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Ultrasonographic Characteristics of Eyes in Patients with Ocular Complaints

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Abstract

Background: Patients presenting with eye-related complaints can exhibit a wide spectrum of conditions, ranging from minor visual disturbances to potentially vision-threatening diseases. Traditional evaluation methods, such as slit-lamp examination and fundoscopy, are often limited in cases where ocular media are opaque. B-scan ultrasonography (USG) provides a non-invasive, radiation-free imaging option that allows detailed assessment of intraocular structures in such circumstances.

Objective: To examine the ultrasonographic findings in patients referred for ocular complaints and to evaluate the clinical utility of B-scan USG in diagnosis and management.

Methods: This descriptive observational study was carried out in the Department of Radiodiagnosis, Vinayaka Mission's Medical College, Karaikal, Puducherry, from January to June 2025. A total of 150 patients with suspected ocular pathology underwent B-scan USG using a linear probe with a frequency range of 5–12 MHz. Parameters assessed included axial length, lens condition, vitreous, retina, choroid, and optic nerve. Data analysis was performed using SPSS version 23.0, with categorical variables presented as percentages and continuous variables as mean ± SD.

Results: The study included 150 patients with a mean age of 56.4 ± 15.9 years, comprising an equal number of males and females. Diminished vision was the most common presenting complaint (99.3%). A majority of patients (78%) had no prior ocular surgery or history of trauma. The mean axial length of the eyes examined was 23.4 ± 0.6 mm, with most eyes (98%) falling within the normal range of 22–25 mm. The most frequent ultrasonographic findings included cataract (30.0%), retinal detachment (17.3%), and vitreous hemorrhage (12.0%). Advanced imaging techniques were used selectively, with indirect ophthalmoscopy being the most frequently employed (41.3%). Operative findings correlated completely with USG diagnoses, demonstrating 100% concordance.

Conclusion: B-scan ocular ultrasonography is a dependable, rapid, and cost-effective imaging modality for evaluating patients with ocular complaints, particularly in situations where conventional examinations are limited by opaque media. It provides precise diagnostic information, supports surgical planning, and helps avoid unnecessary interventions. Due to its safety, portability, and high-resolution imaging of superficial ocular structures, B-scan USG should be regarded as the first-line imaging tool in clinical ophthalmology.

Keywords: Ocular ultrasonography, B-scan ultrasound, Ocular complaints, Cataract

Introduction

Patients presenting with eye-related complaints encompass a wide spectrum, from minor visual disturbances to conditions that may threaten vision. Prompt and accurate diagnosis is essential to prevent complications and preserve sight. Traditionally, ocular evaluation has relied on slit-lamp examination and fundoscopy, which allow clinicians to visualize the anterior and posterior segments of the eye in detail [1]. These methods are non-invasive, can be performed in outpatient settings, and typically cause minimal discomfort, providing sufficient information for diagnosis and management in most cases.

However, conventional techniques have limitations, especially when ocular media are opaque. Dense cataracts, corneal opacities, vitreous haemorrhages, and severe corneal oedema can obstruct the view of deeper structures, including the retina, choroid, and vitreous cavity [2,3]. Under such circumstances, relying solely on slit-lamp or fundoscopy may result in delayed or inaccurate diagnosis, highlighting the need for supplementary imaging methods. Ocular ultrasonography, particularly B-mode scanning, has become an invaluable adjunct in these scenarios. B-scan ultrasound produces two-dimensional cross-sectional images of the eye and orbit, enabling visualization of internal structures even when media opacity prevents direct observation. It is highly sensitive in detecting conditions such as retinal detachment, vitreous haemorrhage, intraocular tumours, lens dislocation, and foreign bodies, each of which produces characteristic acoustic patterns on ultrasound [9,10]. Advances in three-dimensional ultrasonography have further enhanced diagnostic capabilities by allowing volumetric reconstruction of ocular structures for more detailed evaluation [11].

Compared to other imaging techniques like computed tomography (CT) and magnetic resonance imaging (MRI), ocular ultrasonography offers several advantages. CT provides high-resolution imaging but involves radiation exposure, which is a concern in paediatric patients or those requiring repeated scans. MRI delivers excellent soft tissue contrast but is less accessible, costly, and often requires sedation in children or uncooperative patients [4]. In contrast, ocular ultrasound is safe, non-invasive, radiation-free, portable, and cost-effective, making it suitable for both routine and emergency assessments [5–7]. Its portability also allows bedside imaging in critical care and postoperative settings, enhancing efficiency. The principle of ultrasonography involves transmitting high-frequency sound waves into the eye, which are reflected differently by various ocular tissues. These returning echoes are processed to generate detailed images, enabling differentiation between normal and pathological structures. While A-mode ultrasound is primarily used for axial length measurements and lens calculations, it provides limited structural detail [8]. B-mode ultrasound, on the other hand, allows comprehensive visualization of intraocular anatomy—including the vitreous, retina, and optic nerve—and can be complemented with colour Doppler imaging to assess vascularity in lesions such as tumours or vascular malformations.

