MRI findings in symptomatic patients following anterior cruciate ligament surgery

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KEYWORDS
Magnetic resonance; ACL reconstruction; Symptomatic patients

Abstract
Introduction: Considering the large number of patients undergoing anterior cruciate ligament (ACL) surgery, it is important for radiologists to be familiar with these procedures, the normal imaging findings as well as the appearances of common complications that can occur in these patients. Symptomatic patients might present with complications related to the graft itself or due to other causes not related to the graft.

Aim of the work: Evaluate the MRI findings in symptomatic patients following ACL surgery.

Patients and methods: The study included 26 symptomatic patients following anterior cruciate ligament surgery. The examination was done on 1.5 Tesla magnet MRI machines.

Results: Twenty-five patients had reconstruction surgery (96%) and 1 patient had fixation of tibial attachment (4%). Among 25 cases of ACL reconstruction 21 patients had semi-membranosus/semi-tendinosus graft (84%) and 4 patients had Bone-patellar tendon-Bone graft (16%). The most common finding was complete graft tear (32%); followed by abnormal tunnel position (24%); screw failure (16%); graft impingement and partial graft tear (12% each); tibial tunnel and femoral tunnel cysts (8% each); arthrofibrosis (4%).

Conclusions: MRI is the modality of choice in evaluating the causes of symptomatic patients following ACL reconstruction surgery.

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1. Introduction

During the past few decades, graft reconstruction of the anterior cruciate ligament (ACL) has become an accepted treatment for symptomatic ACL deficiency (1,2). The goal of surgery is to prevent joint instability, which may further damage articular cartilage and menisci (3).

Magnetic resonance (MR) imaging of the knee after surgical repair is becoming more common because of the increasing number of therapeutic knee arthroscopic procedures being performed (4).

Considering the increasing number of patients undergoing ACL reconstruction, it is mandatory for radiologists to be familiar with these procedures, and the normal imaging...
findings as well as the appearances of common complications that can occur in these patients (4).

MR signal of the ACL graft varies based on the composition and age of the graft. MRI can non-invasively monitor the serial signal intensity changes noted during the revascularization process of the ACL graft (4).

The normal location of the femoral and tibial graft tunnels should be identified (5–8).

Complications from ACL repair can be related to graft harvesting, graft placement, or the graft itself (9).

Symptomatic patients might present with complications related to the graft itself such as graft failure, roof impingement, post operative stiffness, tunnel widening due to cyst formation, iliotibial band friction syndrome, hardware failure and infection.

Patients might be symptomatic due to other causes not related to the graft such as meniscal injuries, osteochondral lesions and premature osteoarthritis.

Our aim in this study was to evaluate the causes of symptomatic patients following ACL reconstruction surgery and correlate them with the MRI findings.

2. Patients and methods

2.1. Our study included 26 patients (24 males and 2 females) who were complaining after undergoing ACL reconstruction in the period between 2011 and 2013. The average time interval after the reconstruction was one and half year.

2.2. Full clinical history, clinical examinations and plain radiological study were done for all patients. Informed consent was signed by all patients.

2.3. High field MRI evaluation for the 26 patients was performed with a 1.5 T dedicated system using a transmit-receive extremity coil. The knee was placed in 10–15 degree external rotation (to orient the ACL with the sagittal imaging plane). The same scanning protocol was used for all patients: axial, sagittal, and coronal T1 weighted spin echo sequences (repetition time of 600 ms, echo time of 20 ms, 18 cm field of view, 4 mm slice thickness with no interslice gap, and a 256 matrix), and sagittal and coronal proton density fat suppressed (PD FAT SAT) turbo-spin-echo sequences (BLADE) were used (repetition time of 3500 ms, echo time of 48 ms, 18 cm field of view, 3.5 mm slice thickness, and a 256 matrix).

Coronal oblique reconstruction from sagittal proton density (repetition time of 1800 ms, echo time of 37 ms, 18 cm field of view, 0.90 mm slice thickness)

3. Results

3.1. Demographic criteria of patients

Twenty-six patients were included in this study; 24 were males and 2 were females. The age ranged between 24 and 54 years with mean age 32 years (Table 1).

3.2. Clinical data

The presenting complaints of patients were pain in 24 patients (92.3%); instability in 11 patients (42.3%); locking 3 patients (11.5%). Clinical examination revealed negative results in 14 patients (53.8%), positive Lachman and Pivot shift tests in 6 patients (23.1%), and positive Mc-Murray test in 6 patients (23.1%).

3.3. Surgical data

All studied patients had anterior cruciate ligament surgery. Twenty-five patients had reconstruction surgery (96.2%) and 1 patient had fixation of tibial attachment (3.8%). Among 25 cases of ACL reconstruction 21 patients had semi-membranosus/semi-tendinosus graft (80.8%) and 4 patients had Bone-patellar tendon-Bone graft (15.4%) (Table 2).

3.4. MRI

The MRI findings were grouped in two categories; one group included findings related to the operational procedure and another group included findings not related to operational procedure.

3.4.1. Group I (findings related to operational procedure)

The MRI findings related to the operational procedure are listed in (Table 3).

