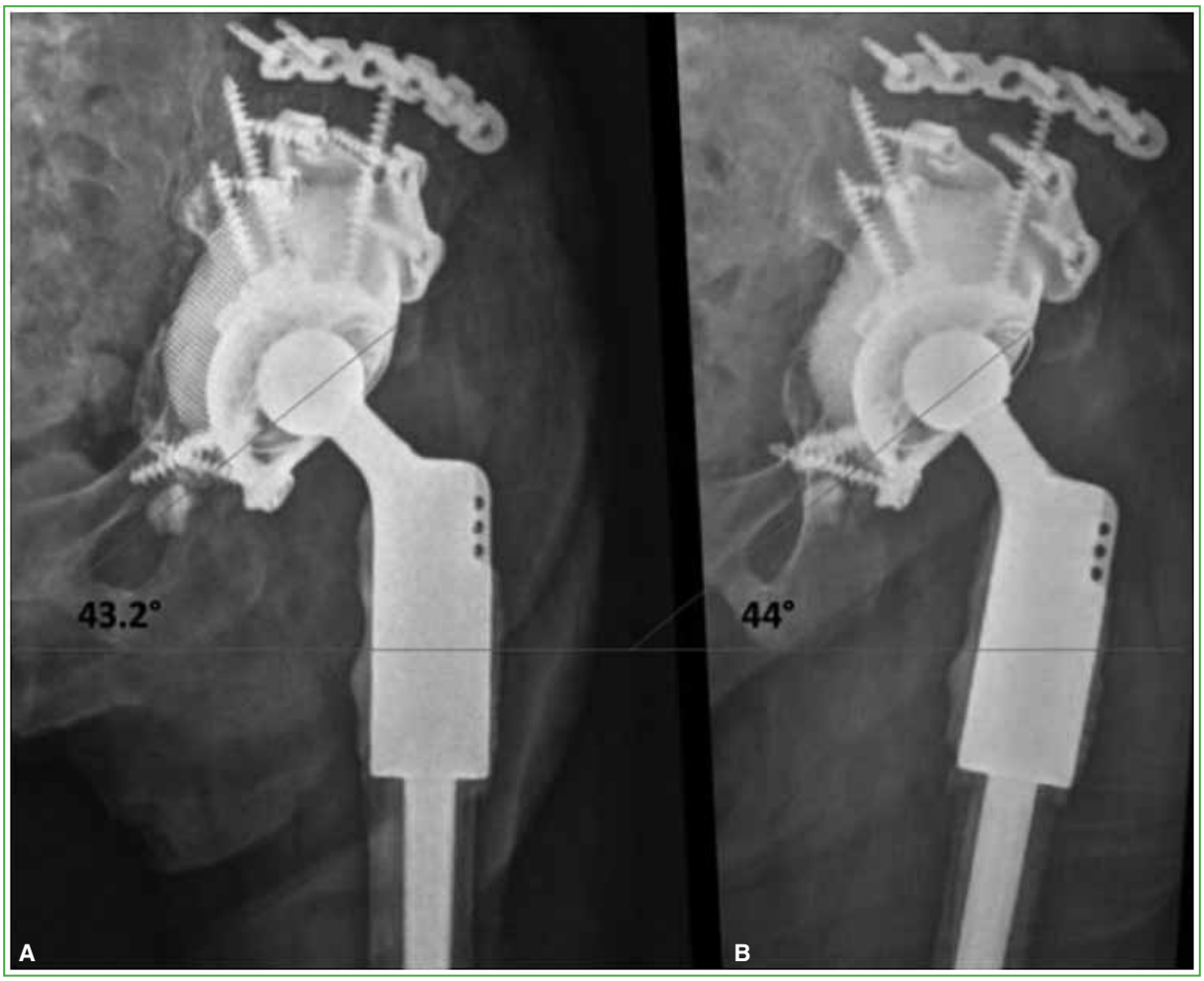

Figure 3. Anteroposterior radiographs of the left hip. Radiographic control of inclination and anteversion. **A.** Immediate postoperative period. **B.** 29 months after surgery.

Regarding the degree of constraint of the cemented cup within the 3D implant, dual-mobility cups were indicated to seven patients who had a sufficient abductor mechanism and appropriate stability. In the remaining three patients, given the loss of continuity of the abductor mechanism and the intraoperative maneuvers with a significant risk of dislocation, it was decided to increase the constraint and cement a tripolar cup. It should be noted that, in these last three patients, acetabular reconstruction was combined with a non-conventional femoral prosthesis, due to the loss of bone stock in the proximal femur. From the above, it is clear that the implant constraint was chosen specifically for each patient based on his or her requirements.

Table 3. Implant survival according to the Kaplan-Meier method.

Patient	Months	Survival %
1	13	100
2	20	100
3	24	100
4	28	100
5	29	100
6	31	100
7	60	100
8	63	100
9	65	100
10	72	100

Complications

Four of the 10 patients suffered complications, resulting in a 40% complication rate. A recurrent dislocation occurred during the first six weeks of surgery; this complication was treated by increasing the degree of constraint by removing a dual-mobility cup and replacing it with a more constrained cup cemented into the 3D implant. One patient suffered from sciatic nerve neuropraxia, which resolved in the third month following surgery. Two patients required mechanical-surgical debridement due to persistent secretion through the wound within the first three postoperative weeks, the evolution was good and no further interventions were necessary.

DISCUSSION

Acetabular bone loss remains a major surgical challenge in revision THA. With custom implants, acceptable outcomes were achieved with a significant improvement in function. In this study, all patients had at least one Paprosky type III acetabular defect and one had pelvic discontinuity.

The optimal surgical strategy for these patients has not yet been defined. The multiple procedures described, such as the use of large-sized cups, structural grafts or reconstruction cages, among others, did not achieve favorable outcomes in the medium and long term. As reported in the study by Sembrano and Cheng,[11] acetabular reconstruction with reconstruction cages had a 5-year survival rate of 87.8% and and a radiological loosening rate of 80.7%. Similarly, Amenabar et al. found that reconstruction cages and structural grafting resulted in an 85% survival rate after 10 years.[12]

In this study, functional and radiographic outcomes were evaluated after custom implant placement in patients with severe acetabular bone defects. This technique is particularly useful in older patients in whom the aim is to resolve the condition and restore function quickly, rather than prioritizing the supply of bone stock. In general, satisfactory clinical and radiographic outcomes were observed. Our results are comparable with those of recent research.

In the study by Wind et al., 19 patients were evaluated after placement of custom-made implants during an average follow-up of 31 months. The HHS improved significantly from 38 to 63.[13]

Similarly, Taunton et al. studied pelvic discontinuity in 57 patients, at an average of 65 months after the use of custom implants, and reported a final HHS of 74.8.[14] In the study with the longest follow-up (average 10 years), HHS improved from 41 to 80.[15]

A systematic review published by Chiarlone et al. investigated custom-made acetabular implants for severe acetabular bone defects and obtained satisfactory medium-term clinical and radiographic outcomes. The survival rate of the acetabular component ranged from 86.5% to 100%, but the reoperation rate was 24.5%.[16] Only one patient

in our study experienced a hip dislocation following 3D cup implantation and underwent revision surgery, which included the implantation of a cup with greater constraint and an improvement in anteversion and tilt, allowing us to intervene in the likely reasons. In this situation, the use of cups with different degrees of constraint will reduce the risk of prosthesis dislocation, one of the main complications described. We believe that the determination of preoperative cup constraint is essential to reduce the risk of dislocations.

In the review by De Martino et al., only 1.7% had aseptic loosening of custom-made implants. However, the overall complication rate was 30%.[17] In our study, the complication rate was 40%. However, none of the implants had to be removed due to postoperative complications.

One of the strengths of the study is that both the surgical interventions and the follow-up of the patients were performed by the same team. Likewise, no patient was lost during the follow-up, so we have a complete record of them and their evolution over time.

This study has several limitations. The main ones are the small sample size and the lack of a control group, as well as its retrospective design. Only retrospective trials investigating custom-made hip implants for severe acetabular defects are available. However, a prospective trial would be beneficial and should be conducted in the future.

CONCLUSIONS

Custom-made acetabular implants represent a valid solution for treating severe acetabular bone defects and Paprosky type IIIA-B pelvic discontinuity. This strategy enables the implant to be adjusted to the residual receptor bone, thereby avoiding bone deficiency and restoring hip biomechanics, as well as to cement inside a cup with an independent orientation to the 3D implant, with satisfactory clinical and radiographic outcomes in the medium-term follow-up. However, long-term results still need to be evaluated.

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

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Preliminary Outcomes with Dual Mobility Cups in Patients Older Than 65 With Hip Fractures. A Retrospective Analysis of 102 Patients

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ABSTRACT

Objective: This retrospective study aimed to assess the functional outcomes and dislocation rate in the treatment with dual mobility prostheses in patients older than 65 with hip fractures. **Materials and Methods:** We analyzed all patients treated between 2017 and 2021 for hip fractures in our service. We included patients older than 65 years, treated with dual mobility cups, and a minimum follow-up of 24 months. We analyzed demographic data, comorbidities, functional outcomes (Parker score and Harris Hip Score, HHS), complications (infection, dislocation, loosening), reoperations, and revisions. **Results:** We included 102 hip fractures (75 medial and 27 intertrochanteric) in 102 patients. Seventy-four (72.5%) were women, the mean age was 80.59 6.92 years, the mean Charlson index was 4.71 (range 3-10), and ASA was 2.47 (1-4). 93.1% started walking on the second postoperative day. 94.1% presented excellent or very good outcomes according to the HHS, the postoperative Parker index did not show significant differences in comparison to the preoperative one ($p < 0.05$). The average follow-up was 30 months (range 24-60). There were 8 (7.84%) complications: 2 (1.9%) deep vein thrombosis, 4 (3.9%) pulmonary thromboembolism, 3 infections (2.9%), and 1 (0.9%) dislocation. The reoperation rate was 2.9%. **Conclusions:** We obtained acceptable functional outcomes using dual mobility cups with a relatively low dislocation rate (0.9%). This suggests that these implants are an option to consider in treating these lesions.
Keywords: Elderly patients; hip fracture; double mobility prosthesis; dislocation; reoperation.
Level of Evidence: IV

Resultados iniciales del uso de cotilos de doble movilidad en pacientes >65 años con fractura de cadera. Análisis retrospectivo de 102 casos

RESUMEN

Objetivo: El objetivo de este estudio retrospectivo fue evaluar los resultados funcionales y la tasa de luxación en pacientes <65 años con fractura de cadera operados con prótesis de doble movilidad. **Materiales y Métodos:** Se analizó a los pacientes tratados por una fractura de cadera entre 2017 y 2021. Se incluyó a pacientes >65 años, tratados con copas de doble movilidad y un seguimiento mínimo de 24 meses. Se analizaron los datos demográficos, las comorbilidades, los resultados funcionales (Parker y puntaje de Harris), las complicaciones (infección, luxación, aflojamiento), las reoperaciones y revisiones. **Resultados:** Se trataron 102 fracturas de cadera (75 mediales y 27 intertrocantéricas) en 102 pacientes. El 72,5% eran mujeres (media de la edad 80.59 6.92 años), el Índice de Comorbilidad de Charlson promedio fue de 4,71 y el puntaje ASA, 2,47. El 93,1% comenzó a caminar al segundo día de la cirugía. Según el puntaje de Harris, los resultados fueron excelentes o muy buenos en el 94,1%; los puntajes de Parker preoperatorio y posoperatorio no difirieron significativamente ($p <0,05$). El seguimiento promedio fue de 30 meses. Hubo 8 (7,84%) complicaciones: 2 (1,9%) casos de trombosis venosa profunda, 4 (3,9%) de tromboembolismo pulmonar, tres infecciones (2,9%) y una (0,9%) luxación. La tasa de reoperaciones fue del 2,9%. **Conclusiones:** Con el empleo de copas de doble movilidad se obtuvieron resultados funcionales aceptables y una tasa de luxación relativamente baja (0,9%). Esto sugiere que estos implantes representan una opción en el tratamiento de estas lesiones.
Palabras clave: Pacientes añosos; fractura de cadera; prótesis de doble movilidad; luxación; reoperación.
Nivel de Evidencia: IV

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INTRODUCTION

The effectiveness of total hip arthroplasty (THA) in elderly adults with hip fracture has been demonstrated, making it a widely accepted therapeutic modality.[1,2]

Despite the excellent functional outcomes achieved with this treatment, dislocation of the prosthesis is a relatively frequent complication.[3] In older adults undergoing THA for hip fracture, the rate of dislocation is as high as 10%, which is five times higher than when performed for hip osteoarthritis.[4]

In recent years, the use of dual-mobility cups to treat these injuries has increased,[5] as it combines Charnley's[6] principle of a low-friction head with McKee and Watson-Farrar's[7] principle of using a larger femoral head to prevent dislocation. Different authors have reported relatively low dislocation rates with these implants in hip fracture patients.[8,9] These cups consist of a head that moves within a larger secondary acetabular cup that, in turn, has mobility over the cup. By breaking down motion, this design allows for a wider range of motion without compromising intraprosthetic stability.[10,11]

Very few reports have been published on the use of these implants in hip fractures in our country.[11,12]

The aim of this retrospective study was to evaluate the functional outcomes and dislocation rate of dual mobility prosthesis treatment in patients >65 years of age with hip fracture.

MATERIALS AND METHODS

We retrospectively analyzed all patients treated consecutively for hip fracture in our Service between January 2017 and June 2021. Inclusion criteria were: hip fracture, treatment with a dual mobility prosthesis, age >65 years and a minimum follow-up of 24 months. Patients treated with another type of arthroplasty (hemiarthroplasty or THA without dual mobility cup), history of surgery on the affected hip, pathological fractures and those treated for inveterate fractures (>90 days) were excluded.

Treatment with dual-mobility prosthesis was recommended for older patients (>65 years old) with poor bone quality evaluated on fracture radiography using the Dorr index, who were able to walk outside the home for at least 100 m, or had symptoms of hip osteoarthritis > Tönnis grade 2.

The national prostheses used were made of a metallic cup (Polygram), a mirror polished stem (Cyclon), and a 28 mm diameter modular metallic head attached to a dual-mobility polyethylene cup (Fico, Ortopedia Alemana, Argentina) (Figure). Depending on the cervico-diaphyseal angle, a standard offset or lateralized stem was used according to the preoperative planning. Prosthesis fixation on both prosthetic components was cemented in all cases.

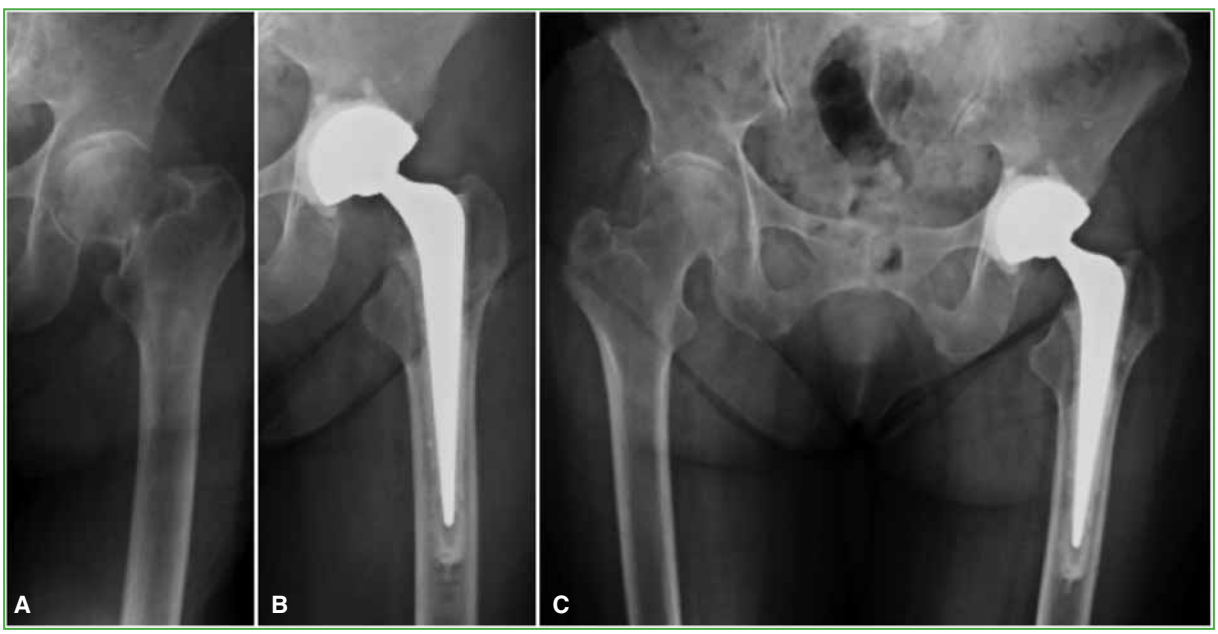

Figure. Anteroposterior radiograph of the left hip. **A.** An alteration of the shape compatible with medial fracture is observed. **B.** Reconstruction with total cemented prosthesis, with a dual mobility cup. **C.** Evolution at 12 months.

Surgical technique

The same surgical team operated on all patients in a laminar flow operating room, utilizing a Bauer approach in dorsal decubitus. Hypotensive spinal anesthesia was administered, except when general anesthesia was administered due to anesthetic or cardiologic indications.

To pressurize the cement, a distal plug was placed, and cementing was done retrogradely with a gun. In all cases, a continuous suture of the abductor mechanism was performed. Antithrombotic prophylaxis consisted of subcutaneous enoxaparin and bandages on both lower limbs for four weeks. As infectious prophylaxis, 1 g of cefazolin was administered intravenously (one dose before surgery and two doses after, every 8 h).

Rehabilitation was the same for all patients and consisted of isometric exercises and bed sitting on the first day after surgery. From the second day on, standing and walking with a walker without weight-bearing restrictions were permitted, depending on pain tolerance. Postoperative clinical-radiological controls were performed after 3 and 6 weeks, after 3, 6 and 12 months, and then annually.

At the time of closing the study, patients who had not attended the control in the previous year or who had not finished the follow-up were summoned for control or phoned to inquire if they were able to walk and if they did so with assistance, and a radiographic control was requested.

Variables analyzed

Gender, age, fracture type (medial or lateral), comorbidities (Charlson Comorbidity Index[13] and American Society of Anesthesiologists (ASA) classification), and previous walking abilities (Parker score)[14] were the variables examined by analyzing hospital records.

The days from admission to surgery were also documented, because some patients required some form of clinical stabilization before surgery due to comorbidities, as well as the postoperative day they began walking.

Anteroposterior and lateral hip radiographs were analyzed for signs of demarcation or loosening of components according to the DeLee-Charnley and Gruen zones.[15] Any complications inherent to the procedure and reoperations were also recorded.

The objective analysis of the results was performed according to the Harris hip score criteria,[16] grouping them into excellent, good, fair and poor, and with the Parker score after surgery.

Statistical Analysis

Qualitative variables are expressed as frequency and percentages, and numerical variables as mean and standard deviation or median and interquartile ranges, according to their distribution. The comparative analysis of the categorical variables was performed with the chi-squared test (or Fisher's exact method), while the numerical variables were analyzed with Student's t-test. A p-value <0.05 was considered statistically significant.

All data were entered into an Excel® spreadsheet (Redmond, USA) and the GraphPad Prism® 9.0 program (LaJoya, CA, USA) was used for statistical calculations.

RESULTS

In the period analyzed, 257 patients with hip fractures were treated, 155 were excluded (98 treated with hemiarthroplasty; 27, with THA without a dual mobility cup; 11 pathological fractures, 11 cases lost to follow-up, 6 with a history of surgery on the fractured hip and 2 inveterate hip fractures).

The final series consisted of 102 patients with 102 hip fractures (75 medial [73.5%] and 27 lateral [26.5%]). The characteristics of the patients analyzed are detailed in the Table.

The average number of days from hospitalization to surgery was 2.12 (range 1-16). Seventy-three patients (71.5%) were operated on before 72 h of admission and a subgroup of 29 patients required stabilization of some clinical parameter to face surgery. The average time from admission to surgery for this group was 5.8 days (range 4-16).

Gait and need for assistance after surgery

Regarding walking, 95 (93.1%) patients started walking on the second day after surgery; five (4.9%), from the third day; one (0.9%), from the fourth day and another (0.9%) did not walk. At the last control, 47% needed assistance, 98 patients (96.1%) walked outside the home and three (2.9%) walked inside the home; one did not walk again.

Table. Summary of the characteristics of the patients included in the series.

Variable	
Female sex, n (%)	74 (72.5%)
Age (years), mean, standard deviation	80.59 ± 6.92
CCI, Median (range)	4.71 (3-10%)
ASA score, median (range)	2.47 (1-4%)
Preoperative Parker score, median (range)	6.36 (3-9%)
Ability to walk before fracture, n (%) Outside the home With assistance	 102 (100) 44 (43.1%)
Days from admission to THA, median (range)	2.12 (1-16%)
Type of fracture, n (%) Medial Lateral	 75 (73.5%) 27 (26.5%)
Follow-up (months), median (range)	30 (12-60)

CCI = Charlson Comorbidity Index; ASA = American Society of Anesthesiologists; THA = total hip arthroplasty.

The median Harris hip score at the end of follow-up was 85.9 (range 62-93), with excellent outcomes in 64 (62.7%) cases, good in 32 (31.4%), fair in four (3.92%) and poor in two (1.9%).

The mean postoperative Parker index was 6.17 (range 0-9), with no significant differences (p = 0.43) in comparison to preoperative values.

Complications, dislocation and reoperations

There were eight complications (7.84%): two (1.9%) cases of deep vein thrombosis that evolved favorably with medical treatment; four (3.9%) patients with pulmonary thromboembolism (two were cured with medical treatment and two were hospitalized in intensive care for three days; in one of them, it was also necessary to place a filter in the vein and antiplatelet therapy; their evolution was favorable). Three patients (2.9%) suffered acute infections: one superficial infection resolved with antibiotic treatment; and two deep infections were treated with surgical debridement plus intravenous antibiotics. One patient evolved favorably and the other died one month after the debridement. Finally, one (0.9%) suffered an intraoperative greater trochanter fracture requiring wiring.

Only one case of dislocation (0.9%) was detected up to the close of the study. Eight months after arthroplasty, the patient sustained a periprosthetic fracture of the greater trochanter as a result of a fall from his own height, had three episodes of dislocation, underwent trochanter osteosynthesis with a cable plate, and no episodes of dislocation recurred.

The reoperation rate was 2.9% (n = 3); two (1.9%) cases for infection and one (0.9%) for trochanter fracture and dislocation.

Finally, the mortality rate within 24 months of surgery was 10.7% (n = 11), two patients died in the immediate postoperative period (within 4 weeks).

Radiographic analysis

At the end of the study, one patient developed demarcation signs (DeLee-Charnley zone 1 and Gruen zone 2-6) that were not clinically significant, therefore he continued with controls.

DISCUSSION

The main finding of this study was that the use of dual mobility cups in older adults with hip fractures achieves acceptable functional outcomes associated with a low dislocation rate.

In the prosthetic treatment of hip fractures in patients >65 years of age, current evidence has shown that THA achieves superior functional outcomes in comparison to other therapeutic options, such as hemiarthroplasty. Blomfeldt et al.[17] and Hedbeck et al.[18] reported higher Harris hip scores in patients treated with a THA. In our series, 94.1% obtained excellent or good functional outcomes, with a mean Harris score of 85.9 at 24 months follow-up.

Another important aspect of treatment in this group of patients is that THA allows for rapid mobilization. This would decrease complications caused by prolonged bed rest, such as urinary tract infections, pneumonia, thrombosis and bedsores.[17,18] Pfeufer et al. demonstrated that with prompt mobilization and full weight bearing, operated patients obtained higher Parker scale scores, indicating improved postoperative ambulatory capacity.[19] In our study, 93.1% of patients were capable of walking 48 hours after surgery, with an average Parker score of 6.17 and no statistically significant differences from their preoperative values.

Postoperative dislocation is still a concern in hip fracture patients treated with THA. Johansson et al.[20] reported a 22% rate of instability after THA for medial fracture in patients >70 years with the use of conventional cups, whereas, in a meta-analysis of 746 patients, Lu-Yao et al.[21] obtained dislocation rates of 10.7%. Comparatively, some reports on the use of dual-mobility cups in hip fracture patients indicate lower rates than those mentioned.[11,21] In a systematic review of 10,783 THAs with dual-mobility cups, Darrith et al.[22] published a dislocation rate of 0.46% in hip fracture patients, and Adam et al.[23] reported a rate of 1.4% on 214 hip fractures. In our study, the dislocation rate was similar to that reported by these authors, with an incidence of 0.9%. We believe that this rate is attributable, in part, to the use of dual-mobility cups and the increased range of motion they provide, but it could also be influenced by the approach taken. the direct lateral approach resulted in lower dislocation rates than the posterolateral technique.[24] We believe it also has advantages in the treatment of fractures, such as facilitating access to the fracture and the removal of the head-neck fragment; on the other hand, the dorsal decubitus position facilitates both limb length measurement and anesthesiologist actions in this fragile group of patients.

Taking into account the condition treated, the mean age of the series (80 years) and the comorbidities (Charlson comorbidity index 4.71), we understand that the complication (9.6%) and reoperation (2.9%) rates in this study were acceptable. Comparatively, Rashed et al.[25] published a 16% complication rate in 31 patients with a mean age of 79 years, while Adam et al.[23] reported a reoperation rate of 3.4% (3 for infection and 5 for periprosthetic fracture) in 214 patients with a mean age of 83 years. The latter is similar to that found in this study, where reoperations were mostly related to infectious processes (2/3) and periprosthetic fracture (1/3).

The limitations of this research are those of a retrospective study, in which the patients analyzed had a substantial amount of clinical history, which, when merged or added together, could influence the outcomes regarding complications through biases. Another limitation, although it was not the objective of the study, is represented by the absence of a control group, which could give greater strength to our results.

The strengths are centered on the number of patients operated on in the same institution, by the same surgical team, with identical preoperative and postoperative evaluations, and treated with the same surgical technique and implant.

