Orthopaedics & Traumatology: Surgery & Research xxx (xxxx) xxx

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.sciencedirect.com/journal/orthopaedics-and-traumatology-surgery-and-research

Original article

Mid to long-term survivorship of hip arthroplasty in patients 40 years and younger

Camille Vorimore [a], Andrew Adamczyk [b], Pierre Laboudie [c], Marc Antoine Ricard [a], Paul E. Beaule [a], George Grammatopoulos [a,*]

[a] Department of Orthopaedic Surgery, The Ottawa Hospital, Ottawa, Ontario, Canada
[b] Department of Orthopedic Surgery, University of Arizona College of Medicine, Phoenix, AZ, USA
[c] Service de Chirurgie Orthopédique, Traumatologique et Oncologique, Hôpital Cochin, Paris, France

ARTICLE INFO

Keywords:
Total hip arthroplasty
Hip resurfacing
Survivorship
Outcomes
Etiology
Osteoarthritis
Pediatric hip sequelae
Young

ABSTRACT

Background: Etiology of hip osteoarthritis (OA) and survival of hip arthroplasty in the young (below 40-years-old) remains poorly described. Furthermore, joint survivorship mid to long-term and PROMs according to the etiology are unclear. The study aims were to 1) identify the indications for arthroplasty in the below 40-years-old cohort; 2) define hip arthroplasty outcomes in the young and 3) test whether patients with sequelae of pediatrics hip disease have inferior outcome compared to other patients.
Hypothesis: Our hypothesis was that hip arthroplasty is a viable option for managing hip disease in patients under 40, with excellent survival rates and outcomes.
Material and methods: This is an IRB approved, retrospective, consecutive, multi-surgeon, cohort study from a single academic center. Indication for hip arthroplasty of 346 patients (410 hips) below 40-years-old were studied; 239 underwent THA (58%) and 171 hip resurfacing (42%). Patient, surgical and implant factors were tested for association with implant survivorship and functional outcome for hip arthroplasty performed with a follow-up of more than two years. Pediatric hip sequelae patients were compared for survival and PROMs with the rest of the cohort.
Results: The most common etiology of OA was FAI (47%), followed by pediatric hip sequelae (18%). The 10-year survivorship was 97.2% $\pm$ 1.2, mean OHS was 45.1 $\pm$ 6.3 and mean HHS was 93.4 $\pm$ 12.6. The pediatric hip sequelae subgroup demonstrated no differences in 10-year survivorship and better PROMs compared to rest (OHS: 46.6 $\pm$ 3.8; HHS: 96.0 $\pm$ 8.5).
Discussion: The most common aetiologies amongst the young with hip OA is FAI and pediatric hip sequelae. Hip arthroplasty in the young presents excellent 10-year survivorship and PROMs. Excellent survival and PROMs in the young with pediatric hip sequelae provide important information for decision-making in this challenging population.
Level of evidence: III; retrospective cohort study.

1. Introduction

Total hip arthroplasty (THA) has been one of the most successful medical procedures in modern day medicine [1]. Although the young ($\leq$50 years old) contribute only a small percentage (4%–10%) of patients undergoing THA, a gradual rise in numbers has been noted [2–4]. The below 40-years old population is of particular interest, as it is an important threshold when assessing patients for hip preservations procedures and their associated outcomes [5,6]. Although THA has been the treatment of choice for hip osteoarthritis (OA) in the elderly, results have historically been less favorable among younger patients [7–9]. Factors such as higher activity level and participation in higher impact sports had been associated with increased polyethylene wear [10] and higher revision rates [11]. With improvements in implant design and materials (e.g. highly cross-linked polyethylene; HXLPE), survival rates have significantly increased [12]. Furthermore, the causes are usually deforming conditions such as slipped upper femoral epiphysis (SUFE), osteonecrosis, Perthes disease and developmental hip dysplasia (DDH),

* Corresponding author.
E-mail address: ggrammatopoulos@toh.ca (G. Grammatopoulos).

https://doi.org/10.1016/j.otsr.2024.103978
Received 3 May 2024; Accepted 23 August 2024
Available online 26 August 2024

often making surgical procedure more complex [13].

Even if historically the results in young people remain inferior [14–16], some early series of patients younger than 40 years-old undergoing THA reported low revision rates and no difference compared to older populations [3,17,18]. The use of the ceramic–ceramic bearing surfaces and the rise of the anterior approach may have influenced the results of THA in young population [19]. OA in young patients is often secondary to multiple causes that are specific to this patient group [20, 21] and may have a significant influence on outcome. The literature is limited on this topic and the indications need to be investigated by further studies. In particular, only a few have focused on the effects of the pediatrics hip sequelae (PHS) [22–25] (SUFE, DDH and Perthes disease) on mid- and long-term survivals and functional outcomes, and none compared the results of this group with other indications for THA in patients under 40 years of age.

The aims of this study were to 1) identify the indications for arthroplasty in the below-40-years old cohort; 2) define hip arthroplasty in the young outcomes (joint survivorship and PROMs) and 3) test whether patients with pediatric hip sequelae have inferior outcome compared to other patients.

Our hypothesis was that hip arthroplasty is a viable option for managing hip disease in patients under 40, with excellent survival rates and outcomes.

