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# Subtrochanteric shortening and uncemented arthroplasty in hips with high dislocation - a cohort study with 13–30 years follow-up

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ABSTRACT

*Introduction:* The aim was to evaluate short- and long-term outcomes in patients with high hip dislocation operated with subtrochanteric shortening osteotomy and uncemented total hip arthroplasty.
*Methods:* Sixty-five hips operated in 1986–2001, at mean age 48 years (15–79), were followed for mean 19 years (13–30).
*Results:* At last follow up, there were two femoral and 35 acetabular revisions. Harris hip score was mean 86 (81–90) in unrevised, and 87 (82–90) in revised hips.
*Conclusions:* Our study shows favorable long-term results for a fully hydroxyapatite (HA) coated stem. Aseptic cup-loosening may be reduced by using better implants.

## 1. Introduction

In patients with high dislocation of the hip, the femoral head has migrated cranially and posteriorly in relation to the true acetabulum and thus articulates in a neoacetabulum on the iliac wing. It has been shown that the true acetabulum has a reduced diameter, the femoral canal is narrower, and the proximal femur has an increased anteversion compared with hips with primary osteoarthritis (OA).[1] A total hip arthroplasty (THA) in patients with high dislocation therefore poses technical difficulties. Some authors have even considered high dislocation a contraindication to THA,[2] whereas others have shown favorable results.[3,4]

In order to implant THA at the level of the true acetabulum in patients with high dislocation, there is a feared complication of overstretching the femoral and/or sciatic nerve causing postoperative neuralgia and/or loss of motor function. To reduce the risk of this complication, a shortening osteotomy of the proximal femur as an adjunct to THA is a solution that has shown satisfactory results.[5] When performing a shortening osteotomy, preservation of the anatomy of the trochanteric region and thereby avoiding problems with soft tissue reattachment is a priority. Several techniques have been described, including subtrochanteric,[5–7] diaphyseal,[8] and distal shortening osteotomies.[9] There are some disadvantages to the osteotomy, including the risk of fracture or non-union. The overall complication rate is reported at a range of 19–43%.[4–8]

At our institution, the preferred technique in patients with high dislocation is subtrochanteric shortening osteotomy and implantation of a cementless THA. We chose uncemented prosthesis to avoid introduction of cement at the osteotomy site, as not to interfere with healing. In the present study we have evaluated short- and long-term outcomes in these patients.

## 2. Methods

### 2.1. Patients

We performed 65 uncemented total hip arthroplasties (THA) with subtrochanteric shortening osteotomy (SSO) in 46 patients with high dislocation in the period 1986 to 2001. The cohort consists of 10 male and 36 female patients. Mean age was 48 years (15–79) at time of surgery. All were operated with the indication severe pain and/or functional impairment affecting walking and activities of daily life. Nineteen patients were operated bilaterally (17 women and 2 men).

The mean preoperative leg length discrepancy, radiographically measured, was 3 cm (0–8). All had positive Trendelenburg gait of the dislocated hip. Two patients had undergone previous Schanz osteotomy and one had had a cemented Charnley prosthesis with a high hip-center and subsequent cup loosening.

### 2.2. Surgical technique

Preoperative planning by templates was done in all cases. A direct

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lateral or a posterior approach was used. After the femoral neck osteotomy was done, the femoral canal was reamed to obtain press fit for the stem. A subtrochanteric transverse osteotomy was then performed, to allow for correction of rotational abnormalities, this also allowed us to gain insight to the true acetabulum. The elongated hypertrophic joint capsule was resected, the proximal parts of the pubic and ischial bones and the teardrop were exposed for evaluation of bone stock, and identification of the small true acetabulum filled with fibrous fatty tissue and the transverse acetabular ligament was done. If the acetabular roof was defective, it was reinforced with a bone graft taken from the resected femoral head. In some cases, the pelvic bone was so scarce that less than 80% of the acetabular cup could be covered by host bone. In such cases the central part of the medial wall was intentionally fractured and pushed medially with its periosteal attachments preserved, to obtain reliable fixation. The new medial wall was then reinforced with reamed cancellous bone, and the uncemented acetabular component was impacted against the new medial wall. All acetabular components were placed in the true acetabulum. With the acetabular component in place, a new subtrochanteric shortening osteotomy, either step-cut or oblique, was performed. This osteotomy was chosen to give rotational stability. The medullary canal of the distal femoral segment was then reamed again to allow for press-fit fixation of the femoral stem and thus increasing rotational stability at the osteotomy site (Fig. 1a–c). Partial weight bearing (15–20 kg) was allowed during the first 3 months postoperatively, with progression to full weight bearing the following weeks.

