

# A Correlation of Glycemic Index and Macular Thickness After Phacoemulsification in Diabetics

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**Purpose:** To study the relationship between HbA1c and macular thickness using Optical coherence tomography (OCT).

**Methods:** Prospective cohort study where 50 eyes of type 2 Diabetes mellitus patients with mild to moderate Non-Proliferative Diabetic Retinopathy (NPDR) were included. They underwent uncomplicated phacoemulsification surgery and were divided into 3 groups based on HbA1c levels – Group 1: <6.5%, Group 2: 6.5% – 8% and group 3: >8%. Nine macular subfields as defined by Early Treatment of Diabetic Retinopathy study (ETDRS) were measured using OCT. The HbA1c level of each patient was measured and compared with the macular thickness as well as visual acuity.

## Abstract

**Result:** No correlation of HbA1c level and central foveal thickness was found in our study ( $p=0.554$ ). The change in visual acuity also had no correlation with HbA1c ( $p>0.05$ ). There was a significant increase in central foveal thickness at 1 month postoperatively, irrespective of HbA1c level ( $p=0.002$ ,  $p=0.001$ ,  $p=0.005$ ).

**Conclusion:** HbA1c has no impact on central foveal thickness or BCVA. Diabetics undergoing phacoemulsification show a change in central foveal thickness post operative but that may not necessarily be due to uncontrolled diabetes.

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**Keywords:** OCT, Diabetics, HbA1c, Phacoemulsification

## Introduction

Diabetes mellitus (DM) is one of the most common microangiopathies that has a multiorgan effect and can lead to serious complications. One of the most common microvascular representations of chronic DM is diabetic retinopathy (DR).<sup>1</sup> For decades, the diagnostic criteria for DM was based on either fasting plasma glucose or 2 hours post prandial glucose. In 2010, plasma glycosylated hemoglobin or HbA1c  $\geq 6.5\%$  was adopted by American Diabetes Association. This laboratory index developed to assess glycemic control over the past 3 months is now a useful tool to diagnose and treat DM. Uncontrolled HbA1c levels are correlated with development of DR in the form of retinal hemorrhages, ischemia, neovascularization and macular edema.<sup>2</sup> Of these, macular edema is the leading cause of vision loss in diabetics, especially after cataract surgery.<sup>3</sup> Particularly, diabetics show a higher incidence of macular edema (DME) which can either be attributed to microvascular changes or due to post surgery inflammation.<sup>4</sup> Optical coherence tomography (OCT) is a non invasive tool which enables an ophthalmologist to evaluate the status of macula by in vivo visualization. Central macular thickness or foveal thickness is considered the main parameter to evaluate DME. This study focuses on impact of HbA1c levels on foveal thickness pre and post uncomplicated phacoemulsification.

## Material and Methods

This was a prospective observational cohort study conducted in the Department of Ophthalmology of a tertiary care hospital. A total of 50 eyes of patients with type 2 DM who underwent uncomplicated phacoemulsification with acrylic

hydrophilic foldable IOL implantation under one surgical platform by a single surgeon with single postoperative protocol were included in the study. All the participants gave informed consent before the study. The study also adhered to the tenets of Declaration of Helsinki. The study was reviewed and approved by the institutional Ethics Committee.

All patients with senile cataract with nuclear sclerosis grade II to IV, known cases of type II diabetes with mild to moderate Non-Proliferative Diabetic Retinopathy (NPDR), without preexisting macular edema (on OCT, macular thickness of <280 microns), with no history of previous laser and uneventful cataract surgery were included in our study. The patients were divided into 3 groups based on their glycemic index i.e HbA1c levels. Group 1 included patients with HbA1c <6.5 %, Group 2 with levels between 6.5 to 8% and Group 3 with level >8%. The fasting blood sugar levels (FBS) and post prandial sugar levels of the patients were also measured on the day before surgery. The patients were already on insulin or oral hypoglycemic agent treatment.