2. Material and methods

2.1. Study design

This is an IRB approved (Protocol ID: 2006856-01H), retrospective, consecutive, multi-surgeon, cohort study of all patients below 40 years of age with an indication for arthroplasty between January 2006–September 2020 at a single, academic, tertiary care center (TCC). A minimum follow-up of 2-years was considered necessary.

2.2. Patient population

The inclusion criteria were all hip arthroplasty performed below 40 years of age. During the study period, a total of 7998 hips underwent primary hip arthroplasty at our TCC, of which 346 patients (410 hips; 5.1%) met inclusion criteria based on age below 40 years-old at time of surgery. 7588 patients were not included because they were over 40 years-old. Among patients under 40 years of age with an indication for hip arthroplasty, 239 (58%) underwent THA (97, 41% male) and 171 (42%) hip resurfacing (146, 85% male). The patients' mean age and BMI were 33.6 ± 6.2 (range: 17.0–40.0) years old and 27.9 ± 6.2 kg/m^2 (range:16.0–48.3 kg/m^2) respectively. Most patients were male (n = 243 hips, 59%). 65 (16%) patients had a previous surgery to the hip of interest and other hip arthroplasties patient demographics are summarized in Table 1.

2.3. Management

The entire cohort was under the care of six fellowship trained arthroplasty surgeons. All three approaches were utilized during the study period based on surgeon's preference (Table 1).

Hip resurfacing was offered as an option to appropriate patients by three of the six arthroplasty surgeons. A trochanteric slide osteotomy/surgical dislocation was utilized by one of the surgeons as this was his preferred technique prior to transitioning to the anterior approach. The second surgeon performing hip resurfacing did so briefly through the lateral approach; however, converted to the posterior approach, which he has utilized for over a decade. All hip resurfacing performed at our center consisted of a MoM bearing surface, of which 90% were performed with the Conserve Plus prosthesis (Microport, Memphis, TN). This is contrary to those undergoing THA, (only 8 (3%) of MoM bearing surface were used), in which multiple combinations of bearing surfaces were utilized and left at the discretion of the treating surgeon (Table 1). Polyethylene liners used before January 2012 were of second-generation annealed polyethylene (X3; Stryker, Warsaw, IN); starting January 2012 first-generation re-melted (Longevity; Zimmer Biomet, Warsaw, IN, USA) highly cross-linked polyethylene liners were used. X3 and Longevity liners were used in 10 and 162 cases, respectively. The implants used in the setting of THA also varied over the course of the study period, depending on the institutional contract at the time of implantation, with the Taperloc Complete/Microplasty (Zimmer Biomet, Warsaw, IN, USA) and G7 Titanium Acetabular Cup (Zimmer Biomet, Warsaw, IN, USA) being the most used implants (n = 107, 45%) (Table 1).

Table 1
Patient demographics and surgical details.

	Cohort (n = 410)	Pediatric hip sequelae (n = 75)	Other (n = 335)	*p = Value*
Age (years)	33.6 ± 6.2	30.6 ± 6.8	34.2 ± 5.9	**<0.001**
Gender (n, female)	167 (41%)	47 (63%)	120 (36%)	**<0.001**
BMI kg/m^2	27.9 ± 6.2	26.1 ± 4.8	28.2 ± 6.4	0.058
FU (years)	7.1 ± 4.3 (2–15.2)	6.9 ± 4.2 (2–15.2)	7.2 ± 4.2 (2–14.8)	0.597
Previous surgery:	65 (16%)	32 (43%)	33 (10%)	**<0.001**
• Osteotomy	27 (7%)	21 (28%)	6 (2%)	
• Fracture ORIF	13 (3%)	0	13 (4%)	
• SUFE fixation	8 (2%)	8 (11%)	0	
• Arthroscopy	7 (2%)	1 (1%)	6 (2%)	
• Synovectomy	5 (1%)	0	5 (1%)	
• Core decompression/ bone graft	2 (1%)	0	2 (1%)	
• Open dislocation (coxa profonda)	1 (0%)	1 (1%)	0	
• Tumor resection	1 (0%)	0	1 (0%)	
• Adductor tenotomy	1 (0%)	1 (1%)	0	
Approach:				**0.002**
• Anterior	219 (56%)	27 (36%)	192 (57%)	
• Posterior	146 (32%)	41 (55%)	105 (31%)	
• Lateral	27 (8%)	4 (5%)	23 (7%)	
• Trans-trochanteric	13 (1%)	1 (1%)	12 (4%)	
THA bearing:				**<0.001**
• MoM	179 (44%)	7 (9%)	172 (51%)	
• MoP	93 (23%)	20 (27%)	73 (22%)	
• CoP	79 (19%)	27 (36%)	52 (16%)	
• CoC	55 (13%)	19 (25%)	36 (11%)	

Bold p-values indicate statistically significant results ($p < 0.05$).

2.4. Data collection & radiographic analysis

Pre-operative X-rays and medical records were reviewed by two independent fellowship-trained arthroplasty hip surgeons (PL and AA), to establish the etiology of end stage osteoarthritis. The following groups were established: 1) Femoroacetabular Impingement (FAI) — CAM and Pincer, 2) Pediatric Hip Sequelae–DDH, SUFE, Leg Calves Perthes (LCP) and Metabolic, 3) Avascular Necrosis (AVN), 4) Dysplasia, 5) Inflammatory 6) Other —Post-traumatic, Tumour, Previous arthrodesis, unknown.

