Muscle Activities during Shoulder Elevation Are Different in Patients with Symptomatic and Asymptomatic Rotator Cuff Tears: An Analysis using Positron Emission Tomography

1Shinozaki, N; 2Sano, H; 3Kishimoto, K N; 4Omni, R; 5Itoigawa, Y; 6Sakoma, Y; 7Yamamoto, N; 8Tashiro, M; 9Itoi, E
+8Tohoku University School of Medicine, Sendai, Japan,
staka@m.tains.tohoku.ac.jp

Introduction:
Rotator cuff tear is one of the most common causes of shoulder pain and disability. It has been known that there are two groups of patients: those with symptomatic rotator cuff tears and those with asymptomatic ones. To date, the difference between symptomatic and asymptomatic patients has not been fully clarified yet.

Recently, muscle activity during exercise was successfully examined by positron emission tomography (PET) using fluorodeoxyglucose (FDG). FDG was injected intravenously before exercise, and the uptake into the muscles was then assessed after exercise. The activity of any muscle in the body could be investigated without limitation as to the type of exercise. [1] The purpose of this study was to determine the difference in the muscle activities during shoulder elevation exercise using PET in patients with symptomatic and asymptomatic rotator cuff tears.

Materials and Methods:
The experimental protocol of the present study was approved by the Institutional Ethics Committee, and a signed consent form was obtained from each patient prior to the FDG-PET examination. Experimental protocol:

Twelve shoulders in 11 patients (5 males and 6 females, average age was 69.2), who had been diagnosed as full-thickness rotator cuff tears by magnetic resonance imaging (MRI), were included in this study. Pain during exercise was graded on a visual analog scale (VAS) (0-10). When the VAS was equal to or less than 1, we defined the rotator cuff tear as asymptomatic, whereas when the VAS was greater than 3, we defined it as symptomatic. All the subjects refrained from eating and drinking for at least 3 hours before the examination. Exercise of scaption (elevation in the scapular plane) was performed before and after the injection of FDG. The exercise consisted of 200 repetitions of scaption between 0 and 90 degrees of elevation with 250-gram weights around the wrists. PET images were collected 40 minutes after the injection with a whole-body positron camera (SET-2400W; Shimazu Co, Kyoto, Japan). To quantify the muscle activities in each muscle, it was necessary to determine the exact location of each muscle on the PET image. For that purpose, MRI scan was performed again for image fusion (Signa Horizon LX 1.5T Ver.9.1; GE Healthcare, Milwaukee, Wisconsin, USA). We displayed transverse images of MRI and PET at the same level and defined the margins of muscle groups by using MR images as references. The volume of interest (VOI) was placed on the MR image for each shoulder muscle including the deltoid, supraspinatus, infraspinatus, infraspinatus, teres minor, trapezius, levator scapulae, rhomboids, and serratus anterior. Both the deltoid and subscapularis muscles were divided into three portions (anterior, middle, and posterior portions for the deltoid; superior, middle, and inferior portions for the subscapularis, respectively). The infraspinatus and trapezius muscles were divided into two portions (superior and inferior). Then, the VOI of each portion of the muscle defined on MR images was superimposed onto the registered PET images using a software, Dr. View/LINUX (AJS Inc., Tokyo, Japan) for evaluation of radioactivity in each muscle. After fusion of PET and MRI images, the standardized uptake value (SUV) in each shoulder muscle was calculated to quantify its activity. Statistical significance of difference between two groups was examined for SUV using Student’s t-test. A p-value less than 0.05 was considered statistically significant.

Results:
The PET images demonstrated that the asymptomatic patients (Fig. 1A) showed increased activity of the deltoid and decreased activity of the trapezius than the symptomatic patients (Fig. 1B). The SUVs of the superior trapezius and levator scapulae were 0.79/1.65 (asymptomatic/symptomatic, p=0.0035), and 0.99/1.49 (p=0.012), respectively. The SUVs of these two scapular muscles were significantly higher in the symptomatic group than in the asymptomatic group (Fig. 2). On the other hand, the SUVs of the middle deltoid was significantly lower in the symptomatic group than in the asymptomatic group (2.41/1.71, p=0.046). The SUVs of the rotator cuff muscles did not show any significant differences.

Discussion:
Kelly et al [2] performed electromyography in patients with symptomatic and asymptomatic rotator cuff tears. They reported that symptomatic rotator cuff tears showed significantly greater muscle activation in the supraspinatus, infraspinatus, and upper trapezius than asymptomatic tears. In the current study, the activity of scapular muscles during shoulder scaption exercise was also significantly greater in the symptomatic patients than in the asymptomatic patients. However, neither the supraspinatus nor the infraspinatus showed any significant differences between the two groups. The discrepancy between these two studies might be caused by the difference in methodology. They used intramuscular wire electrodes for EMG, which could monitor only a very limited area of the muscle, whereas we used FDG-PET, which enabled us to assess the whole muscle activity.

Another interesting finding in the current study was that the middle deltoid was less activated in patients with symptomatic rotator cuff tears than in those with asymptomatic tears. There is a consensus that the deltoid is the most important elevator of the arm in the scapular plane [3]. Decreased deltoid activity observed in the symptomatic patients might be substituted for by the increased activities of the scapular muscles.

References: