REVIEW ARTICLE

A Review of Utility of Magnetic Resonance Imaging Compared to that of Arthroscopy in Diagnosis of Knee Ligamentous Injury

Baheti S[1], Chandrakar A[2], Jadhav M[1], Kumbhare V[1], Goyal L[1], Vijan K[1], Kawde P[1]

1 – Junior Resident, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India.
2 - Senior Resident, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India.

Abstract

Orthopedic surgeons relied absolutely on clinical exam within the late 1960 & early 70's till several reports advised the function of arthroscopy in prognosis and remedy of diverse knee disorders. Whilst comparing the accuracy of Magnetic Resonance Imaging (MRI) with scientific exam in diagnosing meniscal and ACL tears, a few preceding studies confirmed that medical examination is at the least as correct as MRI. The accuracy of MRI is very high in diagnosing knee lesions and has a sensitivity of 80% to a 100%.[5] MRI has been used because the first-line diagnostic exam in sufferers with suspected meniscal injuries, and unnecessary diagnostic arthroscopies have been avoided. In this study we reviewed utility of MRI in diagnosis of knee ligamentous injury, as opposed to arthroscopy.

***Keywords**: MRI, arthroscopy, knee ligament, injury*

Address for correspondence: Dr. Pratik Kawde , Junior Resident, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India. kawadepratik123@gmail.com

Introduction

Orthopedic surgeons relied absolutely on clinical exam within the late 1960 & early 70's till several reports advised the function of arthroscopy in prognosis and remedy of diverse knee disorders.[1,2] Whilst comparing the accuracy of MRI with scientific exam in diagnosing meniscal and ACL tears, a few preceding studies confirmed that medical examination is at the least as correct as MRI.[3,4] The accuracy of MRI is very high in diagnosing knee lesions and has a sensitivity of 80% to a 100%.[5] MRI has been used because the first-line diagnostic exam in sufferers with suspected meniscal injuries, and unnecessary diagnostic arthroscopies have been avoided. [6,7,8,9] The anterior cruciate ligament (ACL) extends from the posterior floor of the medial femoral condyle and attaches to the intercondylar technique of the tibia. Its common length is 31–38 mm and its average intersecting surface location is 36 mm2 in ladies and 44 mm2 in men.[10] It may be divided into anteromedial and posterolateral bundles. With the posterior cruciate ligament, the ACL limits immoderate flexion, and immoderate extension in combination with the posterior cruciate ligament, the medial and lateral collateral ligaments, the articular pill and the indirect popliteal ligament.[11] It additionally contributes to restriction of lateral slip and rotation with the articular pill, the medial and lateral collateral ligaments and the posterior cruciate ligament.[12] Injuries of the ACL are usually sports-associated traumas with almost 3 quarters being non-contact.[13] Frequently, MRI may be beneficial to diagnose the particular knee injuries and manual further appropriate surgical management.[14] It is stated that meniscal tears associated with ACL accidents have been more tough to hit upon on MRI than meniscal tears with an intact ligament.[15] As the ACL injury became greater persistent, a growing prevalence of meniscal tears was suggested.[16,17] Associated injuries of the ACL and different structures are as a result of a diffusion of occasions:

1. ACL injury associated with medial collateral ligament and medial meniscus harm is as a result of pressured flexion-external rotation pressure;
2. Harm associated with lateral compartment damage is as a result of pressured flexion-inner rotation pressure;

3. When related to lateral and medial compartment damage it is resulting from one of a kind institutions of varus-valgus and rotatory stress;
4. When in hyperextension.[13,18]

The sensitivity of this examination may be raised in step with the methods utilized by radiologists.[19] MRI is typically an correct form of complementary exam for knee evaluation, however it has excessive value.[20] MRI has high applicability to the knees, in evaluation with different joints, and it affords wonderful diagnostic ability for comparing lesions of different kinds, such as ligament, meniscal, tendon, bone and chondral injuries.[21] However, no evidence to signify that MRI would possibly reduce the wide variety of negative arthroscopic processes has been confirmed.[22] It has been shown that lesion of the anterior meniscal cornu visible on MRI might not any sizable scientific presentation, and correlation with the bodily examination is suggested.[23] Heterogenous outcomes regarding the accuracy of physical examinations on meniscal injuries were determined because of deficiencies of medical practice.[24,25,26] However, arthroscopy constitutes a noticeably luxurious and invasive exam.[27] Although MRI has lately played an increasing function inside the assessment of knee lesions, its diagnostic ability for ACL damage is limited and analysis fallible.[28] Latest studies have compared the diagnostic accuracy of 1.5 T MRI with 3.0 T MRI,[29] MRI blended with ultrasonography, and MRI mixed with physical exam.[27,30] Studies assessing MRI versus arthroscopy have no longer been reliably in comparison, making it harder to decide the right degree of scientific importance to the published records.[31]

