Meniscus T2 Relaxation Time at Various Stages of Knee Joint Degeneration

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Meniscus T2 Relaxation Time

- Meniscus T2 relaxation time shown to correlate strongly with water content and moderately with dynamic compressive and shear modulus

- Meniscus T2 relaxation time may provide information regarding disease-related and treatment-related changes in composition, microstructure, and biomechanical properties

Meniscus T2 Relaxation Time

T2 of entire medial and lateral menisci significantly higher in subjects with knee osteoarthritis

Meniscus T2 Relaxation Time

Subjects with knee osteoarthritis had much higher frequency of meniscus tears than subjects without knee osteoarthritis.

Meniscus T2 Relaxation Time

Increased meniscus T2 in subjects with knee osteoarthritis due to……

Meniscus degeneration?

OR

High T2 fluid between fibers of torn meniscus?

Purpose

To investigate changes in T2 relaxation time in torn and untorn meniscus in patients with varying degrees of knee joint degeneration.
Methods
Study Design

- T2 mapping sequence acquired using 3T scanner (MR750, GE Healthcare) and 8-channel phased-array extremity coil on knees of 121 patients with isolated tears of posterior horn of medial or lateral meniscus identified on knee arthroscopy performed within 2 months following MRI examination.
Imaging Parameters of T2 Mapping Sequence

- TR: 1500 ms
- TEs: 7, 16, 25, 34, 52 ms
- Flip Angle: 90°
- Bandwidth: 31.3 kHz
- FOV: 16 cm
- Matrix: 256 x 192
- Slice Thickness: 3 mm
- Signal Averages: 1
- Scan Time: 6 min
Analysis of Knee T2 Maps
Analysis of Knee T2 Maps
Analysis of Knee T2 Maps

- T2 of torn posterior horn of meniscus with tear
- T2 of untorn anterior horn of meniscus with tear
- T2 of anterior and posterior horns of contralateral untorn meniscus
Review of Knee Radiographs

Knee radiographs reviewed to determine severity of knee joint degeneration using Kellgren-Lawrence (KL) grading scale

KL0 = No osteoarthritis

KL1 = Tiny osteophytes of doubtful clinical significance

KL2 = Definitive osteophytes with minimal joint space loss
Review of Knee Arthroscopy Reports

• Arthroscopy reports reviewed to determine….
  – Numerical score representing severity of cartilage loss within medial and lateral compartments
  – Type of posterior horn meniscus tear
    • Vertical
    • Horizontal
    • Complex
    • Root
Statistical Analysis

• Kruskal-Wallis tests and Chi-square tests used to compare measured variables between KL grades and meniscus tear types

• Spearman correlation coefficient used to assess relationship between meniscus T2 and severity of cartilage loss in same compartment
Results
### Meniscus T2 Versus KL Grade

<table>
<thead>
<tr>
<th>Meniscus Segment</th>
<th>KL Grade of Knee Joint Degeneration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KL0 (N=61)</td>
</tr>
<tr>
<td>T2 of Torn Posterior Horn of Torn Meniscus</td>
<td>19.7ms (2.6ms)</td>
</tr>
<tr>
<td>T2 of Untorn Anterior Horn of Torn Meniscus</td>
<td>19.0ms (1.6ms)</td>
</tr>
<tr>
<td>T2 of Untorn Contralateral Meniscus</td>
<td>19.4ms (1.7ms)</td>
</tr>
<tr>
<td></td>
<td>KL1 (N=30)</td>
</tr>
<tr>
<td>T2 of Torn Posterior Horn of Torn Meniscus</td>
<td>21.6ms (2.7ms)</td>
</tr>
<tr>
<td>T2 of Untorn Anterior Horn of Torn Meniscus</td>
<td>19.2ms (1.2ms)</td>
</tr>
<tr>
<td>T2 of Untorn Contralateral Meniscus</td>
<td>20.4ms (1.7ms)</td>
</tr>
<tr>
<td></td>
<td>KL2 (N=30)</td>
</tr>
<tr>
<td>T2 of Torn Posterior Horn of Torn Meniscus</td>
<td>23.0ms (1.7ms)</td>
</tr>
<tr>
<td>T2 of Untorn Anterior Horn of Torn Meniscus</td>
<td>20.4ms (1.7ms)</td>
</tr>
<tr>
<td>T2 of Untorn Contralateral Meniscus</td>
<td>21.7ms (1.0ms)</td>
</tr>
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## Meniscus T2 Versus KL Grade

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<th>KL Grade of Knee Joint Degeneration</th>
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<tr>
<td></td>
<td>KL0 vs KL-1</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>T2 of Torn Posterior Horn of Torn Meniscus</td>
<td>P&lt;0.001</td>
<td></td>
</tr>
<tr>
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<td>KL1 vs KL2</td>
<td>P&lt;0.001</td>
</tr>
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<tr>
<td>T2 of Untorn Anterior Horn of Torn Meniscus</td>
<td>P=0.63</td>
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</tr>
<tr>
<td>T2 of Untorn Contralateral Meniscus</td>
<td>P=0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KL0 vs KL2</td>
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Meniscus T2 Versus KL Grade

KL0

KL1

KL2
Significant direct moderate correlation (rho=0.535, p<0.001) between meniscus T2 and severity of cartilage loss in same compartment.
# Variables for Different Tear Types

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meniscus Tear Type Mean (Standard Deviation)</th>
<th>Vertical (N=23)</th>
<th>Radial (N=22)</th>
<th>Horizontal (N=37)</th>
<th>Complex (N=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.3yr (11.7yr)</td>
<td>49.3yr (13.0yr)</td>
<td>49.3yr (10.7yr)</td>
<td>45.6yr (12.8yr)</td>
</tr>
<tr>
<td>KL Grade</td>
<td></td>
<td>0.1 (0.1)</td>
<td>0.9 (0.3)</td>
<td>1.1 (0.3)</td>
<td>1.0 (0.2)</td>
</tr>
<tr>
<td>Cartilage Score in Knee Joint at Arthroscopy</td>
<td></td>
<td>1.6 (2.6)</td>
<td>5.7 (4.6)</td>
<td>6.4 (5.1)</td>
<td>5.7 (5.7)</td>
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<tr>
<td>T2 of Torn Posterior Horn of Torn Meniscus</td>
<td></td>
<td>18.8ms (1.6ms)</td>
<td>20.5ms (1.8ms)</td>
<td>21.6ms (1.9ms)</td>
<td>23.0ms (2.5ms)</td>
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<tr>
<td>KL Grade</td>
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<td>P=0.44</td>
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<td>P=0.76</td>
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Conclusions

• Meniscus T2 is significantly higher in both torn and untorn portions of medial and lateral meniscus in patients with higher KL grades
  – T2 can detect early degeneration-related changes in composition and microstructure of intact meniscus prior to development of meniscus tear

• Direct correlation between meniscus T2 and severity of adjacent cartilage loss reflects important inter-relationship between changes in meniscus and cartilage during knee joint degeneration
Conclusions

- Vertical meniscus tears tend to occur in younger individuals who have less meniscus degeneration and less overall knee joint degeneration when compared to other tear types as vertical tears are due to trauma as opposed to joint degeneration.

- Only distinguishing feature between complex, horizontal, and root meniscus tears is that complex tears have higher T2 in torn portion of meniscus.
THANK YOU!