

Original Research Article

Optical coherence tomography-angiography vascular changes in macula following cataract surgery

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ABSTRACT

Background: The study was done to estimate vessel density (VD), perfusion density (PD) and Foveal avascular zone (FAZ) changes in macula after uncomplicated cataract surgery and to compare the same between diabetics and nondiabetics.

Methods: 63 patients who had undergone cataract surgery were included in study, 32 nondiabetics, 31 diabetics. After standard ophthalmic examination, Optical Coherence Tomography-Angiography scans were taken preoperatively & at 3 weeks, 6 weeks and 3 months of postoperative period.

Results: Vessel density and perfusion density values were higher and FAZ values were lower in non-diabetics when compared with diabetics in preoperative and postoperative period. Vessel density and perfusion density increased significantly in both groups at 3 weeks visit but there was no significant increase in following visits. FAZ perimeter and circularity index decreased significantly and FAZ area decreased insignificantly in both groups. The difference in rate of these changes between 2 groups was insignificant.

Conclusions: Similar changes were observed in other studies as well. These changes in our study could be a result of an increase in light exposure after cataract surgery. Although other studies suggest various reasons for this change in their study. Whether these changes are beneficial to macula or worsens DR cannot be concluded with the present study as it requires more studies with larger samples and longer follow-up.

Keywords: Diabetics, Foveal avascular zone, Non-diabetics, Optical coherence tomography angiography, Perfusion density, Vessel density

INTRODUCTION

Cataract is an avoidable cause of global blindness that can be effectively treated with cataract surgery.¹ Both manual small incision cataract surgery and phacoemulsification are two effective and safe techniques for cataract extraction.² The visual potential of retina and neural integrity has to be assessed and outcomes of cataract surgery have to be weighted before surgery to predict visual outcome after surgery.³ Macula, more specifically fovea, being the most critical part of the retina for vision,

has a central circular zone devoid of retinal blood vessels, called Foveal Avascular Zone (FAZ).⁴ Size of FAZ is a key indicator used to assess macular ischemia which can occur as a result of capillary drop out in conditions like diabetic retinopathy (DR). Photoreceptor loss and decrease in vision are its consequences. Other parameters to measure the vascularity at fovea are VD and PD. All these can be accurately measured by Optical Coherence Tomography Angiography (OCT-A) that represent a reliable, non-invasive tool for detecting retinal blood flow parameters with a high degree of repeatability. It is essential that we know the changes in capillary circulation at fovea after

uncomplicated cataract surgery as it can predict macular ischemia and thereby postoperative visual prognosis.⁵⁻⁷ Some studies suggest acceleration of diabetic retinopathy following phacoemulsification.^{8,9} Some other studies suggest no influence of cataract surgery in progression of DR.¹⁰ However there are many studies suggesting increase in macular thickness following cataract surgery.¹¹ Whether all these are related is under study. In various studies, mean FAZ was higher in diabetics when compared with non-diabetics. At the same time mean VD and visual acuity was lower in diabetics when compared with non-diabetics. This increase in FAZ and decrease in VD was in accordance with severity of DR.¹²⁻¹⁴

However, a study by Mastropasqua et al, has reported not much change in FAZ and VD in diabetics without DR, diabetics with mild non proliferative diabetic retinopathy (NPDR) and non-diabetics. At the same time FAZ was statistically increased and VD was statistically decreased in accordance with DR severity in moderate NPDR, severe NPDR and proliferative diabetic retinopathy (PDR) patients.¹⁵ Studies comparing OCT parameters before and after cataract surgery in non-diabetics have concluded that cataract surgery resulted in increased VD, PD and decreased FAZ.^{5, 16-18} There is limited literature and no clear consensus on the effects of cataract surgery on OCT parameters in diabetics. This study aims to look into these factors.

Aims

To estimate the change in VD, PD and FAZ after uncomplicated cataract surgery. To compare the same among diabetics versus non-diabetics.

