Accuracy of Magnetic Resonance Imaging (MRI) and Dynamic Ultrasound for the Diagnosis of Planar Plate Injuries: A Systematic Review and Meta-Analysis
Manali Chinge, BS, BA1, Rachel Albright, DPM, MPH, AACFAS2, Brandon Brooks, DPM, MPH, Erin E Klein, DPM, MS, FACFAS3, Lowell S. Weil Jr., DPM, MBA, FACFAS3, Adam Fleischer, DPM, MPH, FACFAS1,3
1Center for Lower Extremity Ambulatory Research (CLEAR), 2Dr. William M. Scholl College of Podiatric Medicine, 3Stamford Health Medical Group, 4Weil Foot & Ankle Institute

Background
- Plantar plate injuries are a common condition that can result in foot pain, joint subluxation, and worsening of hammertoe deformities. Diagnosis can be difficult when plantar plate injuries mimic other conditions (e.g., Morton’s neuroma, capsulitis) and may often present as generalized forefoot pain with ambiguous physical exam findings. Advanced imaging modalities are often utilized to confirm diagnosis of plantar plate pathology.
- Ultrasound and MRI have both been extensively studied in relation to the plantar plate and pathology in this region. Ultrasound is generally considered to be a low cost, easy to perform examination. MRI is more costly and time consuming, but utilizes a standardized protocol which creates a more predictable, detailed image.
- Klein et al performed a direct comparison of MRI and US with intra-operative examination of 42 consecutive patients (51 feet) identified that US was the more sensitive exam while MRI was the more specific exam.
- A more recent case series directly compared high-resolution dynamic ultrasonography to MRI utilizing intra-operative examination as the gold standard of reference. Proctor et al performed a direct comparison of MRI and US with intra-operative examination of 42 consecutive patients (51 feet) identified that MRI was superior to ultrasound in diagnosing plantar plate tears.

Purpose
- The purpose of this study was to examine the diagnostic accuracy of MRI and dynamic, musculoskeletal ultrasound in diagnosing plantar plate injuries using a systematic review and meta-analysis.

Methods
- Followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and the Cochrane Handbook
- Inclusion criteria: any study that tested the diagnostic accuracy of MRI, ultrasound, and (initially) the Lachman’s test for detecting a plantar plate tear in adults (18 years or older) and reported on sensitivity and specificity of each test against the gold standard of reference. The authors concluded that both modalities were acceptable for imaging plantar plate tears.

Results

<table>
<thead>
<tr>
<th>Study</th>
<th>MRI</th>
<th>Ultrasound</th>
<th>TP</th>
<th>FP</th>
<th>TN</th>
<th>FN</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV</th>
<th>NPV</th>
<th>Likelihood Ratio: Positive</th>
<th>Likelihood Ratio: Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.3%</td>
<td>100%</td>
<td>100%</td>
<td>12</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>91% (85%, 95%)</td>
<td>95% (90%, 98%)</td>
<td>60.2</td>
<td>16.8</td>
<td>3.52</td>
<td>0.21</td>
</tr>
<tr>
<td>60.5%</td>
<td>100%</td>
<td>100%</td>
<td>12</td>
<td>6</td>
<td>40</td>
<td>6</td>
<td>52% (39%, 66%)</td>
<td>95% (90%, 98%)</td>
<td>2.08</td>
<td>0.64</td>
<td>3.27</td>
<td>0.27</td>
</tr>
<tr>
<td>90%</td>
<td>100%</td>
<td>100%</td>
<td>12</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>95% (90%, 98%)</td>
<td>100%</td>
<td>60.2</td>
<td>16.8</td>
<td>3.52</td>
<td>0.21</td>
</tr>
<tr>
<td>90%</td>
<td>100%</td>
<td>100%</td>
<td>12</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>95% (90%, 98%)</td>
<td>100%</td>
<td>60.2</td>
<td>16.8</td>
<td>3.52</td>
<td>0.21</td>
</tr>
<tr>
<td>90%</td>
<td>100%</td>
<td>100%</td>
<td>12</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>95% (90%, 98%)</td>
<td>100%</td>
<td>60.2</td>
<td>16.8</td>
<td>3.52</td>
<td>0.21</td>
</tr>
</tbody>
</table>

- There were 227 plantar plates examined with MRI and 238 plantar plates examined with ultrasound.
- MRI displayed a pooled sensitivity of 89% (95% CI 0.84, 0.93) and specificity of 83% (95% CI 0.64, 0.96) for detecting plantar plate activity and specificity of 95% (95% CI 0.93, 0.98) and 52% (95% CI 0.37, 0.68), respectively.
- Seven of the final eleven studies were found to have a low risk of bias, three studies displayed a medium risk of bias, and one study had a high risk of bias. The most common source of bias was a lack of a random sampling, where many studies used a convenience sample of patients.

Discussion
- Multiple studies have been conducted to see the accuracy of advanced imaging techniques (MRI and ultrasound) to confirm suspected plantar plate tears. However there have been no definitive conclusions about which is the superior form of imaging.
- MRI was superior to ultrasound in diagnosing plantar plate injuries.
- Ultrasound was more sensitive than MRI, suggesting a negative ultrasound would likely miss a plantar plate injury in the presence of an equivocal physical exam.
- MRI showed greater specificity than Ultrasound, suggesting that determining the presence of a plantar plate injury and the grade of the injury is best served with MRI.
- The studies of MRI (apart from its accuracy) lies in its ability to evaluate associated collateral and suspensory ligaments in addition to the plantar plate structure.
- Based on the current literature, MRI performed better and is a more accurate test in diagnosing plantar plate tears than ultrasound.
- These findings may justify the added costs of MRI to ensure accurate diagnosis of plantar plate pathology.

Conclusion
- Based on our findings, a negative test result via point of care ultrasound (with its high sensitivity) will be helpful in ruling plantar plate pathology out. In contrast, MRI appears to be a slightly more accurate method of diagnosing plantar plate pathology overall and, due to its higher cost, might best be reserved for use only after equivocal ultrasound exams or when added insight into the integrity of the joint’s additional supporting structures (e.g., collagen and suspensory ligaments) is also needed.

References