RESEARCH PAPER

Assessing retinal vascular changes with type 1 diabetes using optical coherence tomography angiography: A cross sectional analytical study.

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ABSTRACT

Background: Diabetic retinopathy (DR) remains a leading cause of visual impairment in diabetic patients and can begin insidiously even in childhood. With the increasing prevalence of type 1 diabetes mellitus among children and adolescents, early detection of retinal alterations before the appearance of clinically evident DR has become critically important. Optical coherence tomography angiography, a non-invasive imaging modality, has shown great promise in detecting subtle microvascular changes in the retina and optic nerve head.

Aims & objectives: To assess the early microvascular changes in the macula and optic disc using optical coherence tomography angiography (OCTA) in children with type 1 diabetes mellitus without clinical signs of diabetic retinopathy.

Methodology: A cross sectional analytical study was conducted among 25 Patients with Diabetes and 25 Healthy child attending out-patient department of Ophthalmology & Pediatrics, at R.L. JALAPPA HOSPITAL, Kolar.

Results: The mean age in Group A was 12.3 ± 4.5 years, while in Group B it was 13.1 ± 2.9 years, indicating that most participants in both groups belonged to the older pediatric age group. I Similarly, in Group B, 15 (60%) participants were male while 10 (40%) were female. On applying unpaired t test, there was stastically significant difference between mean cup/disc ratio, whole image and superior semi and peritoneal vascular density among both groups.

Conclusion: The microvascular retinal changes may occur early in the course of diabetes, even before the development of clinically detectable diabetic retinopathy.

Keywords: Diabetes Mellitus, Optical coherence tomography angiography, Retina, Vascular, Vision.

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Introduction:

Diabetic retinopathy (DR) remains a leading cause of visual impairment in diabetic patients and can begin insidiously even in childhood. With the increasing prevalence of type 1 diabetes mellitus (T1DM) among children and adolescents, early detection of retinal alterations before the appearance of clinically evident DR has become critically important.[1,2] Optical coherence tomography angiography (OCTA), a non-invasive imaging modality, has shown great promise in detecting subtle microvascular changes in the retina and optic nerve head.[3]

Studies have demonstrated that pediatric patients with T1DM can present with retinal microvasculopathy well before any fundoscopic signs of DR become visible.[4] Several risk factors, including poor glycemic control, puberty, and longer diabetes duration, have been associated with early retinal changes in this population.[5] OCTA enables precise visualization and quantification of parameters such as vascular density and foveal avascular zone (FAZ) size, offering insights into subclinical retinal changes.[6]

Recent research using OCTA has revealed that children with T1DM may exhibit reduced superficial vascular density and alterations in the optic disc and peripapillary regions, despite the absence of overt DR.[7]These findings emphasize the role of OCTA in early screening protocols and risk stratification in young diabetic patients.[8]

Although optical coherence tomography angiography (OCTA) has emerged as a valuable tool for detecting early retinal microvascular changes, most studies have focused on adults with diabetic retinopathy (DR). There was a lack of comprehensive data on subclinical retinal and optic disc alterations in pediatric patients with type 1 diabetes mellitus (T1DM) who do not yet show clinical signs of DR. Furthermore, the relationship between these early OCTA-detected changes and clinical predictors such as HbA1c, diabetes duration, and pubertal status remains underexplored in children. **Aims & objectives:** To assess the early microvascular changes in the macula and optic disc using optical coherence tomography angiography (OCTA) in children with type 1 diabetes mellitus (T1DM) without clinical signs of diabetic retinopathy (DR).

Methodology:A cross sectional analytical study was conducted among 25 Patients with Diabetes and 25 Healthy child attending out-patient department of Ophthalmology & Pediatrics, at R.L. JALAPPA HOSPITAL, Kolar, after obtaining ethical clearance from central Ethics committee of Sri Devaraj Urs Academy of Higher Education & Research and after obtaining informed/written consent in their own

vernacular language from parents /guardian & assent from children >14 years, detailed history and ophthalmological evaluation was done.Sample size was estimated by using the difference in Mean Superficial Vascular Density: between T1DM Group and Control Group from the study by Raffa L et al as 48.86±2.3 and 51.23±2.8[1]. Using these values at 95% Confidence limit and 90% power sample size of 25 was obtained in each group by using the below mentioned formula and Med calc sample size software. Patient with history of glaucoma, ocular surgery, or congenital retinal/optic nerve diseases, Presence of systemic conditions affecting retinal vasculature, such as: Hypertension, Local or systemic inflammatory diseases or Presence of other microvascular complications, such as: Diabetic nephropathy , Microalbuminuria and Poor-quality OCTA images, defined by: Signal strength < 7/10, and Motion artifacts or scan decentration were excluded. OCTA imaging was performed using the (CIRRUS HD OCT MODEL 5000). Visual Acuity was assessed by snellen's chart, anterior segment examination was done by Slit lamp and Fundus examination was done by using direct and indirect ophthalmoscope.

