Relative Contribution of the Glenohumeral Joint Stabilizers during the Rotational Range of Motion

INTRODUCTION:
Glenohumeral joint stability is provided by both the passive and active stabilizers. Passive stabilizers include both bony and soft tissue stabilizers. Active stabilizers are the muscles providing function and concavity compression. However, the complex interaction between these stabilizers has not been quantified. Therefore, the objective of this study was to quantitatively evaluate the contributions of both passive bony and soft tissue) and active (muscles) stabilizers using the geometry-driven biomechanical analysis.

METHODS:
Specimen Preparation
Seven male cadaveric shoulders with average age 66 years old (range 57-71) were dissected of all skin and subcutaneous tissue, except the tendons of the rotator cuff, deltoid, pectoralis major, latissimus dorsi muscles, and joint capsule. To define the local coordinate systems three screws were placed on the scapula and the proximal humerus. Anatomic muscle loading was simulated by separating each muscle into 17 multiple lines of pull.

Experimental Design
Three abduction angles in the scapular plane were tested at 0°, 45°, and 90° of shoulder abductions with 2:1 ratio of the glenohumeral to scapulothoracic angles. To quantitatively evaluate the relative contribution of the capsule and muscles, three conditions were tested.

- Condition 1: Compressive loading.
- Condition 2: Capsule with intact capsule was tested.
- Condition 3: Capsule with ressected capsule and muscle.

RESULTS:

**Contribution of the Muscle**
Simulated muscle loading significantly reduced the range of motion compared to compressive loading condition for all abduction angles (p<0.05). Simulated muscle loading did not affect the maximum capsular lengths, compared to those under compressive loading (p>0.05).

**Contribution of the Capsule**
The capsular contribution was found at the end-range of motion. Glenohumeral joint forces measured with intact capsule under simulated muscle loading were significantly larger at end-range of motion (p<0.05).

**Inter-relationship between the Stabilizers**
Under compressive loading, the capsular restraint alone contributed inferior shift of the GCHH at both end-range of motion at 0° abduction, lateral shift at maxER at 45° abduction, and anterior shift at maxIR and posterior shift at maxER at 90° abduction (p<0.05).

The capsular restraint under simulated muscle loading contributed to resist to posterior and lateral shift of the GCHH at maxIR position at 90° abduction, compared to the GCHH positions without capsule under simulated muscle loading (p<0.05).

DISCUSSION:
Relative contribution of both passive and active stabilizers of the glenohumeral joint has been quantified. The findings from this study suggest that bony geometry influenced both the capsule and muscles. Simulated muscle loading significantly reduced range of motion. The capsule under simulated muscle loading contributed to increased glenohumeral joint contact forces, mean pressures, peak pressures as well as the glenohumeral joint forces superiorly and medially at the end-range of motion. Locations of the geometric center of the humeral head demonstrated significant changes in bony kinematics resulting from different restraining mechanisms among intact capsule under compressive loading, intact capsule under muscle loading, and resected capsule under muscle loading conditions.

ACKNOWLEDGEMENTS:
VA Rehab R&D and Medical Research
California Orthopaedic Research Institute

Paper No. 230 • 56th Annual Meeting of the Orthopaedic Research Society