Normalization of Glenohumeral Kinematics in Curved vs. Flat Soft Tissue Interposition Graft: Implications of Glenoid Reaming

INTRODUCTION:

The management of young patients with glenohumeral arthritis is controversial and particularly challenging. In particular, glenohumeral chondrolysis has been identified as a significant source of shoulder pain and instability in young patients. Various treatment methods have been introduced, but have shown mixed results. Resurfacing of the glenoid with biologic interposition of soft tissue and isolated reaming of the glenoid to recreate glenoid concavity have been recently introduced as potential treatment options in this increasingly complex issue. However, mixed clinical results have been reported with failure rates anywhere from 10% to 90%. One factor which may explain this disparity in results may be the type of graft or preparation of graft and the effect on glenohumeral biomechanics. The goal of this study was to determine the change and location of glenohumeral contact pressures in curved vs. flat biologic interposition arthroplasty in a glenoid arthritis model. We hypothesized that biologic interposition with meniscal allograft will lead to the best normalization of glenoid contact pressure throughout glenohumeral range of motion.

METHODS:

Eight fresh-frozen human cadaveric shoulders (age < 45 years) were dissected free of all soft tissues except the glenoid labrum to expose the humerus and bony glenoid, leaving the scapula intact. The scapula and humeral shaft were potted in epoxy cement and placed in a custom jig for the MTS machine (Materials Testing, Eden Prairie, MN), which was used to apply a compressive load of 440 N. A dynamic pressure-sensitive pad (Tekscan 5051 pad, Boston, MA) was used to measure the glenohumeral contact pressure. The testing sequence involved several conditions at 30 degrees and 60 degrees humeral abduction including: 1) intact glenoid, 2) glenoid with cartilage removed (arthritis model), 3) placement of interpositional lateral meniscus allograft, 4) placement of interpositional achilles allograft, 5) arthritis model with concentrically reamed glenoid.

After initial contact pressure testing of the intact glenoid, the glenoid cartilage and labrum were removed with a curette and smoothed flat. Next, the lateral meniscal allograft and Achilles allograft were tested as soft tissue interposition arthroplasty options. The two ends of a lateral meniscus were sutured together to form a ring, and secured with the sutured end at 12 o’clock on the glenoid face and positioned centrally along the face of the glenoid. (Figure 1A) After testing of the lateral meniscal interposition, the meniscus was removed and an Achilles allograft was placed on the glenoid. The Achilles was prepared as a flat interposition graft, sized to the glenoid and harvested from the thin, fan shaped proximal portion of the allograft. (Figure 1B).

RESULTS:

Data from the pressure software were analyzed with descriptive statistics and a repeated measure ANOVA calculation performed to compare the mean values of each testing condition. For comparison between the data sets, Wilcoxon Signed Rank tests were used with p values adjusted for multiple comparisons with the Tukey-Ciminera-Heyse multiple comparison procedure for paired sample data. Post hoc corrections were utilized to ensure differences among each testing condition. In addition, each graft was compared with a regression analysis followed by ANOVA and post hoc testing.

DISCUSSION:

Glenohumeral contact pressure is optimally restored with biologic interposition of lateral meniscal allograft compared to Achilles allograft. Our findings suggest that concentric reaming of the glenoid did not play a significant role in evenly distributing glenohumeral contact pressure compared to the undreamed glenoid. These findings favor the use of concave allograft for biologic interpositional arthroplasty as a potential treatment option in patients with glenoid wear. This leads to normalization of glenohumeral contact forces through recreation of glenohumeral concentricity with resultant increase in contact area and decrease in contact pressure.

Figure 1: A: Lateral meniscus sutured to glenoid; B: Harvest site for Achilles allograft

Figure 2: Contact pressure maps of A: intact glenoid, B: Arthritic model; C: Lateral meniscus allograft; D: Achilles allograft; E: Reamed glenoid

Glenoid with cartilage removed (arthritis model) demonstrated statistically higher peak pressures than both intact glenoid and glenoid with interpositional allograft. Contact pressures increased by 50% in the arthritis compared to the intact model (p<0.05). Biologic interposition of lateral meniscal allograft restored mean contact pressure to 14% less than intact state compared to 4.2% less than intact for the Achilles allograft. (p<0.05) Contact area also significantly increased in the lateral meniscus group, but was similar to the intact state for the achilles. The reamed glenoid showed no statistical difference for all groups in comparison to the arthritis model. Use of the curved allograft (meniscus) in the arthritic glenoid resulted in decreased contact pressure in the anteroinferior quadrant compared to flat allograft (Achilles). Concentric reaming of the glenoid did not decrease peak pressure and edge loading on the periphery of the glenoid compared to the arthritic glenoid model.

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