Section: Ophthalmology & Nephrology

Systematic Review

ASSOCIATION OF RETINAL MICROVASCULAR CHANGES ON OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY WITH ALBUMINURIA IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A SYSTEMATIC REVIEW

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ABSTRACT

Background: Diabetic retinopathy and diabetic kidney disease are important microvascular complications of type 2 diabetes mellitus (T2DM). Optical coherence tomography angiography (OCTA) allows non-invasive assessment of retinal microvascular changes which may be associated with renal involvement. **Objective:** To systematically review the association between retinal microvascular parameters assessed using OCTA and albuminuria in patients with T2DM.

Materials and Methods: A systematic literature search was conducted in PubMed and Scopus for studies published between October 2023 and June 2026. Observational studies reporting direct associations between quantitative retinal OCTA parameters and urinary albumin measurements were considered. The findings were compared according to OCTA parameters, retinal regions and reported statistical associations.

Results: The search identified 112 unique records. Five studies were assessed using available full texts, while one additional study contributed abstract-only evidence. Increased albuminuria was generally associated with reduced superficial and deep capillary plexus vessel density, greater retinal non-perfusion and changes in foveal avascular zone parameters. Liu et al. reported negative correlations of urinary albumin-to-creatinine ratio (UACR) with superficial ($r = -0.56$) and deep capillary plexus vessel density ($r = -0.54$). Significant associations were also reported for macular perfusion and peripapillary capillary density. The strength of association varied according to retinal region, severity of diabetic retinopathy and statistical adjustment.

Conclusion: Retinal microvascular changes assessed using OCTA showed an association with albuminuria in patients with T2DM. OCTA may provide additional information regarding diabetic microvascular involvement. Further prospective studies with standardised measurements are required to establish its clinical utility.

Keywords: Type 2 diabetes mellitus; Optical coherence tomography angiography; Albuminuria; Diabetic kidney disease; Retinal microvasculature; Urinary albumin-to-creatinine ratio.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major public health problem and is associated with several microvascular complications. The increasing prevalence of diabetes has also increased the burden of diabetic retinopathy and diabetic kidney disease.[1] Diabetic kidney disease is an important cause of chronic kidney disease and may progress to renal

failure. Albuminuria is one of the important indicators of renal damage in patients with diabetes. It is commonly assessed by urinary albumin-to-creatinine ratio (UACR), which is recommended along with estimated glomerular filtration rate (eGFR) for routine assessment of renal function.[2]

Diabetic retinopathy and diabetic kidney disease share several common pathological mechanisms. Prolonged hyperglycaemia causes endothelial dysfunction, basement membrane changes and damage to the small blood vessels of the retina and kidneys. These changes may develop together, although the severity of involvement in both organs may differ. Retinal microvascular abnormalities may also be present before the development of clinically detectable diabetic retinopathy.[3,4]

Optical coherence tomography angiography (OCTA) is a non-invasive imaging technique that allows detailed examination of retinal microvasculature without the use of contrast dye. It provides quantitative measurements of superficial and deep capillary plexus vessel density, perfusion density, foveal avascular zone (FAZ) and areas of capillary non-perfusion. These parameters help in identifying early retinal microvascular alterations which may not be visible on routine fundus examination.[4]

Recent studies have evaluated the relationship between retinal OCTA parameters and renal involvement in patients with T2DM. Kim et al. reported an association between retinal capillary non-perfusion and albuminuria in patients with diabetic retinopathy.[5] Xing et al. examined the correlation of renal function with retinal and choroidal OCTA parameters in patients with early-stage diabetes.[6] Jin et al. observed an association of urinary microalbumin and UACR with peripapillary capillary density in patients without clinically detectable retinopathy.[7] Zha et al. reported an association between albuminuria and retinal ischaemic changes assessed using OCTA.[8]

The findings vary according to the retinal parameters studied, severity of diabetic retinopathy and methods used for assessment of renal involvement. Some studies have evaluated diabetic kidney disease or eGFR without examining the direct association between retinal microvascular measurements and urinary albumin excretion. A systematic evaluation of the available evidence may help in understanding whether retinal OCTA parameters reflect albuminuria in patients with T2DM. The present systematic review aimed to evaluate the association between retinal microvascular changes measured using OCTA and albuminuria in adult patients with T2DM.

