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RESEARCH ARTICLE

A new way to detect rim rent tears of the rotator cuff: Real-time sonoelastography

Mehtap Balaban[1], **Atilla Hikmet Çilengir**[2], **Sinem Şığıt İkiz**[3], **İlkay Sedakat İdilman**[4]

[1]Department of Radiology, Faculty of Medicine, Ankara Yildirim Beyazit University, Ankara, Türkiye
[2]Department of Radiology, Faculty of Medicine, İzmir Democracy University, İzmir, Türkiye
[3]Department of Radiology, Dr. Burhan Nalbantoglu State Hospital, Lefkosa, Turkish Republic of Northern Cyprus
[4]Department of Radiology, Faculty of Medicine, Hacettepe University, Ankara, Türkiye

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ABSTRACT

Aim: To evaluate real-time sonoelastography (RTSE) findings of the rotator cuff (RC) in patients with rim-rent tears (RRTs) and compare them with a control group of healthy individuals.

Methods: A total of 101 RC tendons were evaluated in 54 patients with RRTs and 31 healthy individuals. RC tendons were evaluated by routine shoulder dynamic ultrasound (US) and RTSE examination. US and RTSE findings were evaluated in patients with RRTs and healthy individuals for the same tendons of the RC.

Results: A total of 85 individuals (male/female: 34/51) and 101 RC tendons (54 with RRTs and 47 healthy tendons) were included in this study. According to the RTSE evaluation, all of the RRTs had yellow and red areas within green/blue coding, and all of the RC tendons in healthy volunteers had blue and green coding on sonoelastography.

Conclusion: We demonstrated tear areas and softening of the RC tendons in patients with RRTs compared to healthy volunteers. RTSE findings may be associated with RRTs of the RC tendons in this patient population and also can be useful for the evaluation of RRTs.

Keywords: rotator cuff, sonoelastography, supraspinatus, tendon injury

Corresponding author: Atilla Hikmet Çilengir **E-mail:** acilengir@gmail.com
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INTRODUCTION

Codman divided the partial tears of the supraspinatus tendon in the rotator cuff (RC) into 4 subtypes (1). The subtype Partial Articular Surface Tendon Avulsion, also known as PASTA, is also defined as a rim-rent tear (RRT), on the articular surface where the tendon attaches to the greater tuberosity (2). On the B-mode ultrasound (US), RRTs are visualized as a small-sized partial tear area in the anterior segment of the tendon at the articular surface, which leads to intratendinous linear echogenic extension of a small cortical avulsion and a concomitant halo appearance (3). Focal irregularity is also observed in the adjacent cortex due to avulsion. This is a primary and stimulating sonographic finding that leads us to the pathology. Despite the higher incidence among partial tears, it is harder to detect an articular-sided tear in comparison with bursal-sided partial tears (4). The common anisotropy artifact seen on the US may also mistakenly create the appearance of an articular side partial tear. It is necessary to examine whether there is a real tear by giving an angle to the probe and visualizing this section of the tendon in both transverse and longitudinal planes, which requires experience.

With technological developments, the frequency of US examinations of the musculoskeletal system has increased over time, and now US is commonly used in daily practice. Ease of use, low cost, accessibility, repeatability, lack of X-rays, and applicability to all age groups are important advantages of this modality. In addition, compared to magnetic resonance imaging (MRI), US takes less time and is therefore more tolerable for the patients. This makes US to be preferred as the first-line radiological modality for the evaluation of important anatomical structures of the musculoskeletal system, such as tendons. US provides a better assessment of the pathology by offering reliable determination of anatomical localization, real-time dynamic examination, and comparison with the intact side. Recently, sonoelastography has become available for further assessment of tissues, in addition to the standard Bmode imaging. While the findings of RTSE in the musculoskeletal system were limited to a few articles, this number is increasing with the growing commercial use of US devices.

In this study, we aimed to evaluate US and RTSE findings of the RC RRTs in symptomatic patients and compare them with healthy individuals.

MATERIALS AND METHODS

Study population

A total of 101 RC tendons (54 RC tendons of 54 patients with RRTs and 47 RC tendons of 31 healthy individuals) were included in this study. All patients with RRTs had shoulder and deltoid pain, and also a positive Jobe Test. None of the patients had a history of inflammatory arthritis or trauma or operation to the shoulder. The control group had no history of tendon injury or clinical findings that indicate a tendon disorder. This study was approved by our Institutional Review Board (Approval Number: E2-20-76).

