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No differences in clinical and radiographic outcomes between standard versus high offset collared stems for primary total hip arthroplasty at five years follow-up

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Abstract

Purpose To compare clinical and radiographic outcomes of propensity-matched patients undergoing THA using standard versus high offset stems at five years.

Methods The authors retrospectively reviewed a consecutive series of primary THAs performed between 01/09/2015–31/12/2017 using a fully-hydroxyapatite coated collared stem, with either a standard ($n = 365$) or high ($n = 110$) offset. Outcomes collected included: modified Harris Hip Score (mHHS), Oxford Hip Score (OHS), Forgotten Joint Score (FJS), and radiographic measurements including limb length discrepancy (LLD), stem subsidence, and stem radiolucencies.

Results Propensity score matching resulted in 80 hips per group. Preoperatively there were no significant differences in patient demographics, surgical data and radiographic measurements, except the standard offset group had significantly smaller femoral (40.0 ± 7.5 vs 48.4 ± 6.2, $p < 0.001$), acetabular (92. ± 6.3 vs 94.8 ± 7.3, $p = 0.011$) and global (132.0 ± 10.3 vs 143.2 ± 8.2, $p < 0.001$) offsets compared to the high offset group. At a minimum five years follow-up, there were no significant differences in mHHS (93.2 ± 11.0 vs 93.1 ± 10.6, $p = 0.553$), OHS (45.1 ± 4.1 vs 45.3 ± 4.6, $p = 0.623$), and FJS (85.1 ± 19.3 vs 82.7 ± 23.0, $p = 0.910$). There were also no differences in radiographic measurements, including LLD (1.5 ± 4.8 vs 1.1 ± 3.5, $p = 0.537$), stem subsidence (0% vs 0%, $p = 1.000$), and stem radiolucencies (severe: 6% vs 1%, $p = 0.152$).

Conclusion The present matched-cohort study found no significant differences between standard versus high offset straight fully-hydroxyapatite coated collared stems for primary THA in terms of clinical and radiographic outcomes at five years. These findings may suggest that uncemented collared high offset stems are not associated with an increased risk of radiolucencies and loosening compared to uncemented collared standard offset stems.

Keywords Total hip arthroplasty · THA · High offset stem · Collared stem

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Introduction

Total hip arthroplasty (THA) is known to alleviate pain and improve function in patients with hip joint disorders [1, 2]. When performing THA, surgeons aim to restore the patient's native hip anatomy, including femoral offset, as well as muscle tension and gait kinematics [3–6]. In patients with a high native femoral offset, the use of high offset stems has shown to better restore hip range of motion [7, 8] and reduce the risk of dislocations [6, 8] and limb length discrepancy (LLD) [4]. However, high offset stems have been associated with an increased risk of loosening due to higher torsional loading around the long axis of the implant [9, 10].

A number of recent studies on primary THA with high offset stems have reported good clinical and radiographic outcomes, with low rates of complications [4–6]. Biggi et al. [5] evaluated 80 straight uncemented collarless stems implanted via the posterolateral approach with three different offset options (-5 mm, 0 mm, and + 5 mm). At a follow-up of three years, they found a significant improvement in Harris Hip Score (HHS), with no cases of stem subsidence, although 62% (n = 50) of the cohort had slight radiolucencies (< 2 mm) in the proximal femur. Nonetheless, the prevalence of radiolucencies per offset option was not reported. Another study by Weldon et al. [6] compared complications at one year follow-up in 100 standard versus 100 high offset straight uncemented collarless stems implanted via the anterior approach and found, respectively, complication rates of 1% (n = 1, deep infection) versus 0%, and revision rates of 1% (n = 1) versus 1% (n = 1), both cases for aseptic loosening of the stem.

Interestingly, a recent meta-analysis comparing outcomes of collared versus collarless uncemented stems concluded that collared stems have lower revision rates than collarless stems, as well as equivalent or better clinical and radiographic outcomes [11]. The authors suggest that the differences could be due to a protective effect that the collar offers against subsidence. It is therefore warranted to compare the outcomes of standard versus high offset collared stems. The purpose of the present study was to compare clinical and radiographic outcomes of propensity-matched patients undergoing primary THA using standard versus high offset straight uncemented collared stems at 5 years. The null hypothesis was that there would be no differences in outcomes between groups.

