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Choroidal thickness changes following cataract surgery in patients with type 2 diabetes mellitus

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Muhammad Abdullah
Haji Murad Trust Eye Hospital Gujranwala

ABSTRACT

Introduction: Diabetes mellitus (DM) is one of the most frequent metabolic disorders worldwide and its prevalence has been increasing in adults in the last decades secondary to changes in lifestyle. Diabetic retinopathy (DR) is a micro vascular complication while clinical and experimental data suggests that choroidal vascular abnormalities may play an important role in the pathogenesis of DR.

Objective: To determine the mean choroidal thickness changes after cataract surgery in diabetic patients.

Methods: Study Design: It was Quasi Experimental Study.

Study Setting: The study was conducted in Layton Rahmatullah Benevolent Trust Hospital, Lahore.

Study Duration: Minimum six months after the approval of the synopsis [June 15, 2019 till Feb 15, 2020]

Total 166 patients presenting in Layton Rehmatullah Benevolent Trust Hospital Lahore, were enrolled into this study. Written informed consent and detailed history was taken from every patient. Choroidal thickness was measured using the caliper found on the spectralis software from the hyper-reflective band corresponding to Bruch's membrane beneath the retinal pigment epithelium (RPE) to the chorio-scleral junction. The main outcome in this study was choroidal thickness changes after cataract surgery as per operational definition.

Results: The mean age of patients was 50.24 ± 6.33 years with minimum and maximum age as 40 and 60 years. There were 93(56%) male and 73(44%) female cases with higher male to female ratio. The mean choroidal thickness (µm) thickness before surgery was 249.61 ± 17.09 µm and after 1 month of procedure was 257.16 ± 14.21 µm, with significant mean change after surgery (7.55 ± 3.24 µm), p-value < 0.001.

Conclusion: It is concluded that mean choroidal thickness increased after cataract surgery in diabetic patients. Hence appropriate measures may be taken while cataract surgery in diabetic cases so that further complications can be minimized.

Keywords: diabetic patients, cataract surgery, diabetic patients, complications, diabetic retinopathy.

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INTRODUCTION

Diabetes mellitus (DM) is one of the most frequent metabolic disorders worldwide and its prevalence has been increasing in adults in the last decades secondary to changes in lifestyle.[1] Diabetic retinopathy (DR) is a micro vascular complication of DM that may account for 4.8% of all cases of blindness in the world.[2] The principle pathogenesis of DR is the breakdown of the blood-retinal barrier (BRB), retinal vascular integrity impairment and hemodynamic abnormalities. Clinical and experimental data suggests that choroidal vascular abnormalities may play an important role in the pathogenesis of DR.[3]

In the previous studies, different choroidal changes including choriocapillaris obstruction, vascular degeneration, choroidal neovascularization, and choroidal aneurysms have been reported in patients with DR.[4] The choroid is highly vascularized tissue that supplies blood to the outer retina, including the retinal pigment epithelium (RPE) cells and photoreceptors, especially in the foveal region where there is no retinal vasculature.[5]

The choroid plays a crucial part in the physiopathology of many retinal diseases, including diabetic retinopathy (DR). Damage of the choriocapillaris may induce severe harm to the function of the retinal tissue, especially in the macula fovea. Previous histopathologic studies showed vascular abnormalities in the choroid, including obstruction of the choriocapillaris, vascular degeneration, choroidal aneurysms, and choroidal neovascularization in patients with diabetes.[6, 7]

Doppler flowmetry revealed that choroidal blood flow may fall off at early stages of DR.[8] However, little is known about the changes in the structure of the choroid and their possible effects on retinal tissue *in vivo* because of limitations to effective examinations. One of the most important causes of visual impairment in patients with DM is the accelerated development of cataract.[9] This progression may be due to increased release of proinflammatory mediators such as vascular endothelial growth factors (VEGFs), interleukin 1 (IL-1), and hepatocyte growth factor (HGF) into the aqueous humor.[10]

In a study, mean choroidal thickness at baseline was 251.1±35.4µm, while mean choroidal thickness after 1-month was 246.1±27.5µm.[11] In another study, mean choroidal thickness at baseline was 291.2±31.6µm, while mean choroidal thickness after 1-month was 296.5±41.7µm mean change 5.3±10.1.[12]

To the best of candidate's knowledge, there is no local published study on this topic. Owing to lack of local research and the conflict among existing international literature, the purpose of the current study is to repeat

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this study to determine the choroidal thickness changes after cataract surgery in diabetic patients. The results of this study will help in better management of such patients in future practice.

