INTRODUCTION: Glenoid component loosening remains a significant cause of total shoulder arthroplasty failure (1,2). Previous studies have indicated that this implant is very sensitive to eccentric loading (3-5). Distraction or ‘lift-off’ of the implant from the bone surface, potentially inhibiting bone ingrowth or producing interface tension, is of concern. It has been demonstrated that reducing the eccentricity of the applied load by employing a thinner implant may minimize these effects (4), and this may be achieved by eliminating polyethylene and using an all-metal component. In addition, reducing glenohumeral congruency by employing a smaller humeral head may reduce eccentric loading by minimizing edge loading. The purpose of this in-vitro study was to measure the effect of implant thickness and articular congruency on the initial stability of an all-metal glenoid component.

METHODS: A prototypical stainless steel uncemented cross-keeled glenoid component was implanted in ten scapulae of mean age 76.1 ± 10.3 years. A pneumatic loading apparatus was employed to load a stainless steel ball bearing which modeled the humeral head. Testing variables included implant thicknesses of 2, 4 and 6 mm, with a fully congruent articulation. Joint incongruencies of 0, 3 and 6 mm (i.e. glenoid component radius - humeral head radius) were assessed with a 4 mm thick glenoid component. A block randomized loading protocol was used to test the effect of load direction (superior, inferior, anterior, posterior, superoposterior and inferoposterior) and angle (10°, 20°, and 30°). Micromotion between implant and bone was measured with four linear variable differential transformers. Two-way repeated measures ANOVA and Student-Newman-Keuls post-hoc tests were employed to determine the effect of load direction and congruency.

RESULTS: Regardless of the load direction employed, the component was compressed at the site of load application, while the contralateral site opposite to the point of loading was distracted. All specimens displayed significantly greater micromotion when the angle of the load vector was increased. A decrease in implant thickness resulted in less contralateral distraction from the surface of bone, and was significant for the 2 mm component relative to the 4 and 6 mm components (p<0.05) (Figure 1). Incongruency between articular surfaces resulted in less contralateral distraction from the surface of the bone (p<0.05) (Figure 2). The 6 mm mismatch was generally found to produce the least amount of contralateral micromotion (p<0.05). These findings with respect to thickness and congruency were also found to be significant for all load directions (p<0.05).

DISCUSSION: Relative to the array of eccentric loading vectors imparted for the various functions of the shoulder (6), the size of the base of the glenoid implant is small and thus, stabilization is difficult to achieve. In order to reduce the eccentricity of loading, design considerations that shift the load line-of-action inward, may be beneficial from the viewpoint of fixation. One method is to decrease metal glenoid component thickness, which significantly reduces the tendency for lift-off, as previously reported for polyethylene components (4). The congruency of the articular surfaces was also found to have an influence on glenoid component stability. The presence of any level of mismatch between the radii of curvature of the two articular surfaces resulted in less contralateral distraction from implant and bone. It is postulated that congruency between the humeral head and the glenoid will lead to an applied load being transferred to the edge of the component, since the humeral head is always in contact with the entire surface. However, incongruency results in only a small arc of the humeral head in contact with the glenoid (7). Therefore, edge loading will not, in all likelihood, normally occur unless loads become more eccentric. This mismatch also allows translation of the humeral head on the glenoid, perhaps more accurately reproducing physiological motion (8). However, the implications with regard to wear may warrant exploration. In conclusion, assuming that an essential aspect of glenoid component design is minimization of the tendency for lift-off to occur, a thin (all-metal) implant with an incongruent articulation may be efficacious.

REFERENCES: