Stability of Onlay-Inset and Symmetric-Asymmetric Glenoid Component Designs: A Biomechanical Study

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INTRODUCTION: Anatomic total shoulder arthroplasty (TSA) is a common treatment for primary glenohumeral osteoarthritis. However, the effectiveness of TSA can be limited by glenoid component fixation and loosening, and its failure is among the most common indications for revision surgery following TSA. The purpose of this study is to conduct a comparative biomechanical analysis by examining the impact of inset versus onlay and asymmetric versus symmetric designs on glenoid component stability.

METHODS: Finite element models of glenoid implants were built using simulation software. The glenoid implant was modeled using high-density polyethylene with 4 pegs and press-fit into bone block. For the onlay design, the implant's base was level with the outer surface of the bone block. For the inset design, bone was precisely reamed, so that the implant base was 2 mm deeper than the bone surface with edge support. In the symmetric design, the thickness of the implant increased evenly from the center to the edge. In the asymmetric design, one edge was thicker to create a non-uniform concavity. The amount of micromotion (reported as deflection in mm) was measured for the inset, onlay, symmetric, and asymmetric designs under various conditions including different implant thicknesses, loading points, and load magnitudes. Data were analyzed using 2-tailed Student t-tests. The threshold for significance was set at $p = 0.05$.

RESULTS: The onlay glenoid component design had significantly lower deflection compared to the inset design. The mean deflection was 0.653 mm for the onlay design and 0.847 mm for the inset design under a load of 500N ($p = 0.0019$). The same pattern was observed under loads of 750N (deflections of 0.980 mm and 1.271 mm for the onlay and inset designs, respectively; $p = 0.0022$) and 1,000N (deflections of 1.305 mm and 1.694 mm, respectively; $p = 0.0018$). In contrast, there was no significant difference in deflection between the symmetric and asymmetric designs. The mean deflections for the symmetric and asymmetric designs were 0.753 mm and 0.747 mm at 500N ($p = 0.9249$), 1.130 mm and 1.121 mm at 750N ($p = 0.9249$), and 1.505 mm and 1.494 mm at 1000N ($p = 0.9304$), respectively.

DISCUSSION AND CONCLUSION: Our results show that onlay designs experience less micromotion than inset designs across a range of loading conditions. The increased deflection observed with the inset design may be due to deformation of the cancellous bone underlying the implant as opposed to deformation of the implant itself; the two cannot be distinguished with finite element analysis. In addition, the absolute magnitude of micromotion for both onlay and inset designs at normal physiologic loads of 500N is small (less than 1 mm). This may explain why inset designs are not clinically inferior to onlay designs. The lack of a significant difference in micromotion between the symmetric and asymmetric designs has implications on clinical performance of augmented glenoid component for patients with glenoid bone loss.

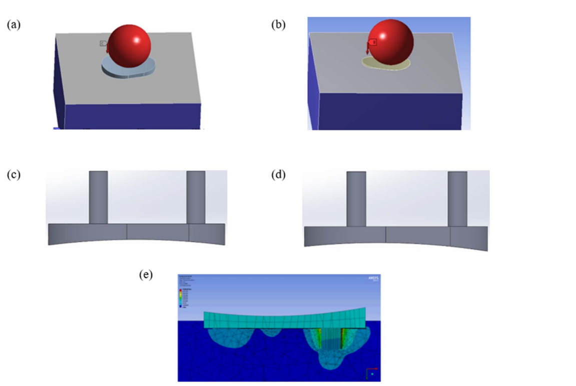

Figure 1. Experimental designs. (**a**) shows the analysis setup for the onlay design while (**b**) shows the setup for the inset design. (**c**) shows a symmetric component, which is equally thick at the edges. (**d**) shows an asymmetric component, which is thicker on the right than the left. (**e**) depicts the experimental setup in ANSYS.

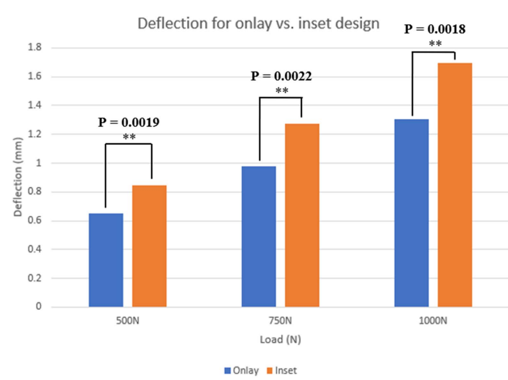

Figure 2. Deflection values for the onlay and inset designs at loads of 500, 750, and 1000 newtons.