The patients had no history of any ocular surgery or any evidence of inflammation such as uveitis. Patients with glaucoma and any other retinal and/or macular pathology including proliferative diabetic retinopathy were excluded. Also, patients who were currently in use of topical or systemic medications that are known to affect retinal thickness were excluded from our study.

A complete ophthalmic evaluation including best corrected visual acuity (BCVA) using Snellens chart which was then converted to LogMAR for analysis, tonometry and slit lamp examination including biomicroscopy was done. The cataract grading was based on the LOCS III classification.

Dilated posterior segment evaluation was done to grade diabetic retinopathy. The above examination was done preoperatively and postoperatively on day 1, day 7, 1 month and 3 months postoperatively.

Phacoemulsification for cataract surgery was performed by a single experienced surgeon using Catarhex easy, Oertli. A clear corneal incision was made, and continuous curvilinear capsulorrhexis was performed. The nucleus was divided and phacoemulsification and aspiration were performed and after cortical aspiration, an acrylic hydrophilic foldable intraocular lens was inserted in the capsular bag. The average phaco power was between 50%-60% and absolute phaco time was 15±7 seconds.

Optical Coherence Tomography (Topcon 3D OCT 1000) was done preoperatively & postoperatively on day 1, day 7, 1 month and 3 months to measure foveal thickness by ETDRS grid. Pupils were dilated for OCT examination in all cases with 0.5% tropicamide and 2.5% phenylephrine. The retinal thickness values in the fovea, parafoveal and perifoveal areas were measured using 3D macular thickness map analysis program. Parafoveal areas were defined as the area between central 1-mm circle and the surrounding circle with 3-mm diameter (i.e. area between 1- and 3- mm diameters) in four equal quadrants (i.e. superior, inferior, temporal, and nasal), while perifoveal areas were defined as the area between parafoveal and surrounding circle of 2 mm width. OCT changes were defined such as cystic spaces or diffuse thickening.

### Statistical Analysis

All quantitative numerical data was presented in mean ± standard deviation and repeated measures ANOVA was used to find statistical mean difference with the groups. P value <0.05 was considered as significant level. SPSS 2.0 was used for post hoc statistical analysis.

### Results

A total of 50 eyes of patients with type 2 DM underwent uneventful phacoemulsification surgery. Out of these, 16 (32%) belonged to group 1, 18 (36%) to group 2 and 16 (32%) to group 3. There were 23 (46%) males and 27 (54%) females (Table 1).

**Table 1: Demographics and preoperative information of all subjects**

Parameters	Group 1 (<6.5)	Group 2 (6.5 – 8)	Group 3 (>8)	P
BCVA (LogMAR)	0.75±0.420	0.82±0.34	0.84±0.39	0.002
Age (years)	55.06±9.77	54.13±4.23	62.67±8.33	NS
Male/Female Gender	9/9	7/9	8/9	NS
CMTµm (±SD)(Preop)	193.00±31.11µ	220.50±49.32µ	225.19±23.77µ	0.554
HbA1c (mean±SD)	4.92±1.58	7.41±1.45	9.84±1.23	0.001

The mean foveal thickness was 193.00±31.11µ preoperatively for group 1, 220.50±49.32µ for group 2 and 225.19±23.77µ for group 3 (Table 1 & 2). The intergroup variation was found to be statistically non significant (p=0.554).

Foveal thickness on postoperative day 1 was found to be 210.00±49.50µ for group 1, 240.39±58.00µ for group 2 and 226.13±28.71µ for group 3. Intergroup variation was statistically non significant (p=0.535).

Foveal thickness at postoperative day 7 was 205.50±30.41µ in group 1, 243.83±51.90µ for group 2 and 230.44±26.47µ for group 3. Intergroup comparison was statistically non significant (p=0.380).