Discussion

Timely and accurate diagnosis and treatment could prevent the emergence of cartilage degeneration, the progression of bone contusion, the aggravation of traumatic arthritis or the occurrence of knee joint dysfunction.[32] MRI studies have higher false positive than false negative results.[33] We also found this to be true when examining the combined results from meniscal lesions and ACL tears. Thus, the key to interpretation of this injury is the recognition of absence or blunting of the inner point of the meniscal triangle.[34] However, it is likely that overuse of the MRI technique in the diagnosis of ACL injury leads to misdiagnosis (estimated at 47%), especially in a chronic incomplete tear which might be due to the special sensitivity to the hydrogen atom and could be associated with volume effects and synovial hyperplasia.[35] Additionally, different studies have attributed different values for sensitivity and specificity, ranging from 63.6%[22,36] to 100% [37,38] and from 68.4% [39] to 100% [40,41,42] respectively, owing to the slightly oblique angle of the ACL crossing the knee joint and to the difficulty of displaying the full ACL in the true sagittal plane via a single MRI scan.[43,44] Meanwhile, the accuracy of MRI diagnosis depends on the scanning technique and the experience of the musculoskeletal radiologist.[45]

False positive MRI scans seen in the posterior horn of the medial meniscus may reflect an inability to completely visualize the area at arthroscopy, and tears that extend to the inferior surface of the meniscus may be difficult to see.[46] Some false positive findings on MRI can be attributed to inadequate visualization of the meniscus at surgery and to the fact that the diagnosis of a tear can be subjective.[47] MRI is the non-invasive imaging technique of choice in evaluating knee pain.[48,49,50] Clinical examination, when combined with MRI, provides the most accurate non-invasive source of information currently available for pathological findings in the menisci and the ACL.[51] MRI films need to be carefully examined because a meniscal tear is unlikely when MRI scans show a focus of high signal in a meniscus that does not unequivocally extend to involve the surface of the meniscus.[52] Arthroscopy has surgical risks, with a complication rate of 2.5% in arthroscopic meniscal surgery,[53] including saphenous and peroneal nerve injures, deep infections, superficial infections, vascular injuries and pulmonary embolism.

Smith *et al*. proved that there is no evidence that 3T scanners had superior diagnostic efficacy for ACL injury when compared with 1.5T machines.[29] Similarly, 2 authors also reported that magnetic field strength had no significant effect on accuracy [54,55] Another important factor that affects the diagnostic accuracy is the

MRI sequence. 1 author reported that improving the MRI sequence could improve diagnostic accuracy.[56] In previous reviews, the impact of the study's year of publication was found to be variable. Oei *et al*. reported that recent studies had better diagnostic accuracy than older studies,[56] which is likely due to improvements made in imaging technology such as the use of specific knee coils, improved sequences and radiologist familiarity with MRI over time. In contrast, one author found that there is a negative trend in diagnostic accuracy with more recent studies,[57,58] which may be due to differences in the prevalence of ACL tears in the selected studies. They also reported that older studies had better methodological quality than recent studies. One author [59] reported low sensitivity in line with our results for the MM and LM, and Sampson et al.[37] mentioned the low sensitivity for LM tears. It was found in one study [60] that most of the missed tears involved the posterior horn.

MRI should be used as an auxiliary tool in diagnosing meniscal and ligament injuries, according to combined methods for diagnosing knee injuries consisting of physical examination and MRI were found to be capable of diminishing the number of negative arthroscopy procedures by 5%, as demonstrated in 1 study.[61] This suggests that MRI has diagnostic value and helps in relation to the type of anesthesia and treatment, and that it may significantly reduce the need for a second arthroscopic intervention. In a double-blind study, authors [62] commented that knee arthroscopy was performed without prior knowledge of the MRI data.

