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Prospective study correlating accuracy of clinical examination,0912 519 25 27magnetic resonance imaging and arthroscopy in meniscal and anterior cruciate ligament injuries of the knee

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Background and objectives: The objectives of this study were to assess the accuracy of clinical tests for diagnosing meniscal (Thessaly, joint line tenderness and Mcmurray test) and anterior cruciate ligament (Lachman, Anterior Drawer and Pivot Shift test) injuries. Compare and correlate clinical and magnetic resonance imaging finding with arthroscopic confirmation, arthroscopy is regarded as gold standard for diagnosis. **Methods:** A prospective study conducted from October 2014 to October 2016. Participants included 79 patients who underwent knee arthroscopy for different indications in Erbil teaching hospital. Clinical diagnosis was established by orthopedic surgeons using clinical tests for meniscal and anterior cruciate ligament injuries. Magnetic resonance imaging was requested for confirmation. This was followed by arthroscopy for making the final diagnosis. **Results:** The Lachman test showed high accuracy (92.4%) to determine anterior cruciate ligament rupture. The accuracy of anterior drawer test was 70.8% and for pivot shift test was 68.3%. The Thessaly test showed high accuracy for medial (91.1%) and lateral (89.5%) meniscus tear.The joint line tenderness showed accuracy for medial (84.8%) and lateral (89.7%) meniscus tear and the McMurray test showed accuracy for medial (72.1) and for lateral (81%) meniscus tear. Validity of the clinical tests was compared to the results got from magnetic resonance imaging and arthroscopy. Accuracy of clinical diagnosis versus magnetic resonance imaging diagnosis for medial (91% vs. 89%) and lateral (89% vs. 86%) meniscal lesions was almost identical. Accuracy of clinical diagnosis compared with the accuracy of magnetic resonance imaging diagnosis for anterior cruciate ligament injuries was slightly higher (92.4% vs. 87.3%). **Conclusions:** The most accurate test for assessing anterior cruciate ligament rapture is Lachman test and for meniscal tear is Thessaly test with Joint line tenderness. Proper clinical examination is as accurate as magnetic resonance imaging in diagnosing meniscal injuries but for anterior cruciate ligament injuries; proper clinical examination has a better diagnostic accuracy in comparison to magnetic resonance imaging diagnosis.
Keywords: Clinical Examination; Meniscus; Anterior Cruciate Ligament; Magnetic Resonance Imaging; Knee Arthroscopy.

Introduction

Proper diagnosis of knee injuries is highly linked to taking a good history and making a careful clinical examination. Meniscal and ligament injuries of the knee can be accessed via magnetic resonance imaging (MRI) examinations, which provide images displaying abnormalities of the morphology which are specifically characterized[1]. Magnetic resonance imaging is generally an accurate kind of supplementary examination for knee evaluation[2]. Meniscal tears are one of the most common injuries to the knee that require surgery. The torn medial meniscus is more common than the lateral meniscus. However, lateral meniscus tears occur more commonly with concomitant anterior cruciate ligament (ACL) rapture. Traumatic meniscal tears are common in young patients with sports-related injuries[3]. Anterior cruciate ligament injury is a common injury comprising between 40% and 50% of all knee ligament injuries. Female athletes have a two to eight times higher risk of ACL tear compared to male athletes[3]. Skiing, basketball, and football are the riskiest sports. The mechanism of the injury is usually a valgus load with internal tibial rotation and anterior tibial translation while the knee is in almost full extension[3]. Special testshave been a historical part of the physical examination for the assessment of musculoskeletal knee pain clinically[4], and a number of these special tests are thought to diagnose torn menisci. McMurray's, joint line tenderness (JLT) andApley's test are usually used in practice[5], andThessaly isregardedas anew dynamic test with high diagnostic accuracy[6]. A number of clinical tests are used for diagnosing ACL rapture. The Lachman, Anterior drawer test and Pivot shift test used in clinical practice[7]. The Lachman test is the commonly useful test in diagnosing ACL

