ОРИГИНАЛЬНАЯ СТАТЬЯ

VALIDITY OF ULTRASOUND AND MAGNETIC RESONANCE IMAGING FINDING IN PATIENT WITH ANTERIOR CRUCIATE LIGAMENT INJURY

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The Anterior Cruciate Ligament (ACL) is one of 4 major ligaments of the knee. Magnetic resonance imaging (MRI) has a highly effective non-invasive diagnostic modality for ACL injuries. Ultrasound (US) technique has a promising and effective tool in the diagnosis of ACL injuries within the knee.

Purpose. To assess the validation of US and MRI in the detection of ACL tears and to determine the accuracy between ultrasound and MRI in the distinguishing of ACL Injury.

Materials and methods. A prospective validation study of 40 patients with knee joint trauma, at a period from 26th July 2023 to 29th May 2024. All these were sent for knee joints MRI with suspicion of ACL injuries. Data collected include age of patient, sex, side of knee (right or left), History of knee injury or surgery and comorbid conditions. US findings included tears, types of tear and associated lesions. MRI findings include ACL tear, direct signs and in-direct signs. US to knee joints was done using B-mode and MRI 1.5-Tesla was used.

Results. In this study, the mean age of patients was 43.35±13.2 yrs, 28 were males (70%) and 12 were females (30%). Right side knee joint effected was reported in 60% of cases while left side was reported in 40%. Ligamentous lesions were visualized in most of 28 patients (70%). The complete ACL tear was detected in four patients. The partial tear seen in 21 patients (52.5%). The commonest MRI sign was thickening of edema noticed in 14 cases (35%). Nine patients (22.5%) were detected with tear by US. MRI showed greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to 90% with a high statistical significant ($p<0.0001$). The MRI was superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint ($p<0.0001$).

Discussion. In 2024, Voinea et al., Schwartz et al., Schulc et al., Gul et al. discussed the roles of MRL in the diagnosed of ligaments tear of knee. They confirmed the superiority of MRI aver US. In the present study, MRI showed greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to 90% in diagnosis of ligamentous lesions of knee joint with a high statistical significant ($p<0.0001$). In regard to US parameters, there was no significant difference in detection of tear (79% sensitivity, 77% specificity) and tear types (78% sensitivity, 77% specificity). The MRI was superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint (Youden's index=0.82 vs. 0.56, AUC=0.967 vs. 0.65, $p<0.0001$). Zhao et al. found that the sensitivity, specificity, and accuracy of MRI in the diagnosis of ACL injury were 95.45%, 91.67%, and 94.87%, respectively, which was higher than we estimated. They showed high accuracy rates among direct MRI sign than indirect. In large meta-analysis study, Raheem et al. searched 199 published papers about MRI roles in diagnosis of knee ligamentous injuries. They found that sensitivity, specificity, of ultrasound were 80.16%, 89.56%, respectively, for ACL tears while for MRI were 96.08%, 84.86%, respectively.

Conclusion. The MRI is superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint. MRI have greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to 90%.

Keywords: anterior cruciate ligament, MRI, ligamentous lesions, complete tear, ultrasonography.

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ДОСТОВЕРНОСТЬ РЕЗУЛЬТАТОВ УЛЬТРАЗВУКОВОГО ИССЛЕДОВАНИЯ И МАГНИТНО-РЕЗОНАНСНОЙ ТОМОГРАФИИ У ПАЦИЕНТОВ С ПОВРЕЖДЕНИЕМ ПЕРЕДНЕЙ КРЕСТООБРАЗНОЙ СВЯЗКИ

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Передняя крестообразная связка (ПКС) является одной из четырёх основных связок колена. Магнитно-резонансная томография (МРТ) является высокоэффективным неинвазивным методом диагностики повреждений передней крестообразной связки. Ультразвуковое исследование (УЗИ) является перспективным и эффективным инструментом в диагностике повреждений передней крестообразной связки в коленном суставе.

Цель исследования. Оценка достоверности ультразвукового исследования и магнитно-резонансной томографии при выявлении разрывов передней крестообразной связки, а также в определении точности этих методов в дифференцировке повреждений передней крестообразной связки.

Материалы и методы. Проведено проспективное валидационное исследование 40 пациентов с травмой коленного сустава в период с 26 июля 2023 года по 29 мая 2024 года.
Все они были направлены на магнитно-резонансную томографию коленного сустава с подозрением на повреждение передней крестообразной связки (ПКС). Собранные данные включали возраст пациента, пол, сторону поражения (правое или левое колено), историю травм или операций на колене, а также сопутствующие заболевания. Результаты ультразвукового исследования (УЗИ) включали данные о разрывах, их типах и сопутствующих повреждениях. Результаты МРТ включали данные о разрывах передней крестообразной свзки, прямые и косвенные признаки повреждения. УЗИ коленных суставов проводилось с использованием В-режима, для проведения МРТ использовался магнитно-резонансный томограф 1,5 Тл.

