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Uncemented Total Hip Arthroplasty Through the Direct Anterior Approach: Analysis of a Consecutive Series of 275 Hips With a Minimum Follow-Up of 10 Years

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ABSTRACT

Background: The purpose of this study was to document complications, outcomes, and 10-year survivorship of primary total hip arthroplasty (THA) using a direct anterior approach with an uncemented, straight, hydroxyapatite-coated stem and an uncemented cup.

Methods: A retrospective, consecutive series of 275 primary THAs through a direct anterior approach with traction table using Medacta Versafit cup and Quadra-H stem with a minimum of 10-year follow-up was identified. The cumulative 10-year survival of the implants was estimated using Kaplan-Meier estimator. All complications, reoperations, and failures were analyzed. Subjective and clinical outcomes (Subjective Hip Value, Western Ontario and McMaster Universities Osteoarthritis Index, and Harris Hip Score) were measured.

Results: Of 256 patients (275 hips, 143 men and 113 women) with a mean age of 63 (range, 24-85) years, 48 (19%) patients (52 hips) deceased not related to the surgery after a mean time 49 months (range, 3-118) postoperatively. At >10-year follow-up, 9 THAs were revised. The overall implant survival rate was 96.8% (95% confidence interval, 94.4-98.7) at 10 years. One cup and 1 stem were revised because of aseptic loosening. At the last follow-up, the median Subjective Hip Value was 90% (range, 20-100), the Western Ontario and McMaster Universities Osteoarthritis Index score reached a median of 0.2 points (range, 0-6.3), and the median Harris Hip Score points was 99 (range, 29-100).

Conclusion: Primary THA through an anterior minimal invasive approach with the mentioned implants showed low revision rates and good to excellent clinical outcome after at least 10 years.

Total hip arthroplasty (THA) is a very reliable surgical procedure in treating end-stage osteoarthritis considering the patient-related outcome measures and the cost-effectiveness [1,2]. Nevertheless, there are still open questions regarding when, how, and with which implant a THA should be performed. The direct anterior approach (DAA) for THA shows raising popularity, because it is the only approach to the hip joint respecting an internervous plane [3]. In recent studies, the DAA showed an advantage in clinical outcome in the first 6 weeks, which seems to level out after that [4,5]. The learning curve of this nowadays popular approach has been studied in several publications. It has been shown that the results are worse during the first 20 to 50 cases but not thereafter [6–11]. However, there is still a debate regarding safety, precision of implant positioning, risk of periprosthetic infection, and patient outcome (clinical scores) using the DAA [12–15]. Furthermore, there are studies that show that early aseptic loosening might be increased when using the DAA [16,17]. Therefore, the surgical approach might have an influence on implant failure. The 5-year results with the used uncemented implants in this study were in line with other uncemented stems on the market [9] but there is an uncertainty whether the long-term outcome, especially the implant survival, remains the same after 10 years.

The purpose of this study was to analyze the implant survival, the clinical outcome, the complication, and revision rate and the

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radiographic outcomes after at least 10 years of primary THA with uncemented implants through the DAA with a traction table.

Materials and Methods

This study was approved by our ethical review board (KEK-ZH-Nr: 2017-01616) and all participants gave written informed consent. This retrospective, consecutive case series was conducted entirely at the author's institution. The surgical technique was performed in supine position using Hueter interval in the anterior minimally invasive surgical approach technique, which is a modification of the DAA respecting a slightly lateral skin incision through the fasciae of the tensor fasciae latae trying to avoid problems with the lateral cutaneus femoris nerve and using a traction table. Intraoperative fluoroscopy for cup placement was used in 85 hips (31%). There were 7 different surgeons. The senior hip consultant (>5 y experience in hip surgery with >500 THAs and >100 THAs with a DAA) and his deputy (>3 y experience in hip surgery and <200 THAs and >30 THAs with a DAA) performed 234 (85%) of all the THAs. The other surgeons were junior hip consultants trained either by the senior consultant or his deputy in the anterior minimally invasive surgical approach technique. Of the 5 junior consultants, only 3 performed THA through the DAA without supervision. The 3 junior consultants who performed a THA without supervision had specific teaching in DAA and performed at least 10 cases supervised. The detailed surgical procedure and postoperative rehabilitation program were described in an earlier study [9].