injuries in the acute setting. The Lachmantest can be performed, while the knee in 30-degree flexion, the distal femur is held securely by one hand while the examiner translates the proximal tibia anteriorly with the other hand. A sense of increased anterior translation and lack of a solid end point are indicative of ACL injury[8].Knee MRI:Kean et al in 1980 started to useMRI in the diagnosis of knee disorders[9]. The ongoing development of technical improvement and personal experience made the MRI to be a useful diagnostic tool with an average accuracy of up to 93%[10,11]. Magnetic resonance imaging scanning of the knee joint has often been regarded as the noninvasive alternative to diagnostic arthroscopy. In the day to day clinical practice, MRI scan is used to support the diagnosis ofmeniscal or ACL injuries prior to recommending arthroscopic examination and surgery[12]. The most common criteria for diagnosing meniscus tear on MRI is an increased signal may be extending in a line or band to the articular surface. Another finding is the abnormal size or shape of the meniscus, which would indicate damaged surfaces[13,14].

Table (1): Classifications of grades of meniscal tear in MRI

Grade 1	Globular increased signal intensity, not adjacent to either articular surface
Grade 2	Linear signal intensity increasedwithin the meniscus
Grade 3	Linear signal intensity that extends to either superior or inferior articular surface
Grade 4	Meniscus fragmentation

The MRI scan includes images in all three planes, and all three should be looked at carefully. Specific tear orientations vary and may only be clear in one of the three planes[16].The simplest method to diagnose a discoid meniscus on MRI is to measure the shortest transverse width of the meniscal body on coronal images; when this is greater than 14 mm, the meniscus is characterized as discoid[17]. On sagittal sequences, appearance of lateral meniscus on threeconsecutive sagittal images is also diagnostic of discoid meniscus[18]. In the sagittal imaging plane, the fibers of normal ACL should be parallel to Blumensaat line[19].Reliable signs of ACL rupture include an abnormal horizontal course, a wavy or irregular appearance, or fluid filled gaps in a discontinuous ligament.In acute injuries secondary signs of ACL rupture manifested as subchondral marrow edema and bone contusions typically in the lateral compartment that resolve within 6 to 12 weeks of injury[20].

Today, knee arthroscopy is the most common procedure performed among arthroscopic sport surgeons[21]. Initially, knee arthroscopy was used as a diagnosed technique. With the advent of MRI and other non-invasive techniques, therapeutic arthroscopy comes into practice. Indications for knee arthroscopy include the treatment of meniscal pathology, specified articular cartilage lesions, osteochondral lesions, loose bodies, advancing synovitis and performing synovial biopsy, cruciate ligament tears and certain tibial plateau fractures[22]. This study aim was to assess the accuracy of clinical tests for diagnosing meniscal (Thessaly, joint line tenderness and Mcmurray test) and anterior cruciate ligament (Lachman, Anterior Drawer and Pivot Shift test) injuries. Compare clinical and magnetic resonance imaging finding with arthroscopic confirmation, arthroscopy is regarded as gold standard for diagnosis.

