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HIP

Uncemented total hip arthroplasty with a tapered titanium femoral component: a minimum 30-year follow-up

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Aims

The purpose of this study is to report our updated results at a minimum follow-up of 30 years using a first generation uncemented tapered femoral component in primary total hip arthroplasty (THA).

Methods

The original cohort consisted of 145 consecutive THAs performed by a single surgeon in 138 patients. A total of 37 patients (40 hips) survived a minimum of 30 years, and are the focus of this review. The femoral component used in all cases was a first-generation Taperloc with a non-modular 28 mm femoral head. Clinical follow-up at a minimum of 30 years was obtained on every living patient. Radiological follow-up at 30 years was obtained on all but four.

Results

Seven femoral components (18%) required revision, and none for septic loosening. Four well fixed stems were removed during acetabular revision and three were revised for late infection. One femoral component (3%) was loose by radiological criteria. The mean Harris Hip Score improved from 47 points (SD 4.62) preoperatively to 83 points (SD 9.27) at final follow-up. With revision for any reason as the endpoint, survival of the femoral component was 80% (95% confidence interval (CI) 61% to 90%) at 32 years. With revision for aseptic loosing femoral component, survival was 99% (95% CI 93% to 99%).

Conclusion

With regards to aseptic loosening, the Taperloc femoral component provides excellent fixation at a mean follow-up of 32 years.

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Keywords: total, hip, arthroplasty, long-term, results, uncemented

Introduction

Excellent intermediate-term results with use of tapered femoral components in primary uncemented total hip arthroplasty (THA) have been reported. These reviews have been published by several different authors originating from multiple centres. They are composed of diverse patient groups including the young, old, obese, and patients with Dorr type C bone.[1-4] The prevalence of aseptic loosening in several published series has ranged from 0 to 12%, at a mean follow-up of 16.6 to 25 years.[1-4] High patient expectation, active lifestyles, and longer life expectancies place extreme demands on prosthetic components. The question remains whether the low incidence of aseptic loosening reported using tapered femoral components at intermediate follow-up still applies at long term.

The Taperloc femoral component (Zimmer-Biomet, USA) was approved for use by the USA Food and Drug Administration (FDA) in 1983. We previously reported the results at a mean follow-up of ten[5] and 20 years with this device.[6] The original cohort consisted of 138 consecutive, non-selected patients (145 hips) operated on by a single surgeon at one centre. In our prior reviews, at a mean follow-up of ten years and 20 years

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Table I. Primary diagnosis.

Diagnosis	Patients, n	Hips, n
Osteoarthritis	14	14
Developemental dysplasia	11	13
Avascular necrosis	7	8
Rheumatoid arthritis	4	4
Trauma	1	1

Table II. Level of activity of the 30 patients (33 hips) who had not undergone stem revision.

Classification	Patients, n (hips)
Heavy manual labour	0 (0)
Moderate manual labour	6 (8)
Light labour	8 (8)
Semi-sedentary	15 (16)
Sedentary	1 (1)

the prevalence of femoral component revision for any reason was 4% and 12%, respectively. The incidence of revision for aseptic loosening was 1% at ten and 20 years. We now report our results in this cohort of patients at a minimum follow-up of 30 years.

Methods

Of 138 consecutive patients (145 hips) who underwent primary uncemented THA with use of the Taperloc femoral component between September 1983 and October 1985, 37 patients (40 hips) survived for a minimum of 30 years (30 to 37), and are the focus of this review. Our institutional review board approved the present study and informed consent was obtained from every patient. All surgeries were performed by a single surgeon at one centre. The cohort of 37 living patients (40 hips) consisted of 20 females (22 hips) and 17 males (18 hips). The mean age of the living patients at the time of surgery was 37 years (20 to 62). A total of 20 patients (22 hips) were aged under 50 years, and 17 patients (18 hips) were aged 50 years or older. The mean BMI of these patients was 28 kg/m^2 (23 to 39). The indication for primary THA was osteoarthritis in 14 hips (35%), developmental dysplasia in 13 hips (32.5%), avascular necrosis in eight hips (20%), rheumatoid arthritis in four hips (10%), and trauma in one hip (2.5%) (Table I). Among the 37 living patients (40 hips), seven had undergone revision of the femoral component (18%). In the 30 patients (33 hips) who had not required revision of the femoral component, complete clinical follow-up was obtained on every living patient at a minimum of 30 years. Radiological follow-up was obtained on 26 patients (29 hips) at a minimum follow-up of 30 years. Four elderly patients provided clinical follow-up, but declined repeat radiographs. Radiographs of all four of these patients had been obtained at a minimum of 25 years.

