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Intermediate-Term Radiographic and Patient Outcomes in Revision Hip Arthroplasty With a Modular Calcar Design and Porous Plasma Coating

Derek F. Amanatullah, MD, PhD,* John P. Meehan, MD,*
Aaron B. Cullen, MD, PhD,† Sunny H. Kim, PhD,* and Amir A. Jamali, MD*

Abstract: This study is a retrospective evaluation of the intermediate-term results of 26 consecutive revision total hip arthroplasties performed with a modular titanium, uncemented femoral component. The average patient age at the time of revision total hip arthroplasty was 72 years, and there were an equal number of males and females. The mean follow-up was 5.7 years (ranging from 4 to 11 years). No re-revision was necessary during this follow-up time. The mean Harris hip score improved significantly (preoperative and postoperative score was 50.7 and 89.6, respectively; $P < .001$). Postoperatively, Short Form 36 functional scores averaged 67.7 across 9 functional parameters. Our observed low revision rate and favorable patient-reported outcome scores support the continuous use of modular titanium, uncemented femoral components in revision total hip arthroplasty. **Keywords:** total hip arthroplasty, revision, modular femoral stem, plasma porous coating, patient outcome.

Revision total hip arthroplasty (THA) historically was initially managed with either long cemented or porous-coated monoblock femoral stems. Cemented revision THA yielded a loosening rate between 20% and 29% [1-3]. Modern cementing techniques have reduced the loosening rate to between 9% and 17% [4,5]. Impaction grafting, a technique that combines cement and morselized allografting to restore proximal femoral bone stock, has shown variable results. A high perioperative fracture rate has been reported with impaction grafting in multiple studies. Extensively porous-coated monoblock femoral stems have shown aseptic loosening rates of between 1% and 3% [6-8]. Hence, a long-stemmed, cementless, extensively porous-coated monoblock femoral stem is a viable and successful option for revision THA.

*From the *Department of Orthopaedic Surgery, University of California at Davis Medical Center, Sacramento, California; and †The Permanente Medical Group, Musculoskeletal Department, Sacramento, California.*

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Reprint requests: John P. Meehan, MD, Department of Orthopaedic Surgery, University of California at Davis Medical Center, 4860 Y Street, Suite 3800, Sacramento, CA 95817.

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In recent years, modular revision femoral stems have grown in popularity owing to their intraoperative flexibility when dealing with challenges of leg length, offset, and version. These implants traditionally relied on distal fixation (cylindrical or tapered) with some designs offering proximal load-bearing (calcar body) options. The addition of conical and milled options with porous coatings for the proximal body in these modular implants has allowed the surgeon to maximize fixation in both the metaphysis and the diaphysis of the compromised revision femoral bone. The potential for calcar load bearing, metaphyseal and diaphyseal scratch fit, and 3-point fixation (with curved stems) provides multiple initial stability points for the revision femur and maximizes the potential for osseous integration into the porous coating. We hypothesized that these multiple points of potential fixation provided by a porous-coated modular calcar body and stem prosthesis would allow its use in most revision femur scenarios, excluding only the most severe cases where both proximal and distal fixation (Paprosky type IV) would necessitate the use of a proximal femoral allograft or proximal femoral replacement prosthesis.

Methods

In this consecutive case series, the mean age of patients undergoing revision THA was 72 ± 12 years. The revision THAs were split equally between men and women. The average follow-up time since revision THA was 5.7 years (ranging from 4 to 11 years). Twenty-six revision THAs in 25 patients were performed using the Mallory-Head design over a 7-year period (1998-2005) at our institution with a follow-up time of 4 to 11 years. All revision THAs were performed by the same surgeon (blinded for review) through a posterolateral surgical approach. This study was performed with approval of the (blinded for review) institutional review board.

The Harris hip scores (HHSs) were calculated preoperatively and postoperatively during the first postoperative visit [9]. Regular postoperative evaluations with clinical and radiographic examination of the reconstructed hips were conducted, and the most recent radiographs for all 26 revision THAs were reviewed for signs of loosening [1]. In addition, a postoperative questionnaire was sent to all patients who received revision THA using the Mallory-Head design to collect Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and Short Form 36 (SF-36) functional scores. Fifteen (60%) patients replied to our survey, only 1 (4%) patient directly refused to participate in our study, and 9 (36%) patients simply did not reply to our mailing.