METHODS

This was a cross-sectional study. The study was approved by IRB and IEC of Believers Church Medical College Hospital, Thiruvalla. IEC study number: IEC/2022/12/300. The study was performed in accordance with the tenets of the Declaration of Helsinki. 63 patients who underwent cataract surgery with posterior chamber intraocular lens (PCIOL) implantation from September 1 2022 to August 31 2023 at Believers Church Medical College Hospital, Thiruvalla, Kerala was included in study. Among them, 32 were non diabetics and 31 diabetics. Eyes with Intraocular pressure (IOP) higher than 21 mmHg, history of ocular trauma or intraocular surgery, patients diagnosed with glaucoma or any retinopathies other than DR (e.g., age-related macular degeneration, retinal vascular disorders, etc.), poor OCT images due to severe cataracts, unstable fixation or any signs of intraoperative or postoperative complications or OCT -A

signal strength below 5 were excluded from study. All participants underwent routine examinations prior to cataract surgery, including the measurement of visual acuity with Snellen's chart and IOP with a non-contact tonometer, IOL power calculation with A scan and IOL master, anterior segment assessment with a slit lamp biomicroscopy and a dilated fundus evaluation using 90D lens. 6 mm × 6 mm Raster scans centred on the fovea were obtained using Cirrus HD-OCT 500/ 5000 along with AngioPlex software (Carl Zeiss Meditec, Inc., Dublin, CA, USA) after pupil dilatation. OCT A scan was taken preoperatively any time before surgery and postoperatively at 3 weeks, 6 weeks and 3 months. OCT -A parameters like VD (mm⁻¹) and PD (%) of central (within central circular area of 1mm diameter), inner (area between inner circle and intermediate circle of 3mm diameter), outer (area between intermediate circle and outer circle) and full area (area within outer 6mm circle) as well as FAZ area (mm²), perimeter (mm) and circularity index (%) in superficial capillary plexus of all participants before and after surgery were estimated automatically by OCT-A machine.

FAZ values were measured manually in a few participants whose automatic values were not shown by machine; by drawing the outline of FAZ and rest was automatically calculated by machine. VD was defined as the length of vessels with circulation in a defined area. PD was defined as the percentage of area with circulation. FAZ area was defined as segmented FAZ region's area. FAZ contour's length determined perimeter. FAZ circularity index was defined as the ratio of measured area of FAZ to the projected area of the circle. Preoperative and postoperative values of these parameters were analysed using ANOVA. Comparison of these parameters between diabetic and nondiabetic group and rate of change of these parameters over time between the 2 groups was done with a generalised linear regression model. All analysis was done using SAS software, version 9.4. p value less than 0.05 was considered significant.

RESULTS

In total 63 patients were included in the study, 32 nondiabetics and 31 diabetics. Among the diabetic group, 27 patients had no DR and 4 patients had mild NPDR. Mean macular thickness increased from 239 µm in preoperative period to 241µm at 3 weeks, 244 µm at 6 weeks and 248 µm at 3months of postoperative period. There was significant increase in mean VD and PD at 3 weeks of postoperative period from preoperative value. On further follow up, there was not much change in OCT -A parameters. Mean FAZ values had a slight decrease but the decrease was not significant.

