Primary Total Hip Arthroplasty With Short Stems in Patients Under 20 Years of Age

Martín Buljubasich, Surya Kohan, Francisco Salagoity, Fernando Comba, Gerardo Zanotti, Pablo A. Slullitel, Martín Buttaro
Hip Center "Sir John Charnley", Institute of Orthopedics and Traumatology "Prof. Dr Carlos E. Ottolenghi", Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina

ABSTRACT

Introduction: To our knowledge, there is no published literature on the outcomes of short-stem total hip arthroplasty (THA) in patients under 20 years old. This study aimed to analyze clinical, radiological, and functional outcomes in patients under 20 years of age undergoing THA with a short uncemented 2B femoral stem. **Materials and Methods:** We carried out a retrospective study of 13 patients (16 THAs) treated between January 2006 and January 2021. The mean age and BMI were 16.5±2.5 years and 22.74±4.06 kg/m2, respectively. The mean follow-up was 43.3 months (range 12-128, SD ± 33.45). Surgical indications, as well as functional and radiologic outcomes, were analyzed. Implant survival was calculated with the Kaplan-Meier estimate. **Results:** The predominant indication was avascular necrosis (9/16 hips [56%]), of which 66% were associated with prolonged use of corticosteroids. Eight (50%) of the cases had undergone surgeries before the THA. The Harris hip score improved significantly from 33±16.5 to 94±5.6 (p<0.001). Ten (76%) patients required assistive devices to walk preoperatively, and no patient required them at the end of follow-up. Radiolucency was evident in one acetabular component, without clinical implications. There were no signs of femoral component loosening. The implant survival was 100% at the last follow-up. **Conclusions:** Short stems in primary THAs in patients under 20 years of age with advanced hip osteoarthritis showed clinical, functional, and radiological outcomes comparable to those previously reported in the literature for conventional stems, with the particularity of being less invasive and sparing femoral bone stock.

Keywords: Total hip arthroplasty; total hip replacement; pediatric patients; young adults.
Level of Evidence: IV

Artroplastia total de cadera primaria con vástagos cortos en pacientes menores de 20 años

RESUMEN

Introducción: El objetivo de este estudio fue analizar los resultados clínicos, radiográficos y funcionales en pacientes <20 años sometidos a artroplastia total de cadera con vástago femoral tipo 2B corto no cementado. **Materiales y Métodos:** Se realizó un estudio retrospectivo de 13 pacientes (16 artroplastias totales de cadera) operados entre enero de 2006 y enero de 2021. La edad media y el índice de masa corporal eran de 16.5 ± 2.5 años y 22,74 ± 4,06 kg/m^2, respectivamente. El seguimiento medio fue de 43.3 meses (rango 12-128, DE ± 33.45). Se analizaron las indicaciones quirúrgicas, y los resultados funcionales y radiográficos. La supervivencia del implante se calculó con la estimación de Kaplan-Meier. **Resultados:** La indicación predominante fue necrosis avascular (9/16 caderas [56%]), el 66% estaba asociada al uso prolongado de corticoides. El HHS para cadera mejoró significativamente de 33 ± 16,5 a 94 ± 5,6 (p <0,001). Diez (76%) pacientes usaban dispositivos de asistencia para caminar antes de la artroplastia, pero ninguno los necesitaba al final del seguimiento. Se observó radiolucidez en un componente acetabular sin repercusión clínica hasta el final del seguimiento. No se registraron signos radiográficos de aflojamiento del componente femoral. La supervivencia del implante fue del 100% hasta el final del seguimiento. **Conclusiones:** La artroplastia total de cadera primaria con un vástago femoral corto no cementado en pacientes <20 años con artrosis avanzada de cadera logró resultados equiparables a los ya publicados, con la particularidad de que es un procedimiento menos invasivo y ahorra capital óseo femoral.