Patients and Methods

This is a prospective comparativestudy of 79 patients who were admitted for elective knee arthroscopy for different indications. This study was performed in Erbil Teaching Hospital, Hawler;from October 2014 to October 2016. Inclusion criteria: those between 18-45 years old with unilateral knee injury. Exclusion criteria: those with degenerative arthritis, loose bodies, previous knee surgeries,chondral injuries, patellofemoral pathological conditions, contraindications of MRI and sequelae of fracture. Allpatients were identified clinically by a proper history and thorough clinical examination and subjected to MRI of the knee and knee arthroscopy. The patients included in this study presented with meniscal and/or ligament injuries, the indications for surgical treatment included knee pain, locking, giving way and recurrent knee swelling. A thorough and detailed clinical examination was performed by a specialist orthopedic surgeon. For evaluating meniscal injuries, joint line tenderness, McMurrey test and Thessalytest were used. For anterior cruciate ligament (ACL) injuries, Lachman, anterior drawer test and pivot shift test were used. Posterior drawer test for PCL injuries, valgus and varus test also were performed. A clinical diagnosis was made and MRI of the knee was requested in all the 79 cases. Magnetic resonance imaging was requested for confirmation of clinical diagnosis and for obtaining additional information. Magnetic resonance imaging was performed in four different imaging centers in Erbil city with magnetic extremity coil (1.5) tesla strength. Each study provided T1 and T2 sequences with 4 mm slice thickness. The MRI of the patients were evaluated and reported by a radiologist who had experience in reporting pathological knee conditions. The radiologist did not have any contact with the patients. Meniscal tears were graded from one to four. Grades three and four were regarded as positive. The patients were positioned supine in the MRI scanner and the involved side was externally rotated 10 to 15 degree during the sagittal imaging to obtain better sections of ACL. The ACL was reported as intact if homogenous low-signal intensity spanned the intercondylar notch continuously from origin to insertion, although some signals within ACL still can be regarded as normal if is not associated with other findings. A rapture of the ACL was diagnosed if this pattern signal was absent, variable, nonhomogeneous, or showed an abnormal origin or insertion. A questionnaire was designed by the researcher. The information was obtained regarding the age, gender, right or left sided knee, brief history including chief complain and duration with mechanism of injury, proper examination and date of taking MRI and arthroscopy. All patients Knee menisci and ACL were reported as normal or tear in both MRI and arthroscopy. All the patients were operated on either under general anesthesia (65 Patients) or spinal anesthesia (14 patients). The surgery was performed by four orthopedic surgeons. The stability of the ligaments was tested again under anesthesia. Arthroscopy was performed by two port anteromedial and anterolateral portals. During the arthroscopic knee procedures, a proper systemic examination of the whole knee was performed. Any type of meniscal tear was regarded as positive, independent of the type of the tear (whether longitudinal, radial, horizontal, parrot beak, root or bucket handle tear), and the side was noted medial and lateral. ACL and PCLwere encountered as normal or rupture. This study has no relation with the type of treatment of meniscal and ligament injuries and the definitive treatment were undertaken at the same time. The arthroscopy was regarded as gold standard for diagnosing meniscal and ligament injuries. Data were analyzed using the statistical package for social sciences (SPSS, version 19). Frequencies and percentages were calculated. Mcmurray test was used (to compare results of clinical tests or MRI findings with the results of arthroscopy).

Table (2): Cross Tabs for Statistical Analysis

		Arthroscopy	
		Positive	**Negative**
Clinical test	Positive	TP	FP
orMRI	Negative	FN	TN
Total		**TP+FN**	**FP+TN**

TP=True positive, TN=True negative, FP=False positive, FN=False negative

Sensitivity = TP / (TP+FN)*100

Specificity = TN / (FP+TN)*100

Positive predictive value = TP / (TP + FP)*100

Negative predictive value = TN / (FN + TN)*100Accuracy = (TP+TN)/Total*100A p value ≤ 0.05 was considered statistically significant.

Results

This study included 79 patients, 68 (86.1%) male and 11 (13.9%) female, with the age group of (19-44) years, and the median age of 29. There were 42 (53.2%) right knees and 37 (46.8%) left knees. The duration of symptoms range from one month to 36 month as shown in Table 3.All the patients were examined by a consultant orthopedic surgeon either in outpatient clinic at Erbil Teaching Hospital or in his clinic and then scheduled to undergo knee MRI and arthroscopy. Fifty two patients received treatment in the form of knee support, physiotherapy and symptomatic treatment for 14- 90 days. The interval waiting time between knee arthroscopy and MRI was 3-12weeks without recent injury during this waiting period.

