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Diagnostic Accuracy of B-Scan Ultrasonography for Assessing Vision Loss in Diabetic Retinopathy

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ABSTRACT

Background: Diabetic retinopathy (DR) is a leading cause of vision loss globally, necessitating effective diagnostic tools for early detection and management. B-Scan ultrasonography is a non-invasive imaging modality that can assess posterior segment anomalies, particularly in cases where direct retinal visualization is impeded.

Objective: To evaluate the diagnostic accuracy of B-Scan ultrasonography for assessing visual impairment in diabetic retinopathy patients.

Methods: A cross-sectional study was conducted at the University of Lahore Teaching Hospital, Lahore, from December 2023 to May 2024. A total of 200 patients with type 2 diabetes (150 males, 50 females) were included. B-Scan ultrasonography was performed using a 10 MHz transducer in a thermally controlled room. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated using clinical diagnoses as the reference standard.

Results: B-Scan ultrasonography showed a sensitivity of 94.6%, specificity of 76.92%, PPV of 92.10%, NPV of 83.33%, and an overall accuracy of 90% in diagnosing vision-impairing retinal pathologies.

Conclusion: B-Scan ultrasonography is a highly sensitive and reliable tool for assessing vision loss in diabetic retinopathy, particularly in cases complicated by media opacities, and should be considered in routine clinical practice.

INTRODUCTION

Diabetic retinopathy (DR) is a leading cause of vision impairment and blindness worldwide, with particularly high prevalence rates in developing regions, including the Middle East and North Africa (1). DR is a microvascular complication of diabetes mellitus (DM) that affects the retinal vasculature, leading to a spectrum of retinal changes, including diabetic macular edema, capillary non-perfusion, and proliferative diabetic retinopathy (PDR), which can ultimately result in significant visual loss (2, 3). Chronic hyperglycemia in diabetes is associated with long-term damage and dysfunction in various organs, including the eyes, where it precipitates a cascade of pathological events such as microangiopathy, capillary occlusion, and the breakdown of the blood-retinal barrier, all of which contribute to retinal hemorrhage and edema (4). As the burden of diabetes increases globally, especially in low- and middle-income countries, there is a pressing need for early detection and timely intervention to prevent the progression of DR and subsequent vision loss (5).

The clinical management of DR requires effective screening and diagnostic tools that can accurately identify and assess the severity of retinal pathology, particularly in cases where direct visualization of the retina is compromised due to media opacities like vitreous hemorrhage (VH). In this context, B-Scan ultrasonography has emerged as a valuable diagnostic modality. This non-invasive imaging technique uses high-frequency sound waves to produce detailed images of the posterior segment of the eye, enabling the detection of retinal detachments, VH, posterior vitreous detachment (PVD), and other posterior segment abnormalities that may not be visible through conventional ophthalmoscopy (6, 7). B-Scan ultrasonography is particularly useful in diabetic patients where optical media opacities obscure the retina, making it difficult to assess the underlying causes of vision loss using standard clinical examination methods (8).

Given the rising incidence of DR and the associated risk of severe visual impairment, there is an increasing focus on the diagnostic accuracy of various imaging techniques, including B-Scan ultrasonography, in the early detection and management of DR-related complications. This study was designed to evaluate the diagnostic accuracy of B-Scan ultrasonography in assessing visual impairment in patients with diabetic retinopathy. By examining a cohort of diabetic patients at different stages of DR, the study aimed to determine the sensitivity, specificity, and predictive values of B-Scan ultrasonography in detecting retinal pathologies that contribute to vision loss. The findings from this study have significant implications for the clinical management of DR, highlighting the potential of B-Scan ultrasonography as

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a reliable and accessible tool for the early detection and monitoring of DR-related visual impairments, thereby facilitating prompt and appropriate therapeutic interventions (9, 10).

MATERIAL AND METHODS

The study was conducted as a cross-sectional analysis at the University of Lahore Teaching Hospital, Lahore, between December 12, 2023, and May 07, 2024. The study population consisted of 200 patients with diabetes mellitus type 2, including 150 males and 50 females, selected through non-probability consecutive sampling. Participants were required to have a confirmed diagnosis of type 2 diabetes and were excluded if they had hypertension, proliferative diabetic retinopathy, or were on insulin therapy. This careful selection aimed to ensure a homogeneous sample, minimizing potential confounders that could influence the study's outcomes.

Prior to initiating the study, ethical approval was obtained from the institutional review board of the University of Lahore Teaching Hospital, in accordance with the principles outlined in the Declaration of Helsinki. A waiver of informed consent was granted due to the retrospective nature of data collection and the minimal risk posed to participants. All procedures adhered to institutional policies and followed the ethical guidelines for research involving human subjects.

