Ultrasound in Med. & Biol., Vol. 41, No. 6, pp. 1779–1783, 2015

0301-5629/$ - see front matter

http://dx.doi.org/10.1016/j.ultrasmedbio.2015.01.013

● *Clinical Note*

# A PILOT STUDY TO ASSESS FATTY INFILTRATION OF THE SUPRASPINATUS IN PATIENTS WITH ROTATOR CUFF TEARS: COMPARISON WITH MAGNETIC RESONANCE IMAGING

Tsuneo Watanabe,* Nobuo Terabayashi,† Daisuke Fukuoka,‡ Hiroki Murakami,‡ Hiroyasu Ito,* Toshio Matsuoka,§ and Mitsuru Seishima*

*Division of Clinical Laboratory, Gifu University Hospital, Gifu, Japan; †Department of Orthopaedic Surgery, Gifu University Graduate School of Medicine, Gifu, Japan; ‡Department of Regeneration and Advanced Medical Sciences, Gifu University Graduate School of Medicine, Gifu, Japan; and §Department of Sports Medicine and Sports Science, Gifu University Graduate School of Medicine, Gifu, Japan

(*Received* 4 *September* 2014; *revised* 12 *January* 2015; *in final form* 19 *January* 2015)

**Abstract—The aim of this study was to quantitatively assess the echo intensity of the supraspinatus muscle and compare magnetic resonance imaging and ultrasound findings for 27 patients (12 women, 15 men, 65.8 ± 11.5 y). Tear size and fatty infiltration were determined by magnetic resonance imaging; five stages were assigned based on Goutallier's classification. Gray-scale histogram analysis was used for ultrasound assessment, which was performed in both subcutaneous fat and supraspinatus muscle in three different regions; the echo intensity ratio was the ratio of echo intensity in subcutaneous fat to that in the supraspinatus muscle. Sonograms of 27 shoulders revealed 3 shoulders with a partial tear, and 4 with a small tear, 6 with a medium tear, 6 with a large tear and 4 with a massive tear; 4 shoulders had no tear. Supraspinatus muscle echo intensity and echo intensity ratio were significantly lower in the stage 0 and 1 than in stages 2–4. Our study suggests that ultrasound can quantitatively and objectively assess fatty infiltration in the rotator cuff muscle. (E-mail: tsuneo_w@gifu-u.ac.jp)** © **2015 World Federation for Ultrasound in Medicine & Biology.**

*Key Words:* **Rotator cuff, Fatty infiltration, Ultrasound, Histogram analysis.**

## INTRODUCTION

Rotator cuff disease is the most common cause of shoulder pain, and rotator cuff tear (RCT) is a frequently encountered orthopedic condition, with significant pain and functional impairment. Clinically, both muscle atrophy and fatty infiltration are independent predictors of failed surgical repair with poor functional outcomes (Laron et al. 2012). Therefore, the assessment of muscle quality with imaging is an important predictor for surgical indications and post-operative prognosis.

Over the last few years, there have been many improvements in high-resolution diagnostic ultrasound (US) equipment; consequently, US and magnetic resonance imaging (MRI) are frequently used in the assessment of RCT. A classification system of fatty infiltration was established by Goutallier et al. (1994). Although it is widely based on computed tomography (CT), recent studies have reported the use of MRI for the evaluation of supraspinatus muscle quality in patients with RCTs (Jo and Shin 2013; Rulewicz et al. 2013). Khoury et al. (2008) reported a positive correlation between US and MRI in the assessment of supraspinatus muscle atrophy and fatty infiltration; however, these reports offered only a subjective assessment of fatty infiltration of muscle and lacked objective and quantitative analysis of the results. To date, there have been few reports on the quantitative and objective assessment of fatty infiltration in rotator cuff muscle using US. The purpose of this study was to quantitatively assess the echo intensity of the supraspinatus muscle and to evaluate the relationship between MRI and US.

## METHODS

### *Patients*

This study was a retrospective analysis of 27 randomly selected patients who visited the outpatient

Address correspondence to: Tsuneo Watanabe, Division of Clinical Laboratory, Gifu University Hospital, 1-1, Yanagido, Gifu, 501-1194, Japan. E-mail: tsuneo_w@gifu-u.ac.jp