Radiographic analyses were performed using pre- and post-operative radiographs (AP pelvis and lateral hip views), which were performed using previously described protocols [26]. The diagnosis of Cam-FAI was confirmed via measurement of alpha angle >55° on either the frog leg lateral, or Dunn views [27]. Lateral centre edge angle (LCEA) was also assessed in all patients which reliable measure could be acquired [26]. Pincer-FAI was defined as LCEA > 40° on AP pelvis X-ray with or without additional radiographic signs such as crossover sign, ischial spine sign and posterior wall sign [28]. Measurements were performed by two reviewers and repeated 2 weeks after the initial radiographic analysis for 10% of randomly selected data sets in a blinded fashion. Excellent intra- and interobserver reliabilities were achieved (ICC: 0.94–0.98; 95%CI: 0.86−0.99; $p < 0.001$). The latest set of radiographs were scrutinised for adverse features that would indicate a hip arthroplasty that is at risk of failure, such as loosening or osteolysis about the hip [29].

2.5. Clinical outcomes

Implant survival for the whole cohort was established at both five- and ten-year post-implantation with any cause revision as the end point of interest. Follow-up dates was the date of last clinical encounter. The patients were followed at regular intervals (1-, 3-, 5-, 10-years post-operatively) in our service, and this follow-up schedule did not change for this study. Patient reported clinical outcome as determined using the Oxford Hip Scores (OHS: 0–48, 48 denoting best outcome) and the Harris Hip Score (HHS: 0–100, 100 denoting best outcome) [30,31]. We have used a 5-point difference for the OHS and an 18-point difference for the HHS as the between group minimum clinically important difference (MCID), which allows the estimation of a clinically relevant difference in change scores from baseline when comparing groups. These scores are consistent with what is reported in the literature as the most appropriate value for applications in clinical research [32,33].

2.6. Statistical analysis

Implant survival and PROMs were established for different sub-groups. Sub-analysis was performed as per age, gender (M:F), surgical approach (anterior, posterior, lateral and trans-trochanteric), implant factors (type and bearing surface) and etiology of OA. Data were summarized using descriptive statistics including count and percentages for categorical variables. Continuous variables were described using the mean and standard deviation (SD) and categorical variables were presented with total count and percentages. The Chi-square and Fisher's exact tests were used to test for differences between categorical variables. The Mann Whitney U and Kruskal–Wallis tests were used for continuous variables. Intra-class correlation coefficient was used to determine inter and intra-observer radiographic analysis reliability. Kaplan–Meier analysis was performed to determine survivorship with any cause reoperation, and implant revision as the end point of interest. Analysis was performed using IBM SPSS software for Windows; a p-value <0.05 was considered to be significant.

3. Results

3.1. Cohort

The hip arthroplasties in the below 40 years-old population at our institution during the study period (2006–2019) demonstrated an increase of 94% (Fig. 1). An increase in the number of conventional THA relative to hip resurfacing being performed was also noticed.

3.2. Indication for arthroplasty

The most common etiologies of end stage OA were FAI (47%) and pediatric hip diseases (18%), mainly represented by DDH (10%). Among other causes, AVN (14%) were the most frequent (Table 2).

3.3. Hip arthroplasty outcome

Mean follow-up after the index procedure was 7.1 ± 4.3 years (2.0–15.2). At latest follow-up, 18 (4.4%) hips had undergone reoperations. Of these hips, 17 (4.1%) underwent revision of either one or multiple components. Reasons for reoperation were infection (n = 6), acetabular aseptic loosening (n = 4), fractured liner (n = 2), instability (n = 1), modular neck fracture (n = 1), pseudotumor (n = 1),

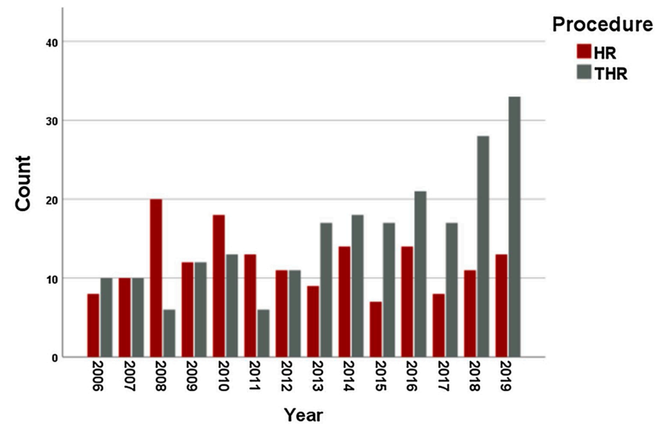

Fig. 1. Trend in hip arthroplasty cases being performed per year in the 40-year-old or younger population.

Table 2
Indication for hip arthroplasty.