Materials and methods

The authors retrospectively reviewed a consecutive series of 475 primary THAs implanted with a conventional-length fully hydroxyapatite-coated collared stem (Corail, Depuy Synthes, Warsaw, IN, USA) between 1 September 2015 and 31 December 2017. All THAs were performed by two senior surgeons (LJ, JC) who predominantly used the anterior approach. Preoperative planning guided the choice between a standard offset stem (n = 365) or a high offset stem (n = 110). The standard offset and high offset stems had exactly the same design, with a neck shaft angle of 135°, although the high offset stem had + 7 mm of offset.

Cohort

Patients were contacted at a minimum follow-up of five years. In the standard offset group, 57 hips (16%) were lost to follow-up, 22 (6%) were deceased, one (< 1%) refused to participate in the present study, and three (1%) had stem revisions due to:

1) excessive limb length discrepancy after surgery,
2) femoral fracture with stem subsidence of 2 cm following a fall three months postoperatively,
3) a ceramic head fracture nine months postoperatively, also requiring cup revision.

In the high offset group, 19 hips (17%) were lost to follow-up, nine (8%) were deceased, one (1%) refused to participate in the present study, and one (1%) had stem revision due to aseptic loosening 21 months postoperatively. This left 362 hips for matching, 282 hips in the standard offset group and 80 hips in the high offset group (Fig. 1). This study was approved by the institutional review board of 'GCS Ramsay Santé pour l'Enseignement et la Recherche' (COS-RGDS-2024-05-006-JACQUOT-L). Informed consent was obtained from all individual participants included in the study.

Clinical assessment

Patients were evaluated preoperatively using the modified Harris Hip Score (mHHS; 100, best; 0, worst), and at a minimum follow-up of five years using the mHHS, Oxford Hip Score (OHS; 48, best; 0, worst), Forgotten Joint Score (FJS; 100, best; 0, worst), and satisfaction with surgery on a visual analogue scale (VAS; 10, best; 0, worst).

Radiographic assessment

Standard antero-posterior pelvic radiographs were performed while standing. Preoperative radiographs were assessed to evaluate femoral morphology according to the Dorr classification (A, B, or C), as well as femoral, acetabular and global (femoral + acetabular) offsets of the operated and contralateral hips. Postoperative radiographs were assessed to evaluate femoral, acetabular and global offsets of

