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Magnetic Resonance Arthrography of Lesser Metatarsophalangeal Joints in Patients with Rheumatoid Arthritis: Relationship to Clinical, Biomechanical, and Radiographic Variables

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ABSTRACT. Objective. Our exploratory study of painful lesser metatarsophalangeal (MTP) joints in patients with rheumatoid arthritis (RA) primarily aimed to compare the clinical, biomechanical, and plain radiography findings with magnetic resonance (MR) arthrography findings. Our secondary aim was to compare standard unenhanced MR with MR arthrography in imaging the lesser MTP joints in RA.

Methods. In 15 patients with RA, the more symptomatic forefoot was imaged using 3T MR imaging. Proton density fat-suppressed images were acquired through the lesser MTP joints prior to arthrography. Under ultrasound guidance, contrast agent was injected into 2 lesser MTP joints. T1-weighted fat-suppressed sequences were subsequently acquired. The MR images were read by 2 musculoskeletal radiologists and consensus was reached. Spearman’s correlation coefficient was used to assess the association between abnormalities seen on MR arthrography and the clinical, biomechanical, and plain radiography findings.

Results. MR arthrography demonstrated pathology at 18 of 28 lesser MTP joints (64%) examined in patients with RA. MR arthrography abnormalities were associated with RA disease duration, forefoot deformity, Larsen score, subluxation, and peak plantar pressure. Unenhanced MR had a sensitivity of 78% and specificity of 90% for detecting pathology compared to MR arthrography.

Conclusion. Capsule and plantar plate pathology occurs in the painful forefoot of patients with RA and is associated with features of disease and deformity at the lesser MTP joints. Compared with MR arthrography, standard MR imaging was highly specific and moderately sensitive for diagnosing lesser MTP joint pathology in patients with RA. (First Release Aug 1 2012; J Rheumatol 2012;39:1786–91; doi:10.3899/jrheum.120392)

Key Indexing Terms:
RHEUMATOID ARTHRITIS  FOOT  MAGNETIC RESONANCE IMAGING

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Standard magnetic resonance imaging (MRI) and MR arthrography of the MTP joints have been used to describe anatomical detail, identify tears in the capsule and plantar plate, and facilitate surgical planning to ease MTP joint pain and instability in subjects without RA. Controversy about the appearance of the distal insertion has been highlighted, in which a hyperintense region has been interpreted as evidence for a tear. Conversely, MR arthrography of MTP joints in cadavers and in subjects without RA has demonstrated improved visualization and delineation of tears in the fibrous capsule and plantar plate, but the technique has not been applied in patients with RA.

A recent MRI study has demonstrated that focal deficiencies attributed to plantar plate pathology of the lesser (second to fifth) MTP joints are common in the forefoot of patients with RA and associated with synovitis, bone edema, and bone erosion.

Our primary aim in this exploratory study was to compare the clinical, biomechanical, and plain radiography findings with MR arthrography at the lesser MTP joints in patients with RA. A secondary aim was to compare standard unenhanced MR with MR arthrography in imaging the capsule and plantar plate of the lesser MTP joints in RA.

**MATERIALS AND METHODS**

*Recruitment of patients.* Local research and ethical approval was received and written consent was obtained from all participants. Consecutive patients diagnosed with RA, according to the 1987 American College of Rheumatology revised criteria for RA (all patients were diagnosed prior to the 2010 RA classification criteria), and having pain on the plantar aspect of their lesser MTP joints were recruited between June 2010 and May 2011. The first MTP joint was not imaged because of the different anatomy and pattern of pathological changes compared to the lesser MTP joints. Patients were excluded if they had a diagnosis of diabetes, peripheral vascular disease, or peripheral neuropathy; a history of forefoot surgery; or vascular disease, or peripheral neuropathy; a history of forefoot surgery; or contraindications to having an MRI scan and injection of the contrast agent.

*Clinical, biomechanical, and radiographic measures.* Demographic data were recorded for each patient. In order to quantify current disease activity, a Disease Activity Score (DAS28) was used. A 100-mm visual analog scale (VAS) score, with the anchors “no pain” and “worst pain imaginable,” was recorded for current pain across the plantar MTP joint area. and was recorded. Subsequently, contrast agent extravasation was assessed on the arthrographic images. MR arthrographic abnormalities at the lesser MTP joints were ordered into 4 grades: (1) no pathology (Figure 1A, 1B); (2) extravasation of contrast agent into the adjacent soft tissues (interpreted as a capsule tear); (3) extravasation of contrast agent into the flexor digitorum longus tendon sheath (interpreted as a plantar plate tear); and (4) extravasation of contrast agent into both the surrounding soft tissues and the flexor tendon sheath (Figure 2).