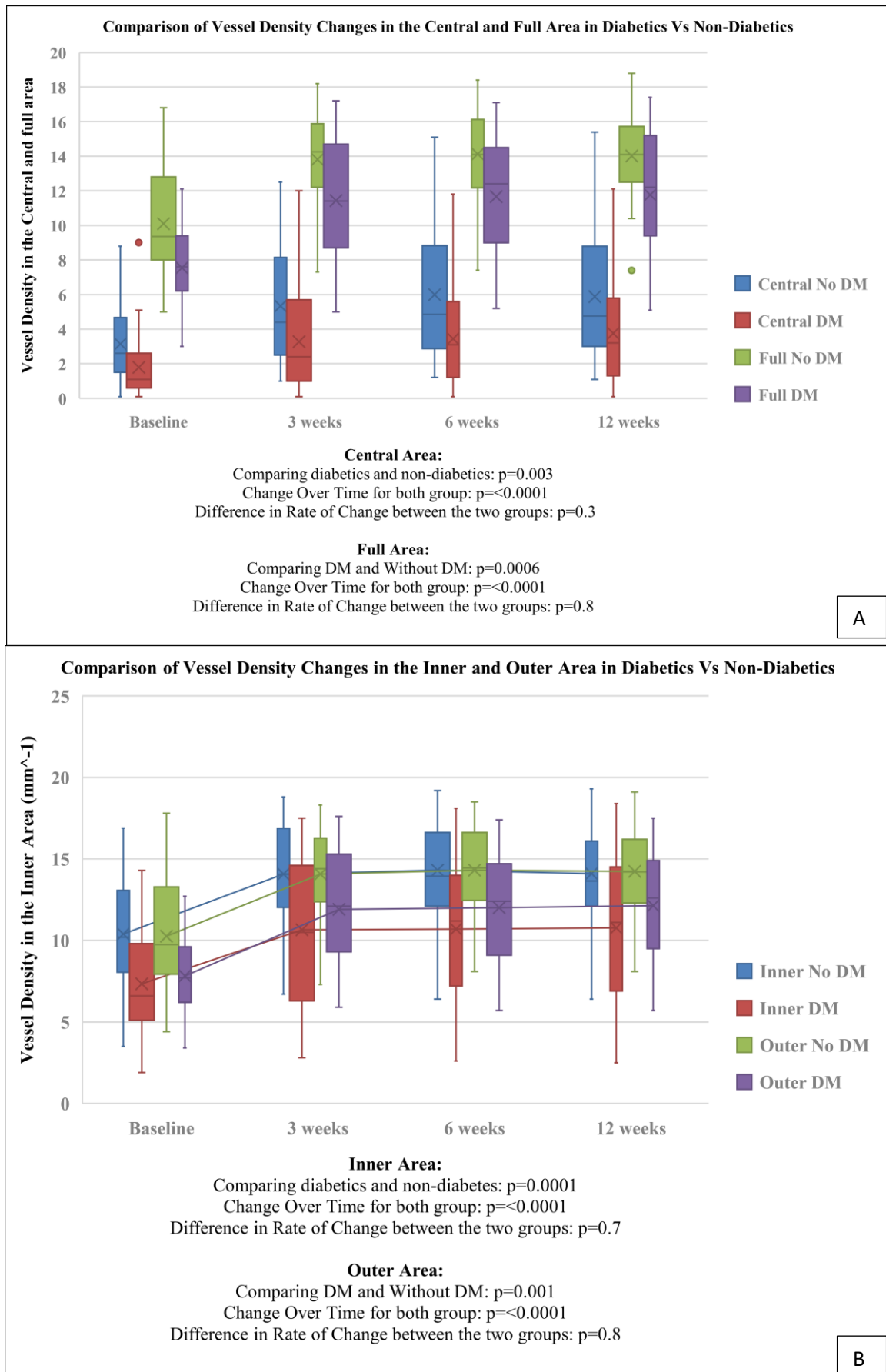


Figure 1 (A and B): Distribution of vessel density.