The first-generation Taperloc femoral component was used in all hips in this series (Figure 1). This implant is a non-collared stem is made of wrought titanium alloy (Ti-6Al-4v). The stem has a tapered rectangular shape designed to achieve fixation mediolaterally within the proximal aspect of the femur. The proximal 40% of the implant has a porous coating of the same titanium alloy applied by a plasma spray technique. All femoral components in this study were a monoblock design with a 28 mm articulating head.

Operative technique. All surgeries were performed by a single surgeon (WFK), using a posterolateral approach to the hip. The proximal femur was serially broached in 2.5 mm increments until a press fit was achieved. The rasping of the femoral canal was performed to match the native version of the proximal femur. The femoral component used was the same size as the last rasp. Antibiotics were administered preoperatively and continued for 48 hours following surgery. Anticoagulation consisted of warfarin administered orally the day of surgery, and continued for 30 days following surgery.

Clinical follow-up. One author (JRM), who was not the operating surgeon, performed the clinical evaluation with use of the same criteria that had been described in our previous reports. The Harris Hip Score (HHS)[7] was used to determine the functional level and to evaluate pain. Patients were specifically questioned about the presence of thigh pain. Activity level was evaluated by the classification of Johnston et al.[8] Heavy manual labour was defined as frequently lifting 23 to 45 kg or engaging in vigorous sports, such as singles tennis. Moderate manual labour indicated lifting 23 kg or less and involved in moderate sports, such as walking greater than 5 km. Light labour included heavy house cleaning, yard work, and walking less than 5 km. Semi-sedentary was defined as a white collar job or light housekeeping. A sedentary activity level indicated a minimum capacity for walking. Bedridden was determined as being confined to a wheelchair or bed.

Radiological follow-up. Radiological evaluation consisted of anteroposterior (AP) views of the hip and pelvis and a true lateral of the hip. These were compared with the radiographs taken immediately after operation and at all subsequent reviews. All radiographs in this study were read by an independent orthopaedic surgeon (JRM), who was not the operating surgeon. The femur was divided into the seven Gruen zones,[9] with the corresponding areas on the lateral radiograph. The presence of radiolucencies or osteolysis was assessed in each of the seven zones and recorded in increments of 0.5 mm. Progressive radiolucencies were identified and recorded. Radiolucencies with a scalloped or cystic appearance, or greater than 2 mm in width, were recorded as oseolysis.[10]

The stability of the femoral component was assessed by the criteria of Engh et al.[11] A component was defined

Fig. 1

Photograph of the first (left) and second (right) generation Taperloc femoral components. A non-modular implant was used in this series (left). An implant with a modular femoral head is in current use (right).

