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Optical Coherence Tomography Angiography of The Retina in Diabetic Patients before and after Phacoemulsification

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ABSTRACT

Background: With optical coherence tomography angiography (OCT**A**), blood circulation in the retina and choroid may be examined non-invasively by means of motion contrast imaging.

Objective: This study aimed to investigate the usage of OCT**A** to look at how the blood vessels in the retina of diabetic patients are changed before and after phacoemulsification that didn't go wrong.

Methods: This controlled prospective not randomized study was conducted through the period from February 2021 to February 2022 in Al-Azhar University hospital.

Results: All of the OCTA measurements of the microvasculature were done before, and after one week, one month, and three months following phacoemulsification for cataract. After three months, the average macula thickness (MT) was 329.68 ± 24.56 micrometer, up from 275.48 ± 14.93 micrometer at the start of the research. The SCP% increased significantly from 40.28 ± 1.09 at baseline to 42.34 ± 1.44 at one-month post-operative, to 43.59 ± 1.72 at 3 months post-operative ($P < 0.05$). This rise was statistically significant ($P < 0.05$).

Conclusion: According to the findings of our research, OCTA helped to diagnose and keep track of DM patients with early diabetic retinopathy (DR). It gave detailed images and data about microvascular changes in the retinal layers that could not be seen with other investigation tools.

Keywords: Optical coherence tomography, Angiography, Retina, Diabetic, Phacoemulsification.

INTRODUCTION

One of the most popular surgical treatments performed by ophthalmologists is phacoemulsification, which removes cataracts using ultrasonic waves. This process enhances patients' eyesight following cataract removal and is crucial for raising quality of life. A split-spectrum amplitude-decorrelation angiography algorithm was combined with high-speed optical coherence tomography (HS-OCT) in a recent study by Jia and colleagues to create a novel technique for performing quantitative angiography of the retina. Previous research has demonstrated that split-spectrum amplitude-decorrelation angiography in optical coherence tomography yields accurate findings (1).

Capillary non-perfusion causes retinal parenchymal neuroglial tissues to become hypoxic, resulting in increased angiogenic responses and vascular permeability that promotes vascular endothelial growth factor (VEGF). Both inflammatory mediators and VEGF-mediated factors contribute to the progression of diabetic macular edema (2). Fluorescein angiography is widely acknowledged to play an important role in both DR diagnosis and therapy. However, venipuncture is required, and although rare, cases of allergy and death due to contrast injections have been reported. The method is both costly and time-consuming, with a suitable frame taking up to 10 minutes to obtain. Nonetheless, it remains the preferred method for analysing DR components (3).

Retinal and choroidal blood vessels may be seen non-invasively using OCTA thanks to motion contrast imaging. This cutting-edge imaging method rapidly produces angiograms from high-resolution volumetric blood flow data (4). Time-domain OCTA is slower than SD OCT, allowing for faster imaging of both structure and blood flow (TD OCT). OCT-derived methods, such as phase-variation optical coherence tomography (PV OCT), phase contrast optical coherence tomography (PC OCT), and split-spectrum amplitude decorrelation angiography (SSADA), have been successfully employed to study in vivo human ocular microcirculation (5). This study's objective was to find retinal vascular changes.

PATIENTS AND METHODS

Clinical prospective and controlled but not randomised trial that took place at the Al-Azhar University Hospital between February 2021 and February 2022. Before any surgeries were done, all patients had their questions answered and given a detailed explanation of the procedures' symptoms and likely consequences. The actual work was always done by the talented surgeons (Azhar University's medical staff).

Inclusion criteria: IOP of 21 mmHg or below, nuclear cataract of grade 2 or 3 or cortical cataract and lack of posterior subscapular or posterior polar cataract.

Exclusion criteria: Axial length (AL) larger than 25.0 mm or less than 20.0 mm, an intraocular pressure (IOP) greater than 21 mm Hg, history of ocular trauma or intraocular surgery, and any aberrant intraocular findings. Also, eyes with poor OCT images because of substantial cataracts, unstable fixation, and any other postoperative or surgical challenges.