Pediatric hip sequelae	74 (18%)	Others	336 (82%)
DDH	39 (10%)	FAI	192 (47%)
LCP	18 (4%)	AVN	57 (14%)
SUFE	13 (3%)	Dysplasia	26 (6%)
Other	4 (0,1%)	Inflammatory	12 (3%)
		Other	49 (12%)

periprosthetic fracture (n = 1) and femoral stem perforation (n = 1).

The 5-year survivorship and 10-year survivorship of the entire cohort were 99.5% ± 0.4 (95% CI: 99.1%–99.9%) and 97.2% ± 1.2 (95% CI: 96%–98.4%) respectively (Fig. 2). No demographic or surgical parameters were associated with survivorship differences. Hip resurfacings had similar survival compared to THAs (98.8 ± 1.2 vs 95.5 ± 2.1; p = 0.097) (Table 3).

OHS and HHS were obtained for 290 hips (71%). The mean post-operative OHS was 45.1 ± 6.3 (8.0–48.0) and the mean post-operative HHS was 93.4 ± 12.6 (32.0–100.0). Hip resurfacings did not show a difference in post-operative OHS compared to conventional THAs (45.5 ± 5.0 vs 44.7 ± 7.0; p = 0.456)

3.4. Outcome of hip arthroplasty relative to etiology

There were no statistical differences in survivorship when comparing etiology. However, significant differences were observed with different indications for surgery, respect to postoperative OHS and HHS. PHS

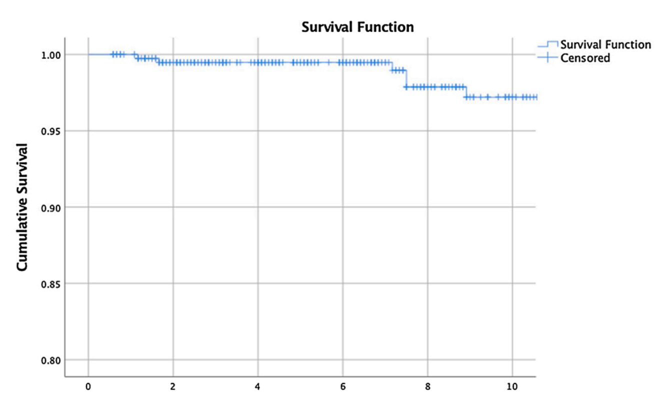

Fig. 2. Kaplan–Meier survival analysis displaying survivorship of hip arthroplasty in patients 40-year-old or younger.

Table 3
Survivorship table.

Factors			10-year survivorship	p = Value
Demographics	Age (years)	<30	96.2% ± 2.9	0.837
		≥30	97.5% ± 1.3	
	Gender	Male	98.1% ± 1.4	0.107
		Female	95.8% ± 2.2	
Surgical details	Hip procedure	Hip resurfacing	98.8% ± 1.2	0.097
		Conventional THA	95.5 ± 2.1	
	Approach	Anterior	96.5% ± 2.2	0.064
		Posterior	96.5% ± 2.1	
		Lateral	100%	
		TT	100%	
	Bearing surface	MoM	98.9% ± 1.1	0.064
		MoP	97.4% ± 1.8	
		CoP	90.9% ± 8.7	
		CoC	95.1% ± 3.4	
Previous surgery		Yes	90.5% ± 6.7	0.4
		No	98.2% ± 1.3	

(OHS 46.6 ± 3.8, HHS 96.0 ± 8.5), AVN (OHS 46.4 ± 4.0, HHS 96.0 ± 9.2) and Dysplasia (OHS 46.7 ± 2.3, HHS 97.0 ± 6.1) demonstrating better scores compared to FAI (OHS 44.7 ± 6.2, HHS 92.8 ± 12.2) and Inflammatory causes (OHS 42.2 ± 12.0, HHS 89.3 ± 22.1) (Table 4).

4. Discussion

The most common etiologies of hip osteoarthritis in young patients were FAI and pediatric hip sequelae. Hip arthroplasty in the young shows excellent 10-year survivorship and PROMs. Survival rates in patients with pediatric hip sequelae were comparable to those of the rest of the cohort, and their PROMs were even better.

The overall demand for hip arthroplasty has been continuously increasing and is projected to do so in the future too [34]. The prevalence of hip arthroplasty amongst the young (below 40 years-old) is also increasing, with our results demonstrating a significant increase (almost doubled) over a 13-year period. Such findings have also been described by others, demonstrating similar trends [3,4], which were higher than the trends observed in the above 50-years old population.

With the ever-increasing demand for arthroplasty, it was important to assess the underlying pathology contributing to this, to help with the development of prevention programs. The most common etiologies of end stage osteoarthritis in our cohort were FAI, followed by pediatric sequelae and avascular necrosis of the femoral head. These indications reflect those observed in previous literature, albeit differing in order [3,35,36]. Clohisy et al., investigated 710 primary THA before 50 years of age and found that osteoarthritis (47.5%), majority due to DDH (48.4%), and osteonecrosis (28.9%) were the most prevalent causes for THA [36]. They stated that within the osteoarthritis group, 121 hips (35.9%) had "unknown etiology"; however, when further radiographic features were investigated, 118 hips (98.8%) had radiographic features of impingement; the majority of whom were male patients (71.4%), which was similar to that found within our group (76%). Mei et al., performed a systematic review and reported on the preoperative diagnosis, prior to THA in the <55-years old population [3]. They found that AVN (32.4%), osteoarthritis (32.4%) and DDH (19.5%) were the most common etiologies. Pediatric developmental abnormalities accounted for a total of 22.8% of the entire cohort, when all causes were included, but radiographic parameters were not assessed to elucidate the potential contribution of FAI to OA and subsequent THA. Taking into context the above studies and the lack of other large cohort studies investigating the etiology of OA in the young, this cohort is one of the most comprehensive and representative of the young patient (below 40 years of age) undergoing hip arthroplasty.