MATERIALS AND METHODS

Study Design and Reporting Guidelines

This systematic review was conducted to evaluate the association between retinal microvascular changes assessed using optical coherence tomography angiography (OCTA) and albuminuria in patients with type 2 diabetes mellitus (T2DM). The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[9] A systematic approach was used for literature searching, study selection, data extraction and assessment of methodological quality.

Literature Search Strategy

A literature search was conducted in PubMed and Scopus in July 2026. Studies published between October 2023 and June 2026 were considered. The search included terms related to optical coherence tomography angiography, diabetes mellitus, albuminuria, microalbuminuria and urinary albumin-to-creatinine ratio (UACR). An additional search using terms such as diabetic nephropathy, diabetic kidney disease and renal function was performed to identify studies reporting albuminuria as a secondary outcome. Boolean operators AND and OR were used to combine the search terms. The publication date restriction was applied during screening, as the database searches covered the publication years 2023 to 2026. The complete search strategies are provided in Supplementary Table S1.

Eligibility Criteria

Original observational studies involving adults aged 18 years or above with T2DM were considered eligible. Studies were included if they evaluated quantitative retinal OCTA parameters and reported a direct statistical association with urinary albumin excretion, microalbuminuria or UACR. Studies comparing OCTA parameters across different albuminuria categories were also considered.

Studies involving only type 1 diabetes mellitus, gestational diabetes or prediabetes were excluded. Studies involving mixed diabetes populations were considered only when T2DM-specific results were available separately. Articles reporting only eGFR, serum creatinine or diabetic kidney disease status without a direct OCTA–albuminuria association were excluded. Reviews, case reports, conference abstracts, animal studies and studies using structural OCT without OCTA were also excluded.

Study Selection and Data Extraction

Records identified from both databases were combined and duplicate entries were removed. Titles and abstracts were screened according to the eligibility criteria. Full-text articles of potentially relevant studies were assessed wherever available. The full text of one study by Xiao et al. could not be retrieved. Its published abstract was used to extract the available findings and was considered separately during evidence synthesis. Complete eligibility verification was not possible for this study.

Data extraction included the first author, publication year, country, study design, sample size, patient characteristics, OCTA device, retinal parameters evaluated, method of albuminuria assessment and main statistical findings. Correlation coefficients, regression estimates, odds ratios, confidence intervals and p-values were extracted wherever available. Both statistically significant and non-

significant associations were considered. For the study available only as an abstract, data extraction was limited to the information reported in the abstract.

Quality Assessment and Risk of Bias

The methodological quality of studies with available full texts was assessed using the Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies.[10] The assessment included patient selection, measurement of OCTA parameters and albuminuria, identification and management of confounding factors and appropriateness of statistical analysis. Each criterion was classified as Yes, No, Unclear or Not applicable. The methodological limitations of individual studies were considered while interpreting the findings. The study available only as a published abstract was not subjected to complete methodological appraisal due to insufficient information.

Data Synthesis

The findings of the included studies were systematically reviewed and compared according to the OCTA parameters evaluated. These included superficial and deep capillary plexus vessel density, perfusion density, foveal avascular zone measurements and peripapillary vascular parameters. Their associations with urinary albumin levels and UACR were examined. The direction and strength of associations were compared across studies. Adjusted estimates were given preference wherever available.

The findings were summarised in evidence tables and compared across studies. Results available only from the published abstract were presented separately, as complete statistical information could not be obtained. Meta-analysis was not performed because of differences in OCTA devices, scanning protocols, retinal regions, methods of albuminuria assessment and statistical measures reported across studies.

