



## Does scapular elevation occur with glenohumeral flexion and abduction? a study through open magnetic resonance imaging and autopsy

Glenohumeral fleksiyon ve abdüksiyonda skapular elevasyon meydana gelir mi?  
Bir açık manyetik rezonans görüntüleme ve otopsi çalışması

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**Objectives:** This study aims to reveal whether there is an elevation in scapula during flexion and abduction of the glenohumeral joint.

**Patients and methods:** In the first stage of our study 32 subjects were randomly divided into two groups. The mobility of the scapular notch was examined using open magnetic resonance imaging (MRI) assay when the glenohumeral joint was in flexion in the first group (5 males, 10 females; mean age 21.1 years; range 18 to 24 years) and in abduction in the second group (8 males, 9 females; mean age 22.1 years; range 18 to 27 years) and the motion range was found to be between 0 and 150 degrees. In the second stage of our study, the mobilities of the scapular notch was examined on autopsy during passive humeral mobility.

**Results:** According to the open MRI results, there was no elevation or depression during the passive flexion and abduction of the glenohumeral joint. While the scapular notch migrated slightly to the medial side during abduction of the glenohumeral joint, it did not move during flexion. Also in an autopsy study, we observed that scapula did not move in vertical direction during the glenohumeral abduction and flexion mobilities.

**Conclusion:** There is no vertical mobility in the scapula during glenohumeral flexion and abduction. Also, there is no medial mobility during flexion except during abduction.

**Key words:** Glenohumeral joint motion; scapular elevation; scapular notch.

**Amaç:** Çalışmada glenohumeral eklem abdüksiyon ve fleksiyon hareketleri sırasında skapular elevasyon meydana gelip gelmediği belirlendi.

**Hastalar ve yöntemler:** Çalışmamızın birinci aşamasında 32 sağlıklı birey rastgele olarak iki gruba ayrıldı. Skapular çentik hareketliliği ilk grupta (5 erkek, 10 kadın; ort. yaş; 21.1 yıl; dağılım 18-24 yıl) glenohumeral eklem fleksiyonunda iken, ikinci grupta (8 erkek, 9 kadın; ort. yaş 22.1 yıl; dağılım 18-27 yıl) ise abdüksiyonda iken açık manyetik rezonans görüntüleme (MRG) yöntemi ile değerlendirildi ve hareket açıklığının 0 ile 150 derece arasında olduğu saptandı. Çalışmanın ikinci aşamasında ise pasif humeral hareketler sırasında skapular çentik hareketleri otopsi üzerinde incelendi.

**Bulgular:** Açık MRG sonuçlarına göre, glenohumeral eklem pasif fleksiyonu ve abdüksiyonu sırasında skapulada elevasyon veya depresyon meydana gelmedi. Glenohumeral eklem abdüksiyonu sırasında skapular çentik hafif şekilde mediale hareket ederken, glenohumeral eklem fleksiyonda iken hareketlilik gözlenmedi. Otopsi çalışmasında da glenohumeral abdüksiyon ve fleksiyon hareketleri sırasında skapulada vertikal yönde hareket gözlenmedi.

**Sonuç:** Glenohumeral fleksiyon ve abdüksiyon sırasında skapula vertikal yönde hareket etmemektedir. Abdüksiyon hariç, fleksiyonda da medial yönde hareket söz konusu değildir.

**Anahtar sözcükler:** Glenohumeral eklem hareketi; skapular elevasyon; skapular çentik.

Measurement of range of motion (ROM) of joints is commonly recorded by health professionals for various reasons, including baseline clinical evaluation, evaluation of treatment procedures, feedback to patients, assessment of work capacity, or research studies.<sup>[1-4]</sup> In clinical evaluation studies, it is striking that the glenohumeral joint (GHJ) has been evaluated more frequently than the scapula, although they are both in the same complex.<sup>[1,3-7]</sup> Scapular elevation has been described with or without GHJ movement in the literature. When these papers are reviewed carefully, it appears that the relationship between scapular elevation and rotational movement is unclear. Scapular elevation along with GHJ movements has been reported in previous studies.<sup>[5,8-14]</sup> Other studies have reported acromial, glenoid cavity or acromioclavicular elevation movements with GHJ movement.<sup>[11,15-18]</sup>

Rotational movement of the scapula with the GHJ is called humeral rhythm.<sup>[12,17]</sup> A review of studies on scapulohumeral rhythm<sup>[11-13,18]</sup> revealed that these series have been focused on scapular movement during humeral abduction and identification of the center point of scapular rotation movement. There is a consensus that scapular rotation occurs during scapulohumeral rhythm, which is due to GHJ abduction;<sup>[5,12,14,15]</sup> however it is controversial if there is scapular elevation. There is only one paper reporting that "there is no scapular elevation" during GHJ abduction.<sup>[19]</sup> Besides this, there is no study in the literature on whether elevation occurs in the whole scapula during humeral flexion. The aim of this study is to reveal whether there is scapular elevation during flexion and abduction of the GHJ through a magnetic resonance (MR) imaging and autopsy study.