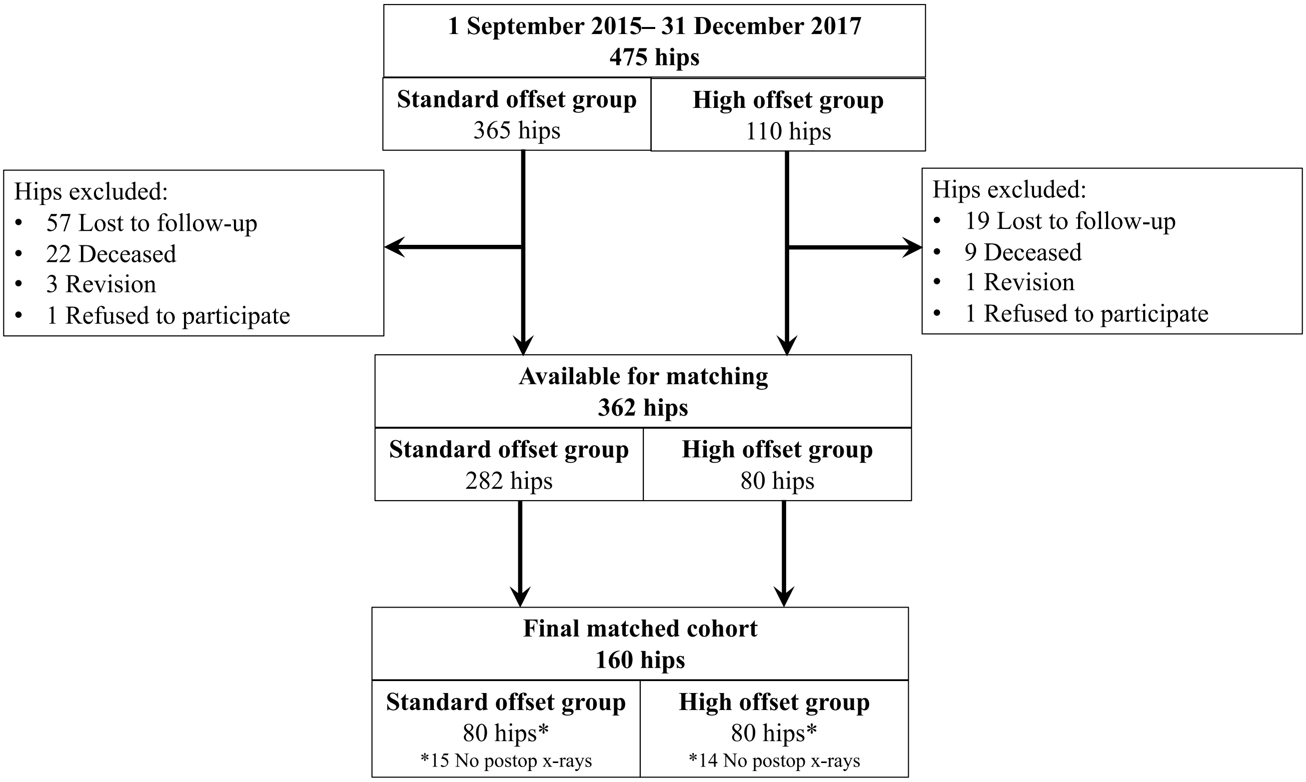

Fig. 1 Flowchart presenting the initial and final cohorts

the operated hip, as well as LLD, stress shielding (yes/no), stem subsidence (yes/no), stem fracture (yes/no), stem misalignment (varus/valgus $\geq 5°$), stem radiolucencies (none/light/moderate/severe), calcar modifications (none/remodeling/osteolysis), cortical and cancellous bone modifications (yes/no), collar-calcar contact (yes/no), granulomas (yes/no), pedestal formation (none/light/moderate/severe), heterotopic ossification (Brooker classification: 0–4), and canal fill ratio (CFR). Stem radiolucencies were considered light if their length was < 1 cm, moderate if their length was 1-2 cm, and severe if their length was > 2 cm. CFR was assessed at the following four locations: (a) at the femoral cut, (b) at the midpoint of the lesser trochanter, (c) at the midpoint of the stem, and (d) at 95% of the length of the stem (Fig. 2).

Statistical analysis

To compare standard versus high offset stems, a propensity score based on age, sex, and body mass index (BMI) was developed using the "matchit" algorithm. The authors performed 1:1 optimal propensity score matching without replacement, using logistic regression. After matching, the authors verified that all standardised mean differences were < 0.1 for the covariates. Descriptive statistics were used to summarise the data, and Shapiro–Wilk tests were used to assess the normality of distributions. Differences between standard offset and high offset groups were assessed using the student t test (normally distributed) or Wilcoxon rank sum test (not-normally distributed) for continuous variables, the Fisher's exact test for binomial variables, and the Chi-squared test for categorical variables. Statistical analyses were conducted using R version 3.6.1 (R Foundation for Statistical Computing). *P*-values < 0.05 were considered statistically significant.

Results

Patient characteristics

Propensity score matching resulted in 80 hips in both the standard offset and high offset groups. There were no significant differences between groups in terms of patient demographics, including age (65.3 ± 10.7 vs 64.3 ± 10.1, $p = 0.523$), sex distribution (females: 28% vs 25%, $p = 0.858$), BMI (26.7 ± 4.2 vs 27.5 ± 5.3, $p = 0.580$), surgical indication (primary osteoarthritis: 79% vs 86%, $p = 0.197$), and preoperative mHHS (43.0 ± 11.6 vs 46.6 ± 11.4, $p = 0{,}114$) (Table 1). There were no significant differences between groups in terms of Dorr type (B: 88% vs 94%, $p = 0.370$); however, the standard offset group had significantly smaller femoral (40.0 ± 7.5 vs 48.4 ± 6.2, $p < 0.001$), acetabular (92.0 ± 6.3 vs 94.8 ± 7.3, $p = 0.011$) and global offsets

