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ORIGINAL ARTICLE • HIP - ARTHROPLASTY

Uncemented total hip arthroplasty in octogenarian and nonagenarian patients

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Abstract

Purpose While uncemented THA has proven benefits over cemented THA, the use of uncemented components in the elderly remains controversial. The purpose of this study was to compare functional outcomes and complication rates of uncemented THA in patients aged > 80 to patients aged < 80, and determine factors that independently influence functional outcomes.

Methods The authors evaluated 411 consecutive uncemented THAs at a follow-up of 3.1 ± 0.9 years (range 1.8–5.2), using the Oxford hip score (OHS), EuroQol 5 Dimensions (EQ-5D) score, and noting any complications. The series was divided into two age groups: elderly group (> 80, $n = 142$) and control group (< 80, $n = 269$). Uni- and multi-variable regressions were performed to test associations between outcomes and patient age, BMI, American Society of Anaesthesiologists (ASA) score, canal bone ratio (CBR) and canal flare index (CFI).

Results The elderly group had femora with higher CBR ($p < 0.001$) and lower CFI ($p = 0.002$). The clinical scores were significantly worse for the elderly group, with a higher OHS ($p = 0.039$) and a lower EQ-5D score ($p = 0.009$), but there were no significant differences in overall complications rates ($p = 0.500$). Periprosthetic fractures were observed in three elderly patients (2.1%), compared to none of the younger patients ($p = 0.041$). Multi-variable regressions revealed that OHS was not correlated with any of the variables, while EQ-5D score was significantly associated with BMI ($p = 0.015$), ASA score ($p = 0.024$) and CBR ($p = 0.019$).

Conclusion Clinical outcomes of uncemented THA do not depend on patient age *per se,* but on more specific preoperative characteristics such as ASA score, BMI and bone quality/morphology.

Keywords Total hip arthroplasty · Uncemented components · Elderly · Periprosthetic fractures · Bone quality · Bone morphology

Introduction

THA in the elderly is associated with poor clinical and radiographic outcomes, as well as higher risks of complications, including dislocations, thromboembolisms, infections and periprosthetic fractures (PPF) [1–3]. Such complications can be life-threatening in octagenarian and nonagenarian patients with fragile health and multiple comorbidities [4–6].

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While uncemented THA has proven benefits over cemented THA in the general population, the use of uncemented components in the elderly remains controversial [1, 7], largely because of poorer bone quality [8], which increases the risks of PPF [7, 9, 10]. However, uncemented THA requires shorter surgery, thereby reducing blood loss and risks of sepsis [11], which are important considerations for older patients with concomitant chronic diseases. For these reasons, over the past decade, the authors preferred uncemented THA for all patients and observed satisfactory outcomes across all age groups.

Recent registry studies reported better survival [2, 4, 12], fewer revisions [1, 4, 7, 13] and fewer complications [13, 14] for cemented THA compared to uncemented THA in octagenarian and nonagenarian patients, though the interpretation of such observational trends may be inappropriate for studies that did not aim to investigate the effect of patient age. It is important to note, however, that most studies compared outcomes for different implant models, without considering the influence of patient characteristics, comorbidities and bone quality/morphology. The purpose of this study was therefore to (1) compare functional outcomes and complication rates of uncemented THA in patients aged > 80 to patients aged < 80; and (2) determine demographic and morphological factors that independently influence functional outcomes. The hypothesis was that outcomes are most associated with bone quality and morphology rather than patient age and gender *per se*.