In one study it was demonstrated that MRI has been used excessively in cases of knee disorders and does not have a favorable cost–benefit relationship in relation to physical examination, in comparisons with arthroscopy.[63] For physical examination, these authors found sensitivity and specificity of 100%, whereas in comparing MRI with arthroscopy, they found values of 95% and 88%. Yavuz Kocabey [64] found that there was no statistical difference between MRI and clinical examination in diagnosing ACL tears ($P > .05$). Dowdy et al [65] concluded that a positive MRI for an ACL tear combined with a normal arthroscopy did not represent a false positive MRI and that an intra-substance tear may be present that is difficult to detect with arthroscopy. In a study done on 63 patients MRI showed a tendency to over diagnose tears with five false positive giving an overall predictive value of only 76%.[66]

Meniscal injuries are a commonplace motive of knee disorder and ends in 2-0.33 of all knee disturbances.[67] MRI, a noninvasive and radiation free diagnostic modality is usually used for these inner derangements.[68] ACL tears to be more common than other ligamentous accidents.[69] Some authors reviewed patients with the clinical prognosis of meniscal tears and recommended MRI as a clarifying diagnostic device for the assessment of meniscal tears, mainly LM ruptures.[70] Sufferers with complete ACL tear showed grade 2 or better ATS, accordingly suggesting that substantial ATS is existent with whole ACL tears. In a observe executed by Chan et al., the presence of torn ACL become established on the premise of measurements of the placement of the lateral tibial plateau relative to the lateral femoral condyle on a sagittal picture.[71]

In a retrospective examine on 21 instances evaluating surgical information and MRI after knee dislocation, Potter et al.[72] showed a first rate correlation (kappa > 0.eight) for the scale and vicinity of the lesions. In a retrospective examine of ten instances, MRI changed into useful to decide the presence of ligament lesions.[73,74] In the region where it crosses the menisco-femoral ligaments of Wrisberg and Humphrey, it takes on a localized nodular look and sometimes displays a neighborhood hyperintensity because of a magic angle artefact. MRI has a diagnostic accuracy of 90% in this example.[75] The main secondary signs of harm to the anterior cruciate ligament described within the literature are:

- Abnormalities of ACL orientation with an angle of underneath 45◦from the tibial plateau and over 15◦from the intercondylar line of Blumensaat; [76]
- The presence of a bone contusion or an osteo-chondral fracture. This particularly includes the lateral tibial plateau.[76,77] This sign however is brief and is decreased especially after nine weeks following the initial effect;[78]
- A loose curvilinear look of the PCL which is an indirect sign of the anterior drawer;[79]

- The presence of a deep scalloping at the lateral femoral condyle;[80]
- Posterior displacement of the lateral meniscus through greater than 3.5 mm [81] mixed with the ‘‘non-recovery’’ sign (a vertical line passing thru the posterior fringe of the tibial plateau have to no longer pass the meniscus);[78]
- The presence of an anterior drawer of at least 5 mm measured from the vertical axis passing via the posterior fringe of the lateral tibial plateau;[78,81]
- Vertical shift of the lateral collateral ligament.[82]

Conventionally, the cruciate ligaments are assessed on indirect sagittal MRIs, with t2-weighted sequences. T2- weighted sequences are related to greater sensitivity, specificity, and accuracy for an ACL tear than are t1-weighted sequences.[83,84,85]

Staeubli et al. advocated the usage of the oblique coronal MRI for visualizing the anatomic diagonal path of the native ACL and its relation with the intercondylar notch and the posterior cruciate ligament.[86] For the local ACL, the use of extra oblique coronal images improves the specificity and accuracy for detecting ACL tear and this additionally increases the accuracy of grading ACL injury.[87] For the ACL graft, one previous examine protected the indirect coronal pix for the assessment of healthy ACL grafts.[88] Majority of the preceding MR studies have hired sagittal, coronal or oblique sagittal pics.[86] Some investigators have conducted MR research the usage of right knee positioning with a view to optimize visualization of an ACL graft.[89]

