The Relationship Between Mechanoreceptors in the Glenoid Capsule and Labrum and Glenohumeral Joint Laxity: An Exploratory Study

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Introduction: Shoulder instability is the most common shoulder injury and the recurrence rate post treatment is 15-20%. A lack of neuromuscular control leads to excessive glenohumeral joint laxity resulting in shoulder instability and recurrent instability post treatment. Mechanoreceptors, in articular tissues, have sensory nerve endings that function to signal proprioceptive information about joint position and joint motion to the rotator cuff muscles stimulating a protective muscular response. In turn, mechanoreceptors are able to regulate neuromuscular control, and ultimately give rise to dynamic glenohumeral joint stabilization. Although mechanoreceptors play a major role in neuromuscular control, their relationship with glenohumeral joint stability has not been well studied. Within the glenohumeral joint, mechanoreceptors have been identified in both the capsule and labrum, two of the joints most important static stabilizers. Injury to the joint can take the form of microtears in these stabilizers. Microtears in the capsule and labrum can not only result in mechanical instability, but also neuromuscular instability. We sought to explore whether the amount of glenohumeral joint laxity varies with the number of sensory nerve endings. The number of mechanoreceptors may be a key component in shoulder instability occurrence as well as recurrences. We expected the number of sensory nerve endings to decrease as joint laxity increased.

Methods: We used five fresh and three frozen cadaveric human shoulder pairs aged 23 and 55 to 98. The skin, subcutaneous tissue, and muscle were removed from the shoulders, scapula, and brachium leaving the capsule and labrum attached. The scapula and distal humerus were partially fixed to a customized base fixture to align the humeral head with the medial border of the scapula in neutral position (20° abduction, 0° rotation). Once neutral position was established, the scapula, mid shaft of the humerus, and distal humerus were secured. The base fixture was then placed in the materials testing system and translated in the posterior and anterior directions for three trials (5 cycles/trial). Subsequently, the shoulders were further dissected and we harvested the anteroinferior and posteroinferior capsule and labrum tissues (63 specimens). The capsular and labral specimens were then stained using our improved gold chloride staining technique (ORS abstract 2013) for the identification of sensory nerve endings (Fig. 1) using light microscopy. The rare event protocol for neurostereological analysis was used to perform a neural count of the sensory nerve endings.

Results: There was an average of 652 total number of sensory nerve endings and 24.41mm of total joint laxity. More specifically, within the anteroinferior and posteroinferior capsule, there was an average of 260 and 223 sensory nerve endings, respectively. The labrum, on the other hand, consisted of an average of 81.4 and 87.6 total sensory nerve endings anteroinferior and posteroinferior. Paired t-test analyses revealed a strong positive correlation (r=.646, p=.009, without outlier) between total neural count (sum of sensory nerve endings in the anteroinferior and posteroinferior capsule and labrum tissues) and total joint laxity (sum of anterior and posterior joint laxity) as shown in figure 2. This relationship appeared to be determined by sensory nerve endings in the anteroinferior and posteroinferior capsule. The relationship between neural count and joint laxity was less apparent in the labrum. ANCOVA analyses revealed age, gender, and injury as three confounding variables (Fig. 3). Age, gender, and injury each showed a significant main effect on the relationship between neural count and joint laxity. However, due to the small sample size we were unable to determine whether the strength of the relationship between neural count and joint laxity changed when taking these variables into consideration. Age (> 55), however, demonstrated a significantly negative correlation (r=-.921, p=.000) with neural count (Fig. 3) and a negative trend with joint laxity. In addition, there was a significant interaction between age and joint laxity (p=.000). The main effects of gender and injury in relation to sensory nerve endings are illustrated in figure 4.

Discussion: The potential relationship between neural count and joint laxity suggests mechanoreceptors should be studied in greater detail relative to joint instability. A positive correlation between joint laxity and sensory nerve endings was unexpected, but may possibly be attributed to mechanoreceptor adaptation. Theoretically, the number of sensory nerve endings may increase to maintain the integrity of proprioceptive signaling in response to increased joint laxity. Post injury, proprioceptive deficits have been identified in the shoulder and knee (Dhillon et al. 2011, Lephart et al. 1997, Lephart et al. 1994). More recently, proprioceptive feedback, in the injured joint has been gaining more attention and a greater appreciation given its importance in functional outcomes and joint stability post treatment (Dhillon et al. 2011).

Significance: This study suggests the number of mechanoreceptors may play an important role in joint stabilization. For this reason, the loss and preservation of mechanoreceptors should be considered following injury and when planning for surgery.

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**References:**


Figure 1. Mechanoreceptors identified in the glenoid capsule and labrum
Figure 2. Illustration showing the relationship between neural count (total sensory nerve endings) and joint laxity. The red circle outlines the outlier.
Figure 3. Illustration showing the relationship between age and neural count (total sensory nerve endings).
Figure 4. Illustration showing the relationship between gender, injury, and neural count (total sensory nerve endings) and joint laxity. The red bars represent females and blue represent males.