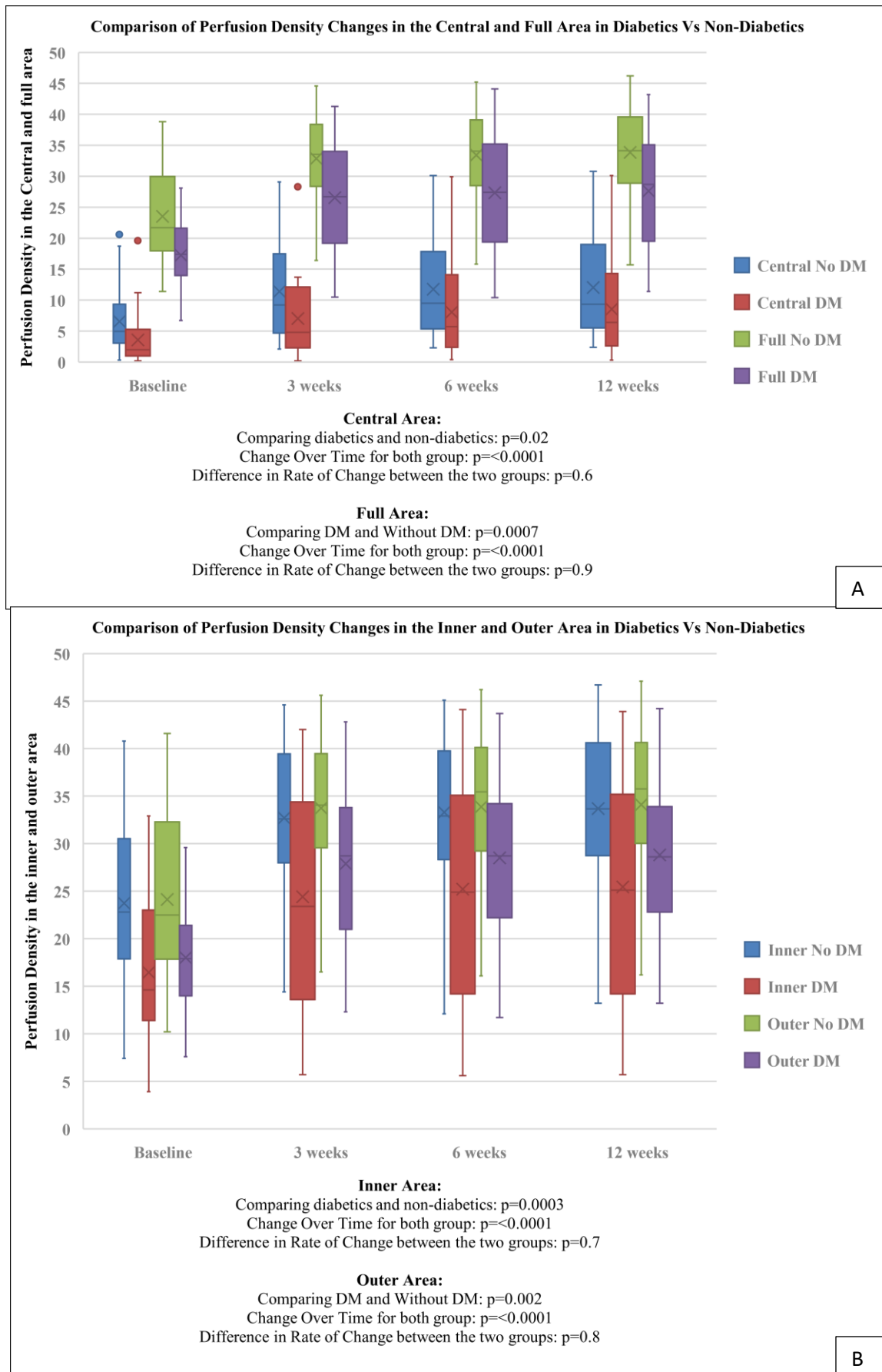