Table (3): Statistical Analysis of Age, Duration of symptoms and MRI/Scope Time Interval

	Age/year	Duration/month	MRI/Scope time interval/wk
No. of Valid cases	79	79	79
Mean	30	11.9	7.8
Median	29	10	8
Standard deviation	6.9	7.6	2.7
Minimum	19	1	3
Maximum	44	36	12

The causes of injury were either sport field injury 64.5%, trauma 22.7% or idiopathic 12.6% without any history of trauma.Joint Line Tenderness:Clinical examination by applying joint line tenderness, there were 32 patients with suspected medial meniscal tear, and from arthroscopy there were 29 patients with meniscal tear. There were 18 cases with suspected lateral meniscus, but on arthroscopy only 17 cases were confirmed as showed in Table 3 McMurray test:Clinical examination by applying McMurray test, there were 26 patients with suspected medial meniscal tear, but from arthroscopy there were 21 patients with meniscal tear. There were 17 cases with suspected lateral meniscus, but on arthroscopy only 13 cases were confirmedas inTable 4.Thessaly Test:Clinical examination by applying Thessaly test, there were 37 patients with suspected medial meniscal tear, and from arthroscopy there were 34 patients with meniscal tear. There were 20 cases with suspected lateral meniscus, but on arthroscopy only 18 cases were confirmed as shown in Table 4.

Table (4): Diagnostic Value of Joint Line Tenderness, McMurray and Thessaly Tests

	Joint Line Tenderness		McMurray test		Thessaly Test	
	Medial meniscus	Lateral meniscus	Medial meniscus	Lateral meniscus	Medial meniscus	Lateral meniscus
Sensitivity %	76.3	70.8	55.26	54.1	89.4	75.2
Specificity %	92.3	98.1	87.8	92.7	92.6	96.3
PPV %	90.6	94.4	80.7	76.4	91.8	90
NPV %	80.8	88.5	67.2	82.2	90.4	89.8
Accuracy %	84.81	89.7	72.1	81	91.1	89.8
P value	0.14	0.7	0.01	0.11	1	0.11

Medial Meniscus Injuries: Based on clinical examination, therewere 37 knees with suspicious medial meniscus tear, out of which there were 34 cases where arthroscopy waspositive in confirming the diagnosis, and 12 cases werebucket handle tear. From a total of 35 cases where MRI showed medial meniscal tear, only 32 cases were confirmed by arthroscopy as shown in Table 5Therefore, thediagnostic accuracy of clinical examination is as high as MRI for assessing medial meniscal tear as shownin Table 6.

Table (5): Diagnostic Value of MRI

	Medial meniscal tear	Lateral meniscal tear	ACL tear
Sensitivity	84.2%,	62%,	91.1
Specificity	92.6%	98%,	78.3
PPV	91.4%	93%	91.1
NPV	86.3%	85%.	78.3
Accuracy	88.6%	87%	87.3
P value	0.5	0.02	1

Lateral meniscus injuries: There were 20 knees with suspicious lateral meniscus tear on clinical diagnosis, out of which, there were 18 cases confirmed by arthroscopy in which four cases were bucket handle and two cases discoid meniscal tear. But from a total 16 cases where MRI showed lateral meniscal tear, only 15cases were confirmed by arthroscopy so the diagnostic accuracy of clinical examination is as high as MRI for diagnosing lateral meniscal tear as shown in Table 6.

Table (6): Comparing Clinical Finding with MRI Finding of Meniscal tear

	Medial Meniscus		Lateral Meniscus	
	Clinical	MRI	Clinical	MRI
Sensitivity %	89	84	75	62
Specificity %	92	92	96	98
PPV %	91	91	90	93
NPV %	90	86	89	85
Accuracy %	91.	89	89	87
P value	1	0.5	0.11	0.02

Anterior cruciate ligament injuries: Clinical examination by applying Lachman test, there were 54 patients with suspected ACL tear, but from arthroscopy there were 52 patients with ACL tear and diagnostic value showed in Table 7.Clinical examination by applying Anterior Drawer test, there were 37 patients with suspected ACL tear, but from the arthroscopic finding there were 35 patients with ACL tearand diagnostic value showed in Table 7. Clinical examination by applying Pivot Shift test, there were 33 patients with suspected ACL tear, but from arthroscopy there were 32 patients with ACL tearand diagnostic value showedin Table 3.6.Lachman test showed higher sensitivity and specificity in comparisonto anterior drawer test and pivot shift test as showedin Table 7.