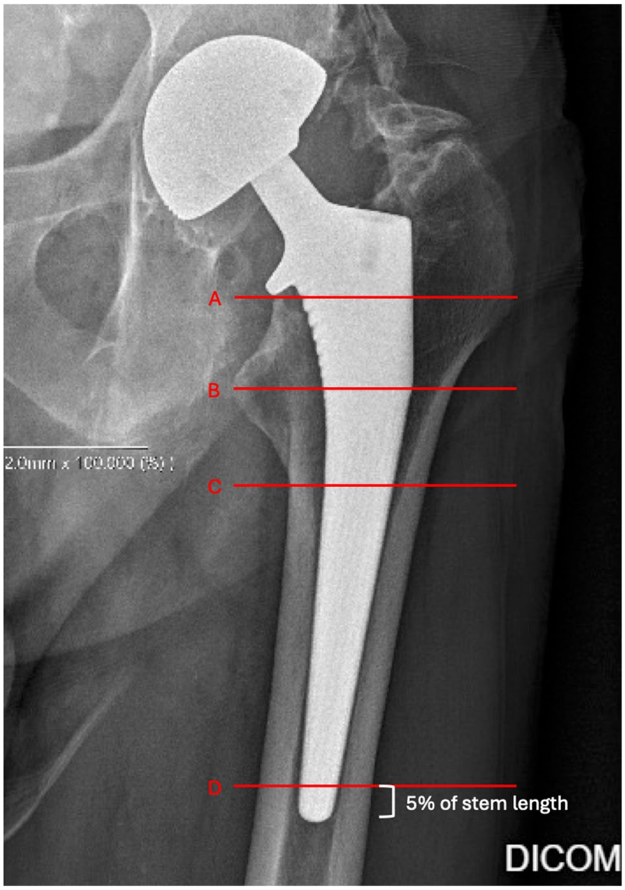

Fig. 2 Canal Fill Ratio was assessed at the following 4 locations: (a) at the femoral cut, (b) at the midpoint of the lesser trochanter, (c) at the midpoint of the stem, and (d) at 95% of the length of the stem

(132.0 ± 10.3 vs 143.2 ± 8.2, $p < 0.001$) of the operated hip compared to the high offset group.

Surgical parameters

There were no significant differences between the standard versus high offset groups in terms of surgical parameters, including surgical approach (anterior: 98% vs 96%, $p = 1.000$), stem size (12: 20% vs 30%, $p = 0.072$), head size (36: 53% vs 59%, $p = 0.631$), head material (ceramic: 90% vs 94%, $p = 0.564$), neck size (medium: 51% vs 56%, $p = 0.713$), and cup type (unipolar: 74% vs 80%, $p = 0.454$). (Table 2). Of note, 5 hips underwent THA via the posterolateral approach, as one surgeon routinely used this approach for elderly (> 80 years old) or obese (BMI > 30) patients.

Postoperative clinical outcomes

There were no significant differences between the standard versus high offset groups in terms of follow-up (6.3 ± 0.7 vs 6.3 ± 0.7 years, $p = 0.836$), mHHS (93.2 ± 11.0 vs 93.1 ± 10.6, $p = 0.553$), net change in mHHS (50.7 ± 14.2 vs 46.0 ± 16.6, $p = 0.119$), OHS (45.1 ± 4.1 vs 45.3 ± 4.6, $p = 0.623$), FJS (85.1 ± 19.3 vs 82.7 ± 23.0, $p = 0.910$), and satisfaction with surgery (9.7 ± 1.0 vs 9.5 ± 1.0, $p = 0.140$) (Table 3).