CONCLUSION

The results of this study suggest that dual-mobility cup THA is a therapeutic option to consider in older adults with hip fracture. The rate of good functional outcomes was 94% and the postoperative dislocation rate was low.

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

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Extended Oral Antibiotic Prophylaxis in Primary Hip Arthroplasty: Does it Decrease Periprosthetic Joint Infections?

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ABSTRACT

The prevalence of periprosthetic infections (PPIs) after primary total hip arthroplasty (THA) is approximately 2%. The objective of this study is to determine if there are statistically significant differences between the proportion of acute PPIs with extended oral antibiotic prophylaxis (7 days) vs standard oral antibiotic prophylaxis (24 hours).

A prospective clinical trial was conducted between July 2021 and May 2022. A total of 28 adult patients with hip fracture underwent a primary arthroplasty and received extended oral antibiotic (EOA) prophylaxis for 7 days with first-generation cephalosporins. They were compared to a secondary database of the hospital registry, which included a total of 95 adult patients with hip fractures who underwent primary arthroplasty and received a standard oral antibiotic (SOA) prophylaxis for 24 hs. In the EOA group, the rate of acute PPI was 10.71%, while in the SOA group it was 17.89%. When comparing the rate in both groups, no statistically significant differences were found (p=0.36). Although the available literature suggests that extended antibiotic prophylaxis can be a simple, safe, and cost-effective measure to counteract the patient's non-modifiable factors and thus reduce periprosthetic infections, our study found no evidence that it reduces the proportion of acute PPI at 30 days in primary hip arthroplasties.

Keywords: Periprosthetic joint infections; primary hip arthroplasty; extended oral antibiotic prophylaxis; standard oral antibiotic prophylaxis.

Level of Evidence: II

Profilaxis antibiótica extendida para pacientes sometidos a una artroplastia de cadera primaria: ¿disminuye el riesgo de infecciones periprotésicas?

RESUMEN

Introducción: La prevalencia de infecciones periprotésicas luego de una artroplastia total de cadera primaria es aproximadamente del 2%. El objetivo de este estudio fue determinar si existen diferencias estadísticamente significativas entre la tasa de infecciones periprotésicas agudas ante una profilaxis antibiótica extendida (7 días) y una profilaxis antibiótica estándar (24 h). **Materiales y Métodos:** Se realizó un estudio clínico prospectivo, entre julio de 2021 y mayo de 2022, que incluyó a 28 adultos con fractura de cadera sometidos a una artroplastia primaria que recibieron profilaxis antibiótica con cefalosporinas de primera generación durante 7 días a quienes se comparó con 95 adultos con fracturas de cadera con una artroplastia primaria y profilaxis antibiótica de 24 h, extraídos de una base de datos secundaria del registro del hospital. **Resultados:** La tasa de infecciones periprotésicas agudas fue del 10,71% en el grupo con profilaxis extendida y del 17,89% en quienes recibieron profilaxis estándar, sin diferencias estadísticamente significativas (p = 0,36). **Conclusiones:** Si bien, según la bibliografía disponible, la prolongación de la profilaxis antibiótica puede ser una medida simple, segura y rentable para contrarrestar los factores no modificables del paciente y así reducir las infecciones periprotésicas; en este estudio, no se demostró que la profilaxis antibiótica extendida disminuya la tasa de infecciones periprotésicas agudas a los 30 días en pacientes con artroplastias de cadera primarias.

Palabras clave: Infecciones periprotésicas; artroplastia de cadera primaria; profilaxis antibiótica extendida; profilaxis antibiótica estándar.

Nivel de Evidencia: II

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INTRODUCTION

Periprosthetic joint infections (PJI) are often devastating and represent a major public health problem. Its prevalence following primary total hip arthroplasty (THA) is estimated to be approximately 2%.[1]

There is no consensus definition of PJI in the world, as there is no single reference diagnostic test. It is a developing concept that will evolve as scientific evidence is updated.[2] In 2018, major and minor criteria for diagnosis were established at the Second International Consensus on Periprosthetic Joint Infection held in Philadelphia (Table 1).[3]

Table 1. Major and minor criteria for the diagnosis of periprosthetic joint infection

Major criteria (any of the following)	Fistula communicating with the prosthesis
	Isolation of the same microorganism in at least 2 samples of periprosthetic tissue or synovial fluid.
Minor criteria (6 or more)	Elevated C-reactive protein or D-dimer values >100 mg/l
	Leukocyte count in joint fluid >10,000
	Leukocyte esterase: ++
	Alpha-defensin: 1.0
	Elevated polymorphonuclear leukocytes in synovial fluid (%): 90%
	Pus inside the affected joint
	Isolation of a microorganism from a single intraoperative tissue or joint fluid sample.
	≥5 polymorphonuclear leukocytes per high-power field observed at ≥5 high-power fields (400x magnification)[6]

Postoperative antibiotics and duration of treatment have been identified as critical factors when discussing PJI. During the first 2 h after surgery, host defense mechanisms decrease the overall bacterial load and, in the following 4 h, it remains constant, as host defenses eliminate bacteria at the same rate as they replicate. The first 6 h are known as the "golden period", after which bacteria multiply exponentially. Postoperative antibiotics effectively decrease the bacterial load and extend this "golden period".[1]

The hypothesis of this prospective study was that administration of antibiotics for 7 days after surgery further prolongs this golden period and that differences in the rate of acute PJI are statistically significant when compared to administration of antibiotics for 24 h postoperatively.

The objective of the study was to determine whether there are statistically significant differences in the rate of acute PJI between extended antibiotic prophylaxis (EAP) and standard antibiotic prophylaxis (SAP).

MATERIALS AND METHODS

A prospective clinical study was conducted between July 2021 and May 2022. Inclusion criteria were: adult patients with a total or partial hip arthroplasty secondary to a lateral or medial fracture, antibiotic prophylaxis with first-generation cephalosporins intravenously. Exclusion criteria were: patients with arthroplasty secondary to hip osteoarthritis, revision arthroplasty, resection arthroplasty, osteosynthesis in hip fractures, prophylaxis with an antibiotic other than a first-generation cephalosporin, subacute or chronic PJI, infection of another concomitant site (urinary tract, respiratory tract, skin or soft tissues), preoperative antibiotic therapy, lack of postoperative follow-up, and deaths before surgery.

Twenty-eight adult patients with hip fracture who had undergone a primary THA and had received prophylaxis with a first-generation cephalosporin for 7 days (EAP group) were included. This EAP consisted of 1 g of a first-generation cephalosporin administered intravenously, every 8 h, for 7 days to patients weighing <80 kg and 2 g for those >80 kg. Five fractures (17.86%) were caused by lateral hip fractures, while 23 (82.14%) were caused by medial hip fractures (Figure 1).

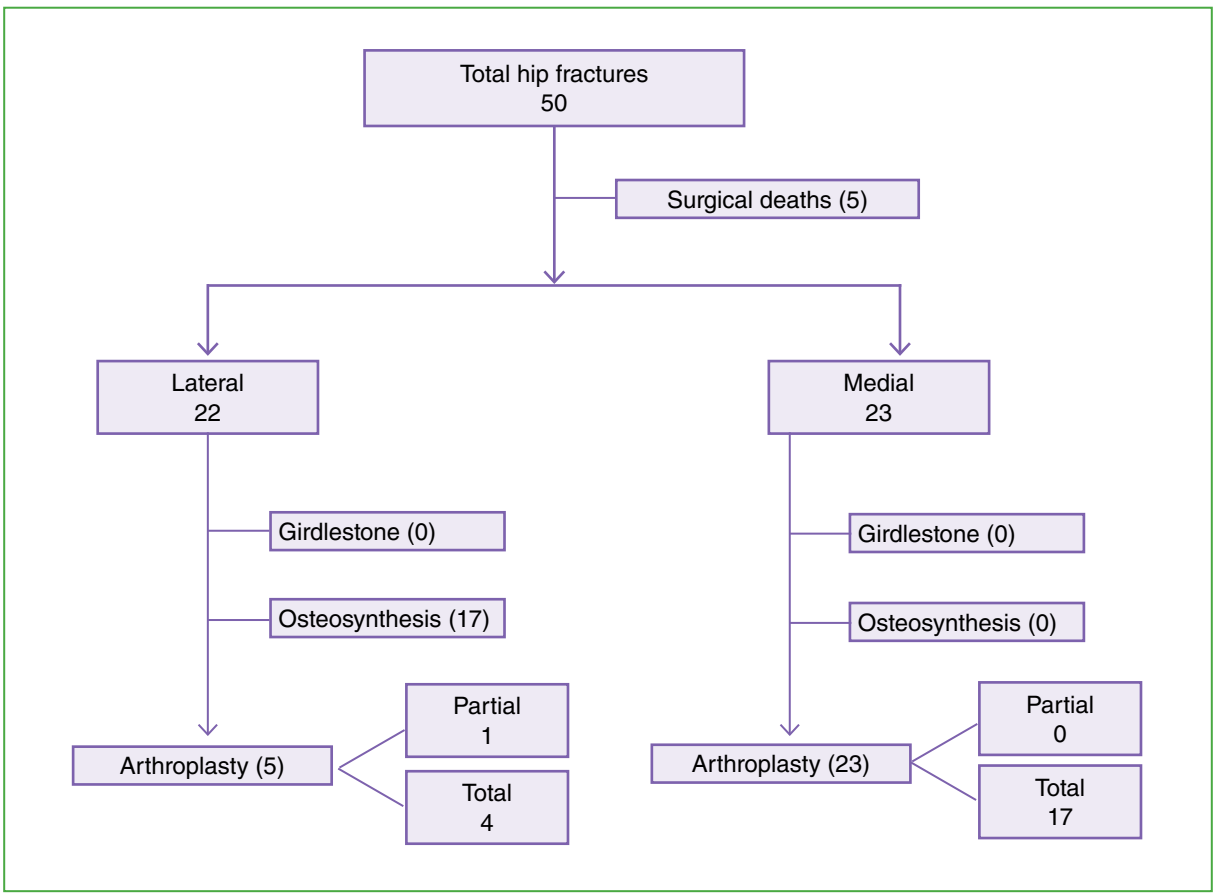

Figure 1. Extended antibiotic prophylaxis (7 days).

For comparison, we used the Department's own secondary database, which contains information on all patients operated on since 2011. The period analyzed was from June 2017 to June 2021. The registry contains patient information, date of surgery, hospital stay, comorbidities, implant survival, postoperative clinical outcomes and complications, including PJI. All data were corroborated by the electronic medical records of the institution's operating system.

The second group (SAP) consisted of 95 adults with hip fracture undergoing primary THA, who had been administered prophylaxis with a first-generation cephalosporin intravenously, for 24 h. This SAP consisted of 1 g of a first-generation cephalosporin administered intravenously every 8 h for 24 h to patients weighing <80 kg and 2 g for those >80 kg. Eighteen fractures (18.95%) were caused by lateral hip fractures, while 77 (81.05%) were caused by medial hip fractures (Figure 2).

In both groups, first-generation cephalosporins were used because they are the antibiotic of choice in Argentina for antibiotic prophylaxis in all trauma surgery.[4]

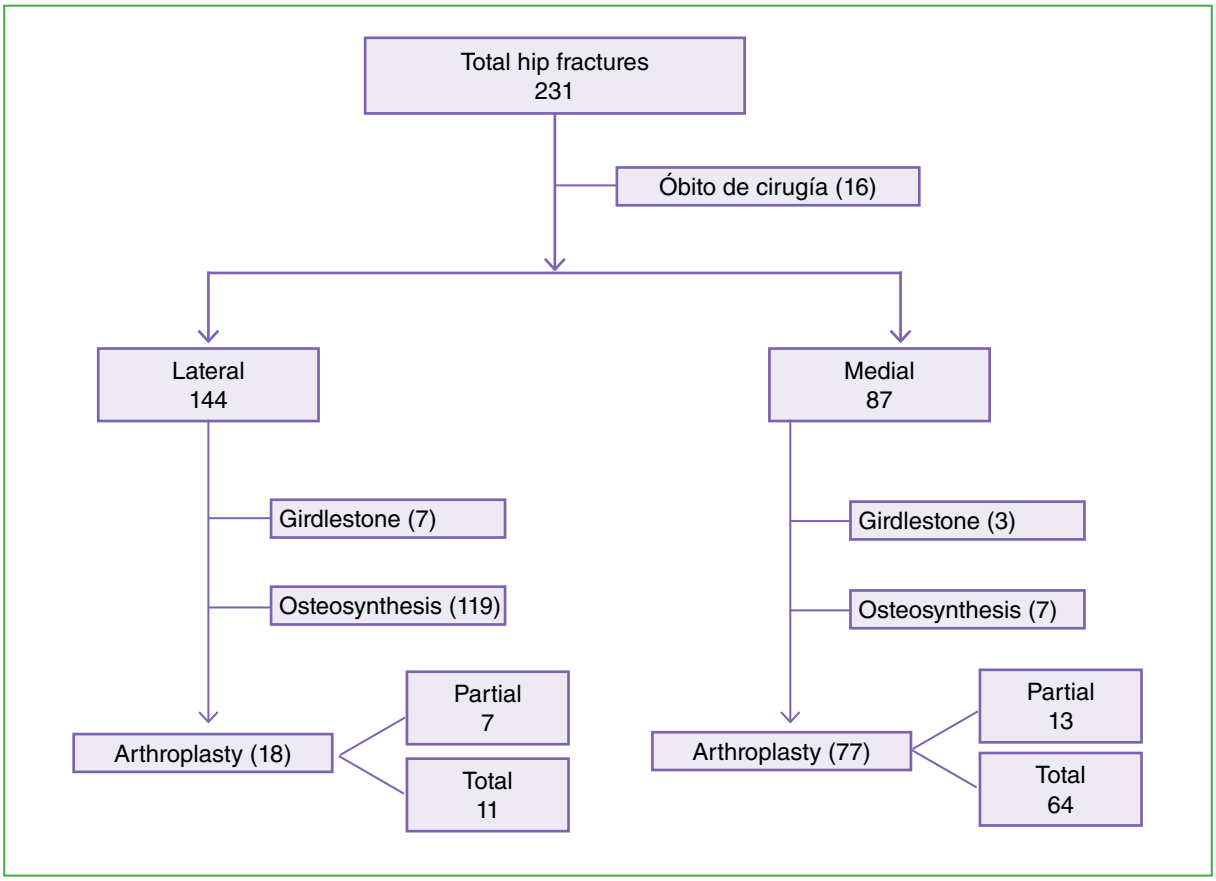

Figure 2. Standard antibiotic prophylaxis (24 h).

The criteria listed in the Second International Consensus on Periprosthetic Joint Infection of 2018 were used to establish the concept of PJI.[3] These criteria were adjusted to the hospital resource of the Orthopedics and Traumatology Service of the Hospital Municipal de Agudos "Dr. Leónidas Lucero", and acute PJI was defined as the presence and combination of one or more of the following signs or symptoms: seropurulent, haemopurulent, or purulent discharge through the wound, wound dehiscence, signs of phlogosis in the wound, persistent pain, wound fistulas, increased serum inflammatory parameters (white blood cells >12000/µl, erythrocyte sedimentation rate >10 mm, C-reactive protein >10 mg/l), temperature ≥37.5 ºC.

Two-thirds of acute PJIs occur during the inoculation of microorganisms in the course of the surgical procedure. Depending on their virulence, they can be acute (within the first 4 weeks), subacute (within 2 to 3 months) or chronic (between 3 months and 3 years).[1] In our series, only acute PJIs, those occurring within the first 30 days postoperatively, were analyzed.

Most surgeons and institutions have implemented key prevention initiatives aimed at reducing PJI risk factors, including non-modifiable factors such as ASA >3, obesity, smoking, diabetes, glucocorticoid exposure, chronic kidney disease, cancer, and rheumatoid arthritis; and modifiable factors such as a duration of surgery >3 h and failure to be prescribed systemic antibiotic prophylaxis.[1,2] Taking these factors into account, in both groups, the following variables were considered: age, sex, days of hospitalization, type of fracture (medial or lateral), type of primary arthroplasty (partial or total), duration of antibiotic prophylaxis (24 h or 7 days), acute PJI (yes or no), comorbidities (yes or no) and type of comorbidities (arterial hypertension, diabetes, smoking, cardiovascular events, psychiatric disease, neurological disease, rheumatic disease, oncological disease and hematological disease).

We analyzed whether there were statistically significant differences in the rate of patients suffering acute PJI according to whether they had received an EAP or an SAP. In turn, we evaluated whether there is an association between the patient's comorbidity variables (yes or no) and the presence of PJI (yes or no) in primary THA.

In all cases, a p-value <0.05 was considered significant. SPSS version 19 and Epidat 4.2 were used for data processing.

RESULTS

The study sample consisted of 28 patients in the EAP group (7 days) and 95 patients in the SAP group (24 h) who had undergone primary THA.

The average age of the EAP group was 79.11 years (Figure 3), 10.71% were male and 89.29% were female. The average hospital stay lasted 10.14 days (Figure 4).

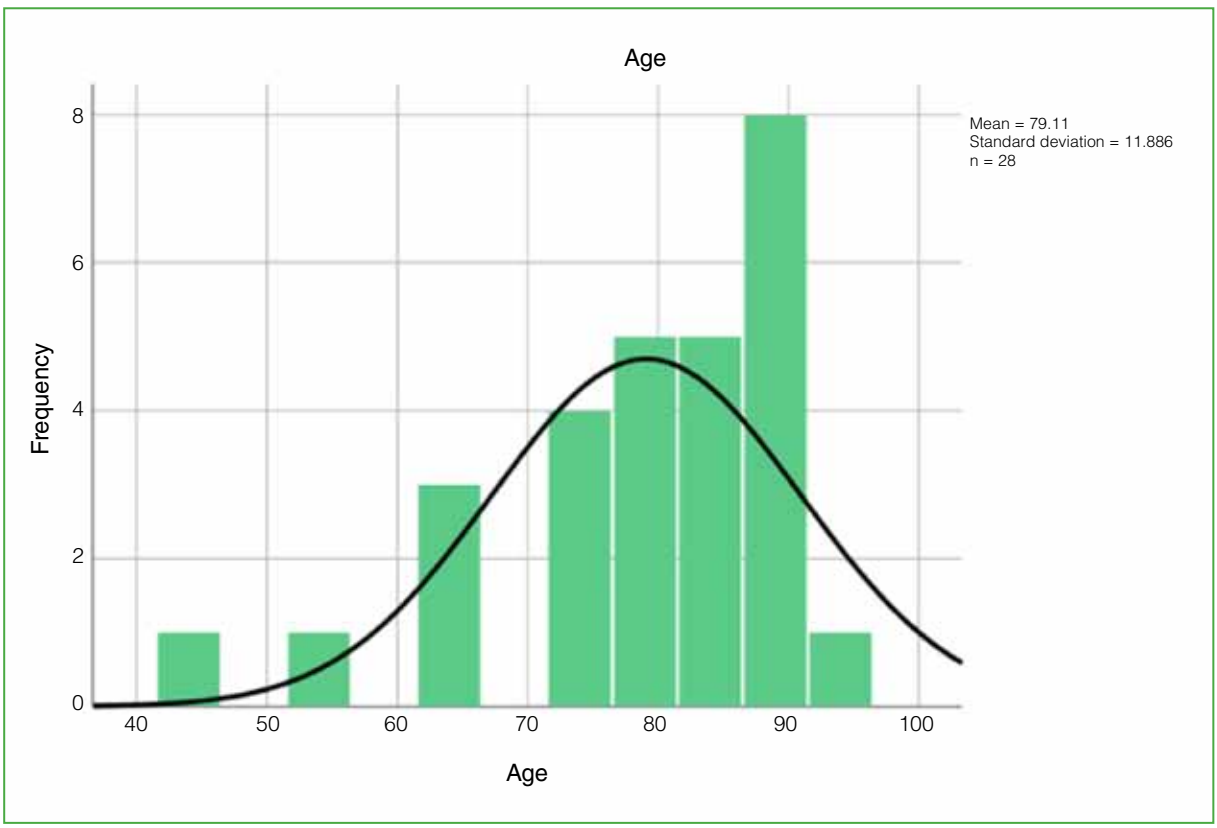

Figure 3. Age distribution in the group with extended antibiotic prophylaxis.

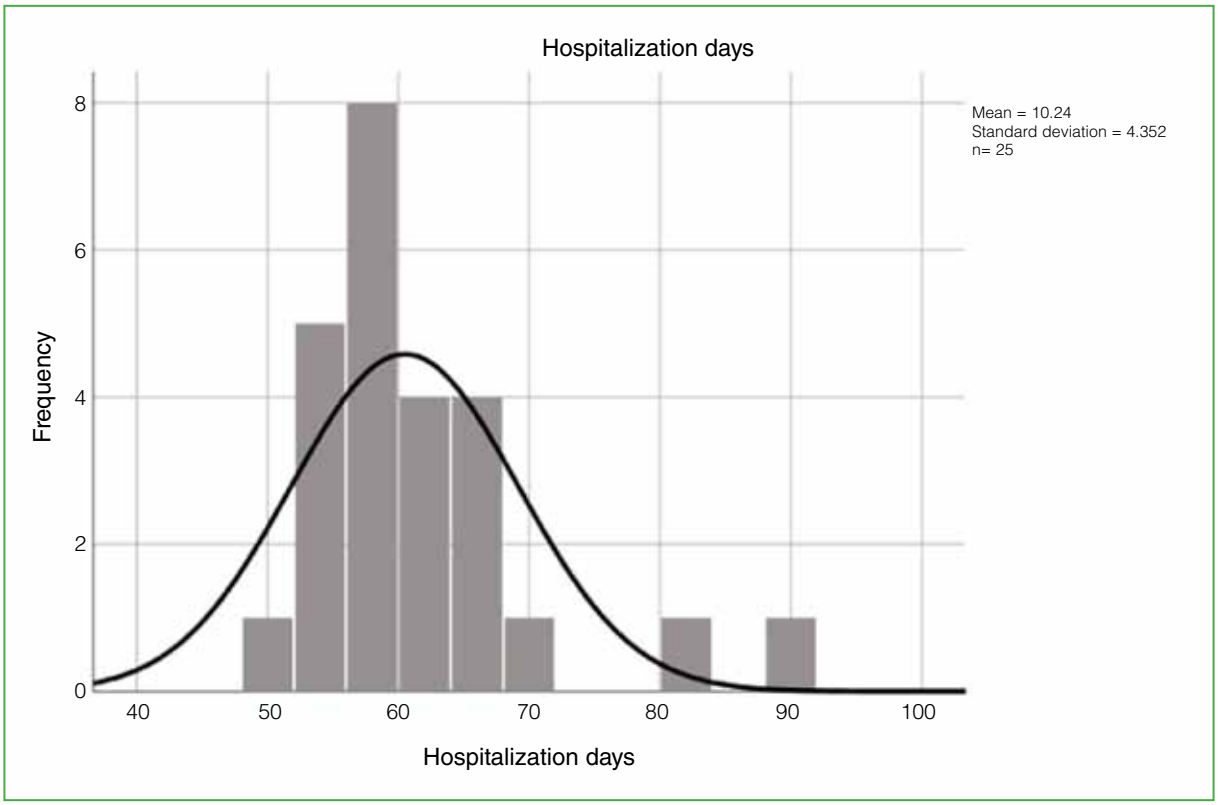

Figure 4. Distribution of days of hospitalization in the group with extended antibiotic prophylaxis.

In this group, 82.14% of the fractures were medial and 75% of the patients had undergone hip arthroplasty. 89.29% had comorbidities and the most prevalent were arterial hypertension (64.29%), cardiovascular events (28.57%), and diabetes and neurological diseases (14.29%). The average number of infected patients in this group was 10.71% (Tables 2 and 3).

Table 2. Variables of patients hospitalized for hip fracture.

	Standard antibiotic prophylaxis (n = 95)	Extended antibiotic prophylaxis (n = 28)
Age		
Average	79.22	79.11
Average, men	79.63	67.67
Average, women	79.14	80.48
Sex		
Male	16 (16.84%)	3 (10.71%)
Female	79 (83.16%)	25 (89.29%)
Days of hospitalization		
Average	13.21	10.14
Average, men	15.63	9.33
Average, women	13	10.24
Type of fracture		
Medial	77 (81.05%)	23 (82.14%)
Lateral	18 (18.95%)	5 (17.86%)
Type of arthroplasty		
Total	75 (78.95%)	21 (75%)
Partial	20 (21.05%)	7 (25%)
Periprosthetic infection		
Yes	17 (17.89%)	3 (10.71%)
No	78 (82.11%)	25 (89.29%)

Table 3. Comorbidities of patients hospitalized for hip fracture.

	Standard antibiotic prophylaxis (n = 95)	Extended antibiotic prophylaxis (n = 28)
Comorbidities		
Yes	79 (83.16%)	25 (89.29%)
No	16 (16.84%)	3 (10.71%)
Type of comorbidities		
Arterial hypertension	48 (50.53%)	18 (64.29%)
Diabetes	12 (12.63%)	4 (14.29%)
Smoking	10 (10.53%)	2 (7.14%)
Cardiovascular events	21 (22.11%)	8 (28.57%)
Psychiatric disease	14 (14.74%)	7 (25%)
Neurological disease	21 (22.11%)	4 (14.29%)
Rheumatic disease	3 (3.16%)	3 (10.71%)
Oncologic disease	11 (11.58%)	1 (3.57%)
Hematologic disease	7 (7.37%)	2 (7.14%)

The average age of the SAP group was 79.22 years (Figure 5), 16.8% were male and 83.16% were female. The average length of hospitalization was 13.21 days (Figure 6). Of the fractures, 81.05% were medial and 78.95% of the patients had undergone hip arthroplasty. A total of 83.16% had comorbidities and the most prevalent were arterial hypertension (50.53%), cardiovascular events (21%), and neurological diseases (21%). The average number of infected patients in this group was 17.89% (Tables 2 and 3).