Materials and methods

The authors reviewed the records of all 411 consecutive THAs performed in 387 patients (24 bilateral) by three surgeons (JC, JCR and LJ), between August 2012 and June 2015, using an uncemented femoral stem (Corail, Depuy, Leeds, UK) and three types of uncemented acetabular components: dual mobility (Novae Sunfit TH, Serf, Décines-Charpieu, France), hemispheric (Pinacle, Depuy, Leeds, UK) and hemispheric with screws (Novae E TH, Serf, Décines-Charpieu, France). The surgical approach was antero-lateral (Watson-Jones) in 242 (58.9%) hips, posterior in 160 (38.9%) hips, direct anterior (Hueter) in 8 (1.9%) and transgluteal (Hardinge) in 1 (0.2%). Indications for surgery were primary osteoarthritis in 340 (82.8%) hips, osteoarthritis secondary to dysplasia in 10 (2.4%), protrusio in 15 (3.6%) or trauma in 6 (1.5%), avascular necrosis in 28 (6.8%) and femoral neck fracture in 12 (2.9%).

The preoperative cases notes were retrieved to document patients' ASA (American Society of Anaesthesiologists) score, BMI, size of stem implanted, as well as history of other orthopaedic or spine operations. The preoperative X-rays were analysed using a DICOM viewer (MicroDicom, Sofia, Bulgaria) to assess bone quality/morphology, including the femoral Dorr classification [15], femoral neck angle (FNA), canal flare index (CFI) [16, 17] and canal bone ratio (CBR) [17] (Fig. 1).

Patients were contacted by telephone and/or mail for routine clinical and radiographic assessments. If patients were deceased, their general practitioner or next of kin was contacted to confirm the date and cause of death, and whether any of their THA components had been revised. From the initial 411 hips, 22 were from patients who had died with their original stems in place and 39 could not be evaluated because patients did not respond. This left a cohort of 350 hips (327 patients) for clinical assessment, including 225 hips (212 patients) with post-operative X-rays, at a mean follow-up of 3.1 ± 0.9 years (range 1.8–5.2). Questionnaires were used to assess function and pain using the Oxford hip score (OHS) [18] and quality of life using the EuroQol-5D score (EQ-5D) [19, 20]. Routine frontal X-rays were assessed to determine implant stability and fixation (Engh score) [21], implant migration and heterotopic ossification. Regarding Engh scores, we could not report radiolucencies at the smooth interface because the implanted stem was entirely corundumised and coated with hydroxyapatite. We therefore attributed a score of zero for this criterion (original scale, − 3 to + 5). All assessments were performed as part of routine post-operative follow-up, and all patients provided informed consent for the use of their data for research and publications. The institutional review board approval was therefore not required for this study.

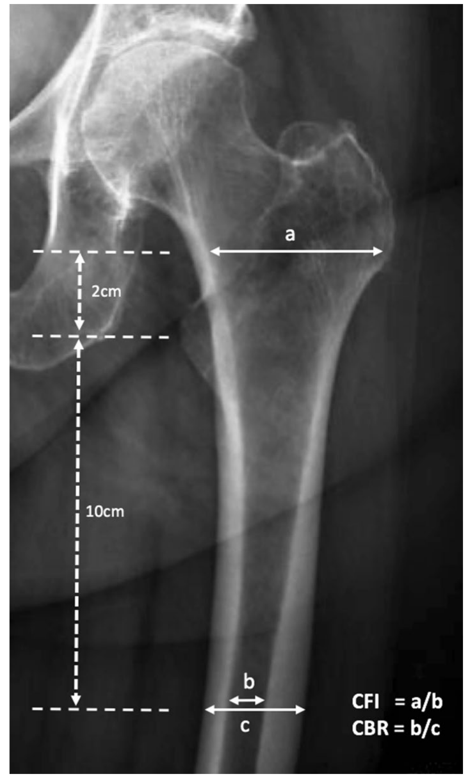

Fig. 1 X-ray preoperative measurements: canal bone ratio (CBR), canal flare index (CFI)

Statistical analyses

Based on previous studies [8, 11, 22], elderly group was defined as aged > 80. The series was therefore divided into two groups depending on patient age at the index operation: aged > 80 (elderly group, $n = 142$) and aged < 80 (control group, $n = 269$). Given differences in bone morphology and quality between men and women [8], descriptive statistics were also analysed according to gender. Shapiro–Wilk tests were used to assess the normality of distributions. For non-Gaussian quantitative data, differences between groups were evaluated using Wilcoxon rank-sum tests (Mann–Whitney U test). For non-Gaussian categorical data, differences between groups were evaluated using Fisher exact tests. Multi-variable linear regressions were performed to determine associations between two outcomes (OHS and EQ-5D) and nine independent variables (gender, BMI, age, ASA score, FNA, CFI, CBR, DORR classification and surgical approach). Statistical analyses were performed using R version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria). p values < 0.05 were considered statistically significant.