*Statistical methods.* Data were entered onto the Statistical Package for the Social Sciences (SPSS version 18). Simple descriptive statistics were reported for all demographic and clinical measures and plantar plate pathology. Mean (SD) scores were reported for interval level data, and median [interquartile range (IQR)] for ordinal data. Standard unenhanced MR images were compared with MR arthrography for sensitivity, specificity, and accuracy. Spearman’s correlation coefficient was used to measure the association between MR arthrography abnormalities at the lesser MTP joints and clinical, biomechanical, and radiographic findings (n = 15). The joint with the highest category of pathology identified by MR arthrography was chosen per patient for analysis. The level of substantive association was identified at p > 0.3. For this exploratory study no formal sample size calculations were performed, and no corrections for multiple comparisons have been made; significance values are presented as guidelines only.

**RESULTS**

Demographic, disease characteristics, patient-reported measures, footprint deformity scores, gait measures, and radiographic scores are given in Table 1.

**MR arthrography.** MR arthrography was performed on 30 lesser MTP joints: 8 second MTP joints, 10 third MTP joints, 8 fourth MTP joints, and 4 fifth MTP joints. Contrast agent was not successfully injected into 2 joints and therefore these were excluded from subsequent analysis.

**Correlation of MR arthrography-reported pathology with disease characteristics.** The associations between MR arthrography abnormalities at the lesser MTP joints in patients with RA and clinical, biomechanical, and radio-
Figure 1. Pre (a) and post (b) contrast agent short-axis images of the third metatarsophalangeal (MTP) joint demonstrating intact capsule and plantar plate (arrows). Precontrast agent short-axis image (c) of the fourth MTP joint of the same patient demonstrating a capsular tear (arrow), which is confirmed in the postcontrast agent T1 short-axis image (d) with extravasation into the soft tissue (arrow).

Figure 2. Precontrast agent sagittal and short-axis images (a) and (b) showing absent plantar plate and laterally displaced flexor tendon (arrow). Post-contrast agent T1 sagittal (c) and short-axis (d) images showing extravasation of contrast agent into the soft tissues and flexor tendon sheath (arrow) confirming an absent plantar plate.
themselves associated with disease duration, foot deformity (Platto’s Forefoot Structural Index score), abnormalities were associated with disease duration, forefoot graphic variables are given in Table 2. MR arthrography.

## Table 2. Spearman’s correlation coefficients between magnetic resonance arthrography-reported pathology at the lesser metatarsophalangeal joints in patients with rheumatoid arthritis and clinical, biomechanical, and radiographic variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>( r_s )</th>
<th>( p )</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease duration</td>
<td>0.728</td>
<td>0.001</td>
<td>15</td>
</tr>
<tr>
<td>VAS</td>
<td>−0.122</td>
<td>0.332</td>
<td>15</td>
</tr>
<tr>
<td>LFIS(_{GP}^r)</td>
<td>−0.162</td>
<td>0.282</td>
<td>15</td>
</tr>
<tr>
<td>LFIS(_{AP}^r)</td>
<td>−0.002</td>
<td>0.497</td>
<td>15</td>
</tr>
<tr>
<td>Platto’s FF Structural Index score</td>
<td>0.535</td>
<td>0.020</td>
<td>15</td>
</tr>
<tr>
<td>Gait velocity</td>
<td>−0.200</td>
<td>0.237</td>
<td>15</td>
</tr>
<tr>
<td>Larsen score</td>
<td>0.818</td>
<td>0.000</td>
<td>15</td>
</tr>
<tr>
<td>Callus present</td>
<td>0.523</td>
<td>0.023</td>
<td>15</td>
</tr>
<tr>
<td>Subluxation present</td>
<td>0.486</td>
<td>0.033</td>
<td>15</td>
</tr>
<tr>
<td>Peak pressure</td>
<td>0.629</td>
<td>0.006</td>
<td>15</td>
</tr>
</tbody>
</table>

VAS: visual analog scale; LFIS\(_{GP}^r\): Leeds Foot Impact Scale to assess impairment and footwear; LFIS\(_{AP}^r\): LFIS to assess activity and participation; FF: forefoot.

graphic variables are given in Table 2. MR arthrography.