Foveal thickness on postoperative 1 month was 212.50±19.09µ for group 1, 260.83±72.99µ for group 2 and 244.50±37.30µ

**Table 2: Comparison of foveal thickness between each group**

Parameter	Group	N	Mean	SD	SE	95% Confidence Interval for Mean		p value
						Lower Bound	Upper Bound	
Fovea Preop	<6.5	16	193.00	31.11	22.00	-86.54	472.54	0.554
	6.5-8	18	220.50	49.32	11.62	195.97	245.03	
	>8	16	225.19	23.77	5.94	212.52	237.85	
Fovea POD 1 day	<6.5	16	210.00	49.50	35.00	-234.72	654.72	0.535
	6.5-8	18	240.39	58.00	13.67	211.55	269.23	
	>8	16	226.13	28.71	7.18	210.82	241.43	
Fovea POD 7 days	<6.5	16	205.50	30.41	21.50	-67.68	478.68	0.380
	6.5-8	18	243.83	51.90	12.23	218.02	269.64	
	>8	16	230.44	26.47	6.62	216.33	244.54	
Fovea POD 1 month	<6.5	16	212.50	19.09	13.50	40.97	384.03	0.460
	6.5-8	18	260.83	72.99	17.20	224.54	297.13	
	>8	16	244.50	37.30	9.32	224.62	264.38	
Fovea POD 3 months	<6.5	16	195.00	33.94	24.00	-109.95	499.95	0.542
	6.5-8	18	240.72	65.81	15.51	208.00	273.45	
	>8	16	237.19	40.70	10.17	215.50	258.87	

for group 3. Intergroup comparison was statistically non significant ( $p=0.460$ ).

Foveal thickness at postoperative 3 months for group 1 was  $195.00 \pm 33.94 \mu$ , for group 2, it was  $240.72 \pm 65.81 \mu$  and for group 3, it was  $237.19 \pm 40.70 \mu$ . Intergroup variation was statistically non significant ( $p=0.542$ ) (Figure 1).

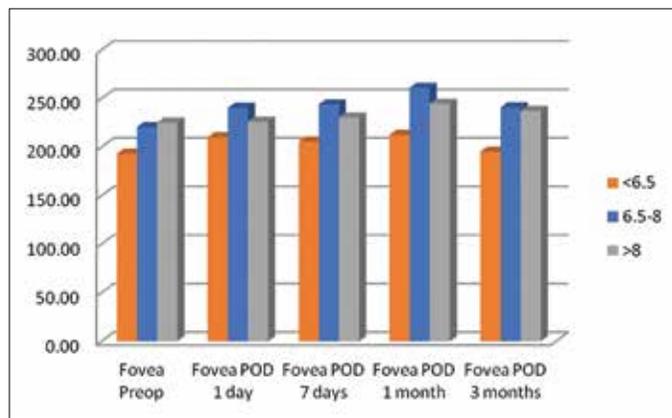


Figure 1: Mean Central foveal thickness for each group

In this study, we found that the mean foveal thickness when compared at preoperative and postoperative 1 month was statistically significant for each group ( $p=0.002$ ,  $p=0.001$ ,  $p=0.005$  respectively). Thus, irrespective of the glycemic index, there was mean change in foveal thickness at 1 month postoperatively which then returned to baseline at 3 months (Table 3) (Figure 2).

Table 3: Comparison of foveal thickness in each group pre operative and post operative

HbA1c	Group Code	Mean	SD	p value
<6.5 (N=16)	Fovea Preop	193.00	31.113	0.002
	Fovea POD 1 day	210.00	49.497	
	Fovea POD 7 days	205.50	30.406	
	Fovea POD 1 month	212.50	19.092	
	Fovea POD 3 months	195.00	33.941	
6.5-8 (N=18)	Fovea Preop	220.50	49.320	0.001
	Fovea POD 1 day	240.39	57.998	
	Fovea POD 7 days	243.83	51.903	
	Fovea POD 1 month	260.83	72.989	
	Fovea POD 3 months	240.72	65.806	
>8 (N=16)	Fovea Preop	225.19	23.772	0.005
	Fovea POD 1 day	226.13	28.714	
	Fovea POD 7 days	230.44	26.470	
	Fovea POD 1 month	244.50	37.299	
	Fovea POD 3 months	237.19	40.696	