Results

The preoperative patient characteristics and bone quality/morphology were considerably different for the elderly group compared to the control group (Table 1). The elderly group had a significantly lower proportion of men (34 vs. 47%, $p = 0.021$), lower BMI (25.5 ± 3.5 vs. 27.8 ± 4.8, $p < 0.001$), and worse ASA scores (2.3 ± 0.6 vs. 2.0 ± 0.5, $p < 0.001$). The elderly group also had femora with higher CBR (0.48 ± 0.08 vs. 0.45 ± 0.07, $p < 0.001$), lower CFI (3.00 ± 0.60 vs. 3.21 ± 0.61, $p = 0.002$), and a greater proportion of Dorr B (73 vs. 62%, $p < 0.001$) and Dorr C (14 vs. 7%, $p < 0.001$). There were no significant differences between the two groups in terms of surgical approach ($p = 0.197$) nor size of implanted stem ($p = 0.358$).

The post-operative outcomes were different in terms of clinical but not radiographic scores for the elderly group compared to the control group (Table 1). The clinical scores were significantly worse for the elderly group, with a higher OHS (19.2 ± 7 vs. 18.7 ± 8.5, $p = 0.039$) and a lower EQ-5D score (0.63 ± 0.33 vs. 0.72 ± 0.29, $p = 0.009$). There were no significant differences in the overall rates of complications ($p = 0.500$), but it is worth noting, however, that PPF were observed in three patients (2.1%) in the elderly group, compared to none (0.0%) in the control group ($p = 0.041$) (Tables 2 and 3). All PPF were repaired using cerclage or screws and plates. Conversely, cracks occurred

Table 1 Descriptive data of categoric and continuous variables stratified by age group

	Patients < 80 years (*n* = 269 hips)			Patients > 80 years (*n* = 142 hips)			*p* value
	N	(%)		*N*	(%)		
	Mean ± SD	Median	(Range)	Mean ± SD	Median	(Range)	
Preoperative							
Male gender	124	(46.5%)		48	(33.8%)		*0.021*
Spine/ortho-surgical history	64	(23.8%)		38	(26.8%)		0.549
DORR							*< 0.001*
A	82	(31.5%)		19	(13.6%)		
B	161	(61.9%)		102	(72.9%)		
C	17	(6.5%)		19	(13.6%)		
Approach							0.197
Watson-Jones	165	(61.3%)		77	(54.2%)		
Posterior	100	(37.2%)		60	(42.3%)		
Others	4	(1.5%)		5	(3.5%)		
BMI	27.8 ± 4.8	27.14	(16.9–43.0)	25.5 ± 3.5	25.51	(17.6–34.0)	*< 0.001*
ASA score	2.0 ± 0.5	2.00	(1.0–4.0)	2.3 ± 0.6	2.00	(1.0–4.0)	*< 0.001*
Stem size	11.5 ± 1.7	11.00	(6.0–18.0)	11.7 ± 1.9	12.00	(8.0–20.0)	0.358
FNA (°)	126.1 ± 6.3	126.2	(104–148)	126.6 ± 6.7	126.0	(108–149)	0.724
CBR	0.45 ± 0.07	0.44	(0.25–0.79)	0.48 ± 0.08	0.47	(0.30–0.78)	*< 0.001*
CFI	3.21 ± 0.61	3.17	(1.87–5.32)	3.00 ± 0.60	2.94	(1.04–4.67)	*0.002*
Post-operative							
Complications	26	(9.7%)		17	(10.5%)		0.500
Heterotopic ossification	22	(16.3%)		16	(22.5%)		0.345
Stem migration	11	(8.1%)		5	(7.0%)		1.000
Stem revision	6	(2.2%)		2	(1.4%)		0.720
Cup revision	2	(0.7%)		2	(1.4%)		0.611
Oxford hip score	18.7 ± 8.5	15.00	(12.0–50.0)	19.2 ± 7.0	17.00	(12.0–48.0)	*0.039*
EQ-5D score	0.72 ± 0.29	0.84	(− 0.31 to 1.00)	0.63 ± 0.33	0.72	(− 0.24 to 1.00)	*0.009*
Engh score	14.0 ± 7.4	19.00	(− 19.5 to 22.0)	14.6 ± 6.6	19.00	(− 8.5 to 22.0)	0.697