Table (7): Diagnostic Value of Lachman, Anterior Drawer and Pivot Shift Test

	Sensitivity%	Specificity%	PPV%	NPV%	Accuracy%	P value
Lachman	92.8	91	96.2	84	92.4	0.68
Anterior Drawer	62.5	91.3	94.6	50	70.8	0
Pivot shift	57.1	95.6	88.8	47.8	68.3	0

From a total 56 cases where MRI showed ACL rapture, only 51 cases were confirmed by arthroscopyand diagnostic value showedTable 5. Therefore, the diagnostic accuracy of clinical examination is slightly higher than MRI for assessing ACL rapture as showed in Table 8.

Table (8): Comparing Clinical Examination with MRI for ACL Rapture

	Clinical finding	MRI finding
Sensitivity %	92.8	91.1
Specificity %	91	78.3
PPV %	96.2	91.1
NPV %	84	78.3
Accuracy %	92.4	87.3
P value	0.68	1

We have 56 cases of ACL injury; of which 16 cases were associated with medial meniscus injury, 9 cases with lateral meniscus injury, 7 cases with both medial and lateral meniscus injuries and 24 cases are isolated ACL injury. Wehad38 cases of medial meniscus injury, of which 13 cases were isolated medial meniscus, 23 cases were associated with ACL injuries. In our study, we have 24 cases of lateral meniscus in which 16 cases were associated with ACL injuries. Wehad9 cases of combined medial and lateral meniscus tear.

Discussion

We studied 79 patients assessing meniscal and anterior cruciate ligament injuries.Meniscus:In our study, several provocative maneuvers were performed to reproduce symptoms of torn meniscus. The McMurray test is the most widely used test and in our study the Accuracywas 72.1 % for medial meniscus and 81% for lateral meniscus whichis comparable to a study done by Karacholios inwhichthe accuracy was74% for medial meniscus and 84% for lateral meniscus. A study by Eren in 2003 concluded thatassessing joint line tenderness in 90 degree knee flexion is the most accurate test for detecting lateral meniscal tearas the accuracy was 96% and for medial meniscus the accuracy was 74%[23], but in our study the accuracy was 89% for lateral meniscus and 84% for medial meniscus.

In a study conducted byKaracholios et al in 2005, Thessaly test at 20 degree of knee flexion is regarded as first-line clinical test for diagnosing meniscal tear in which the accuracy was 94% for detecting medial meniscus tear and 96% for detecting lateral meniscus tear6; but in our study the accuracy was 91% for medial meniscus and 89% for lateral meniscus. ACL:The increasing prevalence of ACL injuries has led to a high financial expense on the health care system. It was difficult to make a distinction between total or partial ruptures of the ACL in some studies. Intwo studies a definition of a partial ACL tear was documented arthroscopically. Lucie et al defined a partial ACL tear as a ligament which had no loss of competence[24], whileBomberg and McGinty. defined it as a tear of a portion of the ACL, leaving the majority of the ligament fibers intact[25]. Based on these definitions we did not consider these tears as ACL ruptures in our data analysis. Anteior Drawer test: In our study, we found that the anterior drawer test has a poor sensitivity of 62.5% and high specificity of 91.3%. Torg et al put forward three potential causes for a false-negative anterior drawer test, especially in isolated ACL tears. First, hemarthrosis and reactive synovitis may reduce knee flexion to 90 degree, hindering performance of the test. Second, protective muscle action of the hamstrings secondary to joint pain provides a vector force opposite to the anterior translation of the tibia. Third, the posterior horn of the medial meniscus becomes buttressed against the posterior-most margin of the medial femoral condyle and may prevent anterior translation of the tibia[26]. Lachman Test: Our results indicate that the Lachman test has a best diagnostic accuracy to detect ACL injury, and is the most sensitive test of 92.8% with a favorable specificity of 91%. The position of the knee during this test (20–30 degree of flexion) is less painful than the position of the knee during the anterior drawer test; therefore, it reduces possible muscle contraction to prevent knee movement during examination. Additionally, the diagnosis to ACL injury is often difficult to assess, especially in acute injuries with hemarthrosis. The