Statistical Considerations

For the comparison of changes in HHS patient-reported outcomes, a paired *t* test was conducted. It computes the difference between the 2 time points for each case and tests to see whether the average difference is significant from 0. All continuous data are reported as the mean with the corresponding error in standard deviation or standard error of the mean where applicable. All dichotomous data are reported as count and percent.

Results

There were 16 (62%) combined femoral and acetabular revisions and 10 (38%) isolated femoral revisions. The distribution of Paprosky femoral classifications at the time of revision was 0 cases (0.0%) with minimal loss of metaphyseal cancellous bone and an intact diaphysis (type I), 9 cases (34.6%) with extensive loss of metaphyseal cancellous bone and an intact diaphysis (type II), 10 cases (38.5%) with extensive loss of metaphyseal cancellous bone and more than 4 cm of intact diaphyseal bone for distal fixation (type IIIA), 5 cases (19.2%) with extensive loss of metaphyseal cancellous bone and more than 4 cm of intact diaphyseal bone for distal fixation (type IIIB), and 2 cases (7.7%) with extensive loss of metaphyseal and diaphyseal bone in conjunction with a widened femoral canal (type IV; Table 1) [10-12]. Four (15.4%) revision THAs involved 2-stage procedures for infection (Table 2). Three (11.5%) revision THAs were undertaken to repair periprosthetic fractures (Fig. 1 and Table 2). One revision THA was the result of a periprosthetic fracture in the setting of infection. The remaining 20 (76.9%) revision THAs were undertaken for aseptic loosening (Fig. 1 and Table 2). Twelve (46.2%) exposures required the addition of an extended trochanteric osteotomy.

Table 1. Distribution of Paprosky Classifications Before Revision THA

Paprosky Classification	No. of Cases (%)
Type II	9 (34.6)
Type IIIA	10 (38.5)
Type IIIB	5 (19.2)
Type IV	2 (7.7)
Total	26 (100)

Twenty-six (100%) revision THAs were considered successful and with re-revision–free survival at latest follow-up. There was 1 (3.8%) reoperation for infection, which was controlled with surgical debridement, retention of the prosthesis, and suppressive antibiotics. Two (7.7%) stems had early radiographic subsidence of 6 and 8 mm, but these have not progressed and the patients are asymptomatic. One of these patients (8 mm subsidence, juvenile rheumatoid arthritis) has a pedestal formation at 2 years but remains asymptomatic. One (3.8%) stem had early trochanteric escape of 1 cm, which is now healed. One patient (3.8%) developed heterotopic ossification, Brooker grade III. One patient died at the time of reporting this case series because of myocardial infarction and respiratory failure unrelated to his revision THA. There were no postoperative dislocations in this series.

The mean HHS preoperatively was 50.7 ± 14.4. The mean postoperative HHS was 89.6 ± 8.8. This increase was statistically significant (paired *t* test, $P < .001$). Fifteen patients responded to our postoperative WOMAC and SF-36 surveys. Within that group, the mean WOMAC was 21.0 ± 18.7 and the mean SF-36 score averaged across the 9 functional parameters was 67.7 ± 4.6.

Discussion

There have been no clinical studies demonstrating an improvement in clinical or patient-reported outcomes prospectively comparing a nonmodular cementless revision femoral implant and a modular cementless revision femoral implant. Yet, modular cementless femoral implants offer considerable intraoperative flexibility during revision THA when compared to

Table 2. Indications for Revision THA

Indication	No. of Cases (%)
Aseptic loosening	20 (76.9)
Infection	4 (15.4)
Fracture	3 (11.5)