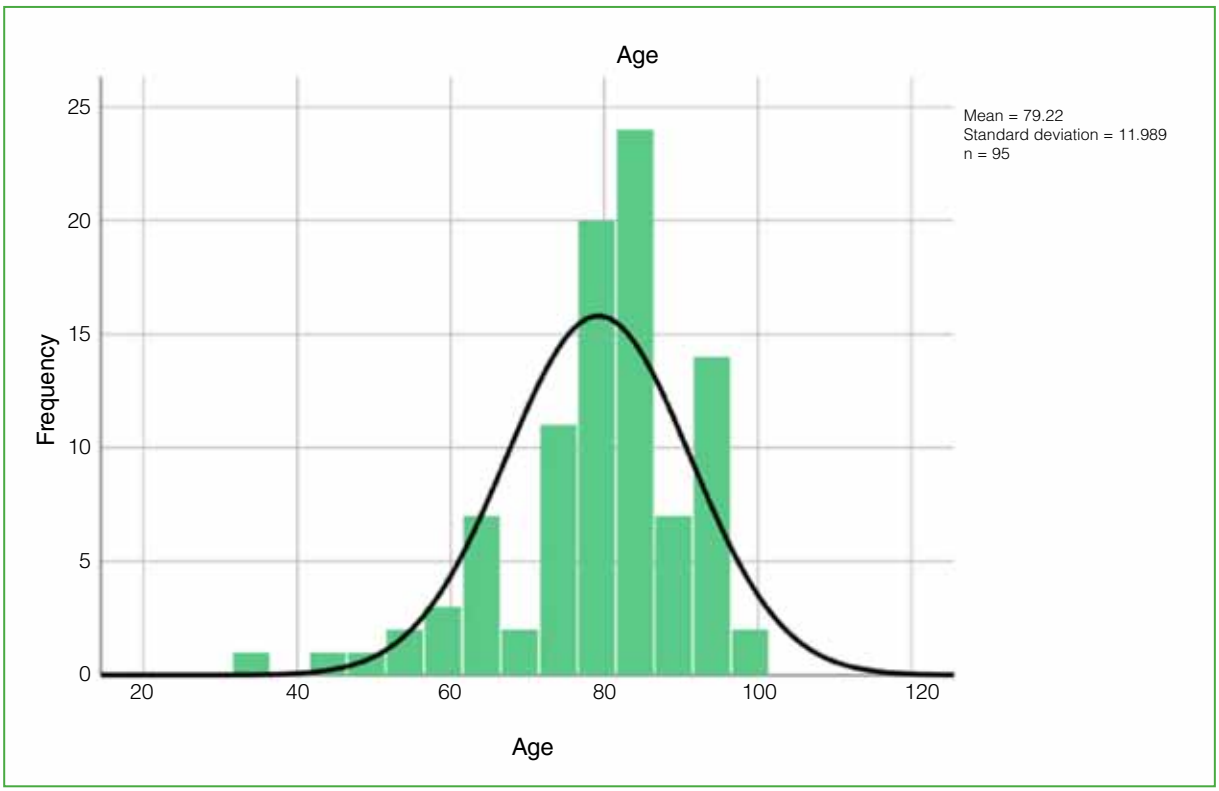

Figure 5. Age distribution in the group with standard antibiotic prophylaxis.

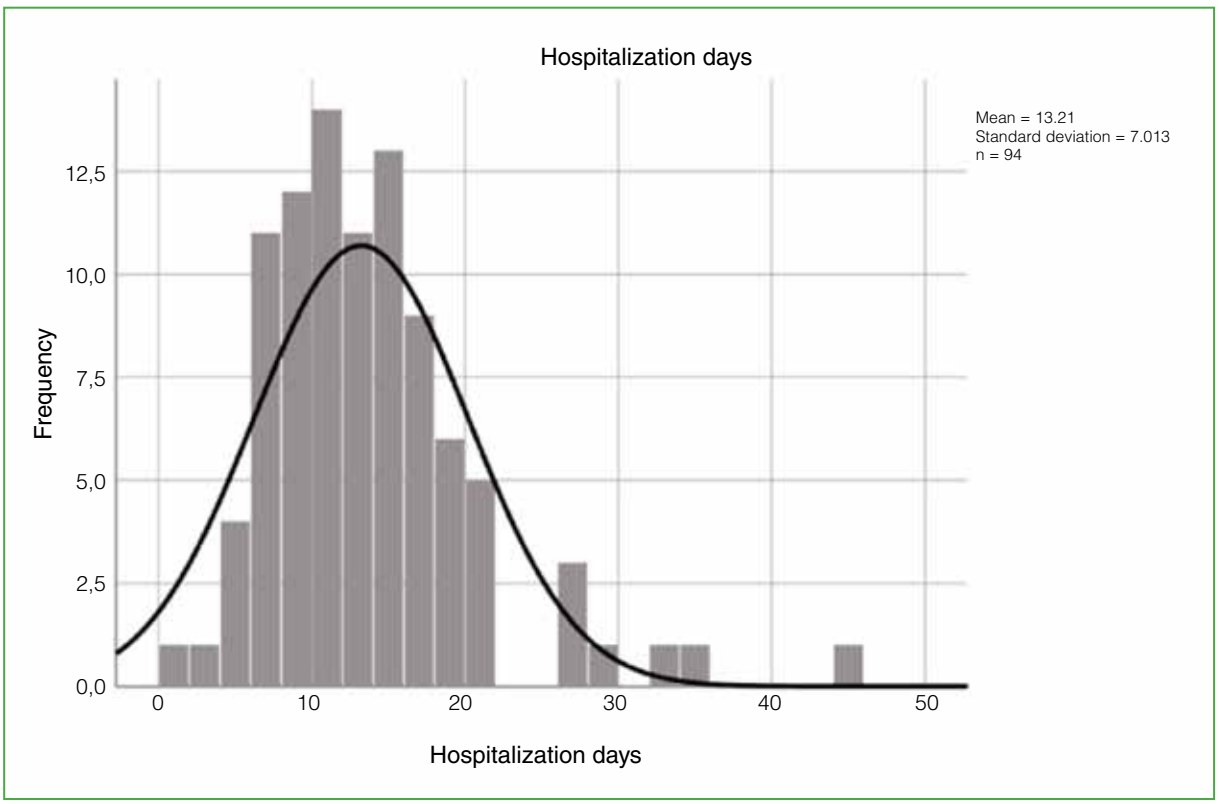

Figure 6. Distribution of days of hospitalization in the group with standard antibiotic prophylaxis.

The age and sex of patients in both groups were comparable (mean age, p = 0.96 and sex p = 0.43). When analyzing the PJI rate between both groups, no statistically significant differences were obtained (p = 0.36) (Table 4).

When the results were adjusted for patients with comorbidities, a total of 22 cases were obtained in the EAP group and 79 cases in the SAP group, the PJI rate was three (13.6%) and 16 (20.2%) cases, respectively, without statistical significance (p = 0.4) (Table 4).

With respect to hospital stay, statistically significant differences were obtained. Patients in the EAP group were hospitalized fewer days than those in the other group (p = 0.005) (Table 4).

Table 4. Analysis of variables of patients hospitalized for hip fracture.

	Standard antibiotic prophylaxis	Extended antibiotic prophylaxis	
Age			
Average	79.22	79.11	0.966 / (-4.985; 5.205)
Average, men	79.63	67.67	
Average, women	79.14	80.48	
Sex			
Male	16 (16.84%)	3 (10.71%)	0.43/(-0.076; 0.198)
Female	79 (83.16%)	25 (89.29%)	0.43/(-0.198; 0.076)
Days of hospitalization			
Average	13.21	10.14	0.005/(0.939; 5.201)
Average, men	15.63	9.33	
Average, women	13	10.24	
Periprosthetic infections			
Yes	17 (17.89%)	3 (10.71%)	0.366/(-0.066;0.210)
No	78 (82.11%)	25 (89.29%)	
Type of fractures			
Medial	77 (81.05%)	23 (82.14%)	
Lateral	18 (18.95%)	5 (17.86%)	
Type of arthroplasty			
Total	75 (78.95%)	21 (75%)	
Partial	20 (21.05%)	7 (25%)	

DISCUSSION

The currently accepted SAP consists of administering the antibiotic within one hour prior to surgery. The World Health Organization and the Centers for Disease Control and Prevention recommend not administering a prophylactic antibiotic after wound closure. However, in 2018, the Second International Consensus on Periprosthetic Joint Infection and the American Association of Orthopedic Surgery disagreed with this behavior. They advised continuing intravenous antibiotic prophylaxis for 24 h after arthroplasty, as in the SAP group in this series.[3-5]

In recent times, there has been increasing research on the use of EAP after hip arthroplasty, especially in those patients at risk of developing PJI, as in our study.[1,3,5-8]

In this series, no statistically significant differences were found when antibiotic prophylaxis was administered for 7 days compared to SAP (p = 0.36). Branch-Elliman et al. obtained similar results, and concluded that prolonging its duration was not associated with a reduction in surgical site infections.[9] Likewise, Kheir et al. found no statistically significant difference in the decrease in the rate of PJI in the SAP group compared to the EAP and risk factor groups.[1] Bukowski et al. evaluated whether EAP in patients undergoing aseptic hip revision decreased the risk of PJI, and also found no statistically significant differences.[10]

A study by Garabano et al. reported a PJI rate of 7.27% in primary THA. The rates were slightly higher in both groups for both EAP and SAP (17.89% and 10.71%, respectively).[4]

According to Inabathula et al., postoperative EAP results in a statistically and clinically significant reduction in the infection rate in selected patients at high risk of infection 90 days after primary THA. On this basis, it is possible that the outcomes would have been comparable if the patients in our study had been followed for a longer period of time. In addition, the study compared the impact of antibiotic prophylaxis in patients undergoing primary THA and multiple risk factors, and it was observed that patients who had not received EAP for 7 days were four times more predisposed to PJI. In contrast, in our series, when adjusting for comorbidities, there were no statistically significant differences.[11]

Regarding hospital stay, patients remained hospitalized for an average of 13 days in the SAP group and 10 days in the EAP group, figures similar to those published by Garabano et al. (mean of 10 days), but significantly shorter in the EAP group.[4]

One limitation of our study is the difficulty in including some variables considered risk factors for PJI, such as nutritional status, alcoholism, chronic consumption of corticosteroids, and colonization by methicillin-resistant *S. aureus*, since secondary data sources were used.[1] Regarding the sample size, it could be considered that if the number of patients in the EAP group increased, statistically significant differences could be obtained with respect to PJI, when compared to the SAP group.

According to published studies, prolongation of antibiotic prophylaxis may be a simple, safe and cost-effective measure to counteract non-modifiable patient factors and thus reduce PJI, but, in this study, no statistically significant differences were found 30 days after surgery. This highlights the need for further research to support the hypothesis.

In summary, the definition of PJI continues to be a point of discussion, subject to the hospital resources and protocols of each institution, coinciding with the diagnostic dynamism proposed by the literature.

In this study, EAP has not been shown to decrease the rate of acute PJI after 30 days in patients with primary THA for fractures of the proximal third of the femur. Considering that antibiotic prophylaxis is a fundamental factor in the prevention of these infections, this measure should be further studied, since it has been shown to be effective in selected patients in reducing PJI at 90 days and one year after surgery.

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Preservation of Fixed Cementless Femoral Stems in Patients with Chronic Periprosthetic Hip Infection

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ABSTRACT

Introduction: Two-stage revision is considered the gold standard for the treatment of chronically infected hip arthroplasty. However, during the removal of a fixed cementless femoral stem, the proximal femur can be damaged, which can lead to difficulties in reimplantation. **Objective:** We intend to determine if chronic periprosthetic hip infection can be treated with a partial exchange of its components, in two stages, keeping a fixed cementless femoral stem. **Materials and Methods:** This retrospective, multicenter case series study included 9 patients with chronic infection following hip arthroplasty, scheduled for single- or two-stage partial exchange with retention of the fixed femoral stem between January 2014 and November 2019. We assessed the patients' progress through clinical examination, Harris Hip Score evaluation, and laboratory and radiological studies. **Results:** In a mean follow-up of 5.8 years in 9 patients with cementless hip arthroplasty, 8 patients achieved infection remission (88.9%) after prosthetic reimplantation, and the mean Harris Hip Score reached 81 points at the last follow-up evaluation. There was no loosening of acetabular or femoral components. **Conclusions:** Uncemented femoral stem retention may represent an acceptable option for patients with chronic periprosthetic hip infection when removal of the femoral component would result in significant bone loss and compromise of the reconstruction. However, more studies are required on this treatment.
Keywords: Partial review; chronic periprosthetic infection.
Level of Evidence: IV

Conservación de tallos femorales no cementados fijos en pacientes con infección periprotésica crónica de cadera

RESUMEN

Introducción: La revisión en dos tiempos se considera el método de referencia para tratar a pacientes con artroplastia de cadera e infección crónica. Sin embargo, durante el retiro de un vástago femoral no cementado fijo, se puede dañar el fémur proximal, lo que puede plantear dificultades en el reimplante. **Objetivo:** Determinar si la infección periprotésica crónica de cadera se puede tratar con un intercambio parcial de sus componentes, conservando un vástago femoral no cementado fijo. **Materiales y Métodos:** Estudio de serie de casos retrospectivo, multicéntrico que incluyó a 9 pacientes con artroplastia de cadera e infección crónica, programados para el recambio parcial en uno o dos tiempos con retención del tallo femoral fijo, entre enero de 2014 y noviembre de 2019. Se evaluó la evolución mediante el examen clínico, el puntaje de cadera de Harris, y estudios de laboratorio y radiológicos. **Resultados:** En un seguimiento medio de 5.8 años de 9 pacientes con artroplastia de cadera no cementada, después del reimplante de la prótesis, la infección remitió en 8 pacientes (88,9%), y el puntaje medio de cadera de Harris fue de 81 en el último control. No hubo aflojamiento de componentes acetabulares ni femorales. **Conclusiones:** La conservación de vástagos femorales no cementados puede representar una opción aceptable para los pacientes con infección periprotésica crónica de cadera cuando la extracción del componente femoral daría como resultado una pérdida significativa de hueso y un compromiso de la reconstrucción. Sin embargo, se requieren más estudios sobre esta técnica.
Palabras clave: Revisión parcial; infección periprotésica crónica.
Nivel de Evidencia: IV

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INTRODUCTION

Periprosthetic joint infection (PJI) of the hip is a devastating complication. It represents a diagnostic and therapeutic challenge for physicians. Approximately 0.5-3% of patients with a primary arthroplasty and 4-6% of those undergoing a revision procedure suffer a deep infection.[1] In our country, according to the VIHDA 2021 program, the rate of hip PJI ranges from 1.88% to 8.64%.[2]

Chronic PJI occurs at a variable time after surgery. Tsukuyama establishes it four weeks after the initial procedure, although there is no internationally agreed definition of chronic PJI.[3-5] It is a type of infection with a mature and stable biofilm.

Several therapeutic modalities have been described to manage the difficult problem of chronic PJI after primary hip arthroplasty. The gold standard procedure is two-stage revision surgery.[6-8] Some authors have advised removing all components to eradicate infection if it occurs more than three weeks after primary surgery.[9]

In recent years, acetabular extraction instrumentation has been refined to the point where these fixed components can be separated efficiently with minimal bone loss.[10,11] However, the removal of the femoral component remains difficult and complicated. An extended trochanteric osteotomy or a cortical window is usually necessary to remove a fixed femoral stem. This may result in unexpected femoral perforation or fracture during surgery, and increase blood loss and surgical time.[12]

The aim of this article is to present a retrospective series of patients with chronic hip PJI in whom it was decided to retain the fixed cementless femoral component because it was considered that removal could generate significant bone loss that would compromise subsequent reimplantation.

Under these circumstances, the hypothesis put forward was that some chronic PJIs could be treated successfully without removing the osseointegrated cementless femoral component in selected patients.

MATERIALS AND METHODS

A multicenter, retrospective, case series study was performed. Between January 2014 and November 2019, nine patients with a diagnosis of chronic hip PJI underwent a single- or two-stage partial revision.

PJI was diagnosed according to the criteria established by the *Musculoskeletal Infection Society*[13] and the guidelines provided by the *International Consensus Meeting on Periprosthetic Joint Infection* (ICM).[14,15]

The inclusion criteria were: 1) patients who had undergone a single- or two-stage partial revision for a diagnosis of chronic PJI according to the Tsukuyama classification, 2) a microorganism isolated in the joint puncture fluid prior to surgery, 3) fixed femoral prosthetic components, as assessed radiographically and intraoperatively, whose removal could result in severe bone loss and compromise future fixation efforts.

Patients with a PJI of <4 weeks' evolution, immune compromise and without an identified microorganism at the time of surgery were excluded.

Prosthesis fixation was evaluated by anteroposterior and lateral hip radiographs. The acetabular cup was considered loose when migration was >2 mm, if there was a change in abduction >4° or demarcation lines in the DeLee-Charnley zones.[16]

RESULTS

The mean age of the patients was 72.3 years (range 64-81). The mean body mass index was 29.1 kg/m^2 (range 26.2 -35.9). Four patients were female and five were male. Surgical procedures prior to infection had been primary cementless hip arthroplasty (3 cases) and aseptic revisions (6 cases). All but one of the included patients had at least one comorbidity (Table 1).

The microorganisms isolated in the fluid from the joint puncture performed prior to surgery are detailed in Table 2. Synovial fluid samples were sent to the laboratory in blood culture bottles and cultured for aerobic and anaerobic bacteria for 14 days. PJI was always diagnosed on the basis of the major ICM criteria, two cultures were positive with phenotypically identical germs.

Preoperative serum levels of erythrocyte sedimentation rate and C-reactive protein were high in all cases (Table 1).

Table 1. Characteristics of the patients with chronic late periprosthetic joint infection

Variable	Value
Age, average (years)	72.3 (range 64-81)
Sex, male/female	5/4
Average body mass index (kg/m^2)	29.1 (range 26.2-35.9)
Arterial hypertension	7
Diabetes	2
Smoking	3
Obesity	3
Preoperative C-reactive protein, average (mg/l)	19 (12-24)
Preoperative erythrocyte sedimentation rate, average (mm/1 h)	62 (48-93)
Duration of symptoms before revision, average (months)	3 (2-5)
Duration of follow-up, average (years)	5.8 (3-8)

Table 2. Microorganisms identified

Microorganism identified	Number of patients
Serratia marcescens	1
Methicillin-sensitive *Staphylococcus aureus*	3
Methicillin-sensitive coagulase-negative *Staphylococcus*	3 *(S. epidermidis, S. haemolyticus, S. caprae)*
Methicillin-resistant *Staphylococcus aureus*	1
Cutibacterium acnes	1

Three patients had demarcation in DeLee-Charnley zones 2 and 3, while the rest had radiolucent lines in all three zones and cup migration. The femoral stem was uncemented in all cases. Radiographs showed no radiolucency lines, osteolysis or remodeling in Gruen zones 1-7.[17] All surgeries were performed through a posterolateral approach. Fixation was verified during surgery by attempting to move the implant in the anteroposterior and mediolateral directions, and rotating it clockwise and counterclockwise, and then attempting to remove the stem using an extractor. There were no visible gaps at the bone-implant interface, wear damage to the implant, frictional corrosion around the femoral cone, or movement of the prosthesis.

During the revision surgery, aggressive debridement and removal of any loose or necrotic tissue was performed. To remove the acetabular components, specific chisels were used and the exposed femoral stem was thoroughly brushed. The femoral head was always replaced (Figure 1).

Figure 1. Acetabular cup removal and femoral head replacement.

After the acetabular component was removed, an extensive pulsatile lavage with saline was conducted. The proximal portion of the preserved femoral component was brushed. In two patients, the revision was completed in one surgical procedure, whereas the remaining patients required two (Table 3).

Table 3. Description of removed and exchanged components and surgical stages

Patient	Retained component	Extracted component	Interchanged modular elements	Surgical stages
1	Uncemented femoral stem with distal fixation	Cementless acetabular cup	Femoral head	2
2	Uncemented femoral stem with distal fixation	Cementless acetabular cup	Femoral head	2
3	Uncemented femoral stem for metaphyseal fixation	Cementless acetabular cup	Femoral head	2
4	Uncemented femoral stem for metaphyseal fixation	Cementless acetabular cup	Femoral head	2
5	Uncemented femoral stem with distal fixation	Cemented acetabular cup	Femoral head	2
6	Uncemented femoral stem for metaphyseal fixation	Cemented acetabular cup	Femoral head	2
7	Uncemented femoral stem with distal fixation	Cementless acetabular cup	Femoral head	2
8	Uncemented femoral stem with distal fixation	Cementless acetabular cup	Femoral head and proximal module	1
9	Uncemented femoral stem with distal fixation	Cementless acetabular cup	Femoral head and proximal module	1

Cemented acetabular components (including cancellous allograft and ilioischial ring) were implanted in the two patients who underwent revision in a single procedure (Figure 2). These two patients had multiple comorbidities and did not accept a two-stage procedure.

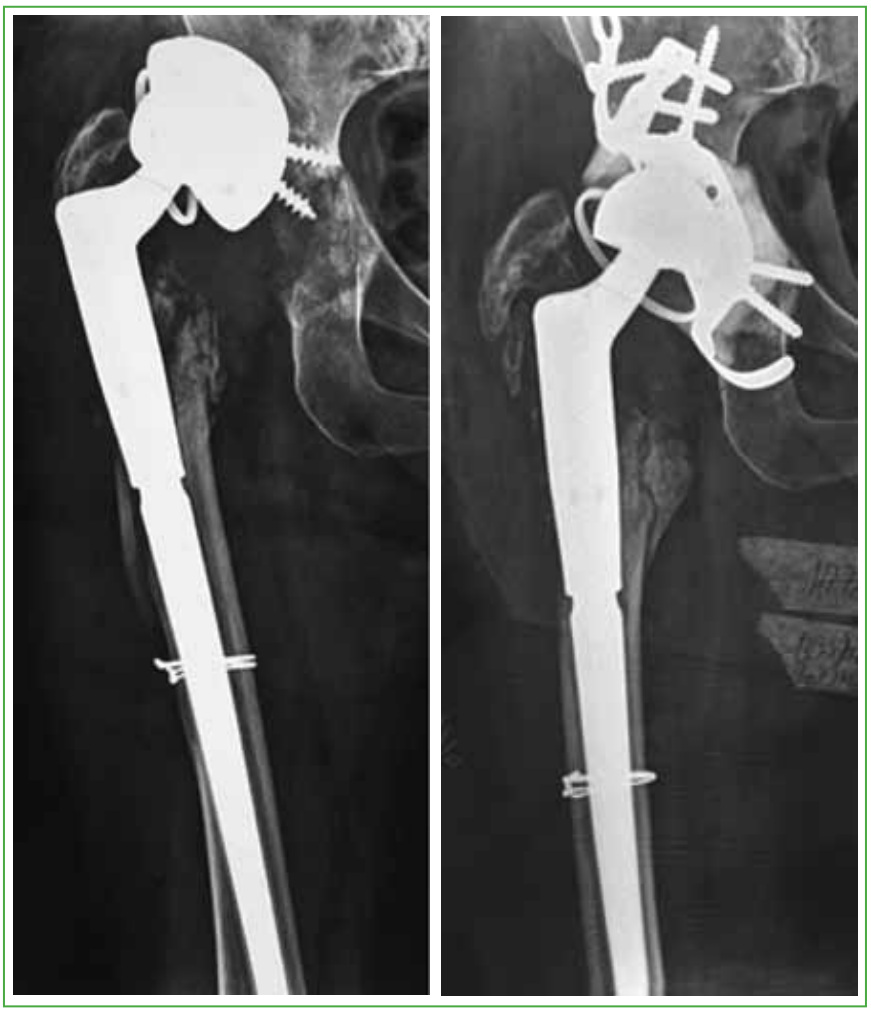

Figure 2. Preservation of the distal fixation cementless femoral stem. Acetabular cup replacement.

Several samples (at least 5) were sent for culture tests. Six matched the microorganisms identified in the joint puncture fluid. Despite not receiving antibiotics prior to surgery, two patients had negative intraoperative cultures. One had a single positive culture for coagulase-negative *Staphylococcus* that had not been discovered on the prior joint puncture, and it was thought to be a contaminant. If osteolytic lesions were detected, curettage was performed. The final lavage was performed with 0.35% povidone-iodine for three minutes.

In the two-stage partial revisions, an articulating functional spacer was cast from an acetabular component that was cemented in advanced stages of setting, resulting in a reduced bone interdigitation surface. A gentamicin-loaded cement (Subiton G, Buenos Aires, Argentina) was used, to which 4 g of vancomycin powder were added.

After surgery, during the 'spacer phase', all patients were administered intravenous antibiotics for at least seven days; during this period, inflammatory markers and various laboratory parameters were monitored periodically. Postoperative antibiotics were selected according to the sensitivity of the microorganism identified in the cultures. Then, patients continued with oral antibiotics, indicated according to the sensitivity of the microorganism, for at least six weeks, according to the recommendation of the physicians of the Infectious Diseases Department, while the normalization or decrease of inflammatory markers (C-reactive protein and erythrocyte sedimentation rate) was evaluated. Intravenous antibiotic therapy consisted of vancomycin, cefazolin, ceftriaxone, clindamycin and ciprofloxacin, following the guidelines established by the Clinical Guide of the *Infectious Diseases Society of America* and previous antibiograms. Rifampicin, levofloxacin and ciprofloxacin were indicated for the oral route.

The decision to perform the reimplantation was made together with these specialists. The criteria for reimplantation were: a stable medical condition and an appropriate response to treatment of the infection (decreased erythrocyte sedimentation rate, normal or decreased C-reactive protein and satisfactory wound status).

The second procedure was performed, on average, 10.3 weeks after the first procedure (range 7-16). The spacer was removed and necrotic soft tissue debridement was performed. Several samples (5) were sent for culture and sensitivity tests, leukocyte count and pathological anatomy analysis. No visible evidence of infection was found in any patient. Nor were any microorganisms identified in the cultures of the samples obtained during the procedure.

Uncemented acetabular components were re-implanted with metal-polyethylene bearings in five patients. In four others, the fixation was cemented.

After reimplantation, antibiotics were administered intravenously for 48 h and then orally for 4.3 months, on average (range 3-8), according to the criteria of the physicians of the Infectious Diseases Department. Oral antibiotics were discontinued when serum biomarker values decreased significantly or normalized and the patient had no symptoms (primarily pain, swelling or erythema).

The minimum follow-up was three years (mean 5.8 years; range 3-8). Patients were monitored in outpatient clinics at 3 and 6 weeks, at 3, 6, 9 and 12 months, and then annually, as part of a standard protocol. Prior to the consultation, blood tests were to be performed, and the results would be available at that time. The Harris hip score was evaluated. All patients attended their consultations.

Treatment was considered successful using the criteria described by Díaz Ledesma et al.,[18] based on a Delphi consensus (eradication of infection, no subsequent surgical intervention and no PJI-related deaths).

In one patient treated with single-stage partial revision, the infection recurred due to the same microorganism (methicillin-sensitive *S. aureus*) and he had to undergo a two-stage revision. The remaining eight patients were free of infection in five years of follow-up. None required suppressive treatment. The infection remission rate was 88.9%. The average modified Harris hip score improved to 81 (range 76-83) at the last assessment. No loosening of acetabular or femoral components was detected.

DISCUSSION

Constant advances in surgical techniques and the improvement of prosthetic materials have significantly improved the integration of implants with bone tissue. This has determined a strong contribution to initial and long-term stability. However, if patients need revision surgery for a reason other than loosening of the prosthesis, it is particularly complex to remove an osseointegrated component, even in the hands of an experienced team with precise instrumentation.

Although specific instrumentation has been developed to facilitate the removal of the fixed acetabular component with minimal bone loss, the removal of an osseointegrated cementless femoral component can cause serious complications and hinder subsequent reconstruction. Removal of a fixed femoral component may result in: 1) a significant loss of bone material; 2) a femoral fracture, especially when an extended trochanteric osteotomy is required; and 3) the formation of a sequestrum due to extensive soft tissue dissection.

In this study, the treatment of chronic PJI with two-stage partial reconstruction preserving the femoral component was evaluated in nine patients. Infection recurred in only one (88.9% remission), there were no treatment-associated deaths, and the average modified Harris hip score was 81, in the qualitative range of "good".

While the accepted treatment for chronic PJI is single- or two-stage revision, the removal of fixed cementless femoral components when bone quality is poor has begun to be questioned, as removal of this component could result in significant bone loss that does not allow reimplantation in certain patients.

It is important to perform an adequate and thorough cleaning of the tissues, as well as the fixed femoral component and to remove the modular components. Likewise, it is essential to know the causal microorganism in a previous puncture sample, in order to decide whether the revision will be in one or two stages, the antibiotic to be placed in the spacer cement, and the antibiotic to be administered.

The ICM (2nd Philadelphia Consensus) states that sub-radical resection arthroplasty (leaving parts of implants in place) may be considered during the management of patients with chronic PJIs when a component is proven to be well-fixed and its removal precludes opportunity for future reconstruction.[15] Success rates with this technique have been acceptable (87-89%). These can be compared with published results on two-stage surgery, although reported success rates are highly variable. Careful patient selection through proper assessment of fixation is the key to determining whether component retention is a viable option.

The ICM reports that overall infection eradication rates with this technique ranged from 80% to 100% (mean 90%). Further on, the ICM states that: "Complete debridement of the hip or knee joint and removal of all hardware is ideal during surgical treatment of PJIs." This principle should be followed whenever possible. However, there may be rare cases of PJI in which removal of all implants may cause increased morbidity and preclude future reconstruction. In this situation, some implants may not be removed. The level of evidence for this statement reaches the "Consensus" category; the delegate vote was 97% "agree" and 3% "disagree" (unanimous and strongest consensus).

Finally, the ICM delegates ask, "Is it possible to have an isolated infection of only a portion of the joint (for example the femur and not the acetabulum, or tibia and not the femur)?" And the answer is: "Unknown. Infection of a prosthetic joint is likely to involve biofilm formation on surfaces of all foreign material. However, **there may be rare circumstances when infective organisms may not be able to reach the surface of a well-fixed implant and form a biofilm**." The level of evidence was limited and, in the delegate vote, 75% agreed (super majority, strong consensus).

In 1989, Struhl et al. published the case of a patient who underwent a two-stage revision with retention of the femoral component and remission of the infection after 18 months of treatment.[19]

Lombardi et al. reported a retrospective study of 41 patients with chronic PJI treated with a two-stage partial component exchange that included complete removal of the acetabular component, retention of the fixed femoral stem with removal of the modular components, and subsequent reimplantation of the prosthesis. The median follow-up was four years, and the recurrence rate of infection with two-stage partial replacement after chronic hip PJI was 19%.[20]

Ji et al. published a retrospective analysis that included 31 patients with chronic PJI undergoing single-stage partial revision. Twenty-seven of the 31 patients (87.1%) had satisfactory outcomes and did not require further medical or surgical treatment for recurrence of infection.[21]

In the study by El-Husseiny et al., 18 patients with chronic PJI were treated with a procedure that preserved the femoral or acetabular component. The minimum follow-up period was five years. In three cases, the infection recurred (83.34% healing of the infection) and the patients were treated with two-stage revision.[22] In our study, only the preservation of femoral components was evaluated.

Kassam et al. published a series of 89 patients in whom fixed cement mantles were retained in chronic PJI by replacing the femoral stem and acetabulum, and with the cement-in-cement technique; the infection remission rate was 92.1%.[23]

The results of these publications are similar to those we have obtained.

Our study has some limitations. This is a retrospective case series, like all the literature published to date, a comparison or control group was not included along with the study group. Patients were selected if they met all inclusion criteria, which were highly selective and subjective for the approach described. Another clear limitation is the sample size. Although nine patients were included, the number of cases in the international literature is low (from 2 to 41), so it is a procedure for highly selected patients.

As strengths, we can mention that it is the first national study on this controversial topic.

Further research is needed to confirm these results before this technique can be recommended for wider use.

CONCLUSIONS

Partial component exchange, with retention of osseointegrated cementless femoral stems may represent an acceptable option for chronic, non-immunocompromised PJI patients with a known microorganism and fixed femoral stem, when their removal could result in significant bone loss and compromised reconstruction. However, further studies on this treatment method are required.

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A Simple Method to Minimize Limb Length Discrepancy and Restore Offset in Total Hip Arthroplasty

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ABSTRACT

Introduction: There are more than 20 different techniques to correct lower limb length discrepancy. The method evaluated in this study is based on a fixed pin in the iliac wing connected to a mobile gauge and another pin in the greater trochanter with which the reference is marked. The objective is to evaluate the reliability of this measurement device used during THA to restore lower limb length and femoral offset. **Materials and Methods:** Two groups were formed: Group A (patients who did not use the device) and Group B (patients who did use the device). Measurements were taken in the pre-surgery panoramic pelvic radiograph with the patient standing and three months later. **Results**: A sample of 80 patients was obtained, with 40 in each group. The difference in limb length could be corrected in each group, however the average correction achieved by both groups did not result in a statistically significant difference (p=0.07). However, when the variance in the correction of the difference in length of each group was examined, a statistically significant difference (p<0.001) was obtained. **Conclusions:** We can conclude that while this device, which serves as a more objective quantifiable measurement technique, does not guarantee a correction of the exact length discrepancy to 0 mm, it does allow us to work within a more dependable and safe range.
Keywords: Lower limb length discrepancy; total hip arthroplasty; hip gauge.
Level of Evidence: III

Método simple para minimizar la discrepancia en la longitud de las extremidades y restaurar el offset en la artroplastia total de cadera

RESUMEN

Introducción: Existen más de 20 técnicas diferentes para corregir la discrepancia de miembros inferiores. El método aquí se evalúa se basa en una clavija fija posicionada en el ala ilíaca asociada a un "calibre" móvil, con otra clavija con la que se marca la referencia en el trocánter mayor. **Objetivo:** Evaluar la confiabilidad de este dispositivo de medición usado durante la artroplastia total de cadera para restaurar la longitud del miembro inferior y el *offset* femoral. Materiales y Métodos: Se formaron dos grupos: grupo A con pacientes en quienes no se había usado el dispositivo y grupo B con pacientes en quienes sí se había usado el dispositivo. Se realizaron las mediciones en la radiografía panorámica de pelvis obtenida con el paciente de pie, antes de la cirugía y 3 meses después. Resultados: Se obtuvo una muestra de 80 pacientes (40 por grupo). Se logró corregir la discrepancia de la longitud de los miembros, pero no se hallaron diferencias estadísticamente significativas en la corrección promedio, entre ambos grupos (p = 0,07). Sin embargo, al analizar la varianza en la corrección de la discrepancia de la longitud de cada grupo se obtuvo una diferencia estadísticamente significativa (p <0,001). **Conclusiones:** Este dispositivo que permite una medición cuantificable más objetiva no asegura una corrección de la discrepancia de la longitud exacta a 0 mm, pero sí permite trabajar dentro de un rango más confiable y seguro.
Palabras clave: Discrepancia de longitud; artroplastia total de cadera; calibre de cadera.
Nivel de Evidencia: III

INTRODUCTION

Limb length discrepancy after total hip arthroplasty (THA) is a cause of poor functional outcomes and can lead to sciatic pain, back pain, abnormal gait, and patient dissatisfaction. It is also the most common reason for lawsuits against orthopedists in the United States.[1,2] In cases of hip osteoarthritis, the affected limb is usu-

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ally shorter and this is due to: 1) loss of cartilage thickness and bone loss (structural shortening), 2) soft tissue contractures, such as hip adduction and flexion deformity (apparent shortening), and 3) compensatory pelvic obliquity (apparent shortening), with the affected hemipelvis higher to avoid leg crossing due to the adducted position.[2] One of the goals of THA is to correct limb length discrepancy caused by structural shortening and soft tissue contractures.

The restoration of femoral offset is also essential to obtain a favorable functional outcome by retaining a hip abductor lever arm to promote implant stability and survival, as well as gait quality.[3]

Careful and thorough preoperative planning is a critical step in preventing limb length discrepancy after THA, but also various intraoperative considerations can help minimize it. Direct comparison of the lower limbs is a widely used technique, but interobserver and intraobserver variability is very wide because of patient position and surgical fields. About 20 different techniques have been published to help correct lower limb discrepancy, all using a stable pelvic landmark and a variable femoral landmark.[4]

The method under study is based on a fixed pin placed in the iliac wing, superior to the acetabulum, and at the level of the anterior superior iliac spine, which is connected to a mobile caliper, and another pin with which the reference is marked on the greater trochanter, from which the length and offset of the hip are controlled (Figure 1).

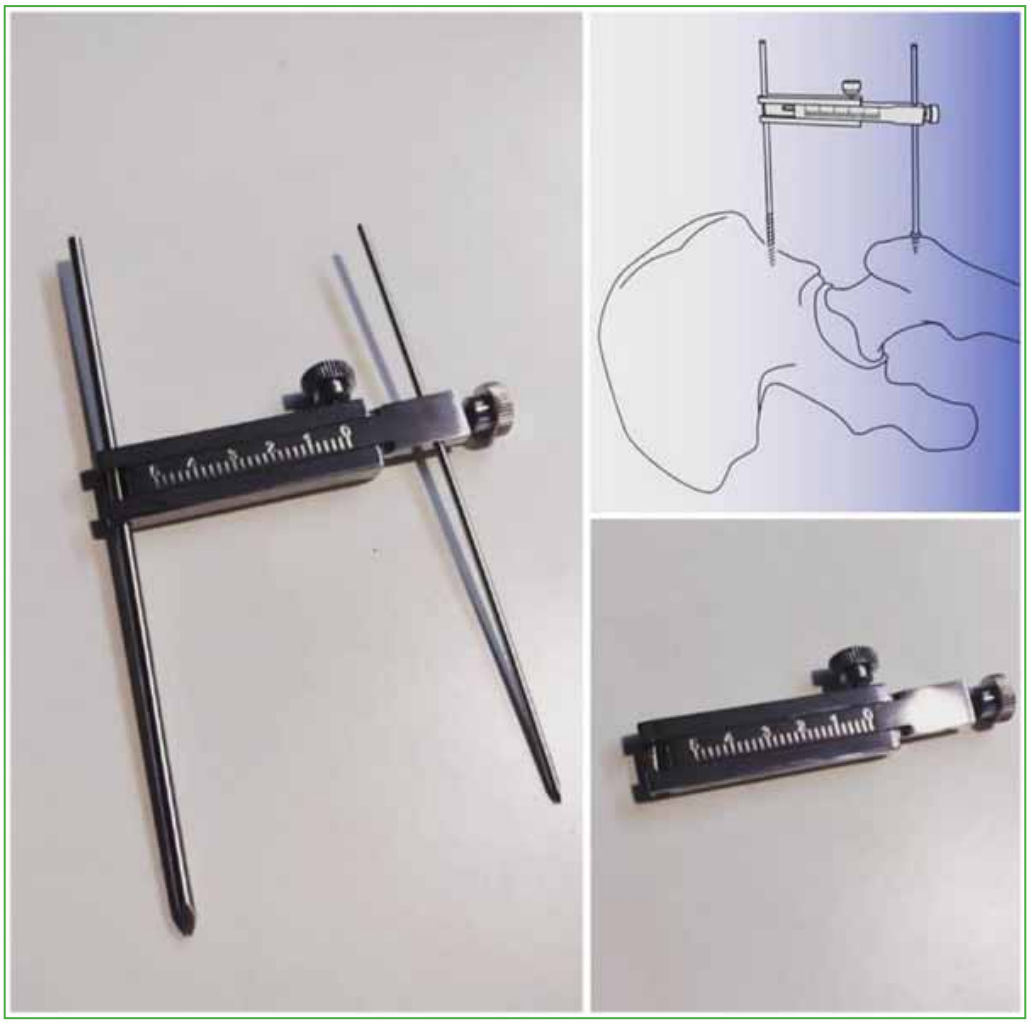

Figure 1. Limb length and femoral offset measuring device used during total hip arthroplasty.

OBJETIVE

To evaluate the reliability of a measurement device used during THA to restore lower limb length and femoral offset. This device, according to the working hypothesis, improves control of lower extremity length and offset.

MATERIALS AND METHODS

A retrospective, observational, longitudinal and analytical study was conducted. Inclusion criteria were: patients >18 years old with elective THA with radiographs at the preoperative period and three months after surgery. The following exclusion criteria were established: complex primary hip arthroplasty (e.g., dysplastic hip, ankylosed hip, fractures around the hip, acetabular protrusion, neuromuscular conditions, skeletal dysplasia, previous bone procedures on the hip), previous length discrepancy not attributable to hip disease, revision cases, tilted radiographs.

Patient demographic data were extracted from medical records. Two groups were formed, with a cutoff point in November 2019, at which time the use of the intraoperative measurement device began (Figure 2). Group A (control group) consisted of patients who had undergone THA before that date, without using this device, and group B (study group) included patients who underwent THA with the use of the measuring device after the aforementioned date.

Measurements were taken on the panoramic pelvis radiograph obtained with the patient standing, before surgery and three months after surgery.

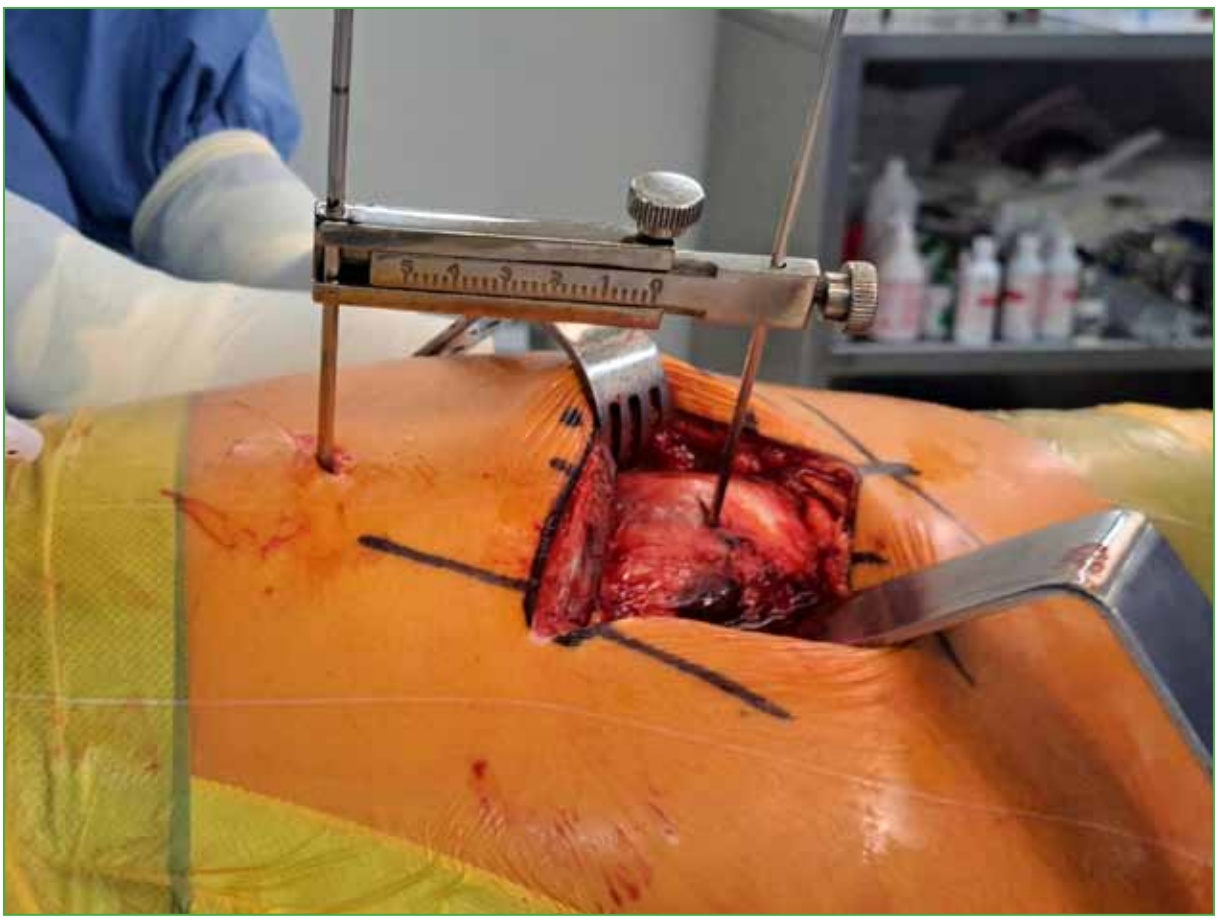

Figure 2. Intraoperative image of the use of the device. The mobile caliper is seen in association with two nails, one fixed in the iliac wing (left) and the other movable resting on a mark placed on the greater trochanter (right).

Limb length discrepancy was measured as the vertical distance between the pelvic reference line that connects the acetabular teardrops and the most prominent medial point of the lesser trochanter.[5] The length discrepancy with respect to the ipsilateral lower limb was measured on the preoperative radiograph, and the actual correction achieved with THA was measured on the postoperative radiograph. The result was recorded as a positive value to indicate lengthening of the operated leg or a negative value to indicate shortening.

All measurements were performed with the Windows MediCAD® program (Figure 3).

The research protocol was approved by the Institutional Ethics Committee and complies with the Declaration of Helsinki and the Declaration of Good Clinical Practices of the National Administration of Drugs, Food and Medical Technology (ANMAT). It also complies with Act 9694 of the Province of Córdoba and the Argentine National Personal Data Protection Act No. 25,326.

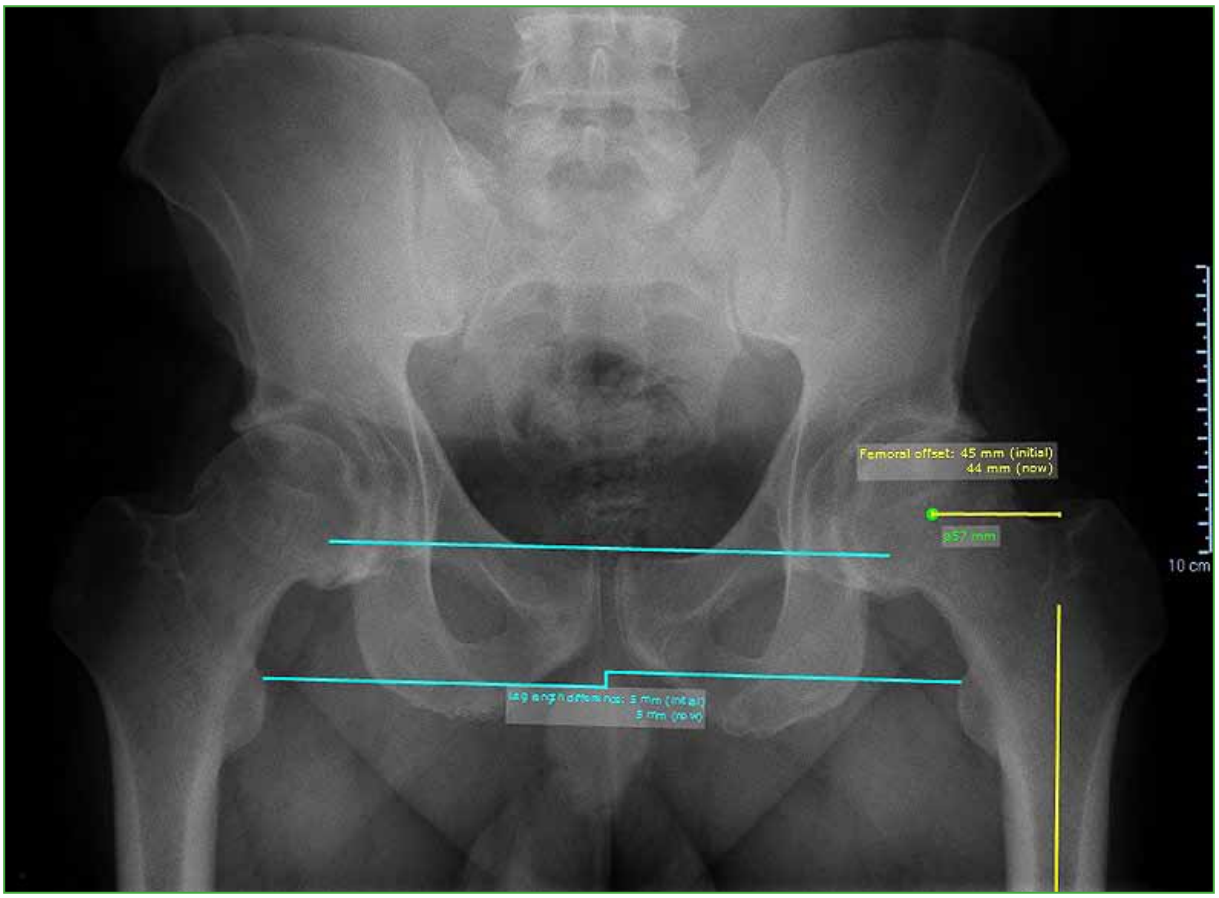

Figure 3. Example of measurements taken before surgery with the MediCAD® program.

Statistical Analysis

Demographic data were compared between the two groups using nonparametric Mann-Whitney and Kruskal-Wallis tests. Categorical variables (change in length and offset) are expressed as means, ranges, standard deviations and variances, and were analyzed with Spearman's exact correlation and Bartlett's homogeneity of variances tests for comparison between groups. The significance threshold was set at $p \leq 0.05$. The R-Medic program was used for the analysis.[6]

RESULTS

A sample of 80 patients was obtained, 40 in each group. Group A had an average age of 61.5 years, whereas Group B had an average age of 60.7 years. In both groups, male sex, right laterality, and osteoarthritis as preoperative diagnosis predominated, all without statistical significance (Table 1).

Table 1. Overall results for both groups

Variables		Without measuring device Group A (n = 40)	With measuring device Group B (n = 40)	p
Age (years)		61.5 ± 11.9	60.7 ± 11.3	0.83
Sex	Male	29 (72%)	23 (57%)	0.82
	Female	11 (28%)	17 (43%)	
Side	Right	21 (53%)	22 (55%)	0.97
	Left	19 (48%)	18 (45%)	
Diagnosis	Osteoarthritis	39 (98%)	38 (95%)	0.07
	Avascular bone necrosis	1 (2%)	2 (5%)	

In group A, the pathologic hip was, on average, 5.78 mm shorter before surgery, and a mean correction of 1.8 mm was achieved, resulting in an average postoperative difference of 3.98 mm (range -20 to +15 mm). 24% of the limbs operated on without the intraoperative measuring device were longer than the ipsilateral limb after surgery when compared with those in group B (10%).

In group B, the pathologic hip was, on average, 6.58 mm shorter before surgery, and a mean correction of 4.75 mm was achieved with surgery using the measuring device. The operated hip was, on average, 1.83 mm shorter (range -9 to +5 mm). In both groups, a statistically significant correction of limb length was achieved, but, when analyzing the average correction achieved between both groups after the operation, no statistically significant difference was found (p = 0.07) (Table 2, Figure 4).

Table 2. Comparative results between the two groups in the correction of length discrepancy and offset.

Variables		Group A Mean (SD)	Group B Mean (SD)	p
Length discrepancy	Preoperative	-5.78 (4.79)	-6.58 (4.8)	0.36
	Postoperative	-3.98 (8.17)	-1.83 (2.74)	0.07
	p	0.026	0.011	
Offset	Preoperative	45.30 (9.31%)	42.43 (8.60%)	0.19
	Postoperative	50.68 (6.78%)	48.63 (8.25%)	0.16
	p	0.001	0.001	

SD = standard deviation.

