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COMPARISON OF SUBFOVEAL CHOROIDAL THICKNESS IN DIABETICS AND VARIOUS GRADES OF DIABETIC RETINOPATHY

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ABSTRACT

Background: Diabetic retinopathy (DR) is a major cause of vision loss in adults and, although traditionally viewed as a retinal microvascular disorder, growing evidence indicates that the choroid also plays an important role in its pathophysiology. Alterations in subfoveal choroidal thickness (SFCT) may reflect early structural changes in diabetic eyes, but previous studies have shown inconsistent results, particularly within the Indian population.

Objectives: To evaluate SFCT in diabetic individuals and compare its variation across different grades of DR using enhanced-depth imaging optical coherence tomography (EDI-OCT).

Methods: This cross-sectional observational study included 180 eyes of diabetic patients aged ≥18 years at a tertiary care center. Participants were classified into diabetes without DR and diabetes with DR, the latter graded according to ETDRS criteria. All subjects underwent detailed ophthalmic examination and EDI-OCT imaging. SFCT was manually measured at the foveal center by a blinded observer. Statistical analysis included the t-test, Kruskal–Wallis test, and Spearman correlation.

Results: The DR group had a significantly longer duration of diabetes compared to those without DR (6.63 ± 5.15 vs. 4.44 ± 3.21 years; $p = 0.002$). Mean SFCT was significantly higher in diabetics without DR (276.90 ± 31.04 μm) than in those with DR (254.20 ± 70.90 μm; $p = 0.002$). Among 105 eyes with DR, SFCT progressively decreased with increasing severity ($p < 0.001$), ranging from 327.56 ± 25.05 μm in mild NPDR to 154.62 ± 16.32 μm in severe NPDR. SFCT showed a significant negative correlation with duration of diabetes ($r = –0.344$; $p < 0.001$).

Conclusion: SFCT decreases significantly with the presence and progression of DR and correlates negatively with diabetes duration. Choroidal thickness measurement may serve as a useful structural biomarker for assessing DR severity and progression risk.

KEYWORDS: Diabetic retinopathy; Subfoveal choroidal thickness; Choroidal thickness; Enhanced-depth imaging optical coherence tomography; EDI-OCT; Non-proliferative diabetic retinopathy; Diabetes duration; Choroidal changes; Retinal microvascular disease; ETDRS grading.

INTRODUCTION

Diabetic retinopathy (DR) is a prevalent sight-threatening microvascular complication of diabetes mellitus, characterized by progressive abnormalities in the retinal capillaries and larger vessels. It remains one of the leading causes of severe visual loss and blindness among adults in the working-age population worldwide. The development of diabetic macular edema (DME) and proliferative diabetic retinopathy (PDR) are the major contributors to visual impairment.[1] Early detection and timely intervention are crucial to prevent vision loss. It is estimated that by 2050, nearly 16 million individuals in the United States alone will have diabetic retinopathy, including approximately 3.4 million with vision-threatening disease.[2–4] Clinical trials such as the UKPDS and DCCT have clearly established the benefit of intensive glycemic control in delaying the onset and progression of DR.

Diabetes is associated with several ocular conditions including cataract, glaucoma, ocular surface abnormalities, recurrent stye, non-arteritic anterior ischemic optic neuropathy, diabetic papillopathy, and diabetic retinopathy. Typical fundus findings of DR include microaneurysms, hard exudates, macular edema, and neovascularization.[5]

Although DR is traditionally considered a retinal microvascular disease, growing evidence suggests that the choroid—being the primary source of oxygen and nutrients to the outer retina and the retinal pigment epithelium—also plays a significant role in its pathophysiology. Histopathological studies have reported increased choriocapillaris dropout in diabetic eyes compared with age-matched controls. Reduced choroidal perfusion in early DR and loss of outer retinal oxygenation have been proposed as mechanisms contributing to photoreceptor dysfunction even in the absence of clinically detectable DR.[6]

