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What Is the Difference Between Modular and Nonmodular Tapered Fluted Titanium Stems in Revision Total Hip Arthroplasty

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Background: Both modular and nonmodular tapered fluted titanium stems are used in revision total hip arthroplasty (THA), with follow-up showing good results for both stems. We aimed to determine whether there were any differences in clinical outcomes, survivorship, or frequency of complications.
Methods: A retrospective review of 160 consecutive THAs (153 patients) revised with a tapered fluted modular titanium stem from 2002 to 2014 and 129 consecutive THAs (128 patients) revised with a tapered fluted nonmodular titanium stem between 2008 and 2014 was conducted. The patient's level of satisfaction, clinical assessment, and complications were examined. A Kaplan-Meier survivorship analysis was performed with the endpoint defined as any reoperation due to septic/aseptic complications.
Results: Mean duration of follow-up was longer in the modular group (6.3 years) than the nonmodular group (5.0 years; $P = .003$). No significant group differences were found in the postoperative Harris Hip Score, the level of overall satisfaction, the 8-year cumulative survival, the rate of infection, dislocation, or postoperative periprosthetic fractures. However, intraoperative fractures occurred significantly more frequently in the modular group (16.9%) than in the nonmodular group (7.0%; $P = .011$), and stem subsidence was significantly less in the modular group (0.95 mm) than in the nonmodular group (1.93 mm; $P = .001$). Two mechanical failures associated with the modular design occurred in the modular group.
Conclusion: Both modular and nonmodular tapered fluted titanium stems provide satisfactory midterm results in revision THA. Although tapered fluted modular stems are gaining in popularity in revision THA, tapered fluted nonmodular stems should not be disregarded as a viable alternative, especially for relatively straightforward cases.

Severe bone loss and altered femoral shape create challenges to adequate fixation in revision total hip arthroplasty (THA). Cylindrical, nonmodular, cobalt-chromium stems have been the standard for femoral side revision in North America for many years, with 88%-96.5% survivorship at 10 years [1–5]. However, concerns regarding severe postoperative thigh pain (8%-9%) and severe stress shielding of the proximal femur (6%-7.6%) remain [5–7].

The first nonmodular, tapered, fluted, titanium stem was developed in 1987 to bypass proximal bone loss and has been widely used in Europe [8]. Tapered, fluted femoral stems engage the diaphyseal cortex, achieve axial stability with the tapered geometry, and use sharp longitudinal ribs to provide rotational stability [9–11]. Tapered, fluted, nonmodular, titanium stems have excellent clinical results and improved proximal bone regeneration; however, a high rate of subsidence and dislocation exists [9–15]. To avoid these complications and provide intraoperative versatility in complex revision surgery, various types of tapered, fluted, modular, titanium stems have been developed. With modular stems, the surgeon can achieve immediate, reliable fixation distally, then add the proximal segment while adjusting the leg length, optimizing the offset and anteversion, and efficiently restoring hip biomechanics. The separation of fixation from the restoration of the hip biomechanics allows an easier and more predictable procedure. High survivorship and promising clinical results have been reported

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with the use of modular, tapered, fluted, titanium stems, albeit with a risk of fatigue fracture and corrosion at the modular junction [16–26]. On the other hand, the nonmodular, tapered, fluted stem is relatively straightforward to use, easy to insert, and is also versatile, with an accurate modular trial system and closely matched trial and final implant sizing. The circular cross-section of the nonmodular stem makes adjusting the anteversion easy [27–29].

To our best knowledge, the outcomes for nonmodular and modular tapered, fluted, titanium stems from a single institute have not been previously compared. We aimed to determine whether there were any differences in clinical outcomes, survivorship, or frequency of complications (including intraoperative fracture, dislocation, postoperative periprosthetic fracture, subsidence, and mechanical failures associated with the modular junction) associated with modular and nonmodular tapered, fluted, titanium stems.

Materials and Methods

Patient Selection

This retrospective study was approved by our institutional review board. Informed consent was obtained from all patients. Patients who underwent revision THA with a tapered, fluted, modular, titanium stem (MP; Waldemar Link, Hamburg, Germany) or a tapered, fluted, nonmodular, titanium stem (Wagner SL; Zimmer, Warsaw, IN) in our department from 2002 to 2014 were reviewed. A total of 175 consecutive patients (182 revision THAs) with modular stems and 145 patients (146 revision THAs) with nonmodular stems were initially identified. Inclusion criteria consisted of a minimum 2-year follow-up. In the modular cohort, 11 of the 182 hips (6%) were lost to follow-up, and 11 (6%) were deceased, with no deaths related to complications resulting from the revision THA, leaving 160 hips (153 patients) available for the minimum 2-year follow-up. A total of 139 (76.4%) of the 182 hips had a minimum 2-year complete radiographic follow-up. In the nonmodular cohort, 8 of the 146 hips (5.5%) were lost to follow-up and 9 (6.2%) were deceased, with no deaths related to complications resulting from with revision THA, leaving 129 hips (128 patients) available for the minimum 2-year follow-up. A minimum 2-year complete radiographic follow-up was available in 114 (78.1%) of the 146 hips. Before 2008, only the modular stem was used due to the unavailability of the nonmodular stem.

