MR imaging of anterior cruciate ligament reconstruction poor outcomes

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Abstract  Purpose: Is to study the diagnostic value of MR imaging in assessment of poor outcomes of ACL reconstruction using second look arthroscopy of the knee as a gold standard.

Patients and methods: 51 patients were included in this study who did ACL reconstruction followed by MRI and second look arthroscopy. Arthroscopy study was performed within 7–15 days from MR examination. The time interval between ACL reconstruction and MRI examination was 10 months to 9 years. MR images were evaluated for; (1) ACL graft failure assessing the primary and secondary signs, (2) Tibial and femoral tunnel location, and (3) Complication of ACL graft reconstruction. MR imaging results were compared with the arthroscopic results.

Results: Second look arthroscopy revealed 23 patients with full-thickness ACL graft tears, 17 partial-thickness ACL graft tears and 11 intact ACL grafts. Complete ACL graft discontinuity, focal ACL graft thinning and preserved 100% graft thickness were the most valuable primary MRI signs in the diagnosis of full thickness ACL graft tear, partial tear and intact graft respectively.

Conclusion: We found MR imaging to be reliable for the evaluation of ACL graft poor outcomes including graft failure and complications.

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1. Introduction

The most commonly reconstructed ligament in the knee is the ACL. Clinical evaluation of 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 (1,2). The most common indications for evaluating ACL reconstructions with MR imaging include (a) failure of ACL reconstruction to stabilize the knee, with imaging used to evaluate for tunnel placement and integrity of the graft; (b) postoperative re-injury to the knee, with imaging performed to assess ACL graft integrity and meniscal and chron-
dral status; (c) postoperative stiffness especially extension loss (flexion contracture), with imaging used to look for impingement and arthrofibrosis; and (d) preparation for revision of a failed ACL reconstruction, all of which aid the surgeon in preoperative planning (3–5).

The purpose of this study was to study the diagnostic value of MR imaging in assessment of ACL reconstruction poor outcomes comparing the results with second look arthroscopy of the knee as a gold standard.

2. Patients and methods

2.1. Patient data

We obtained approval for this project from the investigational review board at our institution. A computer search of MR imaging examinations from February, 2008 through December 2010 yielded 58 consecutive patients who underwent MR imaging of the knee after ACL reconstruction. Using arthroscopy as the gold standard, only 51 patients were included in this study who did ACL reconstruction followed by MRI and second look arthroscopy. They were 46 males and 5 females who ranged in age from 24 to 40 years with the mean age of 27 years. Arthroscopy study performed within 7–15 days from MR examination. The time interval between ACL reconstruction and MRI examination was 10 months to 9 years. Arthroscopy was completed by one of orthopedic surgeons who specialized in sports medicine. Information regarding patient history and physical examination findings (Lachman test) was reviewed from medical records.

2.2. Indications of post operative MRI examination include

- Recurrent knee pain with or without recent trauma.
- Loss of full extension of their knees or developing knee instability according to the Pivotte-shift, anterior drawer, and Lachman test which is a noninvasive clinical test of ACL integrity classified as grade I (proprioceptive appreciation of a positive test), grade II (visible anterior tibial translation), grade III (passive subluxation of the tibia with the patient supine), or grade IV (patient can actively sublaxate the proximal tibia).

MR examination was done for all patients using Magnetom symphony, syngo, 1.5 T machine.

MR imaging protocols included the following:

- T1-weighted spin-echo images in sagittal, coronal and axial planes with TR/TE 500–600/18–20 ms, Proton density-weighted fast spin-echo images with fat saturation in sagittal and coronal planes with TR/TE 1000–4500/12–17 ms. T2-weighted fast spin-echo images in sagittal planes with TR/TE 2000–4500/100–120 ms. Gradient-echo images in axial planes with flip angle 30° and TR/TE 30/15. The echo train length for fast spin-echo images was eight. The number of excitations was one to two. The slice thickness and slice gap for each imaging plane were 3- or 4-mm thick and 1-mm gap for the sagittal plane (except for gradient echo, 1.5-mm thick and 0-mm gap), 4-mm thick and 1- or 0.5-mm gap for the coronal plane, and 10-mm thick and 2-mm gap for the axial plane. Sagittal MR imaging was performed with the knee in 0–10° of external rotation to obtain images sagittal to the plane of the ACL.