Choroidal abnormalities such as inflammation, ischemia, and breakdown of the blood-retina barrier (BRB) may contribute to DR development and progression. Studies have documented choroidal vascular degeneration, aneurysmal changes,

choriocapillaris obstruction, and choroidal neovascularization in diabetic patients. However, earlier limitations in imaging technologies restricted the detection of subtle choroidal structural changes.[7]
Several systemic factors—including hyperglycemia, duration of diabetes, and HbA1c levels—are known to influence the risk and progression of DR. Huang et al. demonstrated that reduced choroidal thickness (CT) was strongly associated with DR severity even after adjusting for these confounders. These systemic factors may also predict DME or correlate with macular thickness (MT).[7] Optical coherence tomography (OCT), particularly enhanced-depth imaging (EDI-OCT), now permits accurate visualization and measurement of choroidal thickness.
However, existing studies evaluating CT in diabetic patients have shown conflicting and inconsistent results, with some reporting increased CT, others decreased CT, and some reporting no significant change across various DR stages. Similar inconsistencies are seen in studies evaluating macular thickness.
Considering these discrepancies and limited data in the Indian population, the present study was conducted to evaluate:
1.Subfoveal choroidal thickness (SFCT) in diabetic individuals, and
2.Differences in SFCT across various grades of diabetic retinopathy.

METHODOLOGY

Source Of Data And Study Setting

This cross-sectional observational study was conducted in the Department of Ophthalmology, Subbaiah Institute of Medical Sciences (SUIMS), Shivamogga. The study included OPD and IPD patients who met the eligibility criteria. The duration of the study was 18 months, and a total of 180 eyes were evaluated.

Inclusion Criteria

Participants aged 18 years or older were enrolled. Subjects were categorized into two groups:

- Group A: Eyes of known diabetic patients without diabetic retinopathy (DR).
- Group B: Eyes of known diabetic patients with DR of any severity.

Exclusion Criteria

Patients were excluded if they had undergone pan-retinal photocoagulation or focal laser therapy, had a history of vitreoretinal surgery, or had vitreoretinal disorders unrelated to diabetes. Additional exclusion criteria included refractive error with spherical equivalent ≥ ±6 D, cataract surgery within the preceding 6 months, media opacities affecting OCT signal, OCT signal strength < 6/10, history of accelerated hypertension, pregnancy, or current use of medications known to alter choroidal thickness.

Study Procedure

Ethical approval was obtained from the Institutional Ethics Committee prior to initiation of the study. Eligible patients were recruited after providing written informed consent. Detailed systemic and ocular histories were recorded, including demographic data, duration of diabetes, glycaemic control, systemic comorbidities, and prior treatments.
A comprehensive ophthalmic evaluation was performed for all participants. This included assessment of best-corrected visual acuity using Snellen's chart, measurement of refractive error (spherical equivalent), slit-lamp biomicroscopy, and indirect ophthalmoscopy. Diabetic retinopathy was graded based on the Early Treatment Diabetic Retinopathy Study (ETDRS) classification into mild (B1), moderate (B2), severe/very severe (B3) non-proliferative DR (NPDR), or proliferative DR (PDR; B4).

Optical Coherence Tomography Assessment

Subfoveal choroidal thickness (SFCT) was measured using spectral-domain optical coherence tomography (SD-OCT) with enhanced depth imaging (EDI) mode (Zeiss Cirrus HD-OCT). All OCT assessments were performed by a masked observer who was blinded to the diabetic status and retinopathy grading of the participants. SFCT was measured manually using the inbuilt caliper tool at the foveal center, defined as the vertical distance from the hyperreflective line corresponding to Bruch's membrane to the choroid–scleral interface.

Results:

Table 1- Duration Of Diabetes In Between Diabetes Without Retinopathy And Diabetes With Retinopathy

group	Mean duration	Std. Deviation	pvalue
Diabetes without retinopathy	4.44	3.212	0.002**
Diabetes with retinopathy	6.63	5.147	

