It is generally accepted that definitive diagnosis of partial anterior cruciate ligament (ACL) tears is difficult without arthroscopic examination. Compared with patients with complete ACL tears, patients with partial ACL tears require fewer ACL reconstructions and more often return to sports when conservatively managed. The distinction between partial and complete ACL tears influences patient management and prognosis, so it is clinically very important.

The reported accuracy of magnetic resonance (MR) imaging performed with conventional two-dimensional spin-echo sequences in the diagnosis of complete ACL tears is as high as 95%\(^\text{2,3}\). MR imaging using conventional sequences, however, has not proved sensitive in the detection of partial ACL tears\(^\text{4,5}\). The currently used three-dimensional (3D) gradient-echo (GE) MR imaging is known to provide high resolution with no loss of information caused by intersection gaps. Although several papers have suggested that 3D GE MR imaging is at least comparable to conventional sequences\(^\text{6,7}\), little has been published concerning the distinction between partial and complete ACL tears in a large population. Moreover, few MR studies on ACL injuries have considered acute and chronic ACL tears separately.

We designed this study to clarify the ability of 3D Field Echo (FE) MR imaging, which is one of the 3D GE sequences, to identify chronic partial ACL tears and to allow the distinction of partial from complete ACL tears. We compared the findings of chronic ACL tears through 3D FE MR imaging with those of an arthroscopic standard in a relatively large group of patients.

The selection criteria for this study were as follows: 1) a history of 3D FE MR imaging prior to diagnostic arthroscopic examination; 2) a median interval since knee injury at the time of 3D FE MR imaging of more than four weeks; and 3) a partial or complete tear of ACL proved by diagnostic arthroscopic examination. Seventy patients fulfilled the selection criteria. They were classified as either partial or complete ACL tears.

All of the MR images were obtained with a commercially available unit (MRT, Toshiba, Japan) operating at 0.5 tesla, and only the 3D Fourier transform FE sequence was performed. The repetition time was 51 msec, and the echo time 14 msec, with a flip angle of 45 degrees. All patients were imaged in the sagittal plane, and section thickness was 1.5 mm with section gaps of 0 mm. For this 3D FE MR imaging, eight or more sagittal sections are required to span both anterior and posterior cruciate ligaments, and normal ACL is consistently well depicted as a linear continuous low-signal band on three or more sections (Fig. 1a).

The 3D FE MR images were retrospectively interpreted by an experienced orthopaedist who was unaware of the arthroscopic findings; they were classified as either partial or complete tears. The MR images of the ACL tears were designated as partial on the basis of the appearance of a linear continuous low-signal band on one or two sagittal sections (Fig. 1b), and as complete when there was no linear continuous low-signal band on any sagittal sections.
The results of the classification of 3D FE MR images are summarized in Table 1. At arthroscopic examination, 16 ligaments showed a partial tear and 54 showed a complete tear. At 3D FE MR imaging, 13 of the 16 partial tears (81.3%) and 52 of the 54 complete tears (96.3%) were diagnosed correctly; 65 of the 70 chronic ACL tears (92.9%) were classified accurately as partial or complete.

Regarding the classification of partial or complete ACL tears by 3D GE MR imaging, Tyrrell et al. reported that 100% of partial ACL tears were correctly diagnosed, whereas Heron et al. reported 50%. Previous studies have not included large populations and have not considered acute and chronic ACL tears separately. In our previous study, which investigated the ability of 3D FE MR imaging to show acute partial ACL tears in a small group of patients, only 36.4% of acute ACL tears were accurately distinguished as partial or complete tears. With these acute ACL tears, the median interval since injury at the time of 3D FE MR imaging was four weeks or less. In this study with a relatively large group of patients, on whom 3D FE MR imaging was performed more than four weeks after knee injury, 92.9% of chronic ACL tears were classified accurately as partial or complete. This discrepancy can be attributed neither to hemorrhage nor to any acute inflammatory condition in the chronic ACL tears.

The very thin, contiguous sections in 3D GE MR imaging, which is known to provide high resolution, afford four principal advantages: minimal volume averaging; no lost pathologic areas in section gaps; multiplanar reconstruction potential; and improved signal-to-noise ratio compared with a spin-echo multisection technique using similar section thickness. Although these advantages may also be realized with 3-dimensional spin-echo MR imaging, the examination time is excessive. The ability of 3D FE MR imaging to accurately diagnose chronic partial ACL tears is a direct result of the thin, contiguous sections. Chronic partial ACL tears demonstrate at least some remaining intact fibers, i.e. the appearance of a linear continuous low-signal band on one or two sagittal sections.

These results suggest that 3D FE MR imaging allows definitive diagnosis of chronic partial ACL tears without arthroscopic examination, which in general is considered to be the only means of making a definitive diagnosis of partial ACL tears.
Table 1 Comparison of the findings in 70 chronic anterior cruciate ligament tears

<table>
<thead>
<tr>
<th>Finding at arthroscopic examination</th>
<th>No. of cases</th>
<th>Finding at MR imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial ACL tear</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Complete ACL tear</td>
<td>54</td>
<td>3</td>
</tr>
</tbody>
</table>

In the past, we also performed diagnostic arthroscopic examinations, but on the basis of the results of this study, we have not performed such examinations recently when 3D FE MR images of ACL tears were obtained more than four weeks after knee injury.

In conclusion, our study shows that 3D GE MR imaging is an accurate and efficient method for definitively distinguishing between partial and complete chronic ACL tears, and may also be used to guide decisions regarding patient management and prognosis without arthroscopic examination.

References


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