Palabras clave: Artroplastia total de cadera; prótesis total de cadera; pacientes pediátricos; adulto joven.
Nivel de Evidencia: IV

Received on June 8th, 2022. Accepted after evaluation on July 16th, 2022 • Dr. MARTÍN BULJUBASICH • buljubasichmartin@gmail.com https://orcid.org/0000-0001-5922-7785
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INTRODUCTION

The treatment of advanced hip osteoarthritis in pediatric and adolescent patients remains controversial. Historically, the options considered in this age group were total hip arthroplasty (THA) and arthrodesis. Currently, arthrodesis is not an option since future conversion to THA poses problems in recovery due to the muscle atrophy it generates and the high rates of postoperative infection and instability.[1,2] Technical challenges of THA in this group of patients include poor bone stock, bone deformities such as axis abnormalities and femoral version abnormalities, limb length discrepancies, and small femoral canals.[3] On the other hand, the chances of revision are high over time; firstly, because the reason for replacement is usually secondary osteoarthritis (that is, more complex than primary osteoarthritis) and, also, because of life expectancy. For this reason, sparing bone stock in primary surgery is of the utmost importance.[4]

The first articles published were on the management of pediatric hip pathology in patients with rheumatoid arthritis treated with cemented stems.[5,6] Today, there are published series of uncemented THA with conventional stems in patients <25 years of age, with good functional outcomes, low rate of complications and a revision rate of 7%, with a minimum mean follow-up of 4.2 years.[7]

Short uncemented stems offer some advantages when compared to conventional designs: 1) they economize on the bone stock used to fix the implant;[8] 2) less blood is lost;[9] 3) they have a lower rate of intraoperative complications;[10] and 4) in case of a future revision, the surgery is less complex.

To our knowledge, there are no reports addressing the outcomes with an uncemented short femoral stem in patients <20 years of age undergoing primary THA.

The objective of this study was to analyze the clinical, radiographic and functional outcomes in a series of patients <20 years old treated with a primary THA with a type 2B short femoral stem.

MATERIALS AND METHODS

After obtaining approval from the institution's Research Ethics Committee, we retrospectively studied 26 THAs in 23 patients <20 years of age who had undergone surgery between January 2006 and January 2021. Only cases of uncemented short femoral stem THA with a minimum follow-up of one year were included. We excluded patients with active oncological diseases related to the pathology, and those operated on with cemented femoral stems (8 patients) and standard-size uncemented stems (2 patients). After applying the selection criteria, 10 patients were excluded; consequently, 13 patients (16 hips) who had undergone primary THA with a short uncemented type 2B stem with cervicometaphyseal fixation (MiniHip™, Corin, UK) were enrolled (Figure 1).[11] The demographic data of the series are detailed in Table 1.

