Introduction

- Bone marrow lesions (BMLs)
  - Common MR imaging findings in osteoarthritis
  - Related to cartilage integrity

- We previously\(^1\) did not detect a relationship between changes in BML size and cartilage morphometry
  - A secondary analysis of a clinical trial
  - Used an approximate measure of BML size

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1. Driban JB et al., 2011
Objective

- The purpose of this study was to assess the relationship between quantitative 3-dimensional assessments of BML volume and quantitative cartilage morphometry in a cohort from the Osteoarthritis Initiative.

- This was a validation step of a new semi-automated BML segmentation method.

Participants

- 4,796 OAI participants
- 732 knees with cartilage segmentation (0- and 24-month visits)
- 196 knees with full thickness cartilage loss (denuded area) on the tibia and femur in the index compartment (defined as the tibiofemoral compartment with greater denuded area)

kmri_qcart_eckstein00 [version 0.4], kmri_qcart_eckstein03 [version 3.3]
Participants

- 20 knees w/ a medial tibiofemoral index compartment
- 20 knees w/ a lateral tibiofemoral index compartment
  - $n = 5$ had the least change in femur denuded area
  - $n = 5$ had the greatest change in femur denuded area
  - $n = 5$ had the least change in tibia denuded area
  - $n = 5$ had the greatest change in tibia denuded area

- These selection criteria were intended to provide a diverse range of denuded area change
- Power computation ($r > 0.40$, $power > 0.80$, $\alpha_2 < 0.05$)

BML Volume Measurements

- Sagittal intermediate-weighted, turbo spin echo, fat-suppressed MR images
- One rater (ICC [3,1 model] = 0.79 to >0.99)

OAI images are publicly available: http://oai.epi-ucsf.org
BML Volume Measurements

- Variables of interest
  - Change in tibia BML volume ($\text{mm}^3$; index compartment)
  - Change in femur BML volume ($\text{mm}^3$; index compartment)

Cartilage Parameters

- Sagittal DESS sequences
  - 2 knees: coronal FLASH water excitation
- Manual segmentation of cartilage
- Part of the OAI public datasets
  - kmri_qcart_ecksteinXX [version 0.4, 3.3]
- Variables of interest
  - Changes in tibia cartilage thickness (mm)
  - Changes in central femur cartilage thickness (mm)
  - Changes in tibia denuded area (%)
  - Changes in central femur denuded area (%)
Statistical Analyses

- Change = 24-month data – baseline data
- Spearman correlation coefficients
- All analyses were limited to the index compartment

Descriptive Data (n = 38)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Mean ± SD n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>25 (66%)</td>
</tr>
<tr>
<td>Progression Cohort Members</td>
<td>36 (95%)</td>
</tr>
<tr>
<td>Kellgren-Lawrence Grade ≥ 2</td>
<td>38 (100%)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>61 ± 8</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>29.9 ± 5.3</td>
</tr>
<tr>
<td>Central Femur Cartilage Thickness: Change (mm)</td>
<td>-0.24 ± 0.32</td>
</tr>
<tr>
<td>Central Femur Denuded Area: Change (%)</td>
<td>11.2 ± 17.3</td>
</tr>
<tr>
<td>Tibia Cartilage Thickness: Change (mm)</td>
<td>-0.14 ± 0.20</td>
</tr>
<tr>
<td>Tibia Denuded Area: Change (%)</td>
<td>7.6 ± 11.6</td>
</tr>
<tr>
<td>Femur BML volume change (mm³)</td>
<td>273 ± 1239</td>
</tr>
<tr>
<td>Tibia BML volume change (mm³)</td>
<td>51 ± 1354</td>
</tr>
</tbody>
</table>
### Associations: ΔBML – ΔCartilage

<table>
<thead>
<tr>
<th></th>
<th>Femur BML Volume: Change (n = 38)</th>
<th>Tibia BML Volume: Change (n = 38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Femur Cartilage Thickness: Change</td>
<td>-0.13</td>
<td>-0.30</td>
</tr>
<tr>
<td>Central Femur Denuded Area: Change</td>
<td>0.06</td>
<td>0.35*</td>
</tr>
<tr>
<td>Tibia Cartilage Thickness: Change</td>
<td>-0.15</td>
<td>-0.46*</td>
</tr>
<tr>
<td>Tibia Denuded Area: Change</td>
<td>0.15</td>
<td>0.42*</td>
</tr>
</tbody>
</table>

*Note: * $p < 0.05$. Spearman Correlation Coefficients.

![Graph 1](https://via.placeholder.com/150)

$r = 0.42*$

![Graph 2](https://via.placeholder.com/150)

$r = 0.06$
Discussion

- Local bone and cartilage changes
  - Tibial BML change – tibial +femoral cartilage change (related)
  - Femoral BML change / femoral cartilage change
  - Not addressing causality

- Construct validity for this semi-automated BML segmentation approach
  - Good reliability
  - Time efficient: 4 to 12 minutes
Discussion

- Local bone and cartilage changes
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  - Good reliability
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Limitations

- Associations among knees with denuded area

- Construct validity
  - Validation may be specific to MR scanners and sequence
  - Additional validation warranted when applied to new studies
Conclusions

- Among participants with knee OA and denuded areas of cartilage an increase in tibia BML volume is associated with longitudinal tibia and femur cartilage loss.

- Significant associations in the tibia and not the femur may be a result of the entire tibia cartilage being assessed while only the weight-bearing region of the femur was evaluated (omitting the patellofemoral region).

Thank You.

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