RESULTS

Study Selection

The literature search conducted in PubMed and Scopus identified 112 unique records after removal of duplicates. Titles and abstracts were screened according to the eligibility criteria. Five studies with available full texts were identified as eligible for synthesis. One additional study by Xiao et al. was available only as a published abstract and its findings were considered separately. Complete eligibility verification and methodological quality assessment could not be performed for this study.

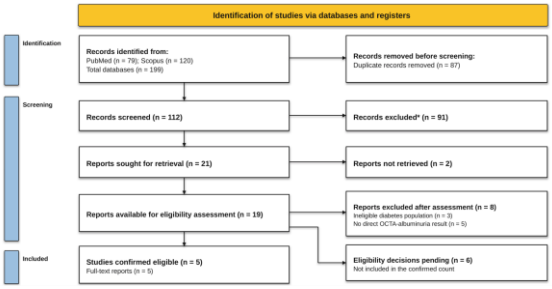


Figure 1: PRISMA 2020 flow diagram

Characteristics of the Included Studies

The five studies with available full texts were published between 2024 and 2026 and were conducted in China and South Korea. Kim et al,[5] included 180 patients with T2DM, while Xing et al,[6] evaluated 164 patients without diabetic retinopathy. Jin et al,[7] included 52 patients with T2DM and 42 healthy controls. Zha et al,[8] evaluated 134 patients with T2DM in the OCTA subgroup. Liu et al,[11] included 220 patients with T2DM, divided according to the presence of diabetic retinopathy and diabetic kidney disease. An additional study by Xiao et al,[12] included 76 patients with T2DM (139 eyes). Only the findings reported in its published abstract were available for assessment.

The studies used different OCTA devices and scanning protocols. The main parameters evaluated were superficial and deep capillary plexus vessel density, perfusion density, foveal avascular zone (FAZ) measurements, capillary non-perfusion area and radial peripapillary capillary density. Albuminuria was assessed using urinary albumin-to-creatinine ratio (UACR), urinary microalbumin measurements or albuminuria categories. The characteristics of the studies are presented in the Table 1.

Table 1: Characteristics of Studies Evaluating the Association Between OCTA Parameters and Albuminuria in Patients with T2DM

Study	Country	Study design and sample size	Diabetic retinopathy status	OCTA device and scan size	OCTA parameters evaluated	Albuminuria assessment
Kim et al., 2024 [5]	South Korea	Retrospective cross-sectional; 180 T2DM patients and 50 healthy controls	No DR to proliferative DR	PLEX Elite 9000 (ZEISS); 12 × 12 mm scan, analysed in 3 × 3, 6 × 6 and 10 × 10 mm regions	Vessel density, FAZ parameters and capillary non-perfusion area	Spot urine ACR; albuminuria ≥30 mg/g
Xing et al., 2025 [6]	China	Cross-sectional; 164 T2DM patients (164 eyes)	Without DR	PLEX Elite 9000 (ZEISS); 6 × 6 mm	SCP and DCP perfusion density, vessel length density and FAZ parameters	UACR

Jin et al., 2025 [7]	China	Prospective cross-sectional; 52 T2DM patients (104 eyes) and 42 healthy controls (84 eyes)	Without DR	RTVue-XR Avanti (Optovue); 4.5 × 4.5 mm	Radial peripapillary capillary density	Urinary microalbumin and ACR
Zha et al., 2026 [8]	China	Two-part cross-sectional; 134 T2DM patients in OCTA subgroup	Different grades of DR, including proliferative DR	TowardPi 400k; 6 × 6 mm macular and 150° ultrawidefield scans	Widefield non-perfusion area and macular SCP perfusion density	Spot urine UACR
Liu et al., 2026 [11]	China	Cross-sectional analysis of prospectively enrolled patients; 220 T2DM patients	No DR (n=82), NPDR without DKD (n=70), NPDR with DKD (n=68)	VG S (Vimicro); 3 × 3 mm	SCP and DCP vessel density, FAZ area, perimeter and acircularity index	Urinary microalbumin and UACR
Xiao et al., 2026 [12]	China	Cross-sectional; 76 T2DM patients (139 eyes)	Not specified in abstract	Device and scan size not reported in abstract	Macular and peripapillary retinal vessel density	UACR

