MR imaging of Anterior Cruciate Ligament reconstruction poor outcomes

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Purpose

was 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.

Methods and Materials

Patients and methods

Patient Data

51 patients were included in this study after obtaining approval from the review board at our institution. They were 46 males and 5 females who ranged in age from 24 to 40 years with mean age of 27 years. They were referred from orthopedic clinics, from February, 2008 to December 2010. Patients included in this study underwent MR examination followed by knee arthroscopy study, performed within 7 to 15 days from MR examination. The time interval between ACL reconstruction and MRI examination was 10 months to 9 years.

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 Pivote-shift, anterior drower, 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 subluxate the proximal tibia).

- Post operative instability.

- Evaluation for meniscus tear, chondral, bone and other ligament injury.

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

Arthroscopy was completed by one of orthopedic surgeon who specializes in sports medicine.

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 1000-4500/12-17ms.

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 degree 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.

MR imaging analysis for:

-Prospective 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.

-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 (the Blumensaat line). In the sagittal plane, the opening of the proximal tibial tunnel should be posterior to the intersection of the 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 interconylar 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 caught 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).

- Screws extrusion.

- Miniscal tear and chondral lesions.

- Retrospective review of the MR images for various primary and secondary findings relative to the ACL graft were then assessed for diagnosis of graft failure. 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)(15). 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). (16, 17)

Retrospective MR imaging results were then compared with arthroscopic results to determine the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of the primary and secondary signs in discriminating full thickness from partial thickness tear and graft tear from intact graft

**Results**

*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 mean age of 27 years. Prospective MR imaging results:
Full thickness tears of the ACL graft.

Partial thickness tears of the ACL graft.

Intact ACL graft.

-Table 1. MRI results for full, partial thickness ACL graft tear and intact graft compared with arthroscopic results.

Of the 23 full thickness graft tear at arthroscopy, 17 were interpreted as full thickness tear, 6 as partial thickness tear graft on MRI imaging. Of the 17 partial thickness tear at arthroscopy, 8 were interpreted as partial thickness tear, 6 were interpreted as intact and 3 interpreted as full thickness tear on MR imaging. Of the 11 intact graft at arthroscopy, 7 were interpreted as intact graft, two were interpreted as full thickness tear and two as partial thickness graft tear on MR imaging.

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

-Table 2 revealed that the MRI had low sensitivity and PPV in diagnosis of partial thickness graft tear.

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

A-The primary signs

1- Diffuse increase in the ACL graft signal intensity
We have 5 patients with intact ACL graft showed increased signal intensity on MRI done 1 to 2 years after the operation (fig.4).

2-ACL graft lax or horizontal orientation

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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</thead>
<tbody>
<tr>
<td>Diagnosis of full thickness tear versus partial thickness tear</td>
<td>47.8%</td>
<td>58.8%</td>
<td>64.7%</td>
<td>45.4%</td>
<td>61.7%</td>
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<tr>
<td>Diagnosis of full thickness ACL graft tear versus intact graft</td>
<td>47.8%</td>
<td>54.5%</td>
<td>68.7%</td>
<td>33.3%</td>
<td>50%</td>
</tr>
<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>41.1%</td>
<td>54.5%</td>
<td>58.3%</td>
<td>37.5%</td>
<td>46.4%</td>
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</table>

3-Complete ACL graft discontinuity

a- Complete ACL graft discontinuity in sagittal plane
<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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<tr>
<td>full thickness tear versus partial thickness tear</td>
<td>65.2%</td>
<td>58.8%</td>
<td>68.1%</td>
<td>55.5%</td>
<td>55%</td>
</tr>
<tr>
<td>full ACL graft tear versus intact graft</td>
<td>65.2%</td>
<td>81.8%</td>
<td>88.2%</td>
<td>52.9%</td>
<td>70.5%</td>
</tr>
<tr>
<td>partial ACL graft tear versus intact graft</td>
<td>41.1%</td>
<td>81.8%</td>
<td>77.7%</td>
<td>47.3%</td>
<td>57.1%</td>
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</tbody>
</table>

