**INTRODUCTION:** *In vitro* testing of glenohumeral joint stability and kinematics under active loading through the use of complex simulators is becoming increasingly prevalent. However, there is no agreed upon set of muscles which must be simulated. Existing simulators have commonly modeled major groups such as the rotator cuff and deltoid\(^4\). Before a well defined set of muscles can be identified as critical in the replication of glenohumeral joint mechanics, it is first necessary to investigate the effect of each muscle which crosses the joint. The conjoined tendon (CT) of the short head of the biceps and coracobrachialis crosses the glenohumeral joint anterior to the humeral head and it is believed that it provides a barrier effect which increases joint stability in various joint configurations\(^5\). However, to our knowledge, the importance of this in terms of *in vitro* replication of *in vivo* conditions had not been investigated. Hence, we investigated the effect of the CT loading on glenohumeral joint stability and range of motion.

**MATERIALS AND METHODS:** Five specimens (average age: 78 yrs) were prepared and mounted to a custom *in vitro* testing device capable of simulating the supraspinatus, infraspinatus, teres minor, subscapularis, three heads of the deltoids, the long head of the biceps, and the CT (Figure 1). Loads were applied using pneumatic actuators and cables routed through a system of pulleys and connected to sutures placed in each muscle group. Tone loads were applied to each muscle with the deltoids and long head each having 5 N, the three rotator cuff groups having 7.5 N, and the CT having one of four load levels 0, 5, 10 and 15 N.\(^5\)

The effect of the CT load magnitude was evaluated by testing the stability and extension range of motion of the shoulder at each load level. Specifically, glenohumeral stability was determined by applying an anterior force of 70 N to the humeral head and recording the accompanying translation. This was determined for adduction and 90° of combined abduction with the humerus in neutral and external rotation in each case. The extension range of motion was recorded in abduction and 60° of ER while also tracking humeral head translation with respect to the glenoid.

Kinematic data were recorded using an Optotrak Certus optical tracking system with sensors mounted to the humerus and scapula. Coordinate systems were created with respect to the humerus and scapula in order to calculate glenohumeral orientation, and on the glenoid to record humeral head translations. Anterior loading data were recorded using a uniaxial load cell.

**RESULTS:** Increasing CT load increased glenohumeral stability in all joint configurations (p=0.01). With the arm abducted and neutrally rotated, translation was markedly less with 5 N (8.7±2.8 mm), 10 N (10.6±6.5 mm) and 15 N (10.6±6.8 mm) CT loads than with 0 N, though not statistically significant (p=0.27, p=0.14 and, p=0.15 respectively). There was no statistically significant difference between 10N and 15N loading cases (p=1.0). The range of extension was not significantly different between any of the CT loading cases (2.2±3.3°, p=0.43–1.0). Anterior humeral head translations during extension were small (<1.4mm) at all load levels and did not change significantly (p=0.3) with increasing CT load.

**DISCUSSION:** *In vitro* testing of the glenohumeral joint through the use of complex simulators which apply physiologic loading to key muscles groups within the shoulder complex is less developed than in other joints. Furthermore, the importance each muscle has in achieving accurate replication of *in vitro* conditions is not fully understood.

The current study found that increasing CT load resulted in greater joint stability for all test configurations. The increased stability, quantified by a decrease in translation during the application of external anterior loads, which was exhibited during loading of the CT indicates that this muscle group does play a role in providing anterior stability to the glenohumeral joint. Therefore, simulation of the CT must be considered with testing protocols aimed at characterizing the stability of the glenohumeral joint.

The translation results for the 90° abducted and neutrally rotated joint configuration, indicate that there is a minimum CT load required to achieve a significant increase in stability. Additionally, there is a maximum load after which stability will not increase significantly further. We found that a 5N load was not sufficient to fully achieve the expected barrier effect of the CT but that 10N did cause a significant increase in stability, which agrees with the results of Itoi et al.\(^2\). However, increasing CT load to 15N did not provide a further increase in stability beyond the 10N load; indicating that loads above 10N will not increase the barrier effect of the CT once it is fully taut.

It was believed that CT loading would decrease anterior translation of the humeral head during extension; however, no level of loading was found to significantly change the translation of the humeral head which was consistently small in magnitude. This finding may be related to the intact state of the joint during testing which was able to effectively reduce the joint without aid from the CT. Despite this, we expect that the CT will have a significant stabilizing effect during extension in joints with simulated pathologies. It was also found that activation of the CT did not limit the extension range of motion.

The results of this study indicate that the CT stabilizes the glenohumeral joint against anterior translation while not limiting the joint’s range of motion in extension and it is believed that during testing of unstable joint conditions it will provide a barrier to anterior translation in extension. These factors indicate that loading of the CT has an effect on joint stability and kinematics without causing non-physiologic limitation of motion and thus it is our belief that simulation of the conjoined tendon is critical during *in vitro* testing.

**REFERENCES:**

2. Schamblin et al., Clinical Biomechanics 24 (2009) 626–631

Figure 1 - *In vitro* shoulder simulator. This device is capable of loading 8 muscle groups of interest while physiologically orienting the scapula and glenohumeral joint. (A) Deltoid and rotator cuff pulley system, (B) biceps and CT actuators, (C) scapular elevation pot, (D) glenohumeral abduction & flexion guide arc.