The potential role of high resolution ultrasound in evaluation of ankle sports injuries; a comparative study with high field MRI.

Poster No.: C-0324
Congress: ECR 2015
Type: Scientific Exhibit
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Keywords: Athletic injuries, Diagnostic procedure, Ultrasound, MR, Musculoskeletal spine, Musculoskeletal soft tissue
DOI: 10.1594/ecr2015/C-0324

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Aims and objectives

To assess the role of high resolution ultrasonography in ankle sports injuries compared to high field MRI.

Methods and materials

80 cases were subjected to high resolution ultrasonography examination, divided them into two groups:

1) control group of 40 asymptomatic volunteers with normal U/S appearance of the ankle ligaments and tendons;

2) The other group were 40 symptomatic patients suffering from unilateral or bilateral ankle sports injuries with a mean age of 36 years.

Inclusion criteria:

Patients proven to have ankle sports injuries by clinical examination and MRI as sequela of trauma.

Exclusion criteria:

Patients with recent or old rheumatological or orthopedic ankle disorders.

ULTRASONOGRAPHIC EXAMINATION:
All patients had standardized ultrasonography of the both ankles to compare the symptomatic ankle to the contralateral normal side. Excess gel was used instead of the gel pad.

Ultrasound examinations were performed using the following device:
# Toshiba sonoline (7.5-9 MHz).

The ultrasonographic examination began with the patient in supine position. Longitudinal scanning of the ankle was first performed to get an overall view of the tibiotalar joint and to detect joint effusion or intraarticular loose bodies. Then, the ankle
joint syndesmosis and ATFL were assessed on transverse plane at anterolateral aspect of the distal tibia.

While the patient in the same position; individual evaluation of the extensor tendons of the ankle was performed in both longitudinal and transverse planes starting from medial to lateral (tibialis anterior tendon, then EHL tendon, and most laterally EDL tendon).

**Thereafter**, slight inversion of the foot was performed while the patient in the same position to examine the lateral collateral ligaments and peroneal tendons.

The ATFL was first examined in oblique transverse plane from the tip of lateral malleolus, anteromedially and slightly downwards, till the talus. Then, the CFL was examined in oblique longitudinal plane from the lateral malleolar tip downwards and slightly backwards to the lateral surface of the calcaneus.

Regarding the peroneal tendons, they were examined from their supramalleolar musculotendinous junction, then just behind the lateral malleolus till their inframalleolar course in both longitudinal and transverse planes.

**Dynamic examination** was obtained in eversion and dorsiflexion position to detect tendon dislocation or subluxation.

The patient was then asked to laterally rotate the lower limb while lying supine to examine the deltoid ligament and flexor tendons. The former was examined in longitudinal scanning from its origin in the tip of the medial malleolus till its insertion into the talus, calcaneus, and navicular bones. The ankle flexor tendons were examined similar to the extensor tendons in longitudinal and transverse planes from medial to posterolateral (tibialis posterior tendon, then flexor digitorum longus tendon, and most laterally flexor hallucis longus tendon).

**Finally**, The patient is asked to lie prone and rest on his/her toes. The Achilles tendon was examined from its musculotendinous junction to its calcaneal insertion in both longitudinal and transverse planes.

All patients then were subjected to MRI ankle examinations (1.5 T) taken in three perpendicular planes (STIR, T2F and T1FS sequences)

**Sonographic findings were correlated with MRI findings.**
Selected cases

CASE (1)

Presentation:

- Male patient, 37 years old, presented with left ankle pain with limited painful movement following violent twist two months before.

Ultrasonography:

Longitudinal and transverse US scanning of the left Achilles tendon revealed:

- Diffuse thickening of the Achilles tendon with inhomogeneous hypoechoic pattern (Figs.1, 2).
- Partial discontinuity of the Achilles fibers at its mid segment (about 50% of the cross-sectional area) which is seen replaced by mild hematoma and herniated into the nearby fat (Fig. 3).