Test used- mann whitney U test, $p<0.05$ significant

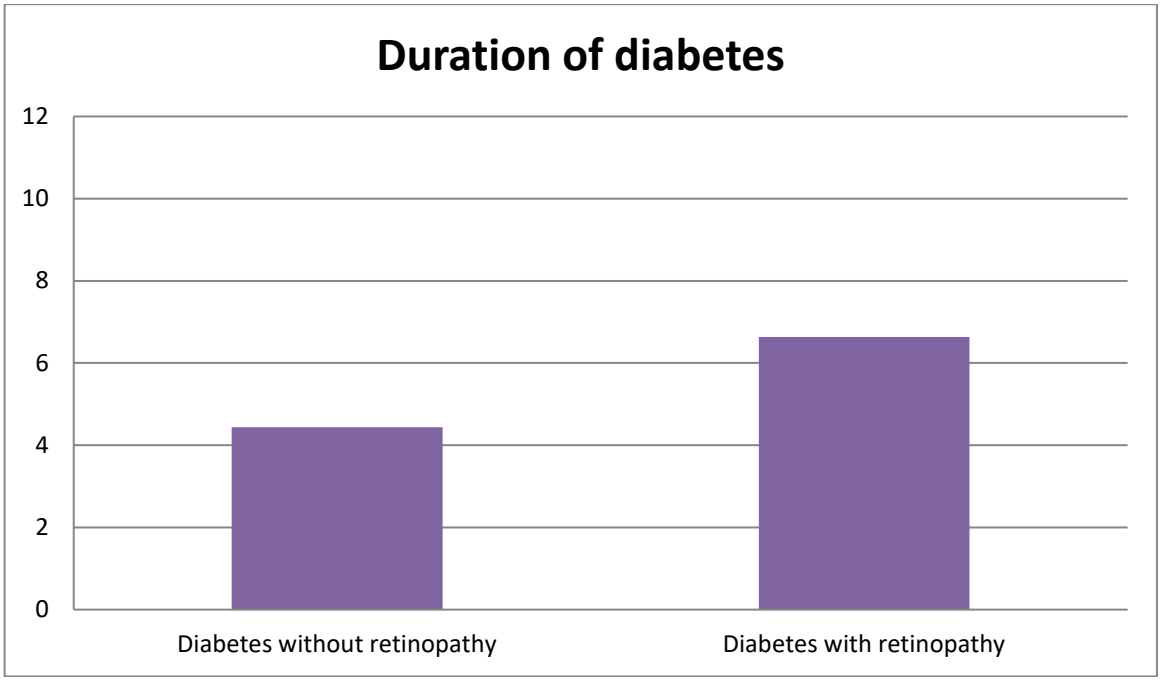


Figure 1- Duration Of Diabetes In Between Diabetes Without Retinopathy And Diabetes With Retinopathy

Mean duration of diabetes in diabetes without and diabetes with retinopathy was 4.44±3.12 and 6.63±5.147 years respectively. Results were found to be significant when comparing duration of diabetes in between diabetes without retinopathy and diabetes with retinopathy.

Table 2- Mean Of Subfoveal Choroidal Thickness (Sfct) In Between Diabetes Without Retinopathy And Diabetes With Retinopathy

Group	Mean SFCT	Std. Deviation	pvalue
Diabetes without retinopathy	276.90	31.038	0.002**
Diabetes with retinopathy	254.20	70.899	

