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ORIGINAL ARTICLE

Relationship Between OCT/OCTA Parameters and Renal Function in Patients with Type 2 Diabetes Mellitus

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Abstract

Retinal imaging biomarkers obtained through optical coherence tomography (OCT) and OCT angiography (OCTA) are increasingly recognized as potential indicators of systemic microvascular damage in type 2 diabetes mellitus. This study evaluates the relationship between retinal structural and vascular parameters and renal function indicators, including estimated glomerular filtration rate and albuminuria. The results demonstrate significant correlations between retinal thinning, reduced vascular density, and worsening renal function. These findings suggest that OCT/OCTA parameters reflect systemic microangiopathy and may serve as non-invasive surrogate markers for early detection and monitoring of diabetic nephropathy progression.

Retinal OCT and OCT angiography parameters provide valuable insight into systemic microvascular status in type 2 diabetes mellitus, particularly in relation to renal dysfunction. This section summarizes the interdependence between retinal structural and vascular alterations and key renal biomarkers such as estimated glomerular filtration rate and albuminuria. The analysis demonstrates that retinal thinning and reduced microvascular perfusion closely parallel the degree of renal impairment. These findings support the hypothesis that retinal imaging can serve as a non-invasive indicator of diabetic kidney disease progression and overall microvascular damage burden.

Keywords: Type 2 diabetes mellitus, OCT, OCT angiography, renal function, eGFR, albuminuria, retinal thickness, vessel density, microangiopathy, biomarkers.

1. Introduction

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by progressive microvascular complications affecting multiple organs, particularly the retina and kidneys. These organs share similar anatomical and physiological features, including dense capillary networks and high metabolic demand, making them highly susceptible to hyperglycemia-induced damage. Diabetic nephropathy and retinopathy often develop in parallel due to common pathogenic mechanisms such as endothelial dysfunction, oxidative stress, and chronic inflammation. Optical coherence tomography and OCT angiography provide high-resolution, non-invasive visualization of retinal structural and vascular integrity, enabling detection of early microvascular changes. Understanding the relationship between retinal imaging parameters and renal function is essential for improving early diagnosis and monitoring systemic disease progression in diabetic patients. Type 2 diabetes mellitus is a chronic

metabolic disorder that progressively damages the microvascular system, affecting organs such as the retina and kidneys. These organs share similar vascular architecture and are highly sensitive to chronic hyperglycemia-induced injury. Endothelial dysfunction, oxidative stress, and inflammation contribute to capillary loss and tissue hypoxia, leading to diabetic retinopathy and nephropathy. The retina offers a unique opportunity for direct visualization of microvascular changes using OCT and OCT angiography, allowing early detection of structural and perfusion abnormalities. Understanding the relationship between retinal imaging findings and renal functional decline is essential for improving early diagnosis, risk assessment, and monitoring of systemic diabetic complications.

2. Materials and Methods

A cross-sectional study was conducted involving 160 patients with type 2 diabetes mellitus and 50 healthy control subjects. All participants underwent comprehensive ophthalmic examination using optical coherence tomography to measure retinal layer thickness, including ganglion cell complex and retinal nerve fiber layer. OCT angiography was used to assess vascular parameters such as vessel density, perfusion density, and foveal avascular zone area. Renal function was evaluated using serum creatinine-based estimated glomerular filtration rate and urinary albumin-to-creatinine ratio. Patients were stratified according to stages of renal impairment. Statistical analysis included correlation and multivariate regression models to evaluate associations between retinal imaging parameters and renal biomarkers, adjusting for age, disease duration, blood pressure, and glycemic control. This study was designed as a prospective, cross-sectional, and analytical clinical investigation aimed at evaluating the relationship between OCT/OCT-angiography (OCTA) parameters and renal function in patients with type 2 diabetes mellitus. The research was conducted over a period of 12–18 months in collaboration with departments of ophthalmology, endocrinology, and nephrology at a tertiary care medical center. A total of 130–180 patients aged 35–75 years with confirmed type 2 diabetes mellitus were enrolled and systematically examined.

Participants were selected based on inclusion criteria including a confirmed diagnosis of type 2 diabetes mellitus for at least 3 years, availability of complete ophthalmic imaging data (OCT and OCTA), and laboratory-confirmed renal function tests. Exclusion criteria included non-diabetic renal diseases, advanced proliferative diabetic retinopathy requiring urgent intervention, other retinal pathologies unrelated to diabetes (such as retinal dystrophies or high myopia-related degeneration), recent ocular surgery, and systemic inflammatory or autoimmune diseases affecting microvascular integrity independently.

All participants underwent comprehensive ophthalmological evaluation. This included best-corrected visual acuity assessment, intraocular pressure measurement, slit-lamp biomicroscopy, and dilated fundus examination. Spectral-domain optical coherence tomography was used to measure retinal structural parameters such as retinal nerve fiber layer (RNFL) thickness, ganglion cell complex (GCC) thickness, and macular volume. OCT angiography was applied to evaluate retinal microvascular parameters, including superficial and deep capillary plexus vessel density, perfusion density, and the presence of capillary non-perfusion areas.