Postoperative radiographic outcomes

There were no significant differences between the standard versus high offset groups in terms of net change in femoral offset (-0.3 ± 7.7 vs 0.2 ± 6.2, $p = 0.723$), net change in acetabular offset (-11.2 ± 8.1 vs -10.9 ± 9.0, $p = 0.989$), and net change in global offset (-11.5 ± 10.9 vs -10.7 ± 10.9, $p = 0.681$). There were no significant differences between groups in terms of LLD (1.5 ± 4.8 vs 1.1 ± 3.5, $p = 0.537$), stress shielding (0% vs 0%, $p = 1.000$), stem subsidence (0% vs 0%, $p = 1.000$), stem fractures (0% vs 0%, $p = 1.000$), stem misalignment ≥ 5° (varus: 0% vs 1%, $p = 1.000$), stem radiolucencies (severe: 6% vs 1%, $p = 0.152$), calcar modifications (osteolysis: 5% vs 1%, $p = 0.348$), cortical bone modifications (1% vs 0%, $p = 0.840$), cancellous bone modifications (9% vs 13%, $p = 0.768$), collar-calcar contact (78% vs 80%, $p = 0.898$), granulomas (1% vs 0%, $p = 0.840$), pedestal formation (severe: 0% vs 0%, $p = 0.728$), and heterotopic ossification (Brooker grade 3: 1% vs 0%, $p = 0.126$). There were no significant differences between groups in CFR at levels A (0.6 ± 0.1 vs 0.6 ± 0.1, $p = 0.566$), B (0.7 ± 0.1 vs 0.7 ± 0.1, $p = 0.566$), C (0.8 ± 0.1 vs 0.8 ± 0.1, $p = 0.310$), and D (0.6 ± 0.1 vs 0.6 ± 0.1, $p = 0.452$). Of note, postoperative radiographs were only available for 65 standard offset hips and 66 high offset hips.

Discussion

The most important findings of the present matched-cohort study comparing standard versus high offset straight uncemented collared stems for primary THA are that there are overall no significant differences in the clinical and radiographic outcomes at five years, thus confirming the null hypothesis. Interestingly, severe radiolucencies were visible in five hips (6%) in the standard offset group versus one hip (1%) in the high offset group ($p = 0.152$). Furthermore, from the original non-matched cohort of 365 standard offset stems and 110 high offset stems, there was only one (1%) revision due to aseptic loosening in the high offset group. These findings may suggest that uncemented collared high offset stems are not associated with an increased risk of radiolucencies and loosening compared to uncemented collared standard offset stems.

The present study found no significant differences in clinical outcomes between patients implanted with standard offset versus high offset uncemented collared stems

Table 1 Preoperative demographic and radiographic data for the matched cohort ($n = 160$)

	Standard offset group ($n = 80$)		High offset group ($n = 80$)				
	Mean ± SD	Range	Mean ± SD	Range	*p-value*	MD	95% CI
	n %		n %			OR	95% CI
Age	65.3 ± 10.7	44.3 – 85.3	64.3 ± 10.1	44.0 – 84.7	*0.523*	1.05	-2.2 – 4.3
Female sex	22 28%		20 25%		*0.858*	1.14	0.6 – 2.3
BMI	26.7 ± 4.2	19.4 – 39.4	27.5 ± 5.3	19.8 – 59.5	*0.580*	-0.78	-2.3 – 0.7
Indication							
Primary osteoarthritis	63 79%		69 86%		*0.197*	0.59	0.3 – 1.4
Secondary osteoarthritis	6 8%		7 9%			0.85	0.3 – 2.6
Femoral neck fracture	3 1%		0 0%			7.27	0.4 – 143.1
Avascular necrosis	8 10%		4 5%			2.11	0.6 – 7.3
mHHS (worst, 0; best, 100)	43.0 ± 11.6	0.0 – 69.2	46.6 ± 11.4	11.0 – 68.1	*0.114*	-3.57	-7.1 – 0.0
Dorr Type							
A	7 9%		4 5%		*0.370*	1.82	0.5 – 6.5
B	70 88%		75 94%			0.47	0.2 – 1.4
C	3 4%		1 1%			3.08	0.3 – 30.2
Femoral offset (mm)							
Operated side	40.0 ± 7.5	18.0 – 57.1	48.4 ± 6.2	31.8 – 66.3	***< 0.001***	-8.46	-10.6 – -6.3
Contralateral side	42.9 ± 6.4	28.4 – 63.5	51.4 ± 5.5	40.0 – 65.2	***< 0.001***	-8.50	-10.3 – -6.7
Acetabular offset (mm)							
Operated side	92.0 ± 6.3	73.9 – 110.2	94.8 ± 7.3	76.2 – 110.1	***0.011***	-2.77	-4.9 – -0.7
Contralateral side	90.8 ± 5.9	75.8 – 110.2	92.7 ± 6.5	76.2 – 105.7	*0.053*	-1.92	-3.8 – 0.0
Global offset (mm)							
Operated side	132.0 ± 10.3	106.0 – 163.0	143.2 ± 8.2	122.0 – 159.7	***< 0.001***	-11.24	-14.1 – -8.4
Contralateral side	133.8 ± 9.3	106.0 – 157.5	144.2 ± 8.3	126.0 – 160.8	***< 0.001***	-10.41	-13.1 – -7.7