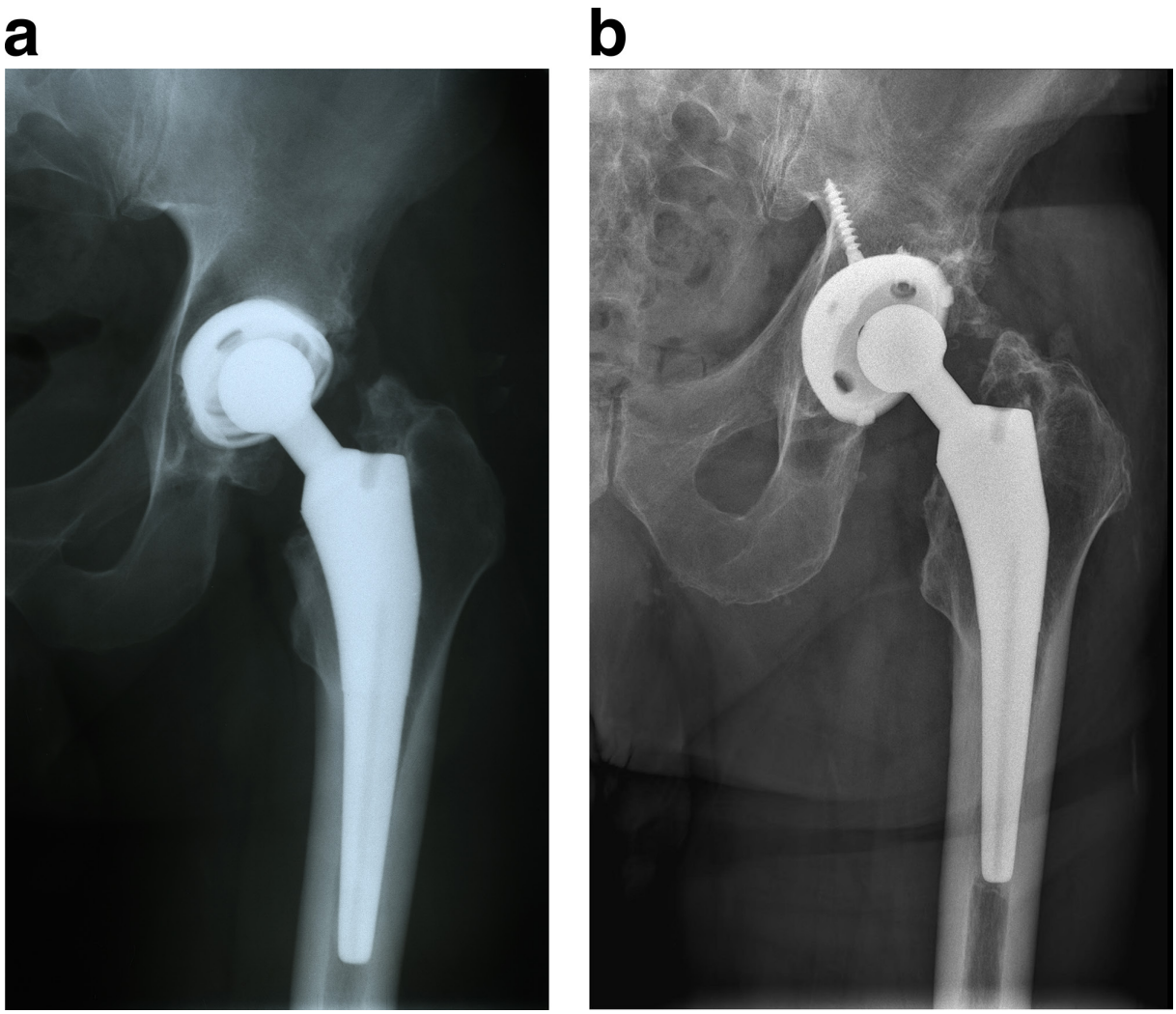


Fig. 2

Anteroposterior radiographs of the left hip taken at a) one month after primary total hip arthroplasty, and b) at 37 years.

as having fixation by bone ingrowth when there was no subsidence and minimal or no formation of a radio-opaque line along the porous-coated portion of the implant. Stable fibrous ingrowth occurred when an implant had no progressive migration irrespective of the presence of a radio-opaque line along the stem. Definitive femoral component loosening was defined as progressive migration of the implant. Subsidence of greater that 3 mm was required for this determination.

While not the focus of this review, we examined the acetabular components used in these patients. The prosthesis used in all cases was a conically shaped, threaded-ring titanium shell without porous coating (T-Tap; Zimmer-Biomet). Ultra-high molecular-weight polyethylene powder HiFax 1900 MG (HiMont, USA) was directly compression-moulded into the shell to form an articulating surface, 28 mm in diameter.

Statistical analysis. The Kaplan-Meier method was used to generate survivorship curves with corresponding 95% confidence intervals (CIs).[12] All 145 hips in this series were included in the survivorship analysis. The Fisher's exact test and multivariate logistic regression were used to determine the significance of the relationship between variables. The level of significance was set at $p \leq 0.05$.[13] All analyses were conducted with use of SAS (version 9.4; SAS Institute, USA).

Results

A total of 37 patients (40 hips) were alive at a minimum follow-up of 30 years required for this review. Seven patients (seven hips; 18%) had undergone femoral component revision. No femoral component was revised for aseptic loosening. Four well fixed stems (10%) were removed during acetabular revision, and three (8%) were revised for infection. The four femoral components, which were removed when revision of the acetabulum was required, were revised at seven, nine, 11 and 18 years after the initial operation. The three stems revised for

Table III. Comparative data on the 145 total hip arthroplasties in living patients and those who have died.