Patients

The patients were consecutively selected from June 2005 until May 2007. Inclusion criteria were DAA with traction table using Quadra-H stem and Versafit-CC cup (Medacta, Castel San Pietro, Switzerland) with a highly cross-linked polyethylene with a 28-mm head size and at least 10-year follow-up. Exclusion criteria were patients receiving THA with a different type of approach or implant system. In the same time period, there were 554 THAs performed in our clinic. In 96 (17%) THAs, another approach or another implant was used because of anatomic reasons (eg, posttraumatic deformities, sequelae of childhood disease). In 458 (83%) THAs, a DAA was used, and in 275 (50%), the above-mentioned implant was used.

Therefore, our patient group comprised of 275 consecutive primary THAs in 256 patients (143 men and 113 women) with a mean age of 63 years (range, 24-85). Forty-eight patients (19%; 52 hips) deceased after a mean time of 49 months (range, 3-118) unrelated to the THA. There were 2 implant failures (1 stem and 1 cup and stem) in the deceased patient group, which are mentioned in the results section below. Thirteen patients (5%; 14 hips) were lost to follow-up because they moved abroad after a mean time of 33 months (range, 4-114). Until last available follow-up, there were no revisions documented.

This left 195 patients with 209 hips (92 women and 103 men) with a mean age of 61 years (range, 24-82) and a mean follow-up of 11.2 years (range, 10-13). In 27 patients (28 hips), the radiographs were missing because they could not show up for the outpatient clinic because of disability (n = 11), refusal (n = 6), or no mobility capability (n = 10). In 10 patients, we obtained the clinical scores by phone (n = 10). In the remaining 17 patients, we could assure that the THA was not revised but they refused to fill out the clinical scores (Fig. 1).

Outcome Measures

Demographic parameters were recorded from our electronic patient's charts. The primary outcome was the survival of the implant (cup and stem). Implant survival was calculated using Kaplan-Meier estimator including the deceased patients. Subjective and clinical outcomes (Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC, 0 = best, 10 = worst result] [18]; Subjective Hip Value [from 0% to 100%, 100% being a perfect hip—in accordance with subjective shoulder value] [19]; and Harris Hip Score [HHS, 0 = worst, 100 = best result] [20]) were measured. All complications, reoperations, and failures were analyzed.

Radiography

Standardized anteroposterior pelvic and axial X-rays were obtained in the operation room immediately after surgery and were available for all 275 hips. Further radiographs were taken after 3 and 12 months and usually 5 and 10 or more years postoperatively. In all 275 hips, the radiographs were analyzed for leg length discrepancy (comparing the lesser trochanter to a horizontal line defined by the 2 tear drop figures), global offset reconstruction (compared to either the healthy side or preoperatively), stem alignment (varus, valgus), and cup inclination/version using the technique of Lewinnek et al [21]. The postoperative radiographs during follow-up visits were also analyzed for stem subsidence (distance between the apex of the greater trochanter and the stem shoulder perpendicular to the femoral stem axis in the first postoperative X-ray comparing with the latest X-rays) and for radiolucent lines in the acetabulum according to DeLee and Charnley I-III and in the femur according to the Gruen zones I to VII [22,23] and were available in 181 hips who reached the 10-year follow-up with the implant in place.