In the course of the research, there were a total of fifty eyes with cataracts taken from fifty different patients who were scheduled to have phacoemulsification and intraocular lens (IOL) implantation. Despite the fact that a patient could have

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two healthy eyes, they can only contribute one of them to the research. In this particular scenario, the study would be conducted on the healthy eye that undergoes the procedure first. Before phacoemulsification, every patient had an OCTA performed. After that, they repeated the procedure once a week, once a month, and once every three months.

Before any surgeries were performed, patients had exhaustive screenings to check for further eye disorders, and their medical histories were carefully considered. Both uncorrected and corrected distance visual acuity (UDVA and CVVA, respectively) were evaluated for each pair of eyes.

The following procedures were applied to all patients:

1. History: Systemic: All patients were questioned about their pre-existing conditions and general health histories. We questioned patients about their HA1c levels, how long they had diabetes, and how well they controlled it. Anemia, hypertension, and hyperlipidemia were the most often reported co-occurring disorders. Patients were questioned about their hormonal replacement treatment, breastfeeding, and/or oral contraceptive medication usage. **Ocular:** The patients were questioned about their ocular history, which included things like prior eye injuries, surgeries, prescription changes, and how often they use glasses. Anti-VEGF injections into the eye: a historical perspective.

2- Examination: Each patient underwent a dilated fundus examination, and their cataracts were evaluated using the Lens Opacities Classification System III. Readings of intraocular pressure (IOP) were considered with scitoz contact tonometer, axial length (AL) was evaluated with an A scan (Biometry), and slit-lamp biomicroscopy were performed. We calculated the mean arterial pressure by first putting the diastolic and systolic pressures together and then deducting a third of the difference in pressures that existed between the two. In addition, the patients' medical histories and family trees were meticulously recorded.

3-Investigations: Complete blood count, random Blood Sugar and HA1c were done.

Preoperative Evaluation: By DRI OCT Triton (Topcon 3D OCT-2000 series, Topcon Company, Tokyo, Japan), which used 1050 nm OCT for posterior segment OCT and optional OCT Angiography imaging (Color photography figure 1).

Figure (1): shows TOPCON DRIOCT Triton Device

Methods: Patients were given information about the treatment's process and what to anticipate before it begins. Pharmaceuticals taken before surgery: Local anaesthesia was used during surgery.

Operative technique

Operative details: The ORTLI system was used for the cataract operations (Figure 2) (The Faros phaco machine of Berne, Switzerland). In brief, after administering local anaesthetic, the corneal self-sealing incision of 2.4 mm, ongoing capsulorhexis, phacoemulsification, hydrodissection, and irrigation/aspiration of the residual lens cortex were all performed throughout the procedure. Because of this, it was determined that a foldable IOL would be implanted into the capsular bag. The stroma has been given some moisture.

Figure (2): ORTlI phacoemulsification system.

Post-operative treatment: Eye drops containing 0.5% moxifloxacin hydrochloride and 1% prednisolone acetate (Econopred Plus; Alcon Laboratories, Inc.; Fort Worth, TX, USA) were given as post-operative eye medicines. A month's worth of nonsteroidal anti-inflammatory drugs (diclofenac sodium 0.1%; Nevenac, Alcon Laboratories, Inc.) were given four times daily for two weeks.

Postoperative evaluation:

Patients were checked out a week, a month, and three months following surgery. The evaluation was conducted using DRI OCT Triton (Topcon 3D OCT-2000 series, Topcon Company, Tokyo, Japan). The macula was photographed using an OCTA device with a three-by-three-millimeter sensor.

Ethical considerations:

Each participant in the study provided written informed consent. The study was approved by The Ethical Committee, Faculty of Medicine, Al-Azhar University, Assiut Campus. The study was also carried out in conformity with Helsinki Declaration

Statistical analysis

IBM SPSS version 20.0 was used to examine the data that were input into the computer (Armonk, NY: IBM Corp). Numerical and percentage descriptions were used to describe the qualitative data.

Distributional regularity was confirmed using **Kolmogorov-Smirnov test**. Minimum and maximum values, as well as means, standard deviations, medians, and interquartile ranges, were used to characterise the quantitative data (IQR).

The acquired findings were deemed statistically significant at the 5% level.