Variable	Living	Deceased
Patients, n	37	101
Hips, n	40	105
Femoral component	Taperloc	Taperloc
Femoral head size, mm	28	28
Surgical approach	Posterolateral	Posterolateral
Complications, n (%)	3 (8)	8 (8)
Femoral revision for any reason, n (%)	7 (18)	11 (10)
Femoral revision for aseptic loosening, n (%)	0 (0)	1 (1)
Hips without femoral revision, n	33	94
Age at time of surgery, yrs	37 (20 to 62)	67 (31 to 88)
Sex, n (hips)		
Males	17 (18)	49 (49)
Females	20 (22)	52 (56)
Mean duration of follow-up, yrs (range)	32 (30 to 37)	13.4 (0.5 to 29.8)
Mean preoperative Harris Hip Score (SD)	47 (4.62)	45.9 (12.58)
Mean postopeative Harris Hip Score (SD)	83 (9.27)	89.92 (5.20)
Classification according to Engh et al,12 **hips, n**		
Class 1	31	92
Class 2	1	2
Class 3	1	0
Osteolysis, n (%)	4 (14)	5 (4.7)

SD, standard deviation.

infection were explanted at six, 12, and 24 years. All three of these femoral components were found to be well fixed at the time of removal. Of the seven patients (seven hips) who had undergone femoral component revision, four were performed in patients aged less than 50 years at the time of initial operation, and three were performed in patients aged 50 years and older. With the numbers available, we could not identify an association between revision of the femoral component and age ($p = 0.343$), sex ($p = 0.421$), or BMI ($p = 0.833$). Although not the focus of this review, the acetabular components were evaluated. Overall, 83% of the acetabular components required revision surgery. This component has been discontinued by the manufacturer.

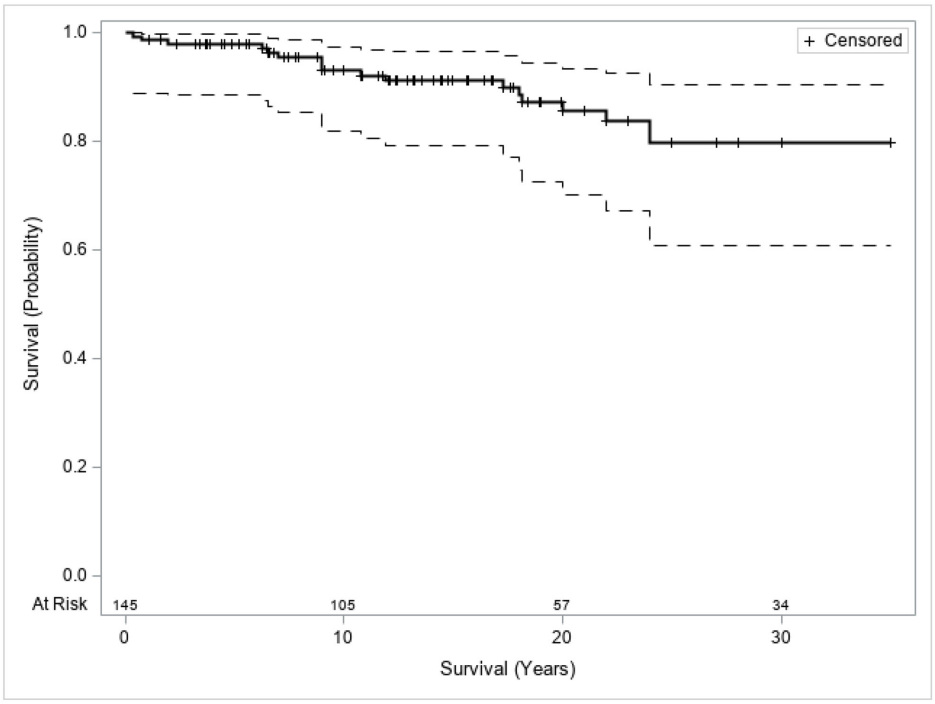
All 30 patients (33 hips) who had not undergone revision of the femoral component were evaluated clinically at a mean of 32 years (30 to 37). In these 30 patients (33 hips), the mean HHS improved from 47 points (standard deviation (SD) 4.62) preoperatively to 83 points (SD 9.27) at the time of last follow-up ($p < 0.001$). Thigh pain was not present in any hip. In the patients who were aged under 50 years at the time of initial surgery, the mean HHS was 83.7 points (SD 9.6). In the patients who were aged 50 years or older, the mean HHS was 80.1 (SD 6.3) At the time of last follow-up, no patients were engaged in strenuous manual labour; six patients (eight hips; 24%) were involved in moderate manual labour, eight patients (eight hips; 24%) were performing light labour, 15 patients (16 hips; 48%) were semi-sedentary, and one patient (one hip; 3%) was confined to a wheelchair. (Table II)

Perioperative complications occurred in three patients (8%). One patient sustained a postoperative dislocation that was treated with closed reduction and did not recur, one patient had treatment for a deep vein thrombosis, and one patient sustained a partial sciatic nerve palsy, which resolved spontaneously.

