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Sonographic evaluation of tendon abnormalities: Added value of elastography

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Abstract--Background: This study aims to evaluate the value of adding elastography (strain elastography) to US in the evaluation of tendon abnormalities with comparison to conventional MRI. Methodology: After institutional review board approval and informed consent taken from all the patients, supraspinatus and tendoachillis tendon sonoelastography performed on 46 patients with shoulder or ankle pain and limitation of movement. Statistical analysis of this research was assessed by Chi-square test, Fisher's exact test and Independent-Samples t-test. Results: This study included 46 patients with shoulder or ankle pain and limitation of movement, 23 male and 23 female patients. Their mean age (years) \pm SD was 51.30 ± 12.4 years. We found that US had perfect agreement with MRI for detection of complete tear ($k=1$), strong agreement in diagnosis of partial tendon tear ($k=0.810$), while moderate agreement in detection of tendinopathy ($k=0.645$). Also we found that elastography increased US sensitivity and accuracy in diagnosis of partial tendon tear from (73.3% and 93.9% to 86.7% and 97% respectively) while it didn't add any effect to US in diagnosis of complete tendon tear. Conclusion: Elastography plays an important role if added to US in evaluation of tendon abnormalities, especially if MRI is contraindicated for any reason.

Keywords--tendon, tendinopathy, tears, elastography.

Background

B-mode ultrasound (B-US), power Doppler ultrasound (PD-US), and magnetic resonance imaging (MRI) are the main diagnostic methods for detecting and monitoring tendinopathies and tendon tears⁵. In the US, tendinopathy-related abnormalities are tendon thickening with hypoechoic areas and/or increased Doppler flow¹. Complete tendon rupture present with complete interruption of tendon fiber continuity with a gap. Close to the site of injury, the tendon is hyperechoic and thickened, with a loss of its normal fibrillar architecture while partial tears present with incomplete disruption of tendon fiber continuity and are seen as focal hypoechoic defects and tendon thickening at the site of injury². Sonoelastography (SE) is a recently developed ultrasound-based method that helps to assess the biomechanical and structural properties of tissues via measuring tissue stiffness⁷ through characterization of the differences in stiffness between 'the regions of interest' (ROI) and the surrounding tissues⁴. This study aims to determine whether elastography can add value when used as a complementary tool to MRI for evaluation of tendon abnormalities in patients with a complaint of shoulder or ankle pain and limitation of movement.

Methods

Study population

Between October 2020 to December 2022, 46 patients (23 males and 23 females), their mean age (years) \pm SD is 51.30 ± 12.4 years) with history of shoulder or ankle pain and limitation of the movement were prospectively evaluated. All patients were subjected to relevant history taking and local examination, supraspinatus and tendoachillis tendon conventional ultrasound, sonoelastography, and MRI examination. This study was approved by our institutional review board. Informed consent was obtained from all patients.

Mode ultrasonography and sonoelastography (SEL)

U.S and elastography were done using Toshiba aplio machine. For examination of supraspinatus tendon, the patient sat on a chair, with the examiner standing behind the patient and the arm in the internal rotation position and pronated on the patient's back, while tendoachillis, the patients were made to lie down prone with the foot hanging from the edge of the bed. A Linear array transducer with a frequency of 12 MHz was used. The transducer was perpendicular to the tendon. For SEL, there was mild repetitive compression and the degree of compression was based on the quality factor shown on the monitor of the ultrasonic apparatus. Both B-mode and elastographic images were simultaneously displayed on the same image. The elastographic images were qualitatively assessed by visual inspection for determination of the elastographic pattern represented by the color map: hard tendon fibers (blue), intermediate softening (yellow & green), and marked softening (red).

MR acquisition

MRI was performed using a 1.5 T magnet (Ingenia; Philips Medical Systems, Best Netherlands). Participants were positioned supine with the arm adducted in mild external rotation with Multi-phased array coils were used. The imaging protocol consisted of a routine shoulder or ankle MRI. Routine MRI includes: Coronal T1-FSE (TR=500 ms, TE=22 ms, slice thickness=3 mm), axial PD FAT SAT (TR= 2970 mm, TE=30 mm, slice thickness=3 mm), sagittal and coronal oblique T2-FSE (TR=3017 ms, TE=100 ms, slice thickness= 3mm), coronal oblique STIR -TSE (TR=2500 ms, TE=30 ms, slice thickness= 3mm).

