Shear Wave Elastography in diagnostics of supraspinatus tendon.

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Purpose

In this study we aim to define the possible diagnostic features of the Shear Wave Elastography (SWE) during various stages of Calcific tendinitis of the supraspinatus tendon of the shoulder joint.
Methods and Materials

Two groups of patients have been examined:

**Group 1 - 30 patients** (15 male and 15 female) - healthy volunteers, no complaints of pain in shoulder and no upper extremity injuries have been recorded in medical history. Age 20-35.

**Group 2 - 35 patients** (25 male and 10 female) - presented with pain in shoulder joint, limited mobility with varying degrees of severity, or upper extremity injuries recorded in medical history. Age - 32-50 years

- Patients in both groups have been subjected to a clinical examination during which the ultrasound of shoulder joints has been completed using Aixplorer (produced by company SuperSonicImagine, France) with broadband linear transducer with a scanning range from 4 MHz to 15 MHz

Total examined: 60 unchanged (healthy) joints and 35 joints with pathological changes.

Patients in both groups during ultrasound examination have been subjected to the B-mode analysis and color mapping of the shoulder joint structure, followed by Shear Wave Elastography (SWE) analysis. During the analysis a qualitative (color) and quantitative (measured in kPa) estimates of the supraspinatus tendon stiffness were defined.

No additional tissue compression by probe was used during the Ultrasound SWE examination. During the scanning process a large quantity of ultrasound gel was used to achieve the best possible surface contact between ultrasound probe sensor and the skin, with minimal joint compression.

Stiffness measurements were taken in two opposite joints on the long axis of the supraspinatus tendon.

- Majority of rotator cuff lesions were localized in the "critical area" of the supraspinatus tendon (m.supraspinatus), within approximately 1 cm from the tendon insertion into greater tubercle. The quantity and quality of the Ultrasound SWE examination of the supraspinatus tendon was assessed in this particular spot.
- The following values were used in data analysis: average value of Young’s modulus (E-mean), maximum value (E-max) and standard deviation (SD). As a reference methods we used the following: X-ray - 35 patients, MRI - 25 patients, CT - 10 patients.
Results

Normally, in the first group of patients the supraspinatus tendon (in B-mode) had a homogeneous structure, middle echogenicity, and it was homogeneously colored in blue during SWE. Quantitative values of SWE are presented in Table 1 and Fig.1.

Table. 1. Supraspinatus tendon. Norm

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Me</th>
<th>Min-Max</th>
<th>5-95 percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>#-mean</td>
<td>28,5</td>
<td>9,6-49,5</td>
<td>11,5-46,6</td>
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<tr>
<td>E-max</td>
<td>45,3</td>
<td>17,5-120</td>
<td>21-99,3</td>
</tr>
<tr>
<td>SD</td>
<td>7,25</td>
<td>3,4-62,9</td>
<td>3,4-29,2</td>
</tr>
</tbody>
</table>

Calcific tendinitis, Stage 1: supraspinatus tendon structure was non-homogeneous; areas of increased echogenicity without acoustic shadowing ranging from 2.5 mm to 5.5 mm were detected. During SWE, areas of increased echogenicity were colored as yellow and turquoise (Fig. 2), SWE values were significantly increased (p <0.001) when compared to the norm (Table 2 and Table 6). On the x-ray film pathology was not detected. (Fig. 3).

Table. 2. Calcific tendinitis. Stage 1.

<table>
<thead>
<tr>
<th>Parameters</th>
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<td>#-mean</td>
<td>85,6</td>
<td>54,1-100,5</td>
<td>63-99,8</td>
</tr>
<tr>
<td>E-max</td>
<td>124,7</td>
<td>85,6-231,3</td>
<td>89,3-206,7</td>
</tr>
<tr>
<td>SD</td>
<td>29,8</td>
<td>5,6-75,5</td>
<td>5,6-57,4</td>
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</table>

Calcific tendinitis, Stage 2: echogenicity of the calcification in B-mode was moderately high, with fuzzy acoustic shadow, calcification sizes range from 7.0 mm to 15 mm. During SWE, areas of increased echogenicity were colored as red and yellow (Fig. 4), SWE values were significantly increased (p <0.001) when compared to the previous stage and the norm (Table 3 and Table 6). Calcification was confirmed by x-ray. (Fig. 5)

Table. 3. Calcific tendinitis. Stage 2.
Calcific tendinitis, Stage 3: echogenicity of the calcification was noticeably hyper-echoic with clear acoustic shadow, structure was homogeneous, calcification sizes range from 8.0 mm to 20.2 mm. Calcification was confirmed by x-ray. (Fig. 8). During SWE, areas of increased echogenicity were colored as bright red (Fig. 6, Fig. 7), SWE values were significantly increased (p <0.001) when compared to the previous stage and the norm (Table 4 and Table 6).

