Stability of a Tapered Femoral Stem in Total Hip Arthroplasty using Radiostereometric Analysis

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Introduction: Implant stability is an important factor in the long-term success of total hip arthroplasty (THA). Radiographic analysis of early micromotion of the femoral component at two years may be predictive of ultimate clinical failure of the prosthesis due to symptomatic aseptic loosening. In order to characterize early radiographic micromotion between the bone-stem interface, previous studies have determined threshold values of stem subsidence predictive of later aseptic failure. One report showed that subsidence of a cemented stem greater than 2.6mm at two years resulted in a 95% failure rate (1). Another study found that stem migration that stabilized within the first 1-2 years did not proceed to clinical loosening or revision surgery (2). All of these studies measured subsidence using conventional radiographic techniques. Radiostereometric Analysis (RSA) provides precise measurements of micromotion of the stem relative to the femur that are otherwise not detectable by measurement of routine radiographs in the early postoperative period. Clinically, RSA’s capacity for detecting very small amounts of component micromotion became a reliable tool, enabling clinicians to accurately predict, at two years, the long-term clinical success or ultimate revision of THAs. This prospective randomized protocol aimed to characterize micromotion of tapered femoral stems in young, active recipients of primary, cementless THA at 5 years follow-up using RSA.

Methods: Forty-six patients (27 women and 19 men, mean age 58), with a diagnosis of osteoarthritis or avascular necrosis, were enrolled in this prospective randomized study approved by the Institutional Review Board. All patients received a proximally porous-coated titanium alloy tapered cementless stem (M/L Taper, Zimmer, Warsaw, IN) with standard offset and a 28mm femoral head. The manufacturer attached three tantalum markers to the stem, two proximal along the medial and lateral borders of the stem and one at the distal tip, for the purposes of monitoring stem migration using RSA. Additionally, tantalum beads (1.0 mm diameter) were inserted into the bone surrounding the stem and in the periphery of the polyethylene liner. All patients were randomized to receive either a highly cross-linked (Longevity, Zimmer) or conventional ultrahigh molecular weight polyethylene liner (Zimmer) in a hemispheric non-cemented acetabular cup. RSA and plain radiographs as well as clinical examinations were performed at 2 weeks, 6 months, 1, 2, 3, 4 and 5 years postoperatively. Patients were evaluated preoperatively and at each subsequent follow-up point with standardized patient-reported health assessment questionnaires: Harris Hip Score, UCLA Score, Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index, and SF-12. Double examinations were conducted at least once during the follow-up for each patient to assess the precision of the RSA measurements defined by the 95% confidence interval. The nonparametric Wilcoxon signed-rank and Mann-Whitney tests were used to determine differences in stem migration over time and differences in stem migration between the conventional and the Longevity™ polyethylene groups, respectively (p≤0.05).

Results: Patients have annual RSA analyses through five years, with limited exclusions due to technical shortcomings. The y-axis subsidence of this cementless titanium tapered stem was greatest in the first six months and stabilized thereafter with minimal further micromotion. The median stem subsidence was 0.01 ± 0.06 mm (standard error, SE) at five years (Figure 1). There was a statistically significant difference in subsidence between the 6-month interval and the 5-year interval (p = 0.027). The median rotational micromotion of the femoral stem was -0.14 ± 0.14 degrees at five years. There was no statistically significant difference among any of the time intervals in the rotation of the stem. The Mann-Whitney test also determined that there was no statistically significant difference in stem subsidence between the conventional polyethylene group and the longevity polyethylene group. All patients had a statistically significant improvement in pain and function measures following THA (p <= 0.05). Within this cohort, two patients were outliers and had significantly higher stem subsidence values than average at 6 months. One stem stabilized at 0.7 mm of subsidence after 6 months, and the other stem subsided over 1 mm at one year with minor subsidence up to year 5 (Figure 2). Neither patient has pain or poor patient reported outcomes.

Discussion: The long-term success of a cementless femoral implant depends on the stability at the bone-prosthesis interface. The cementless tapered stem used in this study demonstrated excellent stability and clinical outcomes among THA patients through five years. RSA exhibits minimal micromotion of the stem in relation to the femur. Stem subsidence occurred primarily during the first six-months after surgery with no detectable micromotion thereafter during minimum 5-year follow-up. The small amount of micromotion seen in this cohort is less than that previously reported for similar tapered, cementless stems. To date,
there are few studies on the micromotion of cementless stems using RSA. RSA provides a far more accurate measurement (up to 50 microns) of stem subsidence compared to conventional radiographs. This cohort included two outliers with significantly more subsidence than the median. One patient subsided 0.7 mm by six months and subsequently stabilized with no further subsidence, perhaps due to the tapered design. The stem in the second patient had subsided 1.59 mm by the 2-year follow-up, with continued minor micromotion at the 5-year follow-up. Both patients are without symptoms associated with micromotion of their stems. Further RSA and clinical follow-up evaluation of this patient cohort is desirable.

**Significance:** In young, active patients cementless THA using a tapered titanium stem demonstrates excellent prosthetic stability by RSA measurement and outstanding clinical outcomes at a minimum of 5 years follow-up.

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**References:**

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**Figure 1:** Stem Y-Translation of the Cohort as a Function of Time (median +/- SE)

**Figure 2:** Individual Patient Femoral Stem Y-Translation (mm) as a Function of Time

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