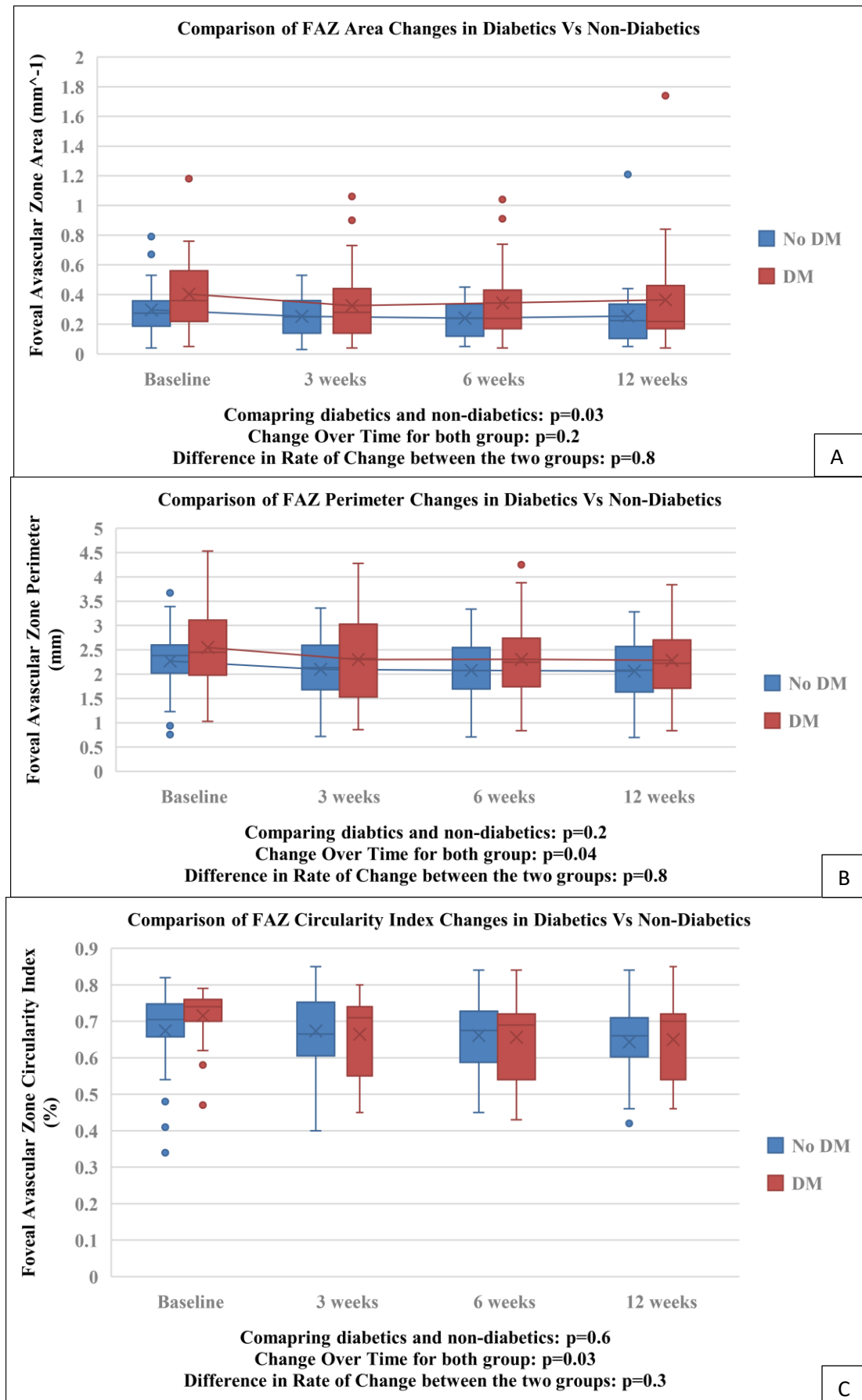