Association of Retinal Vessel Density with Albuminuria

Xing et al,[6] reported a significant negative correlation of UACR with superficial capillary plexus perfusion density and vessel length density in the central macular region. These associations remained significant after correction for multiple comparisons. Liu et al,[11] found negative correlations of superficial capillary plexus vessel density with urinary microalbumin ($r = -0.51$) and UACR ($r = -0.56$). Similar findings were observed for deep capillary plexus vessel density, with correlation coefficients of −0.56 and −0.54, respectively. Xiao et al,[12] also reported significant associations between retinal vessel density and UACR, although exact correlation coefficients were not available in the abstract.

Association of Foveal Avascular Zone and Non-Perfusion Area with Albuminuria

Liu et al,[11] reported positive correlations of FAZ area with urinary microalbumin ($r = 0.54$) and UACR ($r = 0.55$). FAZ perimeter also showed positive correlations with urinary microalbumin ($r = 0.46$) and UACR ($r = 0.36$). Kim et al,[5] found that capillary non-perfusion area was significantly greater in patients with albuminuria and diabetic retinopathy more severe than mild non-proliferative diabetic retinopathy. In the 6 × 6 mm scanning region, mean non-perfusion area was 1.67 mm² in patients with albuminuria compared with 0.76 mm² in those without albuminuria ($p = 0.001$). The corresponding values in the 10 × 10 mm region were 21.8 mm² and 13.5 mm², respectively ($p = 0.001$). No significant differences were observed in patients without diabetic retinopathy or with mild non-proliferative diabetic retinopathy. Zha et al,[8] also found a significant association between UACR and retinal non-perfusion area. Each doubling of UACR was associated with an adjusted increase of 1.49 mm² in widefield non-perfusion area (95% CI: 1.28–1.69; $p < 0.001$).

Association of Peripapillary Microvascular Parameters with Albuminuria

Jin et al,[7] reported significant negative associations of urinary microalbumin (standardised $\beta = -0.234$; $p = 0.018$) and ACR (standardised $\beta = -0.242$; $p = 0.014$) with radial peripapillary capillary density in patients with T2DM without clinically detectable retinopathy. These associations were observed in univariate regression analysis. In the multivariable model, HbA1c and blood urea remained significantly associated with reduced capillary density. Urinary albumin parameters were not retained in the final model.

Adjusted Associations Between OCTA Parameters and Albuminuria

Kim et al,[5] reported that increased capillary non-perfusion area in the 6 × 6 mm and 10 × 10 mm scanning regions was independently associated with albuminuria, with adjusted odds ratios of 1.92 and 1.35, respectively. Zha et al,[8] found that each doubling of UACR was independently associated with increased widefield retinal non-perfusion (standardised $\beta = 0.321$; 95% CI: 0.277–0.365) and reduced macular superficial capillary plexus parafoveal perfusion density (standardised $\beta = -0.317$; 95% CI: −0.365 to −0.269). Both associations were statistically significant ($p<0.001$). The adjusted reduction in perfusion density was 0.82 percentage points for each doubling of UACR. Overall the increased albuminuria was associated with reduced retinal vessel density and greater capillary non-perfusion in several studies. The strength of association differed according to OCTA parameters, retinal region and severity of diabetic retinopathy.

Table 2: Association Between Retinal OCTA Parameters and Albuminuria in Patients with T2DM