Результаты. В данном исследовании средний возраст пациентов составил 43,35±13,2 года; мужчин – 28 (70%) человек, женщин – 12 (30%). Правостороннее поражение коленного сустава отмечалось в 60% случаев, левостороннее – в 40%. Повреждения связок были выявлены у большинства пациентов – 28 (70%). Полный разрыв передней крестообразной связки был выявлен у 4 пациентов. Частичный разрыв наблюдался у 21 пациента (52,5%). Самым распространенным МР-признаком было увеличение отека, отмеченное у 14 пациентов (35%). У 9 пациентов (22,5%) разрыв был выявлен с помощью УЗИ. МРТ показала более высокую чувствительность и специфичность (92% и 90% соответственно), а точность достигла 90% с высокой статистической значимостью (p<0,0001). МРТ превосходила УЗИ по достоверности результатов у пациентов с травмой передней крестообразной связки и повреждениями связок коленного сустава (p<0,0001).

Обсуждение. В 2024 году авторы Voinea et al., Schwartz et al., Schulc et al., Gul et al. обсудили роль МРТ в диагностике разрыва связок колена. Они подтвердили превосходство МРТ над УЗИ. В настоящем исследовании МРТ показала большую чувствительность и специфичность (92% и 90% соответственно), с точностью до 90% в диагностике повреждений связок коленного сустава с высокой статистической значимостью (p<0,0001). Что касается параметров УЗИ, то не было выявлено существенной разницы в обнаружении разрывов (чувствительность – 79%, специфичность – 77%) и типов разрывов (чувствительность – 78%, специфичность – 77%). МРТ превосходила УЗИ в подтверждении у пациентов травмы передней крестообразной связки и повреждений связок коленного сустава (индекс Youden = 0,82 против 0,56, AUC = 0,967 против 0,65, p<0,0001). Zhao et al. обнаружили, что чувствительность, специфичность и точность МРТ в диагностике повреждения ПКС составили 95,45%, 91,67% и 94,87% соответственно, что выше,

чем мы предполагали. Они показали высокую точность прямых МР-признаков по сравнению с непрямыми. В большом мета-аналитическом исследовании Raheem et al. проанализировали 199 опубликованных работ о роли МРТ в диагностике повреждений связок колена. Они обнаружили, что чувствительность и специфичность УЗИ при разрывах передней крестообразной связки составили 80,16%, 89,56%, соответственно, в то время как при МРТ – 96,08%, 84,86% соответственно.

Заключение. Магнитно-резонансная томография (МРТ) превосходит ультразвуковое исследование (УЗИ) в точности диагностики повреждений передней крестообразной связки и повреждений связок коленного сустава. МРТ демонстрирует большую чувствительность и специфичность (92% и 90% соответственно), при этом уровень точности достигает 90%.

Ключевые слова: передняя крестообразная связка, МРТ, повреждение связок, полный разрыв, ультразвуковое исследование.

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Injuries to the anterior cruciate ligament (ACL) typically occur as a result of non-contact incidents, involving a combination of movements like femoral adduction and internal rotation, knee flexion, or tibial rotation, along with the foot and ankle assuming a valgus position [1]. These combinations can lead to either partial or complete tears of the anterior cruciate ligament [1]. Moreover, the risk of injury is significantly elevated during the deceleration of the lower limb, especially when the quadriceps are maximally contracted and the knee is fully extended [2]. Although ACL rupture typically arises from non-contact injuries, incidents during contact sports such as football can [3].

In recent times, MRI has emerged as a highly effective non-invasive diagnostic method for ACL injuries in clinical settings [4]. Apart from diagnosing ACL injuries, MRI also provide insights into other joint lesions, allowing for the precise determination of the location and extent of ligament tears. The advantages of MRI, such as high spatial and soft tissue resolution, enable clear visualization of the overall knee joint structure, facilitating clinical observation of injuries to the anterior and posterior cruciate ligaments [5]. However, when injury occurs, the ACL signal changes, and abnormalities in walking become apparent. The ligament swells, exhibiting diffused high signals due to the destruction of the peptide network structure and the accumulation of fluid, potentially leading to ligament breakage, twisting, or even disappearance. ACL injuries disrupt the stability of the knee joint, causing the tibia to move forward and resulting in abnormalities in the shape and position of the meniscus and posterior cruciate ligament, which serve as indirect signs aiding in the diagnosis of ACL injuries [6].

