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A Cross-Sectional Comparative Study of Knee Joint Mri in a Clinically Suspected Anterior Cruciate Ligament Injuries with Arthroscopy Findings in a Tertiary Care Centre in Chengalpet District

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KEYWORDS
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ABSTRACT:

Background: Introduction: This study aimed to compare MRI grading and arthroscopy findings for ACL injury in patients with clinically suspected anterior cruciate ligament (ACL) injury of the knee and to investigate associated injuries.

Aim: To evaluate and correlate MRI findings with arthroscopy in patients with suspected ACL injuries.

Objectives: Primary: Compare MRI grading and arthroscopy findings of ACL injury.
Secondary: Assess associated injuries in patients with ACL injury.

Materials and Methods: In this cross-sectional study, 110 patients with suspected ACL tears were examined. Informed consent was obtained, and detailed histories were recorded. MRI was performed using a Philips MRI Achieva 1.5 Tesla machine, and results were compared with arthroscopy findings.

Results: The study predominantly involved males aged 20-40 years. Of 61 ACL tears confirmed by arthroscopy, 59 were also identified as complete tears by MRI. MRI demonstrated a sensitivity of 97.2%, specificity of 84.2%, PPV of 92.1%, and NPV of 94.1% for ACL tears, and a sensitivity of 96.7%, specificity of 95.9%, PPV of 96.7%, and NPV of 95.9% for complete ACL tears.

Conclusion: MRI provides diagnostic accuracy comparable to arthroscopy for ACL tears and is a valuable non-invasive imaging technique for assessing knee ligaments and associated soft tissue injuries.

INTRODUCTION

The anterior cruciate ligament (ACL) stabilizes the knee joint, composed of an anteromedial bundle (tightest in flexion, controlling anterior tibial translation) and a posterolateral bundle (tightest in extension, responsible for rotational stability)[1]. ACL tears, often non-contact pivoting injuries, are prevalent among athletes, especially football players[2].

Knee arthroscopy, a common orthopedic procedure, provides excellent visualization for diagnosing intra-articular abnormalities. However, MRI has emerged as a primary diagnostic tool due to its superior image quality, accuracy, cost-effectiveness, and non-invasiveness, even though arthroscopy remains the gold standard[3]. MRI is routinely used to assess meniscal and ligament injuries and other knee joint abnormalities[4].

Imaging the ACL can be challenging due to its oblique orientation. Specific MRI techniques can provide detailed visualization, accurately determining ACL conditions[5]. MRI characterizes ACL tear morphology and signal intensity changes, identifying signs of ligament rupture such as ACL discontinuity and misalignment with Blumensaat's line[6]. Additional indicators of ACL tears include fascicle disruption, bone contusions, and positive posterior femoral line signs[7].

This study aims to assess the sensitivity and specificity of MRI in diagnosing ACL injuries, correlating findings with arthroscopic results.

METHODOLOGY

1. **Study Subjects**: Patients with suspected anterior cruciate ligament (ACL) injuries referred to the Department of Radiodiagnosis at

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Shri Sathya Sai Medical College & Research Institute.

2. **Type of Study**: Comparative Cross-Sectional Study.
3. **Place of Study**: Department of Radiodiagnosis, Shri Sathya Sai Medical College & Research Institute, Ammapettai.
4. **Study Population**: Patients referred for MRI due to suspected ACL injuries.
5. **Study Group**: Patients with clinically suspected ACL injuries.
6. **Sample Size**:

$$n = \frac{4pq}{L^2}$$

Where $p = 52.7\%$, $q = 100 - 52.7 = 47.3$, and $L = 10\%$.

$$n = \frac{4 \times 52.7 \times 47.3}{100} = 99.71 \text{ (rounded to 110 to account for non-response)}$$

7. **Inclusion Criteria**:
    - Patients with clinically suspected ACL injuries undergoing MRI and arthroscopy.
8. **Exclusion Criteria**:
    - Contraindications to MRI (ferromagnetic implants, pacemakers).
    - Active infections in or around the knee joint.
    - Previous knee arthroscopy.
    - Knee joint neoplasms.
9. **Duration of Study**: 18 months.
10. **Data Collection Method**:
    - Written informed consent obtained from all patients.
    - Detailed history and associated symptoms recorded.
    - MRI performed using a Philips Achieva 1.5 Tesla MRI machine, with patients positioned supine, knee extended, and externally rotated by 5-10 degrees.

