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Macular Thickness Changes Following Phacoemulsification In Diabetic And Non Diabetic Patients - An Optical Coherence Tomography (OCT) Guided Tertiary Care Centre Study

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ABSTRACT

Background: Cataract is a leading cause of reversible blindness, and its coexistence with diabetes mellitus poses challenges in post-operative recovery due to the risk of macular edema. Optical coherence tomography (OCT) has emerged as a valuable tool to evaluate subtle retinal changes.

Objective: This study aims to assess and compare the macular thickness changes following phacoemulsification in type 2 diabetic and non-diabetic cataract patients, and to correlate these changes with glycemic control.

Methods: A prospective case-control study was conducted over 18 months at a tertiary care center involving 180 patients, equally divided into diabetic and non-diabetic groups. Preoperative and postoperative macular thickness measurements were performed using OCT at baseline, 1 week, 4 weeks, and 12 weeks after phacoemulsification. Blood sugar profiles, including HbA1c, were evaluated. Statistical analyses was conducted to assess correlations between glycemic control and macular changes.

Results: While preoperative macular parameters were similar between the two groups, diabetic patients demonstrated significantly higher central macular thickness and macular cube volume at 1 week post-surgery ($p<0.05$). Poorly controlled diabetics (HbA1c $\geq$6.5%) exhibited greater macular thickening compared to those with better glycemic control. However, by 12 weeks, differences in macular thickness between groups were statistically non-significant.

Conclusion: Diabetic patients, especially those with poor glycemic control, are at increased risk for early postoperative macular thicknesschanges following phacoemulsification. OCT monitoring and optimal blood sugar control are help to ensure favorable visual outcomes in these patients.

Keywords: *Phacoemulsification, Diabetic Maculopathy, Optical Coherence Tomography (OCT), Macular Thicknes*

1. INTRODUCTION

The worldwide prevalence of diabetes is on the rise and patients with diabetes have higher risk of developing cataract compared to patients without diabetes. At present, the main surgical treatment for cataract is phacoemulsification with posterior chamber intraocular lens implantation [(1)]

The level of pre-existing diabetic retinopathy (DR), the presence of clinically significant macular edema (CSME) before the surgery; and duration and regulation of diabetes all are important indicators of post-operative cystoid macular edema in cataract patients with coexisting diabetes mellitus.[(2)]

Macular edema is one the most common cause of visual loss after uncomplicated cataract surgery and diabetes has been associated with increased incidence of postoperative macular edema more so in patients with uncontrolled diabetes[(3)]

There are various investigation tools which aids in diagnosing Diabetic Maculopathy ,one of the most recent and accurate is Optical Coherence Tomography (OCT).[4]

HbA1c has been accepted as the gold standard with regards to assessment and monitoring of glycemic control in diabetics. The target for attainment of glycemic control has been set at HbA1c <6.5%, since the status of macula is the primary predictor of visual outcome following cataract surgery. [5]Not very many studies have been conducted in North Indian population to study the levels of HbA1cand compare it with macular thickness changes in cataract patients post phacoemulsification surgeryto predict final visual outcome.

Thus, the present study was conducted to find out the association between changes in macular thickness before and after phacoemulsification in diabetics as compared to non-diabetics and also evaluate the role of HbA1cand its association with changes in macular thickness following phacoemulsification surgery. This was done with the aim to analyse the role of diabetes and its control on the presence of maculopathy and final visual outcome post cataract surgery.

2. AIM OF STUDY

To compare and assess the macular thickness changes following phacoemulsification in Type 2 diabetics and non-diabetic cataract patients.

3. MATERIALS AND METHODS

A Tertiary care centre based case control study carried out in department of Ophthalmology, Integral Institute of Medical Sciences and Research, Integral University,Lucknow, Uttar Pradesh, India

Study participants - All Type 2 diabetes mellitus patients and non-diabetic patients more than 40 years of age with cataract, fit to undergo phacoemulsification.

Design of study – A case control study.

Total Duration of study - 18 months(March 2023- October 2024)

Sample size:

Calculating by using – Sample size for comparision of means

$$n = \left(\frac{r+1}{r}\right)\frac{\sigma^2(Z_\beta + Z_{\alpha/2})^2}{(d\text{ifference})^2}$$

$Z_\beta = Z_{0.20} = 0.842$ from (Z table) 80% power.

