Development of A Rotator Cuff Degenerative Tear Model Focusing on The Scapulothoracic Joint

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INTRODUCTION: The shoulder joint is composed of the glenohumeral and scapulothoracic joints. Frozen shoulder is a disease characterized by restricted range of motion (ROM) of the glenohumeral joint, and its pathology has been extensively studied. Persistent inflammation of the shoulder joint induces degeneration of the rotator cuff, leading to further functional impairment due to rotator cuff degeneration and rupture. Degenerative rotator cuff tears (RCTs) have been suggested to be associated with aging, impingement, and diabetes; however, many aspects of their pathology remain unclear. Although animal models have been developed to elucidate the pathology, existing models mainly involve fixation of the glenohumeral joint [1] or surgically induced RCTs [2], and there are no models that reproduce degenerative tears. We focused on scapular dyskinesis, which has recently attracted attention in relation to frozen shoulder and rotator cuff degeneration. We hypothesized that fixation of the scapulothoracic joint would induce impingement and rotator cuff degeneration. The aim of this study was to develop a novel rat model that reproduces degenerative rotator cuff tears by immobilizing the scapulothoracic joint.

METHODS: 12-week-old Sprague Dawley (SD) rats were used. In the sham group (right shoulder), only a skin incision was made. In the fixation group (left shoulder), the medial border of the scapula was sutured to the spinous processes of the vertebrae with nylon thread to immobilize the scapula (Figure 1a). At 2, 4, 6, and 8 weeks, sutures were removed, and one week later, gait analysis (ink footprint method) (Figure 1b) and ROM measurements of the scapulothoracic and glenohumeral joints (Figure 1c) were performed. Seven rats were examined at each time point, resulting in a total of 28 SD rats. At 8 weeks, the joint capsule was harvested for qPCR evaluation of Collagen I/III, IL-6, VEGF, Sox9, TIMP1, and TNFα gene expression. Frozen sections of the harvested joint capsule were prepared and evaluated by hematoxylin–eosin (HE) staining and immunostaining for vascular endothelial cells using Isolectin B4. Each parameter was compared between the sham and fixation groups using Student's t-test.

RESULTS SECTION: At 2, 4, and 6 weeks, no significant differences between groups were observed except for scapulothoracic ROM. At 8 weeks, stride length and scapulothoracic/glenohumeral ROM were significantly reduced in the fixation group ($p < 0.05$). qPCR at 8 weeks showed increased expression of Collagen I/III, VEGF, and Sox9 in the fixation group (Figure 2). HE staining revealed capsular thickening and partial rotator cuff tears at 6 weeks (Figure 3a, b) in the fixation group, with complete tears in all specimens at 8 weeks. Isolectin B4 staining demonstrated neovascular invasion into the joint capsule and rotator cuff (Figure 3c, d).

DISCUSSION: In this study, we attempted to establish an animal model of rotator cuff degeneration by focusing on the motion of the scapulothoracic joint. After eight weeks of scapulothoracic joint fixation, a decrease in the range of motion (ROM) and functional decline of the glenohumeral joint were observed, along with degeneration of the rotator cuff and increased angiogenesis. These results suggest that eight weeks of scapulothoracic joint immobilization in rats may reproduce the functional and histological characteristics of degenerative rotator cuff tears. Future longitudinal observation of capsular thickening and rotator cuff degeneration may contribute to elucidating the detailed pathogenesis of scapulothoracic joint contracture and degenerative rotator cuff tears, as well as to exploring potential therapeutic strategies.

SIGNIFICANCE/CLINICAL RELEVANCE: This is the first report of a rat model reproducing degenerative rotator cuff tears without direct surgical injury. It provides a novel platform for investigating the mechanisms and treatment strategies for shoulder contracture and degenerative rotator cuff disease.

REFERENCES:
[1] Oki et al. Generation and Characterization of a Novel Shoulder Contracture Mouse Model. *JOURNAL OF ORTHOPAEDIC RESEARCH.* 2015;33(11):1732-8.
[2] Liu et al. A Rat Model of Massive Rotator Cuff Tears. *JOURNAL OF ORTHOPAEDIC RESEARCH.* 2011; 29(4):588-95.

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IMAGES AND TABLES:

Figure 1

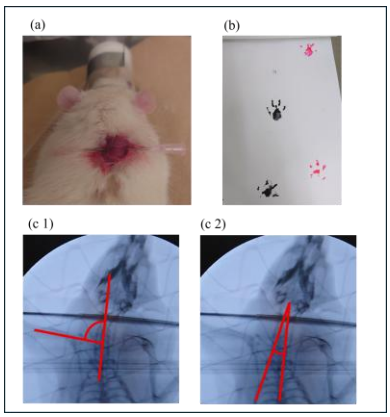

Figure 2

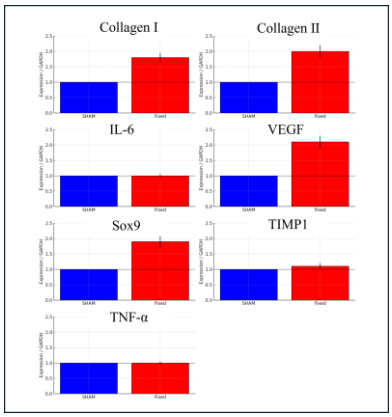

Figure 3