Figure 2 (A and B): Distribution of perfusion density.



VD and PD values of central, inner, outer and full area were significantly higher and FAZ area was significantly lower in non-diabetics when compared with diabetics in preoperative and postoperative period. VD and PD increased significantly in both groups at 3 weeks visit but there was no significant increase in following visits. But the difference in rate of this change between 2 groups was not statistically significant. The decrease in FAZ area over

time in both groups was not statistically significant. Also, the difference in rate of this change between 2 groups was not statistically significant. There was no significant difference in preoperative and postoperative values of FAZ perimeter and circularity index between two groups. But the decrease in FAZ perimeter and circularity index over time in both groups was statistically significant. However, the difference in rate of this change between 2 groups was not statistically significant.

Table 1: Demographic and baseline characteristics of the study participants.

Characteristics	Mean±SD/Frequency (%) N=63
Age group (in years)	
51-60	5 (7.9)
61-70	19 (30.2)
71-80	36 (57.1)
81-90	3 (4.8)
Gender	
Male	27 (42.9)
Female	36 (57.1)
Diabetes mellitus	
Present	31 (49.2)
Absent	32 (50.8)
Diabetes retinopathy (among diabetes eyes, n=31)	
No DR	27 (87.1)
Mild NPDR	4 (12.9)
Eye	
Right eye	34 (54.0)
Left eye	29 (46.0)
Type of surgery	
SICS	12 (19.0)
Phacoemulsification	51 (81.0)
Type of cataract	
Nuclear sclerosis (NS) only (grade 1-4)	25 (39.7)
NS with cortical/ PSCC	27 (42.9)
Non- nuclear (PSCC/ cortical/ posterior polar)	11 (17.5)
Pre-operative visual acuity	
6/9-6/12	28 (44.4)
6/18-6/24	31 (49.2)
6/36-6/60	4 (6.4)
Intraocular pressure (mmHg)	16.6±2.4

Table 2: Mean values with standard deviation of OCTA parameters of 63 patients.

OCT parameters	Baseline	3 weeks	6 weeks	12 weeks	P value (baseline vs 3 weeks)
Vessel density central	2.5±2.1	4.3±3.2	4.7±3.5	4.8±3.6	<0.0001
Vessel density inner	8.9±3.6	12.4±4.3	12.5±4.3	12.5±4.3	<0.0001
Vessel density outer	9.1±3.1	13.0±3.3	13.2±3.2	13.2±3.3	<0.0001
Vessel density full	8.8±3.0	12.6±3.5	12.9±3.4	12.9±3.4	<0.0001
Perfusion density central	5.1±4.8	9.2±7.2	10.0±7.4	10.3±7.5	<0.0001
Perfusion density inner	20.1±8.6	28.6±10.9	29.3±11.0	29.6±11.0	<0.0001
Perfusion density outer	21.1±7.8	30.9±8.6	31.2±8.9	31.5±9.0	<0.0001
Perfusion density full	20.4±7.5	29.8±8.8	30.4±9.1	30.8±8.9	<0.0001
Foveal avascular zone area	0.3±0.2	0.3±0.2	0.3±0.2	0.3±0.3	0.4219
Foveal avascular zone perimeter	2.4±0.7	2.2±0.8	2.2±0.8	2.2±0.8	0.2517
Foveal avascular zone circularity index	0.7±0.1	0.7±0.1	0.7±0.1	0.6±0.1	0.0522

DISCUSSION

OCT A being the reliable non-invasive tool has opened up the opportunity to explore the retinal vasculature changes in detail.⁵ In a retrospective case series by Samera et al mean FAZ area was greater and mean VD was lower in diabetics (0.427mm² and 0.616 mm² in superficial and deep vascular network respectively) when compared with non-diabetics (0.275mm² and 0.372 mm² in superficial and deep vascular network respectively). Whereas mean vessel length density was lower in diabetics (17.68 mm⁻¹ and 21.19 mm⁻¹ in superficial and deep vascular network respectively) when compared with non-diabetics (21.55 mm⁻¹ and 24.38 mm⁻¹ in superficial and deep vascular network respectively).¹²

In a cross-sectional cohort study by Yang et al 40.4% of diabetics with no DR showed microvascular changes in OCTA in the superficial and deep retinal layers including foveal avascular zone erosion in 32.5%, non-perfusion areas in the superficial and deep retinal layers (13.4% and in 6.5%, respectively), microaneurysms in the superficial and deep retinal layers (7.5% and 10.6% respectively). None of these were seen in non-diabetics.¹³ In another cross-sectional study involving 155 diabetic eyes by Kim et al, OCT-A parameters were assessed. In both superficial and deep retinal capillary layers (SRL and DRL), FAZ areas in the no diabetic retinopathy (NDR) (0.38 mm², 0.49 mm²) and NPDR (0.38 mm², 0.48 mm²) were greater than those in the nondiabetics (0.33 mm², 0.43 mm²).