MR Technique Used:

- Scout axial view obtained to plan sagittal and coronal sections.
- Routine MRI sequences included PD FS axial, coronal & sagittal, T1W coronal, T2W coronal & sagittal, STIR coronal, and gradient axial sequences.
- Oblique sagittal sections performed as needed based on coronal images.

Statistical Analysis:

- Data analyzed using SPSS 22.
- Continuous variables expressed as mean ± standard deviation; categorical variables as proportions.
- Chi-square test for comparing proportions; unpaired t-test for comparing means.
- Sensitivity calculated using the standard formula for diagnostic tests.

RESULTS:

In this study, most participants were aged 21-30 years (38.1%), with 68.2% being male. Right-sided injuries were more common (54.5%) compared to left-sided (45.5%). MRI revealed 55.5% complete ACL tears and 13.6% partial tears, while arthroscopy confirmed 55.5% complete and 10% partial tears. The most prevalentprimary sign on MRI was increased signal intensity (93.06%), followed by abnormal axis (73.61%) and discontinuity (48.61%). Secondary signs included anterior tibial translation (68.06%) and bone contusion (61.11%). Lateral meniscus injuries were the most frequent associated injury (54.15%), with the majority of ACL tears occurring in the mid-substance (90.2%). MRI showed high sensitivity for detecting ACL tears, with 96.7% for complete and 97.2% for partial tears. Specificity was 95.9% for complete and 84.2% for partial tears, with strong agreement between MRI and arthroscopy findings.

Table 1: Age Distribution

Age Group	N	%
<20 years	19	17.3
21-30 years	42	38.1
31-40 years	16	14.5
41-50 years	23	20.9
51-60 years	8	7.2
>65 years	2	1.8

Majority were aged 21-30 years (38.1%).

Table 2: Gender Distribution

Gender	N	%
Male	75	68.2
Female	35	31.8

68.2% of participants were male.

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Table 3: Side of Injury

Side	N	%
Right	60	54.5
Left	50	45.5

54.5% of injuries were on the right side.

Table 4: MRI Findings

MRI Diagnosis	N	%
No tear	34	30.9
Partial tear	15	13.6
Complete tear	61	55.5

13.6% had partial tears and 55.5% had complete tears.

Table 5: Arthroscopy Findings

Arthroscopy Diagnosis	N	%
No tear	38	34.5
Partial tear	11	10.0
Complete tear	61	55.5

10% had partial tears and 55.5% had complete tears.

Table 6: Primary Signs of ACL Tear

Primary Sign	N	%
Increased signal	67	93.06
Abnormal axis	53	73.61
Discontinuity	35	48.61
Non-visualization	4	5.56

Increased signal was the most common primary sign (93.06%).

Table 7: Secondary Signs of ACL Tear

Secondary Sign	N	%
Anterior tibial translation	49	68.06
Bone contusion	44	61.11
Uncovered posterior horn of lateral meniscus	39	54.17

Anterior tibial translation (68.06%) and bone contusion (61.11%) were the most frequent secondary signs.

Table 8: Associated Injuries

Associated Injury	N	%
Lateral meniscus	39	54.15
Medial meniscus	14	19.47
Medial collateral ligament	10	13.9

54.1% had lateral meniscus injury.

Table 9: Site of ACL Tear

Site of Tear	N	%
Femoral attachment	5	6.9
Mid substance	65	90.2
Tibial attachment	2	1.1

Most tears were in the mid-substance (90.2%).

Table 10: Sensitivity Analysis

MRI Findings	Sensitivity	Specificity	PPV	NPV
Complete ACL Tear	96.7%	95.9%	96.7%	95.9%
Partial ACL Tear	97.2%	84.2%	92.1%	94.1%

Sensitivity, specificity, PPV, and NPV values for MRI findings in detecting ACL tears are provided.