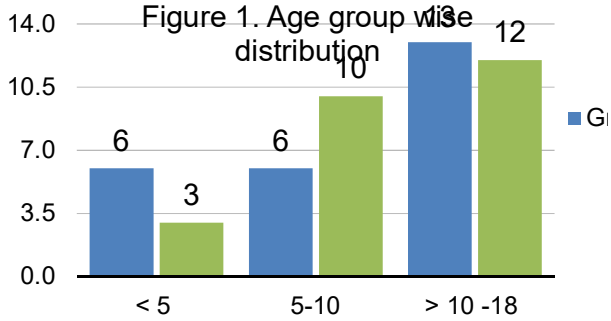
Data entry and analysis: Data will be entered into Microsoft excel data sheet and will be analyzed using SPSS 22 version software (IBM SPSS Statistics, Somers NY, USA). Categorical data will be represented in the form of Frequencies and proportions. Continuous data will be represented as mean and standard deviation. Pie diagrams and Bar diagrams will be used to represent data graphically. Independent t test was used to compare mean between two groups. p value <0.05 will be considered as statistically significant.

Results:

Group A - Children with Diabetic mellitus (n=25) Group B - Healthy children (n=25)

Table 1. Age wise distribution

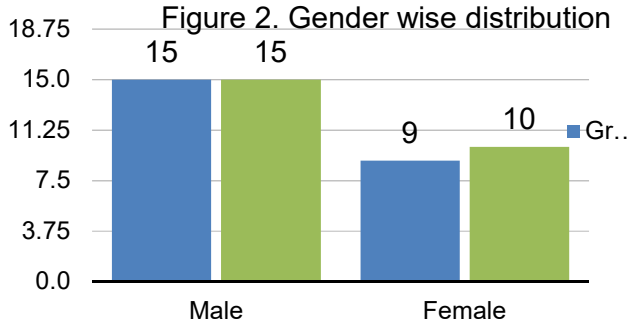
Age group (in years)	Group A	Group B
< 5	6 (24%)	3 (12%)
5-10	6 (24%)	10 (40%)
> 10 -18	13 (52%)	12(48%)
Mean age	12.3 ± 4.5 years	13.1 ± 2.9 year



In Group A, 6 (24%) participants were below 5 years of age, 6 (24%) were in the 5–10 years age group, and the majority, 13 (52%), were in the >10–18 years age group. In Group B, 3 (12%) participants were below 5 years, 10 (40%) were in the 5–10 years age group, and 12 (48%) were in the >10–18 years age group. The mean age in Group A was 12.3 ± 4.5 years, while in Group B it was 13.1 ± 2.9 years, indicating that most participants in both groups belonged to the older pediatric age group. [Table 1]

Table 2. Gender wise distribution

Gender	Group A	Group B
Male	15 (60%)	15 (60%)
Female	9 (40%)	10 (40%)



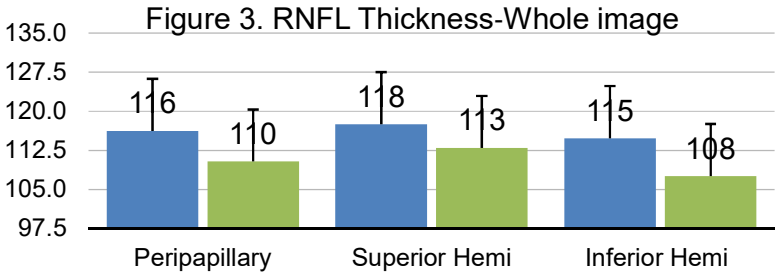
In Group A, 15 (60%) participants were male and 9 (40%) were female. Similarly, in Group B, 15 (60%) participants were male while 10 (40%) were female. [Table 2]