Table 2 Descriptive data of the intra- and post-operative complications stratified by age group

	Patients < 80 years ($n = 269$ hips)			Patients > 80 years ($n = 142$ hips)			
	N	%	Revised	*N*	%	Revised	*p value*
Overall complications	26	(9.7%)		17	(12.0%)		0.50
Leg length discrepancy	1	(0.4%)		0	(0.0%)	1S	1.00
Radiolucency	1	(0.4%)		0	(0.0%)	1S	1.00
Aseptic loosening	1	(0.4%)	1S	0	(0.0%)		1.00
Stem migration	1	(0.4%)	1S	0	(0.0%)		1.00
Dislocation	1	(0.4%)		0	(0.0%)		1.00
Cyst	1	(0.4%)		0	(0.0%)	1S	1.00
Cracks	6	(2.2%)	1C	3	(2.1%)		1.00
Periprosthetic fractures	0	(0.0%)		3	(2.1%)	1S	*0.04*
Haematoma	4	(1.5%)	1B	3	(2.1%)		0.70
Distal femoral fracture	1	(0.4%)		0	(0.0%)		1.00
Pulmonary embolism	1	(0.4%)		0	(0.0%)		1.00
Sepsis	1	(0.4%)		2	(1.4%)	1B, 1C	0.28
Stroke	1	(0.4%)		0	(0.0%)		1.00
Others	5	(1.9%)		6	(4.2%)		0.36

p values in italics indicate statistically significant differences

C cup; *B* bipolar (cup + stem); *S* stem

Table 3 Descriptive data of patients who had a femoral periprosthetic fracture or a femoral crack

Patients	Complication	Time	Age	Gender	DORR	FNA	CBR	CFI	Surgical approach	Cup type
1	PPF	Post-op	94	Man	C	119	0.48	2.69	Posterior	Dual mobility
3	PPF	Post-op	90	Woman	B	108	0.41	2.98	Watson-Jones	Dual mobility
2	PPF	Post-op	83	Woman	B	131	0.60	2.59	Posterior	Dual mobility
4	Crack	intra-op	85	Woman	A	138	0.40	4.25	Watson-Jones	Dual mobility
5	Crack	Post-op	82	Woman	B	130	0.58	2.30	Watson-Jones	Dual mobility
6	Crack	Post-op	82	Man	B	117	0.57	2.73	Posterior	Dual mobility
7	Crack	Post-op	71	Man	A	124	0.46	2.81	Posterior	Dual mobility
8	Crack	intra-op	76	Man	B	118	0.47	2.90	Posterior	Dual mobility
9	Crack	Post-op	79	Man	B	130	0.55	2.46	Posterior	Dual mobility
10	Crack	intra-op	77	Woman	B	122	0.52	2.64	Watson-Jones	Dual mobility
11	Crack	intra-op	71	Woman	B	123	0.50	3.10	Watson-Jones	Hemispheric
12	Crack	intra-op	76	Woman	B	123	0.43	2.66	Posterior	Hemispheric with screws

PPF periprosthetic fracture; *Post-op* post-operative; *intra-op* intraoperative

in three patients (2.1%) in the elderly group compared to six patients (2.2%) in the control group ($p = 1.000$). All cracks were treated with partial weight bearing for 3–6 weeks, with cerclage in large intraoperative cracks. However, there were no significant differences in the rates of cup revisions ($p = 0.611$) or stem revisions ($p = 0.720$), possibly due to the rarity of events. Likewise, there were no significant differences in Engh score ($p = 0.697$), heterotopic ossification ($p = 0.345$) or stem migration ($p = 1.000$).