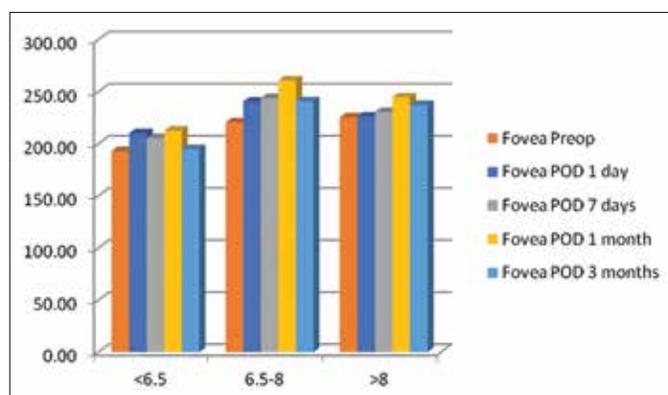


Figure 2: Comparison of Preoperative and postoperative foveal thickness for each group

There was a statistically significant difference between pre and postoperative BCVA for each group ( $p=0.002$ ,  $p=0.001$ ,  $p=0.004$ ). However, there seems to be no correlation between level of HbA1c and change in BCVA (Table 4) (Figure 3).

Table 4: Comparison of BCVA in each group

HbA1c	Group Code	Mean LogMAR	SD	p value
<6.5 (N=16)	Preop	0.75	0.420	0.002
	POD 1 day	0.22	0.140	
	POD 7 days	0.15	0.100	
	POD 1 month	0.12	0.080	
	POD 3 months	0.10	0.008	
6.5-8 (N=18)	Preop	0.82	0.340	0.001
	POD 1 day	0.23	0.170	
	POD 7 days	0.19	0.110	
	POD 1 month	0.10	0.090	
	POD 3 months	0.06	0.080	
>8 (N=16)	Preop	0.84	0.390	0.004
	POD 1 day	0.21	0.140	
	POD 7 days	0.19	0.100	
	POD 1 month	0.11	0.060	
	POD 3 months	0.09	0.020	

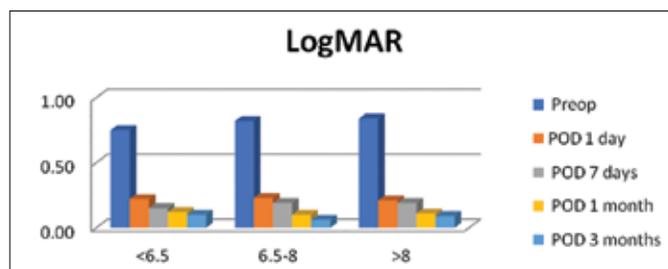


Figure 3: Comparison of BCVA pre and post surgery in each group

## Discussion

There is conflicting evidence as to the significance of glycemic control on the macula of diabetic patients following cataract surgery. Studies by Squirrell et al (2002)<sup>5</sup>, Flesner et al (2002)<sup>6</sup> and Romero-Aroca et al (2006)<sup>7</sup> looked at diabetic patients undergoing monocular phacoemulsification with the fellow eye serving as control. The status of the macula following cataract surgery was assessed using various methods (slit lamp biomicroscopy and fluorescein angiography) and results revealed no significant association with HbA1c. Similar results were found in our study where there was no correlation of foveal thickness with the HbA1c levels. Any change in foveal thickness was therefore not related to glycemic control, but due to other causes such as surgery induced inflammatory reaction or light exposure.