Statistical Analysis

Implant survival was calculated using the Kaplan-Meier estimator. Differences in clinical outcomes between groups were compared by median and the Mann-Whitney *U* test. The

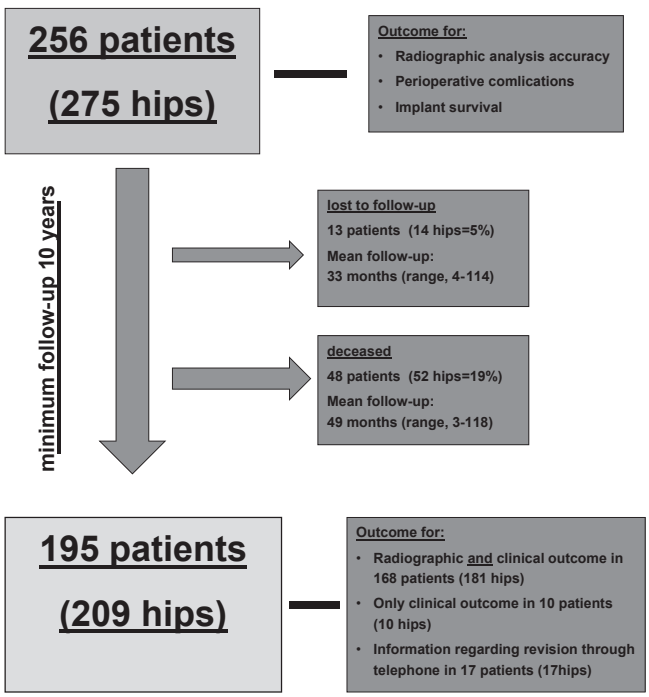

Fig. 1. Flowchart of the study cohort, final study group, and follow-up.

Table 1
Demographic Information.

Demographics	
Number of patients	256
Number of hips	275
Males	143
Females	113
Mean age (y; ±SD)	62 ± 11
Mean BMI (kg/m^2; ±SD)	27 ± 5
Etiology	
Osteoarthritis (%)	95
Osteonecrosis (%)	3
Femur neck fracture (%)	2
Previous surgeries (N)	
ORIF	3
Hip arthroscopy	3
Surgical hip dislocation	3
Femur osteotomy	2

SD, standard deviation; BMI, body mass index; ORIF, open reduction and internal fixation.

significance level was set at 0.05. Statistical analyses were computed using Stata/IC 15.0 (StataCorp LP, College Station, TX).

Results

The demographic information is depicted in Table 1. There were no failed intentions to treat.

Implant Survival

Total implant survival (revision for any reason) was 97.3% at 5 years (standard error [SE], 1.0; 95% confidence interval [CI], 94.3-98.7) and 96.8% at 10 years (SE, 1.1; 95% CI, 94.4-98.7), respectively (Fig. 2). Total stem survival for any reason was 98% at 5 years (SE, 0.9; 95% CI, 95.3-99.1) and did not change at 10 years. Total cup survival was 98% at 5 years (SE, 0.9; 95% CI, 95.3-99.1) and 97.6% at 10 years (SE, 1.0; 95% CI, 94.6-98.9).

Clinical Outcome (N = 185; Failures Excluded)

The median Subjective Hip Value at 5 and 10 years postoperatively was 90% (range, 11-100) and 90% (range, 20-100), respectively. The median WOMAC at 5 and 10 years postoperatively was 0.46 points (range, 0-6.9) and 0.2 points (range, 0-6.3), respectively. The median HHS at 5 and 10 years postoperatively was 99 points (range, 58-100) and 99 points (range, 29-100), respectively. Therefore, the clinical results remained stable over time and did not differ significantly between 5 and 10 years postoperatively.

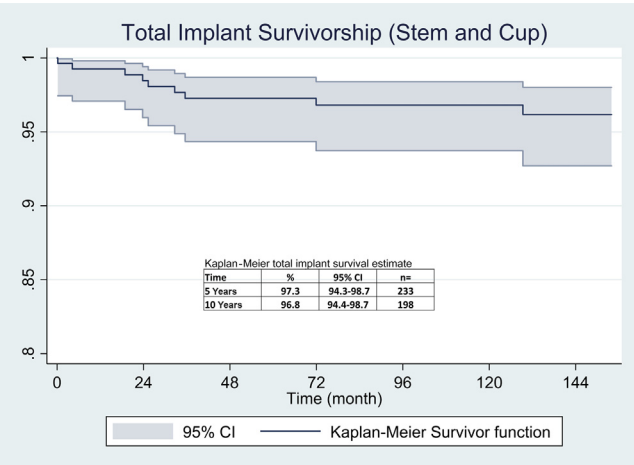

Fig. 2. Kaplan-Meier estimate regarding revision for any reason (cup and stem). CI, confidence interval.