IMAGE GALLERY:

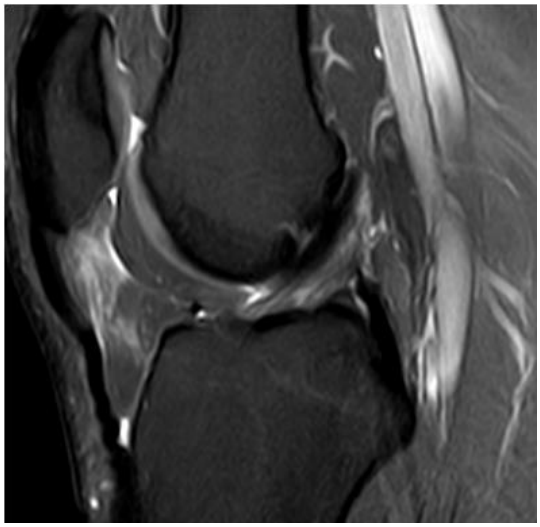

FIGURE 1: T2/PD intermediate signal intensity is noted involving the posterolateral fibres of ACL with loss of <25% fibers seen towards the tibial insertion site–S/o low grade partial tear of anterior cruciate ligament.

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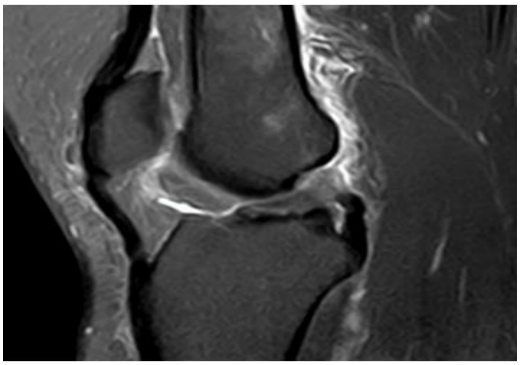

FIGURE 2: Disruption of fibers and intrasubstance PD/T2 high signal intensity involving the anteromedial bundle of ACL towards the tibial attachment site - s/o High grade partial tear

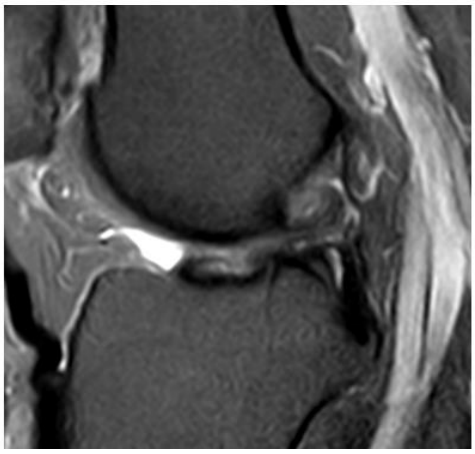

FIGURE 3: Complete ACL tear at femoral attachment and mid portion with laxity of remaining portion of ACL

FIGURE 4: Complete ACL tear in arthroscopy

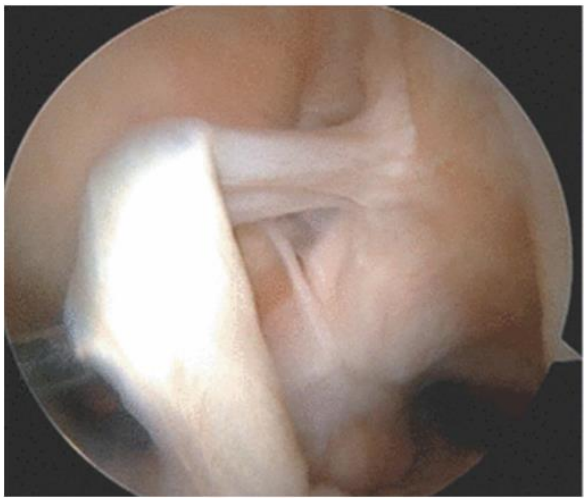

FIGURE 5: Partial ACL tear in arthroscopy

DISCUSSION

In our study, 110 patients with a history of knee trauma and pain were referred from the Department of Orthopaedics for MRI knee joint study to assess the tear of ACL and related ACL injuries. Of the 110 patients, 35 (31.8%) were female and 75 (68.2%) were male. The preponderance of men may be due to increased outdoor activities, participation in sports, and usage of cars. This study found twice as many male knee injury patients with damaged ACL. The age range of these patients was 14 to 64 years old. Of the 110 patients, 58 (52.60%) belonged to the 20–40 age group. Of the 110 knees examined, 50 (45.5%) were on the left side and 60 (54.5%) on the right. Patients with a right knee injury and a left knee injury with ACL tear are comparable in our study.