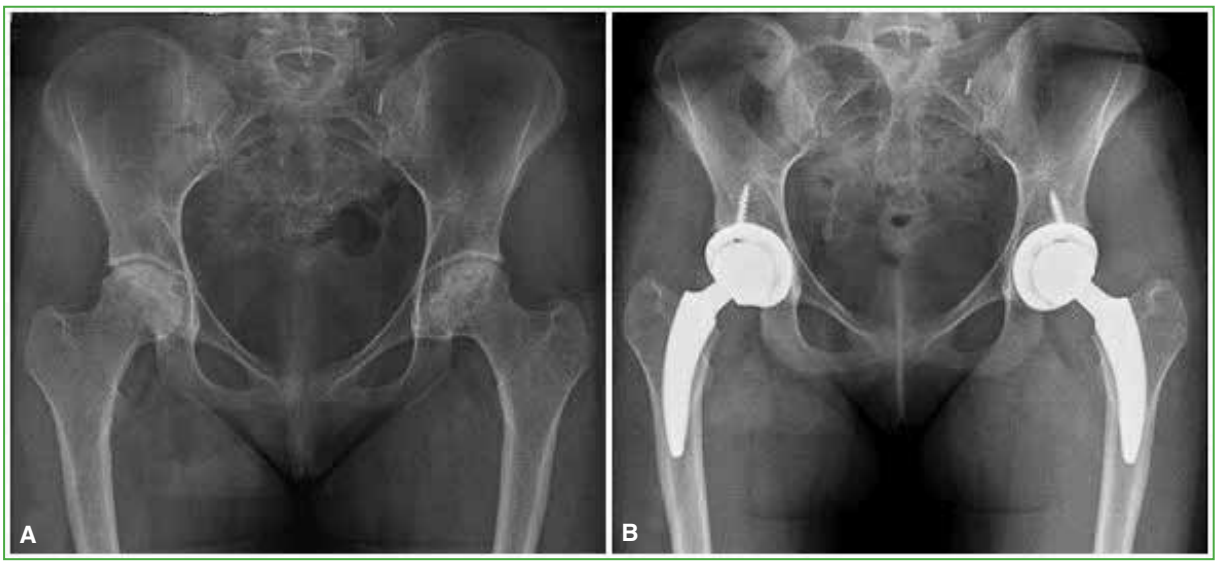

Figure 1. An 18-year-old patient with bilateral avascular bone necrosis secondary to prolonged treatment with corticosteroids for Crohn's disease. **A.** Preoperative anteroposterior radiograph of both hips. **B.** Postoperative anteroposterior radiograph of both hips after single-stage bilateral THA at the end of follow-up.

Table 1. Demographics of the series

Patients (hips) (n)	13 (16)
Mean age (years)	16.56 years (range 12-20, SD ± 2.58)
Gender (Male/Female)	7 (53.8%)/6 (46.2%)
Side	5 Right 5 Left 3 Bilateral
Mean body mass index	22.74 (range 16.3-31.4, SD ± 4.06) Only 1 patient (7.6%), >30
ASA Classification	ASA 1: 10 patients (76.92%) ASA 2: 3 patients (23.07%)
Mean follow-up	43.31 months (range 12-128, SD ± 33.45)

SD = standard deviation, ASA = American Society of Anesthesiology.

All the information was obtained from the prospectively collected electronic medical records of our institution, and was analyzed retrospectively by three researchers. None of them were involved in the original care of the patient. All surgeries were performed in laminar flow operating rooms through a posterolateral approach, and were performed by one of four trained hip surgeons on the surgical team. Epidural hypotensive anesthesia and tranexamic acid were administered before the incision. All patients received prophylactic antibiotics with three doses of intravenous cefazolin (1 g/8 h). Thromboembolism prophylaxis was indicated during the first postoperative month, with 40 mg/day of low molecular weight heparin, subcutaneously, in patients with one-stage bilateral surgery and 100 mg/day of aspirin, orally, in patients with with low clinical risk or unilateral surgery.

In addition to preoperative planning, the Woolson method was used to calculate leg lengthening, with a Steinman pin inserted proximal to the acetabulum as a stable pelvic landmark.[12] A porous acetabular component (Trinity™, Corin, Cirencester, UK) was placed with an uncemented press-fit technique in the acetabular area. The number of screws used to protect the cup fixation was defined during surgery and depended on the degree of pressure impaction obtained. Femoral reconstruction involved a partially neck-preserving osteotomy using the center of the neck as a constant landmark. We added a simple step to the original surgical technique to prevent a lateral cortical perforation. This step involved the use of a curved Mirizzi vascular clamp to enter the intramedullary canal, along the same path as the femoral neck. After using a curved awl at the entry point 3 mm above the center of the neck, progressive rasps were used until the planned size was achieved.[13]

The rehabilitation protocol included early mobilization after surgery, ambulation with a walker, and full weight-bearing for 15 days. Patients were then encouraged to progressively resume normal activities of daily living, as tolerated, with the use of a cane based on the clinical evolution and follow-up radiographic findings.

The clinical evaluation was performed with the Merle D'Aubigné[14] scale and the Harris Hip Score (HHS). Pain was assessed with the visual analog scale. All patients were scored before surgery and at the last follow-up. Whether they used assistive devices for walking before and after surgery was also documented.

