ISSN Print: 2664-9810
ISSN Online: 2664-9829
IJRC 2024; 6(2): 11-15
www.radiologyjournals.com
Received: 12-05-2024
Accepted: 16-06-2024

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Ocular ultrasound in different eye problems compared to MRI

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DOI: https://doi.org/10.33545/26649810.2024.v6.i2a.23

Abstract
Background: Eye disorders such as retinal detachments, vitreous hemorrhages, ocular tumors, and optic nerve abnormalities can significantly affect vision and overall eye health. Accurate diagnosis is crucial for determining appropriate treatment strategies. Ocular ultrasound and magnetic resonance imaging (MRI) are two commonly used modalities for diagnosing eye problems. This study aims to compare the diagnostic effectiveness of ocular ultrasound and MRI in the evaluation of various ocular pathologies.
Methods: This prospective cohort study included 50 patients who underwent both ocular ultrasound and MRI for the evaluation of various eye conditions. Patients were recruited from Benha University Hospitals and select centers in Iraq from July 1, 2023, to February 1, 2024. Both diagnostic tools were used to assess acute and chronic ocular issues such as retinal detachments (RD), vitreous hemorrhages (VH), posterior vitreous detachments (PVD), and ocular tumors. Data were analyzed using SPSS, with statistical significance set at $p \leq 0.05$.
Results: Among the 50 patients, 62% were male, and the mean age was 44.2±10.9 years. Ocular ultrasound identified retinal detachment in 27.77% of cases, PVD in 5.55%, and optic nerve drusen in 5.55%. MRI detected retinal detachment in 37.5%, PVD in 20.83%, and optic nerve drusen in 29.16%. A statistically significant difference was found between ultrasound and MRI in the detection of PVD (p=0.044), RD (p=0.046), coloboma (p=0.031), and optic nerve drusen (p=0.024). For chronic ocular problems, ultrasound was more effective in detecting sebaceous cell carcinoma (p=0.002). Overall, ocular ultrasound identified abnormalities in 66% of cases compared to 60% by MRI (p=0.013).
Conclusion: While MRI offers high-resolution imaging and soft tissue contrast, ocular ultrasound is a more efficient, accessible, and cost-effective tool for diagnosing a variety of eye problems. A combined approach, leveraging both modalities, may offer the most comprehensive evaluation of ocular pathologies.

Keywords: Ocular ultrasound, MRI, retinal detachment, posterior vitreous detachment, ocular tumors

Introduction

Eye problems encompass a broad spectrum of conditions that can significantly impact visual function and overall ocular health. These conditions include retinal detachments, vitreous haemorrhages, ocular tumours, and optic nerve abnormalities, among others [1]. Accurate and timely diagnosis plays a crucial role in the management of these eye problems. Diagnostic accuracy enables healthcare professionals to precisely identify the underlying cause, determine the extent of the condition, and formulate appropriate treatment strategies [2].

Ocular ultrasound and magnetic resonance imaging (MRI) are two commonly employed diagnostic tools in the field of radiology for the evaluation of a wide range of eye problems. Ocular ultrasound employs high-frequency sound waves to visualize the internal structures of the eye, providing real-time imaging and dynamic assessment of anatomical changes and functional abnormalities [3].

Ocular ultrasound is particularly useful in the diagnosis and monitoring of conditions such as retinal detachments, vitreous haemorrhages, intraocular foreign bodies, and ocular tumors. It can provide crucial information about the location, size, and characteristics of these lesions, aiding in treatment planning and patient management [4].

MRI can provide high-resolution images of ocular structures, including the optic nerve, extraocular muscles, lacrimal gland, and orbital fat.

It is particularly useful in the evaluation of conditions such as optic neuritis, orbital tumours, Graves' ophthalmopathy, and inflammatory diseases affecting the orbit [5]. However, it should be noted that MRI examinations can be relatively expensive, time-consuming, and may require patient cooperation during the scanning process [6].

The aim of this study was to compare the effectiveness and diagnostic capabilities of ocular ultrasound compared to MRI in the assessment of different eye problems.

Patients and methods

Design and population

This prospective cohort study was carried out on 50 eyes of 50 patients attending Radiology Department, Benha University Hospitals and some Iraq centres during the period from July 1, 2023, to February 1, 2024.

The selected patients underwent both ocular ultrasound and MRI for the evaluation of different eye problems. The study included both genders, patients with an age of 18 years old or older, those presenting to the radiology department with different eye problems, such as retinal detachments, vitreous haemorrhages, ocular tumours, optic nerve abnormalities, and other relevant pathologies, patients who were able to undergo both ocular ultrasound and MRI examinations, and those who provided informed consent to participate in the study.