ACL tears were clinically diagnosed in 110 individuals. Lachman and anterior drawer tests were done. Joong Lee *et al.* and colleagues found that the anterior drawer and Lachman tests had 79% and 87% sensitivity for diagnosing ACL rupture[11]. Out of the five ACL partial tears that were confirmed by arthroscopy, four were missed by clinical examination[11].

MR knee joint was subjected to patients who had experienced knee trauma and pain. Sagittal, axial, and coronal sections were closely examined to evaluate the ACL. The tibial and mid substance of the ACL were assessed using sagittal images, and the alignment with the femoral intercondylar line was also noted. The ACL's femoral attachment was shown in axial and coronal images.

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The following primary findings results were taken into account to indicate a complete ACL tear: a) an abnormally high signal intensity within the ACL; b) abnormal axis/angle; c) discontinuity in the fibers; and d) non-visualization of ACL. Partial discontinuity, partial angulation, focal increase in signal intensity, and enlarged ligament are the direct indicators of partial tear. The status of ACL was identified as normal, partially torn, or totally torn after examining the primary signs. The arthroscopic confirmation of 72 ACL injuries yielded 61 full tears and 11 partial tears. Based on the analysis of the tear location, 90.2% of cases had an isolated mid substance tear. Separate femoral and tibial attachment tears occurred in 6.9% and 1.1% of the cases. Our study shows findings which are in line with Remer *et al.*'s results that 70% of tears occurred in the mid substance, 3–10% at the tibial attachment and 5-20% were near the femoral attachment[10]. The mid substance was the most common tear site in 66.7% of individuals, according to Lakhkar *et al.*[12].

Out of the 61 ACL tears that were confirmed arthroscopically, 59 were confirmed complete tears by magnetic resonance imaging. In our study, MRI of complete ACL tear showed sensitivity, specificity, PPV, and NPV of 96.7%, 95.9%, and 95.9%. The MRI of an ACL tear has the following values: 97.2%, 84.27%, 92.1%, and 94.1% for sensitivity, specificity, PPV, and NPV. The outcomes matched the results of Joonki *et al.*[11]. A complete ACL tear can be detected on MRI with a 95% accuracy rate, 9.5% false positives, and 4.5% false negatives, according to Mink *et al.* which is similar to our study results[11].

Of the 38 ACLs that were confirmed to be normal through arthroscopy, 28 showed negative MR findings, 8 patients had abnormal intensity signals, and 2 had abnormal angles or axes that were reported as tears. According to Umans *et al.* (1995), partial volume averaging of the intercondylar notch fluid could be the cause of this[13].

All of the patients with ACL tears had primary findings. Out of the 33 patients with complete tear, 28 (84%) showed more than one primary finding. Of the patients surveyed, thirteen had 13 findings and fifteen had 2.

In our study, 50 out of 61 arthroscopically confirmed complete ACL tears had abnormal ACL signal intensity, yielding a sensitivity of 82% and a PPV of 74.6%. The outcomes are comparable to the 79% sensitivity that Lee *et al.* and his colleagues reported in their investigation[11].

Eight complete tears showed abnormal Blumensaat angles or axis, with 83.6% sensitivity and 96.2% PPV. A complete ACL injury was diagnosed with 95.9% specificity and 0.78 Kappa. The specificity was 95.9%, with just two patients exhibiting aberrant axis after arthroscopic confirmation of normal ACLs. Patricia Robertson *et al.* also found that complete ACL injuries could be identified with an 84% accuracy rate, 84% sensitivity, and k value of 0.41, which is in line with our results[10].

Of the 61 complete tears, 35 patients had complete discontinuity. With 100% specificity, none of the arthroscopically verified normal ACLs were observed. To diagnose a complete ACL tear, the sensitivity was 57.4%. In their study of pediatric knees, Kwanseop Lee *et al.* found that the diagnosis of a complete tear had a sensitivity of 21% and a specificity of 100%[15].

Out of 100 patients with complete ACL tears, four did not exhibit visualization of the ACL. While the sensitivity was 6.6% and the specificity was 100%, the Kappa value was 0.059, indicating poor correlation. The p-value for the diagnosis of ACL tear was 0.068, not significant. Based on our study, the most reliable predictor for predicting a complete ACL rupture with a kappa value of 0.76 was an aberrant axis. Among patients with ACL damage, 61.1% had abnormal axis and signal.

