Agreement between Arthroscopy and MRI regarding Graft finding
Postoperative ACL Reconstruction

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ABSTRACT

Background: In sports, the knee is the second most commonly (17%) injured body part after the ankle (26%). An ACL rupture is the most commonly (20%) diagnosed internal derangement of the knee in sports injuries. MR imaging is over 90% accurate for diagnosing complete anterior cruciate ligament tears.

Aim of the study: To evaluate the use of MRI for accurate evaluation of reconstructed and repaired cruciate ligaments as compared to the conventional radiological study.

Subject and Methods: This study included 27 symptomatic patients; 23 males and 4 females with an age ranging from 20 to 43 years (mean age of about 27). This study was carried out at the Radiology department at Zagazig University hospitals. They were assessed by conventional MRI after the ACL operations.

Results: The mean duration since ACL reconstruction operation is 1.5 ± 0.49 years, with a range from 6 months to 2.5 years. The most considerable ACL finding using MRI was intact graft in 48.1%, graft laxity and complete graft tear were found among (11.1% and 37%) of cases respectively. There was no significant difference between MRI and arthroscopy where ACL graft finding among the studied patients by both MRI and arthroscopy both tests agreed that 56.3% of the studied patients had graft tear, 31.3% had intact graft, degree of agreement in diagnosis of graft tear between both MRI and arthroscopy is good (kappa= 0.62, p-value=0.012*). MRI had good diagnostic potentials compared to arthroscopy where sensitivity of MRI in diagnosis of graft findings was 83.3% and specificity was 90%, overall curacy of MRI compared to arthroscopy was 87.5%.

Conclusions: The use of MRI helped for accurate evaluation of reconstructed and repaired cruciate ligaments as compared to the conventional radiological study. MR imaging is the modality of choice for evaluation of failed anterior cruciate ligament graft reconstruction surgery.

Keywords: ACL Reconstruction, Conventional MRI.

I. INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction is one of the most popular orthopaedic operations performed worldwide (1).

The ACL is a band of dense connective tissue that courses from the femur to the tibia in the knee joint. The femoral attachment of the ACL is at the posterior aspect of the medial surface of the lateral femoral condyle. From there, the ACL runs anteriorly, medially, and distally to the tibia. (2).

The typical mechanism of ACL rupture is a sudden change in direction on the weight-bearing knee that results in twisting or a valgus strain of the knee. The ACL ruptures at approximately
2000 N load and at 20% elongation (3).

MR imaging is over 90% accurate for diagnosing complete anterior cruciate ligament tears. Several primary and secondary signs are described for diagnosing anterior cruciate ligament tears. The primary signs include morphologic or signal intensity findings. Morphologic criteria include an absent or discontinuous anterior cruciate ligament, which may be fragmented and show an abnormal angulation.

Anterior cruciate ligament remote tears may be retracted or fibrosed to the posterior cruciate ligament but usually show an abnormal angulation with respect to Blumensaat’s line (4).

Roof impingement often is secondary to an abnormal position of the tibial tunnel anterior to the intersection of the Blumensaat line and the tibia when the knee is fully extended. At MR imaging, the impinged graft is in contact with the anteroinferior margin of the intercondylar roof and may appear posteriorly bowed. Signal intensity alteration selectively involves the anterior two-thirds of the graft. (5).

Findings of ACL graft disruption on T2-weighted MR images include absence of intact graft fibers and increased signal intensity similar to that of fluid within the expected region of the graft (6).

Partial tears of the graft appear as areas of increased signal intensity affecting a portion of the graft with some intact fibers still present (4). Recognition of the normal postoperative MR imaging appearance of postoperative ACL graft and of abnormalities is essential to accurate MR imaging evaluation of those patients (6).

We aimed in this study to evaluate the use of MRI for accurate evaluation of reconstructed and repaired cruciate ligaments as compared to the conventional radiological study.

II-STUDY DESIGN AND PARTICIPANTS

This was a comparative longitudinal observational study was conducted on 27 adult patients. This study was carried out in the radiology department, faculty of medicine, Zagazig university Hospitals, after obtaining institutional review board approval and informed consent from patients or relatives before study, including 27 patients.