$Z_{\alpha/2} = Z_{0.05/2} = Z_{0.025} = 1.96$ (Z table) at type I error of 5%

SD = 19.64 Standard Deviation (based on a previous study)

d =expected mean difference (257.66 - 249.38)

CRITERIA

Inclusion criteria

1. Type 2 diabetes mellitus patients with cataract over 40 years of age
2. Non diabetic patients with cataract over 40 years of age

Exclusion criteria

1. Mature & hyper mature cataract
2. Grade 4 and 5 nuclear cataract
3. Eyes with any significant extra-lenticular media opacity
4. Patients with other ocular co-morbidity that is likely to confound the results of the current study.
5. Any retinal pathology with significant macular thickness changes
6. Patients with any significant systemic comorbidity e.g. ischemic heart disease, uncontrolled hypertension and Type 1 diabetes mellitus
7. Patients not giving consent.

Approval from Institutional research and Ethical Committee was taken before the start of the study.

An informed verbal, as well as written consent was taken from the patients.

Patients attending eye OPD of IIMSR more than 40 years of age and diagnosed with cataract with and without diabetes were included in the study. A detailed history and complete ocular examination including visual acuity, intra ocular pressure, slit lamp examination, dilated fundus examination, A- scan biometry and OCT macular scanning was done, with the help of Zeiss Primus 200 (SDOCT) and the OCT parameters used were Centralsubfoveal thickness (CST), Cube volume (CV)and Cube Average thickness (CAT).Macular thickness evaluation was performed on all the patients pre-operatively followed by systemic blood investigations. All the patients fit to be included in the study underwent phacoemulsification followed by OCT macular evaluation periodically.

4. RESULTS

Table1: Blood sugar markers in the two Groups.

	GROUP A	GROUP B	p-value
FBS mg/dl Mean ± SD	90.91±11.31	98.77±115.25	0.085
PPBS mg/dl Mean ± SD	140.53±45.96	174.82±231.22	**0.004**
HbA1c(%) Mean ± SD	6.57±2.00	6.70±2.03	0.090

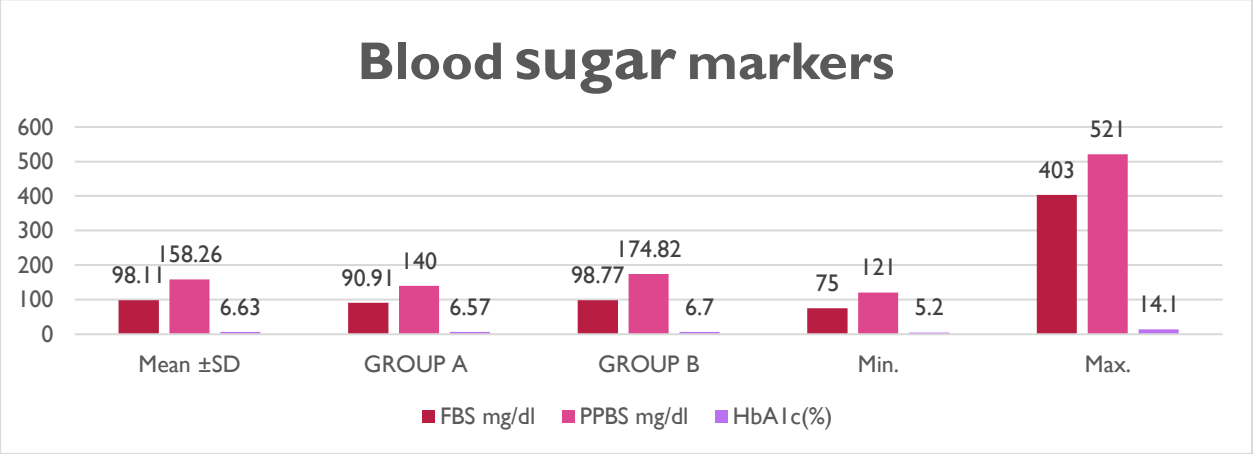

Figure 1 : Blood sugar markers in the two Groups

Table2: HbA1c levels among two Groups

Control of Diabetes	Group A (n=90) (Control)	Group B (n=90) (Case)	Total	p- value
Controlled (HbA1c<6.5)	90	32	122	0.67
Uncontrolled (HbA1c≥6.5)	0	58	58	0.70

