**GLENOID STRESS DISTRIBUTIONS IN TOTAL SHOULDER ARTHROPLASTY: ANALYSIS OF KEELED VERSUS PEGGED IMPLANTS**

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**Introduction:** Although total shoulder arthroplasty maintains popularity with satisfying clinical results, concerns regarding glenoid radiolucencies, early component loosening, and/or mechanical failure persist. The mechanisms for component loosening are not clearly defined, but have been attributed to anatomic and biomechanical factors that are unique to the glenoid. Increasingly, new UHMWPE glenoid resurfacing components are being introduced which use various peg and/or keel configurations for component anchorage. Previous investigations into glenoid component fixation have included characterizations of typical bony architecture and material properties throughout the glenoid, analyses of component lift-off, and finite element analyses of stress distributions. This study uses a photoelastic stress-freezing analysis to visualize and document the 3-D stress distribution patterns in a cemented polyethylene glenoid resurfacing model for keeled and pegged component designs for three clinically relevant loading conditions. The method presented here is intended as an adjunct to finite element analyses for the accurate analysis of three-dimensional, contact and volumetric stresses within the glenoid.

**Methods:** Thirty-six, anatomically accurate scapular models were molded using a photoelastic plastic (PLM-9, Measurements Group, Inc., Raleigh, NC, USA) with glenoid surfaces prepared to accept either keeled or pegged components (Kirschner, Warsaw, IN, USA). Previous orthopaedic biomechanical studies using the stress freezing method have only utilized metal components in conjunction with photoelastic plastics. Since the stress freezing technique is performed at elevated temperatures (115-121°C), and since the mechanical properties of PMMA and UHMWPE vary significantly at elevated temperatures from those at body temperatures, appropriate material substitutes were required for the model. Custom molded Delrin components (Biomet, Inc., Warsaw, IN, USA) and Uni-Heat Epoxy Resin (United Resin Corp., Royal Oak, MI, USA) were used to substitute for UHMWPE components and PMMA to complete the shoulder arthroplasty model constructs. Model materials were selected such that their mechanical properties exhibited the same ratiometric relationship at stress freezing temperatures as bone, PMMA and UHMWPE have at body temperature (see Fig. 1).

![Figure 2. Partial Glenoid Solid Model Reconstruction Using Axial Sections](image)

![Image 378x470 to 525x615](image)

**Results:** Keeled components exhibited higher glenoid surface contact stresses than pegged components of identical tray thickness, radius of concavity and bony anchoring geometries for use in concert with finite element analysis. As such, the model provides a complementary, three-dimensional experimental analysis of component anchoring geometries for use in concert with finite element analysis techniques.

**Discussion:** The stress-freezing model provides a calibrated and repeatable method by which to analyze and visualize the differences in stress distributions produced by various glenoid component designs. Results obtained correlate with previously reported 2-D finite element data. The major disadvantage of the model is that it treats bone as a homogenous, isotropic material. The advantages are that it utilizes an accurate three-dimensional solid model geometry and it appropriately accounts for load and deformation interactions between bone, UHMWPE and PMMA for actual intracompartment load applications. As such, the model provides a complementarily, three-dimensional experimental analysis of component anchoring geometries for use in concert with finite element analysis techniques.

**References:**
1) Barea, C., et al., Trans. 43rd ORS:877,1997
2) Liew, A., et. al., Trans. 43rd ORS:880,1997

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