INTRODUCTION:

Shoulder contracture is caused by various pathologies such as frozen shoulder, rotator cuff tear, post-traumatic, immobilization, etc. Although shoulder contracture is commonly observed in the clinical setting, little is known about its etiology and pathophysiology. One measure to investigate these issues is to develop an animal model with the contracture of the shoulder joint. Numbers of studies have been performed using the knee joint, but little has been investigated using the shoulder joint.

We attempted to newly develop a rat shoulder contracture model using extra-articular immobilization. We further hoped to clarify which tissue was most responsible in the pathogenesis of the joint contracture with this model.

MATERIALS AND METHODS

Twenty-four Sprague-Dawley rats were used for the current study. Twelve of them underwent extra-articular glenohumeral joint immobilization using plates, screws and flexible wires (IM group, Fig.1). Another 12 animals underwent sham operation: screw insertion into the humerus and make a hole at the scapula for wiring (SH group), which were served as controls.

Rats were euthanized either at 8 or 16 weeks after surgery and abduction angle, external rotation, and internal rotation of the glenohumeral joint were measured. The angle was measured using a custom-made device, with which a 10-gram load was applied to the distal end of the humerus, under the following conditions: A) removal of the shoulder girdle from the trunk, B) removal of the skin and the outer muscles, other than supraspinatus, infraspinatus, and subscapularis muscle, C) removal of all the cuff muscles, D) anteroinferior capsulotomy, E) anterosuperior capsulotomy, F) posteroinferior capsulotomy. The step F was performed only in the IM group.

X-ray films were taken in each step. On X-ray, the angle between scapular spine and humeral shaft was measured as abduction angle with a software image J. The supplementary angle between scapular body and forearm was measured as internal and external rotation angle similarly.

In the current study, two types of statistical analyses were performed:
1. The difference between IM group and SH group: Student t-test.
2. The difference of ROM between each step in IM group: One-factor ANOVA and multiple comparisons.

RESULTS

Mean immobilization angle was 61.2 degrees (50.7-69.3). None of the shoulders represented loosening of the screws or the wires in the IM group.

After removal of the all the outer muscles other than cuff, the abduction angle increased more than 40 degrees both in the 8- and 16-week SH group, while this angle did not increase significantly at this stage in the IM group. The angle of abduction in the IM groups gradually increased after serial capsulotomy. The difference in the abduction angle between the IM and SH groups remained statistically significant even after the anterior capsulotomy both for 8 weeks and 16 weeks (Fig. 2). After the anteroinferior capsulotomy, subluxation of the glenohumeral joint occurred in 11 out of 12 shoulders in the SH groups, whereas it was only observed in 6 shoulders after the anterior capsulotomy in the IM group.

In external rotation, the difference between IM groups and SH groups was not significant throughout the cutting procedures. In internal rotation, a significant difference was seen between two groups in all the steps (Fig.3).

In the IM groups, there was not significant difference between the abduction angles after removal from the trunk, after removal skin and muscles other than cuff, and removal all muscles. After anteroinferior and anterosuperior capsulotomy, the difference of the angle became significant (Fig.4, 5).

DISCUSSION

In 1994, Schollmeier et al. investigated the effects after cast immobilization in the canine shoulder. They found that the ROM of forward bending decreased 50% of normal side after 8 weeks of immobilization and that no forward bending occurred after 16 weeks of immobilization. In the current study, the range of motion in abduction and internal rotation also decreased significantly in the IM group. We believed that a rat shoulder contracture was successfully developed using joint immobilization method.

It is noteworthy that the motion increased significantly in the IM groups after each step of serial capsulotomy. On the other hand, after removal of the cuff muscle, the ROM was not significantly increased in both in the 8-week and 16-week IM groups. Based on these results, we speculated that the joint capsule played the most important role in the pathogenesis of shoulder contracture following the immobilization.

The significant difference in abduction angle between the IM and SH groups still existed even after serial capsulotomy. In the current series, the subluxation occurred in 11 out of 12 shoulders in the SH group. We assumed that the abduction angle increased beyond the normal shoulder range of motion due to subluxation of glenohumeral joint. The other possible explanation was the presence of the adhesion inside the joint in the IM group.

Schollmeier reported that the capsule and subscapular bursa showed focal adhesion between the capsule and articular cartilage, and between synovial surfaces. Trudel reported that contracture secondary to immobilization of the knee was mainly due to the capsule, synovium, ligament, and cartilage. Although we could not determine the sites of intraarticular adhesion from the results of the current study, such intraarticular factors might contribute somehow to the development of the contracture following the joint immobilization.

REFERENCE