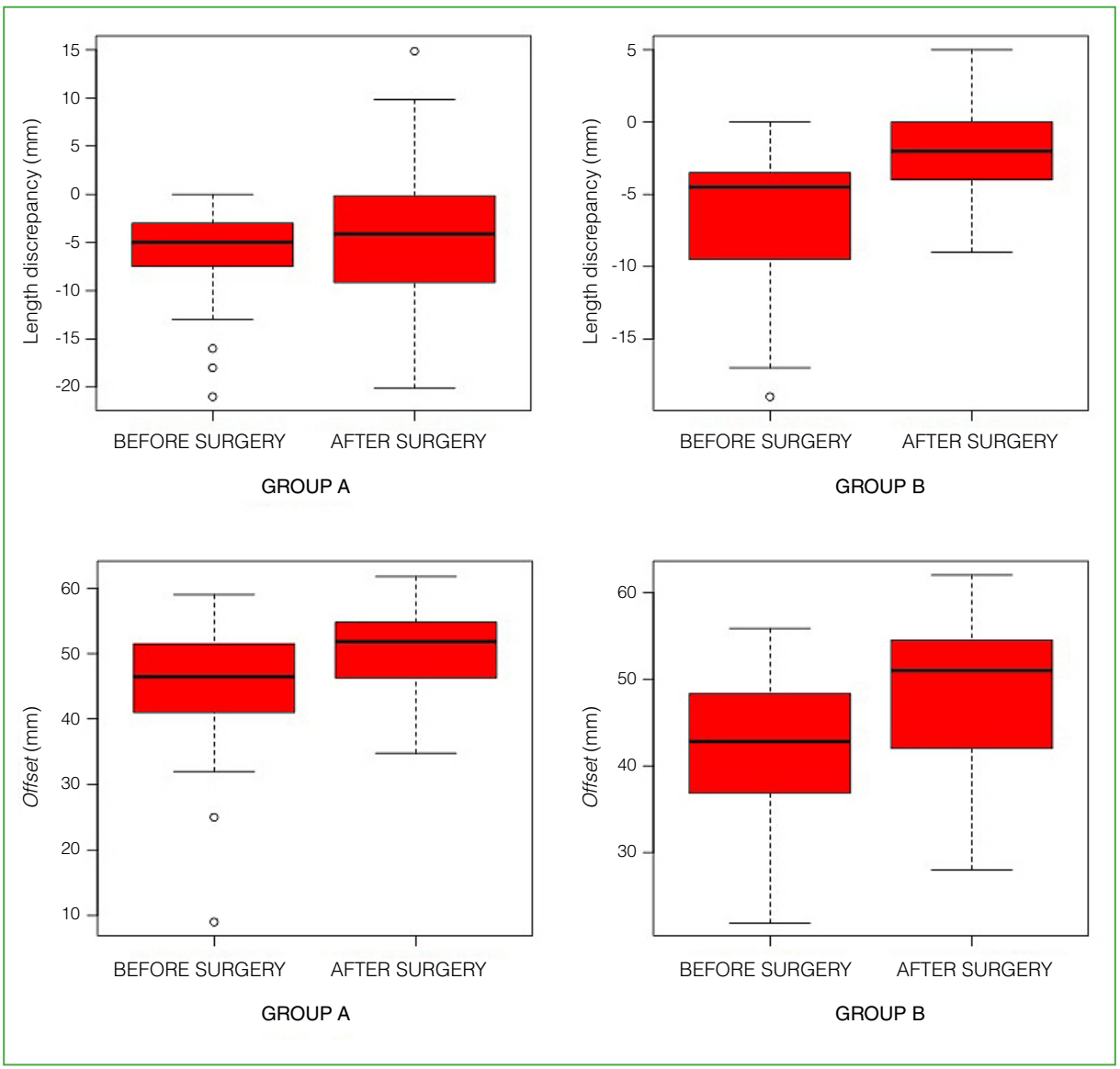

Figure 4. Box plot summarizing the values obtained before and after surgery, in both groups, with respect to length discrepancy and femoral offset.

However, when the variance in the length discrepancy correction of each group was analyzed, a statistically significant difference ($p<0.001$) was obtained (Figure 5).

The mean preoperative offset value in group A was 45.3 mm and increased to 50.68 mm after surgery, with an average increase of 5.38 mm, a statistically significant value. In group B, the average increase in femoral offset was 6.2 mm (42.43 mm preoperatively vs. 48.63), also with statistical significance. However, this increase in femoral *offset* was not statistically significant when comparing the two groups after surgery, nor was the variance in the results of the increase in femoral offset between the two groups significant (Figure 6).

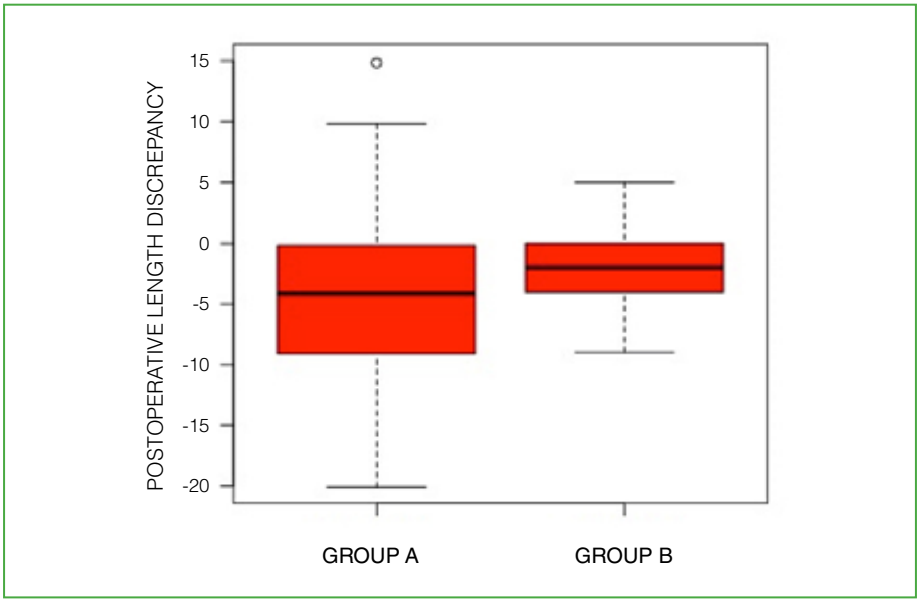

Figure 5. Box plot showing the statistical significance between the variances of each group in the length discrepancy correction ($p<0.001$).

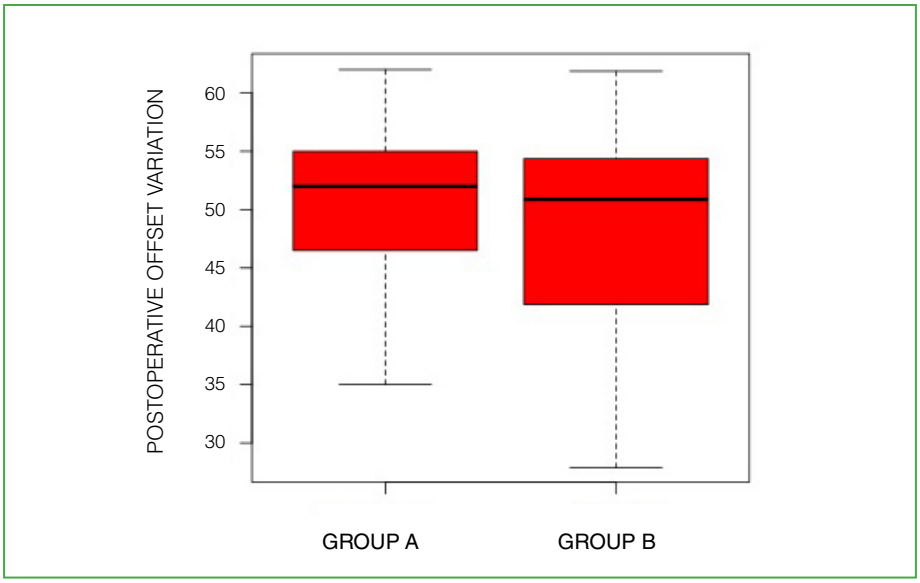

Figure 6. Box plot comparing the postoperative femoral offset of both groups, with no statistical significance in the mean or variance ($p = 0.23$).

DISCUSSION

One of the goals of THA is to accurately restore the length of the lower extremity and, at the same time, to achieve appropriate joint stability. This usually consists of maintaining the existing length or lengthening a shortened lower extremity. It is sometimes necessary to lengthen the lower limb to increase hip stability, because avoiding postoperative dislocation is more important than avoiding a length discrepancy, and it is generally accepted that lower limb length discrepancy is not fully corrected by THA and ranges from 1% to 27%,[7] with multiple causes.[8]

Many studies have been published describing intraoperative techniques for the management of leg length discrepancy. Matsuda et al.[9] obtained a smaller postoperative mean length discrepancy (2 vs. 7 mm) by measuring the distance between the center of the test femoral head and the lesser trochanter with a ruler and selecting the head and neck length closest to that planned before surgery. Using the same method, Gonzalez Della Valle et al.[10] obtained a length discrepancy <5 mm postoperatively in 90 of 103 hips.

The method evaluated here involves the use of a mobile caliper to measure the distance between two fixed points, one pelvic and the other femoral. The difference between the distance measured before dislocation and after trial reduction indicates the lengthening achieved.

This study demonstrated that the use of the intraoperative measuring device allowed a more accurate correction of the lower limb length discrepancy. In both groups, the trend was to leave the postoperative length shorter (on average, 3.98 mm shorter without the use of the caliper vs. 1.83 mm with the caliper). Although no significant difference was observed when examining the average correction attained in both groups, it is worth noting that statistical significance was reached when assessing the variance of each group, indicating that the extreme ranges of correction were narrower with the use of the caliper ($p < 0.001$). As a result, this device, which serves as a more objective measurement technique, does not guarantee a repair of the exact length disparity to 0 mm but does allow operating within a more dependable and safe range.

There was a tendency to leave the limb longer when the caliper was not used (group A: 24% vs. group B: 10%). Along these lines, Bose et al.[11] achieved lengthening >12 mm in 31% of hips without the use of the caliper versus 5% with the caliper, in a total of 117 surgeries.

Other studies have reported similar methods.[12-16] Most appear effective, but only concern limb length control and not offset. Woolson et al.[15] used a caliper attached to the iliac wing that ensured <6 mm discrepancy in 89% of patients. Ranawat et al.[13] used a Steinman nail placed in the ischium, at the inferior aspect of the posterior horn of the acetabulum, and the discrepancy was <6 mm in 87% of the cases. Konyves and Bannister[2] reported a mean discrepancy of 9 mm with a similar device.

Desai et al.[17] concluded that the use of an intraoperative caliper together with adequate preoperative planning were reliable elements in restoring lower limb length discrepancy.

Regarding the evaluation of femoral offset, in both groups, the postoperative offset increased significantly with respect to the preoperative offset by more than 5 mm, but it was not significant when comparing both groups with each other. An inadequate femoral offset reduces soft tissue tension and increases the risk of dislocation; therefore, it is prudent to ensure good abductor apparatus tension.

Kurtz et al.[18] reported a good correlation for limb length, but no difference in offset correction. On the other hand, Chen et al.[19] also achieved an increase in femoral offset with the use of an intraoperative caliper, but without statistical significance with respect to the control group.

This study has several limitations, including its retrospective design and outcome variables that simply collected images and basic patient information without quantifying structural limb length or functional score. Finally, the measurement method may not be accurate in all cases and may generate a measurement bias depending on the quality of the radiograph and the observer.

CONCLUSIONS

This caliper is a simple and reliable method that helps the surgeon to be more accurate in correcting limb length discrepancy and restoring femoral offset in THA. While it does not ensure correction of the exact length discrepancy to 0 mm, it allows us to work within a more reliable and safe range.

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

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Are Customized Implants a Solution in Acetabular Revision Surgery? A Case Study

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ABSTRACT
We present the case of a 73-year-old patient, previously treated with two hip prosthesis revisions due to a chronic infection caused by a multidrug-resistant microorganism, who consulted after the first surgical procedure. Radiographic and computed tomography studies revealed a Paprosky type IV femoral defect and a type IIIA acetabular defect. Following clinical and laboratory monitoring, it was decided to perform acetabular reconstruction using a custom-made implant and a tumor stem. Two years later, the patient shows a favorable evolution: he is able to walk with a cane and without pain. The implant is stable and properly positioned, with no recurrent infection.
Keywords: Revision; acetabular; custom-made.
Level of Evidence: IV

¿Son los implantes "personalizados" una solución en la cirugía de revisión acetabular? A propósito de un caso

RESUMEN
Se presenta a un paciente de 73 años que había sido sometido a dos revisiones de prótesis de cadera debido a una infección crónica por un microorganismo multirresistente. Acude a nuestro centro tras un primer tiempo quirúrgico. En la radiografía simple y la tomografía computarizada, se observan un defecto femoral tipo IV y un defecto acetabular tipo IIIA de Paprosky. Tras un control clínico y análisis de laboratorio, se decide la reconstrucción acetabular mediante un implante "personalizado" y un vástago tumoral. A los 2 años, el paciente evoluciona favorablemente: deambula con bastón y sin dolor. El implante está estable y en posición normal, no hubo recidiva infecciosa.
Palabras clave: Cirugía de revisión acetabular; implante personalizado.
Nivel de Evidencia: IV

INTRODUCTION

The number of revision surgeries after hip arthroplasty is expected to increase by 137% between 2005 and 2030,[1] mainly due to the aging population and arthroplasty performed on younger patients with higher functional demands.[2] Chronic infection is second only to aseptic loosening as a reason for revision surgery, which increases surgical aggressiveness and the number of complications caused by the procedure itself.[3,4] During surgery, there is an added risk of bone stock defect due to the etiology itself and other factors, e.g., removal of prosthetic material.[3]

We present a clinical case of femoral revision surgery with a tumor stem and acetabular revision using the following construction: a) acetabular revision with a custom-made implant (Figure 1) and b) femoral reconstruction using an extended stem (Figure 2).

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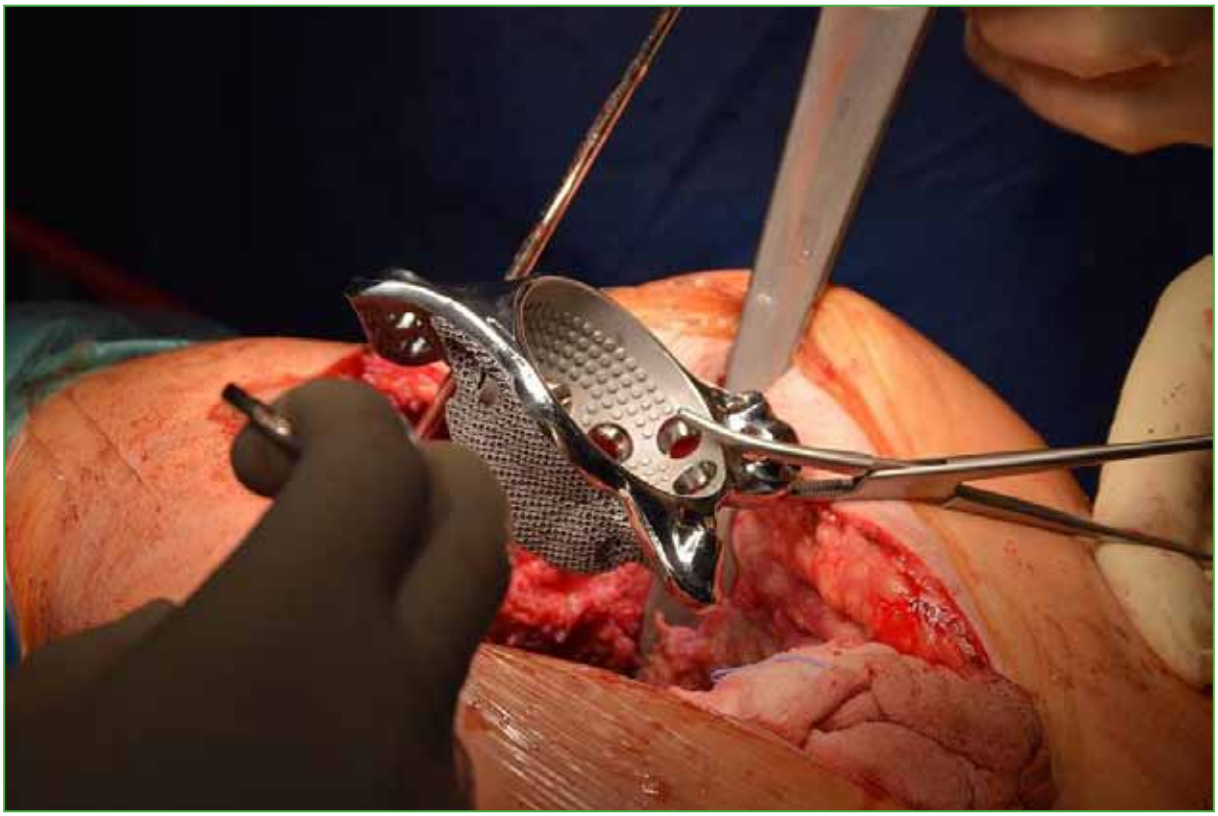

Figure 1. Intraoperative image. Customized acetabular implant before insertion in the acetabular defect.

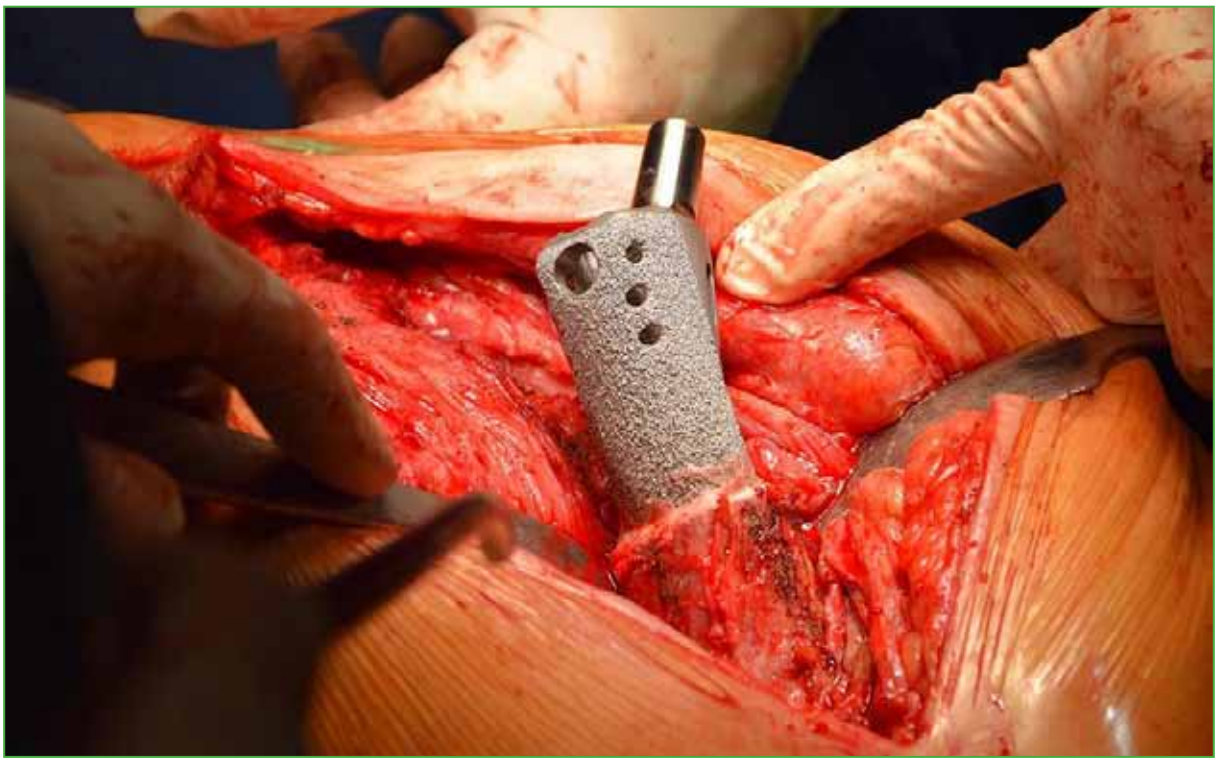

Figure 2. Intraoperative image. Cemented tumor femoral implant after implantation.

CLINICAL CASE

A 75-year-old man, referred to outpatient clinic from another hospital. The medical and surgical history of interest included: complete remission of localized colorectal cancer, obesity, non-insulin-dependent diabetic mellitus, and arterial hypertension treated with standard treatment. He underwent a left total hip arthroplasty in February 2018; six months later (August 2018), he developed a chronic *Staphylococcus capitis* infection (a multidrug-resistant microorganism) and required the first revision surgery, which included a first stage of prosthetic material removal and, two months later (November 2018), a second stage of total hip arthroplasty.

After three months (February 2019), he had a new chronic infection and it was decided to perform another first stage, in which a cement spacer with antibiotic (gentamicin and vancomycin) was placed. During surgery, a considerable bone stock defect was detected: he had a type IV femoral defect and a Paprosky's type IIIA acetabular defect.

In June 2019, he attended outpatient consultations at our hospital center to evaluate definitive treatment (Figure 3).

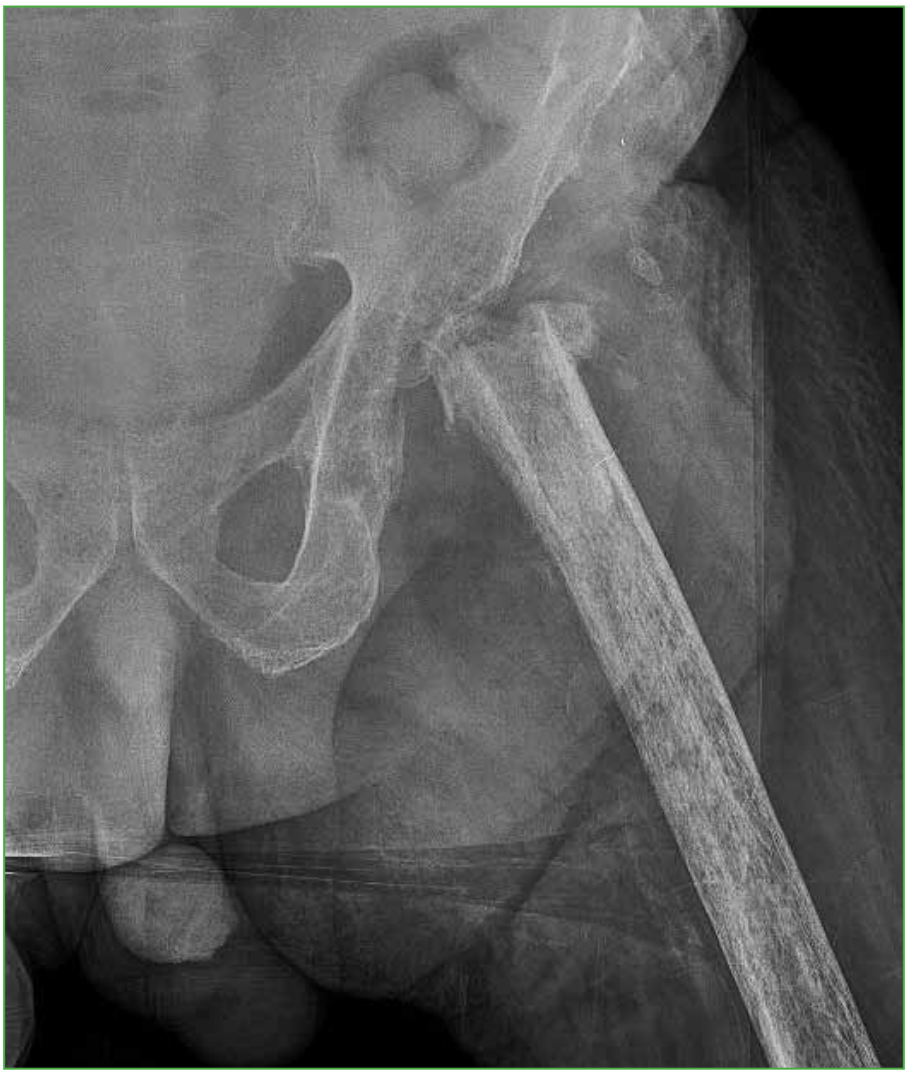

Figure 3. Preoperative anteroposterior radiograph of the pelvis. Femoral and acetabular defects before surgery.

The patient was monitored for eight weeks by clinical and laboratory evaluations until the parameters were in the normal range to plan the second surgical procedure (September 2019).

Due to the femoral and acetabular defects, the placement of a revision tumor stem to solve the proximal femoral defect was planned in a clinical session, along with a custom-made implant to address the acetabular defect.

For the design of the acetabular component, a high-resolution computed tomography of the pelvis was performed, with slices every 3 mm (recommended dimension for the 3D reconstruction of the images). The images obtained were sent to an external center for the manufacture of the component (Materialise, Leuven, Belgium).

The design was made according to the images sent, both of the pathological hip and of the contralateral hip. A scan of the healthy and pathologic bone tissue, as well as the remaining cement (placed during the initial revision operation), was performed. With these variables, we calculated the center of rotation of the hip (Figure 4), the definitive size of the acetabular implant, the estimated bone stock after cement removal, the bone surface to be removed before implantation, the orientation of the definitive cup according to the center of rotation, the custom-made guides for the screws, as well as their order, size and orientation with different templates for correct acetabular fixation (Figure 5).

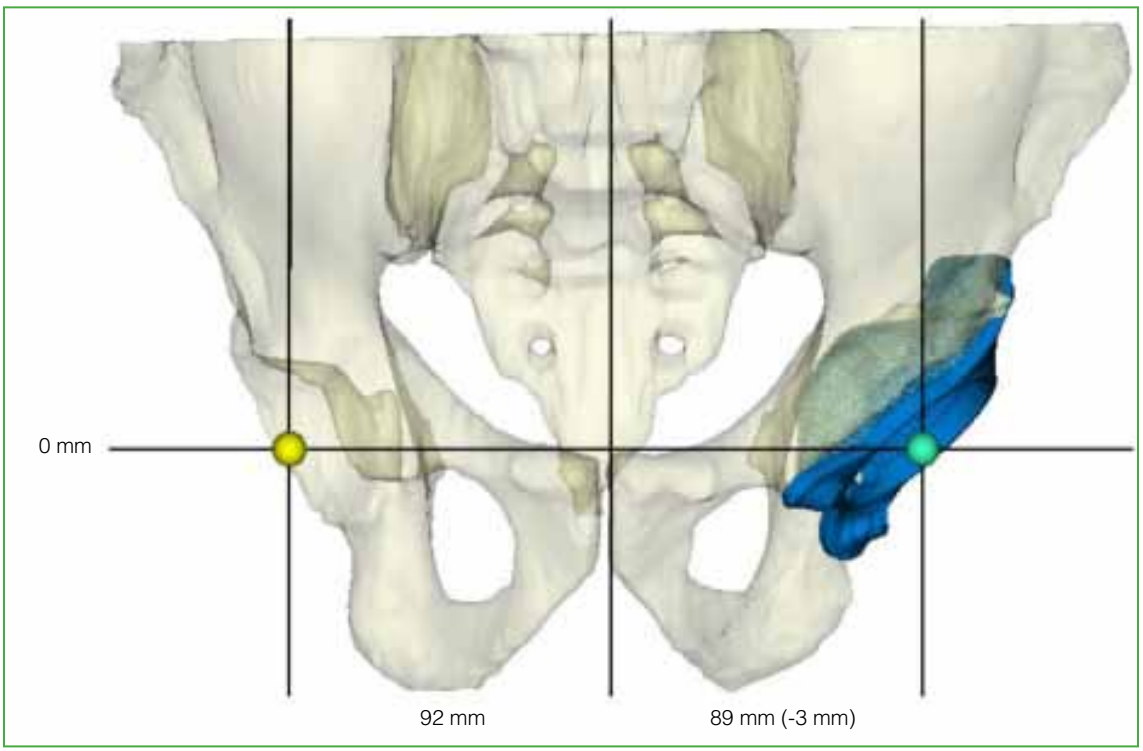

Figure 4. Design of the definitive implant. Calculation of the center of rotation, according to the contralateral hip.