Fig. 1 28 years old male with post operative knee instability. Sagittal PD FSE shows full thickness tear of the ACL graft.

Fig. 2 25 years old male with post operative knee instability. (A) Sagittal T2WIs and (B) coronal fat suppression revealed incomplete tear of ACL graft and moderate joint effusion.

Fig. 3 31 years old male with post operative knee instability. Sagittal T2WIs and coronal fat suppression revealed intact ACL graft.
MR imaging analysis for:

- MR imaging reports of all patients were reviewed by experienced musculoskeletal radiologist. Each MR imaging report was categorized as full thickness graft tear, partial thickness tear and intact graft. These reports were compared with second look arthroscopy to detect the sensitivity, specificity and accuracy of MRI in diagnosis of full thickness ACL graft tear, Partial ACL graft tear and intact graft.

- Then a retrospective review of the MR images for various primary and secondary findings relative to the ACL graft failure were assessed. The primary signs include: diffuse increased ACL graft signal intensity, graft orientation on sagittal images (either taut between femur and tibia or horizontal or lax), complete ACL graft discontinuity, the presence of any ACL graft fiber continuity, and focal graft thinning (100%, 50–99%, or <50% thickness) (5). Evaluation for secondary signs of ACL graft tear included anterior tibial translation (posterior cortex of mid lateral tibia translated >7 mm anterior to the posterior cortex of the femur on sagittal images), uncovered posterior horn of lateral meniscus (line drawn superior from posterior cortex of lateral tibia intersects the posterior horn of lateral meniscus on sagittal images), posterior cruciate ligament (PCL) hyperbuckling (posterior concavity of PCL on sagittal images), and abnormal posterior PCL line (line tangential to posterior margin of distal PCL does not intersect femur in distal 5 cm on sagittal images) (6,7).

Kappa value analysis of the retrospective MR imaging results included number and percentage of occurrence of the primary and secondary signs for each arthroscopic category (intact, partial tear, and complete tear). Retrospective MR imaging results were then compared with the arthroscopic results to determine sensitivity, specificity, positive predictive value, negative predictive value, and accuracy to determine the most valuable signs in discriminating full thickness from partial thickness tear and graft tear from intact graft.

- Location of tibial and femoral tunnels. The femoral tunnel should be placed so far posteriorly as possible without disrupting the posterior cortex of the femur. Ideally a 1–2 mm thick cortical rim should remain on coronal images, the femoral tunnel should open superiorly above the lateral femoral condyle at 10–11 o’clock position in the right knee and 1–2 o’clock position in the left knee (6).

The tibial tunnel should be oriented parallel to the projected slope of the intercondylar roof (Blumensaat line). In the sagittal plane, the opening of the proximal tibial tunnel should be posterior to the intersection of Blumensaat line and the tibia. In the coronal plane, the tibial tunnel should open at the intercondylar eminence (7,8).

ACL graft complications:

- In graft impingement, the ACL graft abuts the roof or wall of the intercondylar notch. It is associated with anterior placement of the tibial tunnel, small osteophytes or small intercondylar notch. It may cause pain or loss of extension. It appears as enlarged graft with high signal intensity on MRI (9).

- Arthrofibrosis is defined as the presence of scar tissue in at least one compartment of the knee joint, leading to decreased range of motion (10). A cyclops lesion is a nodular fibrous lesion is located in the anterior intercondylar notch; sometimes it adheres to the tibial fibers of the ACL graft. It may be taught between the femur and tibia during knee extension (11,12).

