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The Accuracy of MRI in Assessing Graft Integrity After Anterior Cruciate Ligament Reconstruction

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Abstract

To evaluate the efficacy of MRI in assessing anterior cruciate ligament (ACL) reconstruction graft integrity, we compared MRI findings with arthroscopic findings in 52 patients who had undergone arthroscopically assisted ACL reconstruction using semitendinosus and gracilis tendons augmented by woven polyester. MRI and arthroscopy were carried out 12 months after the operation. The MR appearance of ACL grafts was categorized into 3 types by signal intensity and continuity of the ligament according to Rak's method: 1. well-defined type: the graft was visualized as a smoothly continuous band with low signal over the entire course; 2. intermediate type: signal intensity increased and a low-signal band was visualized only in part of the graft; 3. indiscernible type: the graft was not identified through the joint cavity due to markedly increased signal intensity. When the MR appearance of intermediate or indiscernible types was defined as torn, the grafts were presumed to be torn in 9 patients whose arthroscopic findings were 7 intact and 2 torn grafts. All cases with intact MRI findings were intact on arthroscopic examination. Thus, the sensitivity, specificity and accuracy of MRI as an evaluative tool for ACL graft tears were 100%, 86% and 86.5%, respectively. (J Nippon Med Sch 2001; 68: 45—49)

Key words: magnetic resonance imaging, diagnostic accuracy, anterior cruciate ligament reconstruction

Introduction

The usefulness of Magnetic Resonance Imaging (MRI) in the diagnosis of anterior cruciate ligament (ACL) tears[1,2] is well established. In recent years, an increasing number of MRI studies have been reported concerning the integrity of ACL grafts after reconstruction. MRI provides valuable data, particularly with respect to issues such as the impingement of grafts[3,4] or biological processes associated with graft outcome following reconstruction[5].

Questions remain, however, about the efficacy and reliability of MRI in assessing graft integrity. Our review of current published studies reveals the following limitations with regard to using MRI as a postoperative diagnostic tool for the assessment of ACL graft reconstruction: a imited number of cases; MRI timing and interval inconsistency; and contaminatied outcomes. To our knowledge, there has been no precise study evaluating the efficacy of non-invasive MRI findings as compared to invasive arthroscopic findings for the assessment of ACL graft integrity.

The aim of the present study is to compared MRI findings in many patients with those of arthroscopic findings to evaluate the accuracy of MRI diagnosis for ACL graft reconstruction.

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Materials and Methods

(1) Subjects

Between 1995 and 1998, 52 patients who had undergone arthroscopically assisted ACL reconstruction had MRI and arthroscopic examinations 12 months after the operation. The purpose of the experiment was explained to each subject beforehand, and written consent was obtained from each. Arthroscopy was performed when fixation staples were removed. Our study included 37 males and 15 females with a mean age of 27.5±8.0 years (range: 16～54 years). Forty of the 52 patients had associated injuries such as meniscal tears and collateral ligament injuries. The duration between the injury and corrective surgery ranged from one to 180 months with a mean of 30.2 months.

(2) Surgical Procedure

Semitendinousus and gracilis tendons (STG) were harvested through a 3-cm skin incision. Woven polyester (Leeds-Keio, Biomet, Bridgend, UK) was sutured tightly around double-looped STG to make a composite graft with a diameter of 8～10 mm. A tibial bone tunnel was made in the posteromedial portion to the center of the anatomic ACL insertion, and a femoral bone tunnel in the posterosuperior margin of the lateral intercondylar notch. The graft was passed through these bone tunnels, and was fixed to the femur and tibia with 2 staples. A notch plasty was performed if the graft impinged in the intercondylar notch.

(3) Rehabilitation Program

All patients underwent the same rehabilitation program postoperatively. Passive motion from 0° to 90° using a CPM device was begun on the second postoperative day. Partial weight bearing was allowed at 1 week, increasing to full weight bearing at 2～4 weeks. Agility training, including running or other sports-specific training was started at 3 months, and a return to pre-injury sports activities was allowed 12 months after the ACL reconstruction.

(4) MRI and Arthroscopic Evaluations

All MR studies were performed on a 0.5 T MR unit (MRT, Toshiba, Tokyo) with three-dimensional (3 D) field echo pulse sequences (flip angle 45 degrees, TR 51 msec/TE 14 msec). Section thicknesses of 1.5 mm were acquired with no interslice gap in the sagittal or coronal planes. With 3 D-MRI, intact grafts appeared ascontinuous, homogenous bands with low signal intensity. Woven polyester could not be differentiated from STG in any patients.