MRI serve as a valuable diagnostic tool for assessing ACL injuries, and this is done by idenfiying primary and secondary signs associated with this condition. Primary signs specifically focus on the ligament itself, including features such as swelling, increased signal on T2 or fat-saturated PD, fiber discontinuity, and abnormal ACL orientation relative to the intercondylar (Blumensaat) line [7]. Notably, a disrupted ACL line, an angle greater than 15° with an anterior apex, and the empty notch sign indicating femoral attachment avulsion are indicative of a ruptured and collapsed ligament. The empty notch sign serves as a direct indicator of an ACL tear or avulsion at its femoral attachment. This sign is characterized by the presence of a fluid signal observed at the anticipated ACL attachment site within the intercondylar notch (fossa) on both axial and coronal fluid-sensitive MR images [8]. Midsubstance tears typically manifest as ligament discontinuity or abnormal contour, with hyperintense signals on T2 suggesting partial rupture. Isolated postero-lateral bundle tears exhibit unique signs like the gap and footprint signs [9]. Gap sign refers to the presence of a fluid signal or a visible space be-

tween the medial aspect of the lateral femoral condyle and the lateral aspect of the mid-ACL, detectable on axial or coronal MRI images. While, the footprint sign is characterized by inadequate coverage of the lateral aspect of the tibial spine by the distal ACL attachment, observable exclusively on coronal MRI images [10].

Secondary signs associated with ACL injuries include bone contusions in the lateral femoral condyle and posterolateral tibial plateau, the anterior tibial translocation sign indicating >7 mm of anterior tibial translation, and uncovering of the posterior horn of the lateral meniscus. The comprehensive assessment provided by MRI aids clinicians in precisely identifying and understanding the extent of ACL injuries through these distinctive imaging features [7].

Dynamic high-resolution US imaging has emerged as a promising and effective tool in the diagnosis of ACL injuries within the knee [11]. This imaging technique has shown significant potential in accurately visualizing intra-articular pathology, offering a viable alternative to traditional diagnostic methods such as MRI. A recent meta-analysis, assessing the diagnostic accuracy of US in detecting complete ACL tears, reported encouraging data. The study demonstrated a sensitivity of 90% and specificity of 97%, indicating that US is a highly reliable method for diagnosing complete ACL tears [12]. US is a quick, relatively inexpensive, and easily accessible imaging modality. These characters make it a convenient option, particularly for situations where time and cost constraints are crucial factors. The potential for dynamic examinations further enhances its utility, as dynamic US can reveal pathology that may go unnoticed in static examinations. This capability allows for the visualization of the impact of movement on the function and stability of the affected knee structures [13].

Aims of the study are to assess the validation of US and MRI in the detection of ACL tears and to determine the accuracy between ultrasound and MRI in the distinguishing of ACL Injury.

Materials and Methods.

Study design and setting.

A cross-sectional validation study of 40 patients with knee joint trauma were sampling in this research at Department of Radiology in Al-Hilla General Hospital, at a period from 26th July 2023 to 29th May 2024. All these were sent for knee joints MRI with suspicion of ACL injuries.

Data collection.

Data collected include age of patient, sex, side of knee, History of knee injury or surgery and comorbid conditions. Ultrasonography findings included tears, types of tear (complete or partial) and associated lesions. MRI findings include ACL tear, direct and in-direct signs.

Inclusion criteria.

1. No history of knee surgery.
2. Under taking both MRI and US examinations.

Exclusion criteria.

1. Knee-joint history of traumas.
2. Bleeding disorders.
3. Fractures.
4. Contraindication for MRI.
5. Pregnancy and lactation.
6. Osteoarthritis.
7. Developmental deformities.

US.

US (Mindray Doppler ultrasound, DC60, China, 2018) to knee joints was done using B-mode. A Frequency Range: (3.0 - 14.0) MHz, Linear probe transducer (Philips HD 11, USA, 2011, linear probe c6-3) was used. ACL discontinuity of fibers, posterior cruciate ligament wavy pattern and effusion were detected by US.

MRI.

MRI 1.5-Tesla (type Achieva 1.5.0T TX; Koninklijke Philips Electronics NV, Eindhoven, Holland, Netherlands) with Quadrature knee/foot coil (USA) was used. Joint flexible coil was used. The sequence parameters:

• Weighted image with fat saturation sagittal position; RF pulse reputation time 3500 ms; TE 60ms; layer thickness 3mm; FOV 190*145mm.

• Proton Density Weighted image sagittal position; RF pulse reputation time 3553 ms; TE 30ms; layer thickness 3mm; FOV 160*160mm.

• T1-WI sagittal position; RF pulse reputation time 533 ms; TE 8ms; layer thickness 3mm; FOV 160*160mm.

• T2-WI sagittal position; RF puls reputation time 4007 ms; TE 80 ms; layer thickness 3mm; FOV 140*168mm.

Ethical considerations.

The study was approved by the Medical Ethical Committee of College of Medicine, Babylon University (5053 in 26-07-2023).

Statistical analysis.

Statistical package for social science (SPSS version 26.0, NY, IBM Inc.) was used. Data were described as number and percentage for qualitative data, and mean with SD for quantitative data. Diagnostic accuracy was evaluated with ROC curve analysis. The area under curve (AUC) for the diagnostic test was used. The accuracy, sensitivity, and specificity were calculated. A one-sided P value of <0.05 was considered statistically significant.

Results.

Patients results.

In this study, 40 patients with knee joint trauma were enrolled. The mean age of patients

was 43.35±13.2 yrs ranged from 8 yrs to 61 yrs (median =45.5 yrs). Most of patients in included in age group (46-60 yrs) as 18 (45%), followed by those aged (31-45 yrs) as (14, 35%). In regard to gender, 28 were males (70%), and 12 were females (30%). Right side knee joint effected was reported in 60% of cases while left side was reported in 40%. Seven patients were had history of knee injury or surgery whereas (n=33; 82.5%) were free. 22 of 40 cases (55%) suffered from comorbidity (Table №1).

Results according MRI signs.

Table №2 listed MRI signs of ligamentous lesions and tearing of effected knee joints in this study. Ligamentous lesions were visualized in most of patients as 28 (70%) whereas not detected in 12 (30%). In regard to ACL tear, the complete tear was detected in four patients. The partial tear seen in 21 (52.5%) patients. However, 15 of 40 (37.5) cases didn't shown ACL tear. Regarding the direct sign of MRI, the commonest was thickening of edema noticed in 14 cases (35%). Those with atrophy attenuate were 10 cases (25%). Seven patients had interrupt of ACL continuity. In addition, in-direct sign of MRI recorded as followed: 5 (12.5%) posterior cruciate ligament angle, 8 (20%) bone contusion and two cases with anterior tibial displacement. No patients recorded with posterior cruciate ligament index or notch sign (fig. 1 A, fig. 2 A, fig. 3 A, fig. 4 A).

Results according US signs.

Table №3 showed US signs of ligamentous tearing of effected knee joints in this study. Nine patients (22.5%) were detected with tear. The complete tear was detected in three patients. The partial tear seen in 6 patients (15%). However, 31 of 40 (77.5) cases didn't shown tear by US examination. Those presented with associated lesion (medial meniscus) were 3 (7.5%) of patients (fig. 1 B, fig. 2 B, fig. 3 B, fig. 4 B).

Receiver operating characteristic (ROC) curves and accuracy rates results.

MRI showed greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to 90% in diagnosis of ligamentous lesions of knee joint with a high statistical significant (p<0.0001). Furthermore, MRI sensitivity, specificity and accuracy for ACL tear, direct sign and in-direct sign were (81%; 82%; 88%), (66%; 47%; 71%), (55%;48% ;62%), respectively (Table №4, Fig. 5). In regard to US parameters, there was no significant difference in detection of tear (79% sensitivity, 77% specificity), tear types (78% sensitivity, 77% specificity) and medial meniscus (59% sensitivity, 70% specificity) (Table №4, fig. 6).

The net ROC of this study illustrated in Figure 7. The MRI was superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint (Youden's index = 0.82 vs. 0.56, AUC= 0.967 vs. 0.65, p<0.0001).

Table №1. Patients results of this study (n=40).

Variables		No. of patient	%
Age (years)	<15	2	5
	15-30	4	10
	31-45	14	35
	46-60	18	45
	>60	2	5
Gender	Male	28	70
	Female	12	30
Knee joint side	Right	24	60.0
	Left	16	40.0
History of knee injury or surgery	Yes	7	17.5
	No	33	82.5
Comorbid conditions	Yes	22	55
	No	18	45

Discussion.

In this study, 40 patients with knee joint trauma were enrolled. The mean age of patients was 43.35±13.2 years (median =45.5 years), 28 were male (70%), and 12 were female (30%). Right knee joint effected more than left (60% vs. 40%). Seven patients were had history of knee injury or surgery. 22 of 40 (55%) cases suffered from comorbidity. These are dissimilar with Zhao et al. and Sultana et al. whom enrolled cases more than us [14, 15]. Zhao et al. included 78 patients (55 were male and 23 were female, with a mean age of 42.64±6.57 yrs) [14]. Xu and co-authors included more than 300 patients with acute and chronic ACL injuries [16].

In this study, ligamentous lesions were visualized by MRI in most of patients as 28 (70%). In regard to ACL tear, the complete tear was detected in four patients. The partial tear

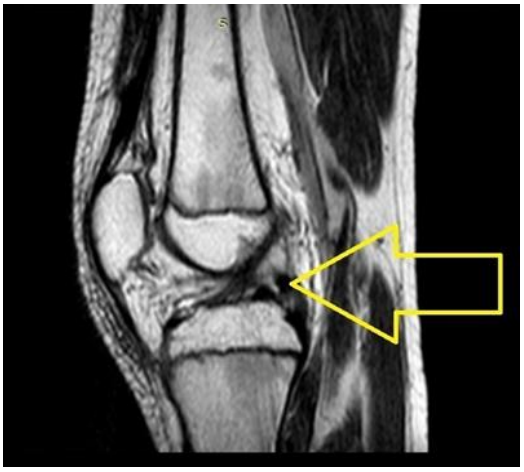


Fig. 1 a (Рис. 1 а)

Fig. 1 b (Рис. 1 б)

Fig. 1. a – MRI of right knee joint, sagittal view. b– US of knee joint.

a – Patient, 13-years-old boy, with ligamentous lesions positive showed partial ACL tear with atrophy attenuate and abnormal walking sign (yellow arrow).

b – Negative for tearing (yellow circle).

Рис. 1. Параметрические карты функции легких здорового добровольца.

а – τ-карты эффективного времени накопления газа ОФЦБ в легких (верхний ряд) и его выведения из легких (нижний ряд), построенные для методики wash-in/wash-out (слева) и single-breath (справа), соответственно.

б – FV-карты накопления газа ОФЦБ в легких (верхний ряд) и его выведения из легких (нижний ряд), построенные для методики wash-in/wash-out (слева) и single-breath (справа), соответственно.

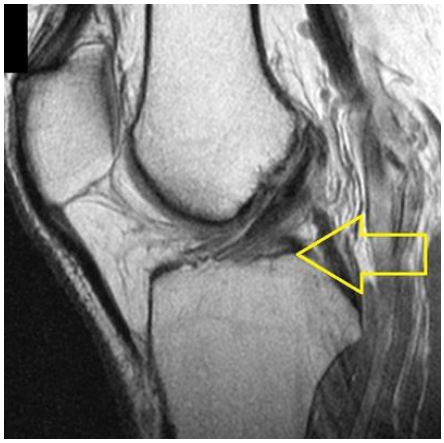


Fig. 2 a (Рис. 2 а)

Fig. 2 b (Рис. 2 б)

Fig. 2. a – MRI of right knee joint, sagittal view. b – US of knee joint.

a – Patient, 49-years-old man with ligamentous lesions positive showed partial ACL tear (yellow arrow), atrophy attenuate and abnormal walking sign.

b – Medial meniscus lesion and negative for tearing (yellow circle).

Рис. 2. Параметрические карты функции легких здорового добровольца.

а – Пациент, 49 лет, с признаками повреждения связок: частичный разрыв передней крестообразной связки (желтая стрелка), атрофия и нарушение походки.

б – Повреждение медиального мениска. Данных за разрыв связки не получено (желтая окружность).

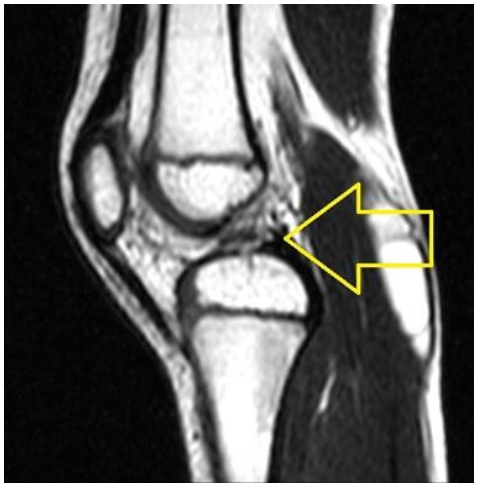


Fig. 3 a (Рис. 3 а)

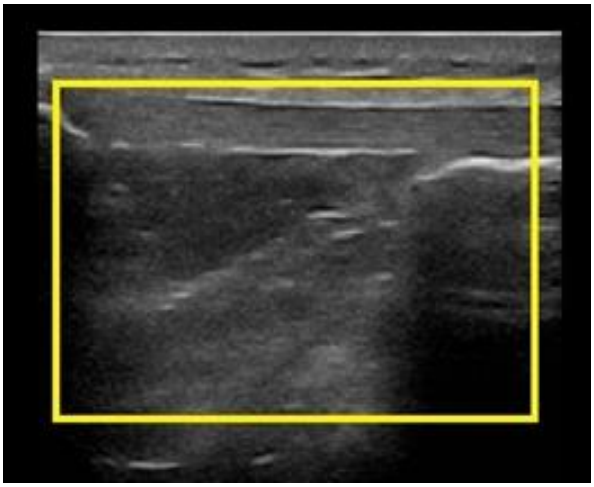


Fig. 3 b (Рис. 3 б)

Fig. 3. a – MRI of right knee joint, sagittal view. b– US of knee joint.

a – Patient, 8-years-old girl with history of knee injury and ligamentous lesions positive showed complete ACL tear with interrupt of ACL continuity (yellow arrow).

b – Medial meniscus lesion and partial tearing (yellow rectangle).