Radiological analysis. Radiographs at a minimum follow-up of 30 years were obtained on 29 of the 33 hips in living patients who had not undergone femoral component revision. (Figures 2a and 2b) Four elderly patients provided clinical follow-up but declined repeat radiographs. Radiographs previously obtained on all four of these patients at 25, 25, 27, and 28 years postoperatively had shown the femoral components to be well fixed. In the remaining hips, radiolucencies occurred in the porous coated region of the femoral component in seven hips (24%), most commonly in zone one. Radiolucencies in the non-porous coated region of the stem occurred in 12 hips (41%). Osteolysis was identified in four hips (14%). Major osteolysis occurred in only one hip (3%). Patients with osteolysis were significantly younger (mean age 27.0 years (SD 6.0) vs 45.2 years (SD 13; $p = 0.021$), and had significantly lower BMI (25.2 kg/m^2 (SD 2.0) vs 28.9 kg/ m^2 (SD 3.4; $p = 0.032$) at the time of implantation. There was no significant association between sex and osteolysis ($p = 0.999$).

In all, 27 of 29 femoral components were rated as having fixation by bone ingrowth. One hip (3%) subsided 4 mm in the first three months postoperatively and remained stable for the next 30 years and was rated as stable fibrous ingrowth. This patient had subsequently undergone revision of the acetabular component at 17 years post-index procedure. At the time of acetabular revision, the femoral component was found to be well fixed. One hip (3%) was loose. This hip was performed in a patient with bilateral lower limb paralysis secondary to polio. The hip arthroplasty had been performed for a nonunion of a femoral neck fracture. There was no association between femoral component loosening and age ($p = 0.999$), sex ($p = 0.999$), or BMI ($p = 0.999$), with the numbers available (Table III).

Overall, 101 patients (105 hips) died prior to achieving the minimum 30-year follow-up for this review. Of these, 11 (10%) femoral components had been revised. Seven (7%) well fixed femoral components were removed during acetabular revision at one, six, seven, nine, 18, 22, and 24 years postoperatively. Three (3%) femoral components were revised for late sepsis at two, 17, and 20 years postoperatively. The one femoral component revised for loosening was revised