Comparison

More advantageous MR research were accomplished to evaluate the periligamentous tissue with its better sign intensity, and this better sign depth was derived from neovascularization, granulation tissue or immature collagen.[90] Previous studies evaluated the oblique axial images obtained at a right perspective to the ACL graft,[91] and one used MR arthrography for ACL graft assessment.[92,93,94] Using the oblique coronal photos decreased the false-positive analysis of partial tear and extended the specificity of MRI for ACL graft harm. Despite the fact that, fake negative diagnoses for ACL graft harm had been nevertheless made with the use of the oblique coronal pictures. We agree with that the femoral attachment website is vulnerable to misinterpretation because of the intense angle shaped between the femoral tunnel and the grafts at the indirect coronal pictures. The indirect sagittal pictures may also help enhance the visualization of the femoral attachment web page of an ACL graft by using showing the femoral tunnel in a plane.[95]

MRI scans had been observed to be increasingly more accurate in the prognosis of acute knee ligament tears. Similarly, an MRI technique became these days stated to be accurate inside the identity of posterolateral knee accidents.[96] Because it has been said that the historic occurrence of posterolateral knee accidents has been underestimated and below-mentioned, with a said occurrence of among 4% and 7%, it changed into believed that a massive prospective MRI study might offer, as intently as possible, the real number of posterolateral knee injuries that occur inside the widespread population.[97,98]

Conclusion

MRI is quite effective in diagnosing meniscal tears, although it should serve as complimentary tool to clinical examination. There is need to conduct multi-centric study with diverse population sample to study the efficacy of MRI in meniscal injuries.

Conflict of Interest: *None declared*
Source of Support: *Nil*

References

1. Gillquist J, Hagberg G, Oretorp N. Arthroscopic visualization of the posteromedial compartment of the knee joint. Orthop Clin North Am 1979; 10(3):545-547.
2. Remer E, Fitzgerald S, Friedman H, et al. Anterior cruciate ligament injury: MR imaging diagnosis and patterns of injury. Radiographics. 1992; 12(5):901-11.
3. Rose N, Gold S. A comparison of accuracy between clinical examination and magnetic resonance imaging in the diagnosis of meniscal and anterior cruciate ligament tears. Arthroscopy 1996; 12; 398-405.
4. Esmaili Jah A, Keyhani S, Zarei R, et al. Accuracy of MRI in comparison with clinical and arthroscopic findings in ligamentous and meniscal injuries of the knee. Acta Orthop Belg. 2005; 71:189-196.
5. DeSmet A, Tuite M, Norris M. MR diagnosis of meniscal tears: analysis of causes of errors. AJR. 1994; 163:1419–23.
6. Grossman J, DeSmet A, Shinki K, et al. Comparison of the accuracy rates of 3-T and 1.5-T MRI of the knee in the diagnosis of meniscal tear. AJR Am J Roentgenol. 2009; 193:509-514.