Perioperative Complications

Perioperative complications occurred in 12 patients (4.4%). There were 2 (0.7%) acetabular floor perforations requiring partial weight-bearing for 6 weeks postoperatively. There were 10 (3.6%) intraoperative femur fractures (5 greater trochanter fractures and 5 femur fractures). Four patients with trochanter fractures were treated conservatively with partial weight-bearing. One patient was treated with an open reduction and internal fixation 3 months postoperatively in an external hospital. One patient with intraoperative femur fracture was treated conservatively with partial weight-bearing. Two patients with femur fracture were treated during the index surgery with cerclage wiring and partial weight-bearing. One patient with an intraoperative femur fracture received a cerclage wiring immediately after surgery on the same day and after 5 days the stem was revised because of subsidence. One patient had a displaced femur fracture receiving a cerclage wiring on the same day without implant revision. The clinical outcome showed a good result in these 12 patients with a median WOMAC score of 0.6 points (range, 0-5.4) not statistically different to the rest of the group. The detailed information about these 12 patients is depicted in Table 2.

Dislocations

Overall, there were 7 (2.5%) anterior dislocations. In 6 patients, it was a single dislocation (11-29 days after surgery) requiring closed reduction without recurrence. In these 6 patients, there was no intraoperative fluoroscopy used, and in 4 of the 7 patients the cup anteversion was above the safe zone. However, they presented with an uneventful further course with a median WOMAC of 1.4 points (range, 0-4.1). In 1 patient, a cup revision was needed because of recurrent dislocations as mentioned in the section below. Six dislocations were seen within the first 100 cases. The detailed information is depicted in Table 3.

Postoperative Late Implant-Retaining Surgical Complications

In total, there were 9 (3.3%) implant-retaining reoperations. In 5 patients, a superficial wound complication was seen, requiring wound debridement and closure of the skin without opening the fascia. Furthermore, there was 1 patient with heterotopic bone formation grade III, which was surgically removed. Two patients required an open reduction and internal plate fixation of a traumatic periprosthetic femur fracture Vancouver C. One patient was reoperated for unclear pain with debridement and bacteriological sampling. No infection could be found and after the debridement the patient was pain free.

Complications Requiring Implant Revision

Until final follow-up, 9 patients (3.3% overall; 7 cups [2%]; 5 stems [1.5%]) received an implant revision. One stem and 1 cup were revised due to aseptic loosening. The stem was placed in proper position in a Dorr type B femur, not being undersized and it did not show subsidence. There were no signs of a septic loosening. The stem was revised 19 months after index surgery and intraoperatively the diagnosis of the loose stem was clear.

The revised cup had a history of intraoperative acetabulum floor perforation and autograft augmentation at index surgery. Although

Table 2
Overview of Patients With a Perioperative Complication.

Perioperative Complications								
P	Fracture	GT	Shaft	Over-Reaming Acetabulum	Outcome	Therapy	Last Follow-Up (mo)	WOMAC Last Follow-Up
1	x	x			Secondary dislocation	Refixation external hospital 5 mt postop	156	1.1
2	x		x		Regular	Conservative	144	0
3	x	x			Regular	Conservative	160	1.3
4	x		x		Subsidence	Stem exchange	n.a.	n.a.
5	x	x			Regular	Conservative	138	0.5
6	x		x		Regular	Screw osteosynthesis while index surgery	134	0
7	x		x		Regular	Cerclage osteosynthesis while index surgery	62[a]	0.7
8	x	x			Regular	Conservative	130	4
9	x		x		Regular	Cerclage osteosynthesis while index surgery	130	0
10	x	x			Regular	Conservative	128	5.4
11				x	Aseptic cup loosening	Cup revision	n.a.	n.a.
12				x	Regular	Partial weight-bearing	137	0.5

P, patient; GT, greater trochanter; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; n.a., not applicable; mt, month.
[a] This patient deceased afterward.

the cup press-fit position was good initially, the cup became loose and had to be revised after 5 years. The other 3 cups were exchanged due to psoas irritation, traumatic acetabulum fracture, and recurrent dislocation. One of the above already-mentioned patient received a cerclage wiring because of an intraoperative fracture. After 5 days, the stem subsided and a loss of press-fit was seen requiring a stem revision. Two patients were revised (cup and stem) due to late hematogenous infection and 1 patient was revised (cup and stem) because of pain by overlength and excessive global offset.