RESULTS

Table (1) showed that 56.0% of the studied cases were males and 44.0% were females. The mean age was 60.06 ± 6.36 with range of 50.0 – 76.0 years.

Table (1): Distribution of the studied cases according to demographic data (n = 50)

Demographic data	No.	%
Sex		
Male	28	56.0
Female	22	44.0
Age		
Min. – Max.	50.0 – 76.0	
Median (IQR)	62.0 (55.0 – 64.0)	

IQR: Inter quartile range.

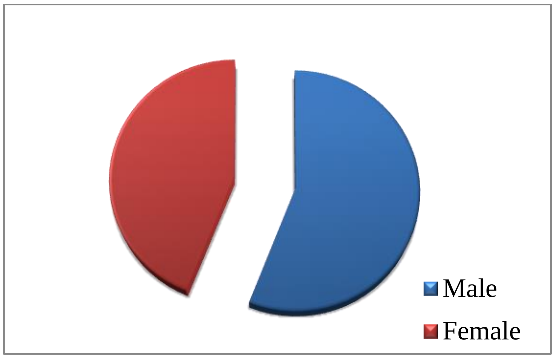

Figure (3): Distribution of the studied cases according to sex.

Table (2) showed that the mean IOP was 16.02 ± 1.63 SD with range of 13.0 –19.0 and the mean AL was 21.86 ± 1.60 SD with range of 20.0 – 25.0

Table (2): Descriptive analysis of the studied cases according to IOP and AL in mm (n = 50)

	Min. – Max.	Mean ± SD.	Median (IQR)
IOP in mmHg	13.0 – 19.0	16.02 ± 1.63	16.0 (15.0 – 17.0)
AL in mm	20.0 – 25.0	21.86 ± 1.60	22.0 (20.0 – 23.0)

IQR: Inter quartile range, **SD:** Standard deviation

Regarding BCVA, table (3) showed that there was highly statistically significant difference between the studied cases in both groups (pre- and post-).

Table (3): Descriptive analysis of the studied cases according to BCVA (n = 50)

BCVA	Pre	Post	Z	p
Min. – Max.	0.10 – 0.25	0.30 – 0.63		
Median (IQR)	0.20 (0.10 – 0.25)	0.40 (0.30 – 0.50)		

IQR: Inter quartile range, SD: Standard deviation, Z: Wilcoxon signed ranks test, p: p value for comparing between **Pre** and **Post,** *: Statistically significant at p ≤ 0.05.

50.0% of the studied cases had no NPDR, 40.0% had mild NPDR and 10.0% had moderate NPDR. The mean duration of DM was 4.96 ± 2.66 with range of 1.0 – 11.0 years. The mean nuclear grading was 2.50 ± 0.51 with range of 2.0 – 3.0). The mean HA1c was 7.67 ± 0.41 SD with a range of 7.0 – 8.50 **(Figure 4)**.

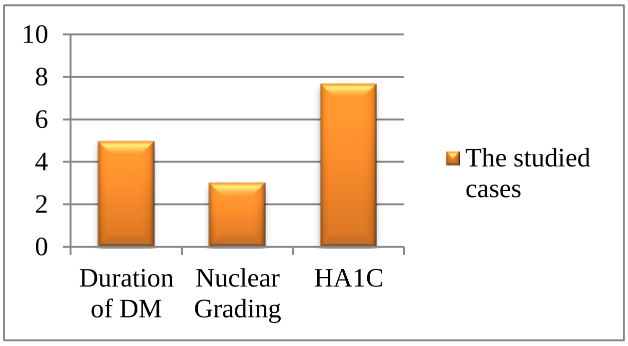

Figure (4): Distribution of the studied cases according to duration of DM, nuclear grading and HA1c.

Table (4) and figure (5) showed that there was highly statistically significant difference between the studied cases as regards SCP%.