The preoperative radiographic evaluation was performed by a complete examination of an anteroposterior radiograph of the pelvis and lateral hip. The degree of preoperative joint degeneration was characterized with the Tönnis[15] classification and the Dorr classification to establish the morphology of the proximal femur.[16]

Anteroposterior and lateral radiographs of the hip were obtained immediately postoperatively, at 15 days, 6 months, 12 months, annually, and at the end of follow-up. Two independent observers, blinded to clinical outcomes, performed all radiographic measurements comparing immediate postoperative radiographs with those at last follow-up. Femoral radiolucency was defined as any irregular line between the stem and the bony interface; periprosthetic osteolysis was defined as progressive bone loss >5 mm and was assessed using Gruen's zones.[17] The

radiographic evaluation of stem fixation was performed according to the method of Engh et al.[18] Femoral stem subsidence was determined using the method described by Loudon and Charnley,[19] by measuring the distance from a selected (but variable) point on the femoral prosthesis to a fixed point on the bone. Definitive loosening was considered sinking >5 mm or progressive demarcation around the stem. The cups were analyzed in the three zones described by DeLee and Charnley.[20]. Radiolucencies were classified into lines extending over <50% of an area, >50% of an area but not completely, or over the entire area. The width of any radiolucent line observed was classified into: <1 mm, 1 to 2 mm, or >2 mm.

All complications were recorded and divided according to the time they appeared. Septic failure was considered to be any case that required revision surgery due to surgical site infection, according to the definitions standardized by the Musculoskeletal Infection Society revised at the International Consensus Meeting. Aseptic implant failure was defined as the need for revision surgery due to non-infectious causes.

RESULTS

The causes that led to the indication for surgery were: three idiopathic chondrolysis, three avascular bone necroses (ABN) secondary to epiphysiolysis, two sequelae of septic arthritis, one sequela of acetabulum fracture, one developmental dysplasia with sequela of failed pelvic osteotomy, and six cases (all three bilateral) of ABN induced by prolonged corticosteroid treatment secondary to Crohn's disease, lupus, and acute lymphoid leukemia. In total, nine (56%) of the cases corresponded to ABN secondary to different causes (Table 2, Figure 2). Eight patients (50%) had undergone surgery before the THA. (Figure 3)