Patients with a history of previous ocular surgery that may impact the accuracy of ocular ultrasound or MRI findings, contraindications to ocular ultrasound or MRI, patients who were unable to undergo both ocular ultrasound and MRI examinations, those with known allergies to contrast agents used in MRI, patients with unstable systemic conditions, and those with conditions or factors that could affect the interpretation of imaging findings were excluded from the study.

Methods

In this study, all selected patients underwent a comprehensive evaluation, including detailed history taking including: demographic data. Medical history, allergies, and family history of ocular diseases. Detailed ocular history including: (patient's ocular symptoms, duration of symptoms, associated systemic conditions, previous ocular surgeries or treatments, and any known risk factors for ocular pathology). Laboratory investigations including: (Blood Tests: (complete blood count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), blood glucose levels, or specific antibody titers), Genetic Testing, and Microbiological Testing.

Ocular Ultrasound

Ocular ultrasound was performed using a high-frequency ultrasound probe. The ultrasound examination was performed by the principal investigator. The patient was positioned comfortably, and a sterile coupling gel was applied to the eye for optimal sound wave transmission.

B-scan Ultrasound

B-scan ultrasound was employed to assess the anterior and posterior segment of the eye, including the retina, vitreous humor, and optic nerve. The transducer was gently placed on the eyelid with minimal pressure to obtain the necessary images. Multiple cross-sectional and longitudinal scans were acquired to visualize the structures of interest in different planes. The images obtained were digitally recorded for subsequent analysis [7].

Magnetic Resonance Imaging (MRI)

MRI examinations were performed using a standard 1.5T MRI scanner. The patient was positioned comfortably on the MRI table, and appropriate immobilization devices were used to minimize motion artifacts. Prior to the scan, the patient was provided with ear protection due to the loud noises generated by the MRI machine.

Imaging Sequences

A standardized imaging protocol was employed, which could include T1-weighted, T2-weighted, and diffusion-weighted imaging sequences. These sequences allowed visualization of the ocular structures, including the globe, optic nerve, and surrounding tissues. The specific parameters, such as field of view, slice thickness, and imaging planes, were consistent among all patients to ensure comparability of the images.

Contrast-Enhanced Imaging (if applicable): In some cases, an intravenous gadolinium-based contrast agent was administered to enhance the visibility of certain structures. The decision to administer contrast was based on the clinical indication and the discretion of the attending radiologist. Patients with known allergies to contrast agents or renal impairment were carefully evaluated before contrast administration.

Statistical methods

Recorded data were analyzed using the statistical package for social sciences, version 23.0 (SPSS Inc., Chicago, Illinois, USA). The quantitative data were presented as mean± standard deviation and ranges. Also, qualitative variables were presented as number and percentages. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk Test. The Comparison between groups with qualitative data was done by using Chi-square test and Fisher's exact test. Significance of the obtained results was judged at the (≤0.05) level.

Results

This study aimed to compare the effectiveness and diagnostic capabilities of ocular ultrasound compared to MRI in the assessment of different eye problems and we applied our study on 50 patients, with the same inclusion and exclusion criteria. As regards sex distribution, there was male predominance with 31 males with percentage 62% and 19 females with percentage 38%. Age was ranged from 26 to 63 years with mean± SD of 44.20±10.91. There were 6 patients (12%) "<30 years", 15 patients (30.0%) 30-<40 years, 10 patients (20.0%) were 40-<50 years, and 19 patients (38.0%) were ≥50 years. Table 1.

Table 1: Sex and Age (years) distribution among study group

Sex	No.	%
Female	19	38.0%
Male	31	62.0%
Total	50	100.0%
Age (years)		
<30 years	6	12.0%
30-<40 years	15	30.0%
40-<50 years	10	20.0%
≥50 years	19	38.0%
Total	50	100.0%

Regarding US findings of acute ocular problems, there was one patient (5.55%) had PVD, 5 patients (27.77%) were RD, one patient (5.55%) was vitreous detachment, one patient (5.55%) was CD, one patient (5.55%) was endophthalmitis, one patient (5.55%) was RD+CD, one patient (5.55%) was FB, 3 patients (1.66%) were VH, one patient (5.55%) was globe rupture, one patient (5.55%) was coloboma, one patient (5.55%) was drusen of optic nerve, one patient (5.55%) was lens dislocation. As for the MRI findings, there were 5 patients (20.83%) PVD, 9 patients (37.5%) were RD, one patient (4.16%) was CD, one patient (4.16%) was FB, one patient (4.16%) was RD+CD, one patient (4.16%) was VH, 2 patients (8.33%) were globe rupture, 6 patients (25.0%) were coloboma, 7 patients (29.16%) were drusen of optic nerve, one patient (4.16%) was was lens dislocation. There is statistically significant difference between ultrasound findings and MRI findings regarding PVD (p=0.044), RD (p=0.046), coloboma (p=0.031), and drusen of optic nerve (p=0.024).