7. Behairy N, Dorgham M, Khaled S. Accuracy of routine magnetic resonance imaging in meniscal and ligamentous injuries of the knee: Comparison with arthroscopy. Int Orthop. 2009; 33:961-967.
8. Crawford R, Walley G, Bridgman S, et al. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: A systematic review. Br Med Bull 2007; 84:5-23.
9. Polly D, Callaghan J, Sikes R, et al. The accuracy of selective magnetic resonance imaging compared with the findings of arthroscopy of the knee. J Bone Joint Surg Am 1988 ;70:192-198.
10. Anderson A, Dome D, Gautam, S, et al. Correlation of anthropometric measurements, strength, anterior cruciate ligament size, and intercondylar notch characteristics to sex differences in anterior cruciate ligament tear rates. The American journal of sports medicine. 2001 ;29: 58–66.
11. Irarrazaval S, Albers M, Chao T, et al. Arthroscopic, and Radiographic Anatomies of the Anterior Cruciate Ligament: Foundations for Anterior Cruciate Ligament Surgery. Clinics in sports medicine. 2017 ;36:9–23.
12. Mallett K, Arruda E. Digital image correlation-aided mechanical characterization of the anteromedial and posterolateral bundles of the anterior cruciate ligament. Acta Biomaterialia. 2017;56:44-57.
13. Boden B, Sheehan, F, Torg, J, et al. Noncontact anterior cruciate ligament injuries: mechanisms and risk factors. The Journal of the American Academy of Orthopaedic Surgeons. 2010; 18(9): 520–527.
14. Munshi M, Davidson M, MacDonald P, et al. The efficacy of magnetic resonance imaging in acute knee injuries. Clin J Sport Med. 2000; 10(1):34-39.
15. De Smet A, Graf B. Meniscal tears missed on MR imaging: Relationship to meniscal tear patterns and anterior cruciate ligament tears. AJR Am J Roentgenol. 1994; 162(4):905-11.
16. Tandogan RN, Taser O, Kayaalp A, et al. Analysis of meniscal and chondral lesions accompanying anterior cruciate ligament tears: Relationship with age, time from injury, and level of sport. Knee Surg Sports Traumatol Arthrosc. 2004; 12(4):262-270.
17. Keene G, Bickerstaff D, Rae P, et al. The natural history of meniscal tears in anterior cruciate ligament insufficiency. Am J Sports Med. 1993; 21(5):672-9.
18. De Maria M, Barbiera F, Lo Casto A, et al. Biomechanical correlations of lesions associated with traumatic diseases of the anterior cruciate ligament. Analysis with magnetic resonance. La Radiologia medica. 1996; 91(6):693–699.
19. Magee T, Shapiro M, Williams D. MR accuracy and arthroscopic incidence of meniscal radial tears. SkeletalRadiol. 2002; 31(12):686–9.
20. Feler J, Webster K. Clinical value of magnetic resonance imaging of the knee. ANZ Surg. 2001; 71(9):534–7.
21. Sanders T, Miller M. A systematic approach to magnetic resonance imaging interpretation of sports medicine injuries of the knee. Am J Sports Med. 2005; 33(1):131–48.
22. Brooks S, Morgan M. Accuracy of clinical diagnosis in the knee arthroscopy. Ann R Coll Surg Engl. 2002; 84(4):265–8.
23. Shepard M, Hunter D, Davies M, et al. The clinical significance of anterior horn meniscal tears diagnosed on magnetic resonance images. Am J Sports Med. 2002; 30(2):189–92.
24. Scholten R, Deville W, Opstelten W, et al. The accuracy of physical diagnostic tests for assessing meniscal lesions of the knee: a meta-analysis. JFam Pract. 2001; 50(11):938–44.
25. Witte H. Magnetic Resonance Imaging in Orthopaedics.in: Canale Terry S, Beaty James, editors. Campbells operative orthopaedics. 11th edition. Philadelphia: Mosby Elsevier; 2008.p.137-140.
26. Rossbach, B, Pietschmann , Gülecyüz M, et al. Indications requiring preoperative magnetic resonance imaging before knee arthroscopy. Archives of medical science: AMS 2014 ;10(6):1147-1152
27. Swain M, Henschke N, Kamper S, et al. Accuracy of clinical tests in the diagnosis of anterior cruciate ligament injury: a systematic review. Chiropractic & manual therapies. 2014 ;1;22:25
28. Khan, H. A. *et al*. Correlation between magnetic resonance imaging and arthroscopic findings in the knee joint. *Trauma monthly* 20, e18635, (2015).
29. Smith, C. et al. Diagnostic Efficacy of 3-T MRI for Knee Injuries Using Arthroscopy as a Reference Standard: A Meta-Analysis. AJR. American Journal of Roentgenology. 2016; 207: 369-377.