Table (4): Descriptive analysis of the studied cases according to SCP% (n = 50)

SCP%	Pre	1week	1month	3months	Fr	p
Min. – Max.	38.99 –43.09	39.70 –45.90	39.44 – 45.45	41.66 –47.98	146.616 *	<0.001*
Median (IQR)	40.06 (39.45–40.65)	41.09 (40.20–41.76)	41.01 (40.09– 41.55)	42.89 (42.09 –44.08)		
p_0		<0.001*	0.001*	<0.001*		

IQR: Inter quartile range, **SD:** Standard deviation**, Fr:** Friedman test, **p:** a comparison value between the researched periods **p_0:** p value for comparing between **Pre** and each other periods, *: Statistically significant at p ≤ 0.05 or less

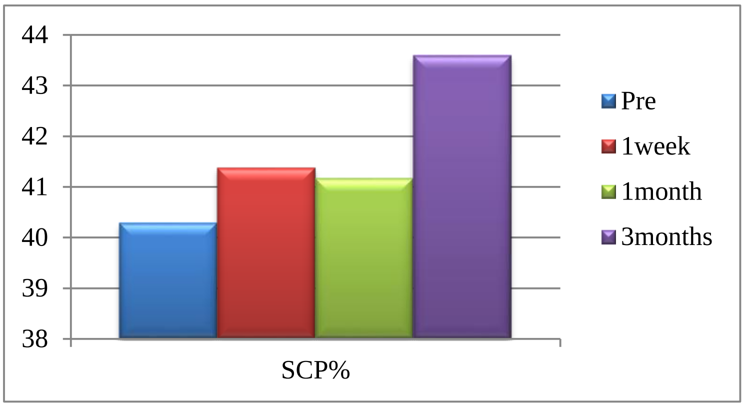

FIG (5): Descriptive analysis of the studied cases according to SCP%

Table (5) and figure (6) showed that there was highly statistically significant difference between the studied cases as regards CMT.

Table (5): Descriptive analysis of the studied cases according to CMT µm (n = 50)

CMT µm	Pre	1week	1month	3months	Fr	p
Min. – Max.	255.0 – 310.0	265.0 – 350.0	278.0 – 360.0	290.0 – 380.0	150.0^{*}	$<0.001^{*}$
Median (IQR)	275.0 (265.0–280.0)	294.0 (278.0–309.0)	307.50 (289.0–320.0)	333.0 (310.0–345.0)		
p_0		$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$		

IQR: Inter quartile range, SD: Standard deviation, Fr: Friedman test, : a comparison value between the researched periods
p_0: p value for comparing between **Pre** and each other periods *: Statistically significant at $p \leq 0.05$ or less

FIG (6): Descriptive analysis of the studied cases according to CMT

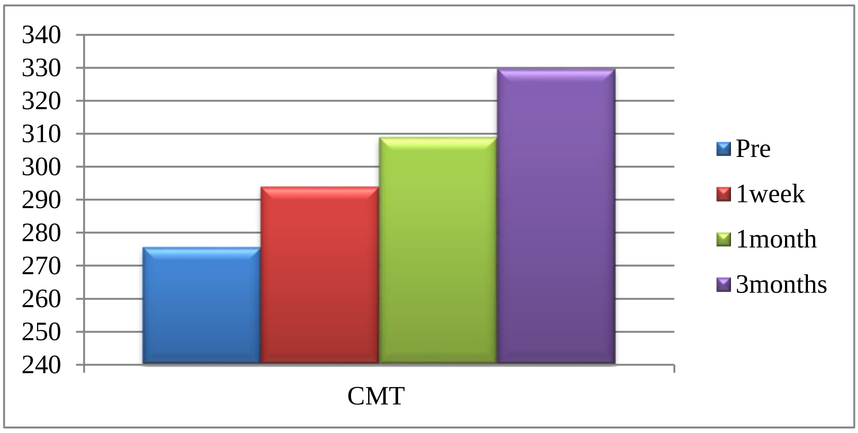

Table (6): Correlation between BCVA with SCP% and CMT (n = 50)

	BCVA							
	Pre		1week		1month		3months	
	r_s	p	r_s	P	r_s	p	r_s	p
SCP%	0.047	0.747	-0.092	0.523	-0.114	0.431	-0.047	0.745
CMT µm	-0.570^{*}	$<0.001^{*}$	-0.411^{*}	0.003^{*}	-0.414^{*}	0.003^{*}	-0.457^{*}	0.001^{*}

r_s: Spearman coefficient *: Statistically significant at $p \leq 0.05$

This table shows There was no correlation between the degree of change in MT and SCP% between baseline and 3 months after surgery and visual acuity.