Test used- mann whitney U test, $p<0.05$ significant

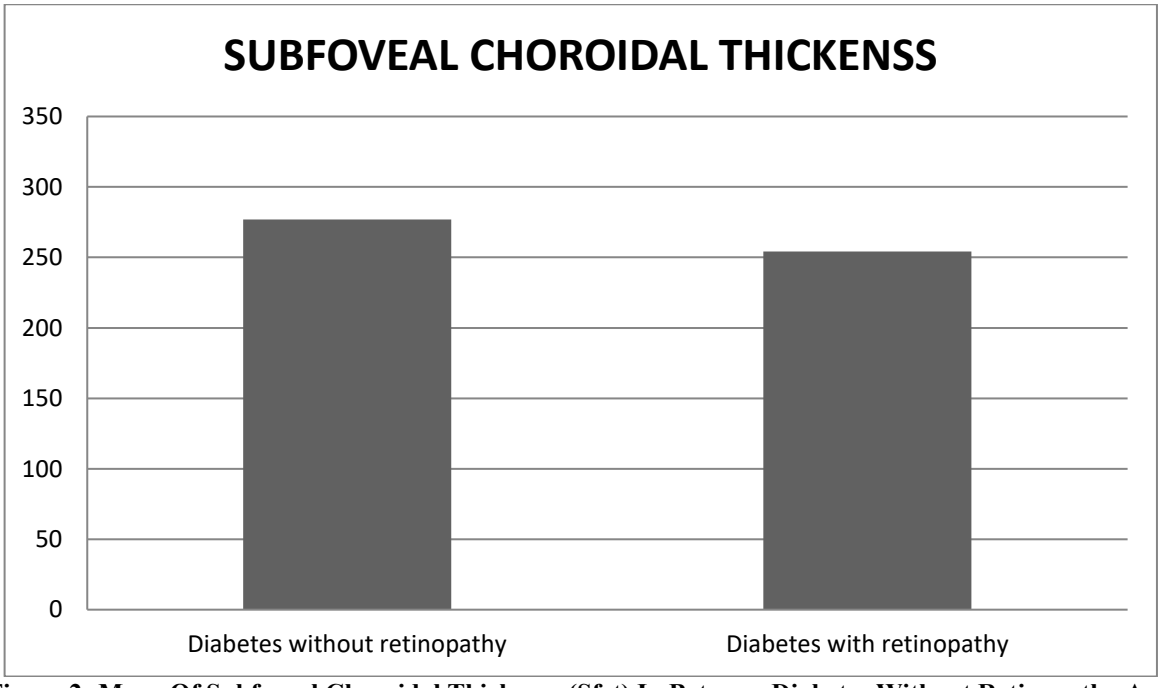


Figure 2- Mean Of Subfoveal Choroidal Thickness (Sfct) In Between Diabetes Without Retinopathy And Diabetes With Retinopathy

Mean subfoveal chorodial thickness in diabetes without and diabetes with retinopathy was 276.90±31.038 and 254.20±70.899 years respectively. Results were found to be significant when comparing subfoveal chorodial thickness diabetes without retinopathy and diabetes with retinopathy.

Table 3- Distribution Of Severity Of Dr Changes In Diabetes With Retinopathy

Severity of DR changes	Frequency	Percent
SEVERE NPDR	13	12.4
MODERATE NPDR	40	38.1
MILD NPDR	36	34.3
PDR	16	15.2
TOTAL	105	100.0

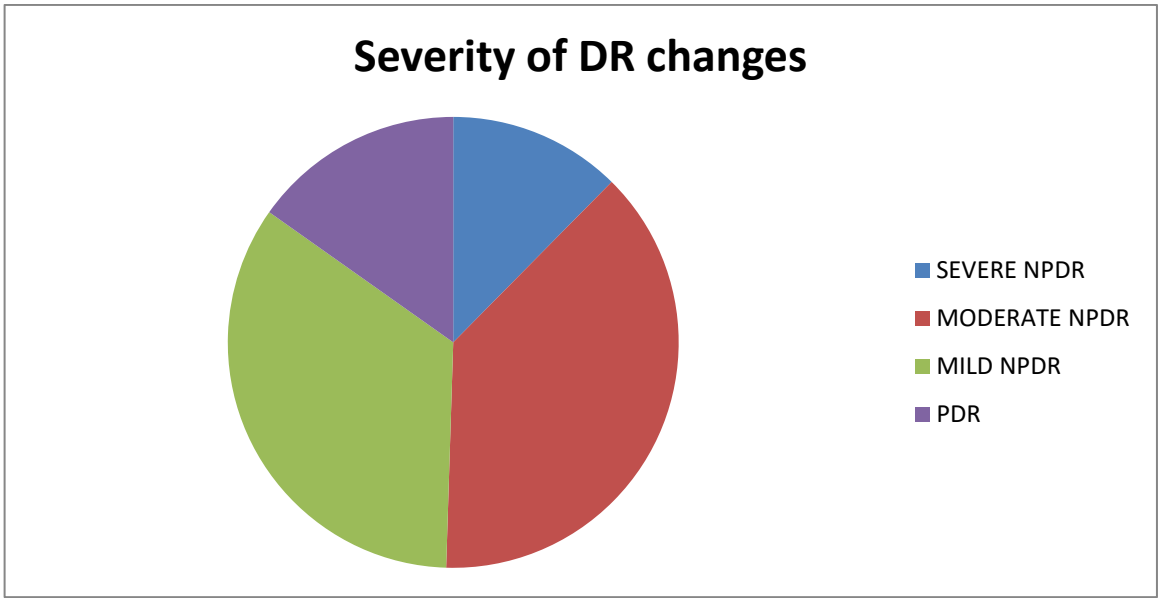


Figure 3- Distribution Of Severity Of Dr Changes In Diabetes With Retinopathy

Among the subjects of diabetes with retinopathy, 13(12.4%) had severe NDPR, majority i.e. 40(38.1%) had moderate NDPR, 36(34.3%) had mild NDPR and 16(15.2%) had PDR.