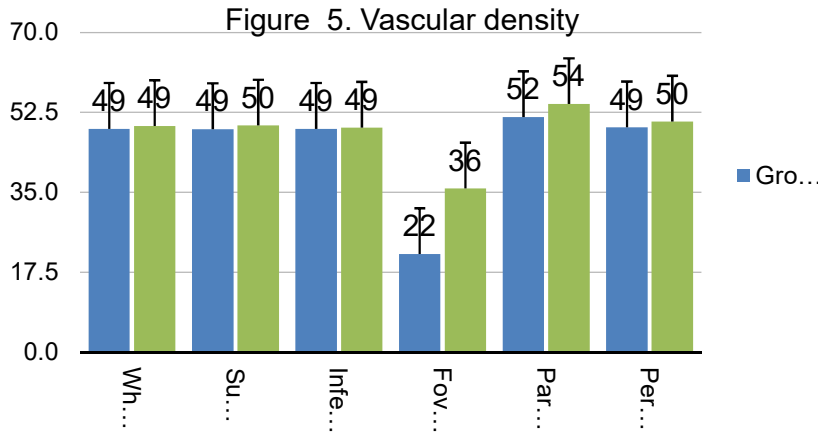
Table 3. Retina examination findings among cases

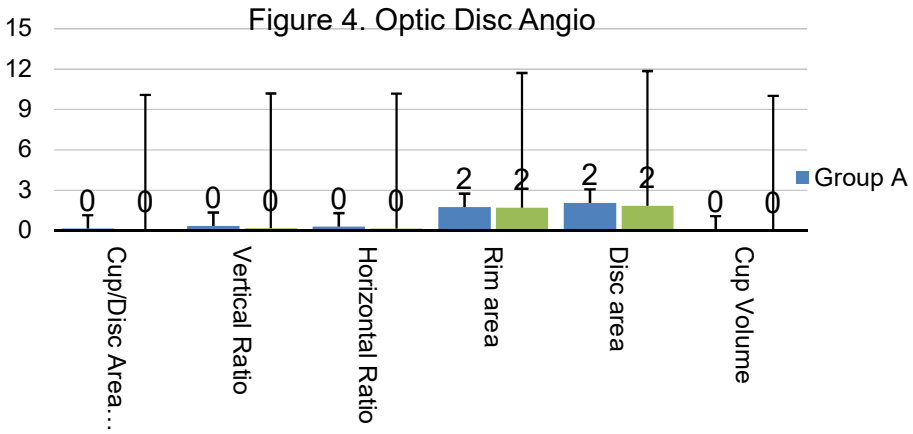
Variables	Group A	Group B	P value
RNFL Thickness-Whole image (Inside disc):			
Peripapillary	116.23±11.2	110.36±16.9	0.319

Superior Hemi	117.53±10.5	112.95±18.2	0.457
Inferior Hemi	114.83±13.5	107.55±16.1	0.190
Optic Disc Angio			
Cup/Disc Area ratio	0.16±0.1	0.07±0.1	**0.05**
Vertical Ratio	0.35±0.2	0.19±0.2	0.054
Horizontal Ratio	0.30±0.2	0.16±0.2	0.694
Rim area	1.76±0.3	1.71±0.2	0.114
Disc area	2.06 ±0.4	1.84±0.2	0.150
Cup Volume	0.09±0.1	0.02±0.0	0.243
Vascular density			
Whole Image	48.90±2.3	49.49±3.7	**0.015**
Superior-Hemi	48.86±2.3	49.64±3.8	**0.003**
Inferior-Hemi	48.93±2.4	49.19±3.7	0.083
Fovea	21.51±7.2	35.90±7.0	0.960
Parafovea	51.50±3.1	54.31±3.7	0.166
Perifoveal	49.23±2.4	50.48±4.0	**0.015**

0.054). The horizontal ratio was 0.30 ± 0.2 in Group A and 0.16 ± 0.2 in Group B (p = 0.694). The rim area







Regarding RNFL thickness (whole image inside disc), the mean peripapillary thickness was 116.23 ± 11.2 µm in Group A and 110.36 ± 16.9 µm in Group B (p = 0.319). The superior hemi RNFL thickness measured
117.53 ± 10.5 µm in Group A and 112.95 ± 18.2 µm in Group B (p = 0.457), while the inferior hemi RNFL thickness was 114.83 ± 13.5 µm in Group A and 107.55 ± 16.1 µm in Group B (p = 0.190). These differences were not statistically significant.

