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Risk Factors for Subsidence of a Modular Tapered Femoral Stem Used for Revision Total Hip Arthroplasty

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ABSTRACT

The purpose of this study was to determine the incidence, and the clinical and radiographic risk factors for significant subsidence of a cementless, modular tapered revision femoral stem. Femoral stem subsidence of at least 10 mm or subsidence requiring revision was considered significant subsidence. Ninety-seven patients (99 hips) were included with minimum radiographic follow-up of one year (mean 34 months; range, 12–91 months). The mean stem subsidence was 4.5 mm (range, 0–44 mm). Fourteen out of 99 (14.1%) stems had significant subsidence and 6 (6.1%) stems required revision due to subsidence. Patient weight greater than 80 kg ($P = 0.04$) and femoral stem press-fit distance of less than 2 cm ($P < 0.01$) were both independent risk factors for significant stem subsidence.

One of the major challenges of revision hip surgery is bone stock deficiency in the proximal femur [1]. There are numerous surgical options available to deal with this difficult clinical scenario, such as circumferentially coated cylindrical or tapered stems for distal fixation, proximal femoral arthroplasty endoprostheses, proximal femoral allograft (PFA) composites, or impaction grafting [2,3]. A cementless prosthesis that achieves distal fixation in the femoral diaphysis is a very good option when there is reasonable diaphyseal bone stock [4]. Total hip arthroplasty (THR) revision using a tapered, gritblasted femoral stem to achieve femoral diaphyseal fixation has had good clinical results [5–9]. A tapered femoral stem will effectively wedge itself into the femoral diaphysis with axial loading, thereby achieving better fixation in a short femoral diaphysis as compared to a cylindrical femoral stem design [10]. Splines are added to the tapered stem to provide rotational stability. Stem subsidence, however, is still a problem that may occur with these tapered revision stems [9–11]. Subsidence may lead to leg length inequality, hip instability, and pain, and may ultimately necessitate repeat femoral revision surgery.

The incidence of subsidence for non-modular tapered femoral revision stems prior to osteointegration has been reported to be 15% to 20% [7,12–14]. New designs of tapered prosthesis have included proximal body modularity that allows for intraoperative adjustments to body size and length, neck offset, and femoral version [15]. Initial distal stability may be achieved first with the stem and then adjustments to overall length, femoral version and femoral offset may be made with the selection of the appropriate proximal body. Although modular prostheses have gained popularity over the past decade, there has been no consistent data in the literature to demonstrate improved outcomes of subsidence with modular revision stems compared to non-modular prosthesis. Reported rates for subsidence of modular prostheses have been between 0% and 43% [9–11,16–18].

The purpose of this study was to report on the incidence of significant subsidence of a modular tapered femoral revision stem and to determine clinical and radiographic risk factors for significant stem subsidence.

Materials and Methods

We reviewed charts and radiographs from 128 patients (130 hips) who underwent a revision THR using the modular ZMR Hip Revision System (ZMR, Zimmer, Warsaw, Indiana, USA) (Fig. 1) with the distal tapered stem at our institution between August 2004 and May 2011. This revision system has the option of using a distal tapered stem with a roughened titanium surface and sharp splines to provide rotational stability [19]. According to the manufacturer, the 3.5° taper geometry over the distal 105 mm of the stem promotes axial load transfer and resistance to subsidence, while the 0.75 mm splines provide rotational stability. Three distal tapered stem lengths are available: 135, 185, and 235 mm. The indication for using this femoral stem was hip revision surgeries with poor proximal femoral bone stock and an intact femoral diaphysis. This was a retrospective study and Institutional Research Ethics Board approval was obtained before initiation of the study.

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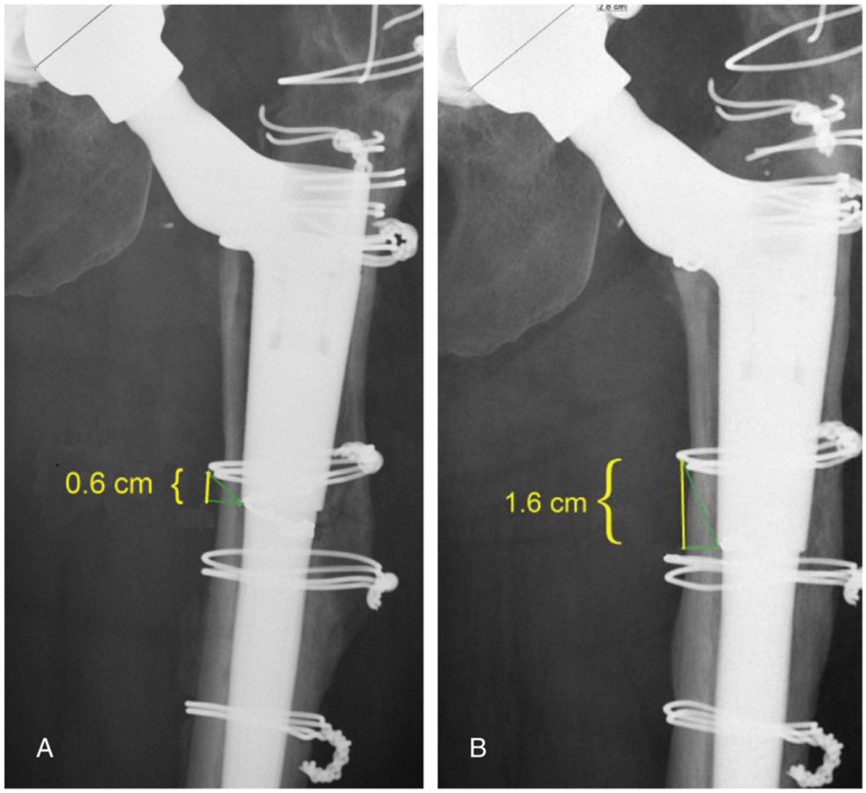