Table 4 - Comparison Of Severity Of Dr Changes With Sfct In Diabetes With Retinopathy

Severity of DR changes	Mean thickness	Std. deviation	pvalue
SEVERE NPDR	154.62	16.317	<0.001***
MODERATE NPDR	257.62	26.948	
MILD NPDR	327.56	25.052	
PDR	163.94	31.963	

Test used- kruskal wallis, $p<0.05$ significant

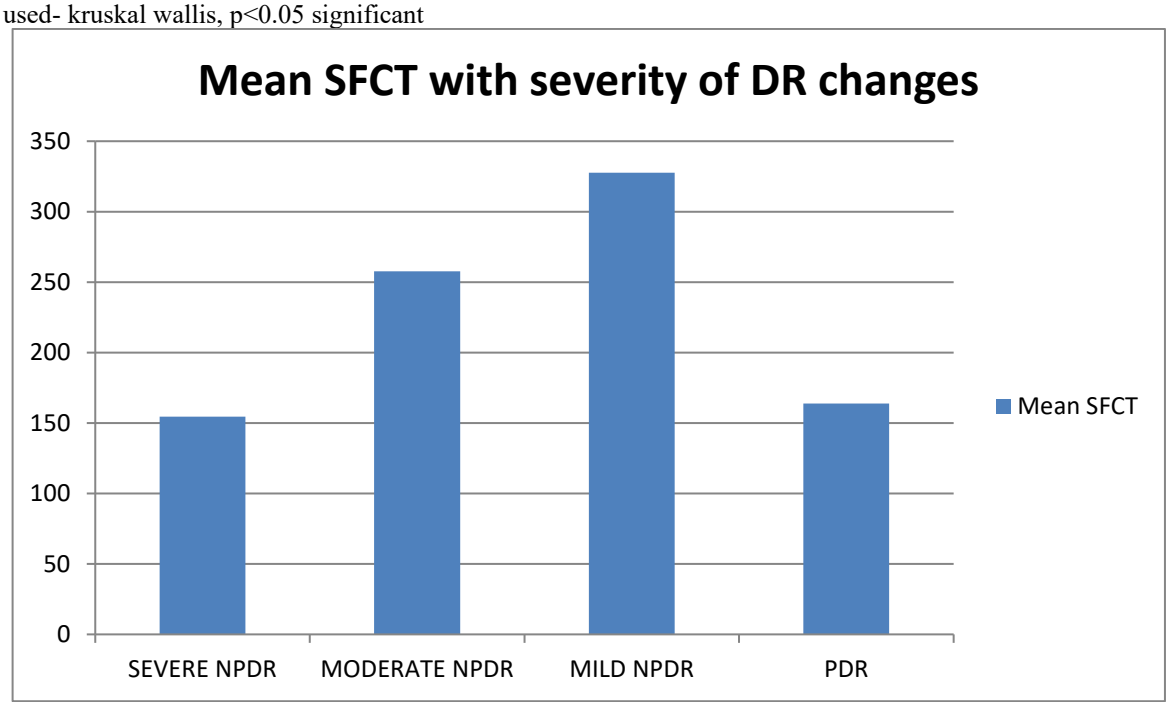


Figure 4 - Comparison Of Severity Of Dr Changes With Sfct In Diabetes With Retinopathy

Mean score of severity of DR changes in severe NDPR was 154.62±16.317 , moderate NDPR was 257.62±26.948, majority i.e. mild NDPR was 327.56±25.052 and PDR was 163.94±31.963 respectively. Results were found to be significant when comparing DR changes with diabetes retinopathy.