Upon recruitment, each patient underwent a comprehensive ophthalmologic examination, including fundoscopy, to evaluate the presence and severity of diabetic retinopathy. The grading of diabetic retinopathy was performed using the Early Treatment Diabetic Retinopathy Study (ETDRS) classification, which categorizes retinopathy into minimal non-proliferative diabetic retinopathy (NPDR), mild NPDR, moderate NPDR, severe NPDR, and proliferative retinopathy (PR) (7). The ophthalmologic assessments were performed by trained ophthalmologists who were blinded to the ultrasound findings to reduce potential bias.

Subsequent to the clinical evaluation, all patients underwent ocular B-Scan ultrasonography using a GE ultrasonic unit equipped with a high-frequency 10 MHz direct contact transducer. The ultrasonography was performed in a thermally controlled room with the patient in a supine position to ensure optimal image acquisition. A standardized scanning protocol was followed, including the use of Minims Tetracaine Hydrochloride 0.5% eye drops for local anesthesia and ultrasound gel as a coupling medium. The sonographic examination was performed by an experienced sonographer who systematically evaluated the eyes for retinal detachments, vitreous hemorrhages, posterior vitreous detachment, and other posterior segment anomalies that could contribute to vision loss.

Data were collected and recorded for each participant, including demographic information, duration of diabetes, HbA1c levels, and results from both the clinical and sonographic evaluations. The diagnostic accuracy of B-Scan ultrasonography was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, using the clinical diagnosis as the reference standard. True positive (TP), false positive (FP), false negative (FN), and true negative (TN) cases were identified based on the concordance between clinical findings and ultrasonography results.

Statistical analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient demographics and clinical characteristics. The sensitivity, specificity, PPV, and NPV of B-Scan ultrasonography were calculated along with 95% confidence intervals. Comparisons between groups were made using chi-square tests for categorical variables, with a significance level set at $p < 0.05$.

The study rigorously adhered to ethical standards and employed robust statistical methods to ensure the reliability and validity of the findings. The results of this investigation provide valuable insights into the utility of B-Scan ultrasonography in the assessment of vision loss due to diabetic retinopathy, potentially guiding future clinical practices in the early detection and management of this condition.

RESULTS

A total of 200 patients with type 2 diabetes mellitus (400 eyes) were included in this study. The cohort consisted of 150 males (75%) and 50 females (25%), with an age distribution presented in Table 1. The majority of male patients were in the 46-58 age range (26.67%), while the smallest group was in the 15-19 age range (6.67%). Similarly, in the female population, the largest proportion was also in the 46-58 age group (40%), with the smallest proportion in the 15-19 age group (2%).

Table 1: Age Distribution of Diabetic Patients

Age Group (years)	Male (n = 150)	Female (n = 50)	Total (n = 200)
15-19	10 (6.67%)	1 (2%)	11 (5.5%)
20-25	21 (14%)	3 (6%)	24 (12%)
26-35	25 (16.67%)	8 (16%)	33 (16.5%)
36-45	37 (24.67%)	17 (34%)	54 (27%)
46-58	40 (26.67%)	20 (40%)	60 (30%)
59-70	17 (11.34%)	1 (2%)	18 (9%)

The grading of diabetic retinopathy (DR) among the studied eyes is summarized in Table 2. Mild non-proliferative diabetic retinopathy (NPDR) was the most prevalent, observed in 35% of the eyes. This was followed by moderate

NPDR in 19.5%, severe NPDR in 13.5%, and proliferative retinopathy (PR) in 8.5%. Minimal NPDR was noted in 23.55% of the eyes.

Table 2: Grading of Diabetic Retinopathy in Diabetic Patients' Eyes

DR Grade	Number of Eyes (n = 200)	Percentage (%)
Minimal NPDR	47	23.55%
Mild NPDR	70	35%
Moderate NPDR	39	19.5%
Severe NPDR	27	13.5%
Proliferative Retinopathy (PR)	17	8.5%

The diagnostic accuracy of ocular B-Scan ultrasonography in assessing vision loss in diabetic patients is detailed in Table 3. Out of 200 patients, 140 cases were true positives (TP) where ultrasonography correctly identified the retinal pathology causing vision impairment. There were 12 false positives (FP), 8 false negatives (FN), and 40 true negatives (TN).

The sensitivity of B-Scan ultrasonography was found to be 94.6%, indicating its high ability to correctly identify patients with vision-impairing retinal pathology. The specificity was 76.92%, reflecting the test's ability to correctly identify patients without the pathology. The positive predictive value (PPV) was 92.10%, and the negative predictive value (NPV) was 83.33%, with an overall accuracy rate of 90%.

Table 3: Diagnostic Accuracy of Ocular B-Scan Ultrasonography

Diagnostic Parameter	Value
True Positives (TP)	140
False Positives (FP)	12
False Negatives (FN)	8
True Negatives (TN)	40
Sensitivity	94.6%
Specificity	76.92%
Positive Predictive Value (PPV)	92.10%
Negative Predictive Value (NPV)	83.33%
Accuracy	90%

The results demonstrate that B-Scan ultrasonography is a highly effective diagnostic tool for assessing vision loss in diabetic retinopathy. The high sensitivity and PPV indicate its reliability in detecting true cases of retinal pathology, making it a valuable modality in the clinical evaluation of diabetic patients, particularly in cases where direct retinal visualization is compromised due to media opacities.

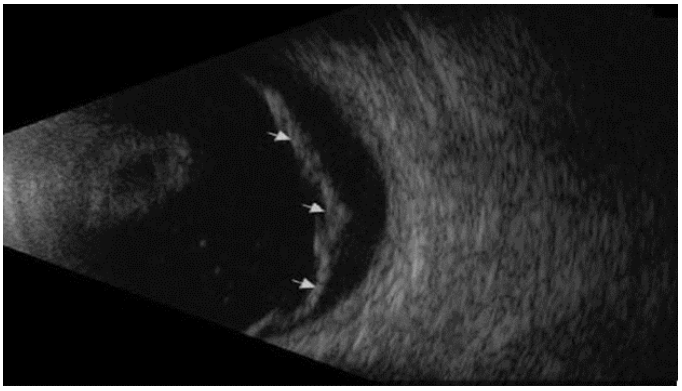

Figure 1: B-Scan shows sonographic features with TRD

The B-Scan ultrasonography image depicts the sonographic features characteristic of tractional retinal detachment (TRD). The image shows a highly reflective line, indicated by arrowheads, corresponding to the detached retina. The retina appears to be elevated and tethered, suggesting the presence of fibrous tissue pulling on the retina, which is typical of TRD. This imaging modality is crucial for visualizing such posterior segment abnormalities, especially in cases where direct visualization is impeded by media opacities like vitreous hemorrhage.

DISCUSSION

The present study aimed to evaluate the diagnostic accuracy of B-Scan ultrasonography in assessing vision loss among diabetic retinopathy patients. The findings demonstrated that B-Scan ultrasonography is a highly sensitive and moderately specific tool, with an overall accuracy of 90%, making it a reliable diagnostic modality in clinical settings where direct retinal examination is challenging. These results align with previous studies that have underscored the utility of ultrasonography in identifying posterior segment anomalies, such as retinal detachments and vitreous hemorrhages, particularly in cases complicated by media opacities (Mohamed et al., 2018; Salz & Witkin, 2015).

The sensitivity of 94.6% observed in this study highlights the effectiveness of B-Scan ultrasonography in detecting true cases of vision-impairing pathologies in diabetic patients. This high sensitivity is consistent with earlier research, which has reported similar values, reinforcing the role of ultrasonography as an indispensable tool in the diagnosis and management of diabetic retinopathy (Rabinowitz et al., 2004; Andrade et al., 2015). The specificity of 76.92%,

although lower than sensitivity, is within an acceptable range and suggests that while the test is reliable, there may still be some false positives, particularly in complex cases where differential diagnosis is required. The positive predictive value (PPV) and negative predictive value (NPV) of 92.10% and 83.33%, respectively, further validate the use of B-Scan ultrasonography as a trustworthy diagnostic method for assessing vision loss.

One of the strengths of this study is the systematic and standardized approach to ultrasonography, which included the use of a high-frequency transducer and rigorous imaging protocols. The study also benefited from a relatively large sample size and a diverse patient population, which enhances the generalizability of the findings. Additionally, the blinding of ophthalmologists to the ultrasound results helped to minimize bias and strengthen the reliability of the diagnostic outcomes.

However, the study also had certain limitations that should be considered when interpreting the results. The cross-sectional design, while useful for assessing diagnostic accuracy, does not allow for the evaluation of long-term outcomes or the progression of diabetic retinopathy. Furthermore, the study excluded patients with proliferative diabetic retinopathy and those on insulin therapy, which limits the applicability of the findings to the broader diabetic population. Another limitation was the reliance on a single imaging modality without the inclusion of comparative imaging techniques, such as optical coherence tomography (OCT), which could have provided additional validation of the ultrasound findings.

Despite these limitations, the study contributes valuable insights into the role of B-Scan ultrasonography in the early detection and management of vision loss in diabetic retinopathy patients. The findings suggest that B-Scan ultrasonography should be considered as a routine diagnostic tool, particularly in cases where other imaging modalities are not feasible due to media opacities. This study also highlights the need for further research, particularly longitudinal studies that could assess the prognostic value of B-Scan ultrasonography and explore its role in monitoring disease progression.

CONCLUSION

In conclusion, B-Scan ultrasonography has proven to be a highly sensitive and reliable diagnostic tool for assessing vision loss in patients with diabetic retinopathy. The study supports its use in clinical practice, particularly in settings where other diagnostic methods may be limited. Future research should aim to address the limitations identified in this study and explore the integration of B-Scan ultrasonography with other imaging modalities to enhance diagnostic accuracy and patient outcomes in diabetic retinopathy management.

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