Рис. 3. Параметрические карты функции легких здорового добровольца.

а – Пациентка, 8 лет, с травмой колена и признаками повреждения связок: полный разрыв передней крестообразной связки с нарушением непрерывности связки (желтая стрелка).

б – Повреждение медиального мениска и частичный разрыв (желтый прямоугольник).

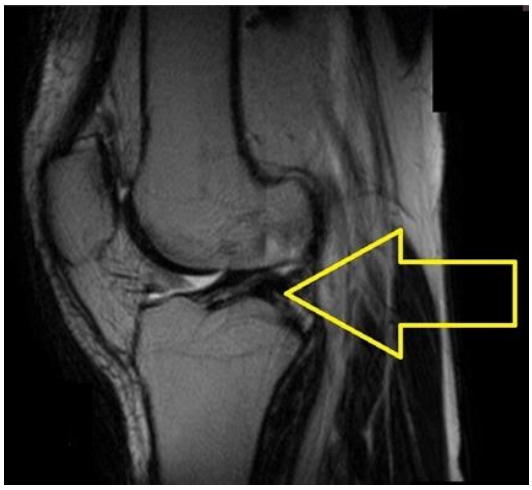


Fig. 4 a (Рис. 4 а)

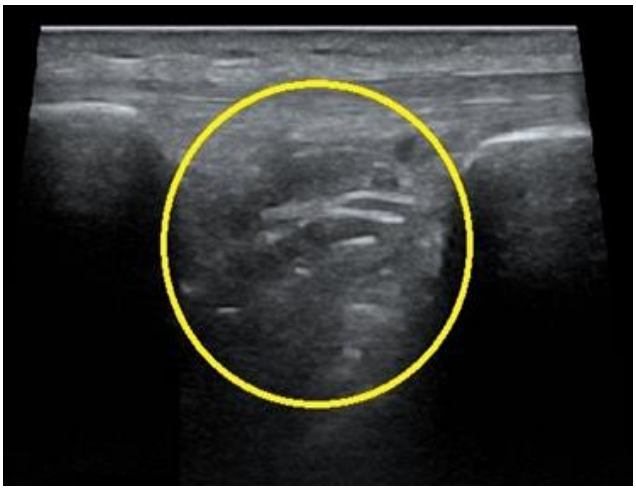


Fig. 4 b (Рис. 4 б)

Fig. 4. a – MRI of right knee joint, sagittal view. b – US of knee joint.

a – Patient, 28-years-old man with history of knee injury and ligamentous lesions positive showed complete ACL tear with interrupt of ACL continuity accompanied by posterior cruciate ligament angle and bone contusion (yellow arrow).

b – Complete tearing (yellow circle).

Рис. 4. Параметрические карты функции легких здорового добровольца.

а – Пациент, 28 лет, травма колена в анамнезе, с признаками повреждения связок: полный разрыв передней крестообразной связки с нарушением её непрерывности, сопровождающийся вовлечением задней крестообразной связки и ушибом костной ткани (желтая стрелка).

б – Полный разрыв (желтая окружность).

Table №2. MRI signs (n=40).

Variables		No. of patient	%
Ligamentous lesions	Yes	28	70
	No	12	30
ACL tear	Complete	4	10
	Partial	21	52.5
	No	15	37.5
Direct sign	Atrophy attenuate	10	25
	Thickening of edema	14	35
	Interrupt of ACL continuity	7	17.5
In-direct sign	Posterior cruciate ligament angle	5	12.5
	Posterior cruciate ligament index	0	0
	Bone contusion	8	20
	Notch sign	0	0
	Anterior tibial displacement	2	5

Table №3. US signs (n=40).

Variables		No. of patient	%
Tear	Yes	9	22.5
	No	31	77.5
Type of tear	Complete	3	7.5
	Partial	6	15
	No	31	77.5
Associated lesion	Lateral meniscus	-	-
	Medial meniscus	3	7.5
	Medial collateral ligament	-	-
	Posterior cruciate ligament	-	-

Table №4. Accuracy rates and AUC in the study.

