INTRODUCTION Malposition of the acetabular component is recognized as a leading cause of dislocation in total hip arthroplasty [4]. Intraoperatively, the most influential surgeon-controlled variables are abduction (tilt) and anteversion (AV) of the cup. Empirically, while 30-50° of tilt and 5-25° of AV is felt to be a “safe-zone” [2], dislocation nevertheless remains a disturbingly frequent occurrence.

To date, most research on the subject has been done for large- or medium-diameter (32, 28, or 26mm) components, and mainly impingement studies. Some surgeons, however, are willing to accept the tradeoff of higher dislocation risk for small-head-size (22mm) implants, given their recognized advantage of reduced volumetric UHMWPE wear and increased liner thickness. In addition, dislocation is a kinetic rather than simply kinematic process, governed also by peak resisting moment (PRM), rather than simply range of motion to impingement. We report results from a physically validated finite element (FE) model of dislocation, examining the effects of tilt and AV on implant stability, specifically for the very vulnerable situation of 22mm head-size.

METHODS A series of three-dimensional FE models (Figure 1) of a widely used titanium-backed total hip implant system* were developed from manufacturer IGES files, using Patran 8.5 pre-processing. Following an established formulation [3], a non-linear, large displacement contact analysis was performed with Abaqus 5.8. The cup backing and liner were modeled with 3920 continuum elements, while the proximal third of the femoral component was modeled with 4238 rigid body Bezier surface elements. The polyethylene liner was characterized by a 4th order constitutive model relating von Mises stress to tangent modulus [1].

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:adduction:endorotation). A physiological load of 942N was used, based on optoelectronic motion analysis. The cup was studied in 25 distinct surgical positions: 5x5 combinations of tilt from 30° to 70° by 10°, and AV from 0° to 40°, by 10°.

RESULTS AND DISCUSSION Resultant resisting moment developed about the cup center was tracked and reported versus flexion angle. As either tilt or AV was increased, the flexion angle at impingement and the PRM both showed gentler (downward) slope in the subluxation regime. We therefore conclude that small head size per se poses no otherwise unexpected caveats as regards appropriate surgical orientation.

major difference between the two head sizes was in PRM, where the 22mm series had values nearly 25% lower than the 26mm head sizes. The apparent stiffness was nearly uniform (2.8 Nm/deg) in both. Both head sizes also showed similar effects of tilt and AV on impingement and resisting moment, and both showed gentler ΔM/Δθ slope in the subluxation regime. We therefore conclude that small head size per se poses no otherwise unexpected caveats as regards appropriate surgical orientation.

Figure 1. (A) FE model undergoing dislocation and (B) von Mises stress plot

Figure 2. (L) constant AV, varying tilt (R) constant tilt, varying AV

Figure 3. Surface plot of range of motion prior to impingement

Figure 4. Surface plot of peak resisting moment for all orientations studied

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REFERENCES

CUP ABDUCTION/ANTEVERSION EFFECTS ON DISLOCATION PROPENSITY FOR SMALL-HEAD-SIZE THR


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INTRODUCTION Malposition of the acetabular component is recognized as a leading cause of dislocation in total hip arthroplasty [4]. Intraoperatively, the most influential surgeon-controlled variables are abduction (tilt) and anteversion (AV) of the cup. Empirically, while 30-50° of tilt and 5-25° of AV is felt to be a “safe-zone” [2], dislocation nevertheless remains a disturbingly frequent occurrence.

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RESULTS AND DISCUSSION Resultant resisting moment developed about the cup center was tracked and reported versus flexion angle. As either tilt or AV was increased, the flexion angle at impingement and the PRM both increased (Figure 2). Tilt variations were more influential on range of motion prior to impingement, while cup AV was more influential on PRM (Figures 3 and 4). Seemingly, “apparent stiffness” (ΔM/Δθ) was unaffected by the surgical positioning perturbations. For several cup orientations, impingement occurred prior to 90° of flexion, which effectively constricted the envelope of the empirical “safe zone”. Subluxation initiated as the femur was flexed beyond the position of PRM, and involved a gentler (downward) slope (ΔM/Δθ) for increasing tilt than occurred for increasing AV. This translates to a more sluggish dislocation, which might give the patient more time to cease an untoward motion.

In an earlier FE study employing 26mm components [3], impingement prior to 90° of flexion occurred at 45° of tilt and 15° of AV or less. Although the two series of sampled tilt and AV angles are not identical, it appears that impingement angle was independent of head size. Dislocation angles for the 22mm and 26mm series were also nearly identical, although hooking occurred in some orientations. (Hooking involves the collar of the femoral component engaging the acetabular metal shell, preventing a frank dislocation.) The