### 2.3. Technical data

In all cases we used a non-modular, straight stem designed for press-fit insertion (Landanger, Chaumont, France). The component was made of grit blasted Titanium, and the outer surfaces were entirely plasma-sprayed with a 155 ± 35 μm layer of Hydroxy Apatite. The purity of the HA was reported to be greater than 98%, the density between 1.2 and 1.6 g/mL, the crystallinity greater than 50% and the porosity less than 10%. The surface roughness of the coating was characterized by Ra (arithmetical mean roughness value) between 7.5 and 9.5 μm and Rt (maximum profile height) between 50 and 65. The surface roughness of the grit blasted metal was characterized by Ra between 4 and 6 μm and Rt between 25 and 40. The bonding strength of the coating to the metal was reported to be more than 35 MPa. The manufacturer reported the technical data.

In 32 hips we used a hemispherical HA coated titanium cup inserted with press fit (cup 1) and in 13 hips a HA coated titanium screw cup (Landanger, Chaumont, France) (cup 2). In 20 hips we used a hemispherical titanium cup designed for press fit insertion that was made of Titanium and coated with a mesh of Titanium (Zimmer, USA) (cup 3). We used stems of sizes 7 to14, and cups of sizes 36 to 56.

### 2.4. Follow-up

At follow-up, clinical rating was done according to Harries Hip Score (HHS). Radiographic evaluation included assessment of cup inclination, polyethylene wear, osteolysis and fixation of the acetabular cup. Linear measurements were made on the AP radiograph using a caliper and corrected by reference to the diameter of the femoral head. Polyethylene wear was measured according to Livermore et al.[10] Appearance of radiolucent lines and osteolytic lesions were documented and classified on the basis of size and regional location according to DeLee and Charnley.[11] Femoral regional analysis was performed as described by Gruen et al.[12] Focal area of bone loss was considered evidence of osteolysis.[13] Radiographic bony incorporation was defined as extensive intimate bone-implant contact, periprosthetic bone formation and remodeling, and absence of migration. We modified the criteria of Massin et al.[14] for cup loosening, applying a variation of more than 5 mm or 5°. Subsidence of the femoral stem was defined as an increase in distance between the tip of the greater trochanter and the lateral stem shoulder of more than 5 mm. This limit was chosen somewhat arbitrary, but based on the findings of Malchau.[15]

During follow-up, 9 patients (13 hips) have died 13–23 years postoperatively. All deaths were of unrelated causes. Furthermore, 3 patients (3 hips) did not want to participate in further follow up examinations due to high age, or as they were doing well with their THA. The data from the last follow-up were used in these patients, who all had follow-up ≥13 years. The information was confirmed by telephone and controlled by data from the Norwegian Arthroplasty Register.

### 2.5. Statistics

SPSS software, version 21 (IBM, Armonk, NY, USA) was used for statistical analysis. The Kaplan-Meier product-limit method was used to estimate the survival function of the stem and the cups used, with revision as end-point.

## 3. Results

All 46 patients with a total of 65 operated hips were followed for a mean period of 19 years (13–30). There were 2 cases of peroneal nerve palsy, one recovered partially, the other was permanent. One patent suffered recurrent dislocations and had revision surgery where a longer neck was used. During follow-up, two patients had a delayed union of the SSO, one of whom was successfully treated with a bone transplant and the other was asymptomatic and did not undergo further surgery.

### 3.1. Femoral stem

There were only two stem revisions. Stem survival was 97% at 20 years (Fig. 2). One patient had subsidence of the femoral stem, which was replaced by a larger stem at 8 months. This stem incorporated, and the patient fared well. One stem was revised due to deep infection 13 years postoperatively.

Radiographs of the stems showed radiolucent lines in Zone I of four stems, and focal osteolysis in 3 cases, also in Zone I. This was associated with wear. Otherwise there was bony incorporation of the stems by intimate bone-implant contact.