Regarding US findings of chronic ocular problems, one patient (6.66%) was choroidal melanoma; one patient (6.66%) was lymphoma, one patient (6.66%) was malignant melanoma, one patient (6.66%) was retinoblastoma, one patient (6.66%) was ocular metastasis, and 10 patients were sebaceous cell carcinoma. As for the MRI findings, one patient (16.7%) was choroidal melanoma; one patient (16.7%) was lymphoma, one patient (16.7%) was malignant melanoma, one patient (16.7%) was retinoblastoma, one patient (16.7%) was ocular metastasis, and one patient (16.7%) was sebaceous cell carcinoma. In addition, it shows that statistically significant higher frequency of overall ocular problems in US was 33 patients (66.0%) comparing to MRI was 30 patients (60.0%), with p-value (p=0.013). Table 2.

Table 2: Comparison between Ultrasound findings and MRI findings according to acute ocular problems, chronic ocular problems, and Overall eye problems

Acute ocular problems	Ultrasound findings (n=18)		MRI findings (n=24)		Test value	p-value
	No.	%	No.	%		
PVD	1	5.55%	5	20.83%	3.805	0.044*
RD	5	27.77%	9	37.5%	3.937	0.046*
Vitreous detachment	1	5.55%	0	0.0%	0.885	0.347
CD	1	5.55%	1	4.16%	0.029	0.866
Endopthalmitis	1	5.55%	0	0.0%	0.795	0.373
FB	1	5.55%	1	4.16%	0.029	0.866
RD+CD	1	5.55%	1	4.16%	0.029	0.866
VH	3	1.66%	1	4.16%	0.648	0.421
Globe rupture	1	5.55%	2	8.33%	2.386	0.682
Coloboma	1	5.55%	6	25.0%	4.582	0.031*
Drusen of optic nerve	1	5.55%	7	29.16%	5.221	0.024*
Lens dislocation	1	5.55%	1	4.16%	0.046	0.831
Chronic ocular problems	Ultrasound findings (n=15)		MRI findings (n=6)		Test value	p-value
Choroidal melanoma	1	6.66%	1	16.7%	0.046	0.831
Lymphoma	1	6.66%	1	16.7%	0.046	0.831
Malignant melanoma	1	6.66%	1	16.7%	0.046	0.831
Retinoblastoma	1	6.66%	1	16.7%	0.046	0.831
Ocular metastasis	1	6.66%	1	16.7%	0.692	0.405
Sebaceous cell carcinoma	10	66.66%	1	16.7%	9.289	0.002*
Overall eye problems	Ultrasound findings (n=50)		MRI findings (n=50)		Test value	p-value
Normal	17	34.0%	20	40.0%	4.797	0.013*
Abnormal	33	66.0%	30	60.0%		

Using: x2: Chi-square test for Number (%) or Fisher's exact test, when appropriate, p-value >0.05 is insignificant, RD: Retinal detachment; CD: Choroid detachment, VH: Vitreous hemorrhage; PVD: Posterior Vitreous detachment.

Case I

Choroidal melanoma in a female patient aged 56 years old, complaining of blurry vision in one eye and sensation of flashing lights (Figure 1).

Fig 1: (A) showing B- scan ultrasonography of dome shaped choroidal mass; the lesion presents acoustic hollowness at its base. (B) The lesion is hyperintense on T1 weighted images. (C) hypointense on T2 weighted images.

Case II

A male patient aged 38 years old presented with symptoms of intraocular foreign body, complaining of tearing, decreased visual acuity, and photophobia after eye trauma (Figure 2).

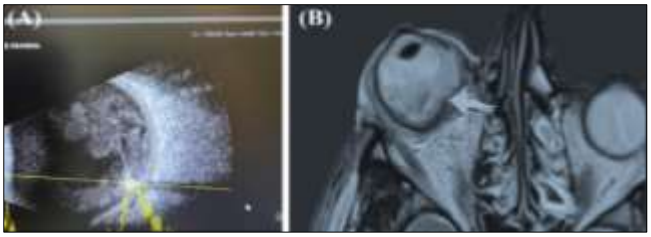

Fig 2: (A) showing B- scan ultrasonography with a focal hyperechoic body with associated shadowing. (B) Axial T2W image shows iso- to hypointense episcleral material surrounding globe

Discussion

The purpose of this study was to compare the efficacy and diagnostic ability of ocular ultrasound versus MRI in the evaluation of various eye disorders in 50 patients. To our knowledge, there are no comparative studies evaluating the efficacy of US versus MRI in detecting eye problems. In terms of gender distribution, the current study results showed a male predominance with males accounting for (62%) of the study population and females accounting for (38%). Similarly, in Adekanmi *et al***,** study in Nigeria there was a preponderance of male participants; (64.8%) of the study population was male and (35.2%) were females. The male to female ratio was 1.84:1 [8].

The mean age of the current study population was (44.20±10.91); (12%) of the study population were "<30 years"; (30.0%) were 30-<40 years; (20.0%) were 40-<50 years and (38.0%) were ≥50 years. While Adekanmi *et al*, reported that patients' ages were ranged from (1-85) years, with a median age of 28 years; (50.7%) were below the age of 30 years [8].

Regarding US findings of acute ocular problems, there was one patient (5.55%) had PVD, 5 patients (27.77%) were RD, one patient (5.55%) was vitreous detachment, one patient (5.55%) was CD, one patient (5.55%) was endopthalmitis, one patient (5.55%) was RD+CD, one patient (5.55%) was FB, 3 patients (1.66%) were VH, one patient (5.55%) was globe rupture, one patient (5.55%) was coloboma, one patient (5.55%) was drusen of optic nerve, one patient (5.55%) was lens dislocation. As for the MRI findings, there were 5 patients (20.83%) PVD, 9 patients (37.5%) were RD, one patient (4.16%) was CD, one patient (4.16%) was FB, one patient (4.16%) was RD+CD, one patient (4.16%) was VH, 2 patients (8.33%) were globe rupture, 6 patients (25.0%) were coloboma, 7 patients (29.16%) were drusen of optic nerve, one patient (4.16%) was was lens dislocation.

There is statistically significant difference between ultrasound findings and MRI findings regarding PVD (p=0.044), RD (p=0.046), coloboma (p=0.031), and drusen of optic nerve (p=0.024). For the detection of RD, ultrasound scan was found to be more sensitive than MRI according to the study of [9]**.**

Sonographic findings in another study done by Gareeballah *et al*, on 102 Sudanese adult patients revealed the presence of (PVD) in (19.2%) of cases, vitreous haemorrhage in (0.98%), and complicated PVD in (1.96%). They also concluded that posterior segment abnormalities should be evaluated by USG prior to surgery. Many studies have demonstrated that ocular US is extremely sensitive [10]. According to a 2019 study from the United States, ocular ultrasound in emergency departments was 94.2% sensitive and 96.3% specific for detecting retinal detachment [11]. A study published in 20199 discovered that after basic training, emergency clinicians of different classes may conduct an ocular US to accurately diagnose a retinal detachment, vitreous hemorrhage, and vitreous detachment. They showed 97% sensitivity in detecting retinal detachments [12].

Regarding US findings of chronic ocular problems, choroidal melanoma; lymphoma, malignant melanoma, retinoblastoma, ocular metastasis was in (6.66%) for each problem, and sebaceous cell carcinoma were in (66.66%) of patients. MRI findings revealed the presence of choroidal melanoma, lymphoma, malignant melanoma, retinoblastoma, ocular metastasis, and sebaceous cell carcinoma in (16.7%) for each problem. There is statistically significant difference between ultrasound findings and MRI findings regarding sebaceous cell carcinoma (p=0.002).

Ultrasound is significant in ophthalmology in defining the difference between the tumor mass and the intraocular bleeding [13]**.** Sonography can also detect intraocular calcification, a key feature of retinoblastoma, but the accuracy is only 80%. Sonography can only provide a limited assessment of tumor extension beyond the globe. Furthermore, the presence of complex intraocular interfaces, such as those caused by vitreous opacities, retinal masses, subretinal fluid, and retinal detachments, limits sonography's utility [14].

Récsán, *et al*, studied the value of MRI for the detection of extra scleral extension of uveal melanoma in 12 patients. They found that MRI had a sensitivity and specificity of 100 and 89%, respectively, for detection of extra scleral extension (15). In many countries, ophthalmologists do not use MRI to diagnose or observe post-irradiation changes in uveal tumour volume, they use only ultrasound. However, the ultrasound technique is routinely available in ophthalmology centres and is not so expensive, compared to MRI [13]**.**

Our study showed statistically significant higher frequency of overall ocular problems in US (66.0%) comparing to MRI (60.0%), (p=0.013). In the hands of an expert, ultrasonic evaluation exceeds other kinds of imaging. In terms of orbital pathology, CT and MR imaging seem to be more detailed. Ultrasound is useful, however, especially as a component of the original clinical work-up and for the monitoring of orbital disease [16]. Ocular ultrasound is a quick, safe, and effective way to supplement current evaluation of eye disease in the emergency [17].

Conclusions

In conclusion, however MRI provides extraordinary soft tissue contrast and multiplanar imaging abilities allowing for high-resolution images of ocular structures; a combined evaluation, including ultrasound imaging, remains advised.

Acknowledgments

There was none to declare.

Declaration of interest statement: None to be declared.

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