Altered medullary signal intensity changes indicative of a bone bruise or contusion were seen in 33 individuals. It was found in 25 out of 61 complete tears, 2 out of 11 partial tears, and 6 out of 38 normal ACLs. Our results show that bone bruises have a sensitivity of 59% for predicting ACL tears, with a specificity of 83.7%. These numbers are comparable to those of the research by Tung *et al.*, who discovered a sensitivity of 44% and a specificity of 93%[19]. Additionally, he mentioned that when an MRI was performed within nine weeks of the injury, the sensitivity rose to 73%. When predicting an ACL tear, Gentili *et al.* found that a bone bruise in the lateral compartment had a 54% sensitivity and a 100% specificity[20].

Our findings indicated that anterior tibial translation > 5mm had a 67.25% sensitivity, an 83.7% specificity, and a p-value < 0.05 for ACL tear diagnosis. In contrast, Amilcare Gentili *et al.* found a sensitivity of 63% and specificity of 80% in their study[20]. For ACL tears, Vahey *et al.* reported 69% accuracy, 93% specificity, and 58% sensitivity[16].

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The study we conducted revealed that the lateral meniscus uncovered posterior horn had a specificity of 91.8%, a positive predictive value of 89.75%, and a sensitivity of only 57.40%. Maccauley *et al.* found that MRI findings for uncovered posterior horn of the lateral meniscus had a sensitivity of 56% and a specificity of 97% for detecting ACL tears[17].

In 29 (47.5%) of the 61 ACL tears and 8 of the 50 normal ACLs, buckled PCL was observed; the kappa value of 0.29, indicating poor agreement, was used to predict the ACL status. Robertson *et al.* retrospective analysis of ACL tears revealed a kappa value of 0.41 and an accuracy of 76%[10].

In our study, 3 out of 50 normal ACLs and 16 out of 61 ACL tears had a deep lateral condylopatellar sulcus measuring more than 1.5 mm. In our investigation, this resulted in 93.9% specificity, 84.29% positive predictive value, and only 26.2% sensitivity. Of the 47 patients with clinically intact ACLs, Warren *et al.* discovered that only one (2%) had a deep sulcus. When comparing patients with acute and chronic ACL injuries, 13 out of 101 patients (13%) and 2 out of 52 patients (4%) with acute tears had sulci that were 1.5 mm deep or deeper, respectively. Cobby *et al.* discovered that out of 41 individuals with ACL rupture, 5 (12%) had deep notch.

Of the 11 arthroscopically confirmed partial tears, 9 were accurately reported to be a partial tear on MRI in our study. Of the fifteen MR-reported partial tears, four arthroscopy findings revealed nothing abnormal. This might be the result of partial volume averaging of fluid in acute haemarthrosis of the knee, which would increase the signal.

Secondary indicators for ACL severity that performed the best in our study were bony contusion and anterior translation of tibia more than 5 mm. 53 meniscal tears (14 medial menisci, 39 lateral menisci) and 61 anterior cruciate ligament tears were found. When compared to arthroscopy results, medial meniscus had a 62% sensitivity and a 94% specificity. Lateral meniscus showed sensitivity and specificity of 94% and 80%, respectively. The best method for determining an ACL tear in children, according to Kwanseop Lee *et al.*, is to use lateral meniscus tears as a secondary indicator[15]. In addition to primary tears, MRI has shown to be helpful in determining the severity and status of ACL injury by evaluating secondary findings.

CONCLUSION

This study concludes that MRI provides diagnostic accuracy comparable to arthroscopy for ACL tears, reinforcing its role as a non-invasive imaging modality. With careful technique and interpretation, MRI can effectively evaluate ligamentous and soft tissue injuries surrounding the knee. The findings emphasize the need for routine MRI assessments in suspected ACL injuries, enabling timely and appropriate interventions while minimizing unnecessary surgical explorations. This approach ultimately enhances patient care and improves clinical outcomes in knee trauma management.