### 3.2. Acetabular cup

There were 35 revisions on the acetabular side. Twenty-three cups were revised due to aseptic loosening (17 HA coated press fit hemispheric cups, (cup 1) 4 HA coated screw cups (cup 2) and 2 hemispheric press-fit porous-coated cups (cup 3)) (Fig. 1d and e). The rate of aseptic loosening was very high (51%) in cup 1, lower in cup 2 (30%) and low in cup 3 (10%). There were no obvious differences in mean time to loosening of the three cups (Table 1). Furthermore, 8 cups were revised due to polyethylene wear, with liner and head exchange. All revisions for aseptic loosening and liner wear are shown in Table 1.

One cup was revised due to a traumatic fracture of the acetabulum, and one cup was revised due to a deep infection at 13 postoperative years. Two cups were revised due to late onset dislocations with a proper acetabular cup exchange. At revision we used a porous coated hemispheric press fit cup, and in the fracture patient, bone transplant was used. Kaplan Meier curve with time to revision of acetabular cup is shown in Fig. 3. Survival of the cups was 97% at 7 years and thereafter gradually decreased to 56% at 20 years.

Radiographic analyses of the surviving and the revised cups revealed radiolucency in Zone I in one hip and in Zone III in three hips, but otherwise the cups showed bony incorporation as indicated by intimate bone-implant contact.

