Cementless Total Hip Arthroplasty in Patients with Osteoarthrosis Secondary to Legg-Calvé-Perthes Disease Compared with Primary Osteoarthrosis: A Case-control Study

Artroplastia total do quadril não cimentada em pacientes com osteoartrose secundária à doença de Legg-Calvé-Perthes em comparação com a osteoartrose primária: Um estudo caso-controle

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Abstract

Objective To perform a comparative clinical, functional and radiographic evaluation of total hip arthroplasty (THA) performed with a cementless prosthesis in cases of osteoarthrosis secondary to Legg-Calvé-Perthes Disease (LCPD) and in cases of primary osteoarthrosis.
Methods In the present case-control study, we reviewed medical records of patients admitted to a university hospital between 2008 and 2015 to undergo THA due to LCPD sequelae and compared them with a control group of patients who underwent the same surgery due to primary hip osteoarthrosis. We recruited patients for clinical, functional, and radiographic analysis and we compared the evaluations in the immediate postoperative period and at the last follow-up visit, considering surgical time, size of prosthetic components, and complications.
Results We compared 22 patients in the study group (25 hips) with 22 patients (25 hips) in the control group, all of whom had undergone THA with the same cementless

Keywords
- Legg-Calvé-Perthes disease
- osteoarthrosis
- arthroplasty, replacement, hip
- intraoperative complications

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prosthesis. There was greater functional impairment in the group of patients with LCPD sequelae ($p = 0.002$). There were 4 intraoperative femoral periprosthetic fractures in the LCPD group and none in the primary osteoarthrosis group ($p = 0.050$).
Conclusions There is an increased risk of intraoperative periprosthetic femoral fracture and worse clinical-functional results in patients undergoing cementless THA due to osteoarthrosis secondary to LCPD sequelae than in those who have undergone the same surgery due to primary hip osteoarthrosis.

Resumo

Objetivo Realizar uma avaliação clínica, funcional e radiográfica comparativa da artroplastia total do quadril (ATQ) realizada com prótese não cimentada em casos de osteoartrose secundária à doença de Legg-Calvé-Perthes (DLCP) e em casos de osteoartrose primária.
Métodos No presente estudo caso-controle, foram revisados os prontuários dos pacientes internados em um hospital universitário entre os anos de 2008 e 2015. Os pacientes foram submetidos a ATQ devido a sequelas da DLCP, sendo comparados com um grupo controle de pacientes submetidos à mesma cirurgia por osteoartrose primária do quadril. Os pacientes foram recrutados para a realização de uma análise clínica, funcional e radiográfica, na qual foram comparadas as avaliações no pós-operatório imediato e na última consulta de acompanhamento, levando em consideração o tempo cirúrgico, o tamanho dos componentes protéticos e as complicações.
Resultados Comparamos 22 pacientes do grupo de estudo (25 quadris) com 22 pacientes (25 quadris) do grupo controle, todos os quais foram submetidos a ATQ com a mesma prótese não cimentada. Houve um maior comprometimento funcional no grupo de pacientes com sequelas da DLCP ($p = 0,002$). Ocorreram 4 fraturas periprotéticas femorais no intraoperatório do grupo DLCP, sendo que não ocorreu nenhuma no grupo de osteoartrose primária ($p = 0,050$).
Conclusões Existe um risco elevado de fratura periprotética femoral no intraoperatório com resultados clínico-funcionais mais desfavoráveis aos pacientes que foram submetidos à ATQ não cimentada devido a osteoartrose secundária às sequelas da DLCP do que naqueles que foram submetidos à mesma cirurgia por osteoartrose primária de quadril.