Table above displayed all OCTA microvasculature parameters collected before and after phacoemulsification cataract surgery at days 1, 7, and 90. Figure (1) also depicted the MT and SCP% shifts that occurred during this time. Changes in mean MT were statistically significant ($P < 0.05$) from the pre-op value of 275.48 ± 14.93 µm to those at 1 week (293.90 ± 21.14 µm), 1 month (308 ± 22.19µm), and 3 months (329 ± 24.56 µm). The SCP % improved considerably with time, from 40.28 ± 1.09 at baseline to 42.34 ± 1.44 at 1 month post-operative to 43.59 ± 1.72 at 3 months post-operative ($P < 0.05$ for each time point). The degree of change in MT and SCP% between baseline and three months after surgery was not related to the length of DM, SBP, HbA1c, or DBP.

CASE

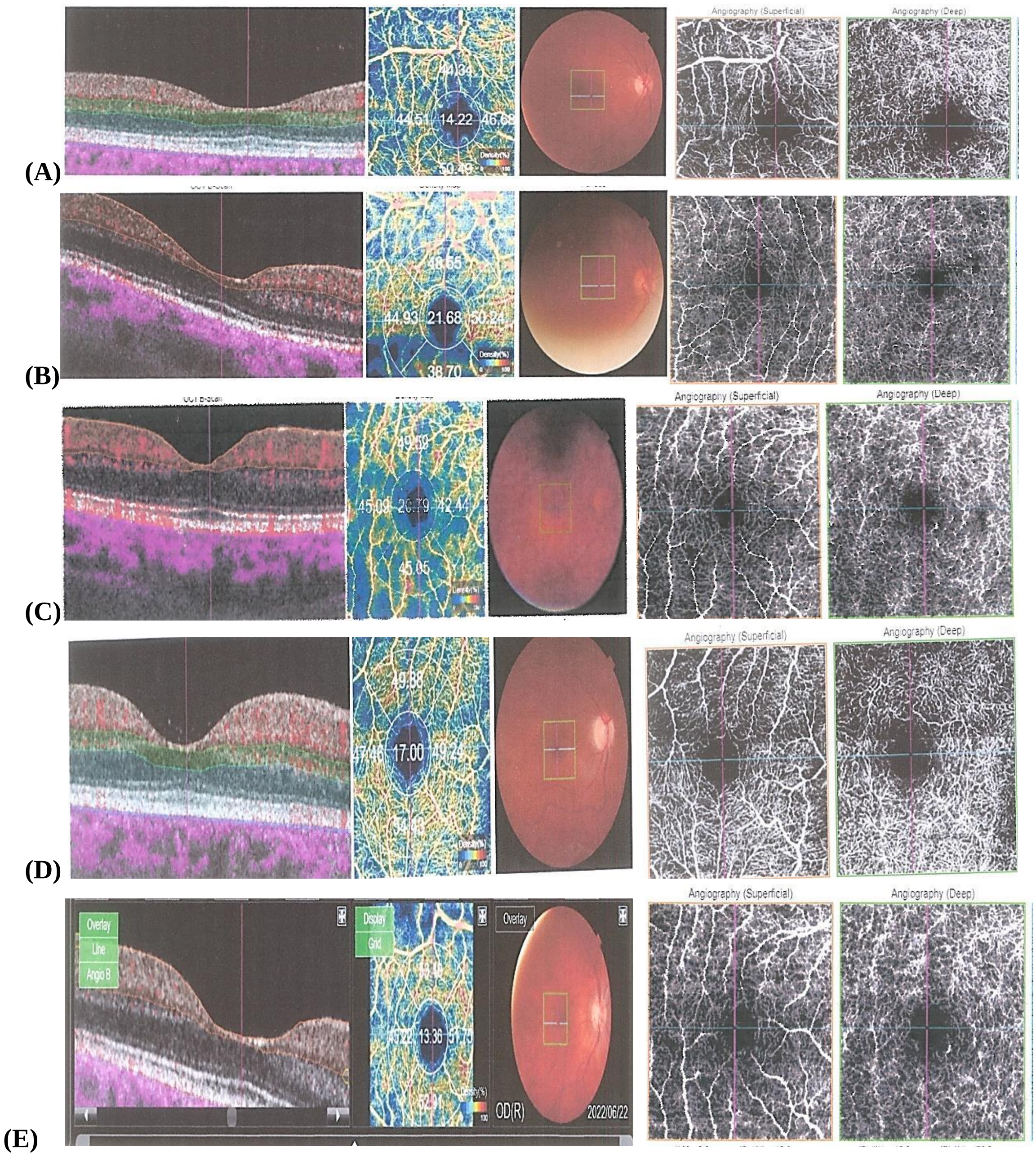

Figure (7): showing case 1 SCP, DCP, MT and VD color images in the diabetic patients at pre-operative1 week, 1 month, 3 months, and 6 months after cataract surgery.

DISCUSSION

Cataract surgery has not been linked to worsening of diabetic retinopathy, as suggested by other research, and it seems that DR and DME develop as a natural progression of the disease in patients who have cataract surgery [(6).] However, several studies have shown that retinal thickness rises following cataract surgery, therefore the subject remains unsolved [(7).] This research employed OCTA to quantitatively examine post-phacoemulsification MT and SCP differences among diabetes individuals. Changes in the microvascular structure of the retina were effectively demonstrated using OCTA in diabetic patients who had cataract surgery. During the first and third postoperative months, patients' vital signs return to pre-op values at a slower rate. MT was considerably greater. Consequently, MT increased throughout our brief monitoring and then levelled off three months following surgery. It's possible that the operation didn't cause the DME risk to rise. **Kilic and Kurt** [(8)] reported elevations in MT at 1 week, 1 month, and 3 months, as well as a relative reduction at month 6, although levels were remained lower than they had been before to surgery. Several authors, including **Zhao *et al.*** [(9)] have recently proposed a novel explanation for this phenomenon that the reported substantial increase in the fovea, parafovea, and perifovea at 1 and 3 months post-op, with the inner layer showed the largest change.