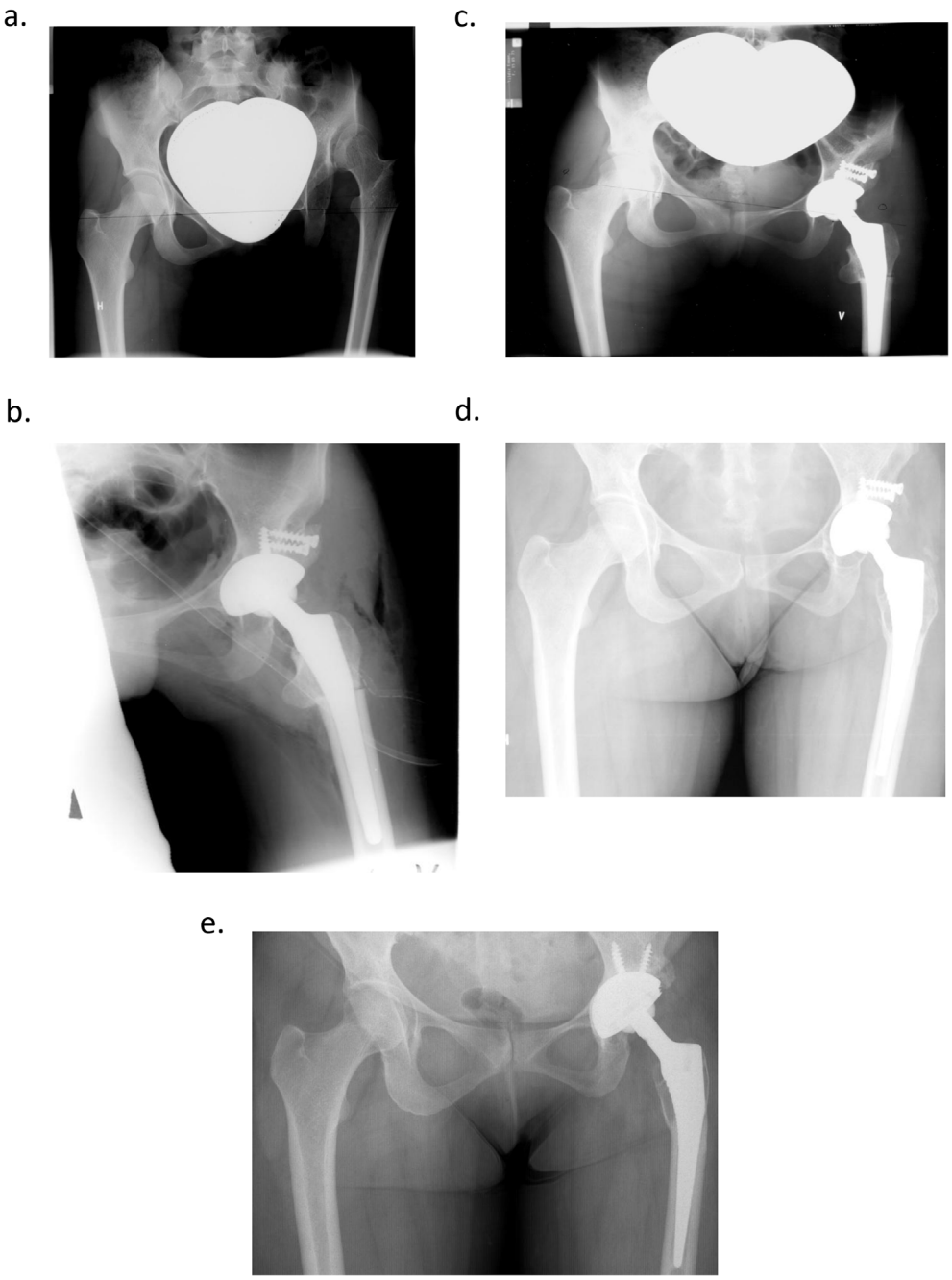


**Fig. 1. a.** Preoperative radiograph of woman 17 years old, showing high dislocation of left hip. **b.** Postoperative radiograph showing SSO and uncemented THA with HA-coated press fit cup (cup 1) in anatomical position. **c.** Radiograph at 6 postoperative months, showing unremarkable status of acetabular component and femoral stem. **d.** Radiograph at 9 postoperative years, showing loosening of acetabular component, osteolysis of the femoral metaphysis and stable bony ingrowth in the diaphysis. **e.** Radiograph 11 years after revision of acetabular cup, showing the porous coated press fit cup.

### *3.3. Functional outcome*

At the last follow up, 12 patients had a positive Trendelenburg test, and the mean leg length discrepancy was 1 cm (0–3). Mean HHS was 86 (81–90) for the unrevised hips and 87 (82–90) for those revised.

## 4. Discussion

In this study we followed a cohort of patients operated with uncemented THA and shortening femoral osteotomy for high dislocation for up to 30 years. In the majority of the cases we used an HA coated acetabular cup with a poor track record (cup 1),[16] resulting in a high rate of aseptic loosening. On the femoral side, however, we found excellent results.

Subtrochanteric shortening osteotomy is an approach that makes reduction easier, but can be associated with complications (nerve damage and nonunion at the osteotomy site) or compromise the long-term survival of the implants. We used a HA coated femoral stem with a rectangular shape for rotational stability and bony ingrowth. Extensive hydroxyapatite coating for fixation of a femoral stem was introduced more than 25 years ago to achieve durable biological fixation and preserve normal periprosthetic bone activity. Despite favorable experimental findings on HA coated stems,[17] there have been concern regarding its porosity and low fatigue strength, as well as degradation

