[INTRODUCTION]
Abnormal feature of the femoral groove is one of the well-known key predisposing factors for the recurrent patellar dislocation [1]. Its abnormality has been representatively expressed as the sulcus angle in a certain axial plane using plain x-ray. However abnormal convex femoral cartilage could not be assessed by sulcus angle. Our hypothesis was that the meticulous morphometry by 3-D MR images is more useful than that by the conventional 2-D method in the assessment of abnormality of the femoral groove. Thus, 3-D morphometric analyses on the femoral groove were performed on those suffering from recurrent patellar dislocation and on the normal volunteers.

[PATIENTS AND METHODS]
The subjects were five knees of the five patients (F;3, M;2) with recurrent patellar dislocation with a mean age of 16 (range:15-28), and five knees of five healthy volunteers (F;1, M;4) with a mean age of 28 (range:23-30).

Image Acquisition: MR images were taken in the supine position at 0, 10, 20, 30, 40 and 50° of knee flexion with the quadriceps muscle relaxed, using 0.5T Open-MRI (GE Sigma, SP2, Version 8.52). 3-D MR images were obtained with the following parameters: 3D-Fast-SPGR, TE: 8.0ms, TR: 17.4ms, Matrix: 256 x 192, FOV: 280 x 280mm.

Three-Dimensional Model Creation: The images were analyzed by the 3D motion analyzing system (Virtual Place-M®). After segmentation including articular cartilage, the segmented 3D-MR images of the femur and patella were automatically superimposed over images taken at the other positions using voxel-based registration to visualize the tracking of the patella.

Patellar tracking: The patellar center was defined as the mid-point between the upper and the lower pole, and the midsagittal plane of the femur was set as the one perpendicular to the transepicondylar axis (TEA) and passing mid-point between the two epicondyles. Tracking of the patellar center through 0 to 50° of knee flexion was pursued by the off-center distance between the patellar center and the midsagittal plane and expressed as its percentage to the inter-epicondylar width at each flexion angle.

Morphometry of the femoral groove: To assess 3-D morphometry of the femoral groove, the femoral condylar planes (FCP) were established around TEA. FCP 0 was defined as the plane that includes TEA and the highest point of the intercondylar notch at the cartilage border. FCP number stands for the angle from FCP 0 (Fig. 3a). The following parameters were evaluated in each FCP. In addition, to compare these newly defined parameters and the conventional sulcus angle, a plane that crosses the femoral condyle at 45° of knee flexion (MR sulcus angle) was also evaluated.

1. Abnormal convexity on the femoral articular surface.
   - The range of convex area (RCA) was defined as the angle made between the most distal and the most proximal FCPs where the articular surface showed convexity (Fig. 3b).
2. Deviated articular cartilage of the lateral condyle (DAC)
   - The deviated articular cartilage of the lateral condyle was defined as the width of the cartilage existing lateral to the top of lateral condyle in each FCP and was expressed by its percentage to the inter-epicondylar width (Fig. 3c).

[RESULTS]
MR sulcus angle was not useful to discriminate two groups (Fig. 1). The patellar center was significantly shifted laterally through 0 to 50° of flexion in the dislocated knees (Table 1, Fig. 2). The mean RCA was 24.7° (3.7°) (1.4°) (2.9°) (1.1°) (1.7°) (2.4°) (4.5°) (6.3°) (4.1) in the dislocated knees and 11.2° (9.5°) (7.3°) (5.9°) (5.7°) (6.2°) in the normal ones. These two values were statistically significant. (Mann-Whitney U test, p=0.009)(Fig 3b).

The % DAC was significantly greater in the dislocated knees through FCP 30 to 80 (Table 2)

[DISCUSSION]
To our knowledge, this is the first study in which the 3-D morphology of the abnormal femoral groove including the articular cartilage was meticulously evaluated. As the previous cadaver studies did not focus the abnormal patello-femoral joints showing recurrent dislocation, this novel approach will enlighten the research on the patello-femoral pathology. This 3-D MR analysis opened the window to quantitatively evaluate abnormal convexity on the proximal articular surface of the femoral groove. This convexity might be one of the key factors which lead to the patellar instability on the groove. Our results also showed that the laterally-shifted patellae from 0 to 50° of flexion in the dislocated knees are somewhat supported by the deviated articular cartilage of the lateral condyle. This suggests that the patello-femoral joint may be relatively stabilized with the medial pull of the medial stabilizers including the mediano patello-femoral ligament.

In conclusion, 3-D MR imaging analysis is the most appropriate measure to express the morphology of the abnormal patello-femoral joint showing recurrent patellar dislocation.

Table 1: The percentage of the off-center distance to the inter-epicondylar width.

<table>
<thead>
<tr>
<th>Knee Flexion (deg.)</th>
<th>0°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>40°</th>
<th>50°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (SD)</td>
<td>24.7° ± 3.7°</td>
<td>23.8° ± 2.8°</td>
<td>20.7° ± 1.8°</td>
<td>18.1° ± 1.6°</td>
<td>16.8° ± 1.5°</td>
<td></td>
</tr>
<tr>
<td>Control (SD)</td>
<td>11.2° ± 4.7°</td>
<td>9.5° ± 4.7°</td>
<td>7.3° ± 5.6°</td>
<td>5.9° ± 6.5°</td>
<td>5.7° ± 6.4°</td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05 (Mann-Whitney U test)

Table 2: The percentage of the deviated articular cartilage of the lateral condyle (%DAC)

<table>
<thead>
<tr>
<th>Knee Flexion (deg.)</th>
<th>0°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>40°</th>
<th>50°</th>
<th>60°</th>
<th>70°</th>
<th>80°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (SD)</td>
<td>10.9° ± 1.9°</td>
<td>9.4° ± 1.4°</td>
<td>6.4° ± 1.8°</td>
<td>5.8° ± 1.9°</td>
<td>6.7° ± 2.2°</td>
<td>7.2° ± 2.7°</td>
<td>4.3° ± 1.4°</td>
<td>3.4° ± 0.6°</td>
<td></td>
</tr>
<tr>
<td>Control (SD)</td>
<td>1.4° ± 2.9°</td>
<td>2.6° ± 3.9°</td>
<td>3.0° ± 2.5°</td>
<td>2.3° ± 3.8°</td>
<td>2.1° ± 3.7°</td>
<td>1.7° ± 2.8°</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05 (Mann-Whitney U test)

[REFERENCES]
1. Kujala UM, et al. JBJS. 71B:788-792
2. Yamada, Y; Toritsuka, Y; Nakata, K; Nakamura, N; Kawakami, H; Hamada, M; Horibe, S; Sugamoto, K; Yoshikawa, H; Shino, K
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