diagnostic accuracy of the Lachman test in acute ruptures when the patient is examined without general anesthetic is superior to that of the anterior drawer test[27]. Pivot shift test: Our results for pivot shift test show high specificity namely 95.6% with poor sensitivity 57.1%.The pivot shift test assesses the combined anterior translation of tibia and tibia femoral internal rotation and that happens when the ACL is injured[28]. The pivot shift test reproduces the phenomenon of giving way of the knee. The reason for the very low sensitivity may be explained by the fact that a patient with a chronic ACL injury is familiar with this unpleasant sign and will display protective muscle action[29]. Our results are nearly matched with the findings of Scholten et al. In the meta-analysis by Scholten et al., the pivot shift test had high specificity of 97% to 99% % but poor sensitivity from 18% to 48%. The Lachman test was the most sensitive test to the diagnosis of ACL tears, showing the sensitivity of 86% and the specificity of 91%[30]. In the study by Benjaminse et al, the pivot shift test showed high specificity of 98% and sensitivity of 24%,but for the Lachman test, the sensitivity of 85% and specificity of 94% was documented7.Both of the studies showed that the pivot shift test is the most specific but has poor sensitivity. For the Lachmantest, both of the studies showed high sensitivity and specificity[7, 30]. These outcomes are consistent with our findings. For the anterior drawer test, neither of the studies recommended that a suitable value of sensitivity was received. Sensitivity of the anterior drawer test was 62% from Scholtenet al and 55% from the Benjaminse et al study[7, 30]; compared with the sensitivity of the anterior drawer test from previous studies listed above, similar results were achieved in our study, namely 62.5%.Comparing clinical finding with MRI findingin a study conducted by Kocabey et al, there was no statistically significant difference in comparing MRI with physical examination, in diagnosing ligament and meniscal injuries of the knee in relation to arthroscopic finding. This recommends that a well-qualified orthopedic surgeon can depend on clinical examination for diagnosing meniscal and ACL injuries [31]. Another study by Severino et al. showed that MRI was a suitable method supporting the clinical examination in cases of meniscus and ligament injuries of the knee with sensitivity, specificity values for MRI of ACL, Medial meniscus and lateral meniscus injuries respectively 82% and 96 %, 96% and 66%, and 87% and 88% in comparison with arthroscopic finding[32]. According to Yousef et al; on correlation between MRI and arthroscopy in diagnosing knee injuries, the following values were displayed including sensitivity, specificity and accuracy respectively 89%,72%,81% for medial meniscus,64%, 88%,76% for lateral meniscus and 90%,93%,92% for the ACL. It wasrecommended that MRI was an appropriate examination for diagnosing meniscal and ACL injuries when physical examinations wereinconclusive[33]. In our study, clinical examination and MRI were assessed and compared with arthroscopy; probably comparable results achievedwith the studies mentioned above. The accuracy of the physical examination for medial meniscal injuries was found to be 91% and the accuracy of MRI was 89%. For the lateral meniscus, the values were 89% for the physical examination and 87% for MRI. For ACL injuries, the accuracy of the physical examination was found to be 92 % and the accuracy of MRI was 87 %.