Inclusion criteria:
Patient who underwent anterior cruciate ligament reconstruction more than six months at time of examination.

Exclusion criteria:
Patient with contraindication for MRI examination:
1) Patients with implanted pacemaker and other cardiological devices incompatible with MRI.
2) Patient with ocular implants.
3) Patient with aneurysmal clips.
4) Arthritis.

All patients meeting the inclusion criteria were subjected to:

Demographic Data including Patient name, age, sex, occupation.

Clinical examination:
Patient were assessed by the outpatient physician then redirected to the radiology unit.
Magnetic resonance imaging:
The target knee was imaged using 1.5 T. scanner (Achieva, PHILIPS Medical Systems) using the following sequences: Axial PD FAT SAT, coronal T2 weighted image, coronal PD FAT SAT, sagittal T2-weighted image and PD and sagittal T1-weighted image. A cylindrical phased-array extremity coil was used. The total time of examination is around 15 min.

**Table (1):** Different parameters of pulse sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>tr</th>
<th>te</th>
<th>Echo train length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Axial T1 localizer</td>
<td>400</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>2-Axial T1</td>
<td>600-700</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>3-Coronal fat saturated PD</td>
<td>1800-2000</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>4-Sagittal PD</td>
<td>2000-2200</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>5-Sagittal T2</td>
<td>4000</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>

The scanning time for each sequence was between 2 and 3.5 minutes.

**Table (2):** Scanning parameters:

<table>
<thead>
<tr>
<th>Region of interest</th>
<th>Target knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>256 × 192</td>
</tr>
<tr>
<td>FOV</td>
<td>14 cm</td>
</tr>
<tr>
<td>Collimation</td>
<td></td>
</tr>
<tr>
<td>Slice thickness</td>
<td>3 mm</td>
</tr>
<tr>
<td>Inter slice gap</td>
<td>1.5 mm (50% overlap)</td>
</tr>
</tbody>
</table>

**Patient Preparation**
Good explanation of the procedure, asking for any implanted medical devices, asking about pregnancy. The MRI machine is a tight, enclosed space. If the patient was claustrophobic, He was given the option to take a sedative or withdraw from the test.

Removal of any non-fixed metal prosthesis, that might interfere with the scanning the region of interest.

Asking the patient to be calm, take quiet breathing and instruct him/her not to move during the procedure.

**Patient Position**
Supine position, headfirst towards the gantry.

**Scanning Instructions**
Table position
Setting the table height so that the area to be scanned (target knee joint) is centered in the scan field.

No change of table position between images so that all images create one unified volume.

Image acquisition
Examination and interpretation of the images was done under the guidance of qualified musculoskeletal radiologists on a workstation) PHILIPS Intelli Space Portal) and the picture archiving and communication system (PACS).
Arthroscopy was done by 16 cases and result were calculated in comparison to MRI.

**Statistical Analysis:**
The acquired data were processed on a computer using the Statistical Package for Social Services version 24 (SPSS), and the results were displayed in tables and graphs. Continuous quantitative data, such as age, were expressed as the mean, standard deviation, and median (range), whereas categorical qualitative variables were expressed as absolute frequencies (number) and relative frequencies (percentage).

The results were considered statistically significant when the significant probability was less than 0.05 (P < 0.05). P-value < 0.001 was considered highly statistically significant (HS), and P-value ≥ 0.05 was considered statistically insignificant (NS).

**III. RESULTS**
The mean age of the studied patients is 29.26 ± 7.79 years old, with a range from 20 to 43 years old, most of the studied patients are male (85.2 %) (Figure 1).

The mean duration since ACL reconstruction operation is 1.11 ± 0.49 years, with a range from 2 months to 2.5 years. (Table 3).

The most considerable ACL finding using MRI was intact graft in 48.1%, graft laxity and complete graft tear were found among (11.1% and 37 %) of cases respectively (Table 4).