- Tunnel cystic changes. Small amount of fluid seen within the tibial and femoral tunnels (13,14).

- Screw extrusion.

- Meniscal tear and chondral lesions.

3. Results

3.1. Patient data

51 Patients were included in this study. They were 46 males and 5 females who ranged in age from 24 to 40 years with the mean age of 27 years.

- Retrospective MR imaging of the primary and secondary signs of ACL graft failure

3.2. Diffuse increase in the ACL graft signal intensity

In this retrospective study we found that diffuse increase in the signal intensity of the ACL graft had 73.9% sensitivity, 35.2% specificity, 60.7% PPV, 50% NPVA, and 57.5% accuracy in discriminating full thickness tear of ACL graft from partial tear, and had 73.9% sensitivity, 54.4% specificity, 77.2% PPV, 50% NPVA, and 67.6% accuracy in discriminating ACL graft tear from intact graft, and had 64.7% sensitivity, 45.4% specificity, 68.7% PPV, 50% NPVA, and 60.7% accuracy in discriminating partial thickness tear of ACL graft from intact graft.

We had five patients with intact ACL graft showing increased signal intensity on MRI which was done 1–2 years after the operation (Fig. 4).

3.3. ACL graft lax or horizontal orientation

In this retrospective study we found that ACL graft laxity or horizontal orientation had 47.8% sensitivity, 58.8% specificity,
Table 1  MRI results for full, partial thickness ACL graft tear and intact graft compared with arthroscopic results.

<table>
<thead>
<tr>
<th>Arthroscopic findings</th>
<th>MRI findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>True negative results</td>
</tr>
<tr>
<td>Full thickness tears of the ACL graft.</td>
<td>23</td>
</tr>
<tr>
<td>Partial thickness tears of the ACL graft.</td>
<td>17</td>
</tr>
<tr>
<td>Intact ACL graft.</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 2  Sensitivity, specificity, PPV, NPV and accuracy of MRI in the diagnosis of full thickness, partial thickness graft tear and intact graft.

<table>
<thead>
<tr>
<th>MR findings</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full thickness tears of the ACL graft (Fig. 1)</td>
<td>79.3</td>
<td>77.2</td>
<td>82.1</td>
<td>73.9</td>
<td>78.4</td>
</tr>
<tr>
<td>Partial thickness tears of the ACL graft (Fig. 2)</td>
<td>76.4</td>
<td>50</td>
<td>76.4</td>
<td>47</td>
<td>66.6</td>
</tr>
<tr>
<td>Intact ACL graft. (Fig. 3)</td>
<td>89.4</td>
<td>53.8</td>
<td>85</td>
<td>63.6</td>
<td>80.3</td>
</tr>
</tbody>
</table>

Table 3  Sensitivity, specificity, PPV, NPV and accuracy of focal thinning of ACL in the diagnosis of partial ACL graft tear.

<table>
<thead>
<tr>
<th>Diagnosis of partial tear versus full thickness tear in sagittal plane</th>
<th>Accuracy (%)</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of partial tear versus full thickness tear in coronal plane</td>
<td>65</td>
<td>71.4</td>
<td>57.8</td>
<td>65.2</td>
<td>64.7</td>
</tr>
<tr>
<td>Diagnosis of partial tear versus intact graft in sagittal plane</td>
<td>70</td>
<td>76.1</td>
<td>63.1</td>
<td>69.5</td>
<td>70.5</td>
</tr>
<tr>
<td>Diagnosis of partial tear versus intact graft in coronal plane</td>
<td>71.4</td>
<td>61.5</td>
<td>80</td>
<td>72.7</td>
<td>70.5</td>
</tr>
</tbody>
</table>

Table 4  Sensitivity, specificity, PPV, NPV and accuracy of anterior tibial translation of ACL in the diagnosis of partial ACL graft tear.