Table 4
Outcome of hip arthroplasty relative to etiology.

	Survival (%) ± SD	OHS ± SD	HHS ± SD
Pediatric hip sequelae	100%	46.6 ± 3.8	96.0 ± 8.5
FAI	97.0% ± 1.8	44.7 ± 6.2	92.8 ± 12.2
AVN	98.2% ± 1.8	46.4 ± 4.0	96.0 ± 9.2
Dysplasia	77.8% ± 1.4	46.7 ± 2.3	97.0 ± 6.1
Inflammatory	100%	42.2 ± 12.0	89.3 ± 22.1
Other	100%	42.5 ± 9.0	88.0 ± 18.2
p-Value*	0.076	**0.017**	**0.028**

Bold p-values indicate statistically significant results ($p < 0.05$).
* Comparison of survival and outcomes (OHS, HHS) based on etiologies.

In this cohort implant survivorship was 97.2% ± 1.2 at 10-years. Survival in young patients under 40 receiving hip arthroplasty is therefore very good and encouraging for patients. We demonstrated no survivorship differences between etiologies. These results also seem to be reflected in more recent literature, with THA in the setting of AVN [37,38] and DDH [39,40] demonstrating excellent results. These trends have been thought to be primarily associated to the development of HXLPE and implant design [38,39]. Although historically the results after THA in young people have shown poorer outcomes, recent studies have shown discordant results. Garcia-Rey et al. found an overall survival at 93.3% at 17 years after THA before the age of 40 and the mean preoperative Harris Hip score increased from 52.8 to 93.4 at the end of follow-up [41]. This outcome of THA in patients under the age of 40 years, close to those found in our study, is similar to the results after THA in the literature in older patients [42]. The high survival rate is probably due to the use of new materials (e.g. HXLPE) and implant design. Early series of patients aged below 40 years undergoing THA reported revision rates as high as 82% when cemented femoral components are used [14]. In contrast, recent studies using cementless femoral components and modern bearing surfaces have shown better results. In a meta-analysis of 743 THA, Walker et al. found a revision rate of 1.3% at 9.9 years in patients with uncemented THAs, compared to the overall revision rate in this study of 5.0% at 8.4 years [15]. Makarewich et al. compared patients aged ≤30 years who underwent THA with patients aged ≥60 years and found an overall revision rate at 11% in the very young group and 3.83% in the elderly group [43]. The author explained this by the use of Metal-on-Metal bearings. Young patients with non-MoM bearings had high survivorship with similar complication profiles to patients aged ≥60 years. However, in our study we did not find any difference in survival between the different bearing surface groups.

To our knowledge, there are no comparative studies in the current literature that have reported mid- to long-term PROMs following hip arthroplasty amongst young patients with pediatric hip sequelae. In this group of patients, surgery is challenging by the presence of unremoved fixation devices due to previous conservative surgery, joint stiffness, former scar tissue, residual bone deformities, abductor muscle weakness and differences in limb length. These conditions can complicate the surgery and thus affect the outcome after hip arthroplasty. Engesæter et al. analyzed the survival of 14,403 THA pediatric hip sequelae based on Danish, Norwegian, and Swedish arthroplasty registers [24]. In its result without any adjustment, the 10-year survival of THAs was 94.7% after PHS and 96.6% after primary OA. The overall risk of revision for THAs after previous childhood hip diseases was 1.4 times than after OA. However, after adjustments in the Cox model for age, sex, and type of fixation of the prosthesis, the 10-year survival of THAs was 93.6% after PHS and 93.8% after OA. No statistically significant difference was found between the overall risk of revision for THAs after PHS and that after OA. These results are consistent with those of our study as we found no significant difference between the PHS group and the non-PHS group in patients under 40 years of age. However, Engesæter et al. did not study PROMs postoperatively. Malcolm et al. found lower postoperative expectations, greater hip-related quality of life, and better mental health scores in the general THA group than the young THA group [44]. This may indicate a need for better management of expectations in young patients undergoing THA. However, in our study, among the cohort of young patients under 40 years of age, the PHS group had excellent functional results, which were numerically superior (OHS: 46.6 ± 3.8 vs 44.7 ± 6.6) than the rest, but unlikely to clinically significant as less than the MCID. We hypothesize that this could be potentially explained by these groups of patients having suffered more pain or disability prior to their surgery, yielding their change in function more significant or perceived more significant, resulting in better post-operative scores.