Study	OCTA parameter	Albuminuria measure	Association estimate (r/β/OR)	Statistical significance	Analysis
Kim et al., 2024 [5]	Capillary non-perfusion area (6 × 6 mm)	Albuminuria ≥30 mg/g	OR = 1.92	$p < 0.05$	Adjusted regression
Kim et al., 2024 [5]	Capillary non-perfusion area (10 × 10 mm)	Albuminuria ≥30 mg/g	OR = 1.35	$p < 0.05$	Adjusted regression
Xing et al., 2025 [6]	Central SCP perfusion density	UACR	Negative correlation; exact r not available in main text	$q < 0.05$	Correlation analysis
Xing et al., 2025 [6]	Central SCP vessel length density	UACR	Negative correlation; exact r not available in main text	$q < 0.05$	Correlation analysis
Jin et al., 2025 [7]	Radial peripapillary capillary density	Urinary microalbumin	$\beta = -0.234$	$p = 0.018$	Univariate regression
Jin et al., 2025 [7]	Radial peripapillary capillary density	ACR	$\beta = -0.242$	$p = 0.014$	Univariate regression
Zha et al., 2026 [8]	Widefield retinal non-perfusion area	UACR (per doubling)	$\beta = 0.321$ (95% CI: 0.277–0.365)	$p < 0.001$	Adjusted regression
Zha et al., 2026 [8]	Macular SCP parafoveal perfusion density	UACR (per doubling)	$\beta = -0.317$ (95% CI: −0.365 to −0.269)	$p < 0.001$	Adjusted regression
Liu et al., 2026 [11]	SCP vessel density	Urinary microalbumin	$r = -0.51$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	SCP vessel density	UACR	$r = -0.56$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	DCP vessel density	Urinary microalbumin	$r = -0.56$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	DCP vessel density	UACR	$r = -0.54$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	FAZ area	Urinary microalbumin	$r = 0.54$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	FAZ area	UACR	$r = 0.55$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	FAZ perimeter	Urinary microalbumin	$r = 0.46$	$p < 0.05$	Correlation analysis
Liu et al., 2026 [11]	FAZ perimeter	UACR	$r = 0.36$	$p < 0.05$	Correlation analysis
Xiao et al., 2026 [12]	Retinal vessel density parameters	UACR	Significant association; exact coefficient not available	Exact p-value not available	Abstract evidence

Methodological Quality of Included Studies

The methodological quality of the five full-text studies was assessed using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies. Most studies clearly described their inclusion criteria, study population and OCTA measurement methods. The main methodological concerns were incomplete adjustment for confounding factors, differences in urinary albumin assessment and limitations in statistical analysis. Jin et al,[7] included both eyes of participants without reporting adjustment for correlation between eyes. Its direct associations with urinary albumin were limited to univariate analysis. Liu et al,[11] reported inconsistencies in the description of urinary albumin measurement and differences in regression estimates between the text and figures. Its adjusted regression models examined diabetic kidney disease status rather than the direct association with UACR. Kim et al,[5] reported different subgroup sample sizes in the abstract and main Results. These limitations were considered while interpreting the findings. The methodological assessment is presented in Table 3.

Table 3: Methodological Quality Assessment of Studies Using the JBI Checklist

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Kim et al., 2024 [5]	Y	Y	Y	Y	Y	Y	Y	U
Xing et al., 2025 [6]	Y	Y	Y	Y	Y	U	Y	Y
Jin et al., 2025 [7]	Y	Y	Y	U	Y	Y	U	N
Zha et al., 2026 [8]	Y	Y	Y	Y	Y	Y	Y	Y
Liu et al., 2026 [11]	Y	Y	U	Y	Y	Y	U	U

For Jin et al., direct urinary albumin associations were limited to univariate analysis. Liu et al. reported direct OCTA–UACR correlations, while its adjusted regression models assessed diabetic kidney disease status rather than UACR as a continuous outcome. The methodological concerns identified in these studies require consideration during interpretation of the findings.

DISCUSSION

The present systematic review evaluated the association between retinal microvascular changes assessed using OCTA and albuminuria in patients with T2DM. The available studies showed that increased albuminuria was generally associated with reduced retinal vessel density and increased capillary non-perfusion. These findings were observed in different retinal regions, including the macula and peripapillary area. The strength of association varied according to the OCTA parameters studied and the severity of diabetic retinopathy. These findings suggest a possible relationship between retinal microvascular alterations and renal involvement in patients with T2DM.