<table>
<thead>
<tr>
<th>Diagnosis of full thickness tear versus partial thickness tear</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full ACL graft tear versus intact graft</td>
<td>36.3</td>
<td>52.9</td>
<td>47</td>
<td>39.1</td>
<td>42.5</td>
</tr>
<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>41</td>
<td>83.3</td>
<td>81.8</td>
<td>43.3</td>
<td>55.8</td>
</tr>
<tr>
<td>Intact ACL graft. (Fig. 3)</td>
<td>31.2</td>
<td>50</td>
<td>45.4</td>
<td>35.2</td>
<td>39.2</td>
</tr>
</tbody>
</table>

Table 5  Sensitivity, specificity, PPV, NPV and accuracy of PCL hyperbuckling in the diagnosis of partial ACL graft tear.

<table>
<thead>
<tr>
<th>Diagnosis of full thickness tear versus partial thickness tear</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full ACL graft tear versus intact graft</td>
<td>39.1</td>
<td>53</td>
<td>53</td>
<td>39.1</td>
<td>45</td>
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<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>23.3</td>
<td>59</td>
<td>63.6</td>
<td>42.5</td>
<td>46</td>
</tr>
<tr>
<td>Intact ACL graft. (Fig. 3)</td>
<td>47</td>
<td>53</td>
<td>63.6</td>
<td>47</td>
<td>57.1</td>
</tr>
</tbody>
</table>

Table 6  Sensitivity, specificity, PPV, NPV and accuracy of Uncovered posterior horn of lateral meniscus in the diagnosis of partial ACL graft.

<table>
<thead>
<tr>
<th>Diagnosis of full thickness tear versus partial thickness tear</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full ACL graft tear versus intact graft</td>
<td>36.3</td>
<td>52.9</td>
<td>47</td>
<td>39.1</td>
<td>42.5</td>
</tr>
<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>41</td>
<td>83.3</td>
<td>81.8</td>
<td>43.3</td>
<td>55.8</td>
</tr>
<tr>
<td>Intact ACL graft. (Fig. 3)</td>
<td>31.2</td>
<td>50</td>
<td>45.4</td>
<td>35.2</td>
<td>39.2</td>
</tr>
</tbody>
</table>

Table 7  Sensitivity, specificity, PPV, NPV and accuracy of Abnormal PCL line in the diagnosis of partial ACL graft tear.

<table>
<thead>
<tr>
<th>Diagnosis of full thickness tear versus partial thickness tear</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full ACL graft tear versus intact graft</td>
<td>29.1</td>
<td>43.7</td>
<td>43.7</td>
<td>29.1</td>
<td>35</td>
</tr>
<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>22.5</td>
<td>65.1</td>
<td>63.6</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Intact ACL graft. (Fig. 3)</td>
<td>26.6%</td>
<td>42.3%</td>
<td>41.4%</td>
<td>28%</td>
<td>33%</td>
</tr>
</tbody>
</table>
64.7% PPV, 45.4% NPVA, and 61.7% accuracy in discriminating full thickness tear of ACL graft from partial tear, and had 47.8% sensitivity, 54.5% specificity, 68.7% PPV, 33.3% NPVA, and 50% accuracy in discriminating ACL graft tear from intact graft, and had 41.1% sensitivity, 54.5% specificity, 58.3% PPV, 37.5% NPVA, and 46.4% accuracy in discriminating partial thickness tear of ACL graft from intact graft.

3.4. Complete ACL graft discontinuity

3.4.1. Complete ACL graft discontinuity in sagittal plane
In this retrospective study we found that complete ACL graft discontinuity in sagittal plane had 65.2% sensitivity, 58.8% specificity, 68.1% PPV, 55.5% NPVA, and 55% accuracy in discriminating full thickness tear of ACL graft from partial tear, and had 65.2% sensitivity, 81.8% specificity, 68.1% PPV, 52.9% NPVA, and 70.5% accuracy in discriminating ACL graft tear from intact graft, and had 41.1% sensitivity, 81.8% specificity, 77.7% PPV, 47.3% NPVA, and 57.1% accuracy in discriminating partial thickness tear of ACL graft from intact graft.