Palavras-chave
► doença de Legg-Calvé-Perthes
► osteoartrose
► artroplastia de quadril
► complicações intraoperatórias

Introduction

Among all total hip arthroplasties (THA) due to hip osteoarthrosis, 0.6 to 4.2% are cases secondary to Legg-Calvé-Perthes disease (LCPD) sequelae.[1–6] Until the present study, only eight case series, one case-control study, and one systematic review have been published about THA to treat LCPD sequelae, and among these, eight reports on intraoperative and postoperative complications.[4,7–15] However, the typical deformities of the proximal femur and of the acetabulum in LCPD patients make THA a challenge to the hip surgeon.[1,6,7]

Approximately 3 to 6% of patients with LCPD sequelae submitted to THA may experience neurological deficit, a rate considerably higher than the overall risk of 0.17% of neurological deficit after THA performed for any other reason.[4,16] Limb length discrepancy after surgery is another possible complication among patients with LCPD,[17] as is the risk of intraoperative femoral fracture.[4,7,15]

However, the literature is poor in providing studies of THA comparing patients undergoing surgery for osteoarthrosis secondary to the sequelae of LCPD with those who have other degenerative diseases of the hip. We hypothesized that THA performed in patients with sequelae of LCPD, due to its technical difficulties, may be associated with an increased risk of perioperative complications and worse clinical and functional outcomes than in patients undergoing surgery for primary hip osteoarthrosis.

The primary objective of the present study was to perform a comparative clinical, functional, and radiographic evaluation of THA performed with one model of a cementless prosthesis in cases of osteoarthrosis secondary to LCPD and in cases of primary osteoarthrosis. The secondary objective was to compare the two groups for complications.

Materials and Methods

Study Design and Ethics

This is a case-control study based on the review of the medical records and of the functional and clinical evaluation of patients submitted to THA for osteoarthrosis of the hip operated in a university hospital. We compared patients who underwent THA due to osteoarthrosis secondary to LCPD sequelae with patients who underwent the same surgery due to primary hip osteoarthritis.

The local ethics review board approved the study protocol. Patients or their legal guardians signed the informed consent for participation in the study and for the use of radiographic images in the present publication.

Participants and Groups

We reviewed the medical records of all patients admitted for THA between 2008 and 2015. For standardization purposes and to avoid bias in the evaluation of clinical results, we selected only patients who had undergone surgery at our hospital using one specific model of a prosthesis and excluded patients operated with other hip prostheses models or materials. This model (Groupe Lépine cementless prosthesis, manufactured in Genay, France) has a femoral component of porous titanium alloy coated with hydroxyapatite (Targos Group Lepine, manufactured in Genay, France) and an acetabular component made of titanium alloy, which is porous and coated with hydroxyapatite (MBA model, Targos, Group Lepine, manufactured in Genay, France). The prosthetic head is made of stainless steel or ceramic alumina, 28 mm in diameter, and the liner/insert is made of polyethylene.

Patients who underwent THA due to osteoarthritis secondary to diseases other than LCPD sequelae were excluded. We also excluded patients from whom the cause of osteoarthrosis had not been identified and those without a minimum of 2 years of follow-up. However, we did not exclude patients with primary osteoarthrosis.

Once we identified all patients who underwent THA due to LCPD sequelae, we scrutinized the medical records carefully in search for confirmation that the disease had been diagnosed during childhood (with radiographs made early in the institution, with open physis) and we invited these patients to come to the hospital for clinical evaluation. We excluded patients for whom our team could not confirm that the diagnosis dated back from childhood.

We then created a group of patients submitted to THA due to primary osteoarthrosis in the same period, paired with the study group of patients (1:1) with LCPD sequelae for gender, laterality, and time of follow-up.In both groups, all patients underwent THA by the direct lateral approach of Hardinge.

Clinical and Demographic Outcomes

We examined medical records to collect demographic and clinical data, including surgical time, size of prosthetic components, intraoperative and postoperative complications, and any indication for surgical revision. We used the Lequesne questionnaire to evaluate clinical outcomes.[18]

Radiographic Outcomes

We evaluated anteroposterior radiographs from the immediate postoperative period and those taken in the last follow-up. We evaluated all these digital exams using the software Philips DICOM Viewer R3.0-SP03 (Koninklijke Philips N.V., Eindhoven, Netherlands) to calculate the acetabular component inclination in relation to the pelvis, the femoral offset, using the Sundsvall method,[19] and the femoral component position in relation to the femoral canal.