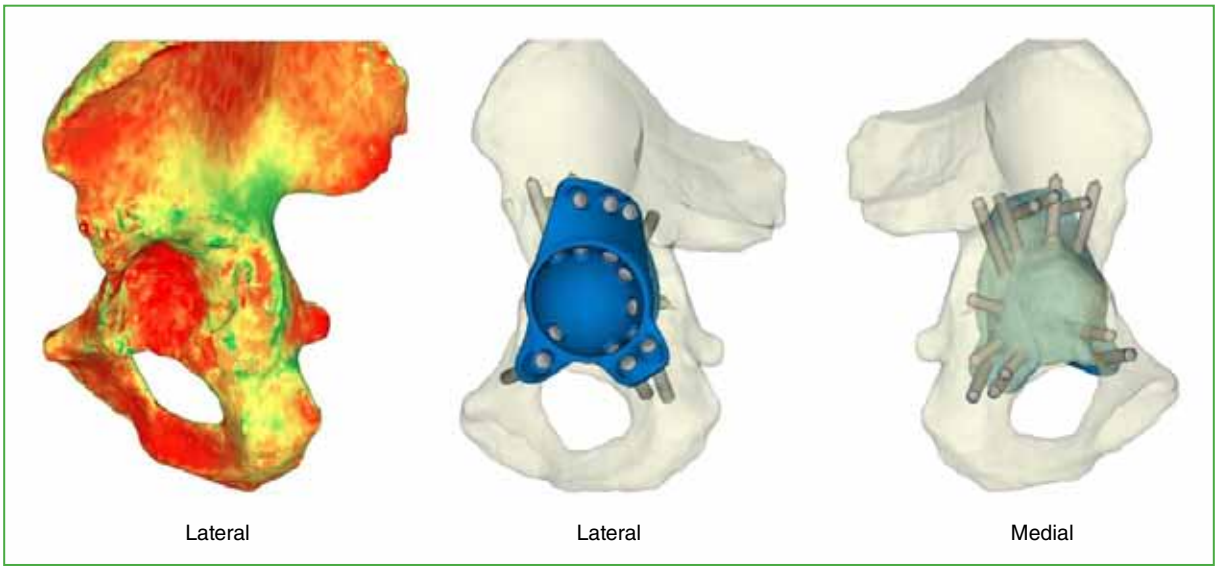

Figure 5. Design of the definitive implant. Lateral and medial views before and after implantation. Visualization of the pathologic bone region (red) and remaining bone stock (yellow color: suboptimal; green color: optimal). Proposed position and orientation of the implant with screw fixation.

Surgical procedure

The operation was performed through an extended posterolateral hip approach. During surgery, tissue and periarticular fluid samples were collected, and an alpha defensin test was done, which yielded a negative result. After cement removal, no other bone defects were observed.

The process of the cup was initiated by removal of osteophytes and bone surface according to the surgical technique, as well as reaming to a size of 62 mm. Once prepared, the customized cup was inserted and the screws were drilled in the indicated order and in the recommended direction. Polyethylene-ceramic bearings with a dual-mobility functional regime were chosen.

After a thorough and systematized pulsatile saline lavage, a 7 cm proximal femoral osteotomy was performed, the canal was reamed and a cemented 18 x 150 mm femoral tumor stem was placed. Before completing the surgery, the mechanical stability of the prosthetic material was checked and found to be optimal, and the surgery was completed by re-anchoring the gluteal and abductor musculature to a polyethylene terephthalate mesh. This component is a restrictive mechanical element that subsequently generates a neo-capsule together with the anchored elements and provides joint stability (Figure 6).

The patient did not require transfusion of red blood cell concentrates during hospitalization. Before discharge, he managed to walk 20 steps in a row with the aid of a walker, with relative independence.

At the last clinical control (two years after the last operation), the patient's evolution was satisfactory (Figure 7). Joint balance was correct, with no reported dysmetria. Barthel test score[5] was 80; the patient was pain-free except after excessive ambulation (over 1000 m) and he walked with a cane. Control radiographs revealed no loosening or subsidence of the acetabular or femoral material. On the other hand, compared to the contralateral hip, the center of rotation was recovered. He has also experienced no neurovascular lesions during his evolution.

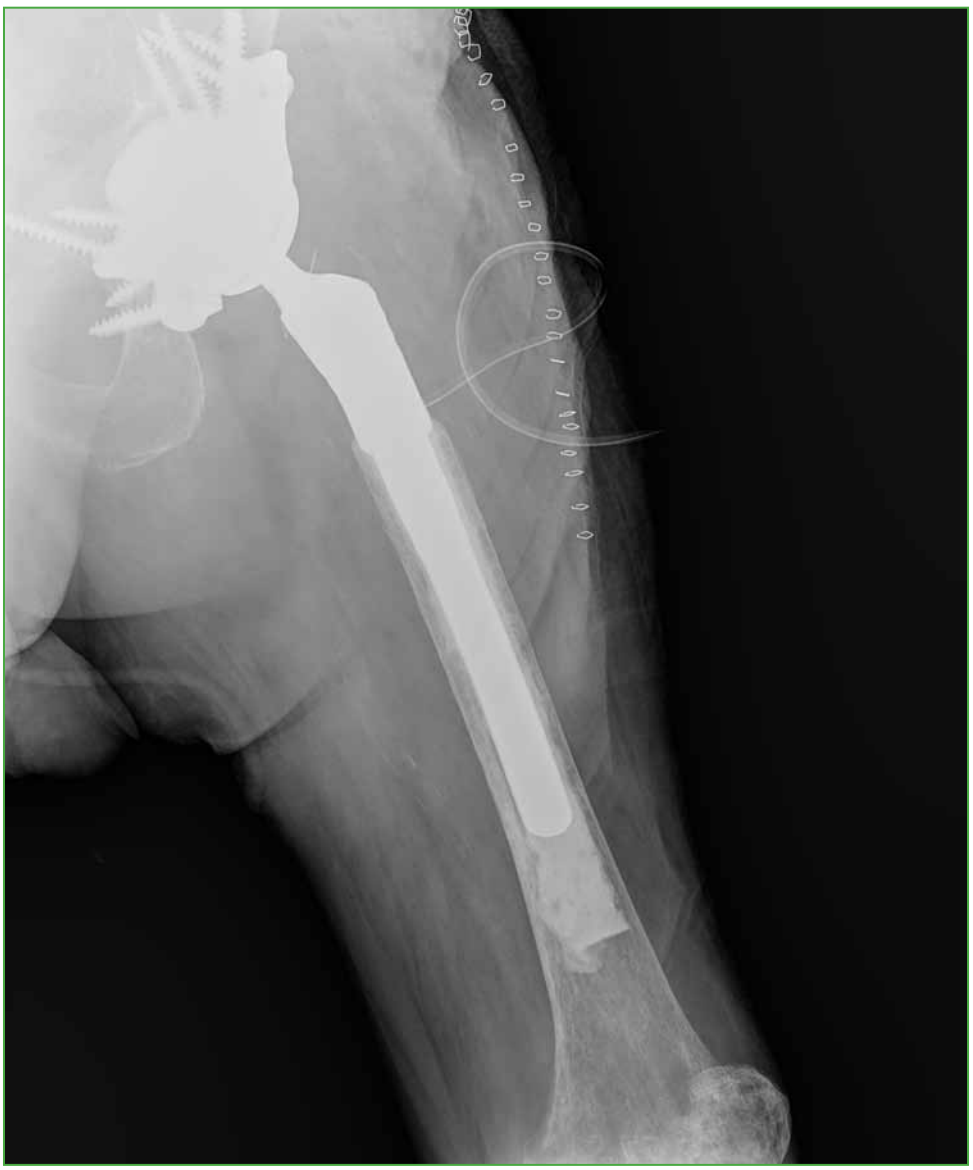

Figure 6. Anteroposterior radiograph of femur. First post-surgical control.

DISCUSSION

Acetabular revision surgery is a complex surgical procedure and the choice of implant is critical. The combination of an acetabular bone defect, anatomical changes and insufficient healthy bone stock requires a revision strategy aimed at restoring the acetabular surface and achieving proper fixation of the prosthetic component.

In 1994, Paprosky[6] defined his classification of acetabular defects based on radiographic criteria studied on an anteroposterior pelvis radiograph. Type III defects already include severe bone loss of the anterior and posterior columns, as well as the superior dome. He defined defect IIIA as one with <50% bone loss, with medial wall involvement, but without pelvic migration, as in our patient.

Multiple therapeutic methods for revision surgery have been presented for defects of substantial severity, one of which is the use of custom-made acetabular components.[6]

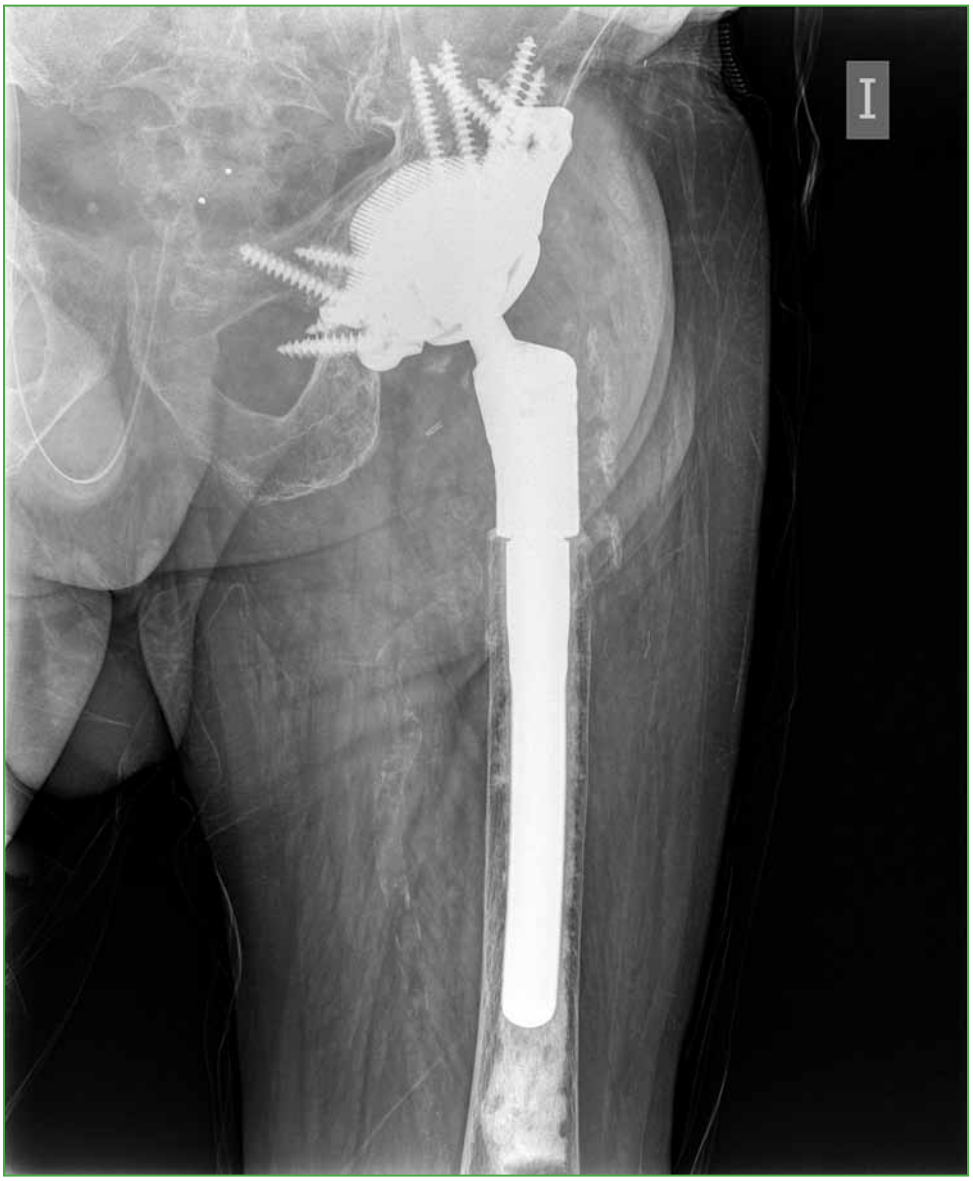

Figure 7. Anteroposterior radiograph of femur. Control after two years of evolution.

Articles have been published on this therapeutic choice, such as that of Van Eemeren et al.,[7] who also presented a clinical case operated on using a "customized" cup, but via the anterior approach.

Citak et al.[8] presented a series of nine patients operated on with a customized cup via the posterior approach. The results obtained were comparable in the short term to those of the cup-cage system, the only drawback being the delay in obtaining the prosthetic material due to the design time. It is not only comparable to other systems, but it can also serve as a rescue for them, as proposed by Zanasi and Zmerly,[9] who chose a customized cup following the aseptic loosening of a triflange cup.

If a new surgical procedure is finally proposed, it ought to be for the following reasons: at least equal clinical, functional, and radiological results in the medium term;[9,10] option or salvage surgery for severe acetabular defects where therapeutic options have already been exhausted;[9] better acetabular orientation; shorter surgical time, and less blood loss.[10] Disadvantages have also been reported, such as higher health care costs, pending more long-term

cost-effectiveness data;[11] a longer time between treatment planning and obtaining the definitive implant; a learning curve for the surgical team. Likewise, postoperative complications have already been published. Gruber et al. reported a clinical case of posterior dislocation three months after surgery.[12]

Delay in manufacturing is likely to be a relative and acceptable disadvantage. According to published articles, it takes between four weeks and months from planning to obtaining the implant.[9,10] This is a process that requires a computerized tomography scan when the patient no longer has the prosthetic material. High resolution images are sent for fabrication, detailing all the aspects mentioned above. Special caution should be taken, since, as described by Di Laura et al.,[13] surgical planning prior to removal of the prosthetic material may lead to discordance of the healthy bone stock present at definitive surgery.

Short- and medium-term functional outcomes after surgery have been published. In the largest series,[8] an improvement of 22.1 (range 9-40) to 58.7 (range 9-92) was obtained in the Harris hip score. This scale has also been used in other studies,[14] in which the mean score was 79 (range 36-100), with no preoperative data collected. In their systematic review of retrospective and prospective studies after a minimum follow-up of two years, Chiarlone et al.[15] published a Harris hip score of 76.1 (standard deviation 8.6).

On the other hand, Li et al.[16] reported that the radiographic evaluation of customized implants is challenging due to the intrinsic design of the devices, and reported an acceptable rate of loosening, implant migration, as well as material breakage and the presence of radiolucency lines.

CONCLUSIONS

Custom-made implants are a valid treatment for acetabular defects with major bone involvement (deficient bone stock). The published results are promising and these implants represent one more option within the clinical and surgical challenge posed by these patients.

More studies are needed to contrast the scientific evidence, as well as more extensive follow-up to draw long-term conclusions.

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Total Hip Arthroplasty with a Revision Stem in Hereditary Multiple Exostoses with Secondary Osteoarthritis

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ABSTRACT
We present a 42-year-old woman with a history of hereditary multiple exostoses (HME), with pain and limited range of motion of the left hip. Radiographic studies showed osteoarthritis added to femoral exostosis with bilateral hip dysplasia and femoral head subluxation. Total left hip replacement was performed using a modular uncemented implant with excellent postoperative results at 7 years of follow-up.
Keywords: Hereditary multiple exostoses; hip joint; osteoarthritis; replacement arthroplasty.
Level of Evidence: IV

Artroplastia total de cadera con tallo de revisión en un paciente con exostosis múltiple hereditaria y osteoartritis secundaria

RESUMEN
Presentamos una mujer de 42 años con antecedente de exostosis múltiple hereditaria, y dolor y limitación de la movilidad de la cadera izquierda. Los estudios radiográficos demostraron osteoartrosis y exostosis femoral con displasia bilateral de cadera y subluxación de la cabeza femoral. Se realizó una artroplastia total de cadera izquierda con un implante no cementado modular. El resultado a los 7 años fue excelente. El objetivo de este artículo es mostrar una opción alternativa de reconstrucción para las deformidades complejas.
Palabras clave: Exostosis múltiple hereditaria; cadera; osteoartritis; artroplastia de revisión.
Nivel de Evidencia: IV

INTRODUCTION

Osteochondromas are primary benign osteocartilaginous bone tumors that are typically located around the knee, proximal humerus, and other endochondral ossification bones, and represent the most common primary bone tumor.[1] They can appear as a solitary lesion or as multiple lesions in the context of hereditary multiple exostoses (HME), an autosomal dominant disease caused by a mutation in the tumor suppressor *EXT* gene family.[2] Their prevalence is one case per 50,000 inhabitants in the general population.[3,4] 30-90% of patients with HME may have proximal femur osteochondroma,[2,5] while pelvic osteochondroma affects 15-64% of patients.[2] In 25% of cases, acetabular dysplasia and coxa valga are detected.[4] This has suggested that valgus hip morphology and femoral neck osteochondroma may contribute, independently or synergistically, to the increased risk of lateral hip subluxation and, consequently, to osteoarthritis.[5] Total hip arthroplasty is a valid therapeutic option when this condition is diagnosed. Good preoperative planning must be carried out given the complexity of the joint deformity and the alteration of intraoperative parameters, in order to achieve correct placement of the prosthetic components.[6-8]

The aim of this article is to communicate an alternative reconstruction option for complex deformities.

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CLINICAL CASE

A 42-year-old woman with a family history of HME in her paternal line who consulted, for the first time, for left coxalgia of two years of evolution. He experienced severe pain during weight bearing and limitations on his daily activities. Hip range of motion was 120º of flexion, 30º of abduction, and limited rotations. The Harris hip score[9] was 75. On the pelvis radiograph, bilateral hip dysplasia with subluxation of the femoral head and bony protrusions (exostoses) in both lesser trochanters toward the femoral head were observed (Figure 1). The left hip had a cervico-diaphyseal angle of 165º, acetabular incongruity, and signs of osteoarthritis that were more evident on the CT scan (Figure 2). On radiographs of the knees and ankles, multiple exostoses and tibiofibular ankylosis were visualized (Figure 3).

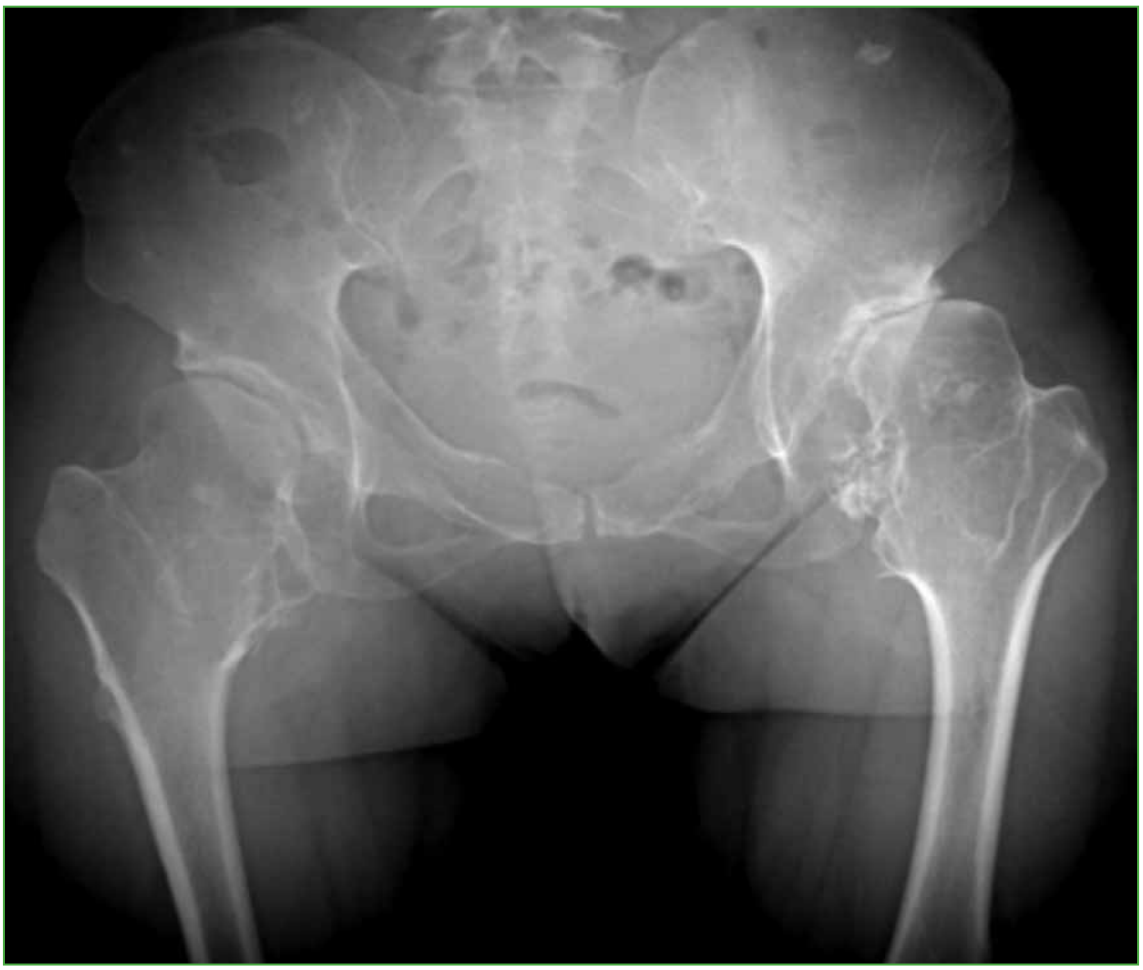

Figure 1. Panoramic pelvic radiograph. Deformity of both hips is observed, with signs of osteoarthritis in the left hip.

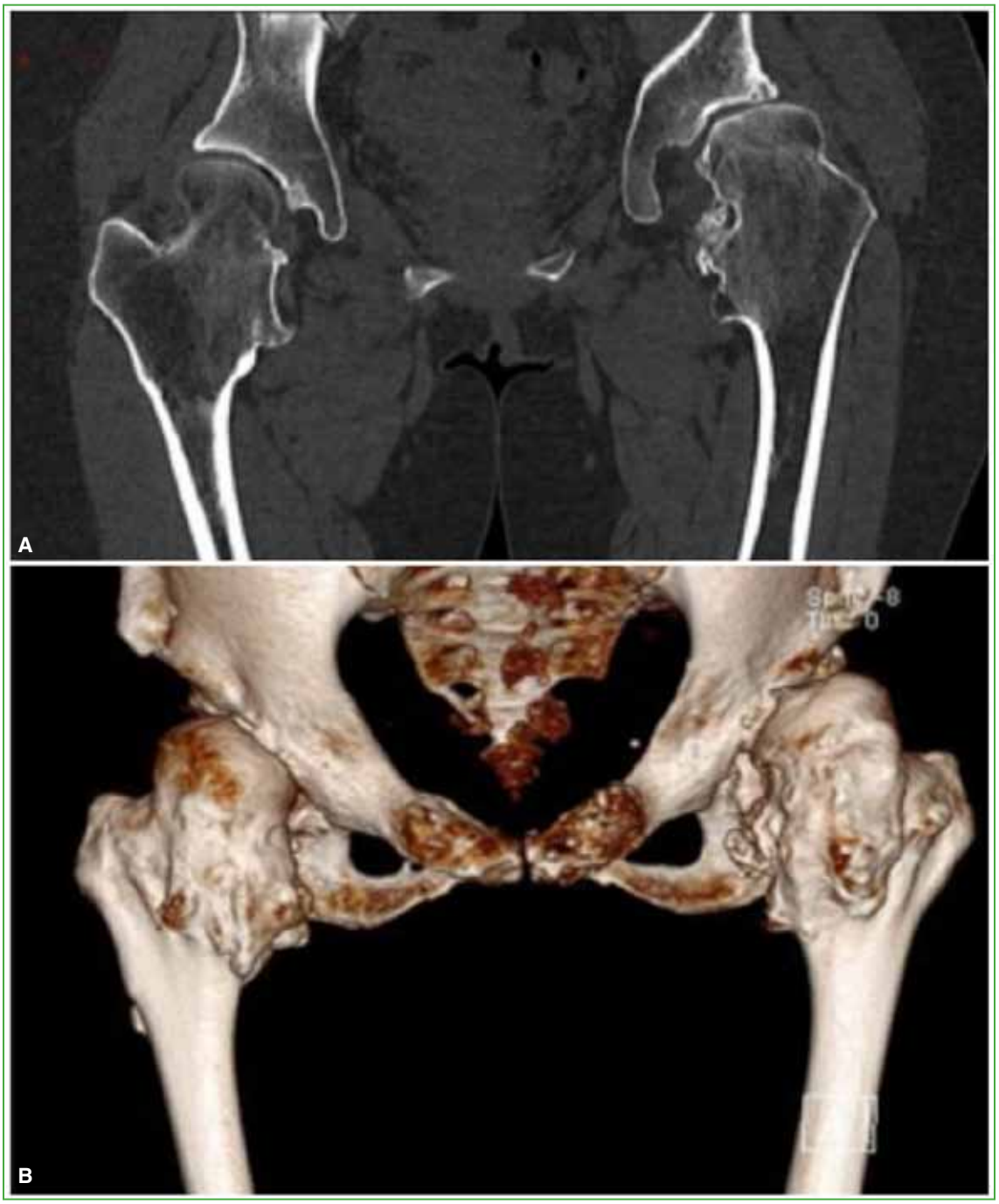

Figure 2, A. Preoperative CT scan of both hips, coronal section, to assess bone stock. **B.** Three-dimensional reconstruction.