Clinical Assessment

The inpatient and outpatient records were examined for complications including infection, intraoperative fracture, dislocation, postoperative periprosthetic fracture, mechanical failure associated with the modular junction, subsidence, and subsequent reoperation. Attending surgeons and their full-time assistants evaluated the patient's outcome using the Harris Hip Score [30] at each visit. A visual analog scale was used to document the pain experienced after a long walk or at rest (0-10, 0 = no pain). The patients were also asked whether they needed any aid when walking. Patients who could not visit the hospital postoperatively were contacted via telephone and mail surveys. Patients rated their satisfaction for the surgical outcome on an arbitrary scale with 5 levels of satisfaction: very dissatisfied, dissatisfied, neutral, satisfied, or very satisfied [31] at each visit; data from the most recent follow-up visit were used in the analyses.

Radiographic Assessment

Two surgeons (Y. H., H. T.) evaluated the degree of the femoral defect from the preoperative X-ray independently according to the Paprosky classification [32,33]. Any discrepancies between the 2 reviewers were discussed, and the final decision was made by the third attending surgeon (J. M. G.). Stem fixation was assessed using the criteria set forth by Engh et al [34]. Subsidence was assessed by measuring the vertical migration of the femoral stem as shown in the study by Callaghan et al [35]. All radiographs were calibrated using the known head size.

Interobserver reliability in the Paprosky femoral bone defect evaluation was tested by examining the agreement between the 2 authors (Y. H., H. T.). Intraobserver reliability was assessed by examining the agreement with the first author (Y. H.) on separate occasions, 4 weeks apart. The kappa values for the intraobserver and interobserver reliability were 0.761 and 0.736, respectively.

As for the reliability in the measurement of subsidence, 50 hips (30 hips from the modular group and 20 hips from the nonmodular group) were measured by the 2 authors (Y. H., H. T.) independently to calculate interobserver reliability. The first author (Y. H.) measured these 50 hips again 1 month later to calculate the intraobserver reliability. The intraclass correlation coefficient values for the intraobserver and interobserver reliability were 0.992 and 0.988, respectively.

Statistical Analysis

Continuous variables were analyzed using Wilcoxon rank-sum tests. Categorical variables were analyzed using the Pearson chi-square or Fisher exact tests. Ordinal categorical variables (preoperative Paprosky femoral bone defect, overall satisfaction level) were analyzed using the Mann-Whitney U tests. Kaplan-Meier survivorship analyses were performed with the endpoint defined as any reoperation due to septic or aseptic complications and with the endpoint defined as any reoperation due to aseptic complications. The significance level was set at $P < .05$. All statistical analyses were conducted using SPSS 17.0 for windows (IBM, Armonk, NY).

Results

Patient demographics, postoperative clinical outcomes, and stem subsidence are summarized in Table 1. There were no significant differences between modular and nonmodular groups in age, gender, body mass index, comorbidities (Charnley class), reasons for the revision, or severity of the preoperative femoral defect and preoperative Harris Hip Score (Table 1). However, the mean duration of follow-up was significantly longer in the modular group (mean, 6.3 years; range, 2.1-14.6 years) than in the nonmodular group (mean, 5.0 years; range, 2.0-8.1 years; $P = .003$; Table 1). In addition, an extended trochanteric osteotomy was performed more frequently in the nonmodular cohort (22.5% [29 of 129]) than in the modular cohort (13.1% [21 of 160]; $P = .037$). Eight surgeons performed the revision THAs, and a significant group difference in the distribution of surgeons was found ($P < .001$).

Clinical Outcome

The modular and nonmodular groups did not significantly differ in the most recent postoperative Harris Hip Score or the level of overall satisfaction at the most recent follow-up (Table 1). In addition, the groups did not differ in the experience of pain ($P = .338$; Table 1), or ability to ambulate without walking aids at the last follow-up ($P = .416$; Table 1). The most recent postoperative Harris Hip Score increased from 40.08 ± 13.77 preoperatively to 85.2 ± 9.8 in the modular group ($P < .001$) and 41.84 ± 13.81 preoperatively to 86.1 ± 10.1 in the nonmodular group ($P < .001$).