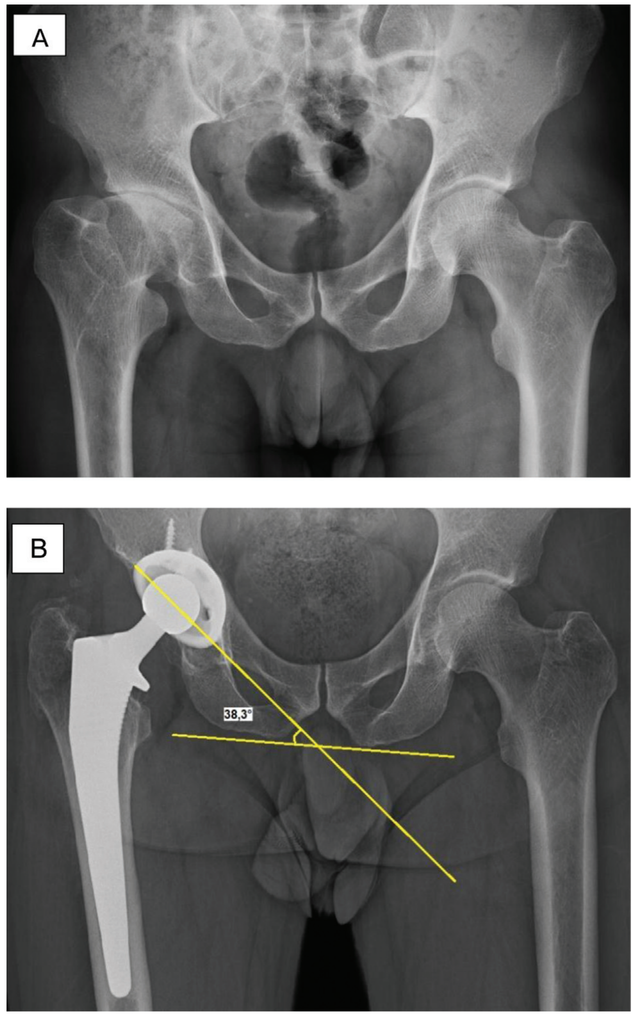

Fig. 1 Acetabular component inclination in relation to the pelvis. Demonstration of the lines used to calculate the angle in anteroposterior hip radiographs. (**A**) Preoperative view. (**B**) Final follow-up and angle calculation.

We used the software to automatically calculate the acetabular component inclination in relation to the pelvis, using the angle between the following two lines in the radiograph: a line joining the proximal and lateral border with the distal and medial border of the largest circumference of the acetabular component and another line joining the most distal regions of the two ischial tuberosities (►**Fig. 1**). Then, we calculated the lateral femoral offset using the Sundsvall method (►**Fig. 2**).[19]

We also evaluated the femoral component position in relation to the femoral canal (centralization). We used the same software to measure (in millimeters) the distance between the most distal region of the femoral prosthesis component and the adjacent inner extremity of the medial femoral cortical and the distance between the most distal region of the femoral component and the adjacent inner extremity of the lateral cortical of the component. We calculated a division between the two distances and we considered