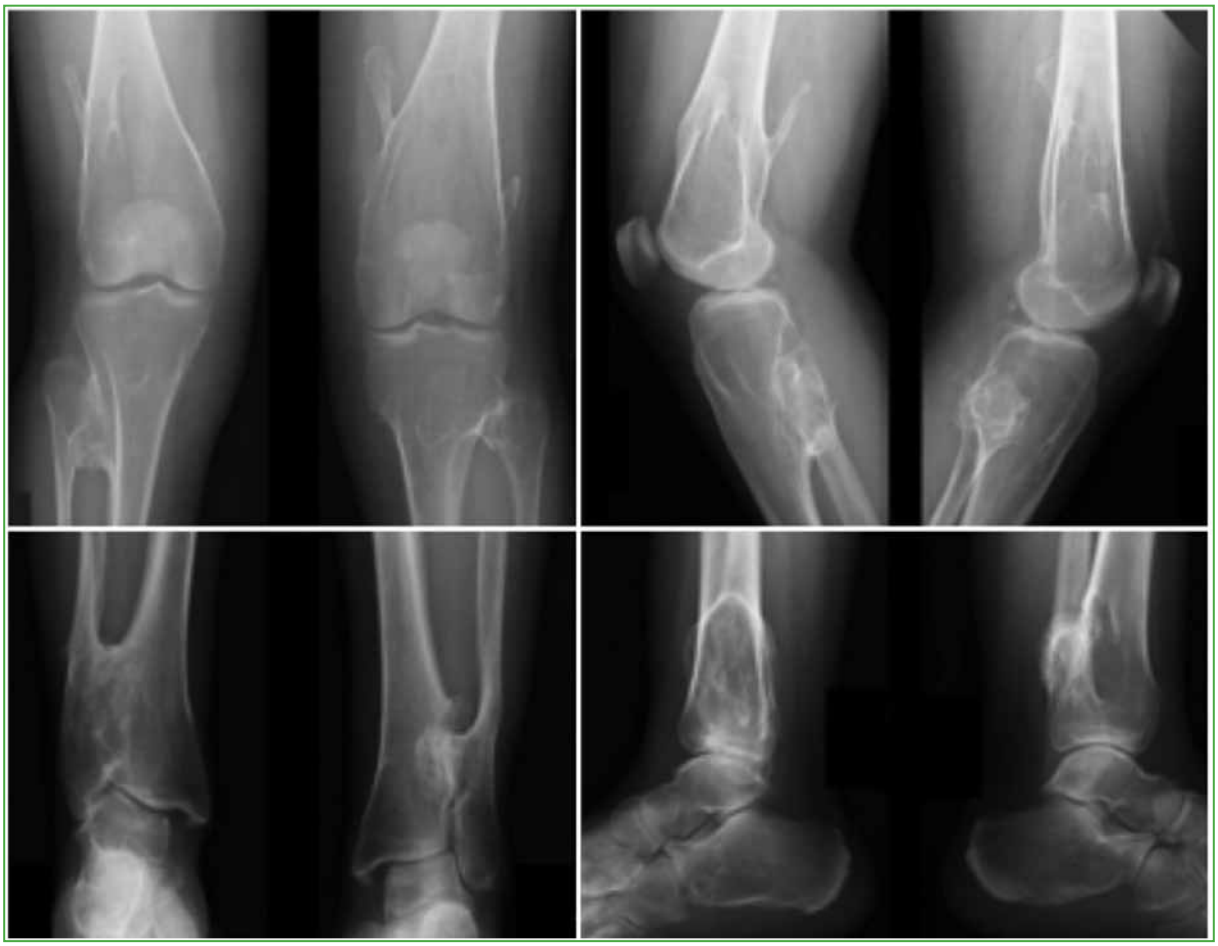

Figure 3. Anteroposterior and lateral radiographs of knees and ankles. Note the multiple exostoses and tibiofibular ankylosis.

Surgical technique

An uncemented total hip arthroplasty through a posterior Kocher-Langenbeck approach was chosen (Figure 4). A modular cementless S-ROM® implant (DePuy, Johnson & Johnson, Warsaw, IN, USA) with a 28 mm diameter ceramic head and a proximal metaphyseal module was used to allow intraoperative control of the deformity.

RESULTS

There were no intraoperative or immediate postoperative complications. Seven years later, the patient remained symptom-free, with 120° flexion, 40° abduction, 15° external rotation, 20° internal rotation and a Harris hip score of 100. The radiographic appearance of the implant was also satisfactory (Figure 5).

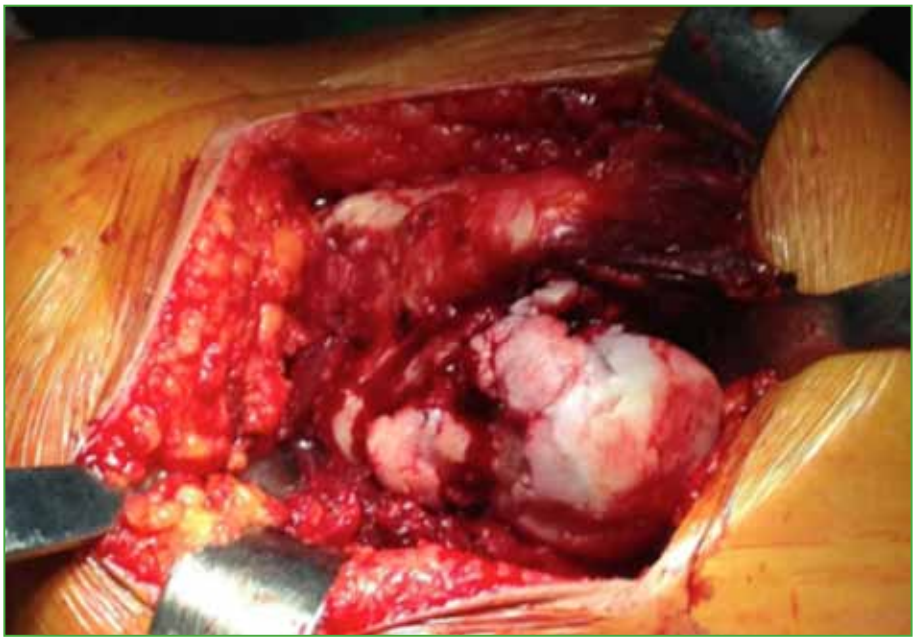

Figure 4. Intraoperative image. The dislocation of the femoral head and its irregular contour corresponding to the voluminous cartilage exostosis is observed.

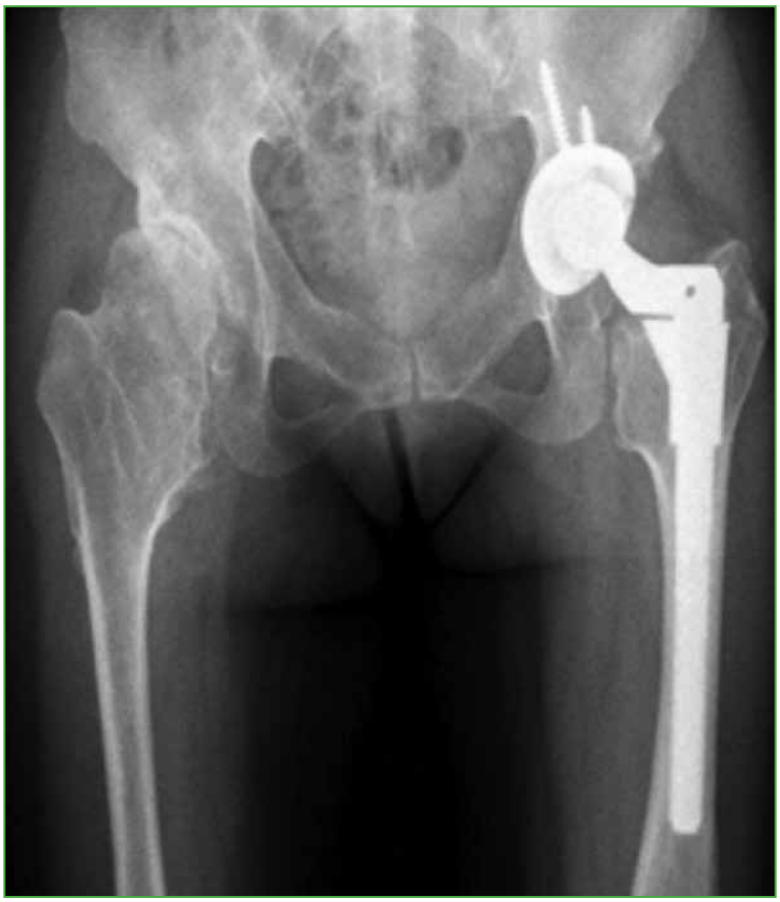

Figure 5. Anteroposterior radiograph of the left hip, 7 years after total hip arthroplasty.

DISCUSSION

HME is an autosomal dominant disease. It tends to be more common in men than in women, and usually affects the femur, tibia with distal and proximal fibula, distal humerus, distal radius and distal ulna.[1-3,5] Hip osteoarthritis due to HME is at increased risk of progression because the femoral neck is thickened by the medial exostosis, which may facilitate subluxation of the femoral head. Shapiro et al.[4] reported that eight of 32 patients (64 hips) <20 years with this disease had coxa valga, as did our patient.[1] Increased femoral anteversion has also been reported.[1]

With regard to the surgical treatment of exostoses, there are many reports on the methods used in pediatric patients, which have achieved good outcomes,[2,3,5] but there are few reports on the treatment of osteoarthritis in advanced stages in adults. Porter et al.[3] described the hips of 12 patients with HME and reported that only one had undergone total hip arthroplasty, without specifying the evolution.

Moran et al.[6] reported on the placement of a bilateral prosthesis in two patients with hip dysplasia secondary to HME and reported good functional outcomes after two years. In these cases, they used modular implants and performed a femoral osteotomy due to the complexity of the technique.

Vaishya et al.[7] presented a 27-year-old patient with HME and osteoarthritis of both hips and a large femoral and acetabular bone deformity. The patient underwent bilateral total hip arthroplasty using a primary implant. The prosthesis dislocated, therefore the stem was replaced to correct its anteversion and a collar with a higher offset was added. This demonstrates the complexity of this type of deformity and the need to use unconventional implants.

Kim et al.[8] published a case of HME with secondary osteoarthritis treated with total hip arthroplasty using a cementless Wagner® cone stem (Zimmer. Warsaw, IN, USA); the outcome was good and the Harris hip score improved from 35 to 82 in the 2-year follow-up.

In our case, due to the underlying metaphyseal alteration and the increased femoral anteversion, we used a cementless diaphyseal fixation stem with a modular system and a proximal femoral sleeve to control the anteversion as a very good option for the correct positioning of the components, thus achieving the desired stability.

CONCLUSIONS

In patients with HME, deformity of the proximal femur is frequent and facilitates progression to osteoarthritis. Modular cementless total hip arthroplasty is a good option for restoring hip biomechanics. However, it requires proper preoperative planning, which should include a CT scan to assess hip anteversion and valgus.

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Infected Pseudotumor in Total Hip Arthroplasty with Metal-on-Metal Friction Couple

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ABSTRACT

Total hip arthroplasty (THA) is the main treatment for advanced hip osteoarthritis and its complications include dislocation, infection, aseptic loosening and, to a lesser extent, adverse reactions to metal. Pseudotumor is a rare complication of THA with a metal-on-metal friction couple; its diagnosis and treatment are extremely important to reduce morbidity and mortality. We present the case of a 63-year-old male patient with a 13-year history of THA with a metal-on-metal friction couple who, at the time of consultation, presented a large palpable mass in the right gluteus and paresthesias in the homolateral sciatic nerve. The diagnosis of an infected pseudotumor was reached and treated with hip revision and antibiotic therapy.

Keywords: pseudotumor; total hip arthroplasty; metal-on-metal friction couple.

Level of Evidence: IV

Seudotumor infectado en un paciente con artroplastia de cadera con par de fricción metal-metal

RESUMEN

La artroplastia total de cadera es el principal tratamiento para la artrosis avanzada de cadera y las complicaciones pueden ser luxación, infección, aflojamiento aséptico y, en menor medida, reacciones adversas al metal. El seudotumor es una complicación poco frecuente con un par de fricción metal-metal. El diagnóstico y el tratamiento correctos son muy importantes para disminuir la morbimortalidad. Presentamos el caso de un hombre de 63 años que había sido sometido a una artroplastia total de cadera con un par de fricción metal-metal, 13 años atrás. Al consultar, tenía una gran masa en el glúteo derecho y parestesias en el territorio ciático homolateral. Se diagnosticó seudotumor asociado a infección periprotésica y el tratamiento definitivo consistió en revisión en un tiempo y la administración de antibióticos.

Palabras clave: Seudotumor; artroplastia de cadera; par de fricción metal-metal.

Nivel de Evidencia: IV

INTRODUCTION

Total hip arthroplasty (THA) has been the treatment of choice for severe hip osteoarthritis in recent decades.[1] The most frequent complications are dislocation, aseptic loosening, infections and, to a lesser extent, adverse reactions to the metal, such as pseudotumors.[2] 'Pseudotumor' is defined as a non-neoplastic periarticular mass caused by an immunological hypersensitivity response to metallic particles.[3] Its prevalence after THA with metal-on-metal bearings ranges between 1% and 4%,[3] although a rate of up to 41% has been reported, mostly asymptomatic pseudotumors.[4] In 32% of cases, it can manifest with groin pain, paresthesia, limping or a palpable mass, along with various complications due to compression on neurovascular and urinary structures.[5] Complementary studies to reach the diagnosis include ultrasound, computed tomography, magnetic resonance, and ionogram. Currently, different treatment algorithms are available that vary according to the clinical condition and electrolyte level.

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CLINICAL CASE

A 63-year-old man, rural worker, with no relevant clinical history. In 2007, he had undergone a cementless right THA with metal-to-metal bearings for the treatment of hip osteoarthritis. In 2014, he consulted another institution due to a painless tumor in the right gluteal region that had developed for two months, associated with paresthesia in the ipsilateral lower limb after several hours of sitting. A puncture biopsy was performed and, in the sample, *Staphylococcus caprae* was isolated, for which he was prescribed oral trimethoprim-sulfamethoxazole for 14 days. The sample from a new puncture biopsy at the end of treatment was negative.

As the symptoms had become more acute, including the tumor in the right glute, the patient consulted our institution in 2018. A physical evaluation was performed (Figure 1), and laboratory tests (Table), radiographs (Figure 2), a CT scan (Figure 3), and a puncture were requested, in which 1800 ml of seropurulent fluid were extracted (Figure 1). The culture was positive for oxacillin-susceptible *Staphylococcus caprae*.

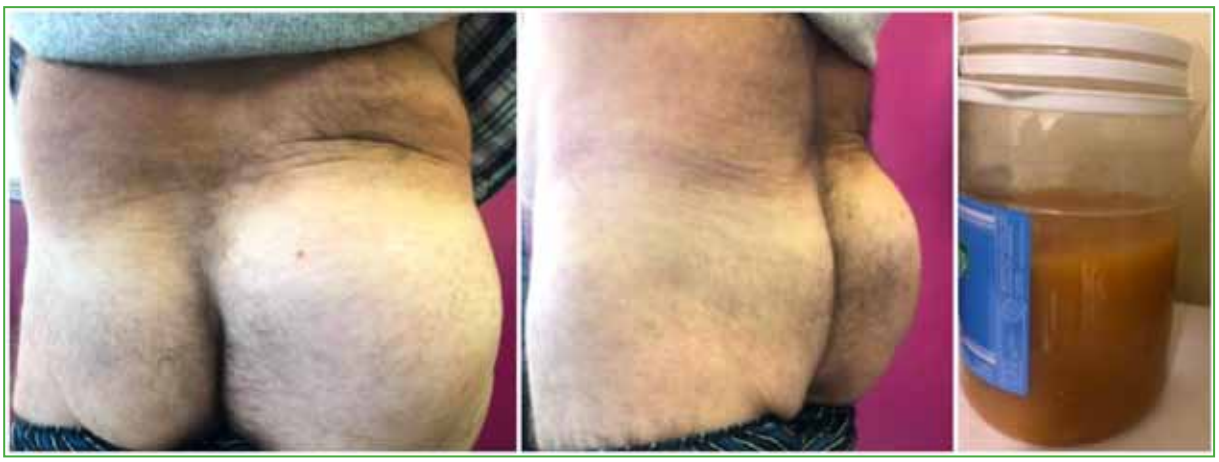

Figure 1. Clinical image of the mass in the right glute. Puncture fluid (1800 ml).

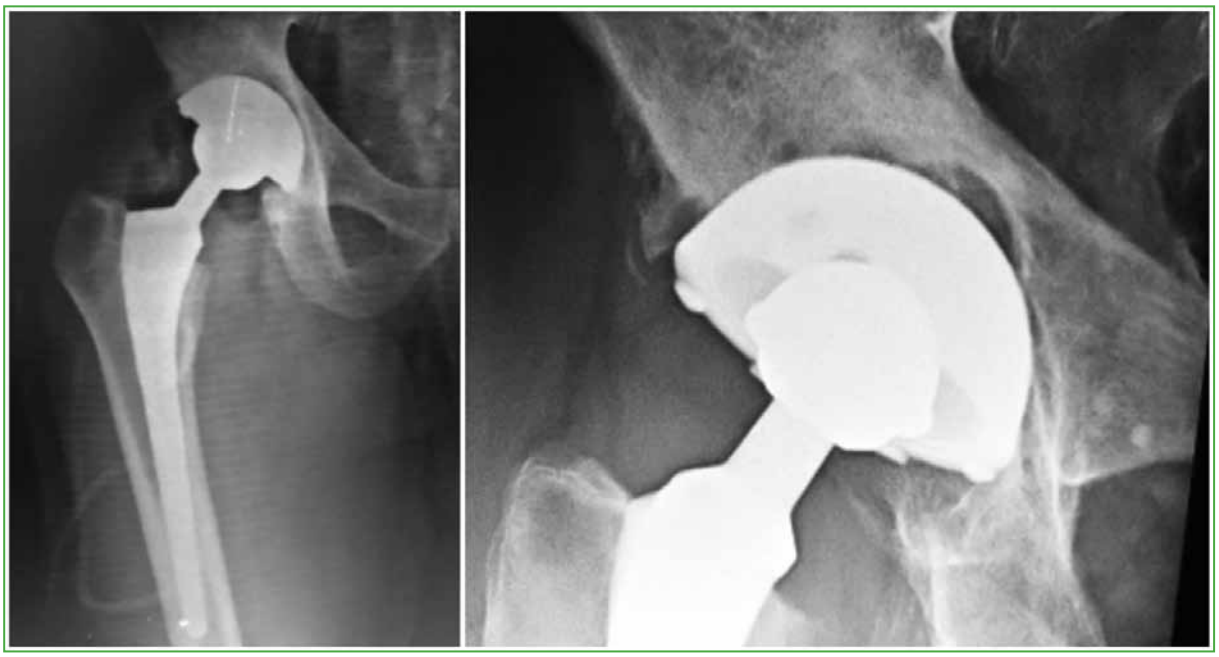

Figure 2. Anteroposterior radiographs of the right hip. Acetabular radiolucency is observed, which is indicative of backside wear.

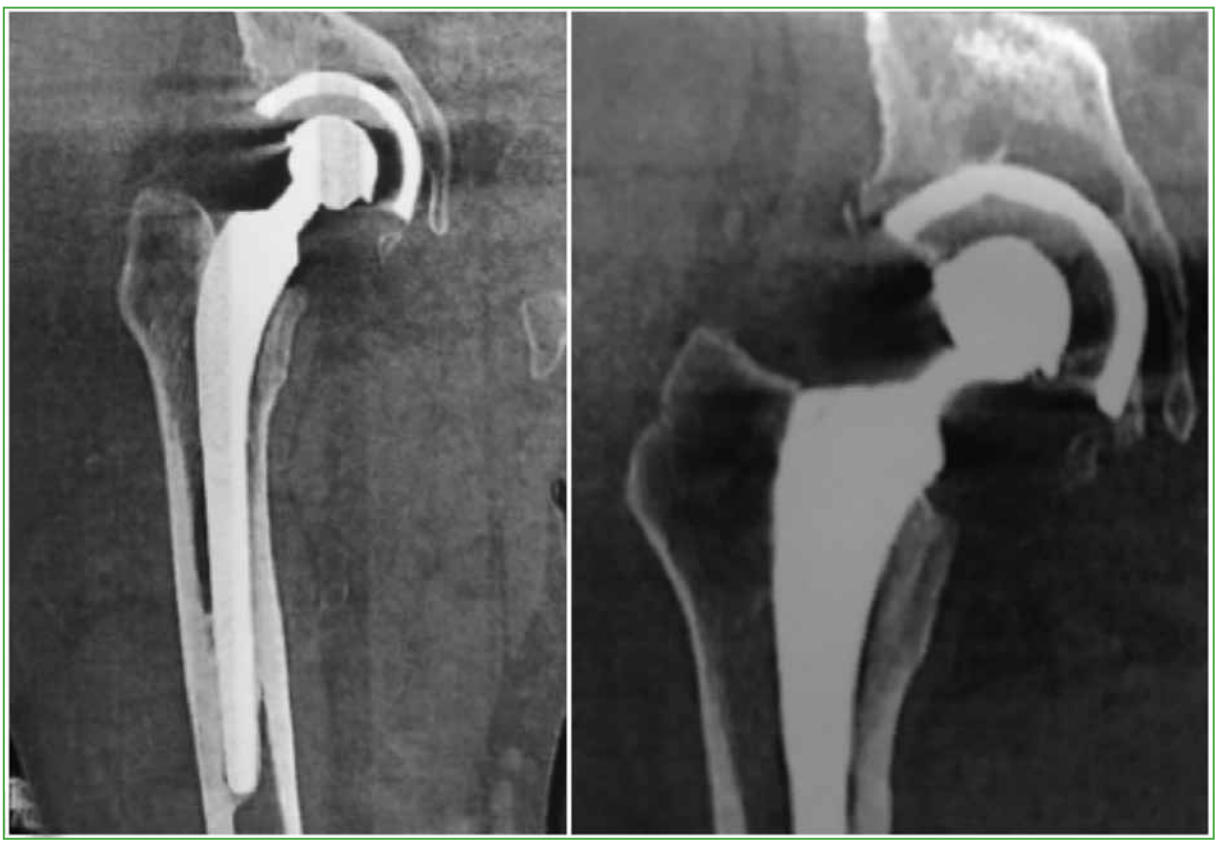

Figure 3. CT scan of the right hip, coronal sections. Note the pedestal sign and backside wear in the inner third of the acetabular roof.

Table. Values of ions and acute phase reactants in blood.

	Result	Normal value
Ions		
Lead	4.30 µg/dl	<26 µg/dl
Cobalt	0.15 µg/dl	<0.05 µg/dl
Chrome	0.06 µg/dl	<0.05 µg/dl
Nickel	0.5 µg/dl	<1 <0.05 µg/dl
Acute phase reactants		
C-reactive protein	10.66 mg/l	0.5 mg/l
Erythrocyte sedimentation rate	53 mm/h	15 mm/h

Given the elevated values of cobalt, chromium, C-reactive protein, and erythrocyte sedimentation rate, as well as the images consistent with acetabular osteolysis and a gluteal tumor, a hip pseudotumor caused by the metal-on-metal bearings was suspected. After isolating the germ and knowing its sensitivity, a single-stage revision was performed.

Therapeutic plan

Tumor resection and acetabular revision were performed in the same procedure. The pseudotumor was identified using a Kocher-Langenbeck approach. With the help of a neurolocator, complete resection of the mass was achieved, avoiding damage to the sciatic nerve that was in close contact with the lesion (Figure 4).

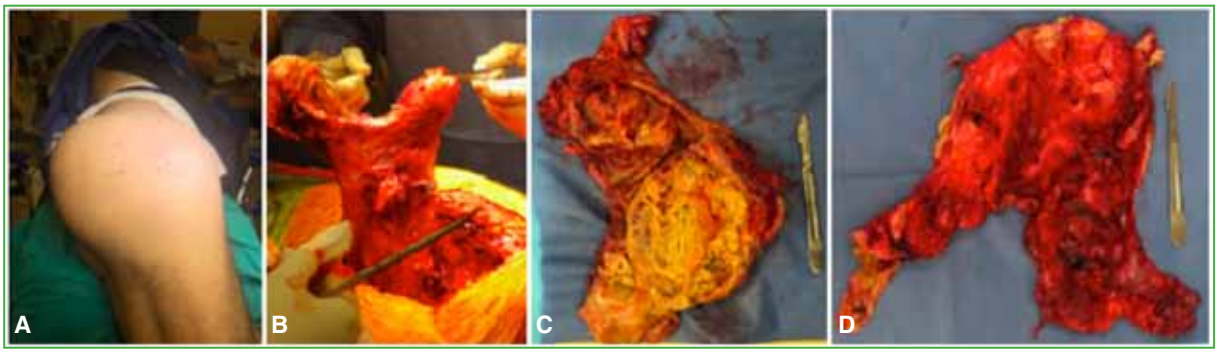

Figure 4. A. Position on the operating table. **B.** Intraoperative piece. **C and D.** Macroscopic image of the pseudotumor (with signs of metallosis).

The metal head and acetabular component Magnum M2a 38 (Biomet, Warsaw, Indiana, USA) were removed. The liner consisted of a metallic layer that covered the polyethylene on its articular face, which resulted in the metal-on-metal friction couple (Figure 5). The acetabular cup was retained, within which a universal cup liner with a 36+9 metal head was cemented, preserving the femoral stem (Figure 6).