There was no significant difference between MRI and arthroscopy where ACL graft finding among the studied patients by both MRI and arthroscopy both tests agreed that 56.3 % of the studied patients had graft tear, 31.3% had intact graft, degree of agreement in diagnosis of graft tear between both MRI and arthroscopy is good (kappa= 0.62, p-value=0.012*).there was no significant difference between MRI and arthroscopy where ACL graft finding among the studied patients by both MRI and arthroscopy both tests agreed that 56.3 % of the studied patients had graft tear, 31.3% had intact graft, degree of agreement in diagnosis of graft tear between both MRI and arthroscopy is good (kappa= 0.62, p-value=0.012*) (Table 5).

MRI had good diagnostic potentials compared to arthroscopy where sensitivity of MRI in diagnosis of graft findings was 83.3% and specificity was 90%, overall curacy of MRI compared to arthroscopy was 87.5%. (Table 6).

Fig. (1): Pie diagram showing sex distribution among the studied patients (N=27).
Table 3: ACL graft age of the studied patients:

<table>
<thead>
<tr>
<th>Graft age</th>
<th>Studied patients (N=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>1.5 ± 0.49</td>
</tr>
<tr>
<td>Median (Range)</td>
<td>(6 months -2.5 years)</td>
</tr>
</tbody>
</table>

Table 4: ACL graft finding using MRI among the studied group:

<p>| Item                    | Studied group (N=27) |</p>
<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact graft</td>
<td>13</td>
<td>48.1%</td>
</tr>
<tr>
<td>Laxity of the graft</td>
<td>3</td>
<td>11.1%</td>
</tr>
<tr>
<td>Complete Graft tear</td>
<td>10</td>
<td>37.0%</td>
</tr>
<tr>
<td>Partial graft tear</td>
<td>1</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Table 5: Agreement between Arthroscopy and MRI regarding graft finding among the studied cases (N=16):

<table>
<thead>
<tr>
<th>MRI No.</th>
<th>intact graft (N=6)</th>
<th>Arthroscopy</th>
<th>p-value of McNemar test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intact graft</td>
<td>Graft tear</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(31.3%)</td>
<td>(6.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Graft tear</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.3%)</td>
<td>(56.3%)</td>
</tr>
</tbody>
</table>

Cohen's kappa coefficient (κ) = measure of agreement

Table 6: Accuracy of MRI in comparison with arthroscopy in post-operative ACL graft complications (N=16):

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PVP</th>
<th>PVN</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.3%</td>
<td>90%</td>
<td>83.3%</td>
<td>90%</td>
<td>87.5%</td>
</tr>
</tbody>
</table>
IV.DISCUSSION

Magnetic Resonance Imaging has gained in popularity as a diagnostic tool of the musculoskeletal disorders especially the knee joint which is the most frequent examined joint with MRI. It offers excellent soft tissue contrast and multiplanar capabilities; MRI enables physicians to radiologically examine muscle, ligament, tendon, cartilage, and bone in a highly detailed manner (7).

Graft failure is defined as pathologic laxity of the reconstructed ACL. The prevalence of recurrent instability after primary ACL reconstruction ranges from 1% to 8% (8). MRI is the preferred advanced imaging modality for the evaluation of symptomatic ACL graft reconstructions.

Other Egyptian studies as those done by Farahat et al., in (9) over 26 and the sex distribution was 7.7% female and 92.3 % male, our study is different from Collins et al., but is relevant to Egyptian studies by Farahat et al.,

**Fig. (2):** MRI images: Sagittal T2 PD (A) & Coronal Stir (B) & Axial T2 (C): Interruption of the normal fascicular arrangement of the ACL graft complete tear. Diagnosis was Complete graft tear.

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and this could be attributed to lesser number of patients in our study and different level of activity and contact sports fractional in our locality compared by western countries.

The age distribution encountered by Collins & Colleagues in 2013 the average age was 47.1 (29 in our study). In our study mean age at diagnosis being 29 years old (Range: 20 – 43 years), which was in concordance with Farahat and colleagues where mean age was 32 years which could be explained by the higher level of activity among western population above 40 years and their higher life expectancy compared to our locality.

