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Original Research Article

Comparative Evaluation of Optical Coherence Tomography and Fundus Photography for Early Detection of Diabetic Retinopathy and Its Correlation with Glycemic Control

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Abstract

Background: Diabetic retinopathy (DR) is a leading cause of preventable blindness worldwide. Early detection is crucial to prevent disease progression. Optical Coherence Tomography (OCT) and fundus photography are widely used imaging modalities, but their comparative efficacy in early DR detection remains under evaluation. Glycemic control, reflected by HbA1c levels, plays a pivotal role in disease progression.

Materials and Methods: A cross-sectional study was conducted on 120 patients with type 2 diabetes mellitus. All participants underwent fundus photography and OCT examination. DR was graded using standard criteria. HbA1c levels were measured and correlated with imaging findings. Sensitivity, specificity, and diagnostic accuracy of both modalities were analyzed.

Results: OCT detected early retinal changes in 78.3% of patients compared to 61.7% by fundus photography. Sensitivity of OCT was significantly higher (92%) than fundus photography (74%). A strong positive correlation ($r = 0.68$, $p < 0.001$) was observed between HbA1c levels and severity of retinal changes.

Conclusion: OCT demonstrated superior sensitivity in early detection of diabetic retinopathy compared to fundus photography. Higher HbA1c levels were significantly associated with increased severity of DR. Incorporating OCT in routine screening may improve early diagnosis and clinical outcomes.

Keywords: Diabetic Retinopathy, OCT, Fundus Photography, HbA1c, Early Detection.

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Introduction

Diabetic retinopathy (DR) is one of the most common microvascular complications of diabetes mellitus and remains a leading cause of visual impairment globally [1].

The rising prevalence of diabetes, particularly in developing countries like India, has led to an increased burden of DR [2]. Chronic hyperglycemia results in microvascular damage through multiple biochemical pathways including the polyol pathway, advanced glycation end-products formation, oxidative stress, and protein kinase C activation [3,4].

Early detection of DR is critical, as timely intervention can prevent irreversible vision loss [5]. Traditionally, fundus photography has been the cornerstone for screening and diagnosis of DR due to its accessibility and cost-effectiveness [6]. However, it primarily detects visible vascular changes and may miss early subtle retinal alterations. Optical Coherence Tomography (OCT) is a non-invasive imaging modality that provides high-resolution cross-sectional images of the retina, allowing early detection of structural changes such as retinal thickening, microcystic edema, and nerve fiber layer alterations [7]. Several studies suggest that OCT can detect subclinical changes before they become apparent on fundus examination [8].

Glycemic control is a major determinant of DR progression. HbA1c reflects average blood glucose levels over the previous 2–3 months and is considered a reliable marker of long-term glycemic control [9]. Studies have shown a strong correlation between elevated HbA1c levels and increased risk and severity of DR [10].

Despite advancements in imaging technologies, there remains a need to compare the effectiveness

of OCT and fundus photography in early DR detection and to evaluate their relationship with glycemic control. Such comparative studies are essential to optimize screening strategies, particularly in resource-limited settings.

The present study aims to compare OCT and fundus photography for early detection of diabetic retinopathy and to correlate imaging findings with HbA1c levels.

Aim and Objectives

Aim: To compare Optical Coherence Tomography and fundus photography in early detection of diabetic retinopathy and correlate findings with HbA1c levels.

Objectives:

1. To evaluate and compare the diagnostic accuracy of OCT and fundus photography in early DR detection.
2. To assess the correlation between HbA1c levels and severity of diabetic retinopathy.

Materials and Methods

A hospital-based cross-sectional study was conducted on 120 patients diagnosed with type 2 diabetes mellitus attending the ophthalmology outpatient department of Parbhani Medical College and R P Hospital and Research Institute. Patients aged 30–70 years were included. After obtaining informed consent, detailed clinical history and ophthalmic examination were performed. Fundus photography was carried out using a standard fundus camera, and DR was graded based on ETDRS classification.

Optical Coherence Tomography was performed using spectral-domain OCT to assess retinal thickness and early structural changes. HbA1c levels were measured using high-performance liquid chromatography (HPLC).

Inclusion Criteria:

- Patients with type 2 diabetes mellitus
- Age 30–70 years
- Willing to participate

Exclusion Criteria:

- Patients with advanced DR or previous retinal surgery
- Other retinal pathologies (AMD, retinal detachment)
- Media opacities affecting imaging

Statistical analysis was performed using SPSS software.

Sensitivity, specificity, and correlation coefficients were calculated. A p-value <0.05 was considered significant.

Results

Table 1: Detection of Early DR by Imaging Modalities

Modality	DR Detected	Percentage
OCT	94	78.3%
Fundus Photography	74	61.7%

OCT detected significantly more early DR cases compared to fundus photography.

Table 2: Diagnostic Performance

Parameter	OCT	Fundus Photography
Sensitivity	92%	74%
Specificity	88%	82%
Accuracy	90%	78%

OCT showed superior sensitivity and accuracy in early detection.

Table 3: Correlation of HbA1c with DR Severity

HbA1c Level	Mild DR	Moderate DR	Severe DR
<7%	30	5	0
7–9%	25	20	5
>9%	10	15	10

Higher HbA1c levels were significantly associated with increased severity of DR.

Discussion

The present study demonstrated that Optical Coherence Tomography (OCT) is superior to fundus photography in detecting early diabetic retinopathy. OCT detected early retinal changes in a significantly higher proportion of patients, which is consistent with previous studies [11,12]. The ability of OCT to visualize retinal microstructure allows detection of subclinical changes such as retinal thickening and cystoid spaces, which may not be evident on fundus photography. Fundus photography, although widely used, has limitations in detecting early changes as it relies on visible vascular abnormalities [13]. Our findings are in agreement with studies by Browning et al., which reported higher sensitivity of OCT in early DR detection [14].

The diagnostic sensitivity of OCT (92%) observed in this study is comparable to previous reports [15]. The higher accuracy of OCT supports its role as an essential tool in screening programs, especially for early disease detection. However, fundus photography still remains valuable due to its cost-effectiveness and ease of use in large-scale screening [16].

A significant positive correlation between HbA1c levels and DR severity was observed in this study ($r = 0.68$, $p < 0.001$). This finding is consistent with landmark studies such as the UKPDS and DCCT trials, which established glycemic control as a key determinant of DR progression [17,18]. Chronic hyperglycemia leads to endothelial dysfunction, capillary basement membrane thickening, and retinal ischemia, contributing to disease progression [19].

Patients with HbA1c levels greater than 9% showed a higher prevalence of moderate to severe DR, highlighting the importance of strict glycemic control. Similar findings have been reported in Indian population studies (20).

The integration of OCT in routine screening may facilitate earlier diagnosis and timely intervention, potentially reducing the burden of visual impairment. However, cost and accessibility remain challenges, particularly in resource-limited settings.

Limitations of this study include its cross-sectional design and relatively small sample size. Longitudinal studies are needed to assess progression and predictive value of OCT findings.

Conclusion

The present study highlights the superior diagnostic capability of Optical Coherence Tomography over fundus photography in the early detection of diabetic retinopathy. OCT demonstrated higher sensitivity, specificity, and overall diagnostic accuracy, enabling identification of subclinical retinal changes that may not be visible on fundus imaging. A strong positive correlation between HbA1c levels and severity of diabetic retinopathy was observed, emphasizing the critical role of glycemic control in disease progression. Patients with higher HbA1c levels exhibited more advanced retinal changes, reinforcing the importance of regular monitoring and strict metabolic control. Although fundus photography remains a valuable and cost-effective screening tool, the addition of OCT can significantly enhance early diagnosis and improve clinical outcomes. Integrating OCT into routine diabetic screening protocols, especially in tertiary care settings, may help reduce the burden of preventable blindness.

Future studies with larger sample sizes and longitudinal follow-up are recommended to further validate these findings.

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