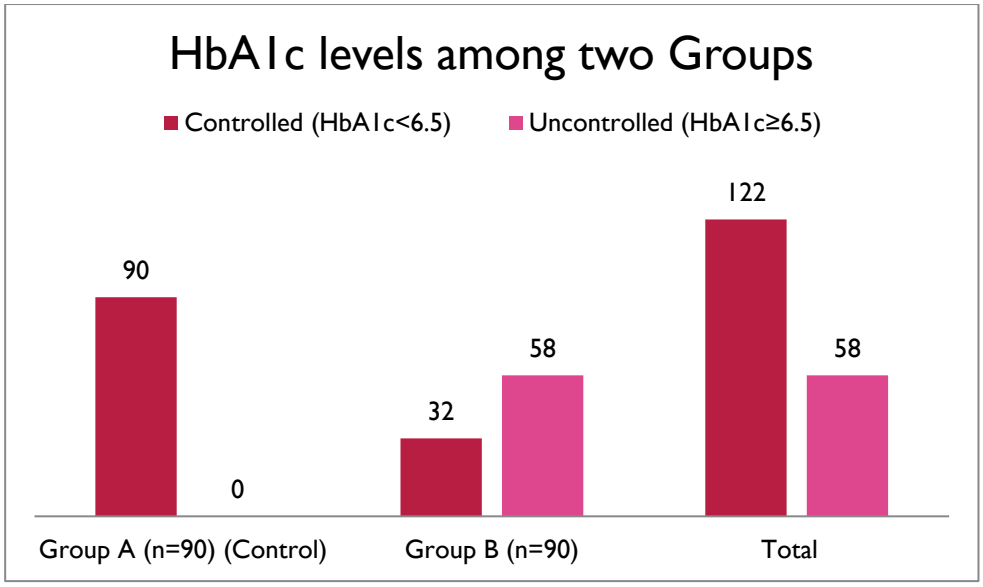

Figure 2: HbA1c levels among two Groups

Table 3: OCT macular finding in Group B with controlled and uncontrolled DM – Preoperatively

OCT	DM controlled N= 36	DM uncontrolled 54	p- value
Biomarker			
Central subfield thickness (CST)	279.95±76.60	286.93±79.29	**0.003**
Cube volume(CV)	10.99±1.80	12.31±1.92	**<0.001**
Central average thickness(CAT)	306.10±68.08	327.80±54.63	**<0.001**