In our study, the HbA1c level was not found to be correlated with the postoperative macular thickness and visual outcome at any postoperative examination time point. This implies that the average level of blood glucose in a limited time period (3 months) prior to phacoemulsification surgery may not be a major risk for short-term postoperative macular edema in diabetic eyes as long as there is no severe diabetic retinopathy. However, similar correlation of HbA1c and postoperative macular edema may be applied to eyes with diabetic retinopathy, because a correlation of HbA1c and progression of macular edema after phacoemulsification in eyes with diabetic retinopathy for as long as 12 months has been reported.<sup>8</sup>

The Action to Control Cardiovascular Risk in Diabetes (ACCORD) Eye Study<sup>9</sup> also demonstrated slower progression of DR under the combination of glycaemic control and dyslipidaemia treatment. The Wisconsin Epidemiology Study of Diabetic Retinopathy (WESDR)<sup>10</sup> showed that higher levels of HbA1c increased the incidence of DMO over a 10-year period (Klein et al. 1995). The Diabetes Control and Complication trial (DCCT)<sup>11</sup> and the UK Prospective Diabetic Study (UKPDS)<sup>12</sup>, both of which were prospective randomized studies, showed that intensive glycaemic control and reduction of HbA1c levels are associated with a decrease in the rates of development and progression of diabetic retinopathy (DR) and DMO.

We used OCT for the measurement of macular thickness prior to and after cataract surgery. OCT provides a more detailed qualitative examination of macular morphology, and also precise and linear quantitative measurements of macular thickness.

In our study, the visual acuity did not deteriorate as the macular thickness increased at 1 month postoperative time point. This indicates that preoperative HbA1c levels have no correlation with change in visual acuity. The improvement in visual acuity was due to removal of cataract which persisted even at 3 months postoperative. According to Eriksson et al, even in eyes with DR, the OCT finding of macular change and the inferiority of visual outcome may only be transient in the short-term (6 weeks) post-phacoemulsification period.<sup>13</sup> The visual outcomes and CMT changes in the diabetic patients were also not related to the level of preoperative HbA1c during this period in our study. Therefore, the short-

term postcataract surgery visual recovery in diabetic patients may not be different from the nondiabetic patients.

In type 2 diabetes, a reduction of HbA1c from 7.9% to 7.0% resulted in a decline in the frequency of laser treatments needed.<sup>14</sup> In type 1 patients, improved blood glucose control with a reduction of HbA1c values from 9.1% to 7.1% reduced the risk of developing DR within 6.5 years by 76%, the risk of progression of DR by 54%, and the risk of developing proliferative diabetic retinopathy by 47%.<sup>15</sup> Therefore an HbA1c level of about 7% should be aimed for from the ophthalmologist's point of view<sup>16</sup>, for the individual patient, a bespoke treatment regime may be needed.

DCCT mentions the risk of developing CSME to be 23% for those with intensive treatment. The incidence of pseudopapillary cystoid macular edema remains to be ranging from 1% – 30% depending on the risk factors defined. But the incidence remains on a higher side for diabetics. Unsal et al<sup>17</sup> observed that the mean CMT (371  $\mu$ m) in eyes with DME was significantly higher than the eyes with PDR (256  $\mu$ m) and Non-Proliferative Diabetic Retinopathy (NPDR) (253  $\mu$ m). The normal incidence of pseudopapillary CME is 1% - 3% and particularly 0.1% - 2.3% after phacoemulsification.

The limitations of this study include the smaller number of patients in each group and short period of our study (3 months). Also, the duration of diabetes was not taken into consideration.

## Conclusion

In this study, there was no correlation found between HbA1c levels and macular thickness in diabetics undergoing phacoemulsification. A significant increase in central foveal thickness was noted at 1 month postoperatively but that had no relation to the level of HbA1c. Similarly, postoperative BCVA change was also not correlated with level of HbA1c.

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