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Choroidal Thickness Changes Following Cataract Surgery in Diabetic Retinopathy Patients Without Macular Edema: An Interventional Study

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ABSTRACT

Background: Diabetic retinopathy (DR) is a major cause of visual impairment globally, with alterations in choroidal thickness (CT) playing a significant role in its pathophysiology. The impact of cataract surgery on CT in diabetic patients without macular edema is not well understood. This study is aimed to investigate CT changes following cataract surgery in DR patients without macular edema compared to non-diabetic controls.

Methods: In this prospective interventional study, 108 patients aged 50–80 years undergoing phacoemulsification cataract surgery were included—54 with DR without macular edema (case group) and 54 non-diabetic individuals (control group). Comprehensive ophthalmic evaluations, including best-corrected visual acuity and intraocular pressure, were performed preoperatively and at 3 months postoperatively. Choroidal thickness was measured using spectral-domain optical coherence tomography. Statistical analyses involved paired t-tests within groups and independent t-tests between groups, with significance set at $p < 0.05$.

Results: The case group showed a significant decrease in mean CT from 252.685 ± 33.882 µm preoperatively to 234.481 ± 32.840 µm postoperatively ($p < 0.001$). In contrast, the control group exhibited a significant increase from 273.704 ± 18.792 µm to 284.519 ± 20.733 µm ($p < 0.001$). The difference in CT changes between groups was statistically significant ($p < 0.001$). Baseline and postoperative CT were significantly thinner in the diabetic group compared to controls ($p < 0.001$).

Conclusion: Cataract surgery leads to a significant decrease in choroidal thickness in DR patients without macular edema, while causing an increase in non-diabetic individuals. These findings suggest that diabetic patients may be more susceptible to choroidal thinning post-surgery, potentially influencing DR progression. Awareness of these effects is crucial for optimizing postoperative management in diabetic patients.

Keywords: Diabetic retinopathy; Choroidal thickness; Cataract surgery; Optical coherence tomography; Diabetic patients without macular edema.

INTRODUCTION

Diabetic retinopathy (DR) is a leading cause of vision impairment and blindness among working-age adults globally. It is a microvascular complication of diabetes mellitus, characterized by progressive retinal alterations resulting from chronic hyperglycemia-induced vascular damage. While much attention has been given to the retinal manifestations of DR, the choroid—a vascular layer supplying the outer retina—has emerged as a significant player in the pathophysiology of diabetic ocular complications [1,2,3].

The choroidal thickness (CT) reflects the health of the choroidal vasculature and has been implicated in various retinal diseases. Advances in imaging technologies, particularly enhanced depth imaging optical coherence tomography (EDI-OCT), have enabled non-invasive, in vivo measurements of CT with high resolution. Studies have reported alterations in CT in diabetic patients, suggesting that choroidal changes may precede or accompany retinal vascular abnormalities [4,5,6].

Cataract formation is another common issue in diabetic patients, occurring at an earlier age and progressing more rapidly compared to non-diabetic individuals. Cataract surgery, while improving visual acuity by replacing the opacified lens, can influence ocular structures and hemodynamics. Postoperative inflammatory responses and changes in intraocular cytokine levels may affect both the retina and the choroid. Understanding these changes is crucial, as they may have implications for postoperative management and the progression of DR [7,8].

Previous research has focused on macular thickness and retinal vascular parameters following cataract surgery in diabetic patients. However, the impact of cataract extraction on CT, particularly in diabetic patients without diabetic macular edema (DME), remains underexplored. Given that DME is a significant cause of vision loss in DR, studying patients without DME provides a clearer understanding of the early choroidal changes without the confounding effects of macular edema.[9] Subfoveal choroidal thickness decreased significantly after cataract surgery in diabetic eyes. It may be secondary to exacerbation of hypoxia in the compromised choroidal vascular network in diabetic eyes secondary to intraocular inflammatory process or elevation of free radical levels in the eyes following cataract surgery. Previous studies showed that DR progressed after cataract surgery in diabetic patients. The choroid is the main source of oxygenation and nutrition of the outer retinal layers and RPE, and choroidal thinning in diabetic eyes may be related to the decrease of the choroidal blood flow and tissue hypoxia in diabetic eyes. Our results suggest that one of the possible mechanisms for progression of DR may be choroidal hypoxia manifested as choroidal thinning.