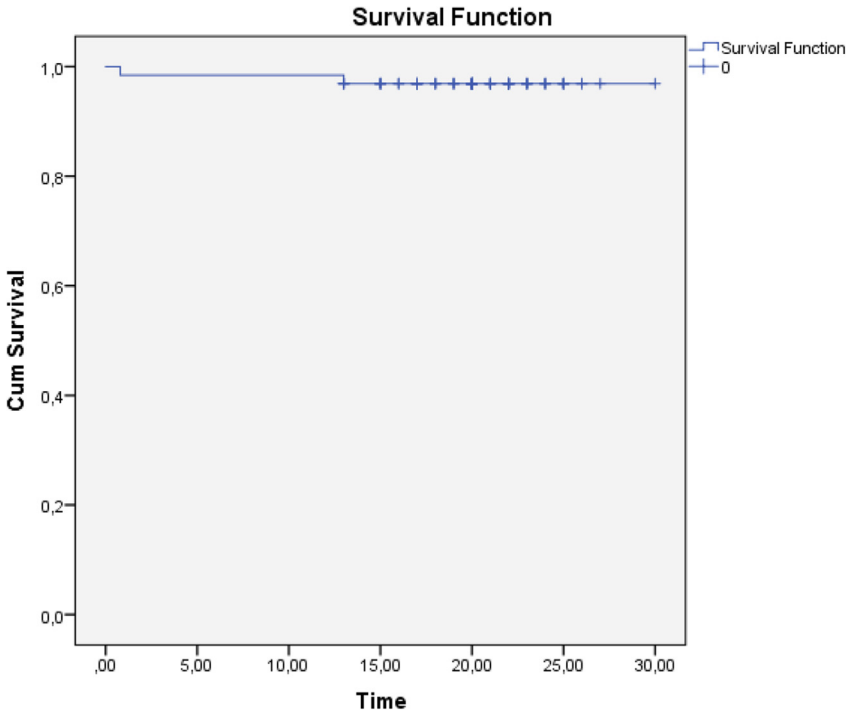


**Fig. 2.** Kaplan-Meier survival curve for femoral stem, with revision as endpoint.

**Table 1**
Revisions for aseptic loosening of acetabular cup and liner wear.

| | Cup 1 | Cup 2 | Cup 3 | Total |
|---|---|---|---|---|
| Aseptic loosening (N) | 17 | 4 | 2 | 23 |
| Years to revision | | | | |
| Mean | 12 | 14 | 11 | |
| Range | (7–17) | (7–17) | (10–12) | |
| Liner exchange (N) | 2 | 3 | 3 | 8 |

Cup 1, HA coated press-fit; Cup 2, Screw cup; Cup 3, Porous coated press-fit. N is number of cups.

and delamination of these implants in the long term. There has also been concern regarding loose HA particles inducing foreign body reactions with subsequent osteolysis and implant loosening. In a meta-analysis it was found that in the long-term HA-coated stems did better than porous coated stems for hip scores and survivorship for aseptic loosening.[18] A recent study has supported these favorable findings.[19] However, other findings do not support the use of HA coating to enhance implant survival of a femoral stem.[20] There are only a few reports on the survivorship of uncemented stems with a follow up of 20 years or more. Low rates of loosening have been reported in the late second and early third decades, and the question of how the HA coated stems will perform in the long term is still somewhat open. Will the coating be resorbed, leaving the implant stabilized in the bony bed with a certain risk of loosening, or will the HA coating remain in a stable site in relation to metal on one side, and bone on the other? Should the HA coating bond to bone in a stable situation, stress on the coating might induce underlying failure by delamination in the interface between the coating and the metal. If, on the other hand, the coating is resorbed, the fixation and stability of the implant must rely solely on bone-metal imbedding. Our study suggests that a fully HA coated stem can provide reliable results up to 30 years. There was a low degree of proximal bone loss and good preservation of diaphyseal bone. The absence of radiolucent lines in the diaphysis also suggests a comprehensive diaphyseal bonding at follow-up.

There are technical problems in fitting the components in an underdeveloped acetabulum in cases with high dislocation. Previous findings suggest that a high positioning of the cup leads to increased rates of loosening,[21] and observations indicate that the acetabular component should be placed in the true acetabular region.[3] Small implants are regularly needed with consequently thin liners. We mostly used a hemispheric, smooth cup coated with HA (cup 1) and we have previously reported a high rate of mechanical loosening of this cup in younger patients with OA, with a survival of 74% at 15 years.[22] When the coating is resorbed, the incorporation between smooth metal and bone fails. These findings were similar to other series of HA coated acetabular cups, where the survival rate decreased dramatically from 97% at 5 years to 46% at 15 years.[3,4,12] Our high rate of cup loosening, therefore, to a high degree, can be ascribed to inferior cup design of the smooth HA-coated cups. Furthermore, a high degree of polyethylene wear was caused by gamma-sterilization in air, causing oxidation and chain cutting of the polyethylene.[23]

Fracture and nonunion at the osteotomy site are common complications in femoral shortening osteotomy. Intraoperative fracture during insertion of the femoral component has been reported at a range of 5–22%.[4–6] We had no perioperative fractures with the use of prophylactic wiring. One patient underwent reoperation and bone transplantation after a year due to delayed union of the osteotomy, and one patient had a delayed union and a positive Trendelenburg gait. In another three hips, there were some migration of the greater trochanter segment previous to successful union of the osteotomy site, but only one experienced recurrent dislocations, and was treated successfully with change to a head with a longer neck.