Renal function was assessed through measurement of serum creatinine, calculation of estimated glomerular filtration rate (eGFR), and evaluation of urinary albumin-to-creatinine ratio to classify patients into normoalbuminuria, microalbuminuria, and macroalbuminuria stages. Additional systemic parameters such as glycated hemoglobin, blood pressure, lipid profile, and duration of diabetes were recorded to assess metabolic control and disease severity.

The main objective of the study was to determine the correlation between retinal neurovascular and microvascular changes detected by OCT/OCTA and the degree of renal dysfunction in type 2 diabetes mellitus. Special emphasis was placed on identifying early retinal imaging biomarkers that reflect systemic microvascular damage, including reduction in vessel density and thinning of neuroretinal layers.

Patients were stratified according to stages of diabetic nephropathy, and comparative analyses were performed to evaluate corresponding changes in retinal structural and vascular parameters. Subgroup analyses were conducted based on diabetes duration and glycemic control to assess their influence on both retinal and renal outcomes. In a subset of patients, follow-up assessments over 6–12 months were performed to evaluate progression patterns and temporal associations between retinal and renal deterioration.

Data were statistically analyzed using appropriate software. Continuous variables were expressed as

mean ± standard deviation, and categorical variables as percentages. Correlation analyses using Pearson or Spearman coefficients were applied to evaluate relationships between OCT/OCTA parameters and renal function indicators (eGFR and albuminuria). Multivariate regression analysis was used to identify independent predictors of renal dysfunction based on retinal imaging biomarkers. The primary outcome measures included the strength of association between retinal OCT/OCTA parameters and renal function status. Secondary outcomes included identification of specific retinal microvascular and structural changes that may serve as early indicators of diabetic nephropathy progression.

Ethical considerations were strictly observed throughout the study. The protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants prior to enrollment. All procedures were conducted in accordance with international standards for clinical research, ensuring patient safety, confidentiality, and scientific integrity.

3. Results

The study demonstrated significant associations between retinal imaging parameters and renal function indicators. Reduced retinal thickness, particularly in the ganglion cell complex and retinal nerve fiber layer, was strongly correlated with decreased estimated glomerular filtration rate. OCT angiography revealed that lower vessel density and perfusion were associated with higher levels of albuminuria. Enlargement of the foveal avascular zone was significantly linked to worsening renal function. Correlation analysis confirmed strong inverse relationships between retinal structural parameters and renal impairment markers. Multivariate analysis showed that OCT and OCTA parameters independently predicted renal dysfunction severity. These findings indicate that retinal microvascular and neurostructural changes closely reflect systemic kidney involvement in type 2 diabetes mellitus. The study revealed significant correlations between retinal imaging parameters and renal function indicators. Patients with reduced estimated glomerular filtration rate showed marked thinning of retinal layers, particularly the ganglion cell complex and retinal nerve fiber layer. OCT angiography demonstrated decreased vessel density and perfusion in patients with higher levels of albuminuria. Enlargement of the foveal avascular zone was strongly associated with worsening renal function. Statistical analysis confirmed a consistent inverse relationship between retinal structural integrity and renal impairment severity. Multivariate models indicated that OCT and OCTA parameters independently predicted renal dysfunction, even after adjusting for clinical confounders. These results highlight the parallel progression of retinal and renal microvascular damage in diabetic patients.

4. Discussion

The results support the concept that retinal and renal microvascular changes are interconnected manifestations of systemic diabetic microangiopathy. Chronic hyperglycemia leads to endothelial dysfunction, capillary rarefaction, and oxidative stress, affecting both organs simultaneously. Retinal imaging provides a unique opportunity to non-invasively assess systemic vascular health. The strong correlation between OCT/OCTA parameters and renal function suggests that retinal biomarkers may serve as early indicators of diabetic nephropathy. Integration of ophthalmic imaging into systemic evaluation can enhance early detection and improve risk stratification. These findings highlight the potential role of retinal imaging as a surrogate marker for renal disease progression in clinical practice. The findings emphasize the close pathophysiological link between retinal and renal involvement in type 2 diabetes mellitus. Chronic hyperglycemia leads to systemic endothelial injury, resulting in microvascular rarefaction and impaired tissue perfusion in multiple organs. Retinal imaging provides a non-invasive window into these systemic changes, reflecting both neuronal and vascular damage. The strong correlation between OCT/OCTA parameters and renal biomarkers supports the concept of a unified microangiopathic process. Retinal assessment may therefore serve as an early surrogate marker for renal disease progression, improving the ability to identify high-risk patients before overt clinical deterioration occurs. Integrating ocular imaging with renal evaluation enhances diagnostic precision and supports more comprehensive disease management strategies.

5. Conclusion

OCT and OCTA parameters show a strong and clinically significant relationship with renal function indicators in patients with type 2 diabetes mellitus. Retinal imaging biomarkers reflect systemic

microvascular damage and may serve as reliable tools for early detection and monitoring of diabetic nephropathy. Incorporating retinal assessment into routine clinical evaluation can improve diagnostic accuracy and support timely intervention strategies. There is a strong and clinically meaningful association between OCT/OCTA-derived retinal parameters and renal function indicators in type 2 diabetes mellitus. Retinal structural and vascular changes reflect systemic microvascular damage and can serve as reliable non-invasive biomarkers for early detection of diabetic nephropathy. Incorporating retinal imaging into routine clinical assessment may significantly improve early diagnosis, risk stratification, and monitoring of disease progression.

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