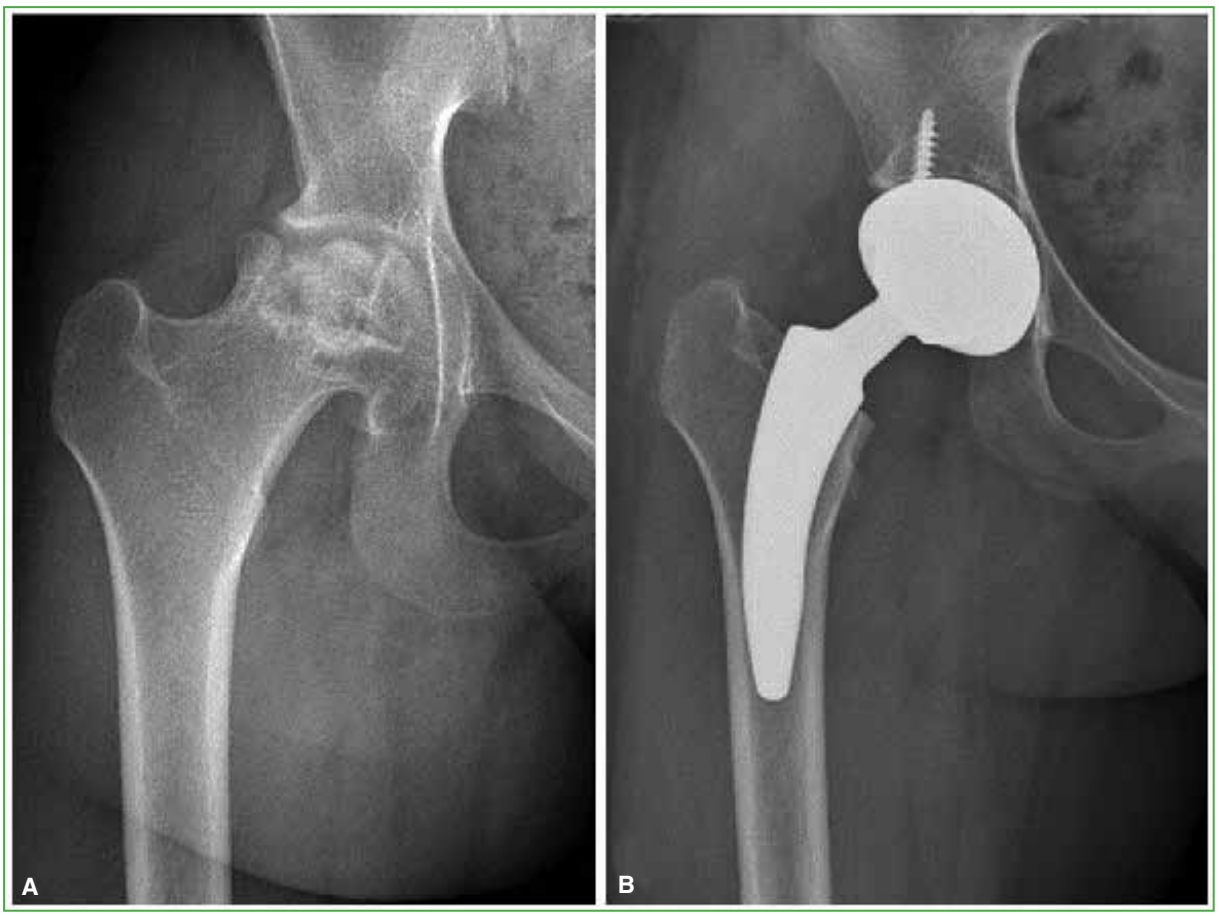

Figure 2. A 19-year-old patient with bilateral avascular bone necrosis secondary to prolonged corticosteroid treatment for acute lymphoid lymphoma. **A.** Preoperative anteroposterior right hip radiograph. **B.** Postoperative anteroposterior right hip radiograph after single-stage bilateral THA at the end of follow-up.

Table 2. Characteristics of each case

Patient	Total hip arthroplasty	Age (years)	Sex	Side	Diagnosis	Previous surgery	Bearing surface	Pre-surgery use of ambulation device	Post-surgery use of ambulation device	Complications
1	1	12	F	Right	IC	CHD	C-P	A pair of crutches	No	No
2	2	14	M	Left	ABN, FNF	R/O	C-C	No	No	No
3	3	14	F	Right	Dysplasia	TPO	C-P	Cane	No	No
4	4	15	F	Left	ABN, FNF	No	C-C	Crutches	No	No
5	5	15	F	Left	SA sequela	CHD	C-C	Cane	No	No
6	6	16	M	Right	IC	No	C-P	Cane	No	No
7	7	18	F	Bilateral	ABN, corticosteroids, Crohn's disease	No	C-P	Walker	No	No
7	8	18	F	Bilateral	ABN, corticosteroids, Crohn's disease	No	C-P	Walker	No	No
8	9	19	F	Bilateral	ABN, corticosteroids, ALL	Bilateral Forage	C-C	Wheelchair	No	No
8	10	19	F	Bilateral	ABN, corticosteroids, ALL	Bilateral Forage	C-C	Wheelchair	No	No
9	11	20	M	Left	SA sequela	No	C-P	No	No	Intraoperative trochanteric fracture, sciatic nerve injury
10	12	20	M	Bilateral	ABN, corticosteroids, lupus	No	C-P	No	No	No
10	13	20	M	Bilateral	ABN, corticosteroids, lupus	No	C-P	No	No	No
11	14	14	M	Left	ABN due to epiphysiolysis	Osteodesis	C-P	Crutches	No	No
12	15	16	M	Right	Sequela of acetabular fracture-dislocation	Acetabulum R/O	C-P	Crutches	No	No
13	16	15	M	Right	IC	No	C-P	Crutches	No	No

M = male, F = female, IC = idiopathic chondrolysis, ABN = avascular bone necrosis, FNF = femoral neck fracture, R/O = reduction and osteosynthesis, SA = septic arthritis, ALL = acute lymphoid leukemia, CHD = controlled hip dislocation, TPO = triple pelvic osteotomy, C-C = ceramic-on-ceramic, C-P = ceramic-on-polyethylene.