Limb length discrepancy is one of the main problems in THA in hips with high dislocation. In bilateral cases, we aimed for a bilateral lengthening of 2 cm. In unilateral cases, we aimed to eliminate the patients leg length difference, often with a more aggressive lengthening of the affected leg, but not exceeding 3–4 cm. Estimating the optimal leg lengthening may be difficult peroperatively, and our estimations were primarily based on desired bone shortening in relation to preoperative templating. Sciatic neuropathy has been reported in patients in whom anatomic positioning of the acetabular cup was a major goal.[24,25] Postoperatively, we positioned the extremity with the hip

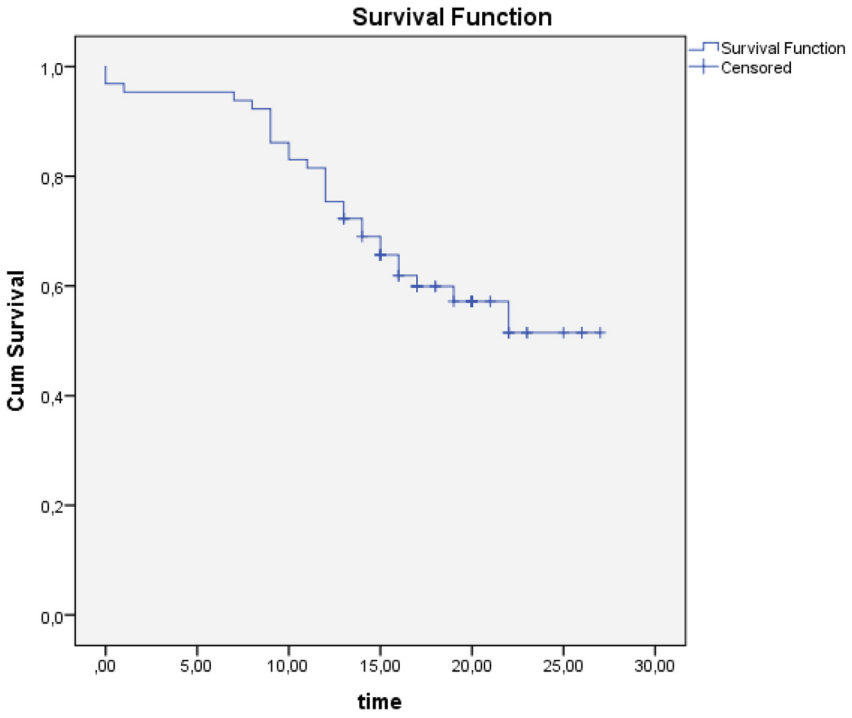


**Fig. 3.** Kaplan-Meier survival curve for acetabular cups with revision as endpoint.

extended and the knee flexed the first 24 h, to reduce tension on the sciatic nerve. Several preoperative risk factors for nerve injury at THA have been identified, including preoperative diagnosis of posttraumatic arthritis or high dislocation, use of a posterior approach, cementless fixation, and excessive limb lengthening.[26] The incidence of nerve injury is greater in difficult than in routine arthroplasties[24,25] and this may be caused by soft tissue adherence and perioperative nerve traction.

In the follow-up evaluations, we used HHS. In a previous study on THA in patients with high hip dislocation, the HHS was reported at mean of 84 with mean follow up of 12 years,[4] and the mean HHS was 89 after THA in younger patients with OA.[27] These results are similar to the mean HHS of 86 and 87 in our study.

There are limitations of our study. First, we had no control group. Second, the high rate of cup revisions may have turned high activity patients to low activity patients with less demand on the stem. Third, an acetabular implant later found to have an inferior long term survival was used in the majority of our cases. The strengths of our study were that no patients were lost to follow up, and a long follow up time.

## 5. Conclusion

Our study suggests that in patients with high hip dislocation, subtrochanteric shortening osteotomy with distal advancement of the trochanter segment provides a predictable adjunct to THA. The complication rate is elevated, compared to routine THAs, but complications resolve in most patients, and the patients have high mean functional score at long term. We found that a fully HA coated stem provided very good results for up to 30 years. Care should be taken in choice of acetabular cup, this would presumably reduce the high revision rate of the cup due to aseptic loosening.

## Conflicts of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Ethical approval

The study was in accordance with the ethical standards of the institutional research committee, the 1964 Helsinki declaration and its later amendments for this type of study a formal consent is not required.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2018.12.005.

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