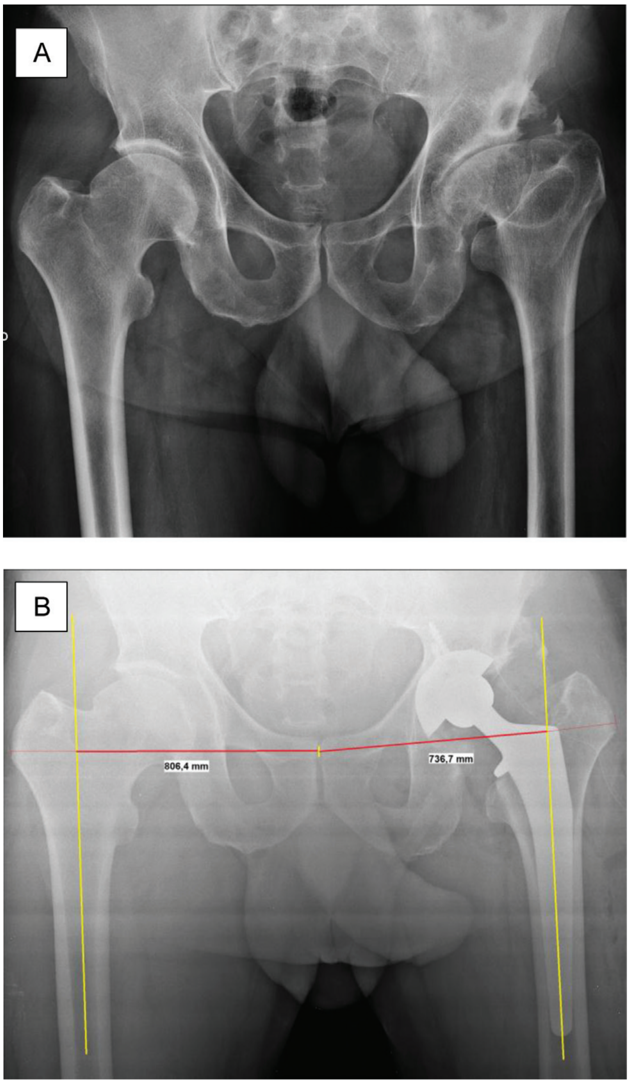

Fig. 2 Femoral offset calculation in anteroposterior radiographs of the hip. (**A**) Preoperative period. (**B**) Immediate postoperative period, with differential lateral femoral offset of - 69.7 mm.

that the result is close to 1 when the femoral components are centralized in the femoral canal, <1 when they are "in valgus", and >1 when they are "in varus" (►**Fig. 3**).

The leading researcher made all measurements through radiographs and we compared all measurements between the study groups.

Statistical Analysis

We recorded data in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) sheets and transferred them to IBM SPSS Statistics for Mac, version 23.0 (IBM Corp., Armonk, NY, USA) for statistical analysis. We compared categorical data between groups using the Pearson chi-squared test. We used the Kolmogorov-Smirnov test to verify the normality of data distribution for continuous variables. Then we used The Student *t*-test for normally distributed data in independent samples or the Mann-Whitney nonparametric test for non-Gaussian data (as for the Lequesne functional score). We accepted a type I error $\leq 5\%$ as a statistically significant difference.