Table. 4. Calcific tendinitis. Stage 3

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<td>230-799,3</td>
<td>285,1-622,7</td>
</tr>
<tr>
<td>E-max</td>
<td>445,7</td>
<td>310,4-799</td>
<td>332,9-799</td>
</tr>
<tr>
<td>SD</td>
<td>81,8</td>
<td>2,1-198</td>
<td>3,6-195,7</td>
</tr>
</tbody>
</table>

Calcific tendinitis, Stage 4: calcification had non-homogeneous structure, the outer loop was hyper-echoic with clear acoustic shadow. Hypoechoogenic rim had appeared around calcifications, sizes range from 8.0 mm to 20.0 mm. During SWE, calcifications were colored in patches in red, yellow and turquoise color (Fig. 9). SWE values were significantly reduced (p <0.001) compared to the previous stage (Table 5 and Table 6).

Table 5. Calcific tendinitis. Stage 4.

<table>
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<td>214,3-296,5</td>
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<td>E-max</td>
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<td>251,4-474,1</td>
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<tr>
<td>SD</td>
<td>29,2</td>
<td>10,1-105,8</td>
<td>10,1-105,8</td>
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</tbody>
</table>

Table. 6. #-mean values on various stages of Calcific tendinitis.
<table>
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<th>Parameters</th>
<th>Me</th>
<th>Min-Max</th>
<th>5-95 percentiles</th>
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<tbody>
<tr>
<td>Norm</td>
<td>28,5</td>
<td>9,6 - 49,5</td>
<td>11,5 - 46,6</td>
</tr>
<tr>
<td>Stage 1</td>
<td>85,6</td>
<td>54,1 - 100,5</td>
<td>63 - 99,8</td>
</tr>
<tr>
<td>Stage 2</td>
<td>136,1</td>
<td>107,1 - 199,4</td>
<td>109,5 - 191,6</td>
</tr>
<tr>
<td>Stage 3</td>
<td>356</td>
<td>230 - 799,3</td>
<td>285,1 - 622,7</td>
</tr>
<tr>
<td>Stage 4</td>
<td>266</td>
<td>208,3 - 298,5</td>
<td>214,3 - 296,5</td>
</tr>
</tbody>
</table>
Images for this section:

**Fig. 1:** Unchanged Supraspinatus tendon. SWE mode. Linear scan.

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Fig. 2: Degenerative changes in supraspinatus tendon. Calcific tendinitis, Initial stage. Patient presented with a dull pain in the shoulder joint when limbs were raised above 90°. Echogram. SWE mode. Linear scan.

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Fig. 3: Degenerative changes in supraspinatus tendon. Calcific tendinitis, Initial stage. Patient presented with a dull pain in the shoulder joint when limbs were raised above 90°. X-ray. No pathology revealed.

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Fig. 4: Calcific tendinitis, Stage 2. Patient presented with a dull pain in the shoulder joint. The pain is aggravated when limbs are risen above 90°. Supraspinatus tendon. Echogram, SWE mode. Linear scan. The arrow indicates the site of pathological coloring of calcifications.

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**Fig. 5:** Calcific tendinitis, Stage 2. Patient presented with a dull pain in the shoulder joint. The pain is aggravated when limbs are risen above 90°. X-ray. The arrow indicates the site of pathological blackening of calcifications.

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Fig. 6: Calcific tendinitis, Stage 3. Supraspinatus tendon. Echogram, SWE-mode. Linear scan. The arrow indicates the site of calcification - area of increased echogenicity with clear acoustic shadow (area colored red).

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Fig. 7: Calcific tendinitis, Stage 3. Echogram, SWE-mode. Enlarged image of calcification. The arrow indicates calcification - area of increased echogenicity with clear acoustic shadow (colored red).

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**Fig. 8:** Calcific tendinitis, Stage 3. X-ray. AP view. The arrow indicates calcification - blackened area.

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Fig. 9: Supraspinatus tendon. Echogram, SWE-mode. Linear scan. The arrow indicates the site of calcification - area of increased echogenicity with clear acoustic shadow (area colored in patches in yellow-red-blue). Pathological coloring in non-homogeneous calcification.

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Conclusion

We have seen, that SWE values in norm and on different stages of the development of Calcific tendinitis significantly vary from each other. They tend to increase with the development of pathological processes and advance of disease pattern. Notice slight drop in the last stage. Thus, both qualitative and quantitative information about the rigidity of the supraspinatus tendon can be obtained with gray-scale ultrasound (B-mode) using SWE mode in real-time in norm and with degenerative changes in the tendon. Also it is possible to determine the hardness of calcifications in tendons tissue with the help of SWE. These findings may be used in clinical practice to select the treatment type.
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