Graft signal was found in 7 patients; 4 of them were normal and 3 reflected graft impingement (Fig. 1); graft tear was found in 11 patients; 3 cases were partial tear (Fig. 2) and 8 cases were complete tear (Fig. 3); abnormal tunnel position in 6 patients (Fig. 3); tibial tunnel cyst in 2 patients (Fig. 4); femoral tunnel cyst in 2 patients (Fig. 5); screw failure in 4 patients (Figs. 6 and 7) and 1 case of arthrofibrosis (Fig. 2).

3.4.2. Group II (findings not related to operational procedure)

The MRI findings not related to the operational procedure are listed in (Table 4).

Meniscal tear was found in 17 patients (65.4%) (Fig. 8); articular cartilage lesion was found in 11 patients (42.3%) (Fig. 9); patellar cartilage lesion in 5 patients (19.2%) (Fig. 10); sprained patellar retinaculum in 1 patient (3.8%) (Fig. 11); and 1 patient with patellar tendinosis (3.8%) (Fig. 11).

4. Discussion

Clinical evaluation of symptomatic patients following ACL reconstructions can be difficult, and MR imaging plays an
important role in evaluating the integrity of the ACL graft, as well as in diagnosing complications associated with ACL reconstruction (4).

In our study intermediate high signal intensity was found in the graft of 7 patients. Four of them were considered to be normal after excluding the causes of graft impingement including assessment of the normal position of the tibial and femoral tunnels and after correlation with the time lapse of operative procedure. All the patients had their operation done more than three months as follows: one patient had the operation since 5 months; one patient since 10 month and two patients since 8 months.

Putting in mind the evolution of signal intensity of the graft attributed to the process of ligamentization. Graft signal is not

<table>
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<th>Table 2</th>
<th>Surgical data of the studied group.</th>
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<td>ACL reconstruction semi-membranosus/semitendinosus graft</td>
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<td>ACL reconstruction bone-patellar tendon-bone graft</td>
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<td>Fixation of ACL attachment</td>
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<th>Table 3</th>
<th>Distribution of the studied cases according to MRI findings related to the operational procedure.</th>
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<td>Graft signal</td>
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<td>Impingement</td>
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<td>Graft tear</td>
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<td>Complete</td>
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<tr>
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<td>Screw failure</td>
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<td>Arthrofibrosis</td>
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Fig. 1 25 year old male patient complaining of knee pain 1.5 years following ACL reconstruction. Mid sagittal intermediate weighted image showing kinking of the ACL reconstruction graft with intermediate high signal intensity impressive of roof impingement.

Fig. 2 31 year old male patient complaining of knee pain and limitation of movement 2 years following ACL reconstruction. Sagittal PD image shows low signal intensity around the ACL graft notably anterior extending to Hoffa’s pad of fat indicating arthrofibrosis (arrow). Noted also linear fluid signal intensity within the proximal fibers of the graft reflecting partial intra-substance tear (dashed arrow).

Fig. 3 24 year old male patient complaining of pain and giving way 5 years post ACL reconstruction. Intermediate weighted fat suppressed sequences A and B sagittal images. (A) Shows torn ACL reconstruction graft with anterior tibial translation. (B) Anterior position of the tibial tunnel.
expected to occur during the first three months which is matching with Amiel et al. (10) who reported that during the first 3 months after ACL reconstruction, graft constructs are typically uniformly low in signal intensity on T1- and T2-weighted images. Thereafter, a progressive vascularization of periligamentous soft tissues with subsequent synovialization and remodeling results in graft ligamentization.

Our results also matched with a study conducted by Jansson et al. (11) who found that during this postoperative phase (12–18 months), the graft may normally show a degree of intrasubstance increased signal intensity on T1- and T2-weighted images that is reflective of synovial and neovascular proliferation around and within the graft, which is referred to as “neoligamentization” of graft tissue.

However a long term follow up study conducted by Saupe et al. (12) showed that small amounts of increased intrasubstance graft signal can be seen after anterior cruciate ligament (ACL) reconstruction at long-term follow-up (4 years) on intermediate-weighted and T2-weighted MR images in approximately two thirds of patients (70% and 64%, respectively).

In our study we cannot confirm this long time of accepted signal intensity within the graft because the longest time lapse we had was 4 years with the graft showed no increased signal intensity and the patient had torn posterior horn of the medial meniscus explaining the pain.
In the patients where we considered the graft signal to be accepted we had other findings to explain their symptoms. Three of them had meniscal tears explaining the pain and the fourth had meniscal tear and articular cartilage lesion.

In our study three cases were diagnosed graft impingement because they had the operation more than two years and there was causes of graft impingement; two of them had abnormal anterior position of the tibial tunnel where the anterior edge of the tunnel emerged anterior to the Blumensaat line with resultant posterior kink of the graft at the intercondylar region and expected graft friction with the intercondylar roof. The third case had a normal tunnel position but a dislodged femoral tunnel screw in the intercondylar fossa abutting the surface of the graft resulting in knee locking and graft impingement.

