

# IS DYNAMIC STABILITY PROVIDED BY THE ROTATOR CUFF MUSCLES IMPORTANT IN END-RANGE OF GLENOHUMERAL MOTION?

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**INTRODUCTION:** The four muscles of the rotator cuff (RC) are the primary dynamic stabilizers of the GH joint. But it is unclear whether the stabilizing effect of the RC in the mid-range of motion is also important for end-range GH stability. The purpose of this study is to estimate the role of the RC in providing stability at end-range as well as mid-range of motion in the abducted and extended shoulder.

**METHODS:** A universal positioner was constructed to place the humerus in a desired position with respect to the fixed scapula (Fig. 1). A six component load-cell permitted precise measurement of the forces applied to the humeral head. An electro-magnetic sensor detected the position of the humerus. The compressive and shear forces to the glenoid were then measured when a known constant force of 2 kg was individually applied to each muscle. The force data was represented as a percentage of the force components in compressive and shear directions, calculated by dividing each vector by the applied force. Ten fresh cadaveric shoulders were harvested (avg. age at death: 51 years). Testing was performed in the GH position of 60° of abduction and 45° of extension. The humerus was rotated from neutral rotation to 90° external rotation (ER) in intervals of 22.5°. Neutral rotation of the humerus represented mid-range of motion, while 90° ER represented end-range motion simulating the clinical position of the anterior shoulder instability.



Figure 1: A universal humeral positioner with the abducted and extended shoulder.

**RESULTS:** The compressive force generated by each RC muscle changed significantly as the humerus was rotated from neutral to 90° ER (Fig. 2-A). In neutral rotation, the compressive force averaged 90%, 85%, 98%, and 96% of the applied force to the teres minor (TM), infraspinatus (ISP), subscapularis (SUB), and supraspinatus (SSP), respectively. In 90° ER, the compressive force by TM and ISP increased significantly to 99% and 96%, respectively ( $p < .05$ ). The compressive force by SSP and SUB decreased significantly to 86% and 93%, respectively ( $p < .05$ ). SSP generated significantly smaller compressive force than the others in 90° ER ( $p < .05$ ). Direction and magnitude of the shear force in anterior/posterior and superior/inferior direction generated by each RC muscle changed significantly with humeral rotation (Fig. 2-B). Anterior shear forces by the TM (19%) and ISP (16%) in neutral rotation changed to posterior shear forces (5% and 8%) in 90° ER. The SSP generated destabilizing anterior shear force as high as 31% of the applied force to the muscle in 90° ER, which was significantly different from the other muscles in this position ( $P < .005$ ). The superior-inferior shear force by

four RC muscles changed significantly with humeral rotation ( $p < .05$ ). Shear index (S.I.), defined as shear force/compressive force, revealed combined effects of the compressive and shear force data (Fig. 3). The SSP had a higher S.I. in anterior direction than the other muscles on 90° ER, suggesting it generated relatively higher destabilizing anterior shear force compared with the compressive force generated.

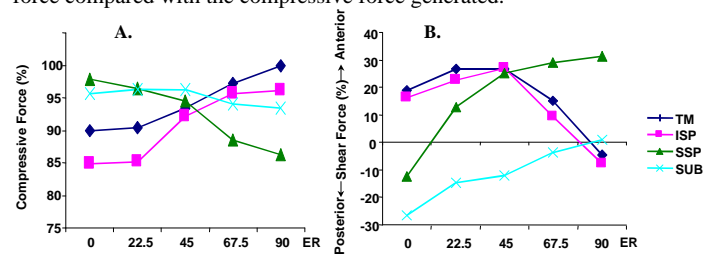


Figure 2: compressive force (A) and anterior/posterior shear force (B) generated by rotator cuff muscles in abducted and extended shoulder (shown as percentage of the applied force), as the humerus was rotated from 0 to 90 degrees external rotation (ER). TM, teres minor; ISP, infraspinatus; SSP, supraspinatus, SUB, subscapularis.

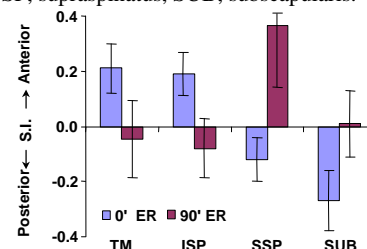


Figure 3: Comparison of the shear index (S.I.=shear force/ compressive force) in anterior/posterior direction between neutral rotation and 90 degrees ER.

**DISCUSSION AND CONCLUSION:** This study shows that the contribution of each RC muscle to dynamic GH stability varied substantially with different humeral positions in the abducted and extended shoulder. Dynamic stability provided by the RC muscle was significant in the end-range of motion in that the compressive force was comparable to that in the mid-range of motion. The transverse shear force generated by muscle contraction could either further enhance the stabilizing function or destabilize the GH joint depending on the direction of the force. The TM and ISP were important for anterior shoulder stability in that they could generate posterior shear force as well as substantial compressive force in end-range motion, which may reduce the strain of the anterior static structures of the GH joint. Shear index could facilitate the comparison of the effectiveness of each RC muscle for dynamic GH stability.

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