Table 5- Comparison Of Severity Of Dr Changes With Duration Of Diabetes With Retinopathy

Severity of DR changes	Mean duration	Std. deviation	pvalue
SEVERE NPDR	6.77	5.199	.70
MODERATE NPDR	6.15	5.758	
MILD NPDR	7.61	5.400	
PDR	6.75	4.553	

Test used- kruskal wallis, p>0.05 insignificant

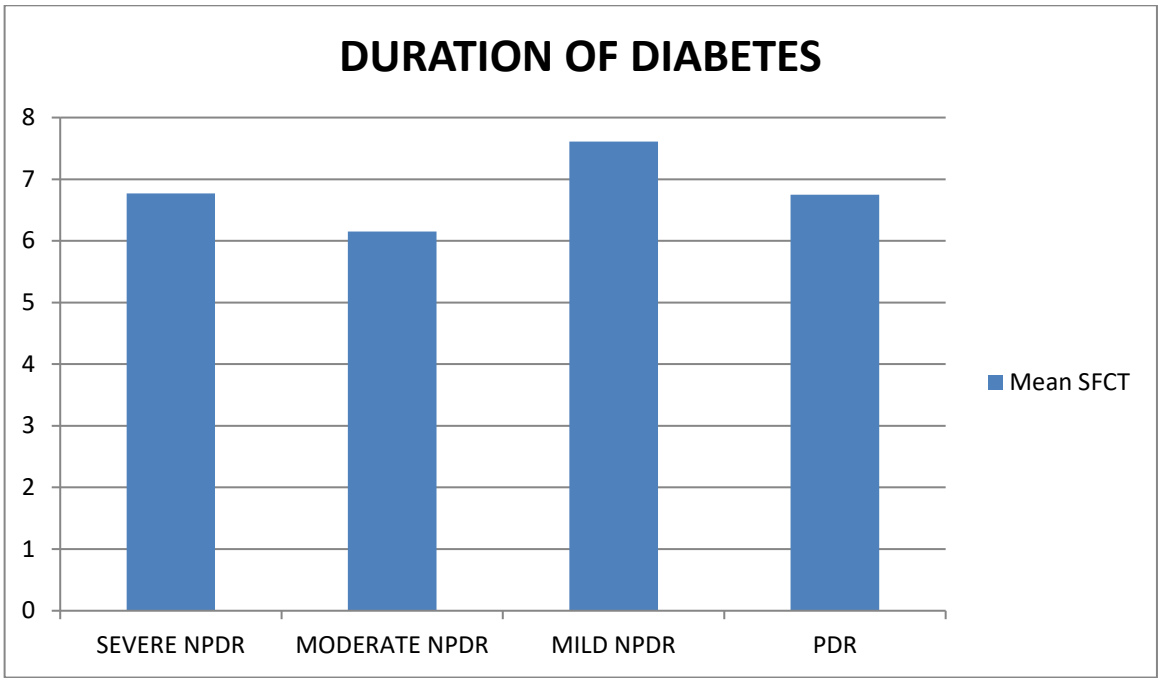


Figure 5- Comparison Of Severity Of Dr Changes With Duration Of Diabetes With Retinopathy

Mean score of duration of diabetes severe NDPR was 6.77±5.199 , moderate NDPR was 6.15±5.758, majority i.e. mild NDPR was 7.61±5.400 and PDR was 6.75±4.553 respectively. Results were found to be insignificant when comparing DR changes with duration of diabetes in diabetes retinopathy.

Table 6- Comparison Of Severity Of Dr Changes With Gender Of Diabetes With Retinopathy

Severity of DR changes	GENDER			pvalue
	male	female	Total	
SEVERE NPDR	10	3	13	.04*
	18.5%	5.9%	12.4%	
MODERATE NPDR	21	19	40	
	38.9%	37.3%	38.1%	
MILD NPDR	19	17	36	
	35.2%	33.3%	34.3%	
PDR	4	12	16	
	7.4%	23.5%	15.2%	
TOTAL	54	51	105	
	100.0%	100.0%	100.0%	