The MR appearance of the ACL grafts was categorized into 3 types by signal intensity and continuity of

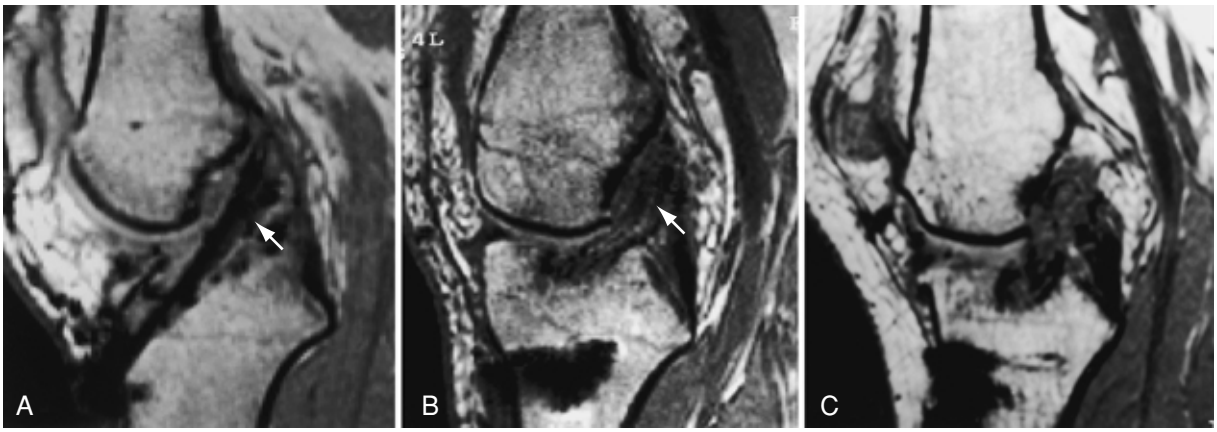

Fig. 1 Sagittal images of ACL graft at 12 months after reconstruction (3-D MRI with field echo sequences, flip angle 45 degree, TR 51 msec/TE 14 msec).
A. Well-defined type: The graft appeared as a continuous, homogenous band with low signal intensity over its entire course. B. Intermediate type: The graft was visualized only in part of its course due to increased signal intensity. C. Indiscernible type: The graft was not identified through the joint cavity due to markedly increased signal intensity.

the ligament according to Rak's method[6] : 1. well-defined type: the graft was visualized as a smooth, continuous band with low signal over the entire course; 2. intermediate type: signal intensity increased and a low-signal band was visualized only in part of the graft; 3. indiscernible type: the graft was not identified through the joint cavity due to markedly increased signal intensity (**Fig. 1**).

Arthroscopic evaluations of the grafts were classified into 2 categories: 1. intact: thick and taut ligamentous tissue observed as in normal ACL and tear; 2. loose and thin ligamentous tissue or ligamentous tissue not observed (**Fig. 2**).

(5) Clinical Evaluation

Postoperative clinical results were evaluated by KT-2000 arthrometer measurement for anterior knee laxity and range of motion (ROM). KT-2000 arthrometer measurement was carried out at a knee flexion of 20. with a force of 134 N. When the injured-uninjured difference exceeded 3 mm, the graft was presumed to be torn.

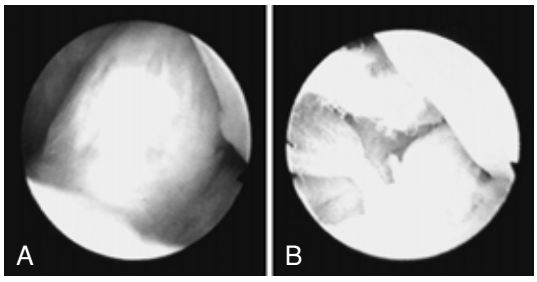

Fig. 2 The criteria of arthroscopic assessment of the graft. A. Intact: thick and taut ligamentous tissue observed as in normal ACL. B. Tear: loose and thin ligamentous tissue or ligamentous tissue not observed.

Results

According to MRI findings, the grafts in 43 patients were categorized as well-defined type, as intermediate type in 3 patients and as indiscernible type in 6. Arthroscopic examination of the same 52 patients resulted in 50 patients demonstrating intact grafts and in 2 patients displaying tears (**Table 1**).