3.4.2. Complete ACL graft discontinuity in coronal plane
In this retrospective study we found that complete ACL graft discontinuity in coronal plane had 73.9% sensitivity, 59.9% specificity, 68% PPV, 60% NPVA, and 65% accuracy in discriminating full thickness tear of ACL graft from partial tear, and had 73.9% sensitivity, 90.9% specificity, 94.4% PPV, 62.5% NPVA, and 79.4% accuracy in discriminating ACL graft tear from intact graft, and had 47% sensitivity, 81.8% specificity, 80% PPV, 50% NPVA, and 60.7% accuracy in discriminating partial thickness tear of ACL graft from intact graft.

3.4.3. Complete ACL graft discontinuity in sagittal and coronal planes
In this retrospective study we found that complete ACL graft discontinuity in sagittal and coronal planes had 78.2% sensitivity, 58.8% specificity, 72% PPV, 66.6% NPVA, and 70% accuracy in discriminating full thickness tear of ACL graft from partial tear, and had 78.2% sensitivity, 91% specificity, 95% PPV, 66.6% NPVA, and 82.3% accuracy in discriminating ACL graft tear from intact graft, and had 41.1% sensitivity, 81.8% specificity, 81.8% PPV, 47.3% NPVA, and 57.1% accuracy in discriminating partial thickness tear of ACL graft from intact graft.

3.5. Preserved 100% graft thickness
In this retrospective study we found that preserved 100% graft thickness in sagittal plane had 72.7% sensitivity, 92.5% specificity, 80% PPV, 92.6% NPVA, and 90.1% accuracy in discriminating intact graft from full thickness tear of ACL in sagittal plane, and had 81.8% sensitivity, 97.5% specificity, 90% PPV, 95.1% NPVA, and 94.1% accuracy in discriminating intact graft from full thickness tear of ACL in coronal plane.

3.6. Focal thinning of ACL graft with the presence of any intact fibers continuity
ACL graft discontinuity, focal thinning and presence of any intact ACL graft fibers were assessed better in coronal plane than in the sagittal plane (Figs. 5 and 6).

Retrospective MR imaging of the secondary signs
1. Anterior tibial translation (Fig. 7).
2. PCL hyperbuckling
3. Uncovered posterior horn of lateral meniscus (Fig. 7).
4. Abnormal PCL line

ACL graft complications
- Non isometric location of the femoral and tibial tunnels with anterior placement of the tibial tunnels in 8 cases (Fig. 8).
- 11 patients with ACL graft impingement, eight of them caused by abnormal anterior placement of the tibial tunnel (Fig. 8), 2 cases caused by abutting the ACL graft to the roof of intercondylar notch (Fig. 9) and one case caused by notch osteophyte (Fig. 10).
- Arthrofibrosis in 2 cases diagnosed by MRI and proved by arthroscopy and pathology (Fig. 11).
- Cyclops lesions diagnosed by MRI in 3 cases confirmed by arthroscopy and pathology (two hard and one soft nodule) (Fig. 12).
- One case with loose body in the anterior knee compartment.
- Tunnel cystic degeneration of the femoral tunnel in 4 cases and the tibial tunnel in 5 cases (Figs. 13 and 14).
- Screw extrusion in 2 cases (Fig. 15).
- Meniscal tear in 10 cases (Fig. 16) and osteochondral ulcer in 7 cases (Fig. 7)

4. Discussion
Post operative ACL graft patients complaining of knee instability and loss of extension or pain are indicated for clinical and radiological examination aiming to diagnose ACL graft failure, ACL graft complication or other internal derangement. MR imaging plays an important role in evaluating the integrity of the ACL graft, as well as in diagnosing complications associated with ACL reconstruction (15).