Our results are matching with White et al. (13) and Trattnig et al. (14) who reported that by 2 years after ACL reconstruction, the literature suggests that a normal graft tendon should resume a uniform normal low-signal-intensity MR imaging appearance.

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Our criteria of diagnosis for partial graft tear are matching with Ilaslan et al. (15) who reported that partial tears of an ACL graft may appear as areas of increased signal intensity within the graft tissue with some residual intact fibers on T2-weighted images. Also in a pictorial essay done by Recht and Kramer (4) and a study done Saupe et al. (12) they reported that T2-weighted acquisitions may also show regions of increased signal intensity within an intact graft, if such signal was not iso-intense relative to fluid and not traversing the full thickness of the graft construct.

Complete graft tears were found in 8 patients; 6 of them had the reconstruction more than two years and showed abnormal anterior tibial tunnel position with resultant expected long term of graft impingement ending with complete graft tear. In these patients complete graft tear was diagnosed due to absence of intact fibers and detection of fluid filled gap associated with secondary signs such as anterior tibial translation. Two patients had their ACL reconstruction since 6 months and showed the same diagnostic criteria of graft tear as well as pivot shift bone bruise and torn posterior horn of the medial meniscus suggesting new twisting injury which is likely the cause of torn graft.

Our criteria of diagnosis go in agreement with Bencardino et al. (3) and McCauley (16) who diagnosed ACL graft tear in their study when the graft fibers could not be identified as extending from the femoral tunnel to the tibial tunnel.

We disagree with Roberts et al. (17) who stated that tears are seen as intermediate to high T2-weighted signal within the graft, taking into account the normal transition of signal intensity during revascularization and resynovialization of the graft in the 4- to 8-month postoperative period. We could not establish sure diagnosis of graft tear if we detect intermediate high signal intensity within the graft.

In our study we found 6 cases of abnormal tibial tunnel position having their anterior margin located anterior to the intercondylar roof (Blumensaat line). The abnormal tunnel position leads to posterior kink of the graft at the site of contact with the intercondylar notch resulting in continuous friction upon knee flexion and extension and subsequent graft impingement with end result of graft tear.

In our study we diagnosed 4 cases of tunnel cysts; two of them were femoral and two were tibial. Tunnel cysts were diagnosed when there was tunnel fluid persistent after two years post operative. Sanders (8) stated that small amounts of fluid may be seen within the tibial and femoral tunnels during the 1st year after ACL reconstruction. In our study these 4 cases of tunnel cyst we depicted associated with partial or complete tear of the reconstructed graft and relative tunnel expansion which matches with Bencardino et al. (3) who reported that the formation of tunnel cysts after ACL reconstruction has been attributed to incomplete incorporation of allograft tissue within the bone tunnels and subsequent tissue necrosis may allow synovial fluid to be transmitted through the tibial tunnel to pretibial subcutaneous tissues (18). Tunnel widening may occur when intra-osseous fixation is not performed. Extrusion of joint fluid into the tunnel may lead to formation of a ganglion, which may enlarge over time and cause postoperative pain.
We diagnosed four patients with screw failure. Two of them had bulging screws from the anterior aspect of the tibia with resultant pre-tibial bursitis attributed to friction with the subcutaneous fat. One case had bulging tibial screw into the intercondylar notch and the last case had completely dislodged femoral tunnel screw into the intercondylar region which was seen abutting the reconstructed graft resulting in graft impingement.

In the literature Bencardino et al. (3) reported that fixation devices may loosen or become displaced, which include bio-absorbable interference screws, metallic setscrews, and pins.

One case of arthrofibrosis was diagnosed among our cases with a percent of occurrence (3.8%). Low signal intensity was detected around the ACL reconstructed graft more evident at its anterior aspect; extending to the Hoffa’s fat of pad. A study conducted by Bencardino et al. (3) defined arthrofibrosis as the presence of scar tissue in at least one compartment of the knee joint, leading to a decreased range of motion.

Lebel et al. (19), Jackson and Schefer (20) as well as Marzo et al. (21) reported that localized anterior arthrofibrosis, or “cyclops” lesion, has been seen in 1–10% of patients with ACL reconstruction.

In our study MRI findings other than those related to the graft were detected including 17 cases of meniscal injury; 11 cases of articular cartilage lesion; 5 cases of patellar cartilage lesion and one case of patellar tendinosis and sprayed patellar retinaculum which were blamed for the patients’ symptoms. However this study has certain limitations including lack of statistical analysis of the MR findings due to small number of cases and also the accuracy of the MR findings could not be evaluated due to absence of arthroscopic or surgical correlation.

5. Conclusion

MRI is the modality of choice in evaluating the causes of symptomatic patients following ACL reconstruction surgery. Findings may be related to the procedure done such as graft impingement, graft tear, tunnel cysts, screw failure or arthrofibrosis.

Other findings such as meniscal injury, articular cartilage lesions, patellar cartilage lesion and patellar tendinosis as well as sprayed patellar retinaculum were found to be the cause of the patients’ symptoms. Further studies are needed to establish the relation between these findings and the time lapse before reconstruction surgery was done especially in cases of meniscal injury.

Conflict of interest

None declare.

References