Test used- chi square, p<0.05 significant

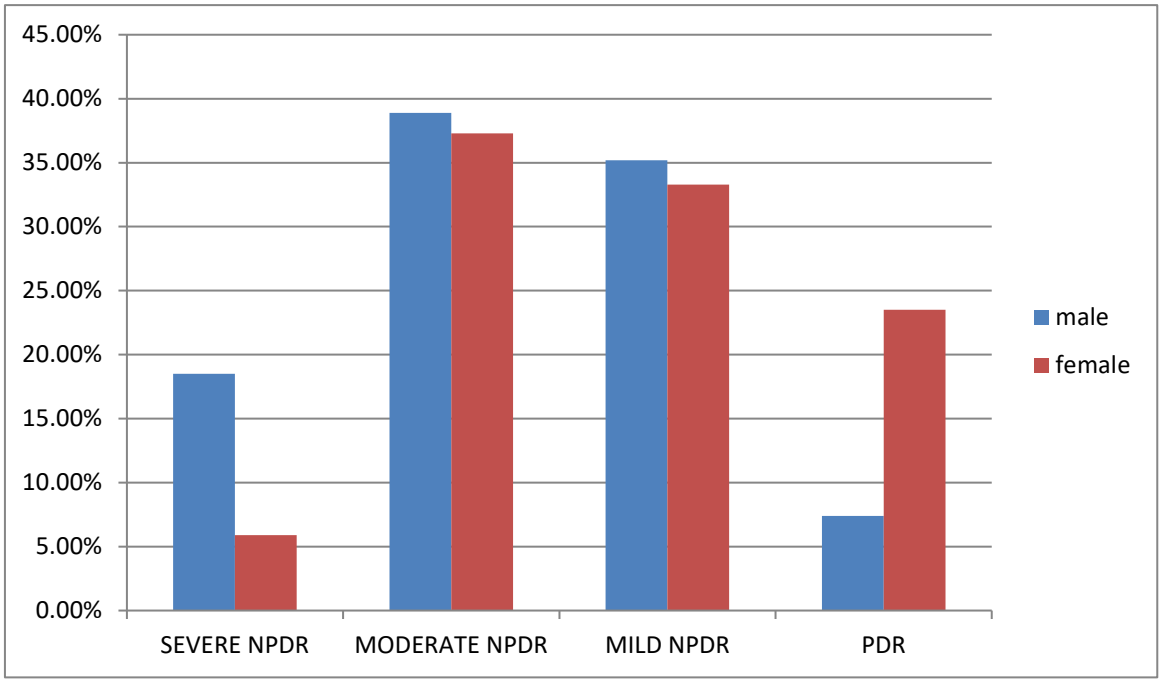


Figure 6- Comparison Of Severity Of Dr Changes With Gender Of Diabetes With Retinopathy

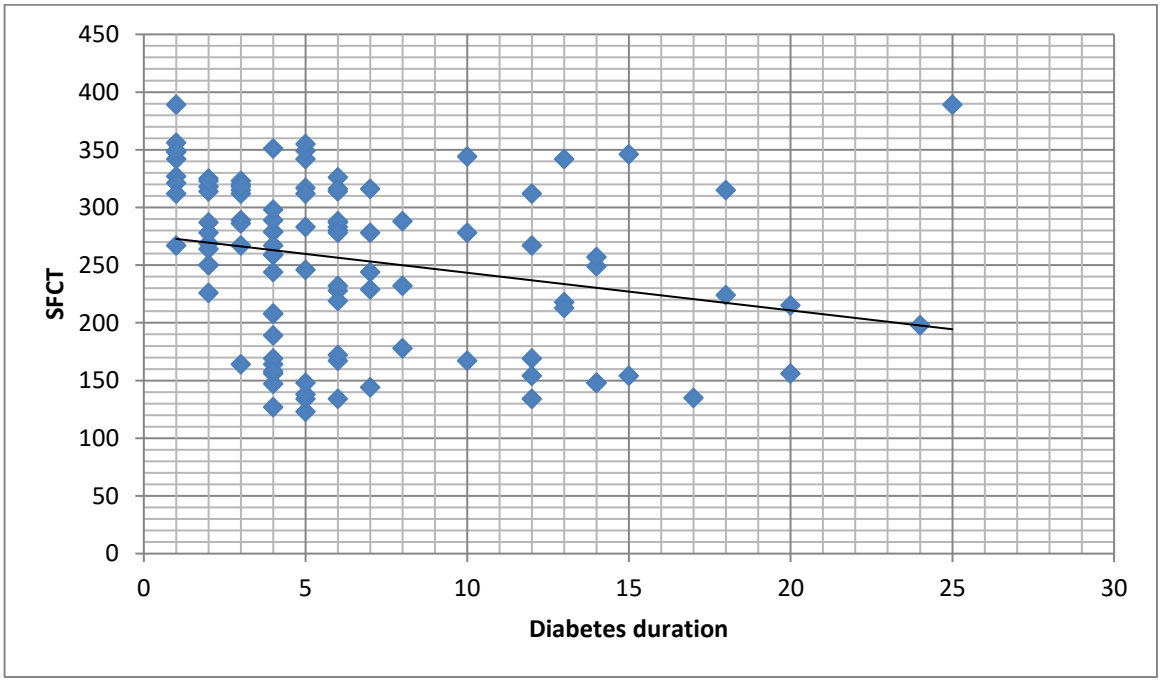
Among the subjects, majority i.e. 21(38.9%) males had moderate NDPR and majority i.e. 19(37.3%) females had moderate NDPR. Results were found to be significant when comparing gender with DR changes in diabetes retinopathy.