30. Huang W, Zhang Y, Yao Z, et al. Clinical examination of anterior cruciate ligament rupture: a systematic review and meta-analysis. Acta Orthopaedica et Traumatologica Turcica. 2016; 50(1):22-31.
31. Vassalou E, Klontzas M, Kouvidis G, et al. Rotational Knee Laxity in Anterior Cruciate Ligament Deficiency: An Additional Secondary Sign on MRI. AJR. American journal of roentgenology. 2016; 206 (1): 151-154.
32. Ahn J, Jeong S, Kang H, et al. Risk Factors of False-Negative Magnetic Resonance Imaging Diagnosis for Meniscal Tear Associated With Anterior Cruciate Ligament Tear. Arthroscopy: the journal of arthroscopic & related surgery. 2016; 32(6):1147-54.
33. Heron CW, Calvert PT (1992) 3D gradient echo MRI of the knee: comparison with arthroscopy in 100 patients. Radiology. 1992; 183: 839–844.
34. Tuckman G, Miller W, Remo J, et al. Radial tears of the menisci: MR findings. Am J Roentgenol. 1994; 163(2):395-400.
35. Orlando J, George D, Oliveira M. Diagnosis of knee injuries: comparison of the physical examination and magnetic resonance imaging with the findings from arthroscopy. Revista Brasileira de Ortopedia. 2015; 50(6): 712–719.
36. Thomas S, Pullagura M, Robinson E,et al. The value of magnetic resonance imaging in our current management of ACL and meniscal injuries. Knee surgery, Sports Traumatology, Arthroscopy. 2007;15(5):533-6.
37. Sampson M, Jackson M, Moran C, et al. Three Tesla MRI for the diagnosis of meniscal and anterior cruciate ligament pathology: a comparison to arthroscopic findings. Clinical Radiology.2008; 63(10):1106-1111.
38. De Maio P, White L, Bleakney R, et al. Diagnostic accuracy of an iPhone DICOM viewer for the interpretation of magnetic resonance imaging of the knee. Clinical Journal of Sport Medicine. 2014; 24(4):308-14.
39. Grubor P, Asotic A, Grubor M, et al. Validity of magnetic resonance imaging in knee injuries. Acta Informatica Medica. 2013; 21: 200–204.
40. Severino R, Camargo O, Aihara T, et al. Comparac¸ão entre a ressonância magnética e aartroscopia no diagnóstico de lesões do joelho. Rev BrasOrtop. 1997; 32(4):275–8.
41. Schaefer F, et al. Value of fat-suppressed PD-weighted TSE-sequences for detection of anterior and posterior cruciate ligament lesions–comparison to arthroscopy. European Journal of Radiology. 2006; 58: 411–415.
42. Duc S, Pfirrmann, C, Koch P, et al. Internal knee derangement assessed with 3-minute three dimensional isovoxel true FISP MR sequence: preliminary study. Radiology. 2008; 246:526–535.
43. Vincken P, ter Braak B, van Erkel A, et al. Magnetic resonance imaging of the knee: a review. Imaging Decisions. 2006; 10(1):24–30.
44. Kostov H, Stojmenski S, Kostova E. Reliability assessment of arthroscopic findings versus MRI in ACL injuries of the knee. Acta Informatica Medica. 2014; 22: 111–114.
45. Challen J, Tang Y, Hazratwala K. et al. Accuracy of MRI diagnosis of internal derangement of the knee in a nonspecialized tertiary level referral teaching hospital. Australasian Radiology. 2007; 51, 426–431.
46. Chissell H, Keightley A, Allum R. MRI of the knee: its cost effective use in a DGH. Ann R Coll Surg Engl. 1994; 76: 26–29.
47. Quinn S, Brown T. Meniscal tears diagnosed with MRI versus arthroscopy: how reliable is arthroscopy? Radiology. 1991; 181: 843–847.
48. Crues J, Mink J, Levy T, et al. Meniscal tears of the knee: accuracy of MRI imaging. Radiology. 1987; 164: 445–448.
49. Elvenes J, Jerome C, Reikeras O. MRI as a screening procedure to avoid arthroscopy for meniscal tears. Arch Orthop Trauma Surg. 2000; 120:14–16.
50. Friemert B, Oblerlander Y, Schwarz W, et al. Diagnosis of chondral lesions of the knee joint: can MRI replace arthroscopy? Knee Surg Sports Traumatol Arthrosc. 2004; 12: 58–64.
51. Glashow J, Katz R, Schneider M, et al. Double-blind assessment of the value of MRI in the diagnosis of ACL and meniscal lesions. J Bone Joint Surg Am. 1989; 71:113–119.
52. Kaplen P, Nelson N, Garvin K, et al. MR of the knee: the significance of high signal in the meniscus that does not clearly extend to the surface. Am J Roentgenol. 1991; 156: 333–336.
53. Small NC. Complications in arthroscopic meniscal surgery. Clin Sports Med. 1990; 9:609–617.