This interventional study aims to investigate the changes in choroidal thickness after cataract surgery in patients with diabetic retinopathy without macular edema. By comparing these patients to non-diabetic controls undergoing similar surgical procedures, we seek to elucidate the differential impact of cataract surgery on the choroid in diabetic versus non-diabetic eyes. We hypothesize that cataract surgery may lead to significant alterations in CT in diabetic patients, potentially contributing to the progression of DR or the development of postoperative complications [10].

Understanding the postoperative changes in CT could enhance our knowledge of the ocular effects of cataract surgery in diabetic patients. It may also inform clinical practices by identifying patients at risk of adverse outcomes and guiding postoperative monitoring and management strategies. Ultimately, this research could contribute to improving visual prognosis and quality of life for diabetic patients undergoing cataract surgery.

MATERIALS AND METHODS

Study Design and Setting

This prospective interventional study was conducted at the Upgraded Department of Ophthalmology, S.M.S. Medical College and Hospital, Jaipur, Rajasthan, India, from December 2022 to December 2023, following approval from the Institutional Ethics Committee (IEC).

Study Population

The study included male and female patients aged between 50 and 80 years who presented to the Ophthalmology Outpatient Department (OPD) at S.M.S. Medical College and Hospital and met the inclusion and exclusion criteria. All participants provided written informed consent prior to enrollment.

Inclusion Criteria

- **For Diabetic Patients (Case Group):**
    1. Patients diagnosed with diabetic retinopathy without diabetic macular edema, possessing immature senile cataract requiring phacoemulsification surgery.
    2. Intraocular pressure (IOP) between 10–21 mmHg.
    3. Age between 50–80 years.
    4. Provided written informed consent.
- **For Non-Diabetic Patients (Control Group):**
    1. Patients with immature senile cataract requiring phacoemulsification surgery.
    2. Intraocular pressure (IOP) between 10–21 mmHg.
    3. Age between 50–80 years.
    4. Provided written informed consent.

Exclusion Criteria

1. Eyes with diabetic macular edema.
2. Eyes with intraocular pressure greater than 21 mmHg.
3. Eyes with mature, posterior subcapsular, or posterior polar cataract.
4. History of retinal laser therapy or intravitreal injections.
5. History of ocular trauma, uveitis, or prior intraocular surgery.
6. Patients with Optical Coherence Tomography Angiography (OCTA) images with a signal strength less than 2 due to severe cataract or unstable fixation.

Study Procedure
All eligible patients underwent a comprehensive ophthalmic examination, which included:

- **Best-Corrected Visual Acuity (BCVA):** Assessed using a Snellen chart.
- **Slit-Lamp Biomicroscopy:** For anterior segment evaluation.
- **Indirect Ophthalmoscopy:** Using a 20-diopter lens for fundus examination.
- **Intraocular Pressure Measurement:** Using applanation tonometry.

Imaging Assessments

- **Spectral-Domain Optical Coherence Tomography (SD-OCT):** Performed to measure macular thickness and choroidal thickness.
- **Optical Coherence Tomography Angiography (OCTA):** Conducted using the Zeiss Cirrus 5000 AngioPlex system to evaluate retinal vascular parameters, including superficial capillary plexus vessel density (SCP VD), perfusion density (SCP PD), and foveal avascular zone (FAZ) area.

Surgical Procedure
Patients in both groups underwent standard phacoemulsification cataract surgery with intraocular lens implantation performed by an experienced surgeon. Postoperative care included topical antibiotics and steroids as per institutional protocol.

Outcome Measures

- **Primary Outcome:** Change in choroidal thickness at 3 months postoperatively.
- **Secondary Outcomes:** Changes in macular thickness, SCP VD, SCP PD, FAZ area, and BCVA.

Follow-Up
Measurements were recorded preoperatively and at 3 months postoperatively. OCT and OCTA scans were performed at each visit to assess structural and vascular changes.

