INTRODUCTION

The scapulohumeral motion is the interaction between the scapula and humerus. This motion, in synchronicity with the scapula (to the torso) motion, provides the global motion capacity of the shoulder joint complex. The ratio of scapulohumeral to scapula rotation has been described from 1.35:1 to 7:1 depending on the motion tested and the measurement technique [1]. However, no data has accurately reported the contribution of the scapula and scapulohumeral rotation during in-vivo shoulder motion using three-dimensional bone models with dual plane fluoroscopy. Therefore, the purpose of this study was to measure the dynamic scapulohumeral motion in healthy shoulders during dynamic abduction of the arm in the scapular plane under a light loading condition, to use as baseline kinematics with which to in the future establish glenohumeral articular contact patterns.

METHODS

Four healthy right hand dominant adults (2 male) average age 25±2 years of age were recruited for this study under the guidance of our institutional review board and with informed consent. Each subject was screened with a clinical shoulder exam to document range of motion and rotator cuff strength. All subjects were without pain and had shoulder motion in what would be considered a normal range. Surface bone models were constructed from each subject’s right shoulder three Tesla T2 weighted MRI with 1.5mm slice spacing (Fig 1). Coordinate systems were placed based on anatomic landmarks [2]. Subjects dynamically abducted their right arm in the scapular plane from 0-90-0 degrees in the field of view of a dual fluoroscopic imaging system [3]. Male subjects held a 4 lbs weight and female subjects a 2 lbs weight. Three continuous cycles were recorded at 30 frames per second and the middle cycle analyzed. A semi-automatic matching technique was used to reconstruct the bone kinematics recorded on the fluoroscopic images. Euler angles and translations were calculated for the scapula and humerus to their rest position (0 degree) and the relative position of the humerus to the scapula in each reconstructed kinematic pose (Fig 1). A 95% confidence interval was calculated for the average Euler angles in the scapular plane for the four subjects.

RESULTS

Consistency was found in the translations and Euler angle rotations for the scapula and humerus to the rest position and the scapulohumeral kinematics among the four subjects. Euler angles in the scapular plane were shown in figure 2. The humerus followed a smooth curve along the abduction cycle 0-90-0 degrees. The scapula similarly followed a smooth curve in abduction in the range of 0-30-0 degrees, though at a slower angular rotation rate than the humerus. At 30° of humeral abduction, the ratio of scapulohumeral to scapula rotation was 3:1:1 and at 90° of humeral abduction, the ratio was 1.9:1. A decreasing ratio was observed from 30 to 90° of humeral abduction. The scapulohumeral rotation plateaued between 35-65% of the abduction cycle, at approximately 52° between the long axis of the humerus and the plane of the glenoid. The ratio of scapulohumeral to scapula rotation was on average 2:1:1 during the plateau phase, in a range of 2.4:1 to 1.9:1.

DISCUSSION

We found a decreasing ratio of the scapulohumeral to scapula rotation with increasing humeral angle abduction. This phenomenon was contradictory to the light loading data reported by McQuade and Smidt, where with increasing humeral elevation, the ratio increased [1]. This difference may be attributed to the differences in measurement techniques, the loading condition and range of motion tested. However, both studies agree that the ratio of scapulohumeral to scapula rotation vary throughout the abduction cycle, contrary to the observation of Inman, Saunders and Abbott that a constant ratio of 2:1 is established from 30-170 degrees of elevation [4]. In our study, we found what we termed the plateau phase, where the angle between the long axis of the humerus and the plane of the glenoid in the plane of the scapula remains relatively constant. For a 0-90-0 degree abduction cycle, this phase occurred between 35-65%, for which what was seen as upward humeral rotation was actually the upward scapular rotation. The scapulohumeral rotation was physically limited during the plateau phase by impingement of the humeral head, the supraspinatus muscle and the acromion. Such that humeral abduction beyond 90° would require additional rotation of the scapula and potentially damaging impingement of the supraspinatus muscle tendon, that overtime may increase the likelihood of a rotator cuff tendon tear. Therefore, it is important to delineate normal scapulohumeral and scapula motion, whereby methods in surgical and physical therapy intervention could be custom tailored to restore the anatomic coupling of the humerus to the scapula to the trunk to minimize changes in articular contact mechanics in effort to delay osteoarthritis and minimize the likelihood of rotator cuff tendon tears.

SIGNIFICANCE

Scapulohumeral motion and ultimately glenohumeral cartilage contact patterns in both healthy and in individuals with pathology will help elucidate the mechanisms of cartilage wear and rotator cuff tendon tears.

REFERENCES

1. McQuade and Smidt. JOSPT. 1998 Feb;27(2):125-33
4. Inman et al. JBJS Am. 1944;26:1-30