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Reproducible fixation with a tapered, fluted, modular, titanium stem in revision hip arthroplasty at 8–15 years follow-up

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ABSTRACT

The use of tapered, fluted, modular, distally fixing stems has increased in femoral revision surgery. The goal of this retrospective study was to assess mid-term to long-term outcomes of this implant. Seventy-one hips in 70 patients with a mean age of 69 years were followed for an average of 10 years. Preoperative HHS averaged 50 and improved to 87 postoperatively. Seventy-nine percent hips had Paprosky type 3A or more bone-loss. All stems osseointegrated distally (100%). Two hips subsided >5 mm but achieved secondary stability. Sixty-eight percent hips had evidence of bony reconstitution and 21% demonstrated diaphyseal stress-shielding. One stem fractured near its modular junction and was revised with a mechanical failure rate of 1.4%. Distal fixation and clinical improvement were reproducibly achieved with this stem design.

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Over the past two decades, arthroplasty surgeons have been met with an increasing burden of revision total hip arthroplasty (THA) [1,2]. Obstacles to restoring clinical function in revision surgery include general debility, compromised soft-tissue envelope, as well as muscular and bony deficiency. Paramount to functional restoration is implant fixation, so as to achieve proper load transfer. Severe bone-loss in the setting of femoral revision surgery creates a challenge in achieving adequate fixation in host bone. Extensively porous-coated, monolithic, cylindrical, cobalt–chrome stems and tapered, fluted, modular, titanium (TFMT) stems have been successfully used for femoral revisions [3–17]. Sporer and Paprosky [18] have demonstrated that, with increasing severity of bone loss, femoral fixation is less reliably achieved with extensively porous-coated, monolithic, cylindrical, cobalt–chrome stems. TFMT stems are being used with increasing frequency in femoral revisions with bone loss. Promising outcomes have been reported by a number of authors [10–17]. A survival rate of 94% to 98% has been reported by studies with a minimum follow-up of 5 years [14,17]. Another study reported a 91% prosthetic survival rate at an average follow-up of 8 years [13]. The potential for implant fracture at the modular junction has raised concerns about the long-term survivorship of TFMT stems in hips with deficient proximal bone stock [17,19]. The goal of this study was to assess clinical function, durability of fixation and implant survivorship at 8–15 years follow-up with a particular design of TFMT stem in femoral revision with bone-loss.

Materials and Methods

After institutional review board approval, medical records of all patients undergoing femoral revision at 2 institutions between 1998 and 2005 by 5 surgeons were reviewed. Cemented stems, proximal fixation stems and extensively porous-coated, monolithic, cylindrical, cobalt–chrome stems were excluded. Ninety-two patients (94 hips) were treated with a TFMT distal fixation cementless revision stem during the study period. Attempts were made to contact each patient by telephone and certified mail. Twelve patients (13 hips) had died and 3 patients (3 hips) were lost to follow up before a minimum 8-year follow-up. None of the deaths were related to complications resulting from their revision THA. We were able to contact the next-of-kin of 10 out of 12 deceased patients who confirmed that these patients had no hip-related problems at the time of death. Seven patients with 7 well-functioning hips either had incomplete records or refused to follow-up and were excluded from final analysis. The remaining 70 patients with 71 revision hips (one patient had both hips revised) formed our study cohort. The follow-up time was a mean of 10 years (range 8 to 15 years). There were 38 (53%) females

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and 32 males (47%) with a mean age of 69 years (range 40 to 91 years) at the time of revision THA. The involved side was the right in 39 hips and left in 32 hips. The indication for surgery was aseptic loosening in 53 (75%) hips (46 cemented and 7 cementless stems), management of femoral periprosthetic fracture (Vancouver B2 or B3) in 10 (14%) hips and reimplantation following treatment for periprosthetic sepsis in 8 (11%) hips. Sixty-seven hips had a previous THA and 4 had a hemiarthroplasty. All hemiarthroplasties were converted to THA during the revision procedure.

Surgical Technique

One of the 5 senior authors performed the surgical procedures. Pre-operative planning was performed to identify the site of optimal bone fixation, and plan the exposure and implant dimensions, as previously described [10]. All hips were exposed through a postero-lateral approach. An extended trochanteric osteotomy (ETO) [20] was used in 31 hips (44%) to facilitate removal of previous femoral component and/or cement. Debridement of the femoral canal was performed to remove all cement, fibrous and granulation tissue. Thorough synovectomy was performed to diminish the particle burden, and halt the osteolytic process. The acetabular component was concomitantly revised in 40 hips (56%), whereas 31 hips (44%) received an isolated liner exchange. The Link MP reconstruction stem (Waldemar Link, Hamburg, Germany) without hydroxyapatite coating was used in all hips. This is a tapered, fluted, modular, titanium, cementless stem designed for distal fixation. The corundum blasted stem surface has a roughness of 70 microns (μm). The "distal segment" or "stem segment" of the implant has a 2-degree taper angle, a 3-degree bow and is available in varying lengths and diameters, with "proximal segment" or body segment" options to vary implant version, offset, neck-shaft angle, as well as leg length through 10 millimeter (mm) modular spacers. Before reaming was initiated, a prophylactic cerclage cable was placed distal to the ETO site to minimize the risk of fracture propagation distally. Intra-operatively, a mini-C-arm was used routinely to assess the reaming process with regards to endosteal contact, bypass of stress risers and protecting against anterior cortical perforation. Reaming was performed by hand and not power. Once the extent of contact was thought optimal, the actual implant was inserted. The proximal bone was then prepared for the proximal component, adjusting version, offset and length to maximize stability and soft tissue tension. The ETO was repaired with 2–4 cerclage cables. Strut-grafts or impaction grafts were not used in any of the hips. In one hip, proximal femoral allograft was used.