Postoperative KT-2000 arthrometer measurement displayed injured-uninjured difference in anterior laxity at 2.5 ± 0.8 mm (range : − 4.8 to 11.1 mm). Thirty-three patients had a difference of 3 mm or less, and 19 patients more than 3 mm. The mean extension and flexion were − 0.1 ± 0.69° and 159.9 ± 0.69°, respectively, while 51 out of 52 patients (98.1%) obtained full range of motion.

When the MR appearance of intermediate or indiscernible type was defined as torn, the grafts were presumed to be intact in 43 patients and torn in 9 patients. The sensitivity, specificity and accuracy of MRI in assessing graft integrity were 100%, 86% and 86.5%, respectively. When a difference of more than 3 mm was defined as a tear, the sensitivity, specificity and accuracy of KT-2000 Arthrometer measurements were 100%, 66% and 67.3%, respectively.

Discussion

There has been some debate about the value of MRI in ACL reconstruction. Some authors[7,8] have reported that MRI is useful in assessing graft integrity, but others[9,10] have stated that it is inadequate. One of the reasons for this discrepancy may be the fact that the diagnostic accuracy of MRI has been mainly compared with clinical evaluations such as those made

Table 1 Sensitivity, specificity and accuracy of MRI and KT-2000 measurement for evaluating graft tear

MRI	Arthroscopy			KT-2000	Arthroscopy		
	Tear	Intact	Total		Tear	Intact	Total
Tear	2	7	9	＞3mm	2	17	19
Intact	0	43	43	≦3mm	0	33	33
Total	2	50	52	Total	2	50	52

MRI: sensitivity = 100%, specificity = 86%, accuracy = 86.5%, KT-2000 measurement: sensitivity = 100%, specificity = 66%, accuracy = 67.3%.

with knee arthrometers, as the present study revealed (**Table 1**).

Knee arthrometers were introduced to increase the diagnostic accuracy of ACL tears. However, it has been reported that graft integrity based on arthrometer testing is questionable[11]. In the present study, the graft showed arthroscopically intact in 17 of 19 patients with differences of more than 3 mm. It is likely that some patients may have morphologically normal, but functionally insufficient grafts. Another reason may be changes in the tissue compliance of joint capsules as second restraints, which often occur in chronic ACL tears. Even normal grafts may not allow complete control of anterior knee laxity in patients with lax second restraints, resulting in high values of arthrometer measurement. Passler et al.[11] stated that arthroscopy or MRI may be required when the clinical determination of ACL graft integrity is equivocal. As a result of our study, we were able to demonstrate that the accuracy of MRI in evaluating graft integrity was higher than that of KT-2000 arthrometer measurements.

Arthroscopy is generally considered the most reliable method[12] for evaluating graft integrity, but, in general, second-look arthroscopy has been performed mainly on patients who continue to have symptomatic knees after ACL reconstruction. Studies comparing MRI with arthroscopy have been limited in scope, focusing on isolated cases. The study of Rak et al.[6] of 12 cases and that of Maywood et al.[13] of 10 cases showed good correlation between MRI and arthroscopic findings. In contrast, Autz et al.[14] reported that in two knees with intact grafts as evaluated by MRI, arthroscopy showed a continuous, but lax graft. The present study demonstrates that the accuracy of MRI (86.5%) for graft tears was almost the same as that for ACL tears, which was reported to be 72～100 %[15-17]. However, there are serious problems such as the high incidence of false-negative cases in diagnosing graft tears.

Stockle et al.[18] reported that graft signal increases during the first year after reconstruction, and they speculated that this signal change might reflect edema or revascularization of the graft following ACL reconstruction. In our study, the grafts were arthroscopically intact in 7 out of 9 patients with intermediate type or indiscernible types due to increased signal intensity. Graft tears are often not depicted directly by MRI. Instead, they are indirectly depicted with increased signal intensity, which may be similar to postoperative biological changes seen in the graft. This may explain false-positive diagnoses.

The woven polyester[19] used in this study may have an impact on MRI images of STG. Intact composite grafts were visualized as emitting a homogenous low signal band similar to STG or patellar tendon autografts reported in published studies[12,20]. Woven polyester was not differentiated from STG in any patients in this study, because of isosignal with STG and the small tissue volume for MRI targeting. We believe that woven polyester may have little effect on the MR imaging of the graft.

Recently there has been a trend toward earlier mobilization and weight bearing after reconstruction[21] to allow many patients a rapid return to their pre-injury level of physical or sporting activities, although advanced rehabilitation programs, especially agility or sports-specific training, have been reported to have the potential to cause a change in graft stability[22]. MRI may provide useful information in monitoring the safety of rehabilitation programs, and in determining practical guidelines for physical training or sporting activities.

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