The data revealed different trends among men and women in each group. Compared to younger women, elderly women had significantly higher CBR (0.50 ± 0.08 vs. 0.46 ± 0.07, $p = 0.002$) and lower CFI (2.99 ± 0.57 vs. 3.19 ± 0.64, $p = 0.016$) (Fig. 2). Compared to younger men, elderly men had significantly worse OHS (20.8 ± 7.3 vs. 18.2 ± 8.3, $p = 0.010$) and EQ-5D (0.61 ± 0.34 vs. 0.76 ± 0.28, $p = 0.019$). Across the two groups, the rates of complications, stem revisions and cup revisions were not significantly different between women and men.

Uni-variable regressions for the entire cohort ($n = 411$) revealed that OHS was significantly associated with cup types ($p = 0.002$) and ASA score ($p = 0.048$) (Table 4). Multi-variable regressions revealed that none of the variables were independently associated with OHS. Uni-variable regressions revealed that EQ-5D was significantly associated with age group ($p = 0.009$), cup types ($p = 0.004$), ASA

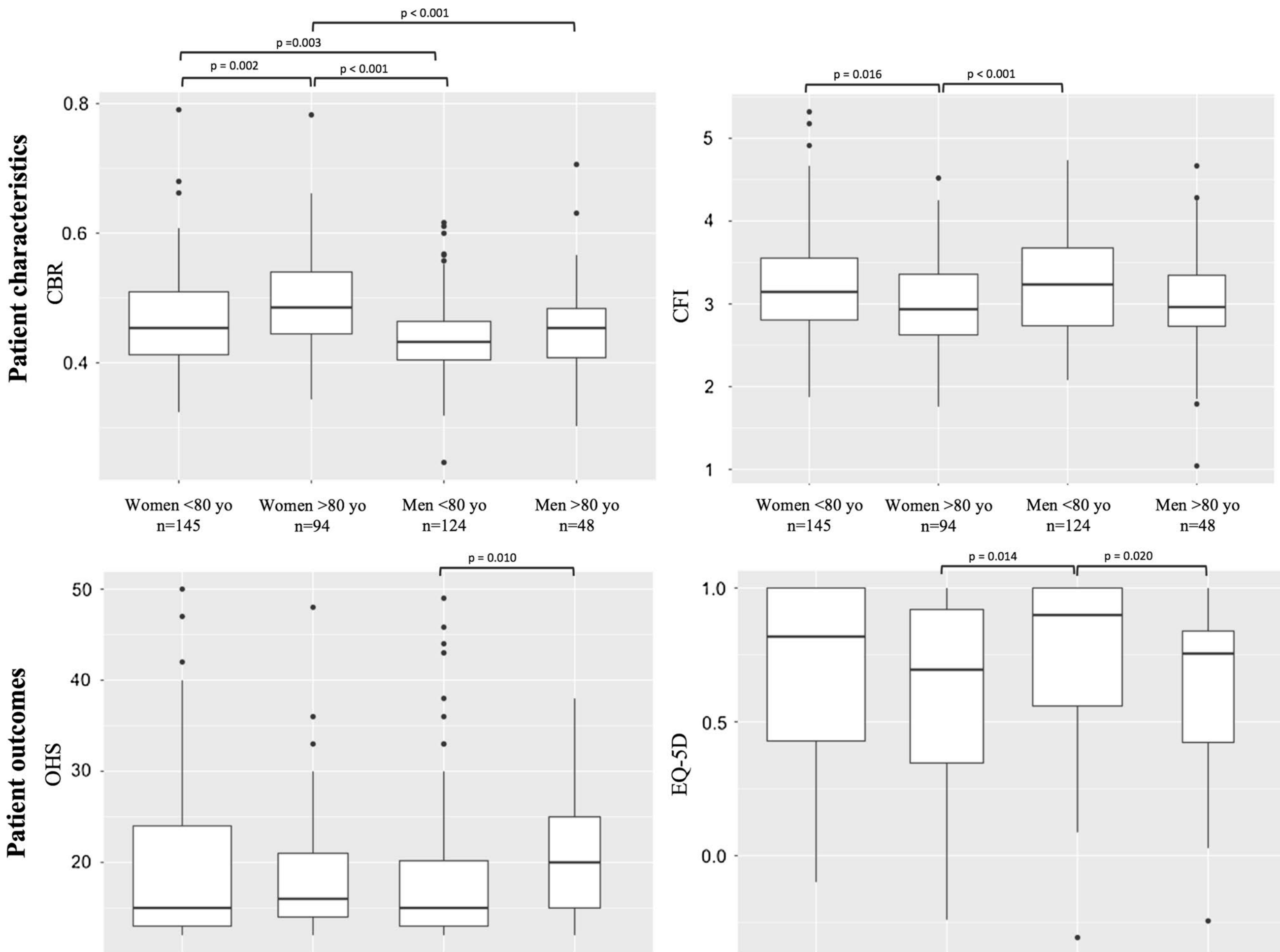

Fig. 2 CBR, CFI, OHS, EQ-5D depending on age group by gender. The plots illustrate median values (bold lines), interquartile ranges (white boxes), 95% confidence interval (whiskers) and outliers (dots). *p* values are indicated only where significant differences were found

score ($p<0.001$) and CBR ($p=0.028$) (Table 5). Multi-variable regressions revealed that EQ-5D was only associated with three variables: BMI (beta, −0.01; CI −0.02 to 0.00; $p=0.015$), ASA score (beta, −0.07; CI −0.14 to −0.01 $p=0.024$) and CBR (for an increment of 0.10 unit: beta, −0.10; CI −0.18 to −0.02; $p=0.019$).

Discussion

The purpose of this study was to investigate factors that influence clinical outcomes of uncemented THA in octogenarian and nonagenarian patients, in comparison with younger patients. It is well known that patient quality of life decreases with age, irrespective of surgical treatment [23]. The principal finding of the study, however, was that clinical outcomes are not influenced by age, but are influenced by bone quality. Given that age is associated with poorer bone quality, many authors suggested to avoid the use of uncemented THA in the elderly population [7, 24, 25]. Still, recent registry studies showed an overall increase in cementless fixation, also among the elderly [13, 26]. In agreement with Gromov et al. [10], our findings suggest that bone quality/morphology, rather than age *per se*, should be considered when planning for THA.

The second important finding of the study was that elderly patients did not have more complications than younger patients, but were at significantly greater risks of PPF. The higher rate of PPF among elderly patients, likely due to decreased bone density and strength, is consistent with the findings of recent studies [1, 7, 24, 27]. It is worth noting that none of the three patients that had with PPF were operated for, none had a femoral neck fractures. All three PPF reported in our series occurred in the elderly group and, that the two of which were non-traumatic PPF were repaired without stem revision (Fig. 3). The overall rate of PPF in our series was 0.7%, which compares favourably to the rates of 2.4% for uncemented THA and