MATERIALS AND METHODS

Study Setting: The study was conducted in Layton Rahmatullah Benevolent Trust Hospital, Lahore.

Study Duration: Minimum six months after the approval of the synopsis.

Study Design: It was Quasi Experimental Study.

Sampling Technique: Non-Probability Consecutive Sampling.

Sample size: The sample size of 166 is estimated by using 95% confidence level and 1% margin of error with an expected mean change choroidal

thickness after 1 month as 5.3±10.1µm in diabetics patients.[12]

SAMPLE SELECTION

Inclusion Criteria:

- Patients of both genders.
- Aged between 40-60 years.
- Having cataract (as per operational definition).
- Having mild-moderate NPDR (as per operational definition).

Exclusion Criteria:

- Patients with history of previous ocular surgery or trauma.
- History of glaucoma, uveitis or other ocular disorders.
- History of any systemic disease other than DM.
- History of postoperative cystoid macular edema (CME).

DATA COLLECTION PROCEDURE:

Total 166 patients presenting in Layton Rahmatullah Benevolent Trust Hospital Lahore, were enrolled into this study. Written informed consent and detailed history was taken from every patient. Complete ophthalmic examination included best corrected visual acuity (BCVA) measurement, slit-lamp examination, intraocular pressure measurement, and fundoscopy was performed. Choroidal thickness was measured using the caliper found on the Spectralis software from the hyper-reflective band corresponding to Bruch's membrane beneath the retinal pigment epithelium (RPE) to the chorio-scleral junction. For each

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case, choroidal thickness was measured at subfoveal area. Cataract surgery in all cases was performed by a single senior surgeon. Acrylic intraocular lens was implanted in the capsular bag in all cases. Topical antibiotic with steroid eye drops were administered for 1 month in all cases that underwent phacoemulsification surgery. The main outcome in this study was choroidal thickness changes after cataract surgery as per operational definition. All the data was collected through a pre-designed proforma (attached).

DATA ANALYSIS PROCEDURE:

All the data was entered and processed by using SPSS v22.0. The age and choroidal thickness was described by using Mean±S.D. Gender was described by using frequencies and percentages. Data was stratified for age and gender Duration of cataract to deal with effect modifiers. Poststratification, Paired t-test test was used. A p-value ≤0.05 was considered significant.

RESULTS

- The mean age of patients was 50.24 ± 6.33 years with minimum and maximum age as 40 and 60 years. **Table -1**
- There were 76(45.8%) cases who were 40-49 years old and 90(54.2%) cases were 50-60 years old. **Fig-1**
- There were 93(56%) male and 73(44%) female cases with higher male to female ratio. **Fig-2**
- A total of 87(52.4%) cases had duration of disease since < 1 year while 79(47.6%) of the cases had disease since ≥ 1 years. **Fig-3**
- The mean choroidal thickness (µm) thickness before surgery was 249.61 ± 17.09 µm and after 1 month of procedure was 257.16 ± 14.21 µm, with significant mean change after surgery (7.55 ± 3.24 µm), p-value < 0.001. **Table -2**

Stratification

- When data was stratified for age, among 40-49 years old cases, the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (257.86 ± 13.56 µm) when compared with baseline (250.51±16.21 µm), p-value < 0.001. Among 50-60 years old cases, the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (256.58 ± 14.79 µm) when compared with baseline (248.86 ± 17.85 µm), p-value < 0.001. **Table -3**