In Table 4, the results are summarized according to the surgeon's experience regarding the implant revisions and the dislocations.

Radiography

The mean inclination angle for cup positioning was 46° (SD, 6; range, 24-62) having 80% in the safe zone according to Lewinnek [21]. The mean anteversion angle was 20° (SD, 5; range, 6-45) and was within the safe zone of Lewinnek in 86%. In 3%, leg-length discrepancy was more than 10 mm. The global offset reconstruction was within 10 mm in 76%. A varus stem position was seen in 59% with a mean of 3° (range, 1-6) and valgus position was seen in 7% with a mean of 2° (range, 1-5).

Stem subsidence was seen in 9% with a mean of 3 mm (range, 1-7) during the first 3 months but not thereafter. More than 5-mm subsidence was seen in 3 patients. One patient had a periprosthetic fracture Vancouver type B1, treated with a cerclage wiring, which healed after 3 months. However, there was a subsidence of 7 mm. This proves that there must have been a B2 fracture. The patient, however, had an excellent clinical outcome with a stable healed stem without further radiographic signs of loosening. One other patient showed a subsidence of 6 mm in the first 3 months but not thereafter. He was 71 years old with a Dorr type A femur and the stem was well seated initially with a slight valgus of 3°. The clinical result was excellent at the latest follow-up at 10 years. The last patient showed a subsidence of 7 mm in the first 3 months and not thereafter. He was 82 years old with a Dorr type B femur and also had a well-seated stem implanted straight. He as well had an excellent result at the 10-year follow-up with a radiographic stable stem.

With regard to the stem, radiolucent lines at final follow-up of more than 2 mm were measured in 10% patients in any zone. Typically they occurred in zones I and VII (Fig. 3). The detailed information regarding radiolucent lines is depicted in Table 5. There were no significant differences in the WOMAC and HHS in patients with or without radiolucent lines. There was no radiolucency found around the cup at latest follow-up.

Discussion

The aim of the present study was to report the outcomes and survival of the used implant system with at least 10-year follow-up operated through a DAA. To our knowledge, this is the first study showing a consecutive series with a hydroxyapatite-coated uncemented straight stem through the DAA having a follow-up of 10 years or more. The total 10-year survival rate of 96.8% (SE, 1.1; 95% CI, 94.4-98.7) is comparable with the 2017 Australian implant registry data of other uncemented hip implants where the only implant systems with a better 10-year outcome was the Zimmer Alloclassic stem/Trilogy cup having a cumulative 10-year revision rate of 3% and DePuy Synthes Summit stem/Pinnacle cup with 3.1% at 10 years. There are studies, which show a higher early aseptic loosening in THA, which are performed through the DAA [16,17,24]. However, the results of these studies have to be interpreted with

Table 3
Summary of Patients Having an Anterior Luxation.

Patients	Cup Inclination	Cup Anteversion	Femoral Antetorsion	Cup Revision	Last Follow-Up (mo)	WOMAC
1	50	29	n.a.	No	156	1.4
2	58	30	n.a.	Yes	n.a.	n.a.
3	43	29	n.a.	No	132	2.6
4	58	26	n.a.	No	60[a]	4.1
5	48	19	n.a.	No	121	1.3
6	51	19	25	No	122	0
7	46	21	n.a.	No	60[a]	n.a.

WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; n.a., not applicable.
[a] Deceased thereafter.

Table 4
Detailed Information Regarding Implant Revisions and Luxations According to the Surgeon's Experience.