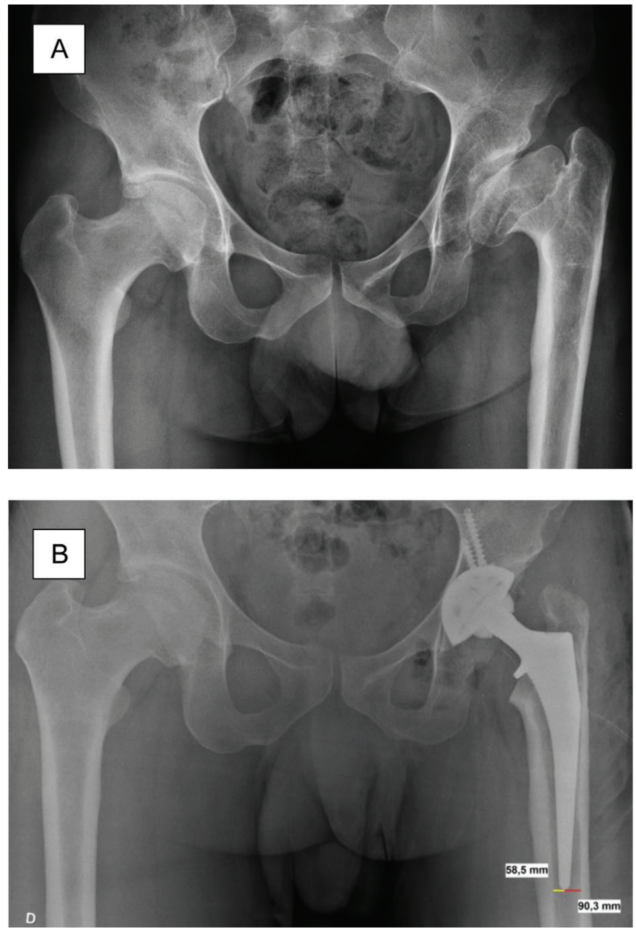

Fig. 3 Evaluation of the femoral component position in relation to the femoral canal (centralization) in anteroposterior radiographs of the hip. (**A**) Preoperative period. (**B**) Immediate postoperative period.

Results

Study Groups and Pairing

During the period of the present study, a total of 810 patients underwent THA of the standardized model for the present study at our institute. All of them had been operated through the hip direct lateral approach. We identified 144 patients with primary osteoarthrosis and 49 operated for LCPD sequelae (6%). From this group, we had to exclude patients, after reviewing medical records and receiving them for clinical appointments, due to the reasons described in the flowchart in ►**Fig. 4**. We also excluded 93 patients >60 years old from the control group. Both the final LCPD group and the final control group, with primary osteoarthrosis patients, had 22 patients (25 hips). ►**Table 1** shows that the groups were homogeneous regarding gender, operated sides, and follow-up time.

Surgical Outcomes

Surgery time ($p=0.62$) and the size of femoral ($p=0.174$) and acetabular prosthesis components ($p=0.149$) used were similar between groups. In the LCPD group, there were four periprosthetic fractures during surgery in the region of the femoral metaphysis and one greater trochanter avulsion fracture. All metaphyseal femoral fractures were treated,