In terms of optic disc angiographic parameters, the cup/disc area ratio was 0.16 ± 0.1 in Group A and 0.07 ±

0.1 in Group B (p = 0.05). The vertical ratio was 0.35 ± 0.2 in Group A and 0.19 ± 0.2 in Group B (p =

measured 1.76 ± 0.3 in Group A and 1.71 ± 0.2 in Group B (p = 0.114), while the disc area was 2.06 ± 0.4 and 1.84 ± 0.2 respectively (p = 0.150). The cup volume was 0.09 ± 0.1 in Group A and 0.02 ± 0.0 in Group B (p = 0.243). Most of these parameters showed no statistically significant difference between the two

groups. For vascular density, the whole image vascular density was 48.90 ± 2.3 in Group A and

49.49 ± 3.7 in Group B, showing a statistically significant difference (p = 0.015). The superior hemi vascular density was 48.86 ± 2.3 in Group A and 49.64 ± 3.8 in Group B, which was also statistically significant (p = 0.003). The inferior hemi vascular density was 48.93 ± 2.4 in Group A and 49.19 ± 3.7 in

Group B (p = 0.083), which was not significant. Similarly, the foveal vascular density was 21.51 ± 7.2 in Group A and 35.90 ± 7.0 in Group B (p = 0.960), and the parafoveal density was 51.50 ± 3.1 and 54.31 ± 3.7 respectively (p = 0.166), both showing no significant difference. However, the perifoveal vascular density was 49.23 ± 2.4 in Group A and 50.48 ± 4.0 in Group B, demonstrating a statistically significant difference (p = 0.015).On applying unpaired t test, there was stastically significant difference between mean cup/disc ratio, whole image and superior semi and peritoneal vascular density among both groups. [Table 3]

Discussion:

The present cross-sectional analytical study assessed early retinal microvascular alterations using optical coherence tomography angiography (OCTA) in children with type 1 diabetes mellitus without clinically detectable diabetic retinopathy. The study included 25 diabetic children and 25 healthy controls. The mean age of the diabetic group was 12.3 ± 4.5 years and the control group was
13.1 ± 2.9 years, indicating that most participants belonged to the older pediatric age group. The gender distribution was comparable between groups, with a predominance of males (60%) in both groups, suggesting that demographic variables were relatively well matched.

In the present study, OCTA parameters showed a statistically significant difference in mean cup–disc ratio, whole image vascular density, and superior and peripapillary vascular density between diabetic patients and healthy controls. These findings suggest that microvascular alterations may occur in pediatric patients with type 1 diabetes even before the development of clinically detectable diabetic retinopathy. The reduction in vascular density indicates early retinal microvascular compromise associated with diabetes.

Similar findings have been reported by Raman et al., who demonstrated that OCTA could detect early retinal microvascular alterations in diabetic patients even before clinical signs of diabetic retinopathy become apparent. Their study highlighted reduced vascular density in the superficial capillary plexus among diabetic subjects compared with healthy individuals, supporting the role of OCTA in early detection of retinal changes. [9]

Another study by Agrawal et al. conducted in an Indian population also reported significantly decreased macular vascular density in diabetic patients compared with controls. The authors concluded that OCTA can identify subtle microvascular abnormalities in diabetic eyes, which may serve as early indicators of diabetic retinopathy. [10] Similarly, Saxena et al. observed significant alterations in retinal vascular parameters among diabetic patients without clinically evident retinopathy. Their findings suggested that OCTA-based vascular density measurements can be used as a sensitive biomarker for early diabetic retinal changes. [11]

A study by Kulkarni et al. in pediatric diabetic patients also demonstrated reduced retinal vascular density and alterations in optic nerve head perfusion parameters on OCTA imaging. The authors suggested that chronic hyperglycemia leads to progressive microvascular damage, which may initially manifest as subclinical retinal vascular alterations. [12] In addition, Goud et al. reported that diabetic individuals exhibit reduced peripapillary vascular density and altered optic disc microcirculation compared with healthy controls. These findings are consistent with the present study, which demonstrated significant differences in vascular density parameters between diabetic and non-diabetic groups. [13]

The findings of the present study therefore support the growing evidence that OCTA is a valuable non-invasive imaging modality for identifying early retinal microvascular changes in diabetic patients, particularly in children and adolescents. Detecting these changes before the onset of clinically visible diabetic retinopathy may help in early risk stratification, monitoring disease progression, and initiating timely preventive interventions. However, the relatively small sample size and cross-sectional design of the study limit the ability to establish causal relationships. Longitudinal studies with larger sample sizes are required to better understand the progression of these early microvascular changes and their relationship with glycemic control, duration of diabetes, and other systemic factors.

Conclusion: The children with type 1 diabetes mellitus without clinical signs of diabetic retinopathy exhibit significant alterations in retinal and peripapillary vascular density as detected by optical coherence tomography angiography. These findings indicate that microvascular retinal changes may occur early in the course of diabetes, even before the development of clinically detectable diabetic retinopathy. OCTA therefore represents a valuable, non-invasive imaging modality for the early detection and monitoring of retinal microvascular abnormalities in pediatric diabetic patients. Early identification of these subclinical changes may facilitate timely intervention and potentially reduce the risk of future vision-threatening diabetic retinopathy.

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