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- In male cases the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (259.46 ± 14.16 µm) when compared with baseline (252.52 ± 17.03 µm), p-value < 0.001. Among female cases, the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (254.23 ± 13.82 µm) when compared with baseline (245.92 ± 16.55 µm), p-value < 0.001. **Table -4**
- Among those who had duration of disease as < 1 year the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (257.80 ± 14.35 µm) when compared with baseline (250.20 ± 17.22 µm), p-value < 0.001. Among those who had duration of disease since ≥ 1 year, the mean choroidal thickness (µm) thickness was statistically increased after 1 month of surgery (256.46 ± 14.12 µm) when compared with baseline (248.97 ± 17.033 µm), p-value < 0.001. **Table -5**

Table-1: Descriptive statistics of age (years)

Age (years)	
Mean	50.24
S.D	6.33
Range	20.00
Minimum	40.00
Maximum	60.00

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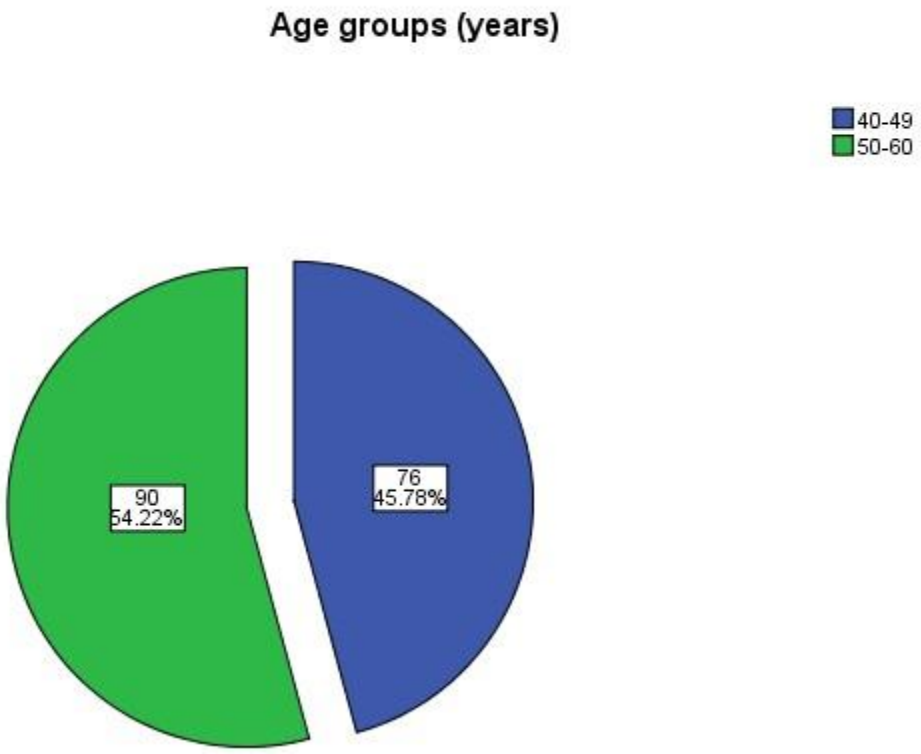

Fig-1: Frequency distribution of age groups (years)