Table 4 Uni- and multi-variable regression analysis of Oxford hip score

	Oxford hip score					
	Uni-variable			Multi-variable ($n = 242$ hips)		
Variable	RC	95% CI	*p* value	RC	95% CI	*p* value
Categoric						
Age > 80 years	0.42	(− 1.5 to 2.3)	0.664	− 0.50	(− 2.9 to 1.9)	0.686
Male gender	0.01	(− 1.8 to 1.8)	0.988	0.20	(− 2.0 to 2.4)	0.857
Approach						
Watson-Jones	REF					
Posterior	0.59	(− 1.2 to 2.4)	0.527	0.73	(− 1.4 to 2.9)	0.505
Cup types[a]						
Dual mobility	REF					
Hemispheric	− 2.48	(− 4.6 to 0.4)	*0.021*	–	–	– –
Hemispheric with screws	− 0.48	(− 4.2 to 3.2)	0.796	–	–	– –
DORR						
A	REF					
B	1.37	(− 0.7 to 3.4)	0.188	− 0.15	(− 3.1 to 2.7)	0.918
C	− 1.41	(− 5.1 to 2.3)	0.460	− 2.53	(− 9.0 to 3.9)	0.440
Continuous						
BMI	0.18	(− 0.0 to 0.4)	0.065	0.14	(− 0.1 to 0.4)	0.224
ASA score	1.61	(0.0 to 3.2)	*0.048*	1.42	(− 0.4 to 3.2)	0.121
FNA (°)	0.12	(− 0.0 to 0.3)	0.079	0.10	(− 0.1 to 0.3)	0.261
CFI	0.00	(− 1.5 to 1.5)	0.997	− 0.22	(− 2.4 to 2.0)	0.847
CBR[b]	0.16	(− 1.1 to 1.4)	0.806	0.82	(− 1.5 to 3.1)	0.480

p values in italics indicate statistically significant differences

RC regression coefficient; *FNA* femoral neck angle; *CFI* canal flare index; *CBR* canal bone ratio

[a]The variable "Cup types" was not included in the multi-variable regression because of its strong association with age groups (90% of the patients aged over 80 had a dual mobility cup)

[b]By increment of 0.10 unit

0.9% for cemented THA reported in a recent multicentre study on 7169 hips [27].

In our series, only one stem revision was due to PPF. Our stem revision rate of 1.4% among the elderly group compares favourably to the 4.5% revision rate of uncemented stems and to the 1.9% revision rate of cemented stems among octogenarians at three years, reported in a recent registry study [1]. The lower success rate of uncemented THA for elderly patients reported in recent studies [1, 7, 13] usually leads to the conclusion that uncemented stems are most adapted to younger patients, notwithstanding that cemented stems expose this fragile population to higher perioperative risks of infections and cardiovascular accidents [11]. In our series, none of the elderly patients had perioperative life-threatening complications, which compares well to the rate of 1% (including cardiac arrest, bradycardia, respiratory failure, intraoperative death) among patients with cemented stems reported in a registry study [4]. Implanting cementless stems is technically demanding and requires experience when used in femura with poor bone quality. One factor rarely evoked that could explain higher rate of periprosthetic fractures of cementless stems among elderly patients is that, during night shifts, most emergency cases of femoral neck fractures are performed by less experienced surgeons.

This study presents several limitations, typical of retrospective study design. First, preoperative functional scores were not collected and post-operative radiographic and clinical data are missing for some patients. Second, radiographic assessment of femoral morphology using the Dorr classification is subjective with unknown intra- and inter-reader variability, though CFI provides a more reliable alternative. Third, the use of two-dimensional frontal X-rays may be insufficient, because the effect of age on femoral canal diameter could be even greater on sagittal