REFERENCES

1. Giuliani JR, Kilcoyne KG, Rue J. Anterior cruciate ligament anatomy: a review of the anteromedial and posterolateral bundles. J Knee Surg. 2009;22(2):148–54.
2. Shimokochi Y, Shultz SJ. Mechanisms of noncontact anterior cruciate ligament injury. J Athl Train. 2008;43(4):396–408.
3. Nikken JJ, Oei E, Ginai AZ, Krestin GP, Verhaar J, Van Vugt AB. Acute peripheral joint injury: cost and effectiveness of low-field-strength MR imaging--results of randomized controlled trial. Radiology. 2005;236(3):958–67.
4. Stoller DW, Genant HK. Magnetic resonance imaging of the knee and hip. Arthritis & Rheumatism. 1990 Mar;33(3):441–9.
5. Burk DL, Mitchell DG, Rifkin MD, Vinitski S. Recent advances in magnetic resonance imaging of the knee. Radiol Clin North Am. 1990;28(2):379–93.
6. Stoller DW, Martin C, Crues JV, Kaplan L, Mink JH. Meniscal tears: pathologic correlation with MR imaging. Radiology. 1987;163(3):731–5.
7. Robertson PL, Schweitzer ME, Bartolozzi AR, Ugoni A. Anterior cruciate ligament tears: evaluation of multiple signs with MR imaging. Radiology. 1994;193(3):829–34.
8. Gupta R, Malhotra A, Sood M, Masih G. Is anterior cruciate ligament graft rupture (after successful anterior cruciate ligament reconstruction and return to sports) actually a graft failure or a re-injury Journal of Orthopaedic Surgery. 2019 Jan;27(1):230949901982962.
9. Hoogeslag R, Brouwer RW, Boer BC, De Vries AJ. Huis In 't Veld R. Acute Anterior Cruciate Ligament

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2386-2392 | ISSN:2251-6727

Rupture: Repair or Reconstruction? Two-Year Results of a Randomized Controlled Clinical Trial. Am J Sports Med. 2019;47(3):567–77.

10. Yu B, Garrett WE. Mechanisms of non-contact ACL injuries. Br J Sports Med. 2007;41(1):47–51.
11. Joong K, Lee L, Yao CT, Phelps CR, Wirth J, Cjzaka J. Anterior cruciate ligament tears: MR imaging compared with arthroscopy and clinical tests. Radiology. 1998; 166:861–4.
12. Lakhkar KV, Rajagopal P. MR Imaging Of Knee With Arthroscopic Correlation In Twisting Injuries. Ind J Radiol Imag. 2004; 14:33–40.
13. Umans H, Wimphfeimer O, Haramati N. Diagnosis of partial tear of the anterior cruciate ligament of the knee: Value of MR imaging. AJR. 1995; 165:893–7.
14. Joyner PW, Mills FB 4th, Brotherton S, Bruce J, Roth T, Hess R, Wilcox CL, Leddon CE, Davis B, O'Grady C, Andrews JR, Roth CA. Blumensaat Line as a Prediction of Native Anterior Cruciate Ligament Length. Orthop J Sports Med. 2020 Aug 6;8(8):2325967120943185.
15. Lee K, Siegel MJ, Lau DM, Hildebolt CF, Matava MJ. Anterior cruciate ligament tears: Mr imaging-based diagnosis in a pediatric population. Radiology. 1999 Dec;213(3):697–704.
16. Vahey TN, Broome DR, Kayes KJ, Shelbourne KD. Acute and chronic tears of the anterior cruciate ligament: differential features at MR imaging. Radiology. 1991; 181:251–3.
17. McCauley TR, Moses M, Kier R, Lynch JK, Barton JW, Jokl P. MR diagnosis of tears of anterior cruciate ligament of the knee: importance of ancillary findings. AJR Am J Roentgenol. 1994;162(1):115–9.
18. Mahapatra P, Horriat S, Anand BS. Anterior cruciate ligament repair – past, present and future. J Exp Orthop. 2018 Dec; 5:1-0.
19. Tung GA, Davis LM, Wiggins ME, Fadale PD. Tears of the anterior cruciate ligament: primary and secondary signs at MR imaging. Radiology. 1993; 188:661–7.
20. Gentili A, Seeger LL, Yao L, Do HM. Anterior cruciate ligament tear: indirect signs at MR imaging. Radiology. 1994 Dec;193(3):835-4.