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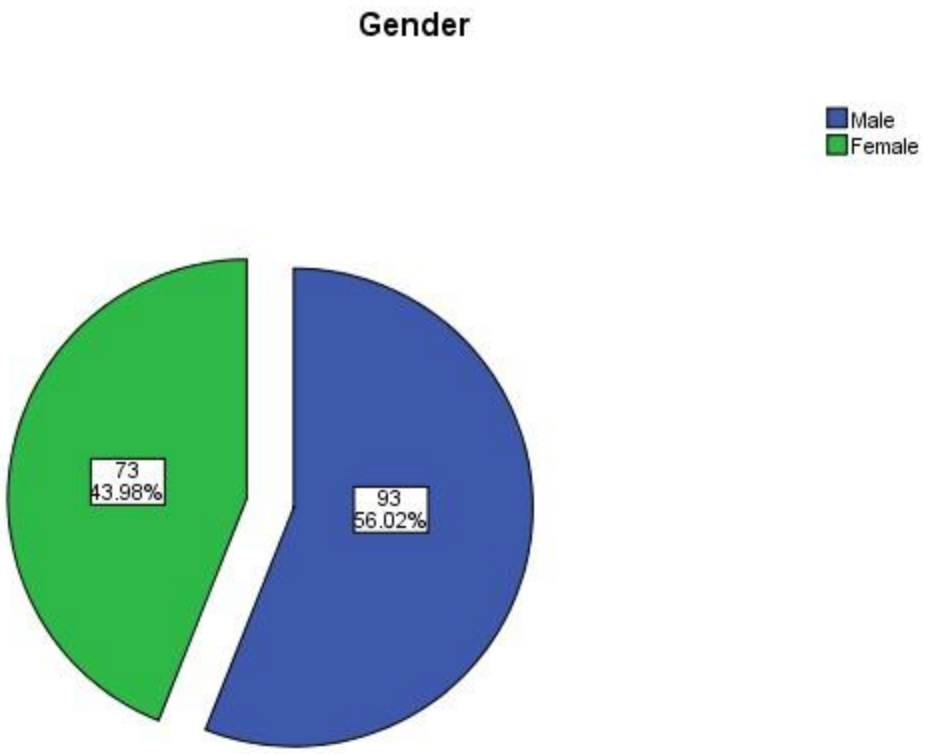

Fig-2: Frequency distribution of gender

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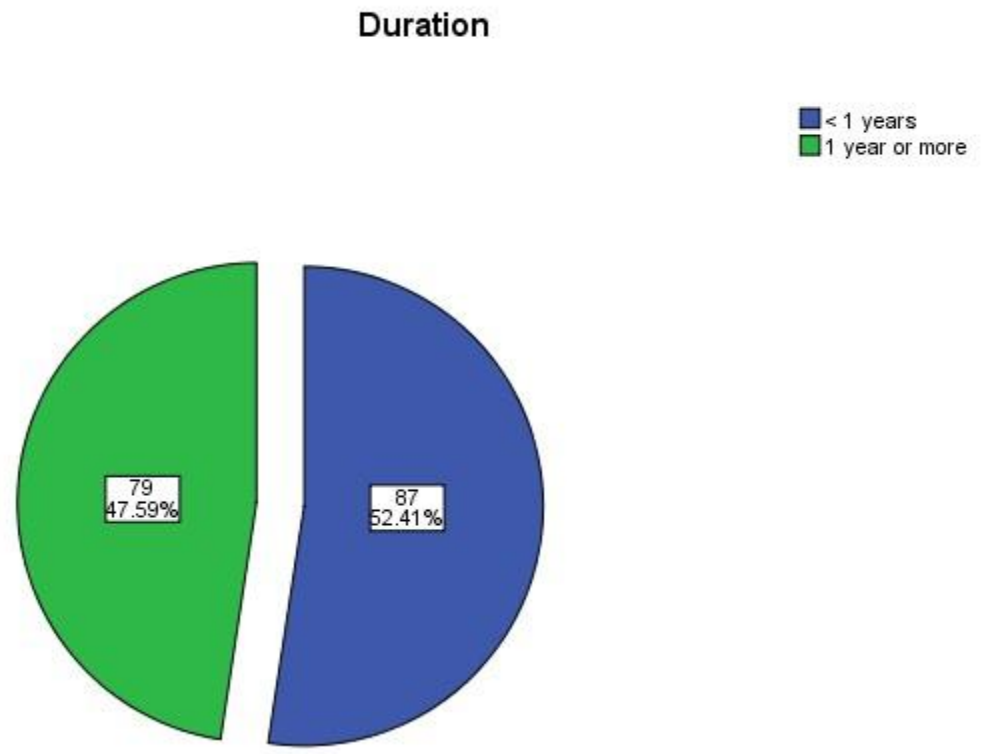