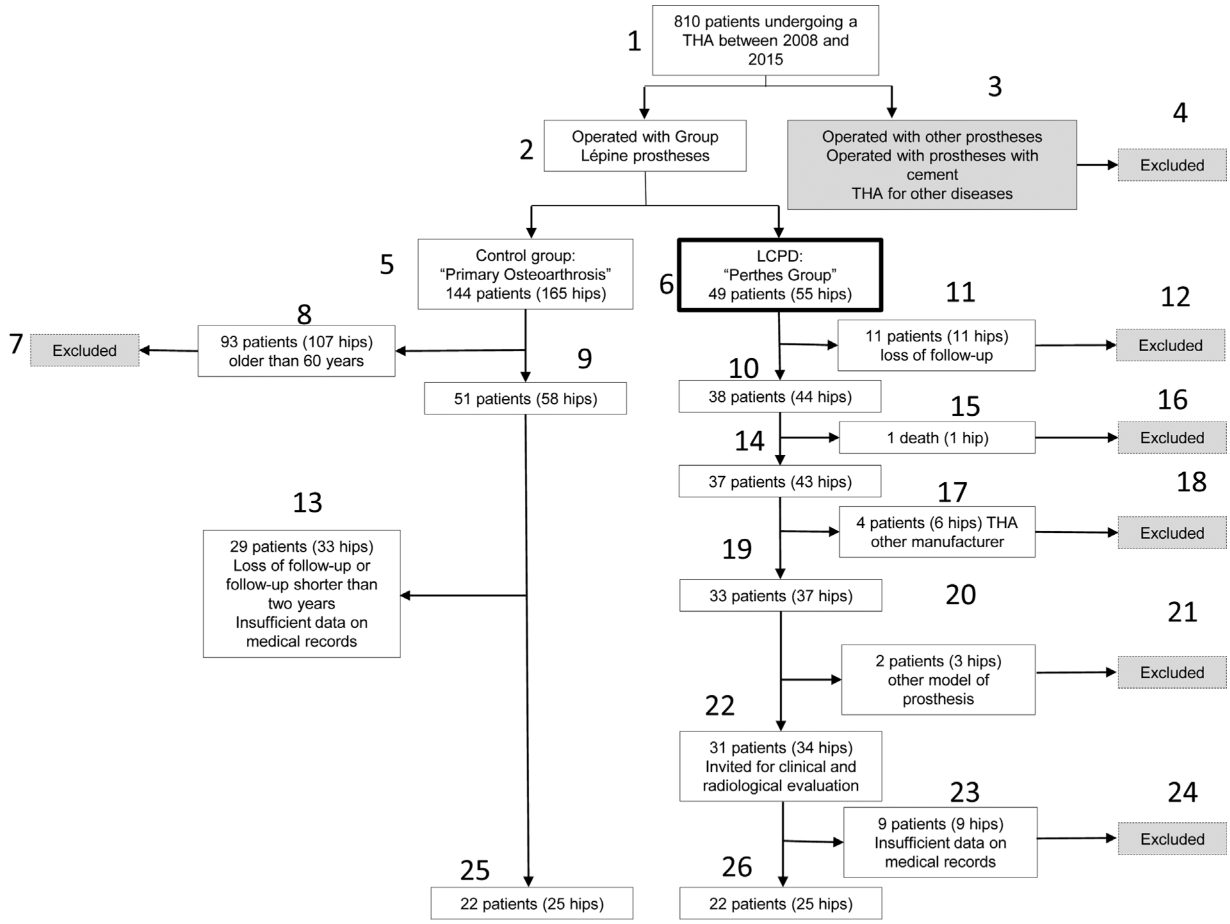

Fig. 4 Flowchart of inclusion and exclusion of patients in the study in both groups.

Table 1 Absolute and relative frequencies of gender, age, operated side and follow-up time in the Legg-Calvé-Perthes Disease (LCPD) group and in the control group of patients with primary osteoarthrosis of the hip

	LCPD Group ($n = 25$ hips)	Control group ($n = 25$ hips)	*p-value*
Gender, n (%)			
Male	17 (68)	12 (48)	0.152
Female	8 (32)	13 (52)	
Age, years old			
Mean (SD)	47.3 (7,4)	53.2 (4.4)	0.001
Median (IQR)	46.0 (42.0–53.0)	54.0 (50.0–56.0)	
Operated side, n (%)			
Right	12 (48)	12 (48)	> 0.999
Left	13 (52)	13 (52)	
Bilateral	3 (12)	3 (12)	
Follow-up time, months			
Mean (SD)	62.2 (18.9)	65.3 (15.3)	0.052
Median (IQR)	59.0 (52.0–67.0)	62.0 (57.0–73.0)	

Abbreviations: IQR, interquartile range; LCPD, Legg-Calvé-Perthes disease; SD, standard deviation.

in the same act, with cerclage wires. The fracture-avulsion of the greater trochanter was not described in the medical record, but it was noticed in the immediate postoperative radiograph. In the Primary Osteoarthrosis Group, there were no records or radiographic images demonstrating intra-operative periprosthetic fractures. The difference between groups for the frequency of fractures was statistically significant ($p = 0.050$).

In the LCPD group, it was necessary to use autologous bone grafts (from the femoral head or neck) for the fixation and better positioning of the acetabular component in 4 cases, 3 of which were structural grafts in the acetabular roof, which were fixed with cortical screws (4.5 mm), and 1 impacted graft in the medial region of the acetabulum to fill the medial component failure. No patient in the control group needed bone grafts ($p = 0.109$). In one patient of the LCPD Group, a femoral shortening osteotomy was necessary in the subtrochanteric region, and it was fixed with plate, screws and cerclage cables (►**Fig. 5**).

