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CLINICAL IMAGING

Magnetic resonance delineation of the anterior cruciate ligament of the knee
Flexed knee position within a surface coil

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Abstract

The purpose of this study was to evaluate the effect of the knee position at three different flexion angles in magnetic resonance (MR) delineation of the anterior cruciate ligament (ACL) in the knee and to determine the optimal knee position. Thirteen knees of normal volunteers were examined at 15°, 30°, and 45° of flexion with a surface coil, and three sets of obtained oblique sagittal MR images were evaluated by four observers. MR images at 30° of knee flexion most clearly delineate compared with those at 15° and 45° of knee flexion. We recommended examining the knee in 30° of flexion.

Keywords: Magnetic resonance imaging; Anterior cruciate ligament; Knee flexion; Surface coil; Knee anatomy

1. Introduction

Magnetic resonance (MR) imaging has been a clinically useful tool in evaluating internal derangement of the knee [1–3]. MR imaging with high field strength and a surface coil has high accuracy for the diagnosis of tears of the anterior cruciate ligament (ACL) [4,5]. However, incomplete visualization of the ACL on MR images is not uncommon. Some authors have reported poor visualization of the normal ACL on sagittal images in 5–10% of patients [6,7]. Volume averaging of the proximal part of the ACL and the femoral lateral condyle has continued to be a problem [8]. To improve image quality with regard to ACL visualization, it is important to perform MR examinations under appropriate conditions. Most previous studies have been performed with knees in extension. However, a cine MR system demonstrated that a normal ACL changes its appearance during the knee extension–flexion cycle [9]. Recently, a few authors postulated that MR images of knees in flexion more clearly delineate normal and torn ACLs [10–12]. Niitsu et al. [10] first demonstrated that MR images of the knee in a flexed position more clearly delineate normal and torn ACLs compared with MR images of the knee in an extended position. However, because they used a specialized mobile knee brace to obtain a flexed knee position, the range of flexion angle varied in each subject because of the variation of the length of the subject's lower legs. Pereira et al. [12] compared 15° of flexion true sagittal MR images with extension sagittal oblique MR images and concluded that flexion true sagittal images delineated both normal and torn ACLs more clearly than extension sagittal oblique images. However, these previous investigators just compared images in a flexed position with images in an extended position. To date, to the authors' knowledge, there have been no reports that have compared MR images at

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Fig. 1. Patient positioning with the knee flexed during MR examinations. A flexible surface coil is wrapped around the knee. A sponge pad is placed beneath the knee for flexion.

different flexion angles with regard to delineation of the ACL and determined the optimal range for knee flexion. In the present study, we examined normal knees in three different flexed knee positions, 15°, 30°, and 45°, and compared the obtained sagittal oblique MR images for accurate delineation of the ACL to determine the optimal knee flexion angle for visualizing the ACL.

2. Materials and methods

Thirteen knees of normal volunteers (age range 22–46 years; 3 males and 5 females, 7 right knees and 6 left knees) without previous history of significant trauma to the knee joint were examined using MR imaging. The MR examinations revealed 13 intact ACLs. All MR imaging was performed using a 1.5T MR unit (Gyroscan Intera 1.5T; Philips Medical Systems, Best, the Netherlands). A flexible surface coil (Synergy Flex-M Coil, Philips Medical Systems) composed of two loops was wrapped around the knee, allowing the knee to flex (Fig. 1). We used a sponge pad, placed beneath the popliteal portion for flexion (15°, 30°, and 45°), and measured angles using a nonmagnetic handheld goniometer. Localizing axial and coronal images of each knee were obtained. By identifying the femoral and tibial attachments on the localizing images, the parasagittal direction approximately 10° oblique from the midsagittal directions of the knee joint, which was considered to be parallel to the ACL, was determined. Sets of 3-mm-thick sections (with 0.3-mm gaps) of proton-weighted, turbo spin-echo MR images were obtained using a TR of 4000 ms, TE of 11 ms (4000/11), and turbo factor (echo train length) of 14. A 15-cm rectangular field of view, a 203 × 512 acqui-

Table 1
MR delineation of the ACL in three different flexed positions

	Knee flexion angle		
Image characteristics	15°	30°	45°
Femoral end			
Reviewer 1	31.0	18.5	28.5
Reviewer 2	31.0	20.0	27.0
Reviewer 3	30.0	24.0	24.0
Reviewer 4	34.5	22.0	21.5
Total	126.5*	84.5	101.0**
Midportion			
Reviewer 1	29.5	17.5	31.0
Reviewer 2	28.0	21.5	28.5
Reviewer 3	29.5	24.0	24.5
Reviewer 4	32.5	22.5	23.0
Total	119.5*	85.5	107.0*
Tibial end			
Reviewer 1	29.5	18.5	30.0
Reviewer 2	25.0	22.5	30.5
Reviewer 3	26.0	24.0	28.0
Reviewer 4	34.0	21.5	22.5
Total	114.5*	86.5	111.0*

Values are the rank sum of 13 subjects.
* $P < .01$ versus 30° value.
** $P < .05$ versus 30° value.

Fig. 2. Oblique sagittal proton-weighted MR images (TR/TE = 4000/11) obtained from a 34-year-old man, with 15° (A), 30° (B), and 45° (C) of flexion. At 30° (B) of flexion, the entire ACL, including the femoral attachment (arrow) is clearly visible. However, at 15° (A) of flexion, volume-averaging artifact with the lateral femoral condyle obscures the femoral attachment (arrow). At 45° (C) of flexion, the ACL appears lax (convex toward the anterior side), causing the femoral attachment (arrow) to be obscured due to partial volume averaging.