Stability of the Glenohumeral Joint with Combined Humeral Head and Glenoid Defects: A Cadaveric Study

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Introduction:
The glenohumeral joint is one of the most commonly injured joints in the body. Studies have shown that approximately 95% of patients with anterior shoulder instability have a bony defect of the humeral head and/or glenoid. The incidence of humeral head defects has been reported to be as high as 90% in unstable shoulders, and the incidence of glenoid defects as high as 87%. Multiple studies have demonstrated a strong correlation between failed arthroscopic Bankart repair and the presence/size of a bony defect of the humeral head or glenoid. In recent years several cadaveric studies have attempted to define the “critical” size of isolated humeral head defects and isolated glenoid defects. The aim of this study is to define the relationship of combined humeral head and glenoid defects on anterior shoulder instability. We hypothesize that combined humeral head and glenoid defects will produce greater instability than either defect found in isolation and that the “critical” size for humeral head and glenoid defects will be smaller when the defects are found together than when either defect is found alone.

Methods:
Eighteen fresh-frozen cadaveric shoulder specimens were used (mean age, 57 years). Specimens were attached to a shoulder testing apparatus with the humerus in 60° of glenohumeral abduction and 80° of glenohumeral external rotation (equivalent to 90° of abduction and 90° of external rotation relative to the trunk). Specimens were randomly assigned to one of three osteotomy pathways using block randomization to allow for six shoulders in each pathway. Pathways were designed to maximize defect size combinations with intermediate sized humeral head and glenoid defects. Sequential humeral head and glenoid osteotomies were made based on the assigned pathway for each specimen. Humeral head defect sizes included 1/16 (6%), 3/16 (19%), 5/16 (31%), and 7/16 (44%) of the humeral head diameter. Glenoid defect sizes included 10%, 20%, and 30% of the glenoid width. The glenoid was translated posteriorly at a speed of 0.5 mm/s until anterior glenohumeral dislocation occurred. A constant medially directed load of 50 N was applied throughout testing to simulate the effect of the static soft tissue load. Stability ratio (peak translational force divided by the applied compressive force) and distance to dislocation were recorded for each trial. Primary outcome measures included Percent of Intact Stability Ratio (stability ratio for a given trial divided by the stability ratio in the intact state for that specimen) and Percent of Intact Translation (distance to dislocation for a given trial divided by the distance to dislocation in the intact state for that specimen).

Results: Figure 1 shows results for Percent of Intact Stability Ratio. There was a progressive decrease in Percent of Intact Stability Ratio as humeral head defect size increased and as glenoid defect size
increased. The decrease in Percent of Intact Stability Ratio reached statistical significance for humeral head defects of 44%, for glenoid defects of 30%, and additionally for the combination of a 19% humeral head defect with a 20% glenoid defect. The mean Percent of Intact Stability Ratio was 65% for a combined 19% humeral head defect with a 20% glenoid defect.

Figure 2 shows results for Percent of Intact Translation. There was a progressive decrease in Percent of Intact Translation as humeral head defect size increased and as glenoid defect size increased. The decrease in Percent of Intact Translation reached statistical significance for humeral head defects of 31% and 44%, for glenoid defects of 20% and 30%, and additionally for the combination of a 19% humeral head defect with a 10% glenoid defect. The mean Percent of Intact Translation was 74% for an isolated 20% glenoid defect. The mean Percent of Intact Translation was 69% for a combined 19% humeral head defect with a 10% glenoid defect.

**Discussion:** The results of this study showed a progressive decrease in stability as humeral head defect size increased and as glenoid defect size increased. This decrease in stability was greater for combined humeral head and glenoid defects than for isolated defects. Prior cadaveric studies on isolated humeral head and glenoid defects have shown a decrease in stability with humeral head defects greater than 31% of the humeral head diameter and glenoid defects greater than 26% of the glenoid width. Our results are consistent with these studies, showing a statistically significant decrease in stability with defects 31-44% of the humeral head diameter and 20-30% of the glenoid width. In addition, our results showed a significant decrease in stability for combined defects with a humeral head defect of 19% and a glenoid defect of 10-20%. Percent of Intact Stability Ratio decreased 35% for a combined 19% humeral head defect with a 20% glenoid defect. Percent of Intact Translation decreased 31% for a combined 19% humeral head defect with a 10% glenoid defect - a greater decrease than was seen in an isolated 20% glenoid defect. These results indicate that in shoulders with combined humeral head and glenoid defects it is necessary to evaluate the size of both defects. The humeral head and glenoid defect sizes required to produce instability are smaller when the defects are found together than when either defect is found alone.

**Significance:** In patients with combined humeral head and glenoid defects bony reconstruction may be indicated for humeral head defects as small as 19% of the humeral head diameter and glenoid defects as small as 10-20% of the glenoid width.
Figure 1: Percent of Intact Stability Ratio (the stability ratio for a given trial divided by the stability ratio in the intact state for that specimen). Mean Stability Ratio in the intact state was 23.6%. ◯ Indicates a defect size combination which was not tested. * P < .05  ** P < .0001

Figure 2: Percent of Intact Translation (the distance to dislocation for a given trial divided by the distance to dislocation in the intact state for that specimen). ◯ Indicates a defect size combination which was not tested. * P < .05  ** P < .0001

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