Statistical analysis

Data were entered and analyzed using IBM-SPSS software (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.) Spearman's correlation was used to assess the association between two quantitative data.

Results

In our study, 46 symptomatic patients (23 male and 23 female patients) . Their mean age (years) \pm SD is (51.30 \pm 12.4 years) were enrolled. All patients were complaining of shoulder or ankle pain and limitation of movement. We found that US had perfect agreement with MRI for detection of complete tear ($k=1$), strong agreement in diagnosis of partial tendon tear ($k=0.810$), while moderate agreement in detection of tendinopathy ($k=0.645$) as outlined in Table 1. Also, elastography was found to increase US sensitivity and accuracy in diagnosis of partial tendon tear. It also showed that elastography didn't add any effect to US in diagnosis of complete tendon tear, when compared to the US only, as they have the same results as outlined in Table 2.

Discussion

Sonoelastography (SE) is a modified US; it is an indirect measurement of the biomechanical properties of musculoskeletal tissue, aiming for early diagnosis, and monitoring therapy ^{3&5}. In our study, 46 symptomatic patients were examined by B-mode ultrasound, sonoelastography and shoulder or ankle MRI. We obtained sonoelastographic images in the longitudinal plane as we found that longitudinal views were easier to acquire and more reproducible than transverse views matching with MRI coronal oblique T2WI /STIR in agreement with ⁴.

Our study has some limitations

First of all, our study population included a small sample size to evaluate changes in SR with different age groups and both gender. Second; with regards the technique applied, variability in the application pressure by the hand-held transducer is a well-known limitation of the free hand technique which could be avoided as suggested by ⁶ by applying moderate pressure or using other technique as shear wave elastography.

Conclusion

Elastography plays an important role if added to US in evaluation of tendon abnormalities, especially if MRI is contraindicated for any reason.

List of abbreviations

US: Ultrasonography; SD: Standard deviation; ROI: Region of interest; SWE: Shear wave elastography; SR: Strain ratio; SEL: Strain sonoelastography; MRI: Magnetic resonance imaging; STIR: Short TI inversion recovery sequence; T1WI: T1-weighted image; T2WI: T2-weighted image; FSE: Fast Spin Echo; FOV: Field of view; TR: Repetition time; TE: Echo time; ms: Millisecond; mm: Millimeter.

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Tables

Table 1
Validity of US for detection of different tendon pathologies with reference to MRI
as a gold standard

US	K	P value	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Complete tear	1	<0.001	100	100	100	100	100
Partial tear	0.810	<0.001	73.3	100	100	92.7	93.9
Tendinopathy	0.645	<0.001	55.6	100	100	85.7	87.9

Table 2
Validity of SEL for detection of different tendon pathologies with reference to MRI
as a gold standard

SEL	K	P value	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Complete tear	1	<0.001	100	100	100	100	100
Partial tear	0.909	<0.001	86.7	100	100	96.2	97
Tendinopathy	0.879	<0.001	83.3	100	100	94.1	95.5

Figures

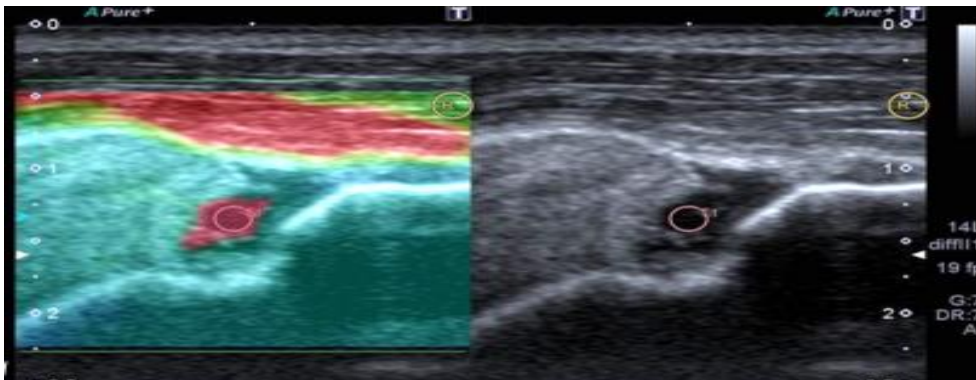


Figure 1. Longitudinal image of B-mode on the right and elastogram on the left of supraspinatus tendon complete tear