## Plantar plate pathology seen on standard MR imaging and MR arthrography.

On standard MR images, 4 plantar plates were absent and subsequent MR arthrography revealed extravasation of contrast agent into the surrounding soft tissue and flexor tendon, confirming a tear in the plantar plate in all 4.

Focal deficiencies were seen in 13 plantar plates (50%) on standard MR with high signal at the insertion in 10 of these. MR arthrography confirmed deficiencies in 10 plantar plates, extravasation of contrast agent was seen in the surrounding soft tissue of 6, confirming a tear in the capsule, and extravasation of contrast agent was seen in the flexor tendon of only 4, confirming a true plantar plate tear. Two plantar plates showed no extravasation of contrast agent on arthrography (contrast agent was not successfully injected into 1 joint); both demonstrated high signal at the insertion on standard MR.

Thirteen plantar plates appeared intact on standard MR images; arthrography confirmed that 8 were intact, with no contrast agent extravasation. High signal was seen at the insertion of all 8. MR arthrography showed capsular tears in 3 with extravasation of contrast agent into the surrounding soft tissue and a tear of the plantar plate in 1 (contrast agent was not successfully injected into 1 joint); high signal was seen in 2 of the torn capsules and in the torn plantar plate on standard MR.

Absence or focal defect of the plantar plate seen on standard MR in 28 lesser MTP joints had a sensitivity of 78% (95% CI 52–93), specificity of 90% (95% CI 54–99), and accuracy of 82% for detecting a tear, compared to MR arthrography (Table 3). High signal at the insertion on standard MR had a sensitivity of 80% (95% CI 56–93), specificity of 15% (95% CI 5–36), and accuracy of 43% for detecting a tear.

## DISCUSSION

To our knowledge, this is the first study to report the use of MR arthrography for the evaluation of the painful forefoot in patients with RA and to compare MR arthrography with clinical, biomechanical, and plain radiography findings in a cross-sectional group of patients with RA and forefoot pain.

We have demonstrated that capsule and plantar plate pathology are common in the painful forefoot of patients with RA and may be associated with features of disease and deformity at the lesser MTP joints.

Previous studies in cadaveric specimens and subjects.
Lesser MTP joint capsule and plantar plate pathology are substantively associated with disease duration, biomechanical changes in the forefoot, and radiographic damage in patients with RA. However, a limitation of the study is the small sample size (n = 15), which prevented a full multivariable analysis to evaluate whether features of disease progression and forefoot deformity were related to MR arthrography abnormalities independently of each other. A further limitation of our study is the lack of a healthy control group without foot pain and RA. Given the invasive nature and the potential for adverse reactions when using contrast agent, it was deemed unnecessary and inappropriate to inject contrast agent into healthy individuals at this exploratory stage, especially because our aims were to compare imaging modalities as they relate to lesser MTP joint pathologies specifically in patients with RA. Despite these limitations, our exploratory study will help inform larger controlled cross-sectional studies and longitudinal followup studies of patients with RA and forefoot pain to help elucidate causality.

MR arthrography has demonstrated that capsule and plantar plate pathology at the lesser MTP joints in patients with RA may be associated with features of disease progression and forefoot deformity. This may have important implications in assessing the progression of forefoot damage and understanding the causes of symptoms in the painful forefoot of patients with RA.

ACKNOWLEDGMENT
The authors thank Carole Burnett and Robert Evans from the NIHR Leeds Musculoskeletal Biomedical Research Unit for conducting the patient MRI.

REFERENCES

Table 3. Absence or focal defect of the plantar plate seen on standard magnetic resonance imaging (MRI) compared to contrast agent extravasation on MR arthrography in 28 lesser MTP joints in patients with RA.

<table>
<thead>
<tr>
<th>MR Arthrography</th>
<th>Contrast Agent Extravasation</th>
<th>No Contrast Agent Extravasation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence or focal defect of plantar plate</td>
<td>14</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Normal plantar plate</td>
<td>4</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>10</td>
<td>28</td>
</tr>
</tbody>
</table>