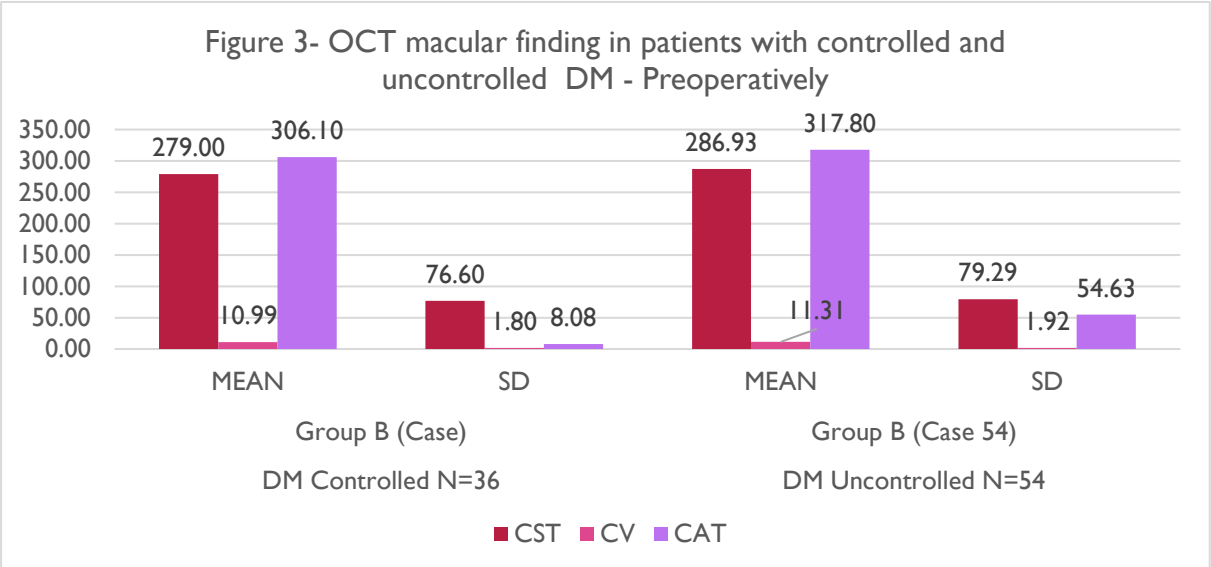

Table 4OCT biomarkers values in subgroups of newly diagnosed and previously diagnosed DM inGroup B (diabetic)- Preoperative

OCT	Newly diagnosed	Previously diagnosed	p- value
Biomarker	Group B (cases) n=29	Group B (cases) n=61	
Central subfield thickness (CST)	196.00±0.00	213.71±37.36	0.094
Cube volume (CV)	9.80±0.00	10.06±1.06	0.017
Central average thickness(CAT)	273.00±0.00	277.79±58.22	0.085

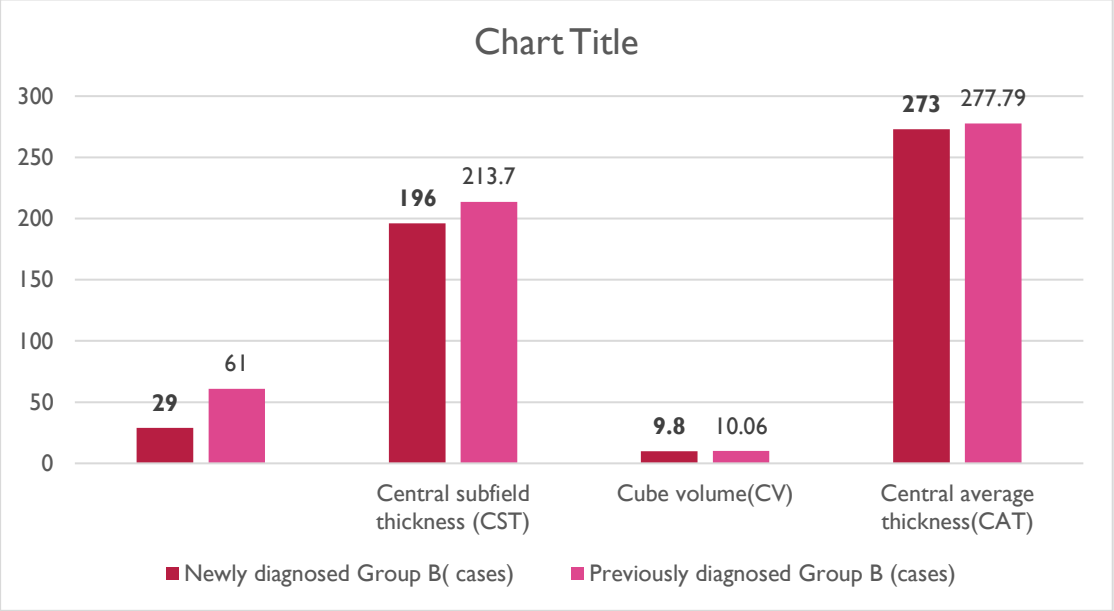

Figure 4- OCT biomarkers values in subgroups of newly diagnosed and previously diagnosed DM inGroup B (diabetic)- Preoperative

Table 5 - Phacoemulsification parameters among the two Groups.