This study suffers from certain limitations. This is a retrospective, cohort study and thus suffers from all limitations pertinent to such design. Secondly, we did not collect OHS and HHS score for these patients pre-operatively and thus cannot report on the change in functional outcome that has occurred with the procedure. Thirdly, the implants used, and the approaches were not homogeneous and reflect institutional change in vendors and individual surgeon practice. As seen in previous studies, these factors may influence long-term survival. However, we did not find any difference in outcome in these different subgroups. Moreover, a significant number of young patients underwent hip resurfacing during the study period, and they were included in the outcome analysis. Excluding them could introduce a selection bias because patients with secondary deformities and AVN were more likely to have been candidates for THA instead of a resurfacing procedure. The latter would have been the primary choice for patients with primary OA. Furthermore, the PROs and survivorship were not different between the two types of implants. Fourthly, pediatric hip sequelae patients usually have had a complex procedure in the past and we did not collect data about osteotomies during hip arthroplasty, or leg length issues between the two groups and continuation of post-op abduction weakness and limp.

Additionally, the number of arthroscopies performed in the past was too small to draw any significant conclusions regarding their potential effect in postponing or reducing the progression of osteoarthritis in patients with FAI. This is why we have opted not to address this aspect in the discussion section of our paper. Among the seven arthroscopies reported in Table 1, six were performed for the treatment of FAI and one for DDH, on average three years before the THA/RSA. Finally, we did not compare the post-hip arthroplasty return to specific activities between the pediatric hip sequelae group and the remainder of the cohort. This comparison would have provided valuable insights since pediatric sequelae patients usually have complex situations, and while they might achieve favorable outcomes, it's possible that they may not reach the same level of activity as non-pediatric hip disease patients after hip arthroplasty surgery.

5. Conclusion

The improvement of THA and their survival has favoured their implantation in very young patients in the last decades. Their main indication before the age of 40 are mainly represented by FAI and pediatric hip sequalae (PHS). This study shows a very good survival of hip arthroplasty at mid and long-term in these young patients. Although PHS often complicate surgery, we found no difference with the rest of the cohort in terms of survival, and PHS have even better PROMs, probably because patients are more responsive to improvement in function.

These results, in line with the recent literature, show similar results to those in older patients and support the idea that we can safely perform this type of surgery in young patients.

Further prospective or larger cohort studies are needed to confirm the present study's findings.

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Camille Vorimore, Pierre Laboudie, Andrew Adamczyk and George Grammatopoulos. The first draft of the manuscript was written by Pierre Laboudie, Andrew Adamczyk, and George Grammatopoulos. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding

None.

Conflicts of interest

The authors have no conflict of interest.

Declaration of generative AI and AI assisted technologies

No artificial intelligence was used for the writing of the submitted work.

References

[1] Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. Lancet 2007;370(9597):1508–19. https://doi.org/10.1016/S0140-6736(07)60457-7.

[2] Hip and knee replacements in Canada: CJRR annual statistics summary, 2018–2019.

[3] Mei XY, Gong YJ, Safir O, Gross A, Kuzyk P. Long-term outcomes of total hip arthroplasty in patients younger than 55 years: a systematic review of the contemporary literature. Can J Surg 2019;62(4):249–58. https://doi.org/10.1503/cjs.013118.

[4] Ravi B, Croxford R, Reichmann WM, Losina E, Katz JN, Hawker GA. The changing demographics of total joint arthroplasty recipients in the United States and Ontario from 2001 to 2007. Best Pract Res Clin Rheumatol 2012;26(5):637–47. https://doi.org/10.1016/j.berh.2012.07.014.

[5] Lerch TD, Steppacher SD, Liechti EF, Tannast M, Siebenrock KA. One-third of hips after periacetabular osteotomy survive 30 years with good clinical results, no progression of arthritis, or conversion to THA. Clin Orthop Relat Res 2017;475(4):1154–68. https://doi.org/10.1007/s11999-016-5169-5.

[6] Lin LJ, Akpinar B, Bloom DA, Youm T. Age and outcomes in hip arthroscopy for femoroacetabular impingement: a comparison across 3 age groups. Am J Sports Med 2021;49(1):82–9. https://doi.org/10.1177/0363546520974370.

[7] Mäkelä KT, Eskelinen A, Pulkkinen P, Paavolainen P, Remes V. Results of 3,668 primary total hip replacements for primary osteoarthritis in patients under the age of 55 years. Acta Orthop 2011;82(5):521–9. https://doi.org/10.3109/17453674.2011.618908.

[8] Bonnomet F, Glorion C. Total hip arthroplasty in patients younger than 30 years old: conclusions and recommendations. Rev Chir Orthop Reparatrice Appar Mot 2008;94 Suppl(6):S192–6. https://doi.org/10.1016/j.rco.2008.07.273.

[9] Bonnomet F, Glorion C. Total hip arthroplasty in patients younger than thirty years old: problematic. Rev Chir Orthop Reparatrice Appar Mot 2008;94 Suppl(6):S133–4. https://doi.org/10.1016/j.rco.2008.07.258.

[10] Ollivier M, Frey S, Parratte S, Flecher X, Argenson JN. Does impact sport activity influence total hip arthroplasty durability? Clin Orthop Relat Res 2012;470(11):3060–6. https://doi.org/10.1007/s11999-012-2362-z.