The pathology report indicated: "fragments with fibrosis, fibrin deposits and chronic lymphocytic inflammatory infiltrate indicative of fibrinolysis/fibrosis/chronic inflammation" and the cultures (3 of 6) were positive for oxacillin-susceptible *S. caprae.* Oral antibiotic treatment with ciprofloxacin 500 mg and rifampicin 300 mg was administered every 12 hours for three months.

Six months after surgery, C-reactive protein, erythrocyte sedimentation rate, cobalt, and chromium values were normal. After two years, the patient suffered a hip dislocation after improper movement and underwent a closed reduction. After four years and five months, he has no symptoms or signs of hip or glute inflammation and could return to his normal activities (Figure 7).

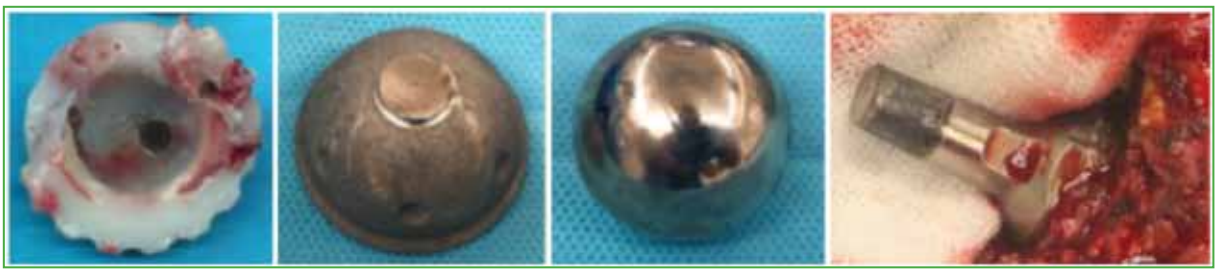

Figure 5. Worn components: liner, cup, metal head and cone.

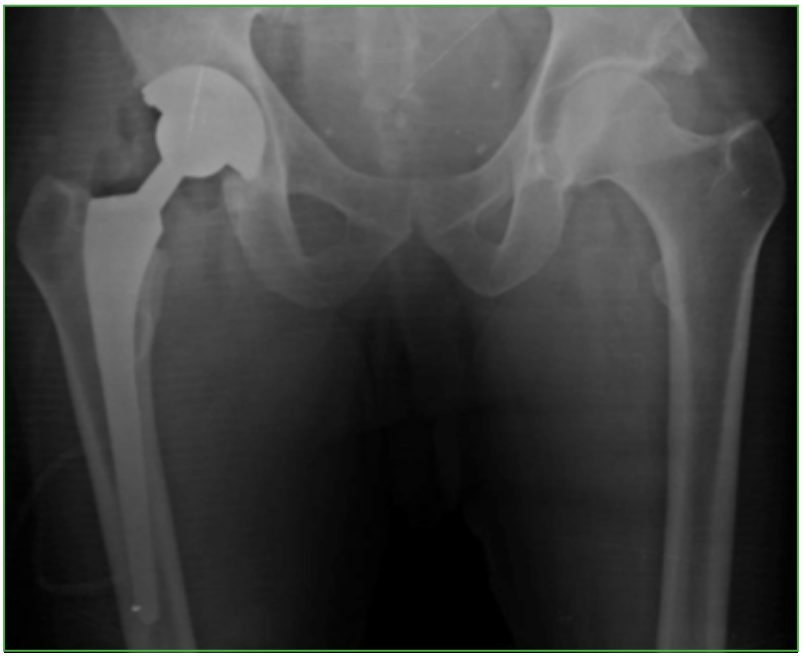

Figure 6. Postoperative radiograph (AP view) of both hips.

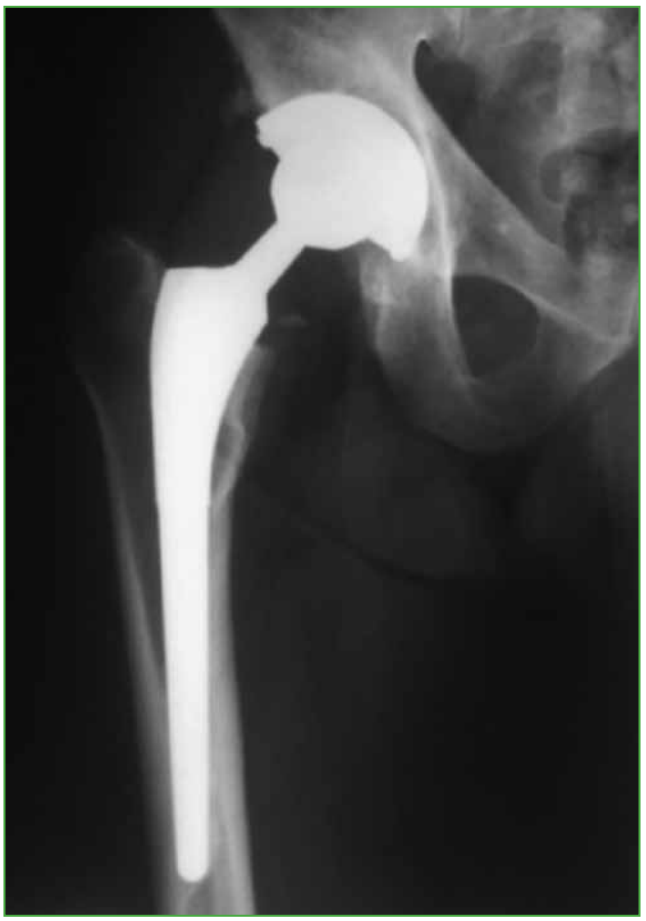

Figure 7. AP radiograph of the right hip, 2 years after surgery.

DISCUSSION

The introduction of metal-on-metal bearings allowed for the elimination of polyethylene and, as a result, an increase in the size of the prosthesis head, which gives improved stability by expanding the range of motion.[6] Several studies point to poor positioning of components and the use of a large femoral head as risk factors for the formation of pseudotumors.[7,8] Other risk factors described include allergy to metal ions.[9] The high rate of friction that occurs between the components generates the release of chromium, cobalt and nickel particles that can produce a local hypersensitivity reaction with the consequent formation of a pseudotumor.[3,10] At a systemic level, complications have been described, such as hemoglobinopathies, hepatocellular and renal necrosis, asthma, cardiomyopathies, osteomalacia, vasculitis, maternal-fetal toxicity and DNA alterations related to carcinogenesis.[9-11]

Although the prevalence of pseudotumors in THA with metal-on-metal bearings was believed to be relatively low,[3] van Lingen et al. evaluated 94 patients with a minimum follow-up of 10 years and reported that the prevalence of pseudotumors in arthroplasties with metal-on-metal bearings was close to 41%.[4] The five-year revision rate in patients with a pseudotumor is 6.2%, more than double than that of other friction couples.[3] Many regulatory bodies, including the British Orthopedic Association, the Food and Drug Administration, and the Government of Canada,[12-14] warned about the complications of THAs with metal-on-metal bearings and suggested monitoring patients with such implants[15] whether or not they have symptoms.

Magnetic resonance imaging is an effective tool for diagnosing periarticular tumors, albeit the 'artifact' formed by the prosthesis can make vision difficult. Computed tomography and ultrasound are also extremely useful studies.[16] Although some studies suggest mandatory monitoring of patients with THA with metal-on-metal bearings using ionograms,[17] this idea is currently under discussion.[4]

Different treatment algorithms have been described for pseudotumors, including that of Lombardi et al.[15] They recommend strict annual monitoring for asymptomatic patients with no or low levels of metals in their blood.[3,15] In the case of symptomatic patients or those with a significant increase in blood ions (chromium or cobalt >7 µg/l), surgical treatment is recommended. It is important to note that approximately 50% of major complications have been reported in hip revisions for pseudotumors, a much higher rate than the 14% in revisions for other causes.[18] Among the complications to be mentioned are those inherent to the surgical process that occur from addressing this type of intrusive mass, such as neurovascular damage. In our case, we used a neurolocator to identify the sciatic nerve and separate it from the pseudotumor in the resection of the tumor mass. We consider residual instability as a consequence of the weakening of the soft tissues, especially the abductor mechanism. In these cases, it would be advisable to consider the possibility of using cups with greater constriction to avoid this complication.

Although pseudotumors after THA have been widely described, reports of their association with periprosthetic infection are very rare, and no cases have been published in our country. In 2010, Watters et al.[19] published the case of a 75-year-old patient with THA with metal-on-metal bearings performed two years earlier. The patient complained of pain and swelling in the leg opposite the hip replacement. On the studies, a pseudotumor mass that compressed the femoral vein was observed. Finally, the patient underwent hip revision surgery, the culture was positive for beta-hemolytic streptococcus, and he was administered intravenous antibiotics for six weeks. In 2013, Artiaco et al.[20] reported an atypical case of a patient with a pseudotumor infected by *Candida albicans*, who was treated with lavage and antifungals, with good outcomes.

Our patient had a large mass that caused a noticeable deformity in the right gluteus and paresthesia in the sciatic territory as the main symptom. Furthermore, the cobalt and chromium values in the blood were slightly increased, so we considered that the revision of the hip arthroplasty was a correct decision.

CONCLUSION

Pseudotumors are one of the possible long-term complications in THA with metal-on-metal bearings. Careful follow-up is required due to the serious consequences that could result from a late diagnosis. The possibility of concomitant periprosthetic infection should be considered, which could lead to an erroneous or incomplete diagnosis.

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

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Surgical Hip Dislocation for the Treatment of Synovial Chondromatosis Associated with a Cam Deformity

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ABSTRACT
Synovial chondromatosis is a rare benign disease of the synovial tissue that can cause joint damage if not properly treated. On the other hand, cam deformity causes friction between the acetabular rim and the femoral neck-head junction, which can lead to chondrolabral damage and, in its natural progression, result in osteoarthritis. The treatment of synovial chondromatosis of the hip is controversial, involving open surgery or arthroscopy, but it should include complete removal of loose bodies and synovectomy to prevent recurrences. In contrast, a cam lesion can often be managed with arthroscopy. We present a clinical case where both conditions were associated and treated with controlled hip dislocation. The choice of controlled dislocation allows for a comprehensive view of the joint and has been successfully used in cases of synovial chondromatosis associated with cam lesions.
Keywords: Synovial chondromatosis; femoroacetabular impingement; surgical hip dislocation; hip arthroscopy.
Level of Evidence: IV

Luxación controlada de cadera en el tratamiento de la condromatosis sinovial asociada a una lesión tipo cam

RESUMEN
La condromatosis sinovial es una rara enfermedad benigna del tejido sinovial que puede causar daño articular si no se trata adecuadamente. Mientras que la lesión tipo cam provoca una fricción entre el borde acetabular y la unión cuello-cabeza femoral que puede generar un daño condrolabral y, en su evolución natural, llegar a la artrosis. El tratamiento de la condromatosis sinovial de cadera es controvertido, entre la cirugía abierta o artroscópica, pero debe incluir la extracción completa de los cuerpos libres y la sinovectomía para evitar recurrencias. Por el contrario, la lesión tipo cam puede manejarse con artroscopia en la mayoría de los casos. Presentamos un caso clínico en el que se asocian ambas patologías y que fue tratado mediante luxación controlada de cadera. La elección de la luxación controlada permite una visión completa de la articulación y se ha utilizado con éxito en casos de condromatosis sinovial asociada a la lesión tipo cam.
Palabras clave: Condromatosis sinovial; fricción femoroacetabular; luxación quirúrgica de cadera; artroscopia de cadera.
Nivel de Evidencia: IV

INTRODUCTION

Synovial chondromatosis (SC) is a rare, benign, proliferative disease of synovial tissue. It is characterized by synovial tissue metaplasia, which results in the formation of cartilaginous bodies, which tend to ossify over time by endochondral ossification and can become free bodies, causing joint injury and osteoarthritis if not detected early.[1,2] SC occurs in structures with synovial lining, such as synovial joints, tendon sheaths, and bursae, although it most commonly affects weight-bearing diarthrodial joints, with the hip being the second most affected joint after the knee. The etiopathogenesis of SC is not clear, and it can be divided into primary or idiopathic and secondary. The most common clinical manifestations are coxalgia, stiffness and mechanical symptoms; and the method of choice for early diagnosis is magnetic resonance imaging.[1,3]

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The treatment of hip SC is controversial, but it should include total excision of the free bodies as well as synovectomy to reduce the risk of recurrence.[4,5] Therapeutic options may be arthroscopy or open surgery, with or without hip dislocation; the average overall recurrence is 19%.[2,6,7] Hip arthroscopy results in less morbidity, but has limitations in access to some areas of the joint, while controlled dislocation poses greater surgical risk and slower rehabilitation, but allows a complete view of the joint.[4,8-11]

Femoroacetabular impingement occurs due to abnormal contact between the proximal femur and the acetabulum.[12] Cam deformity occurs at the expense of the proximal femur, at the intersection of the femoral neck and femoral head, and is diagnosed by imaging showing an alpha angle >55°, although this value is still debated. Cam deformity can cause coxalgia in young adults by impingement on the acetabular rim during physiologic movements. This can lead to chondrolabral damage which, left to natural evolution, can end in osteoarthritis.[14,15] In two case reports, hip SC has been associated as a possible secondary cause of cam deformity, although the evidence is insufficient.[16,17] The treatment chosen for these cases was controlled hip dislocation which was effective in treating the SC and the cam deformity in a single surgical procedure.

The purpose of this technical note is to describe the surgical technique of controlled hip dislocation for cases with one or more conditions requiring a 360° view of the hip, such as SC associated with a cam lesion.

CLINICAL CASE

A 21-year-old man consulted for right coxalgia, with no relevant medical history. Five years earlier, he had started with insidious pain and, gradually, joint stiffness had appeared. He had received conservative treatment, without a clear diagnosis.

The patient reported limitations in daily activities due to pain; the visual analog pain scale score was 9/10 and the range of motion was limited. During the physical examination, he had pain on 90° flexion, a positive FADIR test, and limited rotations. The preoperative modified Harris hip score was 47.

Radiographs showed multiple intraarticular radiopaque round images of different sizes, a cam deformity in the anterior-superior region and absence of degenerative signs. MRI revealed numerous free bodies throughout the joint cavity, as well as edema in the trochanteric and lateral neck areas. The cartilage was found to be intact. The ossified free bodies were located with more precision using computed tomography, and the alpha angle obtained was 64° in the anterosuperior region.[13] It was decided to perform a controlled hip dislocation, as described by Ganz et al., to remove the free bodies, perform a wide synovectomy and resect the cam deformity in the same surgical procedure.[18]

Technical considerations

The patient is placed in the lateral decubitus position. A lateral hip approach of 12-15 cm in length is performed between the anterior third and posterior two thirds of the greater trochanter, with a one-third proximal extension and a two-thirds distal extension. Once the fascia is reached, it is incised and, with internal rotation of the hip, a retractor is placed under the posterior insertion of the gluteus medius and another under the vastus lateralis to expose the greater trochanter. The site of the trochanteric osteotomy is marked, going from the anterior region to the most posterior insertion of the gluteus medius to the origin of the vastus lateralis, in a straight line, approximately 1.5 cm thick. This is performed with an oscillating saw or osteotome and, during this procedure, the sciatic nerve must be protected. Then, the gluteus medius-trochanter-lateral vastus complex is mobilized anteriorly and, with the limb in flexion and external rotation, the joint capsule is exposed in its anterior, inferior and posterosuperior portions. It is critical to protect the insertions of the external rotators during osteotomy, capsulotomy, and limb mobilization to reduce the risk of femoral head bone necrosis. The medial femoral circumflex artery is protected by the obturator externus muscle, and an anastomosis of the medial femoral circumflex artery and the inferior gluteal artery runs along the superior border of the piriformis muscle.[19]

A z-shaped capsulotomy is performed, although it can also be done in an inverted T-shape, and care must be taken not to cross the lesser trochanter in its inferior extension so as not to damage branches of the medial femoral circumflex artery. Before dislocation, it is necessary to divide the ligamentum teres with a tenotome and then, with flexion, adduction and external rotation, the femoral head can be dislocated without causing excessive tension or twisting of the vessels supplying it posteriorly. Once dislocated, the joint can be carefully examined

in 360° to evaluate the state of the labrum, the cartilage and, in our case, the location of the free bodies, the state of the synovial tissue and the cam deformity. First, all the free bodies are removed and a modified complete synovectomy is performed, debriding all the synovial tissue with an electroscalpel, except for the posterosuperior region where the entrance of the retinacular vessels, branches of the medial femoral circumflex artery, is located.[4] It is important to remember to debride the synovial lining of the capsule. Then, the osteochondroplasty of the cam deformity is performed with an osteotome and then with a 5 mm burr until the normal neck-head junction is restored. It is recommended that the resection be thoroughly controlled in order to avoid excessive resection with the consequent risk of stress fracture of the femoral neck. It is important to verify that there are no free bodies adhering to the acetabular background or synovial tissue that has not been debrided. The wound is then irrigated, in our case, with saline solution. Once both conditions have been treated, the hip is gently reduced with traction, flexion and internal rotation and the hip is taken through a full range of motion to search for signs of friction. Capsular closure is performed with absorbable suture #1, without generating excessive tension to avoid collapse of the capsular vessels. The greater trochanter is fixed with two 4.5 mm cortical screws. Histological examination confirmed the diagnosis of SC (Video).

To avoid heterotopic calcifications, celecoxib 200 mg is administered daily for two weeks after surgery, together with a 30-day antiplatelet regimen of aspirin 100 mg daily. Mobilization begins on the first postoperative day, and six weeks of partial weight bearing with crutches is recommended. Active abduction is prohibited during this time to protect the trochanter fixation. After six weeks, gradually increase weight-bearing to full weight-bearing at ten to twelve weeks.

Postoperative evolution

One year after surgery, the patient suffered some pain on days of high activity, but the visual analog scale score improved significantly: 0/10 at rest and 2/10 with activity. In addition, he regained his functional capacity and the modified Harris hip score improved to 94. Postoperative radiography shows no signs of bone necrosis.

FINAL CONSIDERATIONS

Surgical hip dislocation aims to achieve a complete view of the joint, and Ganz et al. described this technique with the necessary precautions to maintain the main blood supply to the femoral head and thus minimize the risk of necrosis. To avoid necrosis, it is necessary to preserve the irrigation that comes mainly from the medial femoral circumflex artery and enters the joint through the posterior muscular plane, with special care for the obturator externus muscle. During surgery, the moments of greatest danger to vascularization are trochanteric osteotomy, capsulotomy, dislocation, synovectomy and capsular closure, which have been detailed above. This technique can be used for multiple purposes, such as the treatment of femoral head fractures, epiphysiolysis, femoroacetabular impingement, and tumor, infectious and osteochondral lesions.[20] The advantages of surgical hip dislocation when there is a combination of SC and a cam deformity are that this procedure allows us to visualize the entire joint to extract the free bodies in all the locations that are detected and, in the case of extraarticular involvement, it can also be accessed.[10] It also allows us to perform a complete synovectomy while preserving the retinacular vessels and leaving no residual diseased synovial tissue, and with the cam deformity exposed, we can ream the deformity with the appropriate care to avoid excessive resection. Furthermore, it is possible to confirm whether the cartilage and labrum are intact, and if a lesion is discovered, it can be repaired in the same procedure. The rate of complications with this technique is low, the most common being wound infection and lack of consolidation of the trochanteric osteotomy, while the most feared is necrosis, which can be prevented with the aforementioned surgical care.[7,10] An alternative to surgical dislocation is arthroscopy, which causes less morbidity, provides a faster recovery and does not pose the risk of bone necrosis. Good outcomes have been reported for the treatment of hip SC, with complete removal of the free bodies, synovectomy, and low complication rates.[8] Hip arthroscopy became the gold standard procedure for the surgical management of cam deformities, and surgical dislocation was relegated to cases with posterior region or circumferential cam deformities.[21] However, arthroscopy restricts access to the posteroinferior region, and SC treatment can be challenging when there are numerous free bodies and substantial synovial involvement that is difficult to approach. Moreover, complications such as iatrogenic chondrolabral injury, neurovascular injury, and traction neuropraxia are possible. It is essential to thoroughly examine the preoperative imaging to

determine the location of the free bodies as well as the presence of degenerative signs and associated lesions. In our case, we opted for surgical dislocation since the length of clinical evolution (5 years) along with the synovial involvement seen in the images led us to believe that numerous free bodies would have adhered to the synovium as a result of the synovitis. Furthermore, with the proper irrigation care, modified complete synovectomy can be better controlled and thus prevent the recurrence of SC. Regarding recurrence, the risk is higher when only the free bodies are removed without resecting the inflamed synovium, which is the seat of cartilaginous metaplasia. In a systematic review, the arthroscopic technique had a recurrence rate of 7.1%, whereas Comba et al. had no recurrences.[8,22] No recurrences have been found with surgical dislocation and the complication rate is very low in recent studies.[3,10] However, as this is a rare disease, there are no studies of high scientific quality available to be able to draw solid conclusions in this regard.

In two studies, the association of hip SC and cam deformity was reported, and the latter was attributed to SC.[16,17] Such hypothesis could be due to the fact that synovial metaplasia occurs mainly in the transition zone between cartilage and synovium where the nodule becomes ossified, or to free body adhesion and, in both cases, the femoral neck-head relationship would be altered. The cam deformity, on the other hand, could be regarded as the primary cause, originating during the developmental stage and not causing symptoms until the onset of clinical SC, or as osteophytes due to an osteoarthritic process caused by damage to the underlying SC. At present, there is insufficient evidence to support this theory, but the treatment we have established serves as a model, since our case had similar characteristics and the results were satisfactory. In addition, it is important to include SC within the differential diagnoses of infrequent coxalgia and a high index of suspicion is necessary to reach an accurate diagnosis and be able to offer timely treatment.

CONCLUSIONS

SC of the hip is a rare disease of the synovial tissue that leads to progressive joint damage. It is possibly related to a cam deformity; therefore, treatment should address both conditions. Surgical hip dislocation is a viable option because it allows for the visualization of the entire joint, allowing for the treatment of both the SC and the cam deformity in a single surgical procedure with minimal chances of residual disease and a low rate of complications that can be minimized by taking precise precautions during the procedure.

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

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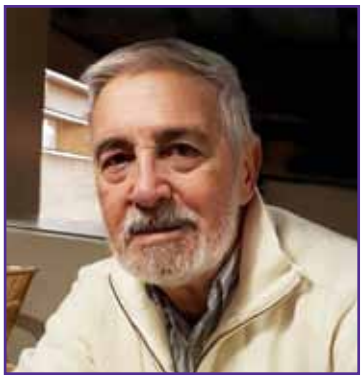
Dr. Gastón Maignon



It is with deep sadness that we remember Dr. Gastón Daniel Maignon, just Gastón for those of us who had the privilege of knowing him.

Gaston entered Hospital Italiano in Buenos Aires with a restless spirit and after completing two undergraduate degrees, first as an Agricultural Engineer and afterwards as a Medical Doctor.

He saw the various departments of this Teaching Hospital, where education and teaching are instilled in its DNA. He was a resident physician, an on-call physician, a staff physician, the head and founder of the Shoulder Team, and the Deputy Chief of the Orthopedics and Traumatology Service at the Hospital Italiano de Buenos Aires.

He spoke outstanding British English as a result of his education at his beloved St. Alban's College. He traveled around the world to complete his training in shoulder surgery, leaving dear friends in many parts of the world.

He was a pioneer in the treatment of shoulder pathology and a pioneer in the dissemination of the subspecialty. He served on various committees for the Asociación Argentina de Ortopedia y Traumatología (AAOT), in addition to his position as president of the Asociación Argentina de Hombro y Codo (AAHC) and the Sociedad Latinoamericana de Hombro y Codo (SLAHOC). He was also a member of multiple national and international scientific associations related to the subspecialty including the prestigious American Shoulder and Elbow Surgeons (ASES). His academic culmination was the Presidency of the World Shoulder Congress, which was held in Buenos Aires in 2019, for which he worked tirelessly and proudly.

His contribution to medical knowledge in the subspecialty is noteworthy. As a sign of his commitment to the sciences he authored numerous publications in PubMed indexed journals such as: Clinical Orthopaedics and Related Research, Orthopaedic Journal of Sport Medicine, Arthroscopy Techniques, Arthroscopy, American Journal of Sport Medicine and Journal of Shoulder and Elbow Surgery, among others. His broad curriculum vitae also includes numerous publications in national journals under the auspices of the Asociación Argentina de Ortopedia y Traumatología, the Asociación Argentina de Artroscopía (AAA), and the Asociación Argentina de Traumatología del Deporte (AATD).

Communication through oral presentations in various formats, such as dissertations, panel discussions, free-topic studies, practical training courses, and casual discussions, was among his strongest qualities.

He was devoted and empathic with his patients, respectful and polite with his colleagues, and as a leader, he was always ready to listen, stimulate, and accompany growth.

His great passion, without a doubt, was his family. Adriana, his wife and children, Martin and Florencia, were his pride and joy. The arrival of his granddaughter Guadalupe filled his days with joy.

He cherished and cared for the friends he had made since boyhood as well as those he had made during his professional career with special devotion. An example of this was his emotional reunion with his rugby team at St. Alban's club a few days before his departure.

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On a daily basis, he was a fun-loving person and an exceptional confidant who genuinely cared about those close to him. Sharing the workday with him was pleasant. He could get upset just as quickly as he could get over it and go on.

In recent years, he faced with courage, fortitude and full awareness a long illness, overcoming with admirable courage the daily difficulties and challenges it presented him.

While we mourn his departure, we take comfort in knowing that the love of his family, friends and colleagues, together with his deep belief in God, accompanied him until his last minute with us.

Our most sincere tribute to our colleague Dr. Gastón Maignon.

Maximiliano Ranalletta
Head of the Shoulder Surgery Sector

Pablo De Carli
Head of the Orthopedics and Traumatology Service

On behalf of their colleagues, the Physicians of the Orthopedics and Traumatology Service of Hospital Italiano de Buenos Aires, Argentina

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