Fig. 1. (A) Immediate postoperative radiograph; (B) same patient one year later showing stem subsidence of 1 cm.

The following information was collected from a retrospective review of patient records: age, gender, weight, contralateral hip arthroplasty, previous infection, type of femoral bone loss, type of bone graft used, type of proximal body, taper stem diameter and length, pre-operative and intra-operative periprosthetic fracture. Any hip related postoperative complications including infection, revisions of the prosthesis, and re-operation for any reason were recorded for a minimum of one year post-operatively.

From the 128 patients identified for review, 28 were excluded from the study because there was less than one year of radiographic follow-up (4 patients died and 24 were lost to follow-up). Three patients who underwent proximal femoral allograft (PFA) using the ZMR distal taper stem were also excluded. Therefore, the total number of patients included in this study was 97 (99 hips), 50 females and 47 males. Average follow-up was 34 (range, 12–91) months. The mean age of the patients at the time of surgery was 62 years (range, 29–91 years). Fifty-five (56%) revisions were performed for aseptic loosening, 18 (18%) for septic loosening (second stage revision), 17 (17%) for periprosthetic fractures, 5 (5%) for stem fracture and 4 (4%) for instability. The classification by Saleh et al [20] was used to assess bone deficiency of the proximal femur (Table 1).

Surgical Technique

All patients were positioned in the lateral decubitus position and the surgical exposure used was generally determined by the femoral stem to be removed. A transgluteal approach was used when the stem was definitely loose. A modified trochanteric slide was used when there was a proximal coated stem that was likely not loose. An extended trochanteric osteotomy (ETO) was used when there was a solid fully porous coated stem and/or a cemented stem.

Surgical exposure was an extended ETO in 36 (36%), a modified trochanteric sliding osteotomy in 58 (59%) and a direct lateral approach in 5 (5%). The previous femoral component was a cementless stem in 41 (42%), a cemented stem in 37 (37%), a cement spacer in 18 (18%) and an excision arthroplasty in 3 (3%). We used a standard junction design (ZMR Crossover) in 44 (44%) cases and an extra large junction design (ZMR XL) in 55 (56%). Stem lengths were 135 mm in 21 (21%), 185 mm in 42 (43%) and 235 mm in 36 (36%).

Sequential flexible reamers followed by rigid tapered reamers were used to prepare the femoral canal. Flexible reamers were used to re-establish the femoral canal. This was especially important if there was a large bony pedestal or cement had been used previously. Reaming with the rigid tapered reamers was always done using power and was performed until there was significant resistance (often enough to stop the power reamer) and there was bone packed within the flutes of the reamer. Prophylactic wires were used about half of the time; however, reaming was aggressive even when they were not used. Intraoperative anteroposterior (AP) and lateral femur radiographs with the trial component in place were obtained for all cases to rule out periprosthetic fractures or perforations, as well as to confirm the appropriate diameter and length of the stem. The definitive femoral stem was impacted with reasonable force until it would no longer advance within the femoral canal. The femoral stem's bevel was placed anteriorly to prevent impingement on the anterior cortex of the femoral canal. The proximal body was assembled with the definitive stem in place.

Patients were seen in clinic at 6 weeks, 3 months, 6 months, one year and then on a biennial basis thereafter. Patients were touched weight

Table 1
Proximal Femoral Bone Deficiency for Study Hips According to Classification by Saleh et al [20].

Type	Description of Classification Type	Hips (%)
Type I	Femoral revision involves no significant bone loss	0
Type II	Represents contained loss of proximal bone stock with thinning of cortices	45 (45.5%)
Type III	Deficient bone loss is segmental, involving the lesser trochanter and calcar, shorter than 5 cm	45 (45.5%)
Type IV	Segmental loss of bone stock greater than 5 cm into the diaphysis defects	1 (1.0%)
Type V	Represent a periprosthetic fracture with circumferential loss of bone stock proximal to the fracture	8 (8.1%)