Recent literature highlights the expanding role of ocular ultrasonography in preoperative planning, postoperative follow-up, trauma evaluation, and detection of intraocular foreign bodies, particularly when conventional examination methods are inadequate. Studies have demonstrated its ability to detect subtle pathology, guide clinical decision-making, and reduce the need for more invasive or expensive imaging [5,6,10]. Its non-invasive nature and minimal patient preparation make it especially useful in paediatric populations and uncooperative patients. In light of this, the present study was designed to systematically evaluate ultrasonographic findings in patients referred with ocular complaints. The objectives were:

1. To document ultrasonographic characteristics across a variety of ocular conditions.
2. To assess the diagnostic and management utility of B-mode ultrasound and colour Doppler imaging.
3. To compare postoperative ultrasonographic findings in selected cases to evaluate structural changes and recovery. Through a detailed analysis of these findings, the study aims to reinforce the importance of ocular ultrasonography as a reliable, accessible, and cost-effective diagnostic tool, particularly when conventional examination techniques are insufficient, thereby enhancing clinical decision-making and patient care outcomes.

Materials & Methods

Study Design

This descriptive observational study was conducted to evaluate the role of B-scan ultrasonography in the diagnosis of intraocular pathologies among patients presenting with ocular complaints.

Study Setting and Duration
The study was carried out in the Department of Radiodiagnosis, Vinayaka Mission's Medical College, Karaikal, Puducherry, over a period of six months, from January 2025 to June 2025. Approval for the study was obtained from the Institutional Human Ethics Committee (IHEC) prior to commencement.

Study Population
The study population comprised patients referred to the Department of Radiodiagnosis for B-scan ultrasonography with clinical suspicion of intraocular pathology. Both adult and pediatric patients fulfilling the eligibility criteria were considered for inclusion.

Sample Size
A total of 150 patients were enrolled consecutively during the study period. (Insert actual sample size.)

Inclusion Criteria
Patients presenting with ocular complaints and referred for B-scan ultrasonography due to suspected intraocular pathology, who were willing to participate and provided written informed consent, were included in the study.

Exclusion Criteria
Patients with active ocular surface infections, orbital trauma, ongoing or impending extrusion of ocular contents, and those unwilling to provide written informed consent were excluded. In pediatric patients, assent along with parental or guardian consent was mandatory for participation.

Data Collection Tool
Following ethical approval, eligible participants were recruited after obtaining informed consent. Clinical and demographic information was collected using a pre-tested semi-structured proforma, which included details regarding age, gender, presenting ocular complaints, relevant medical history, clinical examination findings, and referral diagnosis. All participants underwent B-scan ultrasonography using a high-frequency linear transducer (5–12 MHz) under standardized examination protocols. Ocular ultrasonography was performed with the patient in the supine or sitting position after applying sterile coupling gel over the closed eyelid. Real-time dynamic scanning was performed in multiple planes to obtain comprehensive evaluation of both the anterior and posterior segments of the globe. Morphometric measurements, including axial length, were recorded for each eye. A systematic assessment was performed to evaluate the lens, vitreous cavity, retina, choroid, posterior segment, optic nerve, and surrounding orbital structures. Characteristic sonographic features such as vitreous opacities, retinal detachment, vitreous hemorrhage, choroidal detachment, posterior vitreous detachment, intraocular masses, lens abnormalities, and optic nerve lesions were documented. The ultrasonographic findings were subsequently correlated with the final clinical diagnosis established through ophthalmological examination and relevant ancillary investigations.

Ethical Considerations
The study protocol was reviewed and approved by the Institutional Human Ethics Committee before initiation of the study. Written informed consent was obtained from all adult participants. For pediatric participants, written parental consent along with child assent was obtained wherever appropriate. Participation in the study imposed no additional financial burden or procedural risk beyond routine clinical evaluation. Confidentiality and anonymity of all patient information were maintained throughout data collection, analysis, and reporting. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using SPSS software version 23.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on data distribution. Normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Comparisons of quantitative variables were performed using the paired Student's t-test, whereas qualitative variables were analyzed using the Chi-square test or Fisher's exact test whenever appropriate. A p-value less than 0.05 was considered statistically significant.

Results

Table 1: Baseline Characteristics of Patients with Ocular Complaints (N = 150)

Characteristic	Number (%)
Age (years)	
31–50 years	33 (22.0)
51–70 years	87 (58.0)
>70 years	30 (20.0)
Sex	
Male	75 (50.0)
Female	75 (50.0)
Presenting complaints	
Diminished vision	149 (99.3)
Pain	14 (9.3)
Redness	8 (5.3)
Discharge	7 (4.7)
History of surgery/trauma	
None	117 (78.0)
Trauma	16 (10.7)
Post cataract surgery	15 (10.0)
Post-retinal detachment surgery	2 (1.3)
Comorbidities	
Diabetes mellitus	42 (28.0)
Hypertension	27 (18.0)
Both DM & HTN	3 (2.0)
Laterality of involvement	
Right eye	69 (46.0)
Left eye	66 (44.0)
Both eyes	15 (10.0)

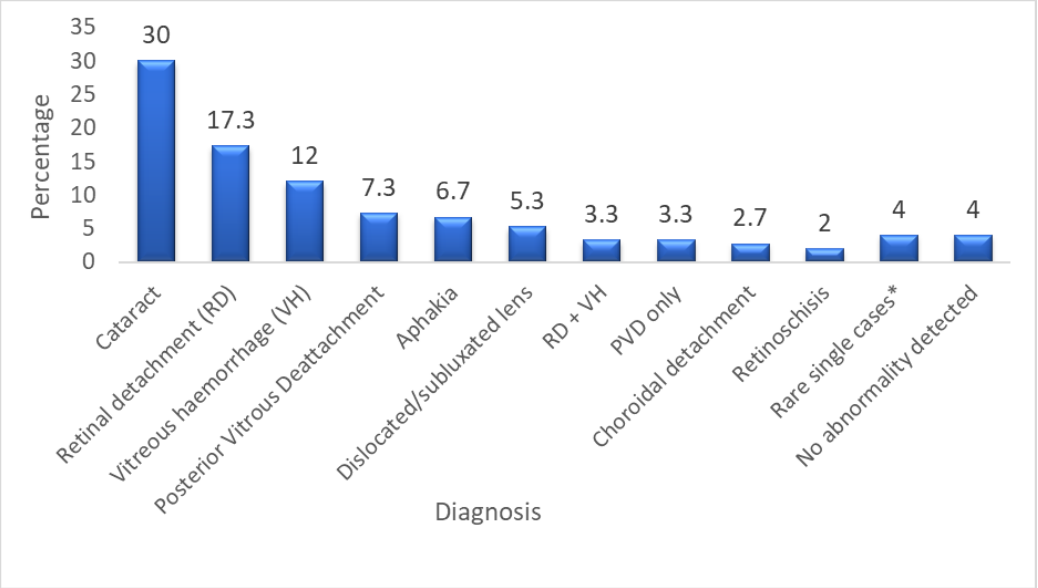
In this study of 150 patients, the majority were between 51–70 years (58%), with an equal distribution of males and females. The most frequent presenting symptom was diminished vision (99.3%), followed by pain (9.3%), redness (5.3%), and discharge (4.7%). Most patients (78%) had no prior history of surgery or trauma, while 10.7% reported trauma and 10% had undergone cataract surgery. Regarding comorbidities, diabetes (28%) was more common than hypertension (18%), with 2% having both. Laterality showed almost equal involvement of right (46%) and left eyes (44%), with 10% having bilateral disease.

Table 2. Axial Length and Lens Status in Involved Eyes (N = 150)

Parameter	Number (%)	Details
Axial length (mm)		Mean (SD): 23.4 (0.6), Range: 21.1 – 27.3
<22 mm	2 (1.3)	Rare
22–25 mm	147 (98.0)	Majority
>25 mm	1 (0.7)	Rare
Lens status		—
Normal location	132 (88.0)	—
Dislocated/subluxated	8 (5.3)	—
Absent (aphakia)	10 (6.7)	—

In this study of 150 eyes, the mean axial length was 23.4 mm (SD: 0.6; range 21.1–27.3 mm). The vast majority (98%) fell within the normal range of 22–25 mm, with only 1.3% measuring below 22 mm and 0.7% above 25 mm. Regarding lens status, most eyes (88%) had a normally positioned lens, while 5.3% showed dislocation/subluxation and 6.7% were aphakic (absent lens).

Figure 1: Ultrasonographic Diagnoses in Involved Eyes (N = 150)



*Rare cases include: old RD with cyst, optic glioma, posterior staphyloma, RD with subretinal hemorrhage, phthisis bulbi, uveitis, and VH with neovascular glaucoma.

The most common diagnosis was cataract seen in 45 eyes (30.0%), followed by retinal detachment (26 eyes, 17.3%) and vitreous hemorrhage (18 eyes, 12.0%). Combined conditions included cataract with posterior vitreous detachment (11 eyes, 7.3%) and retinal detachment with vitreous hemorrhage (5 eyes, 3.3%). Other diagnoses were aphakia (10 eyes, 6.7%), dislocated/subluxated lens (8 eyes, 5.3%), posterior vitreous detachment alone (5 eyes, 3.3%), choroidal detachment (4 eyes, 2.7%), and retinoschisis (3 eyes, 2.0%). Rare single presentations, including isolated conditions, were noted in 6 eyes (4.0%). Interestingly, no abnormality was detected in 6 eyes (4.0%).

Table 3. Other Diagnostic Modalities Used (N = 150)

Modality	Number (%)
Indirect ophthalmoscopy	62 (41.3)
Direct ophthalmoscopy	57 (38.0)
Both direct + indirect ophthalmoscopy	24 (16.0)
Optical coherence tomography (OCT)	3 (2.0)
Fundus fluorescein angiography (FFA)	2 (1.3)
Slit lamp + indirect ophthalmoscopy	1 (0.7)
Operative confirmation	100% concordance with USG findings

Among the 150 patients, the most frequently used technique was indirect ophthalmoscopy (62 eyes, 41.3%), followed closely by direct ophthalmoscopy (57 eyes, 38.0%). A combination of direct and indirect ophthalmoscopy was employed in 24 eyes (16.0%), while advanced imaging modalities such as optical coherence tomography (3 eyes, 2.0%) and fundus fluorescein angiography (2 eyes, 1.3%) were used less frequently. A single case (0.7%) required slit lamp examination combined with indirect ophthalmoscopy. Notably, in cases that underwent surgical intervention, there was 100% concordance between operative findings and ultrasonography (USG) results, highlighting the reliability of USG as a diagnostic tool in ocular evaluation.

Discussion

This study aimed to assess the diagnostic value of ocular B-scan ultrasonography in patients referred with suspected intraocular pathology to the Department of Radiodiagnosis from January to June 2025. A comprehensive evaluation of the lens, vitreous, retina, choroid, and optic nerve was performed in all cases. A total of 150 patients were included, some with bilateral involvement, resulting in a larger number of eyes analyzed. Notably, all ultrasonographic findings were fully consistent with intraoperative diagnoses, demonstrating 100% accuracy in this cohort. These findings are consistent with earlier studies. Yang et al. demonstrated complete agreement between immersion 20-MHz B-scan ultrasonography and clinical findings in alkali burn eyes, reporting 100% concordance for lens pathology [12]. Similarly, Shazlee et al. reported a diagnostic accuracy of 98% for B-scan ultrasonography in ocular trauma, highlighting its reliability as a primary imaging modality in emergency and high-burden clinical settings [15].

In the present study, the most common surgical intervention was lensectomy with intraocular lens implantation, followed by vitrectomy with membrane peeling, endolaser, and tamponade procedures. Postoperative follow-up showed that more than half of the eyes achieved improved visual outcomes. B-scan ultrasonography proved especially valuable for preoperative planning in cases with opaque ocular media, where direct fundus visualization was not possible, a benefit also emphasized by De La Hoz Polo et al. [11].

Despite its advantages, certain limitations should be considered. Ultrasound image interpretation is operator-dependent, and this study relied on a single experienced radiologist, potentially limiting generalizability. Inter-observer variability was not assessed, and the radiologist was aware of the patients' clinical details, introducing possible observer bias—although this reflects real-world clinical practice. Furthermore, as this study was conducted in a tertiary care teaching hospital, the findings may not fully represent community-level populations.

Nevertheless, the results reinforce the role of ocular B-scan ultrasonography as a safe, non-invasive, rapid, and cost-effective diagnostic tool. It is particularly useful in patients with opaque media, enabling accurate visualization of the posterior segment and early detection of vitreoretinal detachments, intraocular tumors, and hemorrhages, as supported by Abramowicz et al. [7]. While CT and MRI retain importance in selected orbital and neuro-ophthalmic conditions, they cannot replace ultrasonography for superficial ocular structures due to its superior resolution, bedside availability, and absence of ionizing radiation.

Conclusion

Ocular B-scan ultrasonography is a highly effective diagnostic modality for evaluating patients with ocular complaints, especially when conventional examinations are limited by opaque media. It is non-invasive, readily available, cost-effective, and capable of providing rapid, accurate diagnoses. In this study, ultrasonography demonstrated excellent concordance with operative findings, reliably differentiating between various ocular detachments, vitreoretinal disorders, and intraocular lesions. Operator expertise is essential for accurate interpretation, and while color Doppler has limited utility in most ocular conditions, B-scan remains indispensable as a first-line imaging tool. Its use facilitates timely and appropriate clinical management, optimizes surgical planning, and minimizes unnecessary procedures, reinforcing its role as a cornerstone in ophthalmic diagnostics.

Conflict of Interest: Nil

Reference

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