BMI body mass index, *mHHS* modified Harris Hip Score, *SD* standard deviation, *MD* mean difference, *OR* odds ratio, *CI* confidence interval

at a minimum follow-up of five years, in terms of mHHS (93.2 ± 11.0 vs 93.1 ± 10.6, $p = 0.553$), OHS (45.1 ± 4.1 vs 45.3 ± 4.6, $p = 0.623$), and FJS (85.1 ± 19.3 vs 82.7 ± 23.0, $p = 0.910$). Similarly, Biggi et al. [5] found no significant differences in HHS between patients implanted with standard offset versus high offset uncemented collarless stems (95.2 ± 8.vs 96.2 ± 6.1, $p > 0.05$) at a minimum follow-up of three years. Furthermore, Peng et al. [4] evaluated outcomes of high offset short collarless uncemented stems at a minimum follow up of three years and reported a mean HHS of 96.8 ± 5.6. Additionally, the clinical outcomes reported in the present study are similar to those of other published literature on uncemented stems for primary THA [12–16].

High offset stems have been associated with increased loosening rates compared to standard offset stems, due to higher torsional loading about the long axis of the implant [4]. Madhavani et al. [17] evaluated radiographic outcomes in high offset uncemented collarless stems ($n = 162$) and recorded subsidence in 113 (%) stems at a minimum follow up of one year; however, radiolucent lines around the stem were only observed in five (3%) stems, exclusively in Gruen zones one and seven. Peng et al. [4] reported outcomes of 55 high offset collarless uncemented stems and found no radiolucent lines, subsidence or loosening at a minimum follow-up of three years. Furthermore, Melbye et al. [18] compared survivorship of standard offset versus high offset collarless stems and found excellent Kaplan–Meier survivorship at ten years with aseptic loosening as endpoint, although standard offset stems had better survivorship than high offset stems (99.1% vs 97.3%). The present study found no significant differences between standard and high offset stems in terms of subsidence (0% vs 0%), radiolucencies (severe, 6% vs 1%), and revisions for aseptic loosening (0% vs 1%). Although not statistically significant ($p = 0.152$), it is interesting to note that severe radiolucencies were more common in the standard offset group compared to the high offset group.

Collared stems may reduce complications, subsidence, and radiolucent lines, as well as improve axial and rotational stability compared to collarless stems. A recent meta-analysis [11] comparing collared versus collarless uncemented stems for primary THA found collared stems have lower revision rates than collarless stems, as well as equivalent or better clinical and radiographic outcomes. The studies

Table 2 Surgical data for the matched cohort ($n = 160$)

	Standard offset group ($n = 80$)		High offset group ($n = 80$)						
	n	%	*n*	%	*p-value*	OR	95% CI		
Surgical approach									
Anterior	78	98%	77	96%	*1.000*	1.52	0.2	–	9.3
Posterolateral	2	3%	3	4%		0.66	0.1	–	4.0
Stem size									
8	2	3%	0	0%	*0.072*	5.13	0.2	–	108.5
9	2	3%	4	5%		0.49	0.1	–	2.7
10	14	18%	8	10%		1.91	0.8	–	4.8
11	26	33%	14	18%		2.27	1.1	–	4.8
12	16	20%	24	30%		0.58	0.3	–	1.2
13	10	13%	12	15%		0.81	0.3	–	2.0
14	3	4%	9	11%		0.31	0.1	–	1.2
15	6	8%	7	9%		0.85	0.3	–	2.6
16	0	0%	2	3%		0.20	0.0	–	4.1
18	1	1%	0	0%		3.04	0.1	–	75.7
Head size					*0.631*				
28	22	28%	17	21%		1.41	0.7	–	2.9
32	16	20%	16	20%		1.00	0.5	–	2.2
36	42	53%	47	59%		0.78	0.4	–	1.4
Head material					*0.564*				
Ceramic	72	90%	75	94%		0.60	0.2	–	1.9
Metal	8	10%	5	6%		1.67	0.5	–	5.3
Neck size					*0.713*				
Short	32	40%	27	34%		1.31	0.7	–	2.5
Medium	41	51%	45	56%		0.82	0.4	–	1.5
Long	7	9%	8	10%		0.86	0.3	–	2.5
Cup type					*0.454*				
Unipolar	59	74%	64	80%		0.70	0.3	–	1.5
Dual mobility	21	26%	16	20%		1.42	0.7	–	3.0
Uncemented cup	80	100%	80	100%	*1.000*				