Imaging

Patient and control groups underwent US and RTSE evaluation for the RC tendons. Sonographic examinations were performed with GE Logiq E9 (GE Healthcare, Milwaukee, Wisconsin, USA) and Toshiba Aplio 500 (Toshiba Medical Systems Corporation, Tochigi, Japan) with 5 – 11 MHz or 7 – 15 MHz linear array transducers by the two experienced radiologists (M.B. and I.S.I.). When evaluating the supraspinatus tendon, the elbow was flexed the arm was in extension, and the dorsal side of the hand was held posterior to the waist so that optimal tension could be achieved in the fibrils, enabling the best visualization of the fibrillar structures.

RTSE images of the tendons were obtained in the transverse plane while the transducer was perpendicular to the tendon to avoid tissue shifting. The local strain was calculated under slight compression and decompression, applied with a freehand technique. The optimal strain was assessed according to the visual indicator of compression . This indicated the average strain in the region of interest between the two frames. The tissue elasticity distribution was calculated in real-time, and the results were represented on a color map superposed on the B-mode images. The color spectrum ranged from blue (hard) to red (soft) and represented the relative

stiffness of the tissue. Red indicated soft tissue; yellow, intermediate stiffness; and blue and green, hard tissue. At least one real-time sonoelastographic image of each tendon RRT area was assessed and the selection and definition of the elastographic patterns were assessed by two radiologists (M.B. and I.S.I) blinded to patient characteristics.

The tendons were classified according to the sonoelastography findings as normal (a tendon with blue and green coded) and abnormal (a tendon with yellow and red areas representing RRT within a blue and green coded appearance).

RESULTS

A total of 85 individuals (Male/Female: 34/51) and 101 tendons were included in this study. The mean age of the participants was 52.9 years (range, 28-72 years). Fifty-four patients with 54 RC tendons had symptomatic RRTs and thirty-one individuals with no symptoms were included as the healthy controls. The mean age of the RRTs group was 53 years (range, 28-72 years), and the mean age of the healthy group was 52.8 years (range, 34-72 years). A common patient history included severe pain in the deltoid region following a sudden arm movement and inability to lie down on that side at night.

A total of 101 RC tendons were evaluated. Sixty-three of them were on the right shoulder and 38 on the left. Fifty-four of these tendons were RRT cases, 53 of which were in the supraspinatus tendon and one of them was in the subscapularis tendon. No additional US pathology was observed in 19 cases, whereas intense contents of fluid were observed in subdeltoid-subacromial bursitis in 35 cases. There were 41 right and 13 left-sided tendons in the RRT group, and 22 right and 25 left-sided tendons in the healthy group. Supraspinatus tendons were evaluated in the control group, and in the case of a rim-rent tear in the subscapularis tendon, the opposite intact subscapularis tendon was evaluated for comparison.

Only 9 of 54 patients underwent shoulder MRI as an additional radiological imaging. Two cases were reported as minimal tendinosis, three as millimetric intratendinous tear, and four as an articular-sided partial tear. MRI examinations were performed in one case two years after the US examination, in one case after nine months, and in one case after three months, and the other six cases were reported in the same month.

RTSE evaluation demonstrated that all RRTs in the symptomatic patients had an abnormal structure (54 of 54 tendons) (Figure 1), and all RC tendons in the healthy volunteers had a normal structure (47 of 47 tendons) (Figure 2).