MRI:

- Thickened Achilles tendon with intra-substance increased signal intensity partially interrupting its mid segment in the different pulse sequences (Fig.4).

Diagnosis:

- Post-traumatic partial tear of the mid Achilles tendon.

CASE (2)

Presentation:

- Male patient, 50 years old, presented with prolonged posterior right ankle pain following old ankle repetitive trauma.

Ultrasonography:

- Diffusely thickened Achilles tendon with loss of its anterior concavity reflecting abnormal hypoechoic pattern of its substance and showing two flecks of calcification (Fig. 1).

MRI:
• Thickened Achilles tendon with loss of its anterior concavity and increased its intra-substance signal in all pulse sequences associated with thin peritendinous fluid signal (Fig. 2).

Diagnosis:

• Achilles tendinosis.

CASE (3)

Presentation:

• Female patient, 52 years old, presented with post traumatic pain in the left ankle increases by walking.

Ultrasonography:

• Marked thickening and heterogeneous hypoechoic pattern of the tibialis posterior tendon with no loss of its fibers continuity and no evidence of intra-substance tear, picture of marked tendinosis. Applying power Doppler revealed increased vascularity. Comparison was made by the other normally appeared side (Fig. 1).

MRI:

• Showed loss of the normal dark signal of the tendon replaced by bright T2/gradient signals and intermediate T1 signal (Fig. 2).

Diagnosis:

• Tibialis posterior tendon partial tear.

CASE (4)

Presentation:

Female patient, 42 years old, presented with right ankle acute pain following sudden twist.

Ultrasonography:
Thickened tibialis posterior tendon with heterogeneous echogenicity and a hypoechoic central area linear band representing partial tear. Associated mild distension of its tendon sheath is noted (Fig. 1).

MRI:
Thickened tibialis posterior tendon with linear high T2 / PD / STIR signals intra-substance intensity denoting longitudinal split partial tear with mild fluid signal seen around the tendon within its tendon sheath (Fig. 2).

Diagnosis:
Tibialis posterior tendon longitudinal split tear.

Images for this section:

Fig. 13: case 1 Fig. 1: Achilles tendon partial tear. Longitudinal US image of Achilles tendon showing thickened inhomogeneous and hypoechoic tendon.
**Fig. 14:** case 1 Fig. 2: Achilles tendon partial tear. Axial US image of the left Achilles tendon showing mildly thickened inhomogeneous and hypoechoic tendon.
**Fig. 15:** case 1 Fig. 3: Achilles tendon partial tear. Longitudinal US image of the left Achilles tendon showing discontinuity of its fibers and herniation into the Kagar's fat.
**Fig. 16**: case 1 Fig. 4: Achilles tendon partial tear. Sagittal STIR (A) and axial MERGE (B) MR images showing increased signal intensity of the Achilles tendon partially interrupting its mid portion.
Fig. 17: case 2 Fig. 1: Achilles tendinosis. (A) Longitudinal and (B) transverse US images of the right Achilles tendon showing its thickening and loss of its anterior concavity as well as intra-substance flecks of calcification.

Fig. 18: case 2 Fig. 2: Achilles tendinosis. A: Sagittal STIR and B: axial MERGE MR images of the right ankle showing fusiform thickening of the Achilles tendon with increased signal of its substance and surrounding rim of fluid signal.
Fig. 19: case 3 Fig. 1: Tibialis posterior tendinosis. (A) Oblique longitudinal US image showing marked thickening and heterogeneous hypoechoic pattern of the tibialis posterior tendon with no loss of its fibers continuity. (B) Applying power Doppler revealed increased vascularity. (C) US split screen image comparing the pathological left TP tendon to the normal right one.
Fig. 20: case 3 Fig. 12: Tibialis posterior partial tendon tear. (A) Axial gradient and (B) oblique coronal T2 MR images of the left ankle showing loss of the normal dark signal of the tendon replaced by bright T2/gradient signals.
**Fig. 21:** case 4 Fig. 1: Tibialis posterior tendon longitudinal split tear. Longitudinal US image of the right ankle showing thickened tibialis posterior tendon with hypoechoic central area (hollow arrow) representing partial tear. Associated mild tenosynovitis is as well shown (solid arrow).
Fig. 22: case 4 Fig. 2: Tibialis posterior tendon longitudinal split tear. Axial PD fat suppressed MR image of the right ankle showing thickened TP tendon with linear high signal intra-substance intensity denoting longitudinal split partial tear with associated tenosynovitis.
Results