OR odds ratio, *CI* confidence interval

included in the meta-analysis showed that HHS tended to favour collared stems (87 ± 11 vs 80 ± 16, $p = 0.084$), while Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) favoured collared stems in one study (97 ± 5 vs 91 ± 12, $p = 0.036$), but there were no differences in another study (97 ± 3 vs 97 ± 3, $p > 0.05$). The present study is the only study on high offset collared stems, and has shown excellent clinical and radiographic outcomes.

The present retrospective study has a number of limitations. First, radiographs were missing for 29 hips, which may reduce the generalisability of our findings. These patients were contacted multiple times for them to acquire radiographs; however, they did not find it necessary. The absence of thigh pain or other symptoms in the patients without radiographs suggest that the stems were well osseointegrated. Second, radiographs were not to scale, therefore instead of selecting the levels to measure CFR according to D'Ambrosio et al. [19], they were selected as ratios along the length of the stem. Third, five hips were operated via the posterolateral approach, while the rest were operated via the anterior approach, which may have influenced outcomes.

Conclusion

The present matched-cohort study found no significant differences between standard versus high offset straight fully-hydroxyapatite coated collared stems for primary THA in terms of clinical and radiographic outcomes at five years. These findings may suggest that uncemented collared high offset stems are not associated with an increased risk of radiolucencies and loosening compared to uncemented collared standard offset stems.

Table 3 Clinical and radiographic outcomes for the matched cohort ($n = 160$)

	Standard offset group ($n = 80$)						High offset group ($n = 80$)										
	Mean *n*	±	SD %	Range			Mean *n*	±	SD %	Range			*p-value*	MD OR	95% CI 95% CI		
Follow-up	6.3	±	0.7	5.0	–	8.0	6.3	±	0.7	5.1	–	8.3	*0.836*	-0.02	-0.2	–	0.2
mHHS (worst, 0; best, 100)	93.2	±	11.0	48.4	–	100.0	93.1	±	10.6	35.2	–	100.0	*0.553*	0.12	-0.2	–	3.6
Net change	50.7	±	14.2	-5.5	–	95.6	46.0	±	16.6	-20.9	–	89.0	*0.119*	4.74	-0.2	–	9.7
OHS (worst, 0; best, 48)	45.1	±	4.1	26.0	–	48.0	45.3	±	4.6	17.0	–	48.0	*0.623*	-0.19	-0.2	–	1.2
FJS (worst, 0; best, 100)	85.1	±	19.3	10.4	–	100.0	82.7	±	23.0	2.1	–	100.0	*0.910*	2.37	-0.2	–	9.0
Satisfaction (worst, 0; best, 10)	9.7	±	1.0	2.0	–	10.0	9.5	±	1.0	5.0	–	10.0	*0.140*	0.19	-0.2	–	0.5
Femoral offset (mm)	39.7	±	5.3	29.7	–	56.6	48.7	±	5.6	36.2	–	66.5	***< 0.001***	-8.90	-0.2	–	-7.0
Net change	-0.3	±	7.7	-13.2	–	18.2	0.2	±	6.2	-13.4	–	14.0	*0.723*	-0.44	-0.2	–	2.0
Acetabular offset (mm)	81.0	±	7.2	64.0	–	101.8	83.3	±	7.2	67.5	–	104.0	*0.066*	-2.36	-0.2	–	0.1
Net change	-11.2	±	8.1	-26.8	–	11.8	-10.9	±	9.0	-28.6	–	20.4	*0.989*	-0.35	-0.2	–	2.6
Global offset (mm)	120.7	±	10.3	101.8	–	148.3	132.0	±	10.6	108.7	–	156.0	***< 0.001***	-11.26	-0.2	–	-7.7
Net change	-11.5	±	10.9	-35.3	–	14.5	-10.7	±	10.9	-39.8	–	23.3	*0.681*	-0.79	-0.2	–	3.0
LLD (mm)	1.5	±	4.8	-8.0	–	13.0	1.1	±	3.5	-6.0	–	11.0	*0.537*	0.40	-0.2	–	1.9
Stress shielding	0		0%				0		0%				*1.000*				
Stem subsidence	0		0%				0		0%				*1.000*				
Stem fracture	0		0%				0		0%				*1.000*				
Stem misalignment ≥ 5°													*1.000*				
None	65		81%				65		81%					1.17	0.6	–	2.2
Varus	0		0%				1		1%					0.33	0.0	–	8.2
Valgus	0		0%				0		0%								
NA	15		19%				14		18%								
Radiolucencies around the stem													*0.152*				
None	55		69%				56		70%					0.94	0.5	–	1.8
Light (length < 1 cm)	5		6%				5		6%					1.00	0.3	–	3.6
Moderate (length 1-2 cm)	0		0%				4		5%					0.11	0.0	–	2.0
Severe (length > 2 cm)	5		6%				1		1%					5.27	0.6	–	46.1
NA	15		19%				14		18%								
Calcar modification													*0.348*				
None	51		64%				57		71%					0.71	0.4	–	1.4
Remodeling	10		13%				8		10%					1.29	0.5	–	3.4
Osteolysis	4		5%				1		1%					7.27	0.4	–	143.1
NA	15		19%				14		18%								
Cortical bone modifications	1		1%				0		0%				*0.840*	3.04	0.1	–	75.7
Cancellous bone modifications	7		9%				10		13%				*0.768*	0.84	0.2	–	1.9
Collar-calcar contact	62		78%				64		80%				*0.898*	0.86	0.4	–	1.8