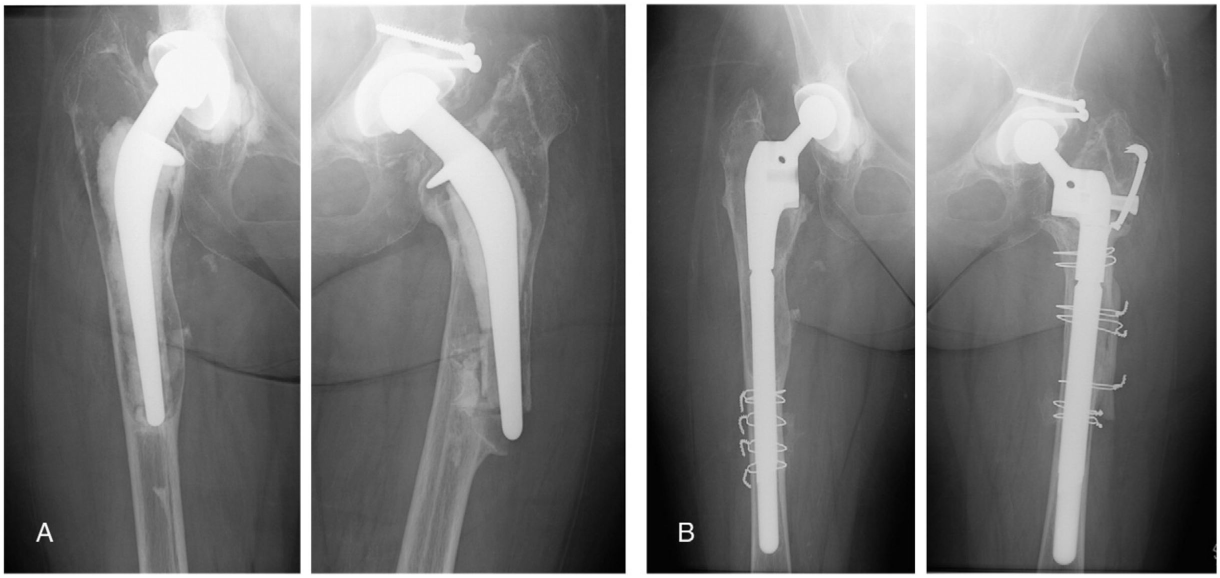

Fig. 1. (A) Anterior-to-posterior radiographs of a 77-year-old patient before revision THA of her left femoral component for periprosthetic fracture after a ground level fall and her right femoral component 1 year later for aseptic loosening. (B) Postoperative anterior-to-posterior radiographs 3 years after revision THA on her left and 2 years after revision THA on her right.

nonmodular cementless femoral implants. Modular cementless femoral implants allow the surgeon to establish optimal intraoperative implant stability and fixation, as well as adjustment of proper leg length, offset, and anteversion [13-15]. However, this flexibility is balanced by the concern for the security and wear of additional metal-metal connections, the potential for increased metallic wear debris, as well as the overall ability of the construct to maintain long-term anatomic stability and function [15-19]. Retrieval analysis on modular stems has shown that fretting and corrosion at the stem-sleeve or stem-body junction are present in 67% of the implants retrieved [20]. However, although 10% of the retrieved implants had damage, only 3% of the retrieved implants had severe damage leading to structural failure [20]. Despite these data, concerns regarding modularity, although pertinent and apparent, have not proven to be clinically relevant [15,21,22].

Modular femoral implants with proximal and distal porous plasma coating combine the benefits of scratch fit and osseous integration allowing for fewer problems with distal stress shielding, high survivorship between 97.3% and 99.9%, as well as low revision rates between 1% and 3% [23-28]. Calcar-replacing designs have been shown to achieve similar results to distally fixed femoral stems while avoiding the proximal stress shielding and decrease in calcar and cortical bone density [29,30]. For the stem used in this study, multiple coats of porous titanium alloy are raised high off the implant surface to provide the scratch fit that allows for initial implant stability by scratching the femoral canal, while providing noninterconnected pores varying in size from 100 to 1000 μm that allows for optimal osseous integration and reduction of clinical osteolysis [23,25,28].

There are several pertinent limitations to this study. This is a small single-surgeon case series with a low response rate to mailed survey questions. The significance of the WOMAC and SF-36 scores was clearly affected by the 60% response rate as well as by the variability in time since revision THA. However, based on our experience, this response rate is indicative of our highly mobile patient population, and we have no reason to believe that it is suggestive of a nonrandom exclusion as a result of poor or excellent outcome. Nonetheless, we must acknowledge that there may be sampling biased introduced by the variable return of our survey. This low sample size affects our ability to approximate the correct functional outcome scores. In addition, WOMAC scores correlate with the radiographic severity of osteoarthritis and joint range of motion but can be confounded by fatigue, symptom count, depression, and low back pain [31,32].

Despite these limitations, our observed low rate of radiographic loosening and re-revision as well as favorable patient-reported outcome scores supports the use of modular, uncemented, titanium femoral components in revision THA. The description of successful revision THA systems is especially pertinent in light of the predicted exponential rise in the revision THA burden in the United States [33].

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