INTRODUCTION: The supraspinatus muscle of the shoulder has traditionally been described as either fusiform, bipennate, or multipennate [5,6]. However, several investigators have recently reported radiological findings of distinct anterior and posterior portions of this muscle and tendon [4,8]. As the supraspinatus is functionally the most active pyramidal muscle [3,5], it is important to understand the geometric relationships between its anterior and posterior muscle and tendon in order to provide further insight into its normal functional mechanics. Furthermore, although form-function relationships in non-homogeneous entities such as articular cartilage and menisci (load-bearing tissues), as well as the knee cruciate ligaments (static joint constraints) have been reported [1,7], relatively few investigations have focused on dynamic stabilizers/mobilizers such as the rotator cuff muscles of the shoulder.

MATERIALS AND METHODS: The intact supraspinatus muscle and tendon were harvested from 25 embalmed shoulders (mean age 82 yrs; 10 male, 15 female). Meticulous dissections were performed, preserving each muscle belly in its entirety. Using a goniometer, multiple measurements of pennation angle were made between the axis of each tendinous portion and its muscle fibers, providing a mean pennation angle for each anterior and posterior muscle belly. Using microsurgical instruments, multiple representative muscle fibers were excised from each muscle belly, and an average fiber length was obtained using precision calipers. Tendon cross-sectional area (CSA) was calculated from the product of mean tendon width and thickness. The tendon was then excised from the specimen, and the volume of the entire muscle mass (including the excised fibers) measured by fluid displacement.

The muscular physiologic cross-sectional area (PCSA) was calculated with the following formula: 

\[ \text{PCSA} = \text{V} \times \frac{\cos \theta}{L} \]

where \( V \) is volume muscle volume in mL, \( \theta \) is pennation angle in degrees, and \( L \) is average muscle fiber length in millimeters [2].

RESULTS: Overall anatomic dimensions of the anterior and posterior supraspinatus muscle and tendon are listed in Table 1. Muscle data are presented as PCSA ratios of the two separate portions of the supraspinatus to minimize any volume artifact from the embalming process. The ratio of anterior PCSA to posterior PCSA was approximately 2.45:1 (Fig.1, p<0.001). However, the tendon CSA ratio of the anterior to posterior supraspinatus was 0.9:1 (Fig.1, p<0.044). The ratio of anterior muscle PCSA to anterior tendon CSA was 6.28:1, whereas posteriorly the ratio was 2.18:1 (p<0.001). Assuming that tensile load is proportional to PCSA [2], it follows that the anterior tendon is subjected to as much as 288% more stress than the posterior tendon. Our qualitative findings were that the anterior muscle belly is essentially fusiform, originating entirely from the supraspinous fossa. A tendinous core runs within the center of the muscle belly, which continues distally into a thicker, tubular tendon. The posterior belly is a smaller, unipennate muscle that originates mostly from the scapular spine and glenoid neck. It contains no tendinous core, and therefore inserts diffusely and directly onto the flatter, wider posterior tendon.

DISCUSSION: The significantly larger PCSA of the anterior muscle belly relative to that of the posterior is structurally consistent with the thicker, more substantial anterior tendon, which is geometrically more able to withstand the greater of the greater contractile loads transmitted through it. Our data reveal a 2.88 times greater stress in the anterior supraspinatus tendon. This finding may be evidence of an additional risk factor for rotator cuff tears in the anterior supraspinatus, either through intratendinous failure or pull-off at the insertion site in the setting of tendon degeneration. It is likely, however, that tensile load is shared through the interface between the anterior and posterior tendons, given the interweaving fiber arrangement of the middle tendon layer [3].

From a clinical standpoint, data showing that the anterior supraspinatus tendon transmits the majority of the contractile load suggest that surgical repair should incorporate the anterior tendon whenever possible, in order to allow the best functional restoration. Though the wider posterior tendon may offer greater coverage of the humeral head, the shoulder abduction and head-depressor actions of the supraspinatus are best effected by its contractile function, for which the anterior muscle and tendon are primarily responsible.

Finally, our findings suggest that biomechanical models of the rotator cuff, and particularly the supraspinatus, should take into account its unique anatomy and kinesiology. Cadaver models in which loads are applied to the supraspinatus by clamps may asymmetrically load the more robust and medially extending anterior internal tendon. In order to simulate true physiologic loading of the supraspinatus tendon, great care must be taken to place both the anterior and posterior musculotendinous portions in tension.

**REFERENCES:**

**ACKNOWLEDGEMENTS:** Supported by a NHI Career Investigative Award (K-08 for ELF). The authors thank G. Brown, P. Georges, C-Y. Huang, D. Joseph, P. Kung, J. Park, A. Stankiewicz, and M. Sugalski for their technical assistance.