Clinical and Functional Outcomes

The mean score in the Lequesne evaluation for the patients in the LCPD group was 9.1 ± 4.7, indicating severe functional impairment, and 4.8 ± 4.0 for the control group (mean difference of 4.3 points; 95% confidence interval [CI]: 1.8–6.7; $p = 0.002$). The distribution of patients according to

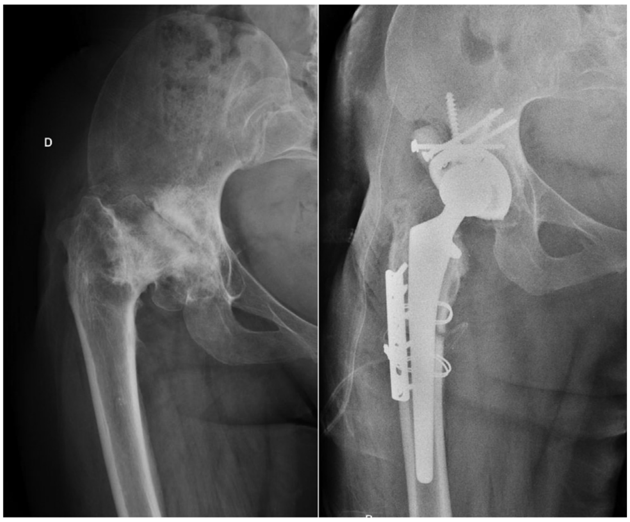

Fig. 5 Preoperative (left) and immediate postoperative (right) anterior-posterior radiographs, showing bone graft impacted in the acetabular roof and shortening osteotomy at the subtrochanteric region.

Table 2 Distribution of patients according to categories of Lequesne functional scores

Impairment categories	LCPD group	Control group	*p-value*
Mild (1 to 4), n (%)	4 (16)	17 (68)	0.002
Moderate (5 to 7), n (%)	6 (24)	4 (16)	
Severe (8 to 10), n (%)	5 (20)	2 (8)	
Very severe (11 to 13), n (%)	5 (20)	1 (4)	
Extremely severe (≥ 14), n (%)	5 (20)	1(4)	

Abbreviations: LCPD, Legg-Calvé-Perthes disease.

categories of functional scores is shown in ►**Table 2**. In none of the cases of the studied groups, there were episodes of infection, dislocation or neurological damage resulting from surgery. No revision surgery was indicated or performed in any of the groups.

Radiographic Outcomes

In the immediate postoperative radiographs, the mean acetabular component inclination in relation to the pelvis was 44.1 ± 6.4° for the LCPD group and 43.8 ± 6.2° for the control group, with a mean difference between groups of 0.3° (95% CI: - 3.9–3.26; $p = 0.628$). In the last follow-up, the mean values were 43.2 ± 6.9° and 43.0 ± 6.2°, respectively, with a mean difference between groups of 0.2° (95%CI: - 3.9–3.6; $p = 0.497$). The mean femoral offset was similar between groups ($p = 0.079$ for the immediate postoperative period and $p = 0.273$ for the last follow-up).

►**Table 3** shows the results for the femoral component position in relation to the femoral canal. The "centralization" was significantly different between groups (mean difference of - 0.4; 95%CI: - 0.1-- 0.7 in the immediate postoperative period; and of -0.5; 95%CI: - 0.2-- 0.8 in the last follow-up). In both moments of evaluation, the femoral components of the prosthesis tended to be implanted more in valgus in the femoral canal (ratio < 1.0) in the LCPD group than among the primary hip osteoarthrosis patients (ratio > 1.0).

Discussion

To our knowledge, the present study is the first in the literature comparing clinical, functional, and radiographic outcomes of THA surgeries made in patients with LCPD and with primary osteoarthrosis that were all operated using the same model of a cementless prosthesis. We took care to exclude patients who had undergone THA with other types and models of prosthetic components to avoid the interference of confounding factors in the clinical outcomes. We observed that, even with the use of the same product, patients with LCPD sequelae are at a higher risk of periprosthetic fractures and have worse clinical-functional results than patients with primary hip osteoarthrosis. These findings evidence the technical challenge imposed by LCPD deformities (requiring surgical times of 142.4[3] to 154.8[13] minutes) and prompt clinical studies to address these issues.