Tendinosis was the most encountered tendon pathology followed by tenosynovitis.

Ultrasonography yielded 66.6% sensitivity for partial tear, 95.8 % sensitivity for complete tear and 50 % sensitivity for tenosynovitis.

Approximately 92% of ligamentous lesions were due to inversion ankle sprain that involved the lateral collateral ligament complex.

The ATFL was the most frequently torn ligament (61.6 %) and in most cases it was an isolated injury.

This was followed by CFL injury (22.2 %) that accompanied ATFL injury in its all cases.

Deltoid ligament was the least injured ligament (16.6 %). Ultrasonography yielded 80 % sensitivity and 95.2 % specificity for stretched ATFL, 98.2 sensitivity and 95.2 % specificity for stretched CFL, 83.3 % sensitivity and 95.2 % specificity for torn ATFL, and 94.7% sensitivity and specificity for torn CFL.

Images for this section:
**Fig. 1:** Distribution and classification of different tendinous pathological entities diagnosed by US.

<table>
<thead>
<tr>
<th></th>
<th>Tendinosis</th>
<th>Partial tear</th>
<th>Complete tear</th>
<th>Tenosynovitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>100%</td>
<td>66.6%</td>
<td>100%</td>
<td>50%</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>+ Ve predictive value</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>- Ve predictive value</td>
<td>100%</td>
<td>95.2%</td>
<td>100%</td>
<td>95.2%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>100%</td>
<td>90.5%</td>
<td>100%</td>
<td>86.3%</td>
</tr>
</tbody>
</table>

**Fig. 2:** Ability of ultrasound for identification and characterization of different tendon injuries.
<table>
<thead>
<tr>
<th>Ligament</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral ligament complex:</td>
<td>13</td>
</tr>
<tr>
<td>- ATFL</td>
<td>11</td>
</tr>
<tr>
<td>- CFL</td>
<td>4</td>
</tr>
<tr>
<td>- ATFL + CFL</td>
<td>2</td>
</tr>
<tr>
<td>Medial (deltoid) ligament:</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>

**Fig. 3:** Distribution of different ligamentous injuries diagnosed by US.
<table>
<thead>
<tr>
<th>Ligament</th>
<th>Number of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATFL</td>
<td>11</td>
<td>61.1</td>
</tr>
<tr>
<td>CFL</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>DL</td>
<td>3</td>
<td>16.6</td>
</tr>
</tbody>
</table>

**Fig. 4:** Incidence of different ligaments injury.
<table>
<thead>
<tr>
<th>Injury</th>
<th>Frequency</th>
<th>Distribution</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretching lesion Tear</td>
<td>11</td>
<td>5 3 3</td>
<td>61.1</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 1 0</td>
<td>38.9</td>
</tr>
</tbody>
</table>

**Fig. 5:** Distribution and pathological classification of ligamentous injury diagnosed by US.
**Fig. 6:** Distribution and pathological classification of ligamentous injury diagnosed by US.