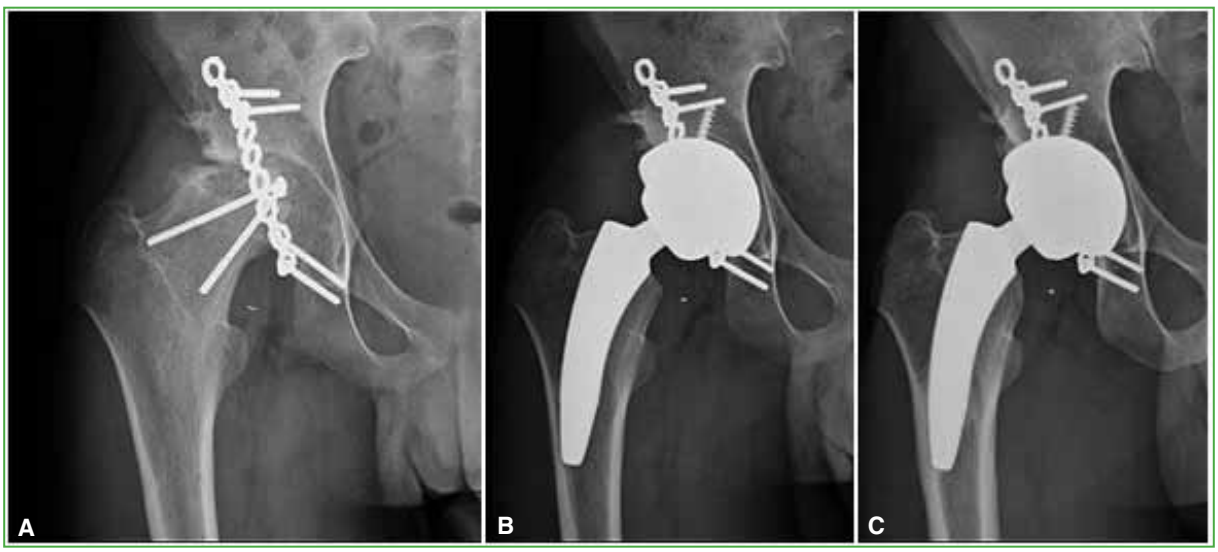

Figure 3. A 16-year-old patient with sequela of a dislocated acetabular fracture. **A.** Anteroposterior right hip radiograph before total hip arthroplasty. **B.** Anteroposterior right hip radiograph in the immediate postoperative period. **C.** Anteroposterior right hip radiograph after 10 years of follow-up.

The average hospital stay was 2.86 days (range 1-4). Only one patient out of the 13 (7%) required transfusions, one of three cases of single-stage bilateral THA.

A fourth-generation ceramic-on-ceramic Delta™ surface (Biolox, CeramTec, Plochingen, Germany) was used on five hips while, in the remaining 11 cases, ceramic on highly cross-linked polyethylene with posterior rim was used. This decision depended on the authorization of the patients' health insurance. Osseointegration was achieved in all cups and, according to the Engh classification, all stems were stable, without any sign of loosening. A patient who had undergone single-stage bilateral surgery had a radiolucent line in acetabular zone 1 of the right hip eight months after the operation; however, as he remained asymptomatic, he received conservative treatment (Table 2).

The mean HHS went from 33.31 (range 8-64; SD ± 16.528) to 94.13 (range 78-100; SD ± 5.691; p<0.001). There was also a significant improvement in the Merle D'Aubigné score when comparing preoperative with postoperative values [8.62 (range 2-13); SD ± 3.30 vs. 17.56 (range 16-18); SD ± 0.81, p<0.001]. Likewise, the global VAS pain score also improved markedly [8.63 (range 2-13) SD ± 3.30 vs. 0.84 (range 16-18), SD ± 5.691; p<0.001] (Table 3). Regarding the use of an ambulatory device, 10 (76.9%) patients needed one before surgery and none required it at the end of follow-up.