Fig-3: Frequency distribution of duration

Table-2: Mean Comparison of Choroidal thickness (um) (baseline, 1 month) and its change

	Choroidal thickness (um)		
	Baseline	**At 1 month**	**Change after 1 month**
Mean	249.61	257.16	7.55
S.D	17.09	14.21	3.24

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Range	60.00	50.00	13.00
Minimum	220.00	230.00	.00
Maximum	280.00	280.00	13.00

t-test = -29.990 p-value <0.001(Highly Significant) **Table-3: Mean Comparison of Choroidal thickness (um) (baseline, 1 month) in different age groups (years)**

Age groups	**Choroidal thickness (um)**	**Mean**	**S.D**	**p-value**
40-49 **(years)**	Baseline	250.51	16.21	<0.001**
	At 1 month	257.86	13.56	
50-60 **(years)**	Baseline	248.86	17.86	<0.001**
	At 1 month	256.58	14.79	

** Highly Significant

Table-4: Mean Comparison of Choroidal thickness (um) (baseline, 1 month) in both gender

Gender	**Choroidal thickness (um)**	**Mean**	**S.D**	**p-value**
Male	Baseline	252.52	17.03	<0.001**
	At 1 month	259.46	14.16	

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Female	Baseline	245.92	16.56	<0.001**
	At 1 month	254.23	13.82	

** Highly Significant

Table-5: Mean Comparison of Choroidal thickness (um) (baseline, 1 month) with respect to duration of disease

Duration	**Choroidal thickness (um)**	**Mean**	**S.D**	**p-value**
< 1 year	Baseline	250.20	17.22	<0.001**
	At 1 month	257.80	14.35	
≥1 year	Baseline	248.97	17.03	<0.001**
	At 1 month	256.46	14.12	

** Highly Significant

DISCUSSION

The choroid is a vessel-rich structure located between the lamina fusca of the sclera and the retinal pigment epithelium. It supplies blood to the outer retinal layers. Choroidal thickness (CT) is thought to indicate the amount of choroidal vascularization and varies by age, sex, axial length (AXL), refractive status, and circadian rhythm. The choroid is reported to play a

role in many vision-threatening diseases such as choroidal neovascularization, polypoidal choroidal vasculopathy, central serous chorioretinopathy, and chorioretinal atrophy associated with high myopia.3–

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6 Thus, choroidal structural alterations are increasingly evaluated in scientific studies to understand the pathophysiology of these critical diseases [73].

Phacoemulsification surgery is the most frequently performed eye surgery, especially at advanced ages, and is generally associated with good visual outcomes. However, cataract surgery is known to have adverse effects on the retina, such as progression in diabetic retinopathy and pseudophakic cystoid macular edema, and the pathogenesis of such conditions is not yet clarified. Also, epidemiological studies show that cataract surgery is associated with the onset of age-related macular degeneration (AMD), although the association is still controversial [96].

The development of AMD may be induced after cataract surgery due to reasons such as inflammatory reactions associated with cataract surgery, increased free radicals after surgery, the release of growth factors and prostaglandins, and increased light exposure during surgery. AMD is a serious disease, threatening vision due to neo-vascularization arising from the choroid. The changes in the choroid after cataract surgery may induce the development of AMD [97].

An increment in the retinal thickness was reported after cataract surgery even in healthy eyes with no detected morphological impairment using spectral domain optical coherence tomography (SD-OCT). Given the close link between the retina and choroid, affected change in CT might also be expected after cataract surgery. Evaluation of choroid has been restricted to ultrasonography and angiography previously, while the choroid can be examined in detail with SD-OCT [98].

SD-OCT provides detailed histological sectional images of the retina in vivo and provides useful information for the diagnosis, evaluation of the treatment options, and follow-up of several retinal diseases [99]. With the assistance of Enhanced Depth Imaging or Swept Source OCT, several researchers have evaluated the choroidal thickness (CT) after cataract surgery; however, the results are conflicting. In the eyes of patients with diabetes, in addition to changes in retinal circulation, various choroidal abnormalities were noted in histopathological studies [100].