Retrospective analysis of the primary MR imaging signs of ACL graft tear evaluated in this study revealed that:-

Fig. 5 21 years old male with post operative knee instability. Partial thickness tears of ACL graft seen in coronal fat suppression image and falsely diagnosed as full thickness rear in sagittal image.
Regarding the primary MRI signs, complete ACL graft discontinuity, preserved 100% graft thickness, and focal thinning of ACL graft were the most valuable primary signs in diagnosis of full thickness, partial thickness ACL graft tear and intact ACL graft respectively. This was in agreement with previous study (16).

As compared with previous study (7), complete ACL graft discontinuity was the most valuable primary sign in the diagnosis of full thickness graft tear having high specificity (91%) and PPV (95%) in discriminating full thickness graft tear from intact graft. However it has low specificity (58.8%) in discriminating full thickness tear from partial thickness tear.

Preserved 100% graft thickness of ACL graft was a valuable sign in the diagnosis of intact ACL graft and discriminating it from full thickness graft tear having high specificity (sensitivity 81.8%, specificity 97.5%, PPV 90%, and NPV 95.1). This was in agreement with the previous studies (8).

Focal thinning of ACL graft with presence of any intact fibers was a more valuable sign in discriminating partial graft tear from intact graft (sensitivity 76.4%, specificity 81.8% and PPV 86.6%) than in discriminating partial ACL graft tear from full thickness graft tear (sensitivity 70.5%, specificity 59.5% and PPV 63.1%). This was in comparable with the previous studies (Table 3)(10).

ACL graft discontinuity, focal thinning and presence of any intact ACL graft fibers were better assessed in the coronal plane than in the sagittal plane.

Increased graft signal was of low specificity and relatively low sensitivity in discriminating full thickness ACL graft tear from intact graft (sensitivity 73.9%, specificity 54.4%), in discriminating full thickness tear from partial thickness ACL graft tear (sensitivity 73.9%, specificity 35.2%) or in discriminating partial graft tear from intact graft (sensitivity 64.7%, specificity 45.4%). In the current study we had four patients with intact ACL graft showing increased MRI signal intensity with MRI done 1–2 years after the operation. This was in accordance with previous study (17) who also reported that
A high signal in ACL graft due to physiological changes may even persist for more than 18 months in an intact ACL graft. This was in accordance to other studies (18). This increase in signal intensity has been attributed to normal temporal changes due to physiologic ligamentization; synovial reaction, graft edema, revascularization and cellular infiltration and has been considered an indeterminate finding in the assessment of graft integrity (19).

ACL graft laxity had low sensitivity, specificity and NPV in discriminating graft tear from intact graft. However it is an important clinical and radiological sign for patients with post operative knee instability. In the current study we had 5 cases of intact ACL graft showing laxity on MRI and were complaining of instability and they were prepared for ACL graft revision.

Retrospective analysis of the secondary signs of ACL graft tear with MR imaging in this study, showed that anterior tibial translation (Table 4) and uncovered posterior horn of lateral meniscus (Table 6) were more valuable than other secondary signs in discriminating full thickness ACL graft tear from intact graft (specificity 81.8%, PPV 83.3%), however they had low sensitivity (43.3%). These two signs also had low sensitivity and specificity in discriminating partial thickness graft tear from intact graft. This suggests that the presence of these findings is helpful in predicting graft tear. The other secondary signs (Tables 5 and 7) were of little values in diagnosis of ACL graft tear having low sensitivity and specificity.
The location of the femoral and tibial tunnels is important issues to be evaluated by MRI. In the present study we had 8 cases with abnormal anterior location of the tibial tunnel. If the tibial tunnel is too far forward it causes ACL graft impingement (9).

In the current study we had 11 patients with ACL graft impingement, 8 of them caused by abnormal anterior placement of the tibial tunnel, 2 cases caused by abutting the ACL graft to the roof of intercondylar notch and one case caused by notch osteophyte. 9 of these cases show diffuse increase in signal intensity and enlargement of the ACL graft. This was in agreement with other studies (8,9). Most cases of impingement develop because the graft contacts the intercondylar roof during knee extension. Graft impingement most commonly occurs when the tibial bone tunnel is anterior to the intersection of the slope of the intercondylar roof with the proximal tibia. With impinged grafts, the tibial tunnel is partially or completely anterior to the projected slope of the intercondylar roof (7).