Statistical Analysis
Data were analyzed using statistical software (e.g., SPSS version 25.0). Continuous variables were expressed as mean ± standard deviation (SD). Paired t-tests were used to compare preoperative and postoperative measurements within groups, while independent t-tests were employed for comparisons between groups. Pearson correlation coefficients assessed relationships between continuous variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations
The study adhered to the tenets of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of S.M.S. Medical College and Hospital, Jaipur. All participants were informed about the nature and purpose of the study, and written informed consent was obtained prior to enrollment.

RESULTS
A total of 108 eyes from 108 patients were included in the study, with 54 eyes in the case group (diabetic retinopathy patients without macular edema) and 54 eyes in the control group (non-diabetic patients). The mean age and sex distribution between the two groups were comparable ($p > 0.05$), ensuring homogeneity in baseline characteristics.

Choroidal Thickness Changes in the Case Group
Table 1 summarizes the choroidal thickness (CT) measurements in the case group before and after cataract surgery. The mean preoperative CT was 252.685 ± 33.882 µm. At 3 months postoperatively, the mean CT significantly decreased to 234.481 ± 32.840 µm. This reduction of 18.204 µm was statistically significant (**$p < 0.001$**), indicating a substantial thinning of the choroid following cataract surgery in diabetic patients without macular edema.

Choroidal Thickness Changes in the Control Group
As shown in Table 2, the control group exhibited an opposite trend. The mean preoperative CT was 273.704 ± 18.792 µm, which significantly increased to 284.519 ± 20.733 µm at 3 months postoperatively. The mean increase of 10.815 µm was statistically significant (**$p < 0.001$**), suggesting that cataract surgery led to choroidal thickening in non-diabetic patients.

Comparison of Changes Between Groups
Table 3 highlights the mean changes in CT between the case and control groups. The case group experienced a significant mean decrease of 18.204 µm, whereas the control group showed a significant mean increase of 10.815 µm. The difference in both the direction and magnitude of CT changes between the two groups was statistically significant (**$p < 0.001$**), emphasizing that cataract surgery impacts choroidal thickness differently in diabetic versus non-diabetic patients.

Baseline Comparison of Choroidal Thickness

Preoperatively, the case group had a significantly thinner choroid compared to the control group (252.685 ± 33.882 µm vs. 273.704 ± 18.792 µm; **p < 0.001**), as detailed in Table 4. This baseline difference suggests that diabetic patients without macular edema inherently have a thinner choroid than non-diabetic individuals.

Postoperative Comparison of Choroidal Thickness

Postoperatively, the choroidal thickness remained significantly lower in the case group compared to the control group (234.481 ± 32.840 µm vs. 284.519 ± 20.733 µm; **p < 0.001**), as shown in Table 5. Despite the surgical intervention, the disparity in CT between diabetic and non-diabetic patients persisted and even widened due to the opposite trends observed in each group.

Table 1 : Comparison of Demographic and Clinical Characteristics Between Case and Control Groups

	Case		Control		P value
	Mean	Std. Dev.	Mean	Std. Dev.	
Age	65.370	6.913	67.537	6.906	0.106
FBS	98.746	6.974	80.130	8.720	p<0.001
PPS	139.222	9.430	120.259	11.146	p<0.001
Hb1AC	6.828	0.624	5.389	0.642	p<0.001
Sex (F/M)	27/27		18/36		0.118

TABLE 2: CHOROIDAL THICKNESS (CT) IN CASE GROUP BEFORE AND AFTER CATARACT SURGERY

Time Point	Mean CD (µm)	SD (µm)	P-value
Preoperative	252.685	33.882	
3 Months Post-op	234.481	32.840	**p < 0.001**

