Normal T2 map profile of entire femoral cartilage using a novel angle/layer dependent approach

Poster No.: C-0481
Congress: ECR 2015
Type: Scientific Exhibit
Authors: Y. Kaneko, T. Nozaki, H. Yu, K. Kaneshiro, R. Schwarzkopf, H. Yoshioka; Orange, CA/US
Keywords: Musculoskeletal joint, MR, Diagnostic procedure, Image registration
DOI: 10.1594/ecr2015/C-0481

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

T2 mapping is a widely utilized MR technique for quantitative assessment of cartilage degeneration. Previous studies have compared T2 values between subregions in the knee joint [1], or between weight-bearing and non weight-bearing region [2]. However, there has been no study that assessed on angular and layer dependent variations of T2 value in entire femoral cartilage. The purpose of this study was to create normalized T2 map profiles from the entire femoral cartilage of normal volunteers to assess regional variations using a novel angle/layer dependent approach.

Methods and materials

Twenty healthy knees with equal number of left/right knees (mean 28.9 years; range: 19-38) were investigated in this study. T2 images were acquired at a 3T MR scanner (Achieva, Philips Healthcare, Netherlands) using an 8-channel knee coil. The imaging protocol included a 2D, turbo spin-echo T2 mapping sequence (TR/TE= 2700/13, 26, 39, 52, 65, 78 and 91ms, FA= 90, imaging plane= true sagittal to B0, FOV/slice thickness/gap= 140/3/0mm, matrix size= 512×512). Manual segmentation of entire femoral cartilage was performed by two raters independently slice by slice using Matlab (Mathworks, Natick, MA). Articular segmentation with angle/layer dependent approach was performed as follows: static magnetic field (B0) was defined as 0 degrees, with negative/positive angles were located anterior/posterior to the central point (Fig.1a); radial lines from a central point divided cartilage into 4-degree segments (Fig.1b) segmentation of cartilage into deep (0-50%) and superficial layers (51-100%) of relative thickness (Fig.1c). The center of the medial condyle (MC), lateral condyle (LC), and trochlea (T) were defined by referring to reformatted coronal images. Then we converted a total of 31 slices into 23 normalized slices in each subject, based on three anatomical landmarks by every 3-mm slice thickness (e.g. MC+3, MC+6, T-3). We calculated the average T2 values for two layers (deep and superficial) and 4-degree step angles over segmented cartilage at each normalized slice. We created 3D-graph of T2 profiles shown as approximate curved surfaces using custom Matlab program. Inter- and intra-rater reliabilities were assessed using intraclass correlation coefficient (ICC). T2 value between the deep and superficial layer at the center of each femoral compartment were compared using unpaired t-test/Mann-Whitney test for normal/non-normal distributed data, respectively. T2 values between magic angle and other representative angles were compared using Kruskal-Wallis test and Steel-Dwass post hoc test. Statistical analyses were performed using R version3.0.2 for Windows software (R Development Core Team, Vienna, Austria). P values less than 0.05 were considered to be statistically significant.
Images for this section:

**Fig. 1:** Articular segmentation with angle/layer dependent approach (a) After manual extraction of cartilage, a central point of circular cartilage shape (red dot) was automatically approximated. (b) Static magnetic field (B0) was defined as 0 degrees, with negative/positive angles were located anterior/posterior to the central point. (c) Radial lines from a central point divided cartilage into 4-degree segments. (d) Segmentation of cartilage into deep (0-50%) and superficial layers (51-100%) of relative thickness. (e) T2 profiles were generated for whole thickness, deep, and superficial layers of cartilage.
**Results**

The inter- and intra-rater ICCs of average T2 values in entire femoral cartilage were either "good" or "excellent" in each layer (Fig.2). The ICCs with respect to each normalized slice showed that the inter- and intra-rater ICCs around the trochlea, and both edges of the condyles were lower than those around the center of the medial and lateral condyle (Fig.2). Average T2 value was significantly higher in the superficial layer than in the deep layer at the center of each femoral compartment (Table 1). T2 profiles on 3D graph exhibited magic angle effect clearly in each layer at the medial and lateral condyle (Fig.3). Scatter plots of T2 values between magic angle and other representative angles showed magic angle effect in each layer, especially in the whole and deep layer at ±54° over the medial and lateral femoral condyle, except for the superficial layer at the medial condyle (Figure 6a-f).