The findings included abnormalities such as arteriosclerosis, obstruction of the choriocapillaris, vascular degeneration, focal scarring, increased tortuosity of vessels, focal vascular dilatation and narrowing, neovascularization, aneurysm, and deficits in the choroidal vasculature. Recently, several studies have investigated CT in patients with diabetes. Most groups reported reduced CT in patients with diabetic retinopathy, and several groups reported that the choroid was thinner in eyes with diabetic macular edema

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(DME) [101]. Although some groups have reported CT after cataract surgery in patients with diabetes, the results have been
inconsistent [88].

In current study the mean age of patients was 50.24 ± 6.33 years with minimum and maximum age as 40 and 60 years. There were 93(56%) male and 73(44%) female cases with higher male to female ratio. The mean choroidal thickness (µm) thickness before surgery was 249.61 ± 17.09 µm and after 1 month of procedure was 257.16 ± 14.21 µm, with significant mean change after surgery (7.55 ± 3.24 µm), p-value < 0.001. In a study, mean choroidal thickness at baseline was 251.1±35.4µm, while mean choroidal thickness after 1-month was 246.1±27.5µm.[11] These findings are different as found in current study. In another study, mean choroidal thickness at baseline was 291.2±31.6µm, while mean choroidal thickness after 1-month was 296.5±41.7µm mean change 5.3±10.1.[12] We also found increases in choroidal thickness after surgery. Recently a study was performed to evaluate the influence of uneventful small-incision phacoemulsification cataract surgery on the subfoveal choroidal thickness (SCT), the central macular thickness (CMT), and aqueous flare in patients with diabetes. They reported that postoperative
CMT continued to increase significantly until 3 months in both groups. Although the CMT was more in patients with diabetes than in patients without diabetes during the follow-up period, there was no significant difference between the two groups. The aqueous flare value increased until 3 months after surgery in both groups. Although the increase was significant at 3 months after surgery in patients with diabetes, the increase in controls was not significant. The aqueous flare values differed significantly between the two groups before and at 3 months after surgery. There was no significant within-group or between-group difference in pre- and postoperative SCT values. Thus, in diabetic eyes with early stage of retinopathy, even small-incision cataract surgery can induce increased aqueous flare and macular thickening until 3 months, although there is no significant change in the choroidal thickness. Further studies are essential to evaluate choroidal changes after the cataract surgery in diabetic eyes [102].

Similarly another study was done to evaluate the choroidal thickness changes after cataract surgery in type 2 diabetic patients. Three groups of patients were enrolled into this prospective study. Group A included diabetic patients without diabetic retinopathy (DR) or with mild non-proliferative diabetic retinopathy (NPDR) who underwent phacoemulsification, Group B included non-diabetic patients with significant cataract who underwent phacoemulsification, and Group C included diabetic patients without DR or with mild NPDR who followed up without surgical procedure. Choroidal thickness in 5 points (subfoveal and

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500 μ temporal, nasal, superior and inferior to the fovea) and central macular thickness were measured before surgery using enhanced depth spectral domain optical coherence tomography. Patients were re-evaluated 1 week, 1 month, and 3 months after operation and compared with the baseline values. The main findings revealed that in total, 63 eyes from 63 patients were enrolled to this study, including 21 eyes in Group A, 22 eyes in Group B, and 20 eyes in Group C. After three months of follow-up of the patients, choroidal thickness in all measured points was decreased significantly, and central macular thickness was increased significantly following cataract surgery in diabetic eyes (group A); meanwhile, both choroidal thickness and central macular thickness were increased significantly in non-diabetic eyes (Group B). In Group C, choroidal thickness and central macular thickness had no significant changes, after three months. Thus, it can be concluded that Unlike in non-diabetic eyes, choroidal thickness in diabetic patients decreased following cataract surgery [87].