Parameters		Sensitivity	Specificity	PPV	NPV	Accuracy	AUC	P- value
		%						
MRI	Ligamentous lesions	92	90	90	55	90	0.963	<0.0001
	ACL tear	81	82	89	66	88	0.907	<0.0001
	Direct sign	66	47	65	45	71	0.615	0.289
	In-direct sign	55	48	60	51	62	0.489	0.918
US	Tear	79	77	70	69	75	0.650	0.16
	Tear type	78	77	70	68	70	0.650	0.16
	Associated lesion	59	70	66	60	65	0.550	0.639

MRI, magnetic resonance image; US, ultrasonography; PPV, positive predictive value; NPV, negative predictive value; AUC, are under curve.

seen in 21 patients (52.5%). Regarding the direct sign of MRI, the commonest was thickening of edema noticed in 14 cases (35%). Those with atrophy attenuate were 10 (25%). Seven patients had interrupt of ACL continuity. In addition, in-direct sign of MRI recorded as followed: 5 (12.5%) posterior cruciate ligament angle, 8 (20%) bone contusion, and two cases with anterior tibial displacement. In the current study, nine patients (22.5%) were detected with tear by US. The complete tear was detected in three patients. The partial tear seen in 6 (15%) patients. Those presented with associated lesion (medial meniscus) were 3 (7.5%) of patients. Zhao et al. found complete tear in 28 cases, 37 partial and one normal [14].

In 2024, Voinea et al., Schwartz et al., Schulc et al. [19], Gul et al. discussed the roles of MRL in the diagnosed of ligaments tear of knee. They confirmed the superiority of MRI aver US [17-19].

In the present study, MRI showed greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to 90% in diagnosis of ligamentous lesions of knee joint with a high statistical significant ($p<0.0001$). Furthermore, MRI sensitivity, specificity and accuracy for ACL tear, direct sign and in-direct sign were (81%; 82%; 88%), (66%; 47%; 71%), (55%;48% ;62%), respectively. In regard to US parameters, there was no significant difference in detection of tear (79% sensitivity, 77% speci-

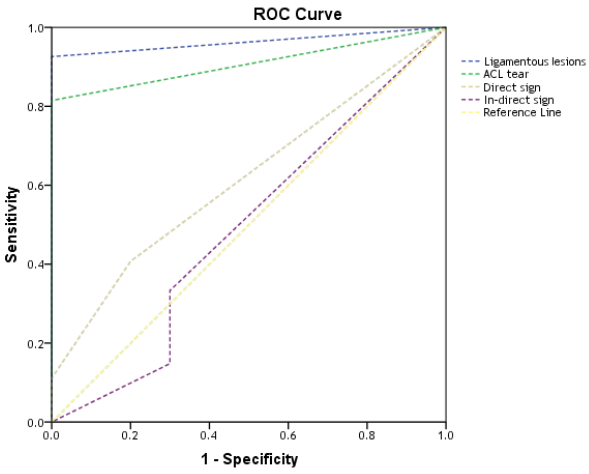


Fig. 5 (Рис. 5)

Fig. 5. ROC-curve of MRI findings.

Рис. 5. ROC-кривая результатов МРТ.

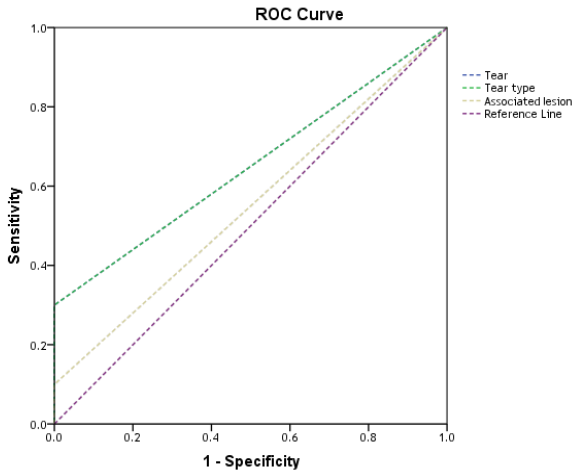
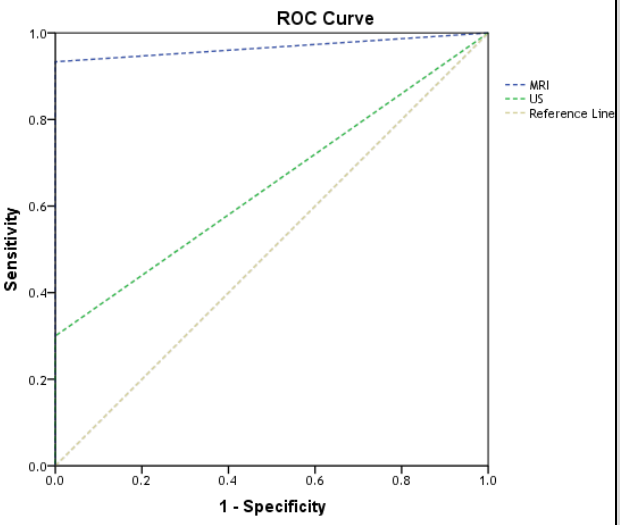


Fig. 6 (Рис. 6)

Fig. 6. ROC-curve of US findings.