The acetabular cavity in patients with osteoarthrosis secondary to LCPD sequelae is morphologically deformed, becoming shallow, enlarged in diameter and retroverted to the pelvis.[6,20] This structural change may hinder the implantation of conventional acetabular components. In our study, although the mean diameter of the implanted acetabular components was similar in the studied LCPD and the control groups, it was necessary to use autologous bone grafts in four cases in the LCPD group for the proper positioning of the components. This data suggests that the acetabular cavity deformity in osteoarthrosis secondary to the LCPD sequelae leads to technical difficulties for implantation of conventional acetabular components.

While the rate of intraoperative periprosthetic femoral fracture is of ~ 3% in cementless THA for any reason,[13] the rate of this complication can be a lot higher in patients with LCPD sequelae, reaching 13.8%[15] using conventional components. Al-Khateeb et al.[9] customized the femoral component according to preoperative tomographic images, and no

Table 3 Femoral component position in relation to the femoral canal (centralization): mean distance in millimeters

	LCPD Group			Control Group			
	n	Mean	SD	*n*	Mean	SD	*p-value*
Immediate postoperative period	25	0.9	0.2	25	1.3	0.6	0.008
Last follow-up	25	0.9	0.4	25	1.4	0.7	0.002

Abbreviations: LCPD, Legg-Calvé-Perthes disease; SD, standard deviation.

fracture was reported. Seufert et al.[11] used short modular THA components in an attempt to overcome the abnormal anatomy of LCPD patients. These authors reported no fracture. We evaluated patients operated with conventional femoral components, and the percentage of this complication was 20%. In osteoarthrosis secondary to LCPD sequelae, the femoral deformities are not limited to the site of necrosis during childhood; that is, in addition to the deformities described in the femoral head,[6] the femoral neck is shortened relative to the extension and medialization of the greater trochanter,[21,22] the cervicodiaphyseal angle decreases, producing a varus deformity, and there is morphological incongruence between the metaphysis and the femoral diaphysis.[22,23] We believe that, depending on the severity of the femoral deformity, the use of modular or customized femoral components should be considered to minimize the risk of intraoperative periprosthetic femoral fracture.

The morphological deformation of the hip in the LCPD patients, in addition to hindering the surgical technique and generating more complications, may also affect the clinical-functional results of THA.[6,24–28] Our LCPD patients presented greater functional impairment in the last follow-up than patients operated for primary osteoarthrosis of the hip.

The mean acetabular component inclination in the present study (44.1° in the immediate postoperative period and 43.2° in the late follow-up) was similar to the numbers obtained in other studies in patients with LCPD,[7,11–14] and were within the range proposed by Lewinnek et al.[29] as safe (30 to 50°). Our study was the first to measure the femoral offset after THA for LCPD sequelae. Therefore, there are no previous references for this measurement in patients with LCPD deformities, and further studies are necessary to verify if the values we found explain the THA results in these patients.

We found that the femoral components of the prosthesis tend to be implanted more in valgus in the femoral canal in the LCPD than in the primary hip osteoarthrosis cases. This finding is different from the results obtained by Traina et al.[7] and Pietrzak et al.,[8] who found this position to be more in neutral. However, the method of calculation of this feature was not well-described in those studies, making comparisons difficult.

Our study presents limitations. We could not control or verify the position of the patient on the table during the radiographic examination because of the retrospective nature of the present study. However, all radiographs were performed at the same institution, following the same protocols. Another feature impossible to control in the present study was the surgical technique: different surgeons performed the THA in the present case series. Because patients were operated in a university hospital, the learning curve could also impact surgical results.

Conclusions

Patients undergoing cementless THA due to osteoarthritis secondary to LCPD sequelae are at increased risk of intraoperative periprosthetic femoral fracture and have worse clinical-functional results than those who have undergone the same surgery due to primary hip osteoarthrosis.

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

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