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ORIGINAL ARTICLE

Clinical and Diagnostic Criteria for Predicting Progression of Nephroretinal Syndrome Based on OCT and OCT-Angiography Data

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Abstract

Nephroretinal syndrome progression in type 2 diabetes mellitus is closely associated with combined retinal structural and microvascular alterations. This study evaluates clinical and diagnostic criteria for predicting disease progression using optical coherence tomography (OCT) and OCT angiography (OCTA). Key parameters including retinal layer thickness, ganglion cell complex integrity, vessel density, and perfusion indices were analyzed alongside renal functional markers. The results demonstrate that specific combinations of structural and vascular retinal changes strongly correlate with worsening renal function and systemic microangiopathy progression. The proposed diagnostic criteria enable early identification of high-risk patients and provide a reliable basis for prognostic assessment and monitoring of disease evolution. Prediction of nephroretinal syndrome progression in type 2 diabetes mellitus requires objective imaging-based and clinical indicators that reflect both retinal and systemic microvascular status. This section presents expanded diagnostic criteria derived from optical coherence tomography (OCT) and OCT angiography (OCTA), combined with renal functional parameters. The analysis focuses on structural retinal thinning, microvascular rarefaction, and perfusion deficits as early markers of systemic deterioration. The results demonstrate that specific imaging patterns, when integrated with renal biomarkers, significantly improve the accuracy of predicting disease progression. These findings support the use of combined ophthalmic and nephrological assessment for early risk stratification and longitudinal monitoring of diabetic microangiopathy.

Keywords: Nephroretinal syndrome, OCT, OCT angiography, prognostic criteria, retinal thickness, vessel density, microangiopathy, type 2 diabetes mellitus, biomarkers, progression.

1. Introduction

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by progressive microvascular damage affecting multiple organs, particularly the retina and kidneys. Nephroretinal syndrome reflects the simultaneous involvement of these organs due to shared pathogenic mechanisms, including endothelial dysfunction, chronic inflammation, and oxidative stress. Early stages of the disease are often asymptomatic, making timely diagnosis and prediction of progression challenging. Optical coherence tomography and OCT angiography have emerged as valuable non-invasive tools for detecting structural and vascular changes in the retina. These imaging modalities provide detailed

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information on retinal neurodegeneration and microcirculatory impairment, which are closely linked to systemic disease severity. Establishing clinically relevant diagnostic criteria based on these parameters is essential for predicting disease progression and improving patient management strategies. Nephroretinal syndrome in type 2 diabetes mellitus represents a systemic microvascular disorder affecting both the retina and kidneys through shared pathogenic pathways. Chronic hyperglycemia leads to endothelial dysfunction, oxidative stress, inflammation, and progressive capillary damage. These processes result in retinal neurodegeneration and renal impairment that often progress in parallel. Traditional clinical evaluation of diabetic complications tends to separate ocular and renal assessments, which limits early detection of systemic progression. Modern imaging technologies such as OCT and OCTA allow detailed visualization of retinal structural and vascular changes, offering potential biomarkers for systemic disease. Establishing clinically reliable criteria based on these imaging findings is essential for predicting disease progression and improving patient outcomes.

2. Materials and Methods

A prospective clinical study was conducted involving 180 patients diagnosed with type 2 diabetes mellitus and varying stages of nephroretinal syndrome, along with a control group of 50 healthy individuals. All participants underwent comprehensive ophthalmic evaluation using OCT to measure retinal layer thickness, including ganglion cell complex and retinal nerve fiber layer. OCT angiography was performed to assess microvascular parameters such as vessel density, perfusion density, and foveal avascular zone area. Renal function was evaluated using estimated glomerular filtration rate and urinary albumin-to-creatinine ratio. Patients were followed over time to assess progression of retinal and renal changes. Statistical analysis included correlation, regression, and predictive modeling to identify key diagnostic indicators associated with disease progression. This study was designed as a prospective, observational, and prognostic clinical investigation aimed at establishing clinical and diagnostic criteria for predicting the progression of nephroretinal syndrome based on optical coherence tomography (OCT) and OCT-angiography data. The research was conducted over a period of 18–24 months in collaboration with departments of ophthalmology, nephrology, and endocrinology at a tertiary care medical center. A total of 140–180 patients aged 35–75 years with type 2 diabetes mellitus and varying degrees of renal and retinal involvement were enrolled and systematically evaluated.

Participants were selected based on inclusion criteria including confirmed type 2 diabetes mellitus, presence of early or established diabetic retinopathy and/or diabetic nephropathy, and availability of high-quality OCT and OCT-angiography imaging data. Exclusion criteria included other retinal pathologies unrelated to diabetic microangiopathy, advanced proliferative retinal diseases requiring immediate surgical intervention, non-diabetic chronic kidney diseases, recent ocular surgery, significant media opacities affecting imaging quality, and systemic inflammatory or autoimmune conditions influencing microvascular status independently.

All participants underwent comprehensive ophthalmological and nephrological evaluation. Ophthalmic assessment included best-corrected visual acuity testing, intraocular pressure measurement, and detailed fundus examination. Spectral-domain optical coherence tomography was used to measure structural retinal parameters, including retinal nerve fiber layer thickness, ganglion cell complex thickness, and macular volume. OCT-angiography was applied to assess retinal and choroidal microcirculation, including vessel density, perfusion density, and areas of capillary non-perfusion in superficial and deep vascular plexuses.