Рис. 6. ROC-кривая результатов УЗИ.



Test	AUC	SE	p-value	95%CI	
				Lower Bound	Upper Bound
MRI	0.967	0.028	<0.0001	0.912	1.000
US	0.650	0.090	0.160	0.474	0.826

Fig. 7. The net ROC curve of findings of this study.

Рис. 7. Чистая ROC-кривая результатов данного исследования.

ficity), tear types (78% sensitivity, 77% specificity) and medial meniscus (59% sensitivity, 70% specificity). The MRI was superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint (Youden's index = 0.82 vs. 0.56, AUC= 0.967 vs. 0.65, p<0.0001). Zhao et al. found that the sensitivity, specificity, and accuracy of MRI in the diagnosis of ACL injury were 95.45%, 91.67%, and 94.87%, respectively, which was higher than we estimated [14]. They showed high accuracy rates among direct MRI sign than indirect. In large meta-analysis study, Raheem et al. searched 199 published papers about MRI roles in diagnosis of knee ligamentous injuries [21]. They found that sensitivity, specificity, of ultrasound were 80.16%, 89.56%, respectively, for ACL tears while for MRI were 96.08%, 84.86%, respectively.

The advantages of US are US suitable for immediate examination (point of care), can used not only for ligaments tears, also to detect other musculoskeletal disorders in knee trauma, capable to compare in real-time between injured and non-injured knee, functional dynamic-US can be performed [22, 23]. This mean that the US is an efficient test for ACL tear determining a complete, but it not an adequate test (low sensitivity and specificity than MRI).

Raheem et al. US is affordable and quick early diagnostic test that can lead to recommendations for further MRI examinations for detecting CL tears in patients with acute knee trauma [21].

There are several advantages to knee MRI, like high soft tissue resolution, high spatial resolution, clear display the overall knee joint structures, and facilitate clinical observations of CL (anterior and posterior) injuries [24]. Furthermore, the combination of MRI direct and indirect signs can be as effective as in the improvement and raising of the accuracy rates in the diagnosis of ACL injuries [14].

Qayyum et al. studied 59 patients (age ranged 15-30 yrs) with knee injuries [25]. All underwent US prior to MRI. Right knee involved in 31 cases and left in 28 cases. MRI showed 48 cases with ACL tear, while US showed 42 cases only (P=0.07). They assumed that MRI as gold standard modality, therefore, US had 85.4% sensitivity, 90.9% specificity and accuracy was 86.4%, which are greater than we observed.

MRI is a non-invasive modality that remain the orthopedic's first choice for the diagnosis of ACL injuries with high sensitivity (73-100%) and specificity (68-100%) [26]. Oei et al defined the MRI sensitivity and specificity in diagnosing ACL injuries as 94.3% (95% CI: 92.7–95.9) and 94.4% (95% CI: 92.3-96.6), respectively, which is greater than our study [27]. This could be explained by small sample selected and short time of our cohort.

Qayyum et al. concluded that US can be utilized as first line imaging modality when MRI is unavailable [25]. US with dynamic scan, was remarkable examination with high accuracy rates. The advantages included give an early clue, easy available, least cost and least invasive and immediate management objective.

In large cohort, Breukers and colleagues, studied 1617 cases presented with knee injuries. Of those, 120 cases showed ACL tears (60 as partial and 59 as complete) [28]. US sensitivity in complete ACL tears was 79% with specificity of 89%, and for partial ACL tears were sensitivity of 52% with specificity 85%. These findings are in accordance with our data.

An important finding is that the US diagnostic accuracy / MRI accuracy in detecting ACL tears, and that US accuracy for diagnosing partial tears is in the range of accuracy findings reported for MRI [29]. MRI detection of a partial tears can be difficult due to various tear status may be seen, however, one study reaveled that partial ACL tears showed MRI signs that are non-differentiated from complete tears or even normal CL [30].

Breukers et al. concluded that the excellent NPV for complete CL tear indicate that dynamic-US technique use as a primer radiological point-of-care examination and the MRI seem not to be superior to US, which is differ from our conclusion [28].

Recently, a review published by Pandya and Melville, concluded that the knee joint pathologies can be imaged by US (majority) and MRI [31]. US provide real-time-dynamic images, easily evaluate the superficial structures, effectiveness (depend on technical skills, body habitus, and depth of pathology), in comparison, MRI effectively diagnose abnormalities (superficial and deep structures); however, it is costly, not available widely and contraindicated in patients with implanted medical devices.

Conclusions.

The MRI is superior to US in the validity finding in patient with ACL injury and ligamentous lesions of knee joint. MRI have greater sensitivity and specificity (92% and 90%), respectively with accuracy rate reached to (90%). US have (79% sensitivity, 77% specificity) in diagnosed of tears.

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