MR Quantification of Fatty fraction in the Muscle Atrophy in Rotator Cuff Tears from T2*-corrected Dixon Fat/Water Separation VIBE

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Objective: Rotator cuff tears (RCT) are the common clinical problem in the shoulder, and can develop significant muscle atrophy or fatty infiltration. Fatty degeneration of muscles accompanied by tendon tears is known to be an important negative prognostic factor. Therefore, an accurate assessment of fat quantification of rotator cuff muscles is very important to set up treatment plan and to predict postoperative prognosis. Further, a reliable fat quantitative grading system on MR is a prerequisite for appropriate decision making in patients with RCT, however, the most widely used method for fatty infiltration is still disputed. Various MR imaging methods have been used to measure the signal fat fraction for over 25 years, however the signal fat-fraction may be confounded with numerous technical and biological factors, which may result in unreliable fat content. To minimize the confounding factors, advanced techniques have been suggested for accurate fat quantification. In this paper, we investigated the quantification of muscle atrophy and fatty infiltration from the T2*-corrected Dixon Fat/Water separation Volume Interpolated Breathhold Examination (VIBE) sequence in the patients with rotator cuff pathology in terms of advanced confounding factor-corrected fat map on a 3-T clinical MRI.

Method: A phantom study was performed by utilizing oil-in-water emulsions stabilized with a gelatin matrix to simulate muscle fat deposits. For clinical study, consecutive 61 patients with shoulder pain who had undergone the routine sequences of shoulder MR arthrography and T2*-corrected VIBE sequence, and fat fraction maps were reformatted from the IP and OP images of T2*-corrected VIBE. Among these, 8 patients were excluded (n=8, postoperative status), and 53 patients were included in this analysis: 27 were male, and 26 were female. The MR arthrographies were retrospectively reviewed by two musculoskeletal radiologists blinded to medical records, and they divided into three groups by consensus: those with tendinopathy or normal tendon, those with partial thickness tear, and those with full thickness. Tear size were measured in patients with tendon tear. Muscular atrophy was quantitatively assessed by calculating the Goutallier grade of occupation ratio on T1-weighted oblique sagittal images Y-view. Quantitative fatty infiltration was assessed on fat map from T2*-corrected VIBE images. The quantitative fatty infiltrations of the supraspinatus muscle on fat map were compared with tendon tears and occupation ratio on MRI. Fatty fractions were quantified after measurement of signal intensity values within the region of interest (ROI) placed over the muscles. The Pearson correlation test was used to correlate the fat fractions with patient groups and with occupation ratio, respectively. The Student's *t* test was used to compare the occupation ratio and fat fraction among the tendon tear groups. Full thickness tear group was compared with other groups in each muscle by using Mann-Whitney *U* test.

Result: Fat fraction map on T2*-corrected VIBE images provided artifact-free fat fraction maps with a high correlation with fat-water phantom. In clinical study, there are significant negative correlations between Goutallier grade of occupation ratios on MRI and fat fractions on T2*-corrected VIBE images for the assessment of rotator cuff muscle atrophy and fatty infiltration, respectively (R = -0.526; R=-0.695; R=-0.677, All $P<0.05$). And, the comparison of the occupation ratios and fat fraction maps demonstrated significant different among the patient groups ($P<0.05$). In each muscle, the fat fractions of full thickness tear group and the other groups are significantly different ($P<0.05$).

Conclusion: This quantitative assessment of rotator cuff muscles on the fat fraction was reliable and correlated well with both the preexisting grade of fatty degeneration and cuff tear size. Furthermore, these fat fraction map from the VIBE images with T2*-corrected Dixon Water/Fat separation can be used for more sophisticated assessment of fat quantification of rotator cuff muscles, and might be utilized as an important prognostic factor to set up treatment plan and to predict postoperative prognosis.

References

Nakagaki K et al. J Shoulder Elbow Surg 1996;5:194-200; Yu H et al. J Magn Reson Imaging 2007;26:1153-1161; Tae SK et al. Am J Sports Med 2011;39:599-606

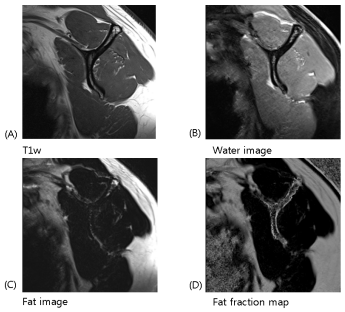

Fig. 1— Shoulder MR arthrography with no tendon tears of rotator cuff of shoulder. Subscapularis, supraspinatus, and infraspinatus muscles showed no muscular atrophy (A). From the T2*-corrected in-phase and oppose-phase VIBE, water image (B) and fat image (C) were reconstructed. Fat fraction map (D) showed normal range of fat fractions of shoulder.

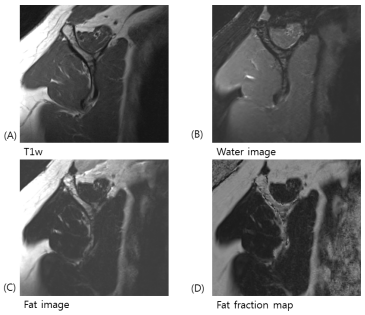

Fig. 2— Shoulder MR arthrography with tiny fat fraction in the supraspinatus muscle. Supraspinatus muscle showed suspicious high signal intensity in T1-wighted image (A). From the T2*-corrected IP and OP VIBE images, water image (B) and fat image (C) were reconstructed. Fat fraction map (D) showed definite high signal intensity in the supraspinatus muscle.

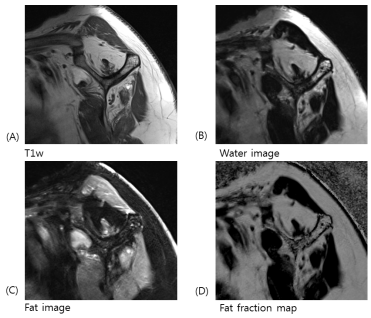

Fig. 3— Shoulder MR arthrography in patient with massive rotator cuff tear and severe fatty change. Supraspinatus muscle showed definite high signal intensity and severe muscular atrophy in T1-wighted image (A). From the T2*-corrected IP and OP VIBE images, water image (B) and fat image (C) were reconstructed. Fat fraction map (D) showed definite high signal intensity in the supraspinatus muscle.