**Images for this section:**
Fig. 2: Inter- and intra-rater reliability of T2 values in each layer of the cartilage with respect to each normalized slice number. MC medial condyle, T trochlea, LC lateral condyle. Phrases shown in parentheses indicate the center of femoral compartment±distance (mm).
Table 1: T2 values in each layer at the center of each femoral compartment. SD standard deviation, CI confidential interval

<table>
<thead>
<tr>
<th>Layer</th>
<th>Average</th>
<th>Median</th>
<th>SD</th>
<th>95% CI</th>
<th>Range</th>
<th>Deep vs Superficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial condyle</td>
<td>Whole</td>
<td>47.3</td>
<td>45.9</td>
<td>4.1</td>
<td>46.2-48.4</td>
<td>41.3-60.7</td>
</tr>
<tr>
<td></td>
<td>Deep</td>
<td>45.3</td>
<td>44.0</td>
<td>7.5</td>
<td>43.3-47.3</td>
<td>35.4-65.1</td>
</tr>
<tr>
<td></td>
<td>Superficial</td>
<td>49.8</td>
<td>50.3</td>
<td>3.5</td>
<td>47.8-51.8</td>
<td>41.9-60.2</td>
</tr>
<tr>
<td>Trochlea</td>
<td>Whole</td>
<td>50.2</td>
<td>49.8</td>
<td>2.4</td>
<td>49.4-51.0</td>
<td>44.9-55.1</td>
</tr>
<tr>
<td></td>
<td>Deep</td>
<td>47.9</td>
<td>47.4</td>
<td>3.9</td>
<td>46.6-49.2</td>
<td>41.0-55.7</td>
</tr>
<tr>
<td></td>
<td>Superficial</td>
<td>52.3</td>
<td>52.3</td>
<td>2.6</td>
<td>51.4-53.2</td>
<td>45.1-56.5</td>
</tr>
<tr>
<td>Lateral condyle</td>
<td>Whole</td>
<td>48.3</td>
<td>47.7</td>
<td>5.2</td>
<td>46.9-49.7</td>
<td>39.3-58.5</td>
</tr>
<tr>
<td></td>
<td>Deep</td>
<td>44.3</td>
<td>43.6</td>
<td>5.1</td>
<td>42.9-45.7</td>
<td>34.5-57.2</td>
</tr>
<tr>
<td></td>
<td>Superficial</td>
<td>52.1</td>
<td>53.2</td>
<td>5.9</td>
<td>50.7-53.5</td>
<td>38.7-60.9</td>
</tr>
</tbody>
</table>

**Table 1:** T2 values in each layer at the center of each femoral compartment. SD standard deviation, CI confidential interval

**Fig. 3:** T2 profiles on 3D graph of (a) the entire femoral cartilage, cross-section at (b) the medial condyle and (c) the lateral condyle. MC medial condyle, T trochlea, LC lateral condyle
Fig. 4: Comparison of T2 values between magic angle and other representative angles with respect to each layer. MC medial condyle, T trochlea, LC lateral condyle
Conclusion

The normal T2 map profile of entire femoral cartilage showed variations in ICCs by location and in T2 values by angles and layers. The results indicate the importance of evaluating cartilage in consideration of these variations for diagnosis of cartilage degeneration in specific location of the knee.

Personal information

Yasuhito Kaneko, MD, PhD
Department of Radiological Sciences, University of California, Irvine, Orange, California; kanekoyasuhito@gmail.com

Taiki Nozaki, MD
Department of Radiological Sciences, University of California, Irvine, Orange, California;

Hon Yu, PhD
Department of Radiological Sciences, University of California, Irvine, Orange, California;

Kayleigh Kaneshiro
Department of Radiological Sciences, University of California, Irvine, Orange, California;

Ran Schwarzkopf, MD
Department of Orthopaedic Surgery, University of California, Irvine, Orange, California;

Takeshi Hara, PhD
Department of Intelligent Image Information, Division of Regeneration and Advanced Medical Sciences, Gifu University Graduate School of Medicine, Gifu, Japan;

Hiroshi Yoshioka, MD, PhD
Department of Radiological Sciences, University of California, Irvine, Orange, California;
References
