Additional Value of Shear Wave Sonoelastography in the Assessment of Non-traumatic Achilles Tendinopathy

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< Seung Hwan Han, MD, PhD>

My disclosure is in the Final AOFAS Mobile App.
I have no potential conflicts with this presentation.
Introduction

- Sonoelastography has recently been adopted to assess Achilles tendon consistency (1-4).
- However, the association of sonoelastography abnormality with pain of the tendon still needs to be elucidated.

Purpose of the current study

To assess whether addition of shear wave sonoelastography to B-mode US shows better performance in distinguishing between symptomatic and asymptomatic tendon than does addition of Doppler US.
Materials & Methods

<Subjects>
- From March 2013 through December 2013, consecutive 19 (7 male, 12 female) patients who underwent US for the assessment of following Achilles tendinopathy.
- Bilateral clinical and US examination of Achilles tendon was performed routinely for all patients.
- Mean age of the patients were 43.2 ± 14.0 years (range, 20-73 years).
- Based on physical examination, tendons were separated into symptomatic (n=26) and asymptomatic (n=10) tendons before the US examination.

<US examination>
- US examinations were performed with the Aixplorer ultrasound system (SuperSonic Imagine, Aix-en-Provence, France)
- US examinations were performed without any knowledge about the patient’s symptom and medical history and as the 3 consecutive sessions in the following order as being stated : B-mode, Doppler US, and sonoelastography.
- Images were evaluated and obtained for the Achilles tendon in longitudinal plane at the 3 different location (0 cm, 3 cm, and 6 cm apart from calcaneal attachment sites).
- Parameters stated below were recorded in consensus by two musculoskeletal radiologists who did not perform US examination based on the obtained images.
Materials & Methods (parameters: B-mode US/Doppler)

1) Echogenicity (5)
- Hyperechoic
- Isoechoic
- Hypoechoic

2) Thickness

- Doppler US:
  - Grade 0 - no Doppler activity
  - Grade 1 - 1 or 2 tiny foci
  - Grade 2 - <5% color inside ROI
  - Grade 3 - 5% to 24% color inside ROI
  - Grade 4 - 25% to 49% color inside ROI
  - Grade 5 - ≥50% color inside ROI (6)
Materials & Methods
(parameters: sonoelastography)

- Sonoelastography: Shear wave velocity color map was obtained by placing a square ROI with 1.2 cm on a side. The mean Young’s modulus ($E_{\text{mean}}$) was measured by placing a round ROI with constant size (3 mm in diameter).

- $E_{\text{mean}}$ (kPa) was automatically calculated and displaced based on the following equation: $E_{\text{mean}} = 3 \rho V_{\text{mean}}$ where $\rho$ is assumed to be constant (1,000 kg.m$^{-3}$) under the assumption of a purely elastic model (1).

- Each measurement of $E_{\text{mean}}$ was done three times at the area occupied by the color that possesses the broadest portion of the square ROI.

- The average $E_{\text{mean}}$ value was recorded at each measurement site.
Materials & Methods (statistical analysis)

- Cut-off values of the representative parameters for each tendon were determined through receiver operating characteristic (ROC) curve analysis. Area under the curve (AUC) of each parameter was presented.

- Sensitivity, specificity, PPV, NPV, accuracy of B-mode alone, B-mode+Doppler, B-mode+sonoelastography were calculated with generalized tendon tenderness on physical examination as a reference standard.

- To compare sensitivity and specificity between B-mode+Doppler and B-mode+sonoelastography to assess which one between Doppler and sonoelastography would be more beneficial to distinguish the symptomatic tendon when adding to B-mode US examination of Achilles tendon.

- Statistical significance was given when p-value was below 0.05
## Results

*(AUC and cut-off value of each parameter)*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AUC*</th>
<th>Cut-off value</th>
<th>P-value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echogenicity</td>
<td>0.731 (0.557-0.864)</td>
<td>Low echo</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.858 (0.701-0.951)</td>
<td>&gt; 5.5 mm</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Doppler</td>
<td>0.806 (0.640-0.918)</td>
<td>Grade 1 or more</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Sonoelastography</td>
<td>0.731 (0.557-0.864)</td>
<td>≤ 324.1 kPa</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

*Numbers in parentheses indicate 95% confidence interval.

†P-values indicate those of AUC
## Results (diagnostic performance)

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-mode alone*</td>
<td>0.81 (21/26)</td>
<td>1.00 (10/10)</td>
<td>1.00 (21/21)</td>
<td>0.67 (10/15)</td>
<td>0.86 (31/36)</td>
</tr>
<tr>
<td>B-mode + Doppler†</td>
<td>0.81 (21/26)</td>
<td>0.90 (9/10)</td>
<td>0.95 (21/22)</td>
<td>0.64 (9/14)</td>
<td>0.83 (30/36)</td>
</tr>
<tr>
<td>B-mode + sonoelastography†</td>
<td><strong>0.92 (24/26)</strong></td>
<td>0.80 (8/10)</td>
<td>0.92 (24/26)</td>
<td><strong>0.80 (8/10)</strong></td>
<td>0.89 (32/36)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are numeric used for calculation.

* B-mode parameter values were considered as positive when any of echogenicity or thickness were positive.

† Values of “B-mode + Doppler” and “B-mode + sonoelastography” were considered as positive when any of the combined parameters were positive.
Case 1.
An example of true positive result in all modalities

US images obtained from the symptomatic tendon of a 36-year-old female patient. B-mode US revealed diffuse thickening of the tendon with iso- to low echogenicity. Doppler US revealed grade 3 abnormality. Sonoelastography revealed positive result showing bluish color on this color map 3-cm apart from calcaneal attachment site. Measured $E_{\text{mean}}$ at this point was 221.2 kPa which was below the cut-off value.
B-mode+sonoelastography showed higher sensitivity and negative predictive value as compared with B-mode alone and B-mode+Doppler. Shear wave sonoelastography is expected to give additional value to the B-mode in the assessment of non-traumatic Achilles tendinopathy.

**Future investigation direction**

- Comparison of the sonoelastography parameters between the patients and normal volunteers with larger study population.
- To assess whether $E_{\text{mean}}$ or shear wave velocity can be used for the treatment response to tendinopathy.