Table 5 Uni- and multi-variable regression analysis of EQ-5D score

Variable	EQ-5D score: Uni-variable RC	Uni-variable 95% CI	Uni-variable *p* value	Multi-variable (*n* = 235 hips) RC	Multi-variable 95% CI	Multi-variable *p* value
Categoric						
Age > 80 years	− 0.10	(− 0.2 to − 0.0)	*0.009*	− 0.06	(− 0.1 to − 0.0)	0.173
Male	0.15	(− 0.0 to 0.1)	0.203	0.02	(− 0.1 to 0.1)	0.569
Approach						
Watson-Jones	REF					
Posterior	− 0.04	(− 0.1 to 0.0)	0.228	− 0.04	(−0.1 to 0.0)	0.269
Cup types[a]						
Dual mobility	REF					
Hemispheric	0.14	(0.1–0.2)	*0.001*	–	–	–
Hemispheric with screws	− 0.05	(− 0.2 to 0.1)	0.459	–	–	–
DORR						
A	REF					
B	0.00	(− 0.1 to 0.1)	0.941	0.07	(− 0.0 to 0.2)	0.173
C	0.05	(− 0.2 to 0.1)	0.468	0.13	(−0.1 to 0.4)	0.271
Continuous						
BMI	− 0.01	(− 0.0 to 0.0)	0.060	− 0.01	(− 0.0 to 0.0)	*0.015*
ASA score	− 0.12	(− 0.2 to −0.1)	*< 0.001*	− 0.07	(− 0.1 to − 0.0)	*0.024*
FNA (°)	0.00	(− 0.0 to 0.0)	0.180	0.00	(− 0.0 to 0.0)	0.144
CFI	0.03	(− 0.0 to 0.1)	0.259	− 0.02	(− 0.1 to 0.1)	0.685
CBR[b]	0.05	(− 0.1 to − 0.0)	*0.028*	− 0.10	(− 0.2 to − 0.0)	*0.019*

p values in italics indicate statistically significant differences

RC regression coefficient; *FNA* femoral neck angle; *CFI* canal flare index; *CBR* canal bone ratio

[a]The variable "Cup types" was not included in the multi-variable regression because of its strong association with age groups (90% of the patients aged over 80 had a dual mobility cup)

[b]By increment of 0.10 unit

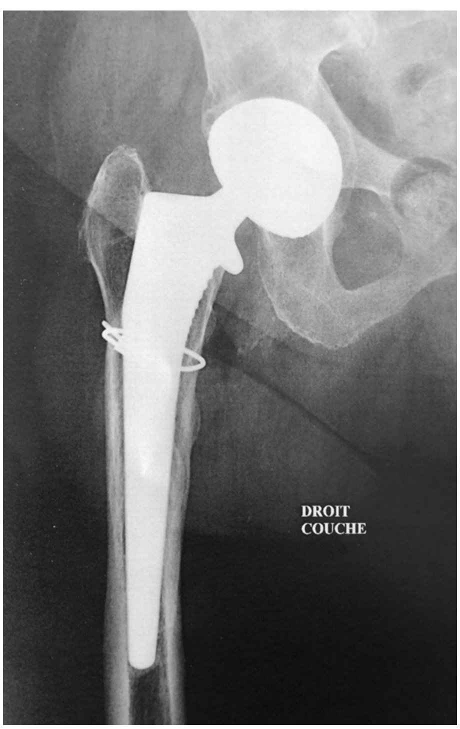

Fig. 3 Non-traumatic periprosthetic fracture in a > 80 years patient repaired with a cerclage (right hip)

X-rays [8]. Fourth, due to the rarity of complications (e.g. revision, stem migrations), we were not able to closely analyse their association with age due to lack of statistical power. Finally, because we investigated a single stem design, our findings may not necessarily apply to other stems. The strengths of this study include: its comparative design with a sizeable group of elderly patients and a control group of younger patients, the consideration of patients' clinical and radiographic characteristics and their associations with outcomes.

Conclusion

Clinical outcomes of uncemented THA are not significantly associated with patient age *per se,* but rather with specific patient characteristics such as preoperative ASA score, BMI and bone quality/morphology. Compared to younger patients, elderly patients were at significantly greater risks of periprosthetic fracture, but not at greater risks of general complications or revisions, possibly due to our limited cohort size.

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Compliance with ethical standards

Conflict of interest Authors LJ, JC and JCR have received fees for educational and promotional events from DePuy-Synthes. Authors LJ and JCR have received royalties from DePuy-Synthes. GT, HG and MS have received personal fees from Artro Institute.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

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