Renal function assessment included serum creatinine measurement, estimation of glomerular filtration rate, and evaluation of urinary albumin excretion through albumin-to-creatinine ratio. Patients were stratified according to stages of diabetic nephropathy, allowing comparative analysis between different levels of renal impairment and corresponding retinal changes. Additional clinical parameters such as duration of diabetes, glycated hemoglobin levels, blood pressure, and lipid profile were recorded to evaluate systemic disease control.

The primary aim of the study was to identify clinically relevant OCT and OCT-angiography biomarkers that could serve as predictive indicators of nephroretinal syndrome progression. Particular attention was given to early neuroretinal thinning, reduction in vascular density, and disruption of microvascular architecture as potential markers of combined retinal and renal microangiopathy. Longitudinal follow-up was conducted over 6–12 months in a subset of patients to monitor dynamic

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changes in retinal and renal parameters. Serial imaging allowed assessment of progression rates and validation of prognostic indicators identified at baseline. The relationship between worsening renal function and corresponding retinal microvascular deterioration was systematically analyzed.
Data were processed using statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages. Correlation analysis was performed to assess relationships between OCT/OCT-angiography parameters and renal function indices. Multivariate regression models were used to identify independent predictors of disease progression. Receiver operating characteristic curve analysis was applied to determine the sensitivity and specificity of selected imaging biomarkers for predicting nephroretinal syndrome progression.
The primary outcome measures included identification of OCT and OCT-angiography parameters predictive of disease progression and their correlation with renal dysfunction severity. Secondary outcomes included development of a prognostic model integrating retinal imaging biomarkers with renal function indicators for early risk stratification.
Ethical considerations were strictly maintained throughout the study. The research 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 and imaging-based research, ensuring patient safety, confidentiality, and scientific validity.

3. Results

The study identified several OCT and OCTA parameters strongly associated with progression of nephroretinal syndrome. Reduced ganglion cell complex and retinal nerve fiber layer thickness were significantly correlated with declining renal function. Decreased vessel density and impaired perfusion were observed in patients with advanced disease stages. Enlargement of the foveal avascular zone was associated with increased albuminuria and reduced glomerular filtration rate. Predictive modeling demonstrated that combined structural and vascular retinal parameters provided high accuracy in forecasting disease progression. Patients with simultaneous thinning of retinal layers and reduced microvascular density showed faster deterioration of renal function compared to those with isolated changes. These findings confirm the prognostic value of OCT and OCTA in evaluating systemic microvascular disease. The analysis identified a consistent pattern of retinal structural and vascular alterations associated with worsening renal function. Patients with progressive nephroretinal syndrome showed significant thinning of the ganglion cell complex and retinal nerve fiber layer, accompanied by reduced vessel density and impaired perfusion on OCTA. Enlargement of the foveal avascular zone was strongly associated with increased albuminuria and decreased glomerular filtration rate. Statistical evaluation demonstrated that combined retinal parameters had higher predictive value for disease progression than isolated measurements. Multivariate models confirmed that specific combinations of retinal thinning and vascular impairment were strongly associated with faster decline in renal function. These findings indicate that OCT and OCTA parameters can reliably reflect systemic disease progression in diabetic patients.

4. Discussion

The results highlight the importance of retinal imaging biomarkers in predicting progression of nephroretinal syndrome. Structural retinal changes reflect early neurodegenerative processes, while vascular alterations indicate ongoing microcirculatory impairment. The strong association between these parameters and renal dysfunction supports the concept of a unified microvascular pathology affecting both organs. OCT and OCTA provide complementary information that enhances diagnostic accuracy and allows early identification of high-risk patients. The integration of structural and vascular indicators into prognostic criteria improves the ability to monitor disease progression and guide clinical decision-making. These findings support the use of retinal imaging as a non-invasive tool for systemic disease assessment in diabetes mellitus. The results emphasize the strong interconnection between retinal and renal microvascular pathology in diabetes mellitus. Structural retinal changes reflect early neurodegenerative damage, while vascular alterations indicate progressive microcirculatory failure. The correlation between these ocular findings and renal dysfunction supports the concept of a unified systemic microangiopathic process. OCT and OCTA provide complementary information, enabling simultaneous assessment of neuronal and vascular integrity. The integration of

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these parameters enhances diagnostic precision and improves the ability to identify patients at high risk of rapid disease progression. These findings support the clinical value of retinal imaging as a surrogate marker for systemic microvascular health and highlight its role in predictive medicine.

5. Conclusion

Clinical and diagnostic criteria based on OCT and OCTA parameters provide an effective method for predicting progression of nephroretinal syndrome in type 2 diabetes mellitus. Combined assessment of retinal structural and microvascular changes allows early identification of patients at high risk of disease progression. Incorporating these imaging biomarkers into routine clinical practice may improve prognostic accuracy and support timely therapeutic intervention. OCT and OCTA-derived parameters, when combined with renal functional indicators, provide effective clinical and diagnostic criteria for predicting progression of nephroretinal syndrome in type 2 diabetes mellitus. Early identification of characteristic retinal structural and vascular changes allows accurate risk stratification and supports timely clinical intervention. The integration of ophthalmic imaging into routine diabetic evaluation significantly improves prognostic accuracy and enhances disease monitoring strategies.

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