Table 3. Functional evaluation

Score	Preoperative value	Range	Postoperative value	Range	p
Harris Hip Score	33	8-64	94	78-100	0.001
Merle D'Aubigné Scale	8	2-13	17	16-18	0.001
Visual analog scale	8	5-10	1	0-5	0.001

A complication was recorded in a 20-year-old patient operated on for sequela of septic arthritis in childhood. At the time of surgery, he had almost complete agenesis of the femoral head with a dysplastic acetabulum and limb shortening of 35 mm. During surgery, there was a fracture of the greater trochanter treated with cerclage wire and, in the postoperative period, he presented motor paralysis of the sciatic nerve and neuropathic pain. Six months after the THA, he required a sciatic neurolysis. At the end of the follow-up, the recovery of motor function was complete, he did not have a limp, but he suffered from persistent neuropathic pain, with dysesthesia in the sole of his foot.

No cases of thigh pain, instability or infection were detected. The implant survival rate was 100% at the end of follow-up.

DISCUSSION

It is increasingly common to face the need to perform a THA for end-stage hip disease in adolescent or young adult patients. There are multiple publications that describe the outcomes with cemented and uncemented prostheses in this age group.

In this study, we presented a series of consecutive patients treated with short-stem uncemented prostheses and a mean follow-up of 43 months. To the best of our knowledge, this is the first study to specifically report the outcome of femoral reconstruction with a uncemented short stem in patients <20 years of age.

The short cervical-metaphyseal stems use the calcar and the lateral femoral cortex as support points, providing stability through metaphyseal fixation and preserving as much of the neck as possible,[11,21] which, associated with a correct biomechanical and functional contribution, makes it a good option in young patients. When performing a radiographic analysis between type 2B short stems and uncemented conventional stems, it was estimated that short stems allow 42% of femoral bone stock to be preserved.[24]

Rainer et al. analyzed a series of 12 patients (13 THAs) <16 years old with uncemented stems with a mean clinical-radiological follow-up of 2.4 years. In the results, they described that 10 of the 13 cases (77%) had ABN as a surgical indication.[22] Clohisy et al. published a series of 88 patients and 102 hips and reported that ABN was the most common cause (incidence 44%).[7] In our series, 56% of the cases corresponded to ABN due to various causes, which is consistent with the trend of these indications.

In this study, a significant improvement in pain and function was demonstrated, which was seen both in functional scores and in the discontinuation of ambulation devices. There was no evidence of radiolucency or signs of loosening at the stem level, and revision of the components was not necessary. Tsukanaka et al. analyzed 111 patients (132 hips) who underwent primary THA before the age of 20, in the period 1987-2010, extracted from the *Norwegian Arthroplasty Register,* with a mean follow-up of 14 years (range 3-26). They reported 31 (27.92%) revisions, 18 of them (58.06%) were due to aseptic loosening; 11 (35,4), due to wear of the acetabular insert and the rest of the causes were due to osteolysis, infection, and instability.[4]

It is important to note that many of these patients arrive at surgery using ambulation devices. Bessette et al. studied a series of patients <21 years old who underwent THA with a minimum follow-up of 10 years. All used ambulation devices, but at the end of the follow-up, only 56% were still using them.[23]

Our study has limitations. Firstly, its retrospective design and the inherent biases of said design. The size of the sample meant that a small number of cases were included, which restricted the production of a more precise statistical analysis. Secondly, the study lacked a control group with similar characteristics. Thirdly, our survival rates should be viewed as estimates at best. Since the follow-up was short-term, we expect some of these patients to still undergo revision arthroplasty for any reason at a longer follow-up. However, it is the only study on the clinical and radiographic outcomes of this hip implant in patients <20 years of age.

CONCLUSION

THA with a short uncemented femoral stem in patients <20 years of age with advanced hip osteoarthritis obtained clinical, functional and radiographic outcomes comparable to those already published, with the particularity that it is a less invasive procedure and preserves bone stock.

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

M. Buttaro ORCID ID: https://orcid.org/0000-0003-3329-778X
F. Comba ORCID ID: https://orcid.org/0000-0002-2848-2983
G. Zanotti ORCID ID: https://orcid.org/0000-0001-8090-4832
P. A. Slullitel ORCID ID: http://orcid.org/0000-0002-8957-075X
S. Kohan ORCID ID: https://orcid.org/0000-0003-2703-8554
F. Salagoity ORCID ID: https://orcid.org/0000-0001-6062-7188

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