Using microvascular density as a proxy, our study found that three months after surgery, the SCP had dramatically risen in comparison with pre-op values. **Yu *et al.*** [10] discovered an increase in perfusion as well as an increase in vessel density in both the SCP and the DCP after cataract surgery in images measuring 3 by 3 millimeters. Furthermore, the researchers hypothesised that inflammation could influence density parameter assessments. Not only did the majority of our diabetic patients have a history of or moderate retinopathy, but the extent of the damage to their deep blood vessels was also relatively minor.

OCT measurements of MT were taken preoperatively, 1, 6, 15, 30, 60, 90, and 360 days after surgery by **Giansanti *et al.*** [11] who found that in diabetic patients, it was not until day 360 following surgery that MT was measured in healthy participants, but it began to grow rapidly on day 30 and reached its maximum thickness by day 60. After phacoemulsification, cystoid macular edema formed in both diabetic and non-diabetic individuals who did not have retinopathy, according to the findings of **Haleem and colleagues** [12], SCP and DCP in diabetic individuals who had surgery have not been mentioned in the literature. We also planned to look into post-operative MT and SCP causes.

It was shown that preoperative parameters such diabetes duration, HbA1c, blood pressure (BP), and diastolic blood pressure (DBP) did not significantly affect postoperative MT and SCP changes from baseline. We were unable to establish correlations between SBP, TC and DBP data and OCTA changes of patients because of the large variation in patients and the limited sample size. The complexity of cataract surgery was not a primary focus of our study, and there was not large variation in bottle height across the groups to guarantee an unmoving anterior chamber. Therefore, there was little effect of CDE and bottle height on alterations in the retinal microvasculature. Patients with extreme opacity due to cataracts were excluded since the scan and data quality for OCTAs would have suffered. Therefore, additional study is required to address these gaps and investigate the variables that influence macula thickness.

CONCLUSION

While we discovered that diabetes patients' macular thickness rose 1 month and 3 months after cataract surgery, OCTA found that diabetic patients' SCP increased 3 months after cataract surgery, which may have a prognostic influence on the course of postoperative DR.

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