Kim et al,[5] reported that retinal capillary non-perfusion was significantly associated with albuminuria, particularly in patients with more advanced diabetic retinopathy. Their findings suggest that retinal microvascular changes may become more prominent with increasing severity of diabetic complications. Xing et al,[6] observed a significant negative association between UACR and superficial capillary plexus perfusion density in patients without diabetic retinopathy. This indicates that retinal microvascular alterations may be associated with albuminuria even in patients without clinically detectable diabetic retinopathy.

Similar findings were reported by Liu et al,[11] who observed negative correlations of superficial and deep capillary plexus vessel density with urinary microalbumin and UACR. FAZ area and perimeter showed positive correlations with these renal parameters. These findings suggest that increased urinary albumin excretion may be associated with both reduced retinal capillary density and enlargement of the avascular area. Xiao et al,[12] also reported significant associations between retinal vessel density and UACR, although detailed statistical findings could not be evaluated because only the published abstract was available.

Jin et al,[7] evaluated peripapillary microvascular changes in patients without clinically detectable diabetic retinopathy. Urinary microalbumin and ACR were negatively associated with radial peripapillary capillary density in univariate analysis. These associations were not retained in the final multivariable model, in which HbA1c and blood urea remained significantly associated with capillary density. The findings indicate that the observed association between urinary albumin and retinal microvascular parameters may be influenced by other clinical factors.

Zha et al,[8] reported a significant association between higher UACR and increased retinal non-perfusion area after adjustment for relevant clinical factors. A negative association was also observed between UACR and superficial capillary plexus perfusion density. These findings support the results of Kim et al,[5] and Liu et al,[11] although the retinal regions and statistical methods differed between studies.

The retina and kidneys have similar microvascular characteristics and are affected by several common mechanisms in diabetes. Persistent hyperglycaemia causes endothelial dysfunction, increased vascular permeability, basement membrane thickening and capillary damage. In the retina, these changes may result in reduced capillary perfusion, enlargement of the FAZ and development of non-perfusion areas. Similar microvascular injury in the kidneys may lead to increased urinary albumin excretion.[3,4]

The association between retinal OCTA parameters and albuminuria may be related to common pathological processes affecting retinal and renal microvasculature in diabetes. Reduced retinal vessel density and increased albuminuria may represent different manifestations of systemic microvascular injury. The findings of Xing et al,[6] and Jin et al,[7] are relevant because they demonstrated associations with renal parameters even in patients without clinically detectable diabetic retinopathy. The available studies were mainly cross-sectional, and the sequence of retinal and renal microvascular changes could not be established.

Differences were observed in the strength and statistical significance of associations reported across studies. Kim et al,[5] found a stronger relationship between capillary non-perfusion and albuminuria in patients with more severe diabetic retinopathy. Xing et al,[6] and Jin et al,[7] evaluated patients without clinically detectable retinopathy and reported associations involving different retinal regions. These differences may be related to the stage of diabetic microvascular disease.

The OCTA devices, scan sizes and parameters also differed between studies. Some investigators evaluated superficial and deep macular capillary plexuses, while others examined widefield non-perfusion or peripapillary capillary density. Urinary albumin was assessed using different measurements, including urinary microalbumin and UACR. The statistical methods also varied, with some studies reporting unadjusted correlations and others using multivariable regression. These differences limit direct comparison of the findings.

Wang et al,[13] in the Kailuan Eye Study involving 447 patients with T2DM without diabetic retinopathy, reported that higher UACR was significantly associated with reduced retinal vessel density and perfusion density. These findings were consistent with the observations of Xing et al,[6] in the present review. Cankurtaran et al,[14] also reported reduced superficial capillary plexus and peripapillary

vessel density in patients with microalbuminuria compared with those without microalbuminuria. Similar findings were reported by Ucgul Atilgan et al,[15] who observed reduced retinal vessel density in patients with microalbuminuria, including those without clinically detectable retinopathy. These studies support an association between albuminuria and retinal microvascular changes in patients with T2DM.