Table 7- Correlation Of Sfct With Duration Diabetes In Diabetes With Retinopathy

Variables	Thickness ®	p value
Duration of diabetes	-.344	<0.001***

Test used- spearman correlation, p<0.001*** highly significant

Negative correlation (®=-.344) was seen between duration of diabetes and subfoveal choroidal thickness. Results were found to be statistically significant on comparing SFCT with duration of diabetes.



DISCUSSION

In this study of 180 eyes, the mean age was higher in diabetics with DR compared to those without DR, consistent with the known association between age and DR progression. The duration of diabetes was significantly longer in the DR group, aligning with studies by Ambiya et al.[6] and Rifada et al.[7] who also demonstrated that longer diabetes duration increases the likelihood of developing DR.

The mean SFCT was significantly lower in diabetics with DR compared to those without DR. This is in agreement with studies by Sudhalkar et al.8, Jain et al.[1], and Ambiya et al.[6], who also reported reduced choroidal thickness in DR patients.

A clear progression-dependent decrease in SFCT was observed: mild NPDR exhibited the highest SFCT, while severe NPDR and PDR demonstrated marked thinning. This pattern supports the hypothesis that early diabetic changes may cause choroidal thickening due to inflammation or vascular hyperpermeability, with subsequent choroidal atrophy and ischemia in advanced stages.

Studies by Wang et al.9, Sudhalkar et al.8, and Ambiya et al.[6] also reported similar findings, confirming SFCT thinning with increasing DR severity. However, other studies such as Rewbury et al.10 found an opposite trend, highlighting the heterogeneous nature of choroidal involvement in diabetes.

Gender-based comparison showed a significant distribution difference, with more males in the moderate NPDR group and more females in the PDR group. Ambiya et al. noted a similar higher female proportion in PDR, which may reflect gender-based differences in choroidal structure or diabetes control.

A significant negative correlation between SFCT and duration of diabetes further reinforces the role of chronic hyperglycemia in causing progressive choroidal thinning, comparable to findings of Ambiya et al.[6].

This study highlights the integral role of the choroid in DR pathogenesis. Eyes with DR, particularly advanced stages, demonstrate substantial choroidal thinning. These structural changes may precede clinical findings and have diagnostic value. Choroidal thickness assessment using OCT may serve as an early biomarker for predicting DR severity and the risk of progression.

Strenght Of The Stuudy

This study has several important strengths. First, a largesample of DM patients with no history of ocular treatmentwere included in this study. Second, the latest available technology, OCT, was adopted, which has higher resolutionand more accuracy for CT measurement than EDI SD-OCT.

Limitations

The measurement of SFCT may not be precise in the eyes that did not show a clear outer limit of the choroid on OCT. Another limitation is the small number of eyes in the individual subgroups with different

CONCLUSION

This study demonstrates that subfoveal choroidal thickness (SFCT) is significantly reduced in diabetic patients with retinopathy, with progressive thinning corresponding to increasing DR severity. Longer duration of diabetes was also associated with greater choroidal thinning, supporting the role of chronic hyperglycemia in choroidal degeneration. These findings highlight choroidal involvement in DR pathogenesis and underscore the value of EDI-OCT–based choroidal assessment as a potential early biomarker for disease severity and progression. Larger longitudinal studies are needed to validate these associations and strengthen the role of choroidal imaging in the early detection and management of diabetic retinopathy.

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