Knee Articular Cartilage in an Asymptomatic Population: Comparison of T1rho and T2 Mapping

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• Nothing to disclose
Introduction

- Hyaline articular cartilage
  - Chondrocyte 4%
  - Water (65-85%)
  - Extracellular matrix
    - type II collagen (15-20%)
    - proteoglycan (3-10%)
Biochemical MRI

- **T1rho (T1ρ)**
  - spin-lattice relaxation time in the rotating frame
  - a time constant for transverse magnetization decay in a very weak B1 field strength produced by spin-lock RF pulse
  - positive association with the severity of knee osteoarthritis
  - sensitive to changes in proteoglycan content in articular cartilage

- **T2**
  - spin-spin relaxation related to dipolar interaction of water proton in ECM
  - sensitive for collagen and water content and orientation
  - elevated in knee osteoarthritis
Introduction

- **Magic angle effect**
  - regions of tightly bound collagen at 54.74° of the main magnetic field (Bo)
  - maximal at relatively short TE
Introduction

- **Inconsistent results** on magic angle effects on T2 and T1\(\rho\) in knee cartilage
  - strong orientation dependence of T2
  - substantially less orientation effect in vivo knee cartilage T2
  - elimination of laminar appearance at magic angle due to reduced dipolar interaction with spin-lock technique
  - magic angle may be cause of higher T1\(\rho\) in the patella
Purpose

- Analyze subregional differences in T1p and T2 values in the medical femoral condyle and patella
- Correlation of T1p and T2 in asymptomatic knee cartilage
- Evaluate angular dependence with magic angles on cartilage T1p and T2 mapping
Material and Methods

- Six healthy adult volunteers
  - 4M and 2F; mean, 32.3 yrs; range, 26-45 yrs
- 3.0T MR scanner (Magnetom Trio, A Tim, Siemens Medical Solutions)
- T1ρ mapping
  - trueFISP-based 2D T1ρ pulse sequence
  - time of spin lock (TSL) = 0, 10, 20, 30, 40 ms, spin lock frequency = 500 Hz, TR/TE = 8/4 ms
- T2 mapping
  - multi-echo spin echo sequence
  - TR = 2000 ms, TE = 10, 20, 30, 40, 50, 59, 69, 79 ms
Material and Methods - Image Analysis

- **T1ρ and T2 quantification**
  - Two independent review by musculoskeletal radiologists
  - Manually drawn ROIs (2-3mm²)
  - Nine anatomical subregions in the medial femoral condyle
  - Two locations in the center of the patella
Nine anatomical subregions in the medial femoral condyle,
At angles of $\pm 0^\circ$, $15^\circ$, $35^\circ$, $55^\circ$, $75^\circ$ respective to a vertical line (B0) bisecting
the width of the distal femur
Perpendicular to a horizontal line crossing the posterior margin of MFC cartilage
Material and Methods – Statistical Analysis

• Intraclass correlation coefficients (ICC)
  – Inter-reader agreement

• Kruskal-Wallis test and post-hoc Tukey’s test
  – significant differences between T1ρ and T2 values in three divided MFC portions (anterior: -75°, 55°, 35°, central: -15°, 0°, 15°, and posterior: 35°, 55°, 75°) and patella

• Pearson’s rank correlation
  – correlation between T1ρ and T2 values

• Wilcoxon signed-rank test
  – evaluation of angular dependence with magic angle influence
  – between values of anatomical subregions in the MFC and values at ±55°
Results

- T1ρ
  - lowest at +15°, highest at -55°
  - superior patella > inferior patella
  - lowest in the central portion of the MFC
  - highest in the anterior portion of the MFC
Results

- T2
  - lowest at $+75^\circ$, highest at $+35^\circ$
  - superior patella $>$ inferior patella
  - lowest in the posterior portion
  - highest in the central portion of the MFC
Results

• Significant differences in the three divided portions of the MFC for both T1ρ (p<0.05)

• No significant differences in three portions of the MFC for T2 (p=0.767)

• Weak correlation (r=0.217, p=0.127) between T1ρ and T2 values of the MFC and the patellar cartilage
Results - Magic angle effects

• T2
  – minimal angular dependence with the magic angle effect
  – significant differences between -55° and (-35°, +75°)

• T1ρ
  – more angular dependence
  – -55° and (-35°, -15°, 0°, +15°, +35°, +55°, 75°),
  – +55° and (0°, +15°) (p<0.05)

<table>
<thead>
<tr>
<th>Location</th>
<th>T1ρ</th>
<th>T2</th>
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<tbody>
<tr>
<td></td>
<td>p(1)</td>
<td>p(2)</td>
</tr>
<tr>
<td>-75°</td>
<td>0.119</td>
<td>0.109</td>
</tr>
<tr>
<td>-55°</td>
<td></td>
<td>0.028 *</td>
</tr>
<tr>
<td>-35°</td>
<td>0.028 *</td>
<td>0.173</td>
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<tr>
<td>-15°</td>
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<td>0.463</td>
</tr>
<tr>
<td>0°</td>
<td>0.028 *</td>
<td>0.028 *</td>
</tr>
<tr>
<td>15°</td>
<td>0.028 *</td>
<td>0.028 *</td>
</tr>
<tr>
<td>35°</td>
<td>0.028 *</td>
<td>0.173</td>
</tr>
<tr>
<td>55°</td>
<td>0.028 *</td>
<td></td>
</tr>
<tr>
<td>75°</td>
<td>0.028 *</td>
<td>0.249</td>
</tr>
</tbody>
</table>

p(1) = p-values in comparison to 55°
p(2) = p-values in comparison to 135°
Conclusion

- Significant subregional variations in T1ρ and T2 values of the MFC and patella cartilage
- Only T1ρ showed significant differences in the three divided portions of the MFC
  - Lowest in the central and highest in the anterior portion
- A weak correlation between T1ρ and T2 in the knee articular cartilage
- T1rho showed more angular dependence than T2
Conclusion

• T1ρ and T2 mappings
  – differences between T1ρ and T2 in asymptomatic knee will aid in assessment of cartilage in a specific subregion of the knee
References