Navali et al. in 2013 declared that clinical examination and MRI had adequate diagnostic power in relation to knee injuries, although clinical examination was slightly superior. Therefore, because of the cost, MRI must be recommended for doubtful and complex knee injuries [34]. In a study by Ercin et al. in 2012, it was stated that clinical examinations that were performed by well-qualified experienced surgeons using multiple maneuvers, were adequate for making the diagnosis of meniscal injuries[35].

Conclusions

Thessaly test at 20 degree knee flexion is the most accurate clinical test for diagnosing meniscal tear followed by joint line tenderness. Our study concluded that Lachman test is regarded as the test with high diagnostic accuracy in terms of sensitivity and specificity and Pivot shift test has a very high specificity for diagnosing ACL rupture. Clinical examination and MRI have adequate diagnostic accuracy for assessing meniscus and ACL injuries of the knee. In suspected cases where there is inconclusive clinical finding, MRI is very helpful in making decision for arthroscopy.

References

1.Magee T, Shapiro M, Williams D. MR accuracy and arthroscopic incidence of meniscal radial tears. Skeletal radiology. 2002;31(12):686-9.

2.Feller JA, Webster KE. Clinical value of magnetic resonance imaging of the knee. ANZ journal of surgery. 2001;71(9):534-7.
3.Miller MD, Thompson SR. Miller›s Review of Orthopaedics. Seventh ed: Elsevier Health Sciences; 2016. 339-52 p.
4.Hegedus EJ, Cook C, Hasselblad V, Goode A, Mccrory DC. Physical examination tests for assessing a torn meniscus in the knee: a systematic review with meta-analysis. journal of orthopaedic & sports physical therapy. 2007;37(9):541-50.
5.Malanga GA, Andrus S, Nadler SF, McLean J. Physical examination of the knee: a review of the original test description and scientific validity of common orthopedic tests. Archives of physical medicine and rehabilitation. 2003;84(4):592-603.
6.Karachalios T, Hantes M, Zibis AH, Zachos V, Karantanas AH, Malizos KN. Diagnostic accuracy of a new clinical test (the Thessaly test) for early detection of meniscal tears. The Journal of Bone & Joint Surgery. 2005;87(5):955-62.
7.Benjaminse A, Gokeler A, van der Schans CP. Clinical diagnosis of an anterior cruciate ligament rupture: a meta-analysis. Journal of Orthopaedic & Sports Physical Therapy. 2006;36(5):267-88.
8.Lieberman JR. AAOS comprehensive orthopaedic review: American academy of orthopaedic surgeons; 2009.
9.Mandelbaum BR, Finerman GA, Reicher MA, Hartzman S, Bassett LW, Gold RH, et al. Magnetic resonance imaging as a tool for evaluation of traumatic knee injuries: anatomical and pathoanatomical correlations. The American journal of sports medicine. 1986;14(5):361-70.
10.Reicher MA, Rauschning W, Gold R, Bassett L, Lufkin R, Glen Jr W. High-resolution magnetic resonance imaging of the knee joint: normal anatomy. American journal of roentgenology. 1985;145(5):895-902.
11.Mink JH, Levy T, Crues 3rd J. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. Radiology. 1988;167(3):769-74.
12.Rayan F, Bhonsle S, Shukla DD. Clinical, MRI, and arthroscopic correlation in meniscal and anterior cruciate ligament injuries. International orthopaedics. 2009;33(1):129-32.
13.Huysse WC, Verstraete KL, Verdonk PC, Verdonk R, editors. Meniscus imaging. Seminars in Musculoskeletal radiology; 2008: © Thieme Medical Publishers.
14.Anderson MW. MR imaging of the meniscus. Radiologic Clinics of North America. 2002;40(5):1081-94.
15.Quinn SF, Brown TF. Meniscal tears diagnosed with MR imaging versus arthroscopy: how reliable a standard is arthroscopy? Radiology. 1991;181(3):843-7.
16.Gökalp G, Nas O, Demirag B, Yazici Z, Savci G. Contribution of thin-slice (1 mm) axial proton density MR images for identification and classification of meniscal tears: correlative study with arthroscopy. The British journal of radiology. 2014.
17.Araki Y, Yamamoto H, Nakamura H, Tsukaguchi I. MR diagnosis of discoid lateral menisci of the knee. European journal of radiology. 1994;18(2):92-5.
18.Rohren EM, Kosarek FJ, Helms CA. Discoid lateral meniscus and the frequency of meniscal tears. Skeletal radiology. 2001;30(6):316-20.
19.Miller MD, Thompson SR, Hart J. Review of orthopaedics: Elsevier Health Sciences; 2012.
20.Canale ST, Beaty JH. Campbell›s operative orthopaedics. Twelfth ed: Elsevier Health Sciences; 2016. 136-7 p.
21.Marshall S. Combined arthroscopic-open repair of meniscal injuries. Surgery and Arthroscopy of the Knee: Springer; 1988. p. 317-27.
22.Metcalf RW. Symposium on arthroscopic knee surgery: Saunders; 1982.
23.Eren OT. The accuracy of joint line tenderness by physical examination in the diagnosis of meniscal tears. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2003;19(8):850-4.
24.Lucie RS, Wiedel JD, Messner DG. The acute pivot shift: clinical correlation. The American journal of sports medicine. 1984;12(3):189-91.
25.Bomberg BC, McGinty JB. Acute hemarthrosis of the knee: indications for diagnostic arthroscopy. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 1990;6(3):221-5.
26.Torg JS, Conrad W, Kalen V. Clinical I diagnosis of anterior cruciate ligament instability in the athlete. The American journal of sports medicine. 1976;4(2):84-93.
27.Mitsou A, Vallianatos P. Clinical diagnosis of ruptures of the anterior cruciate ligament: a comparison between the Lachman test and the anterior drawer sign. Injury. 1988;19(6):427-8.
28.Bach JR BR, Warren RF, Wickiewicz TL. The pivot shift phenomenon: results and description of a modified clinical test for anterior cruciate ligament insufficiency. The American journal of sports