54. Phelan N, Rowland P, Galvin R, et al. A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. Knee surgery, Sports traumatology, Arthroscopy. 2016; 24(5):1525-39.
55. Smith T, et al. The diagnostic accuracy of anterior cruciate ligament rupture using magnetic resonance imaging: A meta-analysis. European Journal of Orthopaedic Surgery and Traumatology. 2012; 22: 315–326.
56. Oei E, Nikken J, Verstijnen A, et al. MR imaging of the menisci and cruciate ligaments: a systematic review. Radiology. 2003; 226: 837–848.
57. Crawford R, Walley G, Bridgman S, et al. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: a systematic review. British medical bulletin. 2007; 84: 5–23.
58. Bossuyt P, et al. The STARD statement for reporting studies of diagnostic accuracy: explanation and elaboration. The Standards for Reporting of Diagnostic Accuracy Group. Croatian Medical Journal 2003; 44:639–650.
59. Jee W, McCauley T, Kim J. Magnetic resonance diagnosis of meniscal tears in patients with acute anterior cruciate ligament tears. J Comput Assist Tomogr. 2004; 28:402-406.
60. Laundre B, Collins M, Bond J, et al. MRI accuracy for tears of the posterior horn of the lateral meniscus in patients with acute anterior cruciate ligament injury and the clinical relevance of missed tears. AJR Am J Roentgenol. 2009; 193:515-523.
61. Munk B, Madsen F, Lundorf E, et al. Clinical magnetic resonance imaging and arthroscopic findings in knees: a comparative prospective study of meniscus anterior cruciate ligament and cartilagelesions. Arthroscopy. 1988; 14(2):171–5.
62. Rappeport E, Wieslander S, Stephensen S, et al. MRI preferable to diagnostic arthroscopy in knee injuries. A double-blind comparison of 47 patients. ActaOrthop Scand. 1997; 68(3):277–81.
63. Gelb H, Glasgow S, Sapega A, et al. Magnetic resonance imaging of knee disorders. Clinical value and cost-effectiveness in a sports medicine practice. Am J Sports Med. 1996; 24(1):99–103.
64. Kocabey Y, Tetik O, Isbell W, et al. The value of clinical examination versus magnetic resonance imaging in the diagnosis of meniscal tears and anterior cruciate ligament rupture. Arthroscopy 2004; 21:696–700.
65. Dowdy P, Vellet K, Fowler P, et al. Magnetic resonance imaging of partially torn anterior cruciate ligament: an in vitro animal model with correlative histopathology. Clin J Sports Med. 1994; 4(3):187-91.
66. Winters K, Tregonning R. Reliability of magnetic resonance imaging of the traumatic knee as determined by arthroscopy. NZ Med J. 2005 ;118(1209):11-20.
67. Bui-Mansfield L, Youngberg R, Warme W,et al. Potential cost saving of MR imaging obtained before arthroscopy of the knee. Evaluation of 50 consecutive cases. AJR. 1997; 168:913-18.
68. Shahriaree, Heshmat (Editor): O'Connor's Text book of arthroscopic surgery. Philadelphia: J.B Lippincot; 1984, pp. 814-821.
69. Singh J, Garg L, Shrimali R, et al. MR Imaging of knee with Arthroscopic Correlation in Twisting Injuries. Ind J Radio. 2004; 14(1):33-40.
70. Schurz M, Erdoes J, Platzer P, et al. The value of clinical examination and MRI versus intraoperative findings in the diagnosis of meniscal tears. Scripta Medica(BRNO). 2008; 81(1):3-12.
71. Chan W, Peterfy C, Fritz R, et al. MR diagnosis of complete tears of anterior cruciate ligament of the knee: Importance of anterior subluxation of tibia. AJR. 1994; 162:355-60.
72. Potter H, Weinstein M, Allen A, et al. Magnetic resonance imaging of the multiple-ligament injured knee. J Orthop Trauma. 2002; 16:330-9.
73. Lonner J, Dupuy D, Siliski J. Comparison of magnetic resonance imaging with operative findings in acute traumatic dislocations of the adult knee. J Orthop Trauma. 2000; 14:183-6.
74. Twaddle B, Hunter J, Chapman J, et al. MRI in acute knee dislocation. A prospective study of clinical, MRI, and surgical findings. J Bone Joint Surg Br. 1996; 78:573-9.
75. Guenoun D, Le Corroller, Amous Z, et al. The contribution of MRI to the diagnosis of traumatictears of the anterior cruciate ligament. Diagn Interv Imaging. 2012; 93:331-41.