## PATIENTS AND METHODS

### Open magnetic resonance imaging

The patients were divided into two groups for MR imaging group 1 (GHJ flexion) (5 males 10 females; mean age 21.1 years; range 18 to 24 years) and group 2 (GHJ abduction) (8 males 9 females; mean age 22.1 years; range 18 to 27 years). All participants were healthy volunteers and all were functionally right-handed. Any individual with a history of illness or injury involving any joint of either upper extremity or cervical spine was excluded from the study. Images were taken via open MR imaging with 0.2 T (Tesla) magnetic field power (GE Profile-i) and 9" multi-purpose rounded surface coil. Magnetic resonance imaging examinations were performed when each subject's shoulder was positioned in abduction (group 2) or flexion (group 1). A goniometer was used to describe the degree of the shoulder. In group 1, right arms were

up and subjects were in left-lying horizontal position. Images were taken when GHJ was in 0, 30, 60, 90, 120 and 150 degrees of flexion. In group 2, the subjects were lying down horizontally with abduction position and images were taken when the GHJ was in 0, 30, 60, 90, 120 and 150 degrees of position. During this process, heads and necks were held in neutral position, there was no rotation, flexion or extension movement of the bodies and there was no protraction or retraction movement in the shoulder regions. The examinations were performed with spin echo (SE) T1-weighted MR. The parameters were as follows: TR: 420 msn, TE: 20 msn, NEX: 2 and matrix 256 x 160. Consequent coronal sections were taken from the shoulder joint with 4 mm thickness and 1 mm interval. After that, the notch movements in vertical and medial directions for all GHJ periods were measured via computer.

### Autopsy study

In the second part of the study, the right shoulders of five fresh cadavers were studied. A radio-opaque metal rod was first positioned horizontally at the level of the 5<sup>th</sup> thoracic vertebrae, parallel to the frontal axis of the shoulders (Figure 1a). X-ray images were then taken when the GHJ was in 30, 60, 90, 120, and 150 degrees of flexion and abduction (Figure 1b). After that, the notch movements in vertical directions for all GHJ periods were measured using a ruler in cm.

## RESULTS

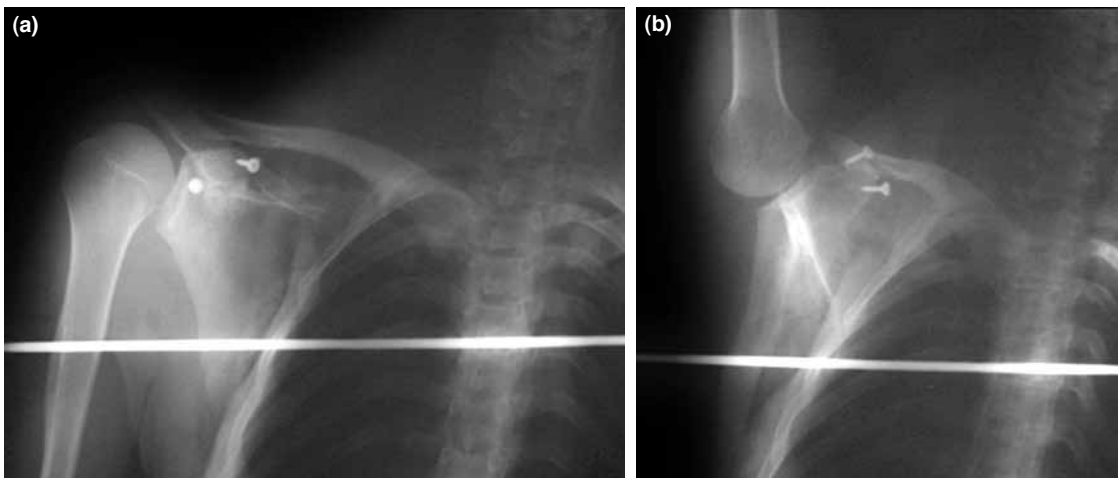
In open MR imaging, it was observed that the notch of scapula elevated less than 1 cm vertically from 0 to 150 degrees of abduction of GHJ. The same results were observed during flexion of the GHJ (Table I).

Mediolateral movement of the scapular notch during 0 to 150 degrees of the GHJ abduction was examined and it was seen that the notch moved 3.5 cm medially. However, the notch moved first medially and then laterally approximately 0.5 cm during 0 to 150 degrees of GHJ flexion (Table II).

In the cadaveric part of the study, elevation of the notch started at 60 degrees of humeral flexion/abduction and its elevation continued about 0.6 cm (Table III).