<table>
<thead>
<tr>
<th>US</th>
<th>Number of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickened ligament</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Regular contour</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Peripheral hypoechoic line</td>
<td>4</td>
<td>57</td>
</tr>
</tbody>
</table>

**Fig. 7:** Incidence of US criteria for stretching lesion in 7 ligaments diagnosed as stretched by US.
<table>
<thead>
<tr>
<th>US</th>
<th>Number of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Irregular thickening</td>
<td>33</td>
<td>100</td>
</tr>
<tr>
<td>- Wavy contour</td>
<td>33</td>
<td>100</td>
</tr>
<tr>
<td>- Partial interruption of the fibers</td>
<td>15</td>
<td>45.5</td>
</tr>
<tr>
<td>- Adjacent edema</td>
<td>26</td>
<td>78.74</td>
</tr>
<tr>
<td>- Adjacent hematoma</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

**Fig. 8:** Incidence of US criteria for ligament tear in 33 ligaments diagnosed as showing tear by US.
Fig. 9: Correlation between US and MRI findings in 11 ligamentous injuries diagnosed as stretching lesion by US.

<table>
<thead>
<tr>
<th>Modality</th>
<th>Pathology</th>
<th>Number of cases</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Diagnosis</td>
<td>Stretching lesion</td>
<td>ATFL 5</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFL 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DL 3</td>
<td></td>
</tr>
<tr>
<td>MRI Diagnosis</td>
<td>Stretching lesion</td>
<td>ATFL 4</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tear</td>
<td>ATFL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DL 1</td>
<td></td>
</tr>
<tr>
<td>Modality</td>
<td>Pathology</td>
<td>NO. of cases</td>
<td>Total</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>U.S. Diagnosis:</td>
<td>Tear</td>
<td>ATFL 6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DL 0</td>
<td></td>
</tr>
<tr>
<td>MRI Diagnosis:</td>
<td>Tear</td>
<td>ATFL 5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CFL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stretching lesion</td>
<td>ATFL 1</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 10:** Correlation between US and MRI findings in 7 ligamentous injuries diagnosed as tears by US.
<table>
<thead>
<tr>
<th></th>
<th>Stretching lesion</th>
<th>Tear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATFL</td>
<td>CFL</td>
</tr>
<tr>
<td>- Sensitivity</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>- Specificity</td>
<td>95.2%</td>
<td>95.2%</td>
</tr>
<tr>
<td>+ Ve predictive value</td>
<td>80%</td>
<td>66.6%</td>
</tr>
<tr>
<td>- Ve predictive value</td>
<td>95.2%</td>
<td>100%</td>
</tr>
<tr>
<td>- Accuracy</td>
<td>87.6%</td>
<td>90.5%</td>
</tr>
</tbody>
</table>

**Fig. 11**: Ability of ultrasound for identification and characterization of different ligamentous injuries.
<table>
<thead>
<tr>
<th>Case</th>
<th>Injuries</th>
<th>No. of cases</th>
<th>No. of pathological entities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Achilles tendon complete tear.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Bilateral Achilles tendinosis.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Bilateral Achilles partial tear.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Deltoid ligament sprain.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Tibialis posterior enthesopathy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tibia fissure fracture.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ankle hematoma.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FDL tenosynovitis.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ATFL tear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CFL tear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>TA tendinosis.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>FHL tenosynovitis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATFL tear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-10</td>
<td>ATFL tear.</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Peroneal brevis partial tear.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Fibula fracture and callus.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATFL complete tear.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-15</td>
<td>ATFL stretch.</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>CFL stretch.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>AEFL stretch.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fissure fracture fibula.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-18</td>
<td>Deltoid ligament stretch.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>19-20</td>
<td>CFL stretch.</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Fig. 12:** shows distribution of all 33 pathological entities diagnosed on the total 20 cases of the study.
Conclusion

Ultrasonography with the advent of high resolution linear-array probes provides a good alternative or complementary to high field MRI as a dynamic, rapid and inexpensive tool in detailed examination of the ankle sport injuries.

Personal information

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Stoller:

Susan A and Floyd R:

Taveras JM and Ferrucci JT:

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Theodore T. Miller, MD, FACR:

Tuit:

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Williamson D, Watura R, Cobby M: