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ADVANCED DIAGNOSTIC TECHNOLOGIES IN THE ASSESSMENT OF DIABETIC RETINOPATHY

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Abstract. *Diabetic retinopathy is one of the leading causes of visual impairment among patients with diabetes mellitus. The present study evaluated the diagnostic significance of biomicroscopy, optical coherence tomography (OCT), B-scan ultrasonography, and fundus photography in 60 patients with diabetic retinopathy treated at the Regional Hospital of Eye Diseases in Andijan. Comprehensive ophthalmological examination enabled early detection of retinal microvascular abnormalities, diabetic macular edema, proliferative changes, and vitreoretinal complications. OCT demonstrated high sensitivity in identifying early retinal structural alterations, while B-scan ultrasonography was especially informative in patients with vitreous hemorrhage and media opacity. Fundus photography provided effective documentation and dynamic monitoring of retinal pathology. The combined application of modern diagnostic methods improved the accuracy of diabetic retinopathy assessment and contributed to timely therapeutic decision-making and prevention of disease progression.*

Keywords: *Diabetic retinopathy; diabetes mellitus; optical coherence tomography; biomicroscopy; B-scan ultrasonography; fundus photography; diabetic macular edema; retinal pathology; ophthalmological diagnostics.*

Introduction. Diabetic retinopathy (DR) is one of the most common and severe microvascular complications of diabetes mellitus and remains a leading cause of preventable blindness among the working-age population worldwide. The rapid increase in the prevalence of diabetes mellitus has resulted in a parallel rise in the incidence of retinal vascular complications, significantly affecting patients' quality of life and social activity. [1] Chronic hyperglycemia leads to progressive damage of retinal capillaries, microaneurysm formation, vascular permeability disorders, ischemia, and pathological neovascularization, which eventually contribute to visual impairment and irreversible blindness if not diagnosed and treated in a timely manner. [2] Early detection of diabetic retinopathy plays a crucial role in preventing disease progression and preserving visual function. Modern ophthalmological diagnostic methods allow clinicians to identify retinal structural and vascular changes even at subclinical stages. Comprehensive examination of the posterior segment of the eye is essential for accurate assessment of disease severity, monitoring of retinal pathology, and selection of optimal therapeutic tactics. [2, 3]

Among the most informative diagnostic techniques currently used in ophthalmology are biomicroscopy, optical coherence tomography (OCT), ocular ultrasound (B-scan ultrasonography), and fundus photography. Biomicroscopy enables detailed visualization of the anterior and posterior segments of the eye and allows assessment of vitreoretinal changes. OCT provides high-resolution cross-sectional imaging of retinal layers and is particularly valuable in

detecting diabetic macular edema and subtle retinal structural alterations. B-scan ultrasonography is especially important in cases with media opacity, vitreous hemorrhage, or suspected retinal detachment, where direct visualization of the fundus is difficult. Fundus photography serves as an effective method for documentation, screening, dynamic observation, and comparative evaluation of retinal lesions. [3] Despite significant advances in diagnostic technologies, optimization of comprehensive diagnostic approaches for diabetic retinopathy remains an aкtyal issue in clinical ophthalmology. Accurate combination of modern imaging methods improves early diagnosis, facilitates timely intervention, and reduces the risk of severe complications.

The aim of this study was to evaluate the diagnostic significance of biomicroscopy, optical coherence tomography, ocular ultrasound (B-scan), and fundus photography in patients with diabetic retinopathy and to improve the effectiveness of early detection and assessment of retinal pathological changes.

Materials and methods. The study was conducted at the Regional Hospital of Eye Diseases in Andijan and included 60 patients diagnosed with diabetic retinopathy associated with diabetes mellitus. Patients underwent comprehensive ophthalmological examination aimed at evaluating retinal structural changes, determining the stage of diabetic retinopathy, and identifying possible complications affecting visual function.

All patients were examined according to a standardized diagnostic protocol that included clinical and instrumental ophthalmological methods. The diagnosis and staging of diabetic retinopathy were established on the basis of clinical findings and imaging results.

Biomicroscopic examination of the anterior and posterior segments of the eye was performed using a slit lamp biomicroscope. Examination with additional non-contact lenses allowed detailed visualization of the vitreous body, retina, optic disc, and macular region.

Particular attention was paid to the presence of microaneurysms, retinal hemorrhages, exudates, neovascularization, vitreoretinal traction, and signs of diabetic macular edema.

Optical coherence tomography was used to assess retinal morphology and measure retinal thickness in the macular region. OCT enabled high-resolution cross-sectional imaging of retinal layers and identification of intraretinal edema, cystic changes, serous retinal detachment, and structural disruption of the macula. The obtained images were analyzed to evaluate the severity of diabetic macular edema and progression of retinal pathology.

B-scan ultrasonography of the eye was performed in patients with insufficient visualization of the fundus caused by vitreous hemorrhage, lens opacity, or advanced proliferative diabetic retinopathy. Ultrasound examination allowed assessment of the vitreous cavity, retinal attachment, tractional retinal detachment, and intraocular pathological changes. The method was especially useful for diagnosing posterior segment complications in advanced stages of the disease.

Fundus photography was carried out for documentation and dynamic monitoring of retinal pathological changes. Digital retinal images were obtained after pupil dilation and analyzed for the presence of microvascular abnormalities, hemorrhages, hard exudates, cotton-wool spots, and neovascularization. Comparative analysis of sequential fundus photographs enabled evaluation of disease progression and treatment effectiveness.

The obtained clinical and instrumental data were systematized and statistically analyzed.

The effectiveness of each diagnostic method was evaluated according to its ability to detect early retinal changes, assess disease severity, and identify complications of diabetic retinopathy.

Results. A total of 60 patients with diabetic retinopathy were examined during the study.

According to clinical and instrumental findings, non-proliferative diabetic retinopathy (NPDR) was diagnosed in 38 patients (63.3%), while proliferative diabetic retinopathy (PDR) was identified in 22 patients (36.7%).

Biomicroscopic examination revealed microaneurysms in 52 patients (86.7%), retinal hemorrhages in 47 patients (78.3%), hard exudates in 35 patients (58.3%), and neovascularization in 20 patients (33.3%). Signs of vitreoretinal traction were detected in 12 patients (20.0%) with advanced proliferative stages of diabetic retinopathy.

Optical coherence tomography (OCT) demonstrated diabetic macular edema in 31 patients (51.7%). Increased retinal thickness in the macular area was observed in 28 patients (46.7%), while cystoid macular changes were identified in 19 patients (31.7%). In 14 patients (23.3%), OCT detected early structural retinal abnormalities that were not clearly visible during routine ophthalmoscopy, confirming the high sensitivity of this method for early diagnosis. (Figure 1)

OCT Findings	Number of Patients (n=60)	Percentage (%)
Diabetic macular edema	31	51.7%
Increased retinal thickness	28	46.7%
Cystoid macular changes	19	31.7%
Early structural retinal abnormalities	14	23.3%

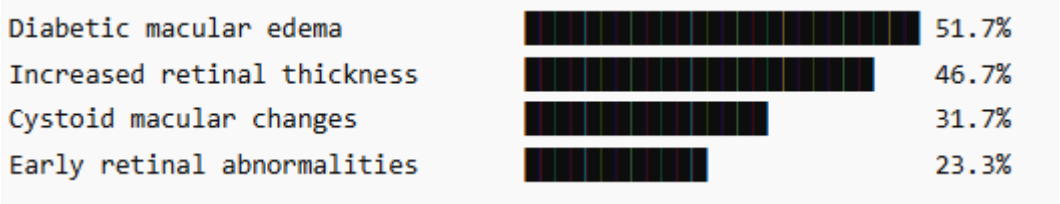

Figure 1. Distribution of OCT-detected retinal abnormalities in patients with diabetic retinopathy. OCT demonstrated high sensitivity in detecting diabetic macular edema and early retinal structural changes.

B-scan ultrasonography was performed in 18 patients (30.0%) with reduced transparency of ocular media caused mainly by vitreous hemorrhage. Vitreous opacities were detected in 15 patients (25.0%), tractional retinal detachment in 7 patients (11.7%), and fibrovascular proliferative membranes in 9 patients (15.0%). In 5 cases (8.3%), ultrasound examination revealed retinal complications that could not be adequately visualized by standard fundus examination.

Fundus photography enabled objective documentation of retinal vascular changes in all examined patients. Comparative analysis of sequential retinal images demonstrated progression of retinal lesions in 21 patients (35.0%) without timely treatment, whereas stabilization of retinal pathology after therapeutic interventions was observed in 34 patients (56.7%).

The combined use of biomicroscopy, OCT, B-scan ultrasonography, and fundus photography increased the diagnostic accuracy of diabetic retinopathy by approximately 27% compared with routine ophthalmoscopy alone.

Comprehensive diagnostic assessment allowed earlier identification of retinal pathology and improved selection of therapeutic tactics for patients with diabetic retinopathy.

Discussion. The results of the present study demonstrated that the combined use of biomicroscopy, optical coherence tomography (OCT), B-scan ultrasonography, and fundus photography significantly improves the diagnostic effectiveness in patients with diabetic retinopathy. Early identification of retinal structural abnormalities and accurate assessment of disease severity allowed timely therapeutic decision-making and prevention of vision-threatening complications.

Our findings are consistent with previous studies reporting the high prevalence of diabetic macular edema and retinal microvascular abnormalities among patients with long-standing diabetes mellitus. In the current study, diabetic macular edema detected by OCT was observed in 51.7% of patients, which corresponds with the data reported by American Diabetes Association and several international ophthalmological studies, where the prevalence of diabetic macular edema ranged from 45% to 55% among patients with moderate and severe diabetic retinopathy. [4] Biomicroscopy revealed retinal hemorrhages in 78.3% and microaneurysms in 86.7% of examined patients. Similar results were described by studies conducted by American Academy of Ophthalmology, which emphasized that retinal hemorrhages and microaneurysms remain among the earliest and most characteristic clinical manifestations of diabetic retinopathy. The high frequency of these findings in our study confirms the importance of routine slit-lamp biomicroscopy in primary ophthalmological evaluation. [5]

Optical coherence tomography demonstrated high sensitivity in detecting early retinal changes that were not clearly visualized during standard ophthalmoscopy. Early structural retinal abnormalities were identified by OCT in 23.3% of patients despite minimal ophthalmoscopic changes. These findings support previously published studies showing that OCT is superior to conventional fundoscopy in detecting subclinical macular edema and subtle retinal layer alterations. International studies have reported OCT sensitivity rates exceeding 90% for diabetic macular edema detection, which correlates with the results obtained in our investigation.

B-scan ultrasonography proved especially valuable in advanced proliferative diabetic retinopathy complicated by vitreous hemorrhage and media opacity. Tractional retinal detachment was identified in 11.7% of patients in our study. Similar rates were reported in studies evaluating proliferative diabetic retinopathy in tertiary ophthalmological centers, where tractional retinal detachment occurred in approximately 10–15% of advanced cases. Ultrasound examination allowed visualization of posterior segment pathology even when direct ophthalmoscopy was impossible, confirming its important diagnostic role in severe diabetic eye disease.

Fundus photography provided effective documentation and dynamic monitoring of retinal lesions. Sequential retinal imaging enabled objective evaluation of disease progression and treatment outcomes. Previous studies have also demonstrated that fundus photography improves screening programs and facilitates long-term follow-up of diabetic retinopathy patients, particularly in large-scale clinical practice. [6]

The present study confirms that no single diagnostic method alone is sufficient for complete assessment of diabetic retinopathy severity.

Comprehensive multimodal examination combining biomicroscopy, OCT, B-scan ultrasonography, and fundus photography significantly increases diagnostic accuracy and allows earlier detection of pathological retinal changes. The obtained results support the recommendations of international ophthalmological guidelines emphasizing the importance of integrated diagnostic approaches for effective management of diabetic retinopathy. [6]

Conclusion. The present study demonstrated that comprehensive ophthalmological examination using biomicroscopy, optical coherence tomography (OCT), B-scan ultrasonography, and fundus photography significantly improves the early diagnosis and evaluation of diabetic retinopathy. The combined use of these diagnostic methods allowed accurate identification of retinal microvascular abnormalities, diabetic macular edema, vitreoretinal complications, and proliferative changes at different stages of the disease. Biomicroscopy proved effective for routine clinical assessment of retinal vascular lesions, while OCT showed high sensitivity in detecting early macular structural changes and diabetic macular edema. B-scan ultrasonography was particularly valuable in advanced proliferative diabetic retinopathy with vitreous hemorrhage and reduced transparency of ocular media. Fundus photography enabled objective documentation and dynamic monitoring of retinal pathological changes during follow-up.

The integration of modern imaging techniques increased the diagnostic accuracy of diabetic retinopathy, facilitated timely therapeutic decision-making, and contributed to prevention of severe visual complications. Early detection of retinal pathology and comprehensive assessment of disease progression improve the effectiveness of patient management and may reduce the risk of irreversible vision loss in patients with diabetes mellitus. The results of the study confirm the clinical importance of a multimodal diagnostic approach in diabetic retinopathy and support the implementation of comprehensive ophthalmological screening programs for patients with diabetes mellitus. Further studies involving larger patient populations are recommended to optimize diagnostic algorithms and improve long-term treatment outcomes.

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