INTRODUCTION

Malposition of the acetabular component is a leading cause of dislocation in total hip arthroplasty (Woo, 1982). The two most influential surgeon-controlled variables are thought to be abduction (tilt) and anteversion of the cup. Empirically, while 30-50° of tilt and 5-25° of anteversion is felt to be a “safe-zone” (Morrey, 1992), dislocation nevertheless remains a disturbingly frequent occurrence.

To date, most research on the influence of surgical placement on dislocations has been done for large- or medium-diameter (32, 28, or 26mm) components. Some surgeons, however, are willing to accept the tradeoff of higher dislocation risk for small head size (22mm) implants, given the latter’s recognized advantage of reduced polyethylene wear. We here report results from a physically validated finite element (FE) model of dislocation, examining the effects of tilt and anteversion on implant stability, specifically for the vulnerable situation of 22mm heads.

METHODS

A series of three-dimensional FE models of a widely utilized titanium-backed total hip implant system were developed from manufacturer IGES files, using Patran 8.5 pre-processing. Following an established formulation (Scifert, 1998), a non-linear, large displacement contact analysis was performed with Abaqus 5.8. The cup backing and liner (Duraloc 22-52mm, DePuy, Inc.) was modeled with 3920 continuum elements, while the proximal third of a femoral component (22mm Endurance std+3, DePuy, Inc.) was modeled with 4238 rigid body Bezier surface elements (Figure 1A). The polyethylene liner was characterized by a 4th order constitutive relationship between stress and tangent modulus (Cripton, 1993).

Figure 1: FE model (A) and typical Von Mises stress plot after impingement (B). Note high stress at the head egress site as well as at the neck impingement site.

Starting from 90° of femoral flexion, 0° adduction, and 0° endorotation, a seated leg cross maneuver was incrementally input to the femur (Δθ = 2:1:0 ratio of flexion to adduction to endorotation). A physiological load of 942N was used, based on optoelectronic motion analysis. The cup was studied in 10 distinct surgical positions: 50° of tilt with 0°, 5°, 10°, 20°, 30°, and 40° of anteversion, and then 20° of anteversion, varying tilt from 30° to 70° in 10° increments.

RESULTS AND DISCUSSION

As either tilt or anteversion was increased, the flexion angle at impingement, the maximum resisting moment, and the flexion angle at the onset of hooking increased in a nominally linear fashion (Figure 2). (Hooking is when the upper collar surface of the skirted femoral component engages the
metal backing of the cup at large flexion angles, causing an upward spike in resisting moment). This shift of motion range and resisting moment was much more sensitive to cup tilt than to anteversion, although “apparent stiffness” (\(\Delta M/\Delta \theta\)) was unaffected by the surgical positioning perturbations (Figure 3). For anteversion of 5° or less at 50° of tilt, and for tilt of 40° or less at 20° of anteversion, impingement occurred prior to 90° of flexion, which affectively constricted the envelope of the “safe zone”. Subluxation initiated as the femur was flexed beyond the position of maximum resisting moment, and involved a gentler (downward) slope for increasing tilt than occurred for increasing anteversion. However, hooking ensued at an earlier flexion angle for the increased-tilt positions.

In an earlier FE study employing 26mm components (Scifert, 1998), impingement prior to 90° of flexion occurred at 45° of tilt and 15° of anteversion or less. Although the two series of specific tilt and anteversion angles are not identical, it appears that impingement angle was independent of head size. Due to hooking, frank dislocation was not observed in the present 22mm series, although comparable dislocation angles for the 26mm series were nearly identical. Very dissimilar maximum resisting moments were observed, however: the 22mm series had values nearly 25% lower than the 26mm series. The apparent stiffness was nearly uniform (2.8 Nm/deg) in both series. Both series also showed similar effects of tilt and anteversion on impingement and resisting moment, and both showed gentler \(\Delta M/\Delta \theta\) slope in the subluxation regime.

**SUMMARY**

For 22mm head size, the dependence of resisting moment on cup tilt and anteversion showed similar trends as for larger head size, but with the important caveat of a smaller maximum resisting moment for the 22mm heads. Of course, while increased cup tilt or anteversion reduces the likelihood of posterior dislocation, a tradeoff is increased propensity for anterior dislocation.

**REFERENCES**


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