medicine. 1988;16(6):571-6.
29.Steinbrück K, Wiehmann J. Examination of the knee joint. The value of clinical findings in arthroscopic control. Zeitschrift fur Orthopadie und ihre Grenzgebiete. 1987;126(3):289-95.
30.Scholten R, Opstelten W, van der Plas CG, Bijl D, Deville W, Bouter LM. Accuracy of physical diagnostic tests for assessing ruptures of the anterior cruciate ligament: a meta-analysis. Journal of family practice. 2003;52(9):689-96.
31.Kocabey Y, Tetik O, Isbell WM, Atay ÖA, Johnson DL. The value of clinical examination versus magnetic resonance imaging in the diagnosis of meniscal tears and anterior cruciate ligament rupture. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2004;20(7):696-700.
32.Severino NR, Camargo O, Aihara T, Cury R, Oliveira V, Vaz C, et al. Comparação entre a ressonância magnética e a artroscopia no diagnóstico das lesões do joelho. Rev Bras Ortop. 1997;32(4):275-8.
33.Yousef WJ, Thiele ES, Scuisato DL. Correlação diagnóstica da ressonância magnética com artroscopia nas lesões intra-articulares do joelho. Rev bras ortop. 1999;34(6):375-80.
34.Navali AM, Bazavar M, Mohseni MA, Safari B, Tabrizi A. Arthroscopic evaluation of the accuracy of clinical examination versus MRI in diagnosing meniscus tears and cruciate ligament ruptures. Archives of Iranian medicine. 2013;16(4):229.
35.Ercin E, Kaya I, Sungur I, Demirbas E, Ugras AA, Cetinus EM. History, clinical findings, magnetic resonance imaging, and arthroscopic correlation in meniscal lesions. Knee surgery, sports traumatology, arthroscopy. 2012;20(5):851-6.