Surgeon	THA	Experience in THA	Experience in THA Through DAA	Implant Revision (N)	Implant Revision (%)	Luxation (N)	Luxation (%)
Senior hip consultant	156	>500	>100	5	3.2	2	1.3
Deputy senior hip consultant	78	>200	>30	2	2.6	2	2.6
Junior consultant 1	9	>100	>10	0	0		
Junior consultant 2	5	>100	>10	1	20		
Junior consultant 3	5	>100	>10	1	20		
Supervised by senior hip consultant	14			0	0		
Supervised by deputy senior hip consultant	8			0	0	3	37.5
Total	275			9	3.3		

THA, total hip arthroplasty; DAA, direct anterior approach.

caution. In a study by Janssen et al [16] there were only 3 cases of aseptic loosening with the shoulder stem through the DAA. In a study by Eto et al [17] in our opinion a big limitation is the surgical experience. There is no information about the surgical experience in that study and therefore can bias the results. In a study by Long et al [24] the main problem was the cup and not the stem. However, there were only 5 cases with such a problem. In our study, there was an excellent and stable performance of the implants with very low rate of aseptic loosening. The aseptic cup loosening was in 1 of the 2 patients with acetabular over-reaming requiring autografting of the acetabulum. Therefore, that case can be declared as a technical and not an implant failure. Another patient with the aseptic stem loosening had a proper position, a stem that was not undersized, and a Dorr type B femur, and the infection was ruled out. Therefore, the loosening remains unclear in this case.

The perioperative complication rate was quite high and included 12 patients (4.4%); however, it was still lower than in 2 other studies using the DAA where the learning curve is included [25,26]. In 2 patients (0.7%), the acetabulum was over-reamed and needed cancellous acetabular autografting. Intraoperative femur fractures (5 trochanteric and 5 femur shaft) occurred in 3.6%, requiring additional surgery in only 2 patients. These fractures occurred throughout the complete patient group and do not seem to be explained with the fact of an early series. However, this is in line with the literature where intraoperative fractures are documented with uncemented implants using the anterior approach between 0.9% and 6.5% [9,27–32]. Furthermore, the shape of the stem may have an impact on the fracture rate. In a study by Dietrich et al [28] the straight stem had a significantly higher intraoperative fracture rate with 6.8% compared with shorter curved stems with 1.6%. When comparing intraoperative fracture rates of different surgical approaches, the results vary in literature from 1.4% to 5.4% using uncemented stems in the lateral, the posterior, and the anterolateral approach [33–38], and therefore, the approach alone seems not to be the only factor of more intraoperative fractures. Complications requiring a surgical intervention occurred in 18 cases (6.5%; 9 implant revisions and 9 implant retaining). Worth mentioning are the 4 (1.5%) wound complications requiring wound debridement. Dietrich et al [28] showed a significant local complication rate, that is, wound healing, hematoma with straight stems compared to short curved stems using the anterior approach. However, in a recent study by Purcell et al [39] there was no increased risk of deep infection or wound complications in DAA patients compared with posterior approach patients. We believe that it is very important to take care of the proximal wound while broaching the femur using this approach to avoid wound complications in the proximal part of the wound.

The dislocation rate of 7 cases of 275 (2.5%) is higher than that in other studies, ranging from 0.6% to 1.5%, using the anterior approach [15,40–42]. One reason could be the use of 28-mm heads. Another reason might have been the fact that in 3 cases a junior consultant performed the operation, although under supervision of the deputy head of the hip team. Nevertheless, this could be the explanation of the higher luxation rate because the learning curve was not yet over with. However, 6 dislocations occurred in the first 100 cases and thereafter only 1 dislocation was observed in the following 175 THAs. In 6 of the 7 patients with a dislocation, intraoperative fluoroscopy was not used and the anteversion of the cup was rather high in all of the patients and in 4 of the 7 above 25° (see Table 3). One explanation is the still early series of this patient group and moreover the not regularly used fluoroscopy. However, only 1 patient required a reoperation and a cup exchange and the other 6 had an uneventful further good to excellent hip function