The period elapsed between the reconstruction & MRI study in the paper published by Kamel And Darwish (12) in 2014 over 32 patients was less than 1 year in 40.6% and more than 1 year in 59.4% .In our study range be was (2 month – 2.5 years) with the average being 1 year.

Thomas et al. (13) in 2001 studied 68 patients with bone-patellar tendon– bone graft 2, 12, 52, 76, and 104 weeks postoperatively and found that the signal intensity of the graft was low in the first week and at 2-week follow-up in all ACL grafts. The signal intensity and the degree of enhancement of the graft increased after 12 weeks post-surgery. At the 1-year postoperative MRI study all grafts exhibited high signal intensity and enhancement so that it was impossible to determine whether the grafts were intact or not. At 76 and 104 weeks, the authors noticed a significant and progressive decrease in signal intensity and contrast enhancement of the graft (13).

Bellelli et al. (14) in 1999 summarized the ACL signal intensity changes to be during the first 1-3 months the graft signal is low due to peri-ligamentous proliferation, at 3-9 months the Graft signal becomes progressively hyper intense due to intraligamentous proliferation while after 12 months complete ligamentization occurs due to Definitive healing with incorporation (14).

Kamel and Darwish (12) in 2014 showed diffuse increased signal in the region of the ACL graft on the proton density–weighted images was found in 45% of the full-thickness tears, 55% of partial-thickness tears, and 10% of intact grafts. In our study the graft signal intensity findings were as follows: The graft signal intensity findings were as follows: Low signal (normal) in 20 patients (45.5 %), intermediate with partial tear in 10 patients (22.8 %), immature graft in 6 patients (13.7 %), Full thickness tear (mixed low and intermediate signals) in 2 patients (4.6 %) and Complete tear in 6 patients (15.6 %).

Galal et al. (10) showed that all 48 patients in his study had a graft tear on MRI scans showed positive tests of torn ACL on clinical examination (anterior drawer, Lachman test, and pivot shift test). Of those patients, 20 (41.66%) had partial tear, 6 (12.5%) had near total tear and 8 (16.66%) had complete tear of the ACL graft. New injury was experienced in most cases, as 26/48 patients (76.47%) had a history of major twisting trauma after reconstruction. 3/48 patients (8.82%) had history of early aggressive rehabilitation. Other 3/48 patients (8.82%) had history of minor trauma, while the remaining 2/48 patients (5.88%) had residual instability after the reconstruction.

In our study the most considerable ACL finding using MRI was intact graft either alone in 18.5% or accompanied with normal SI in 22.2%, also abnormal high SI was found in 22.2% of cases, Graft impingement, graft failure and graft tear were found among (11.1%, 11.1% and 7.4%) of cases respectively . 14.8% of the studied patients have joint effusion, PCL buckling and bone marrow edema were found in (7.4%) of the studied patients.

According to vanderlist et al., (11) post-operative MRI following arthroscopic primary ACL repair can be used to assess re-rupture of the repaired ligament with excellent sensitivity (75%), specificity (90%) and accuracy (86%), in our study ACL graft finding among the studied patients by both MRI and arthroscopy both tests agreed that 43.8 % of the studied patients had graft tear, 37.5% had intact graft, degree of agreement in diagnosis of graft tear between both MRI and arthroscopy is good (kappa= 0.62, p-value=0.012*).

V.CONCLUSION

The use of MRI helped for accurate evaluation of reconstructed and repaired cruciate ligaments as compared to the conventional radiological study. MRI is ideally suited for the evaluation of pain or instability in the post-operative anterior cruciate ligament patient. Graft integrity can be determined, and clinically challenging diagnoses such as graft tear or hardware failure are readily diagnosed with MRI. With the increasing prevalence of arthroscopic repair of the anterior cruciate ligament, the importance of MRI in the evaluation of this patient population will only increase. We conclude MR imaging is the modality of choice for evaluation of failed anterior cruciate ligament graft reconstruction surgery.

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