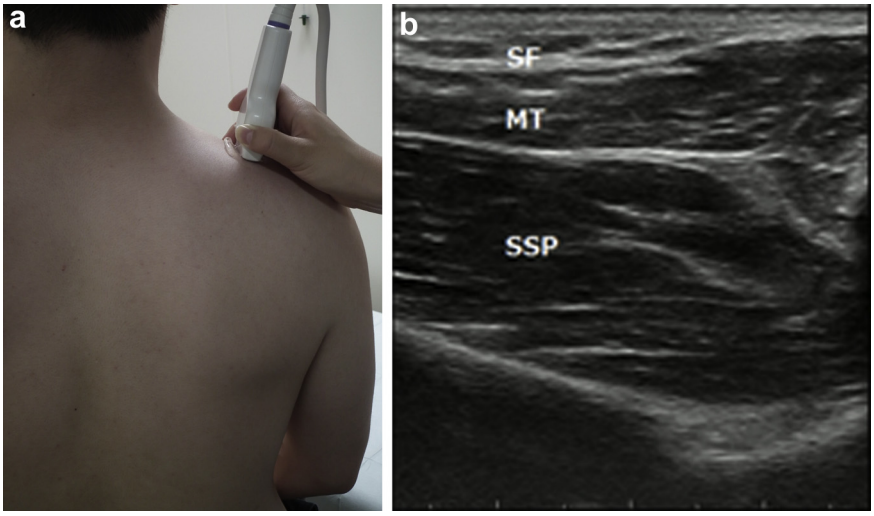


Fig. 1. (a) Probe position for imaging supraspinatus muscle echogenicity. (b) Sonogram of a cross section of the supraspinatus muscle. MT = middle trapezius; SF = subcutaneous fat; SSP = supraspinatus.

clinic of our hospital. Patients included in this study had undergone shoulder US and MRI for the assessment of rotator cuff abnormalities (12 women, 15 men; age: 65.8 ± 11.5 y, age range: 25–81 y). Patients whose MRI study was poor quality (motion artifact, poor 'Y'-view delineation) or who could not undergo US examination within 3 mo of MRI were excluded. There were 21 right and 6 left shoulders. There were 4 shoulders with no tear, 3 with a partial tear, 4 with a small tear, 6 with a medium tear, 6 with a large tear and 4 with a massive tear. This study was conducted in accordance with the 1964 Declaration of Helsinki and was approved by the institutional ethics committee; informed consent was obtained from all participants.

*MRI assessment of fatty infiltration*

Magnetic resonance imaging was performed using a 1.5-T unit (Intera Achieva 1.5 T Pulsar, Philips Medical Systems, Amsterdam, Netherlands). The shoulder was placed in a dedicated receive-only shoulder coil. The arm was placed alongside the body in a neutral position. Sagittal oblique non-fat-suppressed T2-weighted fast spin-echo (TR/TE, 2,185–4,968/100 ms; imaging matrices, 512 × 512; field of view, 18 × 18 to 20 × 20 cm; section thickness/gap, 4/1 mm; number of slices, 22) images were obtained. All findings on MRI were reviewed by an orthopedic surgeon who had more than 10 y of clinical experience with the shoulder joint and was blinded to the US findings. Fatty infiltration was classified into five stages according to the method of Goutallier et al. (1994): stage 0 = completely normal muscles, without any fatty streak; stage 1 = muscle containing some fatty streaks; stage 2 = significant fatty infiltration, but still more muscle than fat; stage 3 = as much fat as muscle; stage 4 = more fat than muscle. In this pilot study, we combined stages 0 and 1 because stage 1 was almost normal. Tear size was assessed according to the classification of Cofield (1985).

*Sonographic assessment of fatty infiltration*

Sonographic examination was performed by a board-certified sonographer using a 6.0- to 14.0-MHz linear array probe (portable real-time apparatus: ProSound $\alpha$7, Hitachi Aloka Medical, Mitaka, Tokyo, Japan). Each subject initially underwent a routine sonographic examination according to the musculoskeletal technical guidelines of the European Society of Musculoskeletal Radiology (Martinoli 2010). The tendons of the biceps, subscapularis, supraspinatus, infraspinatus and teres minor muscles were examined. During fatty infiltration examinations, patients were seated with the shoulder in 0° flexion. Fatty infiltrations of the supraspinatus muscle were measured in the sagittal view at the middle of the scapular spine (Fig. 1). The supraspinatus was visualized at the bottom of the B-mode image.

For assessment of fatty infiltration, we used the gray-scale histogram analysis function on the ProSound $\alpha$7; to determine the echogenicity value, each pixel included in the region of interest (ROI) was divided into 64 gradients (0 = black, 63 = white; one gradient corresponds approximately to 1 dB) by built-in equipment on the basis of its intensity, and frequency distributions of the gradients were displayed as a histogram. The histogram analyses provide information about the most frequent gradient ($L$), the number of the pixel that constitutes the $L$-value ($M$) and the mean of all pixels' gradients included in the ROI ($MN$). The MN value was used to evaluate fatty infiltration in this study. ROIs were placed in both the