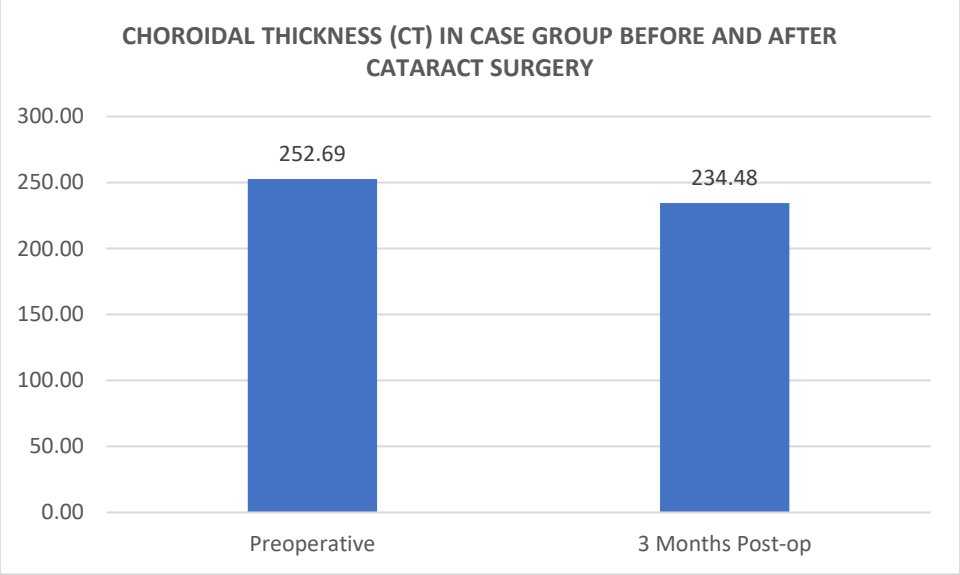


TABLE 3: CHOROIDAL THICKNESS (CT) IN CONTROL GROUP BEFORE AND AFTER CATARACT SURGERY

Time Point	Mean CD (µm)	SD (µm)	P-value
Preoperative	273.704	18.792	
3 Months Post-op	284.519	20.733	**p < 0.001**

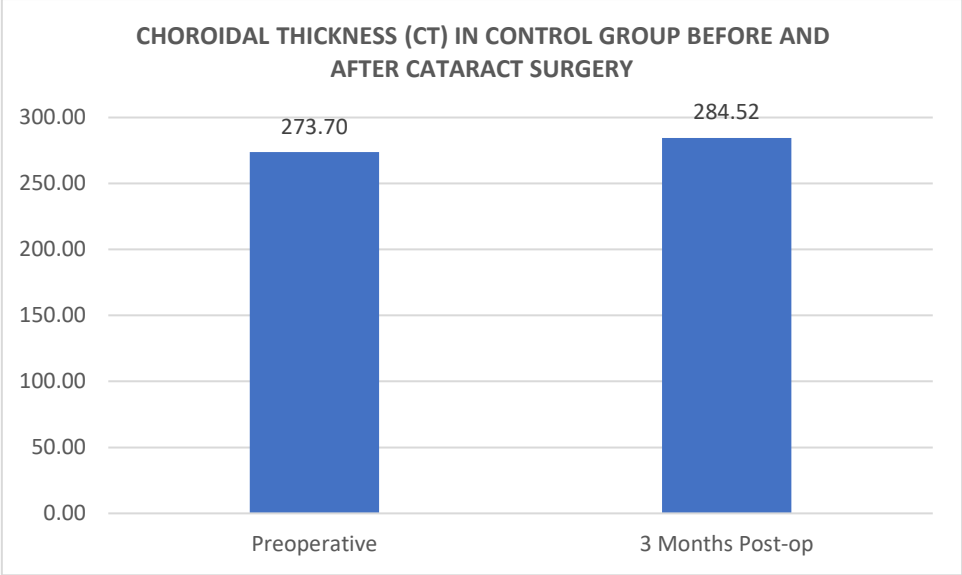


TABLE 4: MEAN CHANGE IN CHOROIDAL THICKNESS (CT) BETWEEN CASE AND CONTROL GROUPS

Group	Mean Change in CD (µm)	SD (µm)	Direction of Change	P-value
Case Group	**-18.204**	N/A	Decrease	
Control Group	**+10.815**	N/A	Increase	**p < 0.001**