Likewise another prospective case–control study was conducted to assess the structural changes in the choroid of diabetic patients following cataract surgery, using choroidal vascularity index and choroidal thickness. The study was conducted in 18 diabetic and 18 non-diabetic patients undergoing cataract surgery (phacoemulsification) in one eye. Enhanced depth imaging optical coherence tomography images were obtained before and after surgery. Niblack's image binarization of images was performed to derive the choroidal vascularity index. The result demonstrated that baseline choroidal vascularity index was significantly lower in diabetic patients for both operated (mean difference vs non-diabetic: 0.0184, 95% CI: 0.004–0.0324, p = 0.012) and non-operated (mean difference vs non-diabetic: 0.0145, 95% CI: 0.003–0.0256, p = 0.012) eyes. Choroidal thickness increased following cataract surgery (diabetes: mean difference = 12.4, 95% CI: 0.70–24.0, adjusted p = 0.036; non-diabetic: mean difference = 21.0, 95% CI: 4.39–

37.6, adjusted p = 0.011). Hence, Diabetic patients have reduced choroidal vascularity index than non-diabetic patients, suggestive of possible reduction in choroidal vascularity in diabetes. Choroidal thickness increased following cataract surgery in both diabetic and non-diabetic patients [103].

In 2018, another study was done to investigate the effect of cataract surgery on subfoveal choroid thickness (SFCT) using enhanced-depth imaging optical coherence tomography (EDI-OCT). A total of 13 studies with 802 eyes from 646 patients were identified for inclusion. +ere was a significant increase of SFCT at 1 week (MD = 6.62, 95% CI: 1.20–12.05, P = 0.02, I2= 0%), 1 month (MD= 8.30, 95% CI: 3.20–13.39, P = 0.001, I2 = 0%), and 3 months (MD = 8.28, 95% CI: 1.84–14.73, P = 0.01, I2 = 0%) after cataract surgery.

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In subgroup analysis, SFCT in Asians and patients without nonsteroidal anti-inflammatory drugs (NSAIDs) in postoperative medication was significantly thicker ($P < 0.05$). No statistically significant increase of SFCT was found in diabetic mellitus (DM) patients for 1 day ($P= 0.89$), 1 week ($P= 0.59$), 1 month ($P=0.52$), and 3 months ($P =0.42$) after cataract surgery. So, the meta-analysis suggested that SFCT increased since 1 week after the cataract surgery and the increase lasted for at least 3 months. Asians and patients without NSAIDs in postoperative medication were more likely to have a thicker SFCT after cataract surgery, whereas DM patients were less likely to increase in SFCT [104].

Similarly, a prospective study was done to analyze the effects of uneventful phacoemulsification surgery on choroidal thickness (CT) using spectral domain optical coherence tomography (SD-OCT). In this study, 38 eyes of 38 patients having phacoemulsification surgery were included. The CT was measured perpendicularly at the fovea and 1.5 mm temporal, 3.0 mm temporal, 1.5 mm nasal, and 3.0 mm nasal using SD-OCT preoperatively and 1 month postoperatively. Changes in the CT after surgery and correlation of this change with age, AXL, preoperative IOP, and IOP change were evaluated. The result has showed that there was a statistically significant increase in the CT at all regions evaluated. This increment was more prominent in the nasal and subfoveal regions. The IOP decreased significantly 1 month after surgery (16.14±4.94 mmHg vs 13.91±4.86 mmHg; $P<0.001$). The change in IOP was correlated with the CT changes at all regions, whereas age, AXL, and preoperative IOP had no significant correlations with the changes in CT. So, the study concluded that Phacoemulsification surgery may cause significant increase in CT, which is correlated with surgery-induced IOP change in the short term. Long-term follow-up of eyes having phacoemulsification surgery may provide further insight into the effects of cataract surgery on the choroid [84].

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CONCLUSION

It is concluded that mean choroidal thickness increased after cataract surgery in diabetic patients. Hence appropriate measures may be taken while cataract surgery in diabetic cases so that further complications can be minimized.

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