Surawatsatien et al,[16] evaluated 93 patients with T2DM and found significantly lower superficial and deep capillary plexus vessel density in patients with early diabetic nephropathy compared with those without nephropathy. No significant differences were observed in FAZ area between the groups. Zhuang et al,[17] reported reduced retinal vessel density in patients with T2DM and chronic kidney disease. Their multivariable analysis showed that eGFR was associated with superficial retinal vessel density, while UACR was associated with macular thickness. In contrast, Tom et al,[18] in a small study involving 10 patients with diabetes and chronic kidney disease, did not find a significant association of UACR with retinal non-perfusion or vessel density. These differences indicate that the relationship between retinal microvascular measurements and renal parameters may vary according to the study population, retinal measurements and renal outcomes evaluated.

Chen et al,[19] reported that increasing albuminuria was associated with greater severity of diabetic retinopathy in patients with T2DM. Their study also identified associations involving dyslipidaemia and circulating angiogenic cytokines, suggesting possible common mechanisms affecting retinal and renal microvasculature. Paterson et al,[20] using retinal fundus photographs in the UK Biobank, found an association between reduced retinal vascular fractal dimension and albuminuria after adjustment for diabetes and other confounding factors. Gupta et al,[21] in a systematic review and meta-analysis, reported that diabetic retinopathy was associated with progression of diabetic kidney disease (pooled HR = 2.42; 95% CI: 1.70–3.45). These findings provide further evidence of a relationship between retinal vascular abnormalities and renal involvement. The studies used different retinal assessment methods and cannot establish the predictive value of OCTA parameters for albuminuria.

OCTA provides a non-invasive method for assessing retinal microvascular alterations in patients with T2DM. Its ability to identify changes in vessel density and capillary perfusion may help in understanding the relationship between retinal and systemic diabetic microvascular complications. The associations observed with albuminuria suggest that OCTA parameters may have potential as additional markers of microvascular involvement.

At present, the available evidence is insufficient to recommend OCTA for screening or predicting diabetic kidney disease. UACR and eGFR remain essential investigations for assessment of renal involvement.[2] OCTA may provide additional information during ophthalmic evaluation, but its role in renal risk assessment requires confirmation through larger prospective studies.

The present review focused specifically on studies reporting a direct association between quantitative retinal OCTA parameters and urinary albumin measurements in patients with T2DM. Studies reporting only eGFR or diabetic kidney disease status without a direct albuminuria association were excluded. This helped maintain a clear focus on the relationship between retinal microvascular changes and albuminuria. Certain limitations need consideration. The number of studies with available full texts was small, and all were conducted in China or South Korea. Most studies were conducted at single centres. Differences in OCTA devices, scanning protocols, retinal regions and statistical methods limited comparison between studies. Several associations were based on unadjusted analyses, and the influence of important confounding factors could not be excluded. Methodological concerns included the use of both eyes without accounting for within-patient correlation in Jin et al,[7] and inconsistencies in urinary albumin measurement and statistical reporting in Liu et al.[11] The full text of Xiao et al,[12] was unavailable, and its findings could not be fully assessed. The mainly cross-sectional nature of the evidence also prevents conclusions regarding causality or prediction of renal disease progression.

Further multicentre studies with larger sample sizes are required to establish the association between retinal OCTA parameters and albuminuria in patients with T2DM. Standardisation of OCTA scanning protocols and retinal vascular measurements would improve comparison across studies. Longitudinal studies may help determine whether retinal microvascular changes precede the development or progression of albuminuria. Future studies should also evaluate whether OCTA parameters provide additional clinical information after adjustment for HbA1c, diabetes duration, blood pressure, eGFR and other established risk factors.

CONCLUSION

The present systematic review found that increased albuminuria in patients with T2DM was generally associated with reduced retinal vessel density, increased capillary non-perfusion and changes in foveal avascular zone parameters. These findings suggest that OCTA may be useful as an additional non-invasive tool for assessing retinal and renal microvascular involvement in T2DM. Further large-scale prospective studies with standardised OCTA measurements are required to establish its clinical utility in the early detection and monitoring of diabetic kidney disease.

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