A NOVEL MODEL OF ANTERIOR GLENOHUMERAL DISLOCATION

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INTRODUCTION

Study of anterior glenohumeral dislocation has been hampered by the lack of a cadaveric model that simulates the in vivo mechanism and yields the Bankart lesion. Dislocation occurs when the shoulder is placed forcibly in the apprehesion position of abduction, external roatin and horizontal abduction. In prior models an anterior directed force was applied to the humeral head after icision of anterior capsulolabral structures from the anteroinferior glenoid. Increased anterior translation resulted but the joint did not dislocate. (1) The purpose of this study was to describe a novel glenohumeral dislocation model that simulated the dynamic restraints, forcible apprehension positioning and passive pectoralis major muscle loading.

MATERIALS AND METHODS

Seven cadaveric entire upper extremities (mean age 72 years) were dissected of all soft tissue proximal to the glenohumeral joint except for the tendons of the rotator cuff and the deltoid (anterior and middle portions). The scapula was rigidly fixed to a 6-degree of freedom load cell (Assurance Technologies, Garner, NC) on a custom shoulder testing device that permits simulation of all the shoulder muscle forces using a pneumatic system. The passive force in the pectorais major tendon was simulated with a rod/cable system. In addition, a servo motor controlled system was incorporated into the custom shoulder testing device for changing horizontal abduction of the humerus. An intramedullary metal rod was rigidly fixed into the humeral shaft to minimize fracture during testing. The scapula was abducted 30 degrees while the glenohumeral joint was abducted 60 degrees and externally rotated 90 degrees to simulate the apprehension position. The humeral shaft was placed in 10 degrees of anterior horizontal adduction relative to the plane of the scapula. After pilot study indicated its alignment relative to the humeral shaft, a rigid rod was attached to the pectoralis major tendon insertion site with a rigid clamp and aligned with the centroid of its sternal head. Loads were then applied to the tendons of the rotator cuff and deltoid (anterior and middle portions) as described previously. (2) After venting of the joint, the humerus was moved into further horizontal abduction at a rate of 50 mm/sec (Figure 1). Testing stopped when the glenohumeral joint dislocated. The joint force was measured and resolved into three orthogonal components: 1) force perpendicular to the glenoid (compression force); 2) force directed anterior to the glenoid (anterior directed force); 3) force directed superior to the glenoid (superior directed force). The force in the pectorais major tendon was measured with an additional load cell and a Labview data acquisition system. All joints were arthroscopically examined at the end of study for intracapsular pathology.

RESULTS

All seven glenohumeral joints dislocated, three with a Bankart lesion and three by stretching of the capsuloligamentous structures and one by capsuloligamentous avulsion from the humeral insertion site. There was 26±3 degrees (mean±SEM) of horizontal abduction before dislocation. Force in the simulated pectoralis major muscle and the glenohumeral joint forces progressively increased with horizontal abduction until the point of shoulder dislocation. The greatest force and a sharp transition was observed for all three orthogonal force components of the glenohumeral joint and the pectoralis major force at this point of shoulder dislocation. The magnitudes of the pectoralis major force 468±57 N was similar to the glenohumeral joint compression force 502±62 N suggesting the necessity of including this passive pectoralis major force in a biomechanical model of the shoulder (Figure 2).

DISCUSSION

This model consistently provided anterior glenohumeral dislocation as well as intracapsular pathology similar to that in vivo. The Bankart lesion found in this study was very different from that created by incision of the anteroinferior capsuloligamentous structures. Instead, the anteroinferior labrum was avulsed from the bone of the glenoid rim and the soft tissues were stripped off the glenoid neck. This is similar to the in vivo, arthroscopic appearance of the Bankart lesion. It also concurs with the lesion expected from recent anatomic study of the insertion site of the anterior band of the IGHL, which revealed direct attachment to the labrum and indirect attachment to the bone of the glenoid neck. (3) The pectoralis major muscle was included because it has been implicated to play a role in anterior dislocations. After a Bankart lesion was found with concurrent pectoralis major tendon rupture and anterior dislocation, Arcecio and Cruser theorized eccentric lengthening of the pectoralis let to capsuloligamentous failure and subsequent dislocation. (4) Sinha and coworkers (5) also implicated the pectoralis major as an irreducible anterior dislocation caused by spasm of this muscle was successfully treated with paralysis from botulinum toxin injection. This study validates a novel in vitro human cadaver model for producing shoulder dislocation and Bankart lesion.

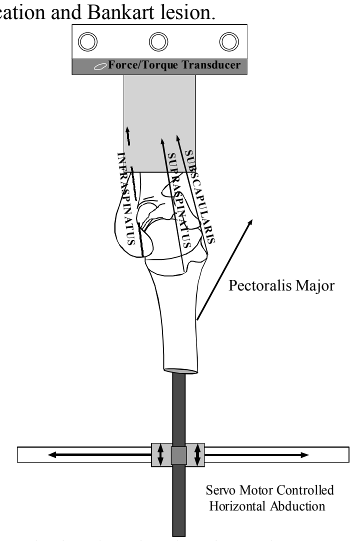

Figure 1. Schematic drawing showing the testing setup for shoulder dislocation model.

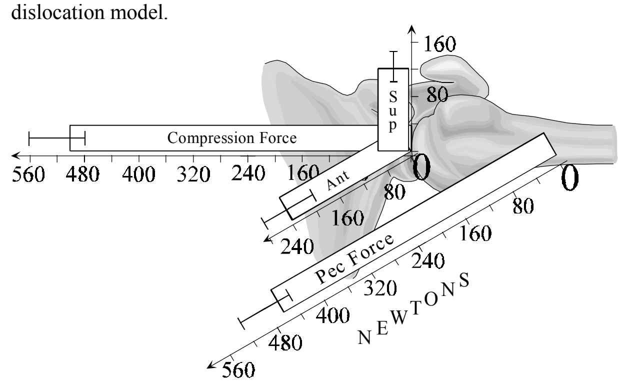

Figure 2. Schematic drawing and histograms of the glenohumeral joint forces and pectoralis major force at the time of shoulder dislocation.

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