TABLE 5: COMPARISON OF PREOPERATIVE CHOROIDAL THICKNESS (CT) BETWEEN CASE AND CONTROL GROUPS

Group	Mean CD (µm)	SD (µm)	P-value
Case Group	252.685	33.882	
Control Group	273.704	18.792	**p < 0.001**

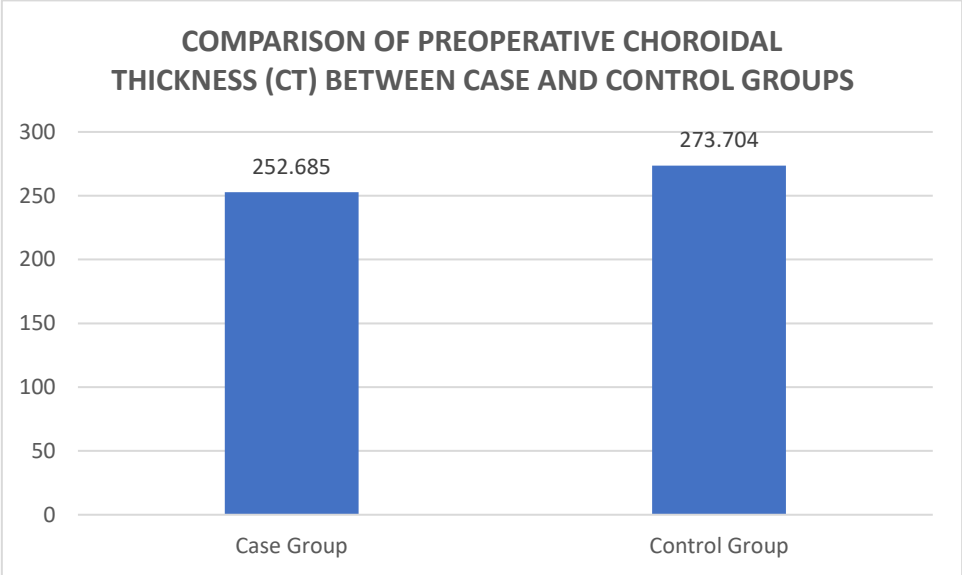
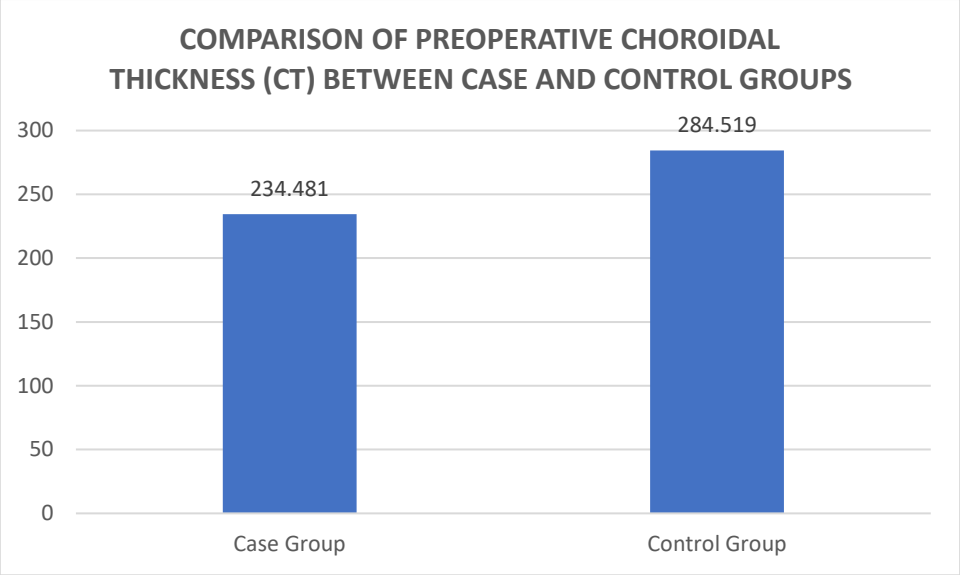


TABLE 6: COMPARISON OF POSTOPERATIVE CHOROIDAL THICKNESS (CT) BETWEEN CASE AND CONTROL GROUPS

Group	Mean CD (µm)	SD (µm)	P-value
Case Group	234.481	32.840	
Control Group	284.519	20.733	**p < 0.001**



DISCUSSION

This study explored the impact of cataract surgery on choroidal thickness in diabetic retinopathy patients without macular edema compared to non-diabetic controls. The findings revealed a significant postoperative decrease in choroidal thickness in the diabetic group and a significant increase in the control group. These opposing trends highlight the differential vascular responses to cataract surgery between diabetic and non-diabetic eyes.