b- Complete ACL graft discontinuity in coronal plane

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>full thickness tear versus partial thickness tear</td>
<td>73.9%</td>
<td>59.9%</td>
<td>68%</td>
<td>60%</td>
<td>65%</td>
</tr>
<tr>
<td>full ACL graft tear versus intact graft</td>
<td>73.9%</td>
<td>90.9%</td>
<td>94.4%</td>
<td>62.5%</td>
<td>79.4%</td>
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<tr>
<td>partial ACL graft tear versus intact graft</td>
<td>47%</td>
<td>81.8%</td>
<td>80%</td>
<td>50%</td>
<td>60.7%</td>
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</table>

c- Complete ACL graft discontinuity in sagittal and coronal plane

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>full thickness tear versus</td>
<td>78.2%</td>
<td>58.8%</td>
<td>72%</td>
<td>66.6%</td>
<td>70%</td>
</tr>
</tbody>
</table>
partial thickness tear

Diagnosis of full ACL graft tear versus intact graft

78.2% 91% 95% 66.6% 82.3%

Diagnosis of partial ACL graft tear versus intact graft

41.1% 81.8% 77.7% 47.3% 57.1%

4-Preserved 100% graft thickness

<table>
<thead>
<tr>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of intact versus graft tear in sagittal plane</td>
<td>72.7%</td>
<td>92.5%</td>
<td>80%</td>
<td>92.6%</td>
</tr>
<tr>
<td>Diagnosis of intact versus graft tear in coronal plane</td>
<td>81.8%</td>
<td>97.5%</td>
<td>90%</td>
<td>95.1%</td>
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</table>

5-Focal thinning of ACL graft with presence of any intact fibers continuity.

<table>
<thead>
<tr>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>Diagnosis of partial tear versus full thickness tear in sagittal plane</td>
<td>64.7%</td>
<td>65.2%</td>
<td>57.8%</td>
<td>71.4%</td>
</tr>
<tr>
<td>Diagnosis of partial tear versus full thickness tear in coronal plane</td>
<td>70.5%</td>
<td>69.5%</td>
<td>63.1%</td>
<td>76.1%</td>
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</table>
Diagnosis of partial tear versus intact graft in coronal plane

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>Diagnosis of</td>
<td>70.5%</td>
<td>72.7%</td>
<td>80%</td>
<td>61.5%</td>
<td>71.4%</td>
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<tr>
<td>full thickness</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>tear versus</td>
<td>76.4%</td>
<td>81.8%</td>
<td>86.6%</td>
<td>69.2%</td>
<td>78.5%</td>
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</tbody>
</table>
| partial thickness tear versus intact graft in coronal plane

ACL graft discontinuity, focal thinning and presence of any intact ACL graft fibers were assessed better in coronal plane than in sagittal plane (fig. 5,6).

Retrospective MR imaging of the secondary signs

1-Anterior tibial translation (fig. 7).

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of</td>
<td>39.1%</td>
<td>47%</td>
<td>52.9%</td>
<td>36.3%</td>
<td>42.5%</td>
</tr>
</tbody>
</table>
| full thickness tear versus partial thickness tear
| Diagnosis of   | 43.3%       | 81.8%       | 83.3%| 41%  | 55.8%    |
| full ACL graft tear versus intact graft
| Diagnosis of   | 35.2%       | 45.4%       | 50%  | 31.2%| 39.2%    |
| partial ACL graft tear versus intact graft

2-PCL hyperbuckling

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<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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</thead>
</table>
Diagnosis of full thickness tear versus partial thickness tear

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full thickness tear versus partial thickness tear</td>
<td>39.1%</td>
<td>53%</td>
<td>53%</td>
<td>39.1%</td>
<td>45%</td>
</tr>
<tr>
<td>Diagnosis of full ACL graft tear versus intact graft</td>
<td>42.5%</td>
<td>63.6%</td>
<td>59%</td>
<td>23.3%</td>
<td>46%</td>
</tr>
<tr>
<td>Diagnosis of partial ACL graft tear versus intact graft</td>
<td>47%</td>
<td>63.6%</td>
<td>53%</td>
<td>47%</td>
<td>57.1%</td>
</tr>
</tbody>
</table>

3-Uncovered posterior horn of lateral meniscus (fig. 7).

