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Original research

Glenohumeral joint translation and muscle activity in patients with symptomatic rotator cuff pathology: An ultrasonographic and electromyographic study with age-matched controls

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ABSTRACT

Objectives: To determine whether patients with symptomatic rotator cuff pathology had more glenohumeral joint translation and different patterns of rotator cuff muscle activity compared to controls.
Design: Repeated measurements of glenohumeral translation and muscle activity in two positions and six testing conditions in two groups.
Methods: Twenty participants with a symptomatic and diagnosed rotator cuff tear and 20 age, and gender matched controls were included. Neuromuscular activity was tested by inserting intramuscular electrodes in the rotator cuff muscles. Anterior and posterior glenohumeral translations were measured using real time ultrasound in testing conditions (with and without translation force, with and without isometric internal and external rotation), in two positions (shoulder neutral, 90° of abduction) and two force directions (anterior, posterior).
Results: Symptomatic pathology group demonstrated increased passive glenohumeral translation with posterior translation force ($p < 0.05$). Overall, rotator cuff muscle contraction in the pathology group limited joint translation in a similar manner to the control group, but they did not show the normal direction specific pattern in the neutral posterior position ($p < 0.03$). The pathology group demonstrated reduced EMG activity in the upper infraspinatus muscle relative to the reference position ($p < 0.02$) with anterior translation force and in the supraspinatus ($p < 0.05$) muscle with anterior and posterior translation force in the abducted position.
Conclusions: Symptomatic pathology resulted in increased passive glenohumeral joint translation. Although there were some reductions in muscle activity with injury, their rotator cuff still controlled glenohumeral translation. These results highlight the need to consider joint translation in the assessment and management of patients with rotator cuff injury.

1. Introduction

Rotator cuff tears are a common cause of shoulder pain and disability, especially in the elderly population and the prevalence and size of tears increase with advancing age.[1] From 30 to 54% of individuals over the age of 60 years have cuff tears, and this increases to 80% in those older than 80 years.[2] To date, the effect of rotator cuff injury has largely been investigated in terms of alterations in articular kinematics and muscle activation patterns.[3] However, little is known about the effect of rotator cuff tears on glenohumeral joint stability.

Quantitative assessment of glenohumeral joint translation in cadaveric shoulder specimens reported that a 50% decrease in the rotator cuff muscle forces resulted in nearly a 50% increase in anterior displacement of the humeral head,[4] but the elimination of the natural shoulder girdle motion makes it difficult to generalize these assessments to living subjects. In vivo studies on pathological populations have also reported an increased glenohumeral translation during active shoulder movements.[5] However, none of these studies have delineated the differences in glenohumeral joint translation with and without rotator cuff muscle contraction and against external translation forces. Addressing the consequences of symptomatic cuff injury on glenohumeral joint translation and muscle activation patterns will contribute to a more comprehensive understanding of the association between symptomatic cuff tears and

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loss of shoulder function and may have clinical implications for treatment and rehabilitation of symptomatic rotator cuff tears.

Therefore, we aimed to compare the effect of rotator cuff muscle contraction on glenohumeral joint stabilization in patients with symptomatic rotator cuff pathology and a control group. Three hypotheses were examined. First, it was hypothesized that the symptomatic pathology group would show increased passive glenohumeral joint translation compared with a control group. Second, contraction of the rotator cuff muscles in the symptomatic pathology group would result in less stabilization than in the control group, in that the symptomatic pathology group would not show the direction specific pattern when a translation force was applied. Third, the symptomatic pathology group would demonstrate altered electromyographic (EMG) activity across different testing conditions compared to the control group.

2. Methods

The study involved repeated measurements of humeral head translation and muscle EMG activity in two positions and six testing conditions in two groups. Forty shoulders from 39 participants were included in the study. The pathology group had 19 participants, 18 with unilateral rotator cuff tear and 1 with bilateral rotator cuff tears (counted as two independent pathology shoulders) (N = 20 shoulders with cuff tears). The control group had 20 age, gender and limb-dominance matched participants (N = 20). Based on mean translation of 1.9 mm (SD 0.3 mm) of posterior translation in an abducted shoulder position[6] and assuming a mean difference between groups of 0.3 mm is clinically significant, for power of 0.8 and alpha level of 0.05, we required a sample of N = 34. To allow for attrition and loss of data during testing we recruited N = 40 shoulders. Participants were included in the symptomatic pathology group if they had sought treatment for shoulder symptoms and had a confirmed tear in at least one of the four rotator cuff muscles using diagnostic imaging (magnetic resonance imaging or ultrasound). Control group participants were age (±5 years), gender and limb-dominance matched with no current or previous history of rotator cuff tears in the tested arm. The study was approved by the Human Ethics Committee of the University (HEC 15–103) and the local hospital (reference number 921) and all participants gave written consent prior to participation. This study was registered with Australian and New Zealand clinical trial registry (ACTRN12616000055404). Shoulder-related disability was measured using the self-reported disabilities of the arm, shoulder and hand (DASH) outcome measure score.[7] Pain levels during testing were measured using a visual analogue scale (VAS).[8]

Six bipolar fine-wire intramuscular electrodes were inserted under real time ultrasound (RTUS) (Sequoia 1200, Samsung, USA) guidance using published guidelines into the upper and lower subscapularis,[9] teres minor,[10] supraspinatus[11] and upper and lower infraspinatus[12] of the tested shoulder of each participant. A Delsys Trigno wireless EMG system and its associated software analysis package (EMGWorks version 4.2, Delsys Inc., Boston, USA) were used to collect and analyze raw EMG data. Raw signals (gain of 1000; band pass filtered 20–900 Hz) were sampled at 2000 Hz.