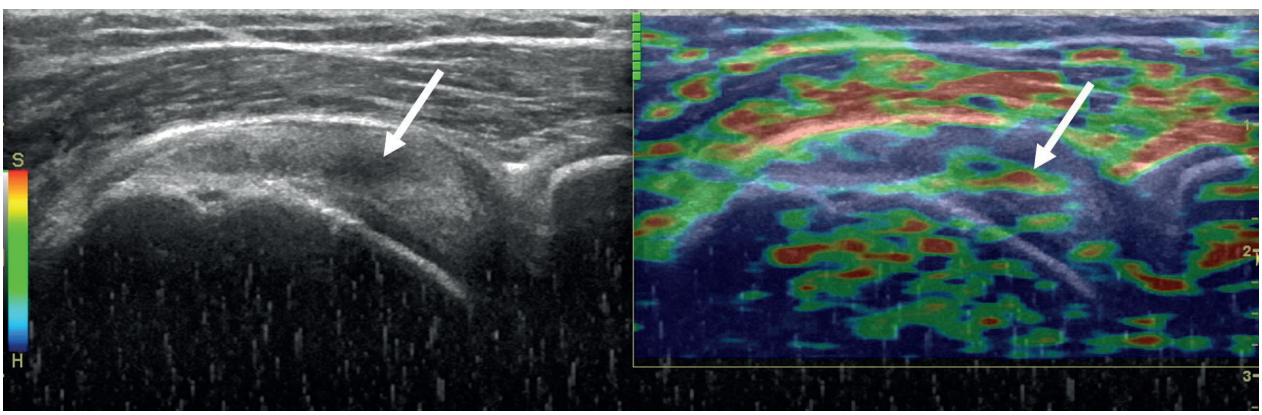

Figure 1. Rim-rent tear of the supraspinatus tendon (arrow). On the grey-scale ultrasound, the rim-rent tear area is hypoechoic relative to the hyperechoic normal tendon. The rim-rent tear is visualized as yellow and red areas within green on the real-time sonoelastography, indicating its intermediate to soft tissue characteristics.

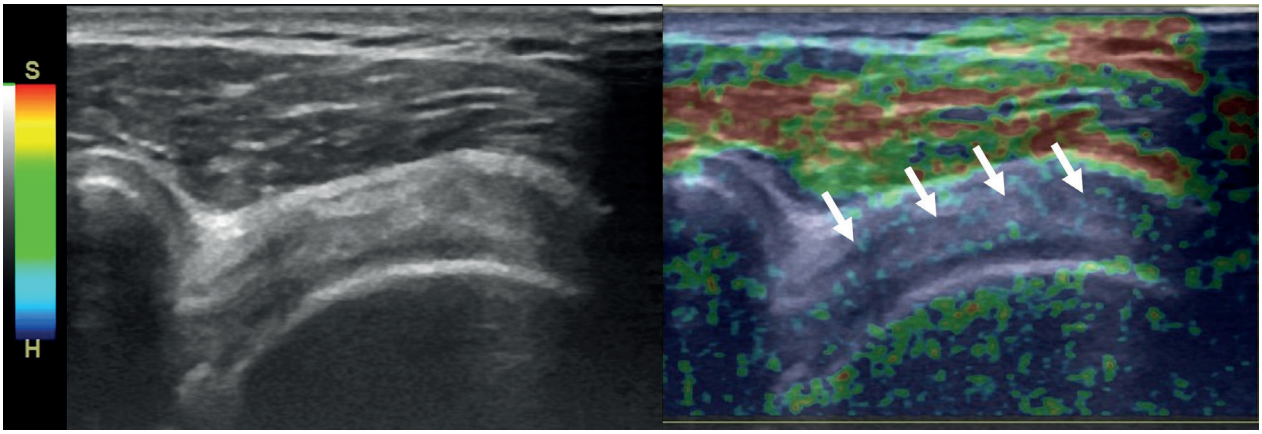

Figure 2. Normal sonographic and sonoelastographic appearance of the supraspinatus tendon (arrows). On the grey-scale ultrasound, the tendon is homogenously hyperintense with smooth contours. The supraspinatus tendon exhibits predominantly blue with some green coloration on the sonoelastography, indicating its hard tissue characteristics.

DISCUSSION

In this study, we evaluated US and RTSE findings of RC supraspinatus and subscapularis tendons in patients with RRTs by comparing them with a healthy control group. In the RTSE evaluation of the RC tendons with RRTs, we observed that all RRTs had an abnormal structure and all RC tendons in healthy individuals had a normal structure according to the main sonoelastography evaluation.

US is a reliable imaging modality in the evaluation of musculoskeletal system (3,4). The RC tendons can be visualized optimally with high-resolution linear probes. The echogenicity of the fibrillar structures of the RC tendons should be iso-hyperechoic compared to subcutaneous soft tissue and hypoechoic compared to subdeltoid-subacromial bursal layers.