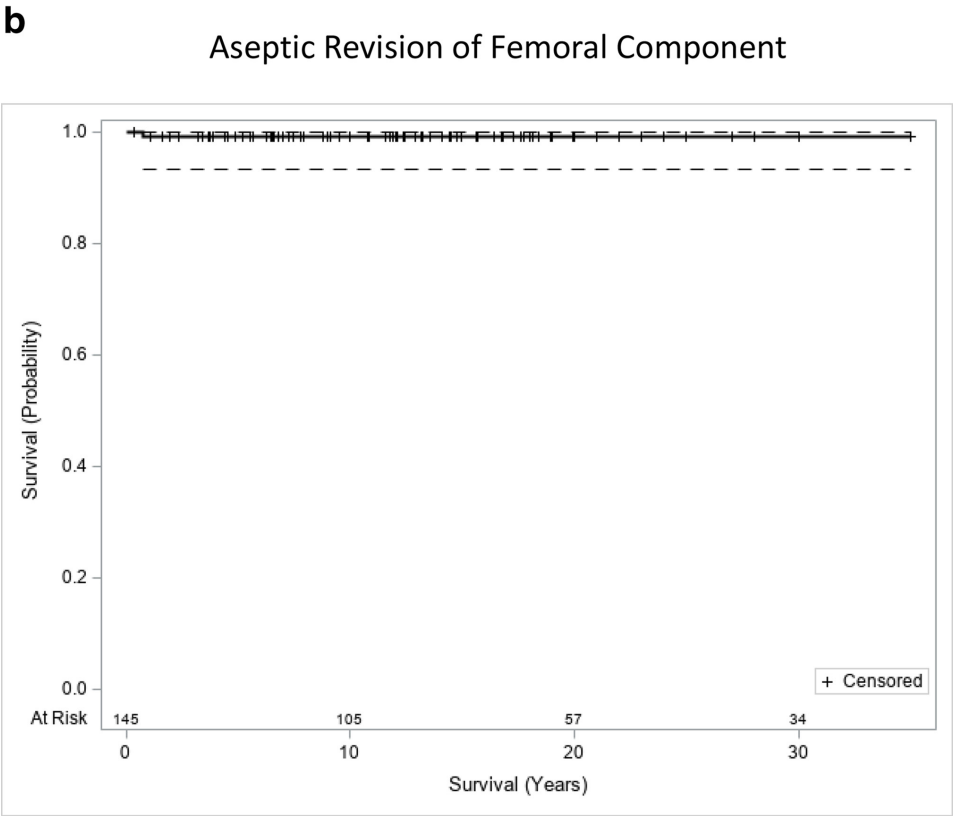


Fig. 3

a) Survivorship curve with 95% confidence intervals (CIs), as determined by the Kaplan-Meier method. With revision of the femoral component for any reason as the endpoint, Kaplan-Meier analysis demonstrates a survival rate of 80% (95% CI 61% to 90%) at 35 years for the entire series of 145 primary total hip arthroplasties. Patient deaths (censored) are depicted by the vertical lines on the graphs. b) Survivorship curve with 95% CIs, as determined by the Kaplan-Meier method. With revision of the stem for aseptic loosening as the end point, the 35-year survival rate was 99% (95% CI 93% to 99%). Patient deaths are depicted by the vertical lines on the graphs.

postoperatively secondary to an unrecognized intraoperative calcar fracture. The stem subsided 2 cm and was found to be grossly loose at the time of revision surgery.

Survival analysis. With revision of the stem for any reason as the end point, Kaplan-Meier analysis demonstrated a survival rate of 80% (95% CI 61% to 90%) at 35 years for the entire series of 145 primary THAs. With revision of the stem because of aseptic loosening as the end point, the 35-year survival rate was 99% (95% CI 93% to 99%). (Figures 3a and 3b)

Discussion

Approved by the US FDA in 1983, the Taperloc femoral component was one of the earliest cementless prosthesis authorized for use in primary THA. Although the component was a first-generation device, the porous coated region of the Taperloc has never been changed. Publications with a minimum follow-up of 30 years are rare. This study, to our knowledge, is the only review using the Taperloc femoral component with this duration of time. Compared to our previous reports at a mean follow-up of ten and 20 years, revision of the femoral component for aseptic loosening has remained stable. No additional femoral components had required revision for aseptic loosening, and no additional femoral components were judged to be loose by radiological criteria. Femoral component revision for any reason was increased with time. Five additional stems had been revised since our 20-year report. In each of these revision procedures, the stems were not loose. They were either removed because the non-modular femoral head obstructed surgical exposure during acetabular revision or due to late sepsis.

Strengths of this study include the long duration of follow-up. Complete clinical follow-up was obtained on every living patient at a minimum of 30 years. Radiological follow-up was obtained on all but four patients at a minimum of 30 years, and every patient at a minimum of 25 years. Limitations of this study include the death of 101 patients (105 hips) prior to obtaining a minimum 30-year follow-up. In each of these patients, the outcome of the femoral component with regard to revision versus retention of the stem was determined. Another limitation of this study was the use of a non-modular femoral component. The rate of revision for any reason with use of a monoblock stem was 18%. The current design of this femoral component has a modular head-neck junction. Our published rate of revision for any reason with the modular Taperloc stem was 3.2% at 22 years.[14] Revision for aseptic loosening was 0%. Similar results with a modular Taperloc stem have been published by Parvizi et al[15] at 11 years.

The most striking finding of this report was the low prevalence of aseptic loosening of the femoral component at a mean follow-up of 32 years. In the group of 40 hips that had been followed for a minimum of 30 years, no femoral component had been revised for aseptic loosening, and only one (3%) was loose by radiological criteria. In the entire cohort of 145 hips, only one femoral component (1%) was revised for loosening. Based upon these findings, we believe that the Taperloc femoral component can provide durable long term fixation in patients undergoing primary THA.

Take home message

- We followed 145 consecutive total hip arthroplasties (THAs) in 138 patients using the Taperloc femoral component for 37 years.
- In all patients, living and deceased, only one femoral component (0.7%) required revision for aseptic loosening, and only one (0.7%) was loose by radiographical criteria.
- These results demonstrate that the porous coated Taperloc femoral component provides exellent long-term fixation in patients undergoing primary THA.

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- M. A. Johnson: Data curation, Project administration, Writing – review & editing.
- K. R. Lee: Original data aquisition, Formal analysis, Writing, review and editing

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Data sharing:
- The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Ethical review statement:
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