The observed choroidal thinning in diabetic patients post-surgery aligns with the understanding that diabetes induces microvascular changes due to chronic hyperglycemia, oxidative stress, and inflammation [1,5]. The choroid's rich vascular network makes it particularly vulnerable to such changes. Cataract surgery may exacerbate these alterations by inducing inflammatory responses that further compromise choroidal vasculature in diabetic patients [7].

Subfoveal choroidal thickness decreased significantly after cataract surgery in diabetic eyes. It may be secondary to exacerbation of hypoxia in the compromised choroidal vascular network in diabetic eyes secondary to intraocular inflammatory process or elevation of free radical levels in the eyes following cataract surgery. Previous studies showed that DR progressed after cataract surgery in diabetic patients.

The choroid is the main source of oxygenation and nutrition of the outer retinal layers and RPE, and choroidal thinning in diabetic eyes may be related to the decrease of the choroidal blood flow and tissue hypoxia in diabetic eyes. Our results suggest that one of the possible mechanisms for progression of DR may be choroidal hypoxia manifested as choroidal thinning.

Conversely, the increase in choroidal thickness in non-diabetic patients may result from normal postoperative inflammatory responses leading to vasodilation and increased vascular permeability [7]. This suggests that, in the absence of diabetes-related microvascular damage, the choroid can respond adaptively to surgical stress, potentially aiding in recovery.

Baseline choroidal thickness was significantly lower in diabetic patients, consistent with previous studies indicating early choroidal involvement in DR pathogenesis [6]. This supports the notion that choroidal alterations may precede retinal changes and could serve as an early biomarker for DR progression [11].

The prevalence of diabetic retinopathy and its complications, such as macular edema, varies globally but remains a significant concern [11-13]. Ding and Wong [11] reported that DR is a leading cause of blindness, with its epidemiology influenced by factors like disease duration and glycemic control. The Wisconsin Epidemiologic Study of Diabetic Retinopathy highlighted the importance of early detection and management to prevent vision loss [12,13].

Clinically, these findings emphasize the importance of monitoring choroidal thickness in diabetic patients undergoing cataract surgery. The significant postoperative thinning could contribute to DR progression or increase susceptibility to macular edema. Incorporating regular OCT assessments may help detect early changes, allowing for timely interventions. Limitations of this study include the relatively short follow-up period of three months. Long-term studies are necessary to determine whether the observed changes in choroidal thickness persist and how they correlate with DR progression. Additionally, factors such as glycemic control, duration of diabetes, and systemic hypertension were not accounted for, which could influence choroidal thickness and vascular responses [14,15].

Future research should investigate the mechanisms underlying choroidal thinning post-cataract surgery in diabetic patients. Exploring the roles of inflammatory cytokines, endothelial dysfunction, and vascular endothelial growth factor (VEGF) levels could provide valuable insights. Interventional studies assessing the efficacy of anti-inflammatory or anti-VEGF therapies in mitigating postoperative choroidal thinning may also be beneficial.

In summary, this study highlights that cataract surgery affects choroidal thickness differently in diabetic patients without macular edema compared to non-diabetic individuals. The significant choroidal thinning observed in diabetic patients underscores the need for vigilant postoperative monitoring and may have implications for the management of DR following cataract surgery.

CONCLUSION

This study demonstrates that cataract surgery induces significant choroidal thinning in diabetic retinopathy patients without macular edema, while non-diabetic patients experience choroidal thickening postoperatively. These differential effects suggest increased susceptibility of the diabetic choroid to surgical stress. Recognizing these changes is crucial for clinicians to optimize postoperative care, potentially improving visual outcomes and slowing DR progression in diabetic patients undergoing cataract surgery.

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