EFFECT OF HUMERAL ROTATION ON ROTATOR CUFF STRAIN, LOADING AND KINEMATICS: AN IN-VITRO STUDY

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Introduction

Despite its main function as abductor, the role of the supraspinatus (SSP) as stabilizer and rotator cannot be neglected [1, 2]. A SSP tear may not only influence humeral head rotation during abduction but also the strength and loading of the acting (intact) rotator cuff (RC) muscles. The purpose of this study was, therefore, to investigate the effect of constrained humeral rotation on RC loading, strain and kinematics with intact and torn RC conditions.

Methods

Twelve fresh-frozen cadaveric shoulders were dissected to retain only the humerus, RC muscles and joint capsule. A speckled pattern was created in the bursal side of both SSP and infraspinatus (ISP) tendons for digital image correlation analysis (Figure 1). Optical tracking markers (GOM, Braunschweig, Germany) were fixed to the humerus and scapula, and anatomical landmarks were digitized to create bone fixed local coordinate systems [3].

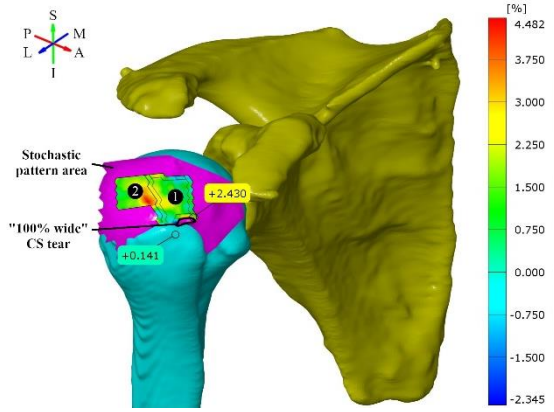

Figure 1: 3D geometries of humerus and scapula, and surface generated from stochastic pattern. Strain (%) was analyzed in regions 1 (SSP) and 2 (ISP).

Glenohumeral abduction until 30° was simulated in the scapular plane by loading the SSP at 2 mm/s (EletroPuls E10000, Instron, MA, USA), with (1) free humeral rotation (+R) and (2) blocked humeral rotation (–R). A constant load was applied to the remaining RC. The loading protocol was applied to (a) the intact SSP, (b) after a 50% wide full-thickness tear was created in the SSP and (c) after the tear was further extended to 100% of the width of the tendon. Two SSP tears were investigated: a crescent-shaped (CS) tear (n = 6) and a reverse L-shaped (rLS) tear (n = 6) [4].

Results

Range of motion was significantly reduced in 7 of the 12 specimens due to blocked humeral rotation. The 100% CS tear led to an anterior translation in both test series (+R and –R). In the 100% wide rLS tear group, –R resulted in an anterior translation of the humeral head, in contrast to the posterior translation observed with +R. There were no significant differences in superior-inferior and anterior-posterior translations between +R and –R, for both CS and rLS tear groups. Translation in the medial-lateral direction was significantly different ($p<0.05$) between the +R and –R test series, for both tear shapes. Constrained rotation led to an increase in SSP loading force (Figure 2) and maximum SSP strain for both tear shapes. ISP strain exceeded SSP strain in the 50% CS and rLS tear groups with +R and –R.

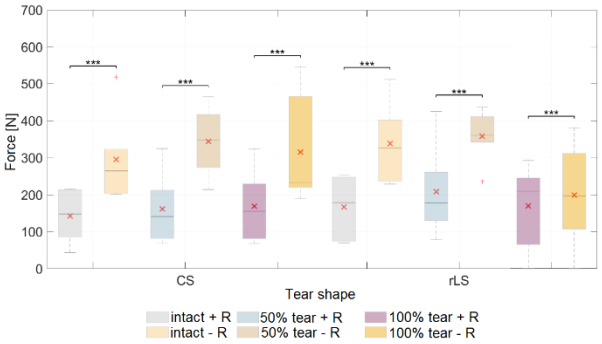

Figure 2: Maximum SSP loading force of all specimens during free (+R) and blocked (–R) rotation and various SSP conditions (intact, 50% tear and 100% tear). Mean values (x) and p-value ≤ 0.001(***) are indicated.

Discussion

This study shows that blocking the rotational function of the SSP leads to an increase in SSP and ISP strains. As shown by Santos et al [4], the strain and load on the ISP (an external rotator of the shoulder) is higher than on the SSP at the beginning of abduction. However, since small RC tears do not biomechanically result in increased humeral rotation, it can be assumed that the load on the ISP is compensated by the subscapularis. These findings need further investigation.

References

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