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Real-time sonoelastography in the diagnosis of rotator cuff tendinopathy

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Background: Real-time sonoelastography can be used to assess tissue elasticity. The present study evaluated the relationship between tendon stiffness on sonoelastography and the magnetic resonance imaging (MRI) tendinosis grade in patients with rotator cuff tendinopathy.

Methods: The study included 39 patients with chronic pain and no history of trauma or rotator cuff tear. The supraspinatus tendons were graded according to MRI findings (grade 0, normal; grade 1, mild tendinosis; grade 2, moderate tendinosis; grade 3, marked tendinosis), and the subcutaneous fat-to-tendon (Fat/T) and gel pad-to-tendon (Pad/T) strain ratios were assessed. We used the trend test to analyze the relationship of the MRI grade with the Fat/T strain ratio and the Pad/T strain ratio.

Results: Of the 39 patients, 9 had grade 0, 17 had grade 1, 12 had grade 2, and 1 had grade 3 tendinosis. The mean real-time elastography Fat/T and Pad/T strain ratios were 2.92 ± 2.13 and 20.77 ± 21.78 in patients with grade 0 tendinosis, 4.08 ± 4.09 and 21.78 ± 17.16 in patients with grade 1 tendinosis, 13.48 ± 10.19 and 83.00 ± 48.26 in patients with grade 2 tendinosis, and 12.3 ± 0.00 and 16.58 ± 0.00 in patients with grade 3 tendinosis, respectively. The Fat/T and Pad/T strain ratios were positively associated with the MRI grade ($P < .001$).

Conclusion: The MRI tendinosis grade is associated with stiffness assessed using sonoelastography in patients with rotator cuff tendinopathy. Therefore, sonoelastography might be a useful diagnostic tool for supraspinatus tendinopathy.

Level of evidence: Level III; Diagnostic Study

Keywords: supraspinatus tendon; rotator cuff; tendinopathy; magnetic resonance imaging; sonoelastography; grade; diagnosis

Overuse tendon injuries, namely tendinopathies, are a significant and highly prevalent problem in musculoskeletal medicine.[15] Ultrasonography has been used for rotator cuff pathology because of several advantages such as availability, cost-effectiveness, and patient preference for ultrasonography over magnetic resonance imaging (MRI).[16]

The Insitutional Review Board of Incheon St. Mary's Hospital, the Catholic University of Korea, approved this study (Study No.: OC13RISI0023).

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However, diagnosing tendinosis is difficult and in some cases impossible with conventional ultrasonography because it often presents with the same echogenicity as the surrounding healthy tissue, especially in the case of tendinopathy.

Real-time sonoelastography is a new ultrasonography-based technique that can assess tissue elasticity.[28] That inflammation and tumors can cause changes in tissue elasticity is well known.[8] In recently published studies, tendon and ligament strain measurements were obtained with elastography.[3-7,26,30] However, to our knowledge, there is no report on sonoelastography for the diagnosis of supraspinatus tendinopathy. The present study evaluated the relationship between tendon stiffness on sonoelastography and the MRI tendinosis grade in patients with rotator cuff tendinopathy.

Materials and methods

This observational study prospectively enrolled 42 patients from the shoulder and elbow clinics at our institution, and informed written consent was obtained from all the participants. Patients who complained of chronic pain for more than 3 months were enrolled. We included only patients with mild to moderate pain during activity and tenderness of the greater tuberosity area, without motion limitation, which suggested supraspinatus tendinopathy. The patients were able to perform daily activities and activities at the work place. We excluded patients who had a history of surgery, trauma, or shoulder disease, including adhesive capsulitis, calcific tendinitis, inflammatory arthritis, rotator cuff tear, and impingement syndrome.

Of the 42 patients enrolled, 3 patients were diagnosed with calcific tendinitis on MRI and were excluded; therefore, 39 patients were finally included in this study. There were 13 (33%) men and 26 (67%) women, and patients were a mean age 39.8 years (range, 28-48 years). The patients underwent MRI, followed by real-time sonoelastography performed by an orthopedic surgeon (S.-U.L.) who was blinded to the MRI findings.

MRI examinations

The MRI examinations were performed based on a standardized protocol for the evaluation of rotator cuff pathology. All patients were placed supine with the arm externally rotated, and a shoulder coil was positioned over the shoulder. Oblique coronal proton density (PD)-, fat-suppressed T2-, oblique sagittal T2-, and axial PD-weighted images were obtained using a 3-T MAGNETOM Skyra system (Siemens, Erlangen, Germany). The oblique sagittal views were extended at least 1 cm medial to the spinoglenoid notch to include sections showing the bulk of the muscles in the supraspinatus and infraspinatus fossae.

Rotator cuff status was categorized according to the MRI tendinosis grade[27] as follows:

- grade 0 (normal)—a complete homogenous low signal intensity on all pulse sequences or minor intratendinous hyperintense signal intensity, which is comparable with a magic angle artifact (Fig. 1, *a*);
- grade 1 (mild tendinosis)—a mild intratendinous focally increased signal intensity (not equal to that of fluid) on PD- and fat-suppressed T2-weighted images (Fig. 1, *b*);
- grade 2 (moderate tendinosis)—a moderate intratendinous focally increased signal intensity (not equal to that of fluid) on PD- and fat-suppressed T2-weighted images (Fig. 1*c*); and
- grade 3 (marked tendinosis)—a generalized intratendinous increase in the signal intensity without frank fluid signal intensity (Fig. 1, *d*).

The MRI images were interpreted by a radiologist with 8 years of experience in musculoskeletal imaging (S.K.K.). The images were randomly sorted, and the radiologist was blinded to the sonoelastography findings to avoid bias.

Real-time sonoelastography

Shoulder ultrasonography was performed, using a standardized protocol, by an orthopedic surgeon (S.-U.L.) with 7 years of experience in musculoskeletal ultrasonography of the shoulder. The supraspinatus tendon was examined with the patient sitting and the arm internally rotated and hyperextended. The transducer was placed anterior to the acromioclavicular joint and was oriented at an angle of 45° anteriorly to examine the supraspinatus tendon. Ultrasonography gel and a 10-mm-thick Sonar Aid gel pad (Geistlich Pharma, Wolhusen, Switzerland) were used. Real-time sonoelastography was performed using a linear-array EUB-8500 transducer (Hitachi Medical Systems, Tokyo, Japan).

Sonoelastography images were obtained by repeatedly compressing the shoulder with the probe.[24] Several compression-decompression cycles were performed before the force and frequency of the probe compression were appropriate, and the subcutaneous fat layer and gel pad were seen in red. We used multicompression imaging to improve the signal-to-noise ratio of the real-time sonoelastography images.[6,30] With slight compression and decompression using a free hand technique, local strain was measured, and then, according to the visual indicator for compression on the video screen, which indicates the average strain in the region of interest between 2 frames, pressure was applied to the supraspinatus tendon to be adjusted.[9]

The color scale ranged from red for components with the greatest strain (softest components) to blue for those with no strain (hardest components). Green indicated the average strain in the region of interest. The stiffness of the supraspinatus tendon that was level with the medial side of the greater tuberosity was measured. Stiffness was assessed as the subcutaneous fat-to-tendon (Fat/T) and gel pad-to-tendon (Pad/T) strain ratios (Fig. 2). Measurements were repeated thrice,