76. Fitzgerald S, Remer E, Friedman H, et al. MR evaluation of the anterior cruciate ligament: value of supplementing sagittal images with coronal and axial images. AJR Am J Roentgenol. 1993; 60:1233-7.
77. Murphy B, Smith R, Uribe J, et al. Bone signal abnormalities in the postero-lateral tibia and the lateral femoral condyle incomplete tears of the anterior cruciate ligament: a specificsign? Radiology. 1992; 182:221-4.
78. Tung G, Davis L, Wiggins M, et al. Tears of the anteriorcruciate ligament: primary and secondary signs at MR imaging. Radiology. 1993; 188:661-7.
79. Robertson P, Schweitzer M, Bartolozzi A. Anterior cruciate ligament tears: MR imaging evaluation. Radiology. 1994; 193:829-34.
80. Cobby M, Schweizer M, Resnick D. The deep lateral femoral notch: an indirect sign of a torn anterior cruciate ligament. Radiology. 1992; 184:855-8.
81. Gentilli A, Seeger L, Yao L, Do H. Anterior cruciate ligament tear: indirect signs at MR imaging. Radiology. 1992; 193:836-40.
82. Palle L, Reddy B, Reddy J. Sensitivity and specificity of vertically oriented lateral collateral ligament as an indirect sign of anterior cruciate ligament tear on magnetic resonance imaging. Skeletal Radiol. 2010; 39:1123-7.
83. Mink J, Levy T, Crues J. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. Radiology. 1988; 167:769e74.
84. Hong S, Choi J, Lee G, et al. Grading of anterior cruciate ligament injury. Diagnostic efficacy of oblique coronal magnetic resonance imaging of the knee. J Comput Tomogr. 2003; 27:814e9.
85. Chen W, Shih T, Tu H, et al. Partial and complete tear of the anterior cruciate ligament. Acta Radiol. 2002; 43:511e6.
86. Staeubli H, Adam O, Becker W, et al. Anterior cruciate ligament and intercondylar notch in the coronal oblique plane: anatomy complemented by magnetic resonance imaging in cruciate ligament-intact knees. Arthroscopy. 1999; 15:349-359.
87. Hong S, Ahn J, Ahn J, et al. Postoperative MR findings of the healthy ACL grafts: correlation with second look arthroscopy. Clin Imaging. 2005; 29:55-59.
88. Nakanishi K, Horibe S, Shiozaki Y, Ishida T, Narumi Y, Ikezoe J, et al. MRI of normal anterior cruciate ligament (ACL) and reconstructed ACL: comparison of when the knee is extended with when the knee is flexed. Eur Radiol. 1997; 7:1020-1024.
89. Howell S, Knox K, Farley T, et al. Revascularization of a human anterior cruciate ligament graft during the first two years of implantation. Am J Sports Med. 1995; 23:42-49.
90. Murakami Y, Sumen Y, Ochi M, et al. MR evaluation of human anterior cruciate ligament auto graft on oblique axial imaging. J Comput Assist Tomogr. 1998; 22:270-275.
91. McCauley T, Elfar A, Moore A, et al. MR arthrography of anterior cruciate ligament reconstruction grafts. AJR Am J Roentgenol. 2003; 181:1217-1223.
92. Nakayama Y, Shirai Y, Narita T, Mori A, Kobayashi K. The accuracy of MRI in assessing graft integrity after anterior cruciate ligament reconstruction. J Nippon Med Sch. 2001; 68:45-49.
93. Horton L, Jacobson J, Lin J, et al. MR imaging of anterior cruciate ligament reconstruction graft. AJR Am J Roentgenol. 2000; 175:1091-1097.
94. Howell S, Berns G, Farley T. Unimpinged and impinged anterior cruciate ligament grafts: MR signal intensity measurements. Radiology. 1991; 179:639-643.
95. LaPrade R, Gilbert T, Bollom T, et al. The magnetic resonance imaging appearance of individual structures of the posterolateral knee. A prospective study of normal knees and knees with surgically verified grade III injuries. Am J Sports Med. 2000; 28:191-199.
96. DeHaven K. Diagnosis of acute knee injuries with hemarthrosis. Am J Sports Med. 1980; 8:9-14.
97. DeLee J, Riley M, Rockwood C. Acute posterolateral rotatory instability of the knee. Am J Sports Med. 1983; 11:199-207.
98. Nielsen A, Yde J. Epidemiology of acute knee injuries: A prospective hospital investigation. J Trauma. 1991; 31:1644-1648.