[11] Flugsrud GB, Nordsletten L, Espehaug B, Havelin LI, Meyer HE. The effect of middle-age body weight and physical activity on the risk of early revision hip arthroplasty: a cohort study of 1,535 individuals. Acta Orthop 2007;78(1):99–107. https://doi.org/10.1080/17453670610013493.

[12] Rames RD, Stambough JB, Pashos GE, Maloney WJ, Martell JM, Clohisy JC. Fifteen-year results of total hip arthroplasty with cobalt-chromium femoral heads on highly cross-linked polyethylene in patients 50 years and less. J Arthroplasty 2019;34(6):1143–9. https://doi.org/10.1016/j.arth.2019.01.071.

[13] De Salvo S, Sacco R, Mainard N, Lucenti L, Sapienza M, Dimeglio A, et al. Total hip arthroplasty in patients with common pediatric hip orthopedic pathology. J Child Orthop 2024;18(2):134–52. https://doi.org/10.1177/18632521241229608.

[14] Dorr LD, Kane TJ, Conaty JP. Long-term results of cemented total hip arthroplasty in patients 45 years old or younger. A 16-year follow-up study. J Arthroplasty 1994;9(5):453–6. https://doi.org/10.1016/0883-5403(94)90090-6.

[15] Walker RP, Gee M, Wong F, Shah Z, George M, Bankes M, et al. Functional outcomes of total hip arthroplasty in patients aged 30 years or less: a systematic review and meta-analysis. Hip Int 2016;26(5):424–31. https://doi.org/10.5301/hipint.5000376.

[16] Girard J, Glorion C, Bonnomet F, Fron D, Migaud H. Risk factors for revision of hip arthroplasties in patients younger than 30 years. Clin Orthop Relat Res 2011;469(4):1141–7. https://doi.org/10.1007/s11999-010-1669-x.

[17] Mahiques-Segura G, Lizaur-Utrilla A, Vizcaya-Moreno MF, Miralles-Muñoz FA, Lopez-Prats FA. A comparison study of the outcomes of ceramic-on-ceramic total hip arthroplasty in young vs older patients: a minimum 10-year follow-up prospective matched study. J Arthroplasty 2019;34(8):1731–5. https://doi.org/10.1016/j.arth.2019.03.049.