Elastography is a sonographic modality used to evaluate the elasticity of different tissues. It was first performed on humans in 1987 by Krouskop et al. (5). The basic principle of RTSE is based on the strain (displacement) due to compression applied to the tissues. This displacement can be calculated with the modified US and reflected on the color scale (6-8). In most tissues and lesions where external compression is applied, different results may be seen due to the different internal molecular structures. A small amount of deformation occurs in the hard tissues, whereas this deformation is significant in soft lesions for the same degree of compression. These deformation results are reflected in the color spectrum on the monitor. The blue color in this color map indicates hard areas, the red color indicates soft areas, and the green color indicates medium-hard areas.

In our study, we observed an abnormal appearance in the RC tendons (mostly supraspinatus, one case subscapularis) with RRTs (green-yellow-red color) and a hard with normal appearance (green-blue color) in the control group of healthy volunteers. This is similar to the previous studies evaluating RTSE findings in tendinopathy cases (9,10).

In a series of 214 patients whose clinical examination suggested tendinopathy or underwent surgical treatment but had no sonographic abnormality on B-mode US, 164 patients had positive findings supporting tendinopathy on RTSE (11). Another study by Prado-Costa et al. evaluated tendon damage in 26 cases of different tendons including the patellar tendon. Compression-based elastography examination showed a decrease in the tendon stiffness as a soft appearance (red coding) in the presence of tendinopathy (12). Porta et al. emphasized that compression-based RTSE examination is a useful and easily applicable method in the evaluation of patellar tendons in healthy

subjects (13). They found that the tendon was coded as hard on RTSE in healthy subjects. However, tendons with pathological changes were coded as soft. Egyptian researchers evaluated the benefits of RTSE in a study of 40 patients with shoulder pain and 40 healthy volunteers. Comparing their results with MRI, they found RTSE to be a sensitive method for RC tears and tendinosis (14).

These findings point to very early changes in tissue elasticity, possibly due to histopathological changes, edema, and inflammation. As a result, it was determined that small changes in the elasticity and mechanical properties of the tissues can be detected by RTSE and RTSE is an additional modality to complement US imaging.

Due to the elasticity of the different tissues depending on their hardness, different color codes are detected on RTSE. It is based on the color scale response of the signals due to acquired displacement with compression of the tissue and/or lesion (15). With this measurement, objective information about the degree of stiffness of a tissue and/or lesion can be obtained (16). The supraspinatus tendon is frequently damaged and affected by tendinosis. Therefore, tendon stiffness and elastic properties should be considered for diagnosis, after treatment and follow-up period.

RTSE examination is successful in showing degeneration that may not be seen on the sonographic image. This provides valuable results when combined with clinical examination and US examination findings. We think that the tendon may not be sufficiently tight, and these small tears may not be clearly visualized, because the arm cannot be in optimal external rotation position on MRI. By evaluating it in this position, it is possible to see the RRTs of the supraspinatus tendon at the tendon adhesion site at the anterior part of the greater tubercle, which is small and could be easily overlooked. In the same position, a torn area is observed in soft, green-red color, coded according to the scale on the color-coding map on synchronous RTSE examination.

Our study has several limitations. One of them is the bias risk in the RTSE examination, because it was possible to determine whether there was a tear in the previous US examination, or it was already known whether the patient was healthy. Another limitation is that a gold standard method such as arthroscopy or MRI is not used for the confirmation of tears.

RRTs should be diagnosed early because they are symptomatic and may progress progression to full-thickness tears. Although MR arthrography is a highly sensitive imaging method to detect RRTs, RTSE is an additional cost-effective sonographic modality that provides early and timely diagnosis. It shows soft-coding in mostly red color in tendons with RRTs and can be performed simultaneously by the same radiologist within a few seconds of routine US examination time. Tendon stiffness and continuity are useful for treatment planning and prognosis.

Ethical approval

This study has been approved by the Ankara City Hospital Institutional Review Board (approval date 16.12.2020, number E2-20-76). Written informed consent was obtained from the participants.

Author contribution

Concept: MB, İSİ; Design: MB, AHÇ; Supervision: İSİ; Materials: MB, AHÇ; Data Collection and/or Processing: MB, AHÇ, SŞİ, İSİ; Analysis and/or Interpretation: MB, AHÇ, SŞİ, İSİ; Literature Search: MB, AHÇ, İSİ; Writing Manuscript: MB, AHÇ, SŞİ, İSİ; Critical Review: MB, AHÇ, SŞİ, İSİ. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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