INTRODUCTION: Newer generation metal-on-metal hip resurfacing components have been recently approved for clinical use in the U.S. for treatment in young, active patients. With the anticipated increase in resurfacing procedures, the importance of surgical technique in hip resurfacings should be highlighted [1,2]. Radiographic assessments of resurfacing femoral components have shown stem-shaft orientations ranging from 110° to 170° [1,3,4]. The biomechanical and clinical consequences of extreme valgus or varus oriented resurfacing femoral components are still unclear. Significantly higher incidence of revision for femoral loosening and femoral neck fractures in hips with more varus orientations have been reported by some [2,3], while no adverse effects were reported by others [1]. Additionally, stem fixation through cementing or altering stem-bone interface conditions has been described as affecting proximal bone stress shielding [1,5]. Stem fixation may also be altered by overreaming the stem canal, but its effect on stress transfer is not as well understood.

This study examines the effects of femoral component orientation and stem canal reaming (stem-bone gap sizes) on the biomechanics and initial bone remodeling of the Birmingham hip resurfacing (BHR) arthroplasty.

METHODS: A 3-D finite element (FE) model of the natural femur was generated based on the geometry and material properties of a 45-year-old female donor hip with no known bone disorder (Scheurich Anatomical, Phoenix, AZ). One mm thick slice images of the hip (523 slices total; 0.781 mm x 0.781 mm resolution), along with a European Spine Phantom were obtained using a computed tomography (CT) scanner. The protocol was approved by an Institutional Review Board. Linear brick elements were used to model the femoral trabecular bone (TrueGrid, XYZ Scientific Applications, Inc., Livermore, CA). The final mesh consisted of 150,120 brick elements and 10,176 shell elements, with 155,819 nodes (Fig. 1). Non-homogeneous, isotropic, linear elastic material properties were assigned to the trabecular bone based on the QCT data and reported density-modulus relationships [6].

A BHR FE model was also constructed by incorporating a 46 mm O.D. femoral component oriented at an initial stem-shaft angle of 136° (“neutral”) (Fig. 1). The BHR model comprised of 152,848 brick elements and 7,576 shell elements, with 165,073 nodes. The femoral head was assumed to be fixed to the cement layer, while the uncemented stem was assumed to be either bonded or sliding (μ=0.3). Two additional BHR models were generated with ±15° stem-shaft angles. Stem canal reaming effects were also evaluated for the neutrally oriented BHR femur: 0, 0.1, 0.5, and 1 mm stem-bone interfacial gaps.

Clinically relevant femoral joint (2.4xBW) and muscle loads were applied to simulate peak joint loading during gait [7]. The effect of femoral offset due to the change in stem-shaft angles was also considered. Femoral bone stresses (min. principal) and strains (von Mises) in the natural and BHR femurs were compared. Bone stresses and strains in the natural and BHR femurs were compared. Bone remodeling stimuli were also determined for the BHR femurs using changes in strain energy.

RESULTS: Proximal femoral bone stress and strain were non-physiologically regardless of implant orientation when the BHR femoral head was fixed to bone. The reduction of strain energy within the superolateral femoral head was of sufficient magnitude to invoke early bone resorption. Less reduction of stress was demonstrated when the BHR femoral component was completely debonded from bone. Uncorrected femoral offset for the valgus BHR femur led to increased resorption, especially around the periphery of the neck.

Simulated over-reaming of the stem canal reduced stress and strain transfer through the distal stem tip and subsequent distal bone apposition. However, bone resorption in the central and superolateral head regions was still predicted. Stem-canal gaps of 0.1, 0.5, and 1 mm produced similar results.

**References:**
[8] Kishida et al., JBJS Br, 2004
[9] Beaulé et al., J Arthroplasty, 2004

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