Table 3 (continued)

	Standard offset group ($n=80$)						High offset group ($n=80$)										
	Mean *n*	±	SD %	Range			Mean *n*	±	SD %	Range			*p-value*	MD OR	95% CI 95% CI		
Granulomas	1		1%				0		0%				*0.840*	3.04	0.1	–	75.7
Pedestal formation													*0.728*				
None	60		75%				60		74%					1.07	0.5	–	2.2
Light	5		6%				5		6%					1.00	0.3	–	3.6
Moderate	0		0%				1		1%					0.33	0.0	–	8.2
Severe	0		0%				0		0%								
NA	15		19%				14		18%								
Brooker grade (heterotopic ossification)																	
0	56		70%				49		61%				*0.126*	1.48	0.8	–	2.8
1	7		9%				9		11%					0.76	0.3	–	2.1
2	1		1%				8		10%					0.11	0.0	–	0.9
3	1		1%				0		0%					3.04	0.1	–	75.7
NA	15		19%				14		18%								
Canal fill ratio																	
Level A	0.6	±	0.1	0.5	–	0.8	0.6	±	0.1	0.5	–	0.7	*0.566*	-0.01	0.0	–	0.0
Level B	0.7	±	0.1	0.4	–	0.8	0.7	±	0.1	0.5	–	0.9	*0.566*	-0.01	0.0	–	0.0
Level C	0.8	±	0.1	0.6	–	1.0	0.8	±	0.1	0.4	–	1.0	*0.310*	0.02	0.0	–	0.1
Level D	0.6	±	0.1	0.4	–	1.0	0.6	±	0.1	0.4	–	0.9	*0.452*	0.02	0.0	–	0.1

mHHS modified Harris Hip Score, *OHS* Oxford Hip Score, *FJS* Forgotten Joint Score, *LLD* limb-length discrepancy, *SD* standard deviation, *MD* mean difference, *OR* odds ratio, *CI* confidence interval

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Data Availability Data is available from the corresponding author upon reasonable request.

Declarations

Ethical approval This study was approved by the institutional review board of GCS Ramsay Santé pour l'Enseignement et la Recherche (COS-RGDS-2024–05-006-JACQUOT-L). Informed consent was obtained from all individual participants included in the study.

Institution at which work was performed Clinique d'Argonay, Centre Le Périclès, Allée de la Mandallaz 74370, Annecy, France.

Conflict of interest LJ, AM, and JC have received royalties and consultancy fees from DePuy-Synthes. SRP, BG, MS, and SD have nothing to declare.

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