## DISCUSSION

In this study we found that only minimal movement occurs in the scapular notch during GHJ flexion or abduction. In the first part (open MR imaging) of the study, the maximal elevation of the notch was found to be 0.5 cm during GHJ abduction and 0.9 cm in flexion (Table I). On the other hand, it was found to be below 0.6 cm in the second part (autopsy study; Table III). Although scapular elevation during



**Figure 1.** A metal rod was placed horizontally on 5<sup>th</sup> thoracal vertebrae level of the cadavers was used as a reference. **(a)** Firstly, when the glenohumeral joint was in 30 degree of abduction, notch distances in vertical directions were measured on the X-ray diagrams. **(b)** Glenohumeral joint was measured in 150 degree of abduction with the same method. We found elevation differences of the notch at glenohumeral joint 30-150 degrees of abduction.

scapulohumeral rhythm has been reported in some previous papers,<sup>[6,10,16]</sup> our results revealed that there was no scapular elevation in both MR imaging and autopsy studies (Table III, Figures 1a, b). If the notch (hence the scapula) does not elevate during humeral elevation, this means that there is only scapular rotation in scapulohumeral rhythm. The scapular notch also moved 3.5 cm and 0.3 cm in a medial-lateral direction during GHJ abduction and flexion respectively (Table II). We say that the scapula does not move in both vertical and medial directions in humeral flexion-abduction except for medial motion in humeral abduction.

**TABLE I**

Vertical movement values\* of the notch during flexion and abduction of the glenohumeral joint

|           | Degree of the GHJ range of motion |      |      |      |      |      |
|-----------|-----------------------------------|------|------|------|------|------|
|           | 0°                                | 30°  | 60°  | 90°  | 120° | 150° |
| Abduction | 0                                 | 0.18 | 0.42 | 0.58 | 0.25 | 0.08 |
| Flexion   | 0                                 | 0    | 0.12 | 0.46 | 0.73 | 0.97 |

Data are given in cm; \*: Mean value; GHJ: Glenohumeral joint.

**TABLE II**

Motion values\* of the notch in lateral / medial directions during flexion and abduction movements of the glenohumeral joint

|           | Degree of the GHJ range of motion |      |      |      |       |      |
|-----------|-----------------------------------|------|------|------|-------|------|
|           | 0°                                | 30°  | 60°  | 90°  | 120°  | 150° |
| Abduction | 0                                 | 0.38 | 0.94 | 1.85 | 3.25  | 3.53 |
| Flexion   | 0                                 | 0    | 0.26 | 0.06 | -0.16 | -0.3 |

Data are given in cm; \*: Mean value; GHJ: Glenohumeral joint; -: indicates movements in lateral direction.

The scapular movement in a vertical direction during GHJ movement has been defined in different terms such as “scapular elevation, shoulder bone elevation, elevation of the glenoid cavity”,<sup>[6,16,18,20]</sup> “scapular elevation”,<sup>[10,16-18,21]</sup> elevation of acromioclavicular,<sup>[15]</sup> scapular retraction-elevation-upward rotation, scapular retraction-depression-downward rotation<sup>[21]</sup> and “shoulder girdle elevation”<sup>[22]</sup> in the literature. Although classical textbooks describe this movement,<sup>[6]</sup> careful review of the literature revealed few data on scapular elevation during GHJ abduction-flexion. Although previous authors have mentioned scapular elevation motion, most of them focus on degree of upward rotation of the scapula and clavicle elevation in the literature.<sup>[4,10,11,15-17,23]</sup> As far as we know, Saha<sup>[14]</sup> was the first to measure this movement and reported about 12-15 degrees of clavicle elevation, with the scapula attached. The same methods were used by Berthonnaud et al.,<sup>[16]</sup> McClure et al.<sup>[17]</sup> reported about 40, 10 and 30 degrees of clavicle elevation respectively. In a radiological study conducted by Hallaceli et al.<sup>[19]</sup> Scapular elevation had been measured with regard to vertical and transverse axes of five anatomical landmarks (acromioclavicular joint, center of glenoid cavity, scapular notch, angulus superior and inferior) in GHJ abduction. They

**TABLE III**

Motion amount\* of the scapular notch in vertical direction in shoulder joints of the fresh cadavers

|           | Degree of the GHJ range of motion |     |      |      |      |      |
|-----------|-----------------------------------|-----|------|------|------|------|
|           | 0°                                | 30° | 60°  | 90°  | 120° | 150° |
| Abduction | 0                                 | 0   | 0.30 | 0.25 | 0.50 | 0.6  |
| Flexion   | 0                                 | 0   | 0.50 | 0.50 | 0.50 | 0.6  |

Data are given in cm; \*: Mean value; GHJ: Glenohumeral joint.

reported that the scapular notch was the center of the scapular rotation in abduction and there was only rotation and no elevation in the scapula.<sup>[19]</sup>

Beside this, there is no study in the literature regarding whether elevation occurs in the whole scapula during both humera abduction and flexion. This prompted us to conduct the study. In the light of the results obtained from this study, it can be concluded that the scapular movement pattern with no elevation during GHJ flexion and abduction is a property of shoulder biomechanics and an important factor. We think that this can reduce energy consumption of the rotator cuff muscles during activities of daily living.<sup>[20,24]</sup> In addition to this, we think that the minimal amount of movement of the scapular notch is distinct in very flexible scapulohumeral motion. According to the results obtained from this study, there is no scapular elevation or depression during the GHJ flexion and abduction. The results of the present study indicate that the scapular notch acts like a joint between the scapula and thorax during abduction and flexion of the GHJ. We believe that our findings may therefore explain why ganglia<sup>[9]</sup> and suprascapular nerve entrapment occur in the scapular notch.<sup>[20]</sup>

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