In our study, 2 cases of arthrofibrosis were detected by MRI and confirmed by arthroscopy and pathology appear as synovial hyperplasia with excessive production of fibrous and inflammatory cell infiltration around the ACL graft.

3 cases of Cyclops lesions were also depicted by MR imaging anterior to the distal segment of the ACL graft above the tibial plateau resembling an eye ball at arthroscopy and appear on MRI as a focal area of low to intermediate signal intensity. This was comparable to the results of other study (20).

One case of loose body was noted by the MRI anterior to the distal ACL and could be discriminated from Cyclops lesion. MR imaging may help distinguish between loose bodies in the notch, graft impingement, and Cyclops lesion.

Cystic degeneration in 4 cases of the femoral, tunnels and 5 cases of the tibial tunnel of ACL graft were found in our study. The formation of the tunnel cysts after ACL reconstruction has been attributed to several causes. Incomplete incorporation of the allograft tissue within the bone tunnel and subsequent tissue necrosis may allow synovial fluid to be transmitted through the tunnel.

10 meniscal injuries (5 of them bucket handle) and 7 osteochondral ulcers were also noted in the current study.

In the present study, the MR sensitivity, specificity, positive predictive value, negative predictive value and accuracy for the diagnosis of complete thickness tear of ACL graft were 73.9%, 82.1%, 77.2%, 79.3% and 78.4% respectively, for partial thickness tear of ACL graft were 47%, 76.4%, 50%, 76.4% and 66.6% respectively and for intact ACL graft were 63.6%, 85%, 53.8%, 89.4% and 80.3% respectively (Table 2). MRI had low sensitivity and PPV in diagnosis of partial thickness tear. These results were comparable to those of Recht et al. (18). (See Tables 1 and 3–7).
Of the 17 partial thickness ACL graft tear in our study, eight of them were interpreted as partial thickness tear on MRI, six were falsely diagnosed on MRI as intact graft based on their morphological appearance, however they were diagnosed on arthroscopy as partial thickness tear based on their contour irregularity and laxity. The remaining three false negative cases were diagnosed on MRI as full thickness tear due to artifact from the operation masking the intact fibers.

Of the 23 full thickness ACL graft tear on arthroscopy, 17 were interpreted as full thickness tear, six as partial thickness tear on MRI. The falsely diagnosed 6 cases on MRI were explained by the presence of fibrous scar at the femoral or tibial attachment at arthroscopy and interpreted as intact fibers on MRI.

Of the 11 intact ACL graft at arthroscopy, seven were interpreted as intact graft examination, two were interpreted as full and two as partial thickness tear on MRI examination. The MRI examination of these four false negative cases was done 1 to 2 years from the operation with subsequent increased graft signal intensity interpreted as graft tear on MRI.

Limitations in this study included post-contrast Gd-DTPA for the evaluation of temporal physiological changes of the ACL graft which was not applicable in this study. Some selection bias was introduced because the orthopedic surgeons had knowledge of the original MR imaging results before arthroscopy. Several types of ACL grafts and fixations were used, their effect on ACL graft poor outcomes was not included in this study.

5. In conclusion

We found MR imaging to be reliable for the evaluation of ACL graft reconstruction poor outcomes including ACL graft failure and complications. Complete ACL graft discontinuity was the most valuable primary sign in the diagnosis of full thickness tear, discriminating full thickness tear from partial thickness tear and intact graft. Preserved 100% graft thickness was the most valuable primary sign in the diagnosis of intact ACL graft discriminating intact graft from graft tear. Focal thinning of the ACL graft and any intact fibers may help discriminating partial thickness from full thickness tear.

References