Postoperatively, all hips receiving an ETO were allowed toe-touch weight-bearing for 6 weeks followed by full weight-bearing. Additionally, patients with an ETO were advised against active abduction exercises for 6 weeks. Hips without an ETO were allowed immediate full weight-bearing. All patients received posterior hip precautions (flexion, adduction and internal rotation) for 6 weeks. Patients were advised to follow up with their surgeon at 6 weeks, 12 weeks, 1-year and annually thereafter. Clinical and radiographic data were obtained during these office visits.

Medical records were reviewed to collect data on pre-operative and most recent clinical examination, intra-operative findings, and complications. Clinical evaluation was performed by the operating surgeon at each visit and outcomes recorded using the Harris Hip Score [21]. Radiographic evaluation was performed with an antero-posterior view of the pelvis and of the hip to include the entire implant, along with a so-called false-profile view [22]. Serial radiographs were evaluated by two independent observers not involved in the clinical care of patients to assess temporal changes over time. The most recent radiographs were compared to the initial post-operative radiographs in order to evaluate changes in implant position and bony remodeling. The degree of bone loss was assessed using the classification of Della Valle and Paprosky [23], based on pre-operative radiographs along with the intra-operative findings. Postoperatively, implant migration was assessed by measuring the vertical subsidence of the femoral stem, according to the method of Callaghan et al [24]. In hips where the greater trochanter could not be used as a fixed bony point, the lesser trochanter was used as described by Malchau et al [25]. If this was not possible, any other fixed point on the femur (eg. cerclage cable) was utilized. Subsidence of 5 mm or more was considered significant. A spot-weld was defined as new bone bridging the endosteum and porous surface of the implant. The development of spot-welds at their characteristic locations was noted as previously described for this implant [26]. Restoration of the proximal part of the femur was classified according to Kolstad et al [27], either as definite, possible or absent bony reconstitution. Stress shielding was defined as an area of diminished cortical radio-density between 2 areas of spot-welds. Osseointegration was assessed as previously described [26]. This system is a modification of the Engh et al [28] criteria of osseointegration (developed for extensively porous-coated cylindrical stems) made applicable to TFMT stems. A stem was considered distally osseointegrated if there was no progressive subsidence, absence of radio-opaque lines along the distal fixation segment of the implant with or without presence of endosteal spot-welds.

Statistical Analysis

Descriptive statistics, including the mean, standard error (SE) and Kaplan–Meier survival analyses were performed. SPSS software, version 16, was utilized (Predictive analytics Co, Chicago, Il).

Results

Clinical Results

Pain and function improved in all patients after the revision procedure. Pre-operative Harris Hip Score averaged 50 (range 22 to 73) and improved to an average of 87 (range 63 to 99) at last follow-up. The Harris Hip Score improved an average of 37 points (range 13 to 58). At last follow-up, 51 (73%) patients were able to ambulate without walking aids, 15 (21%) used a cane, and 4 (6%) used a walker to ambulate. Clinically, leg-length inequality averaged 5 mm longer on the revision side (−5 to +12 mm).

Radiographic Results (Fig. 1)

Pre-operative femoral bony deficiencies were classified as type 2 in 15 hips (21%), type 3A in 31 hips (44%), type 3B in 23 hips (32%), and type 4 in 2 (3%) hips. Subsidence of >5 mm occurred in 2 hips (6 mm and 10 mm; mean 8 mm) with a subsidence rate of 2.8 %. In both hips, subsidence occurred within the first 6 weeks of full-weight bearing and each of these stems remained stable thereafter. Of 2 subsided stems, bone loss was 3A (1 hip) or 3B (1 hip) and both hips had an associated ETO. Both stems achieved secondary stability and demonstrated evidence of osseointegration at most recent follow-up.

None of the hips had radiolucent lines around the "distal segment" or "stem segment" of the implant, however, 27 hips (38%) had partial or circumferential radiolucent lines around the "proximal segment" or "body segment" with no compromise on distal fixation. All stems demonstrated spot-welds by the end of third year follow-up. These spot-welds were most commonly seen at the distal end of the stem, followed by the modular junction as described in a previous study [26]. At last follow up, all 71 stems (100%) had distal spot-welds and 57 stems (80%) had spot-welds involving the shoulder of the "stem segment," just distal to the modular junction.

Bony reconstitution of the femur was observed in majority of the hips and was classified as definite reconstitution in 48 hips (68%), possible reconstitution in 5 hips (7%) and absent in 18 hips (25%). Fifteen hips (21%) showed an area of diaphyseal stress-shielding between the proximal and distal spot-welds and 3 hips had proximal