The Effect of Middle Trapezius Transfer on Humeral Head Translation and Subacromial Pressure in Irreparable Supraspinatus Tears- a dynamic biomechanical investigation

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INTRODUCTION: Despite advancements in the treatment of rotator cuff tears, there remain significant challenges in managing irreparable supraspinatus (SSP) tears. Recent methods like middle trapezius transfer (MTT) have been introduced to restore function; however, biomechanical data on its efficacy in restoring superior humeral head translation and physiological subacromial pressure conditions in the setting of an irreparable SSP tear is lacking.

METHODS: Ten fresh-frozen cadaveric shoulders were mounted to a 6-DOF robotic arm (KUKA KR-60) and underwent biomechanical testing in three states: (1) intact, (2) simulated irreparable SSP tear, (3) MTT (*Figure 1*). Each shoulder was brought to 30°, 45°, 60°, 75°, and 90° of abduction, and 60 N of superior force was applied to the humerus at each position to simulate loaded glenohumeral abduction. Superior humeral displacement was measured by the robot and subacromial contact area and peak pressure were measured using a contact pressure sensor (Tekscan 5503). A 1-factor random-intercepts linear mixed effects model was created for each outcome and each abduction angle. ANOVA analysis was used to determine the effect of specimen state, and post-hoc pairwise comparisons were made between all states, using Tukey's method to adjust for multiple comparisons.

RESULTS SECTION: The humeral head significantly translated superiorly in the SSP defect state across all abduction angles (+1.6 to +3.8 mm, $p < 0.0001$) compared to native. Peak pressure significantly increased in the SSP cut state for the entire ABD <90° compared to native (+0.48 to +0.55 MPA, $p < 0.05$). There was a significant decrease in subacromial contact area between the native state and the SSP cut state for ABD >30° (-15 to -40 mm^2, $p < 0.05$). The MTT significantly reduced superior translation across all abduction angles (-0.7 to -1.6 mm, $p < 0.05$) compared to the defect state. Nonetheless, the MTT failed to fully restore native superior translation, with a significant increase persisting throughout the entire abduction range of motion (+0.89 to +2.3 mm, $p<0.001$). The MTT successfully restored peak pressure conditions comparable to the native state across the entire ABD ROM and a notable reduction in peak pressure was observed at 30° and 45° of abduction when compared to the SSP cut state (0.33 to 0.38 MPA, $p < 0.05$). After MTT, the contact area was significantly higher compared to the SSP cut state at 30° of abduction (+32 mm^2, $p < 0.005$). While the MTT was able to restore condition that did not significantly differ from native in 30°, 45° and 75° of ABD ($p>0.05$), the MTT was unable to fully restore native contact area conditions, with a significant decrease persisting at 60° (-22 mm^2, $p < 0.05$) and 90° of abduction (-20 mm^2, $p < 0.001$).

DISCUSSION: In this study, isolated irreparable supraspinatus tears were found to significantly increase superior glenohumeral translation and subacromial peak pressure, while decreasing the subacromial contact area. Performing an MTT reduced superior translation, subacromial peak pressure, and increased subacromial contact area. This partially restored the shoulder kinematics to native conditions in the presence of an irreparable supraspinatus tear. MTT has a unique advantage because it addresses both static and dynamic components, contributing to the restoration of joint compression and providing dynamic shoulder stabilization.

SIGNIFICANCE/CLINICAL RELEVANCE: To our knowledge, this study is among the first to investigate the biomechanical performance of a MTT in regards to humeral head kinematics and subacromial pressure. The results of this biomechanical investigation may affect clinical decision making regarding this novel tendon transfer in daily practice.

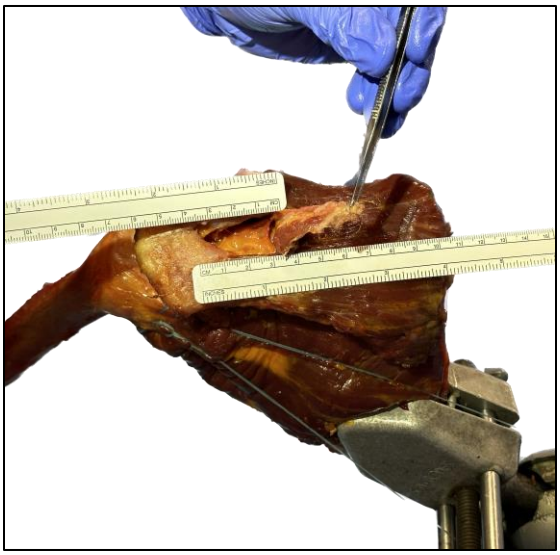

Figure 1A: Harvesting dimensions

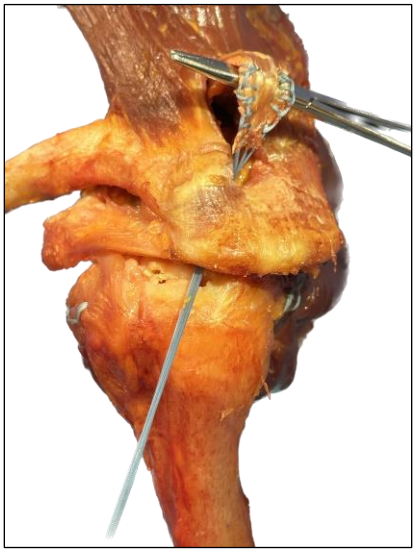

Figure 1B: MT Tendon Transfer Technique

Figure 1C: MTT state