Humeral head translation was measured using RTUS (model no 75L53EA, Mind Ray-6500 Ultrasound System, North America) on B mode using a 50 mm 10 MHz linear transducer based on the established protocol that has shown excellent intra-rater reliability (ICC 0.98)[7] and moderate to high levels of criterion validity (r = 0.79, $r^2 = 0.62$).[13] An externally applied translation force of 60 N, similar to that used in previous studies,[6] was applied by an assistant with force monitored through a hand-held dynamometer (Lafayette, USA).

Participants were seated upright in a chair with backrest and feet resting on the floor to ensure maximum stability during testing. The upper limb was held in one of two positions, shoulder neutral and shoulder 90° abduction, without the need for any muscular activity using Velcro straps, and an elbow, hand and wrist orthosis (Fig. 1A and B). Glenohumeral translations were measured in two positions (shoulder neutral, abduction), two force directions (anterior, posterior) and six testing conditions (rest, isometric internal rotation (IR), isometric external rotation (ER), translation force, translation force with IR (translation force + IR) and translation force with ER (translation force + ER).[6]

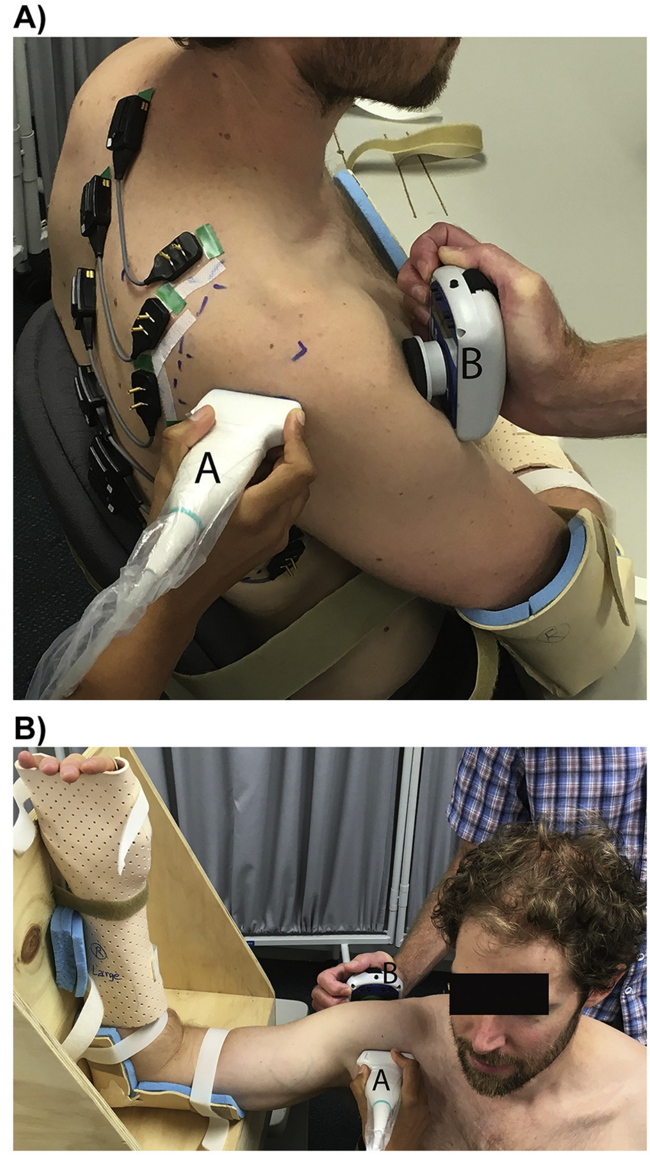

Fig. 1. Neutral position (posterior view) (A), abducted position (anterior view) (B). A, location of RTUS to measure glenohumeral translation; B, location of hand held dynamometer while applying the translation force.

Participants were instructed on how to produce a maximal internal and external rotation isometric contraction and the contractions were maintained until a satisfactory ultrasound image was obtained (usually less than 10 s). Two trials of each testing condition were performed with 30 s rest between trials. The humeral head position was determined as the perpendicular distance between the humeral head and the glenoid in the neutral position anteriorly and posteriorly, and between the greater tuberosity and the glenoid in the abducted position posteriorly.[6]

Intramuscular EMG signals from each muscle segment in the six testing conditions were high pass filtered (4th order Butterworth,

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