4-Abnormal PCL line

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of full thickness tear versus partial</td>
<td>29.1%</td>
<td>43.7%</td>
<td>43.7%</td>
<td>29.1%</td>
<td>35%</td>
</tr>
</tbody>
</table>
thickness
tear

| Diagnosis of full ACL graft tear versus intact graft |
|---------------------------------|---------|---------|---------|---------|
| 40%                             | 63.6%   | 65.1%   | 22.5%   | 45%     |

| Diagnosis of partial ACL graft tear versus intact graft |
|---------------------------------|---------|---------|---------|---------|
| 28%                             | 41.4%   | 42.3%   | 26.6%   | 33%     |

**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, 8 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 (fig. 13, 14, 15).

- Screw extrusion in 2 cases (fig. 16).

- Miniscal tear in 10 cases (figure 17) and osteochondral ulcer in 7 cases (figure 7)

**Conclusion**

**Discussion**

Post operative ACL graft patients complaining of knee instability, 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 (1-2).

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

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 retrospectively. This was in agreement with Nakayama Y et al (19).

Complete ACL graft discontinuity was the most valuable primary sign in 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 diagnosis of intact ACL graft and discriminating it from full thickness tear (sensitivity 81.8%, specificity 97.5%, PPV 90%, and NPV 95.1). 

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 tear (sensitivity 70.5%, specificity 59.5% and PPV 63.1%).

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

Increased graft signal was of low specificity and relatively low sensitivity in discriminating full thickness ACL graft tear from intact tear (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 have 4 patients with intact ACL graft showed increased MRI signal intensity with MRI done 1 to 2 years after the operation. This was in accordance with Kimbberlee et al (14) who also reported that 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 (19). 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 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 and uncovered posterior horn of lateral meniscus 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 full thickness graft tear from partial tear and in discriminating partial thickness tear from intact graft. This suggests that the presence of these findings is helpful in predicting graft tear.

The other secondary signs 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 have 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 have 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 Tmoczak et al (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 resembles eye ball at arthroscopy and appear on MRI as focal area of low to intermediate signal intensity. This was comparable to the results of Recht et al (15).

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

In the present study, the prospective MR sensitivity, specificity, positive predictive value, negative predictive value and accuracy for 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).

Of the 17 partial thickness ACL graft tear in our study, 8 were interpreted as partial thickness tear on MRI, 6 were falsely diagnosed on MRI as intact graft based on their morphological appearance, however they diagnosed on arthroscopy as partial thickness tear based on their contour irregularity and laxity. The remaining 3 false negative cases were diagnosed on MRI as full thickness tear due artifact from the operation masking the intact fibres.

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

Of the 11 intact ACL graft at arthroscopy, 7 were interpreted as intact graft, 2 were interpreted as full and 2 as partial thickness tear on MRI. The MRI examination of these 4 false negative cases were done 1 to 2 years from the operation with subsequent increased graft signal intensity interpreted as graft tear on MRI.

From the previous we can conclude that the most valuable indications for second operation for ACL graft patients are:

1- ACL graft failure. Clinically it is diagnosed by positive anterior drawer, pivote shift and Lachman test. On MRI graft failure is diagnosed by full thickness ACL graft tear (complete graft discontinuity and absence of any intact fibres), ACL graft laxity, non isometric and cystic changes of the femoral and tibial tunnels. Partial thickness ACL graft tear with no knee instability does not indicate graft revision

2- Postoperative complication including arthrofibrosis, Cyclops lesion, and meniscal tear.

Limitations in this study included post-contrast Gd-DTPA for evaluation of temporal physiological changes of the ACL graft 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 grafts poor outcomes were not included in this study.

In conclusion, we found MR imaging to be reliable for evaluation of ACL graft reconstruction poor outcomes including ACL graft failure and complications. Complete ACL graft discontinuity was the most valuable primary sign in 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 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.

Images for this section:
Fig. 3
Fig. 5
References


Personal Information