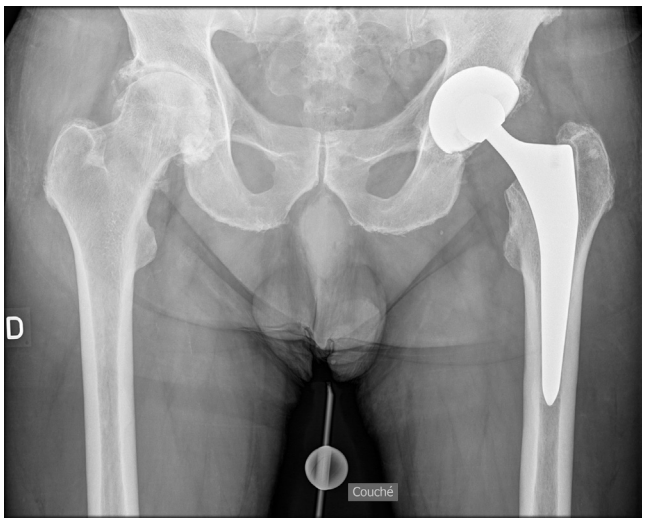

Fig. 3. An example of a radiograph (anteroposterior pelvis) at 10-year follow-up with the typical radiolucent lines in zones I and VII.

Table 5
Summary of All the Patients With Radiolucent Lines.

Follow-Up Radiographs	Radiolucency Stem (>2 mm)					
	Zone 1	Zone 2	Zone 6	Zone 7	Zone 1 + 7	Any Zone[a]
1-y Follow-up radiographs (195)	**1.5%**	0%	0%	**0.5%**	0.5%	3.1%
5-y Follow-up radiographs (120)	**5.8%**	0%	0.8%	**4.2%**	1.7%	9.8%
10-y Follow-up radiographs (181)	**7.2%**	0.6%	1.7%	**5.0%**	2.2%	9.9%

[a] No radiolucency in other zones.

and satisfaction. Our standard nowadays is still the DAA with traction table and the same implant system but the fluoroscopy for the cup placement is always used. The intraoperative fluoroscopy for cup placement has been shown to improve cup positioning, not only the inclination but also the anteversion, especially when using the size and shape of the obturator foramen to reference the fluoroscopy beam [43]. The overall radiographic accuracy was reasonable, although intraoperative fluoroscopy was not regularly used with cup inclination being in the safe zone of Lewinnek in 80% and cup anteversion in 86%.

The radiolucent lines (>2 mm) in zones I and VII, which were seen at final follow-up in overall 10%, did not correlate with the clinical outcome. There was a slight progress over time from 1.5% in the first year to 7.2% in the final follow-up in zone I. Therefore, in our opinion, this finding is nothing to be concerned of but of course has to be further observed in the long-term follow-ups. However, this is in line with other uncemented straight stems [44,45].

The clinical outcome regarding WOMAC (median, 0.2 points [range, 0-6.3]) and HHS (99 points [range, 29-100]) was excellent at the latest follow-up, stable over time, and in line with other studies [46,47].

The present study has several limitations, especially the relatively high proportion of patients lost to follow-up, which is unavoidable in long-term studies involving patients of advanced age at index surgery. However, from the 19% deceased patients, which is in line with other studies with a 10-year follow-up [48,49], there is still a reasonable follow-up available of 49 months (range, 3-118). Thirteen patients (5%; 14 hips) were lost to follow-up because they moved abroad after a mean time of 33 months (range, 4-114). Therefore, this series possesses a good and true validity and is of informative value. Another limitation is the fact that there were several different surgeons. However, most of the surgeries were performed by the head or the vice head of the hip department in our hospital or under their supervision. An additional limitation is the fact that fluoroscopy was not used in all cases.

Conclusion

At >10-year follow-up, patients after primary THA through a DAA show excellent clinical and radiological results. The DAA with a traction table showed a reasonable complication rate similar to that in other approaches in the literature. The used cup and hydroxyapatite-coated straight stem are reliable implants with excellent implant survival for aseptic loosening at 10 years.

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