MAGNETIC RESONANCE IMAGING-BASED MEASUREMENT OF 6-DEGREE-OF-FREEDOM RELATIVE MOVEMENT SCAPULA AND THORAX

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INTRODUCTION

The shoulder joint has numerous intricately-interlocking parts. Especially, glenohumeral joint, which consists of the head of humerus and the glenoid of scapula, is susceptible to injury from sports-related stresses and strains. To diagnose this injury, orthopedists need to evaluate the glenohumeral joint movements. However, the in-vivo measurement of relative movement between the scapula and thorax was difficult clinically, primarily due to the limitation of measurement methodology. To achieve such in-vivo measurement, we developed a new method capable of measuring 6 degree-of-freedom movement of the scapula relative to the thorax, using an open MRI.

METHODS

We employed an open MRI (Magnetom Open, Siemens, Germany) to measure shoulder kinematics. However, it was difficult to measure the entire thorax with the scapula, because of the limitation between the field of view and S/N ratio of the device. To obtain the position of the thorax, we used a jig which fixed the position of the thorax. The jig was mounted on the bed of the device. To measure the position of the thorax, we used a rectangular marker (gel marker, ALCARE Co., Ltd., Japan), which was imaged by a MR device. This marker was mounted on the jig. The subjects laid themselves at abdominal position on the jig to measure their shoulder joints (Fig.1).

Three volunteers (24.3±2.31 years old), who possessed no distinct kinetic dysfunctions in their shoulders, served as subjects, in this preliminary study. Their shoulder movements were sampled at five humeral elevation angles (30°, 60°, 90°, 120°, 150°) on scapula plane by obtaining sagittal MR images of left shoulder. 96 slice images were acquired with 1.56mm slice thickness. The contour of scapula, humerus and marker were reconstructed from all MR-images (Fig.2). The position and orientation of scapula and humerus were estimated using the registration technique (Besl, 1992). The scapula orientation was described using euler angles (Veeger, 1993).

RESULTS AND DISCUSSION

The all subjects maintained about 30° of the horizontal adduction of humerus, during humeral elevation on scapula plane. This result showed that the humerus was elevated on scapula plane. Figure 3 shows average and standard deviation of the scapula orientation for three subjects. The backward tilt and lateral rotation of scapula, in this instance, tended to agree with previous report (Fung, 2001). However, the protraction showed a little different trend. This reason was considered as the difference of measurement posture, which was abdominal position in this study. An advantage of our method is that open MRI allows measuring the bony shape directly. The estimated orientation of the in-vivo scapula movements were reasonable to compare with the previous study.

SUMMARY

We measured scapula movement during humeral elevation on scapula plane, using open MRI. The position and orientation of scapula were estimated relative to the thorax by the registration technique. The result showed that our method was capable of evaluating of the in-vivo shoulder joint movement quantitatively.

REFERENCES


Figure 1: The measurement of shoulder joint using open MRI.

Figure 2: The reconstructed scapula, humerus and marker at 30° and 120° humeral elevation.

Figure 3: The scapula orientation during humeral elevation on scapula plane.