[18] Pallante GD, Statz JM, Milbrandt TA, Trousdale RT. Primary total hip arthroplasty in patients 20 years old and younger. J Bone Joint Surg Am 2020;102(6):519–25. https://doi.org/10.2106/JBJS.19.00699.
[19] Kuijpers MFL, Hannink G, Vehmeijer SBW, van Steenbergen LN, Schreurs BW. The risk of revision after total hip arthroplasty in young patients depends on surgical approach, femoral head size and bearing type; an analysis of 19,682 operations in the Dutch arthroplasty register. BMC Musculoskelet Disord 2019;20(1):385. https://doi.org/10.1186/s12891-019-2765-z.
[20] Clohisy JC, Beaulé PE, O'Malley A, Safran MR, Schoenecker P. AOA symposium. Hip disease in the young adult: current concepts of etiology and surgical treatment. J Bone Joint Surg Am 2008;90(10):2267–81. https://doi.org/10.2106/JBJS.G.01267.
[21] Polkowski GG, Callaghan JJ, Mont MA, Clohisy JC. Total hip arthroplasty in the very young patient. J Am Acad Orthop Surg 2012;20(8):487–97. https://doi.org/10.5435/JAAOS-20-08-487.
[22] Whitmarsh-Brown MA, Christ AB, Lin AJ, Siddiqui AA, Herman RY, Allison DC, et al. Modernizing our understanding of total hip arthroplasty in the pediatric and young adult patient: a single-center experience. J Pediatr Orthop 2023;43(4): e290–8. https://doi.org/10.1097/BPO.0000000000002316.
[23] Buddhdev PK, Vanhegan IS, Khan T, Hashemi-Nejad A. Early to medium-term outcomes of uncemented ceramic-bearing total hip arthroplasty in teenagers for paediatric hip conditions. Bone Joint J 2020;102-B(11):1491–6. https://doi.org/10.1302/0301-620X.102B11.BJJ-2020-0668.R1.
[24] Engesæter LB, Engesæter IØ, Fenstad AM, Havelin LI, Kärrholm J, Garellick G, et al. Low revision rate after total hip arthroplasty in patients with pediatric hip diseases. Acta Orthop 2012;83(5):436–41. https://doi.org/10.3109/17453674.2012.736171.
[25] Kim YH, Park JW, Jang YS, Kim EJ. Does an ultra-short anatomic cementless femoral stem improve long-term (up to 17 years) results in patients younger than 30 years? J Arthroplasty 2022;37(11):2225–32. https://doi.org/10.1016/j.arth.2022.06.003.
[26] Clohisy JC, Carlisle JC, Beaulé PE, Kim YJ, Trousdale RT, Sierra RJ, et al. A systematic approach to the plain radiographic evaluation of the young adult hip. J Bone Joint Surg Am 2008;90(Suppl 4):47–66. https://doi.org/10.2106/JBJS.H.00756.
[27] Barton C, Salineros MJ, Rakhra KS, Beaulé PE. Validity of the alpha angle measurement on plain radiographs in the evaluation of cam-type femoroacetabular impingement. Clin Orthop Relat Res 2011;469(2):464–9. https://doi.org/10.1007/s11999-010-1624-x.
[28] Rhee C, Le Francois T, Byrd JWT, Glazebrook M, Wong I. Radiographic diagnosis of pincer-type femoroacetabular impingement: a systematic review. Orthop J Sports Med 2017;5(5). https://doi.org/10.1177/2325967117708307. 2325967117708307.
[29] Van Der Straeten C, Calistri A, Grammatopoulos G, De Smet K. Radiographic evaluation of hip resurfacing: the role of X-rays in the diagnosis of a problematic resurfaced hip. Hip Int 2020;30(2):167–75. https://doi.org/10.1177/1120700019836373.
[30] Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris Hip Score (HHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), Oxford Hip Score (OHS), Lequesne Index of Severity for Osteoarthritis of the Hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) hip and knee questionnaire. Arthritis Care Res (Hoboken) 2011;63 Suppl 11:S200–207. https://doi.org/10.1002/acr.20549.
[31] Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. J Bone Joint Surg Br 1996;78(2):185–90.
[32] Singh JA, Schleck C, Harmsen S, Lewallen D. Clinically important improvement thresholds for Harris Hip Score and its ability to predict revision risk after primary total hip arthroplasty. BMC Musculoskelet Disord 2016;17:256. https://doi.org/10.1186/s12891-016-1106-8.
[33] Beard DJ, Harris K, Dawson J, Doll H, Murray DW, Carr AJ, et al. Meaningful changes for the Oxford hip and knee scores after joint replacement surgery. J Clin Epidemiol 2015;68(1):73–9. https://doi.org/10.1016/j.jclinepi.2014.08.009.
[34] Inacio MCS, Graves SE, Pratt NL, Roughead EE, Nemes S. Increase in total joint arthroplasty projected from 2014 to 2046 in Australia: a conservative local model with international implications. Clin Orthop Relat Res 2017;475(8):2130–7. https://doi.org/10.1007/s11999-017-5377-7.
[35] Murphy NJ, Eyles JP, Hunter DJ. Hip osteoarthritis: etiopathogenesis and implications for management. Adv Ther 2016;33(11):1921–46. https://doi.org/10.1007/s12325-016-0409-3.
[36] Clohisy JC, Dobson MA, Robison JF, Warth LC, Zheng J, Liu SS, et al. Radiographic structural abnormalities associated with premature, natural hip-joint failure. J Bone Joint Surg Am 2011;93(Suppl 2):3–9. https://doi.org/10.2106/JBJS.J.01734.
[37] Min BW, Cho CH, Son ES, Lee KJ, Lee SW, Song KS. Highly cross-linked polyethylene in total hip arthroplasty in patients younger than 50 years with osteonecrosis of the femoral head: a minimum of 10 years of follow-up. J Arthroplasty 2020;35(3):805–10. https://doi.org/10.1016/j.arth.2019.10.021.
[38] Hart A, Janz V, Trousdale RT, Sierra RJ, Berry DJ, Abdel MP. Long-term survivorship of total hip arthroplasty with highly cross-linked polyethylene for osteonecrosis. J Bone Joint Surg Am 2019;101(17):1563–8. https://doi.org/10.2106/JBJS.18.01218.
[39] Hitz OF, Flecher X, Parratte S, Ollivier M, Argenson JN. Minimum 10-year outcome of one-stage total hip arthroplasty without subtrochanteric osteotomy using a cementless custom stem for Crowe III and IV hip dislocation. J Arthroplasty 2018;33(7):2197–202. https://doi.org/10.1016/j.arth.2018.02.055.
[40] Greber EM, Pelt CE, Gililland JM, Anderson MB, Erickson JA, Peters CL. Challenges in total hip arthroplasty in the setting of developmental dysplasia of the hip. J Arthroplasty 2017;32(9S):S38–44. https://doi.org/10.1016/j.arth.2017.02.024.
[41] Garcia-Rey E, Bizot P, Garcia-Cimbrelo E. Ceramic-on-ceramic cementless total hip arthroplasty in patients aged 40 years or under: do preoperative conditions affect long-term results? Orthop Traumatol Surg Res 2021;107(1):102763. https://doi.org/10.1016/j.otsr.2020.102763.
[42] Blumenfeld TJ, Politi J, Coker S, O'Dell T, Hamilton W. Long-term results of delta ceramic-on-ceramic total hip arthroplasty. Arthroplast Today 2022;13:130–5. https://doi.org/10.1016/j.artd.2021.11.006.
[43] Makarewich CA, Anderson MB, Gililland JM, Pelt CE, Peters CL. Ten-year survivorship of primary total hip arthroplasty in patients 30 years of age or younger. Bone Joint J 2018;100-B(7):867–74. https://doi.org/10.1302/0301-620X.100B7.BJJ-2017-1603.R1.
[44] Malcolm TL, Szubski CR, Nowacki AS, Klika AK, Iannotti JP, Barsoum WK. Activity levels and functional outcomes of young patients undergoing total hip arthroplasty. Orthopedics 2014;37(11):e983–92. https://doi.org/10.3928/01477447-20141023-55.