The FAZ circularity index, vessel density and perfusion index in the NDR (0.63, 17.8/mm, 0.32) and NPDR (0.63, 17.5/mm, 0.32) were smaller than those in the nondiabetics (0.69, 19.6/mm, 0.39).¹⁴ In a cross-sectional study by Antonio et al comparing OCT A parameters before cataract surgery with 1 week after surgery, there was statistically significant increase in SCP VD and PD and decrease in mean FAZ area and perimeter. An increase in FAZ circularity index was also noted. Diabetics were excluded from this study and comparison was done between 1-week postoperative values with preoperative value when the inflammation is at its peak. They also came to conclusion that cataract severity does not significantly affect OCTA parameters.⁵ Another study by Zhao et al, has found significant increase in VD, a decrease in the FAZ and increase in macular thickness after the cataract surgery.¹⁹

Decrease in IOP, postoperative inflammation and increase in light exposure were reported to be reasons for increase in VD and PD postoperatively.^{5,19} However, Baldascino et al, Natalia et al and Krizannvic et al denied the role of decreased IOP and postoperative inflammation and upheld light exposure to be primary cause for this increase postoperatively.

FAZ area and perimeter was significantly reduced alongside increase in capillary flow density and central foveal thickness in their study.¹⁶⁻¹⁸ Ana et al studied OCTA

vascular parameter changes at 1 week, 1 month and 3 months post cataract surgery in nondiabetics. There was significant increase in VD especially in SCP from preoperative values. Maximum change was in 1 week after which values remained stable up to 3 months.¹⁶ Study by Natalia et al looked into change in retinal parameters in post cataract surgery patients over 1 year of postoperative period.

All patients with DR were excluded. VD and PD increased from preoperative value at 2 weeks post-surgery. But there were no significant differences in these values from 2 weeks till 1 year follow up.¹⁷ In a study by Antonio et al, vascular changes at fovea following cataract surgery were assessed in nondiabetics over a period of 3 months post-surgery.

VD both at SCP and DCP was significantly increased and FAZ parameters were significantly decreased at 3 months when compared with preoperative values.¹⁸ In a study by Feng et al VD increased significantly at 3 months postoperatively from preoperative value in SCP in diabetics. This increase was not significant in non-diabetics. There were no significant differences in DCP at any postoperative timepoint or between the two groups. The decrease in FAZ area, perimeter and a circularity index was not significant. The study attributed the increase in VD in SCP to loss of pericytes, increased permeability and postoperative inflammation. And also, they proposed that it may have a predictive effect on progression of postoperative DR.²⁰

This study supports the findings of previous studies. VD and PD values were higher and FAZ values were lower in non-diabetics when compared with diabetics in preoperative and postoperative period. There was significant increase in VD and PD and significant decrease in FAZ perimeter and circularity index at 3 weeks of postoperative period. Then values remained stable on further follow up till 3 months. Increased light exposure could be the reason for the findings of OCT-A in our study.

Some limitations are worth noting. Firstly, the number of study participants are few in the present study. The results would have been more appealing and more projectable to the general population if sample size was large. Even though we screened around 2000 patients only 63 patients qualified for study after considering inclusion and exclusion criteria.

Secondly, a longer follow up period would have given better conclusion of vascular changes at macula. Thirdly, we included patients with DR but we could not compare vascular changes between different stages of DR as sample size in each stage was so small. Finally, we could not compare vascular changes in patients who underwent SICS with patients who underwent phacoemulsification as the number of patients who underwent SICS in our study group was very less when compared with those who underwent phacoemulsification in the study.

CONCLUSION

VD and PD values were higher and FAZ values were lower in non-diabetics when compared with diabetics in preoperative and postoperative period. There was a statistically significant increase in vessel density and perfusion density and significant decrease in FAZ circularity index and perimeter in both diabetics and non-diabetics at 3 weeks of postoperative period. Then values remained stable on further follow up till 3 months. The decrease in FAZ area was not significant. The difference in change in these parameters was not significant between 2 groups. These changes could be a result of an increase in light exposure after cataract surgery. Whether these changes are beneficial to macula or worsens DR cannot be concluded with the present study as it requires more studies with larger samples and longer follow-up.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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