Phaco parameters	Group A(n=90) (Control)	Group B (n=90) (Case)	p- value
Power (%)	37%	49%	0.06
Duration (sec)	0.5sec	0.9sec	0.07
Vaccum (mmHg)	50mmHg	65mmHg	**0.005**
Aspiration (cc/min)	28cc/min	36cc/min	**0.004**

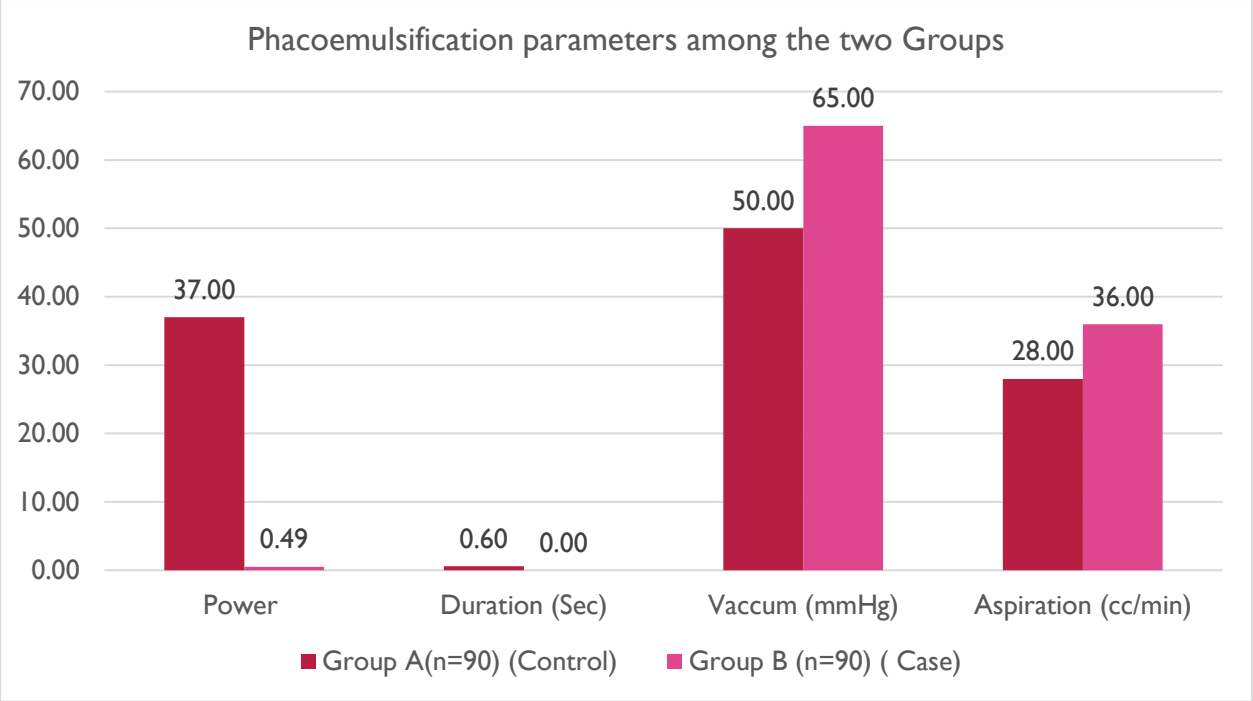

Figure 5- Phacoemulsification parameters among the two Groups

Table6- Comparison of mean macular thickness between the twoGroups over three months follow up .

Biomarkers		Group A (Control)		Group B (Cases)		Inter group
		Mean	SD	Mean	SD	p-value
Central macular (subfield) thickness	Pre op	249.38	19.64	249.66	23.65	0.133
	week 1	264.53	30.29	295.81	80.53	0.046
	week 4	270.88	63.97	281.25	60.20	0.507
	week 12	258.50	67.26	264.09	23.96	0.66
Mean macular cube volume	Pre op	9.44	0.38	9.51	0.55	0.062
	week 1	9.60	0.44	9.94	0.81	0.042
	week 4	9.60	0.48	9.92	0.83	0.067
	week 12	9.40	0.66	9.58	1.77	0.59
Average macular thickness	Pre op	267.94	12.70	270.34	13.92	0.059
	week 1	274.94	13.29	282.66	19.98	0.074
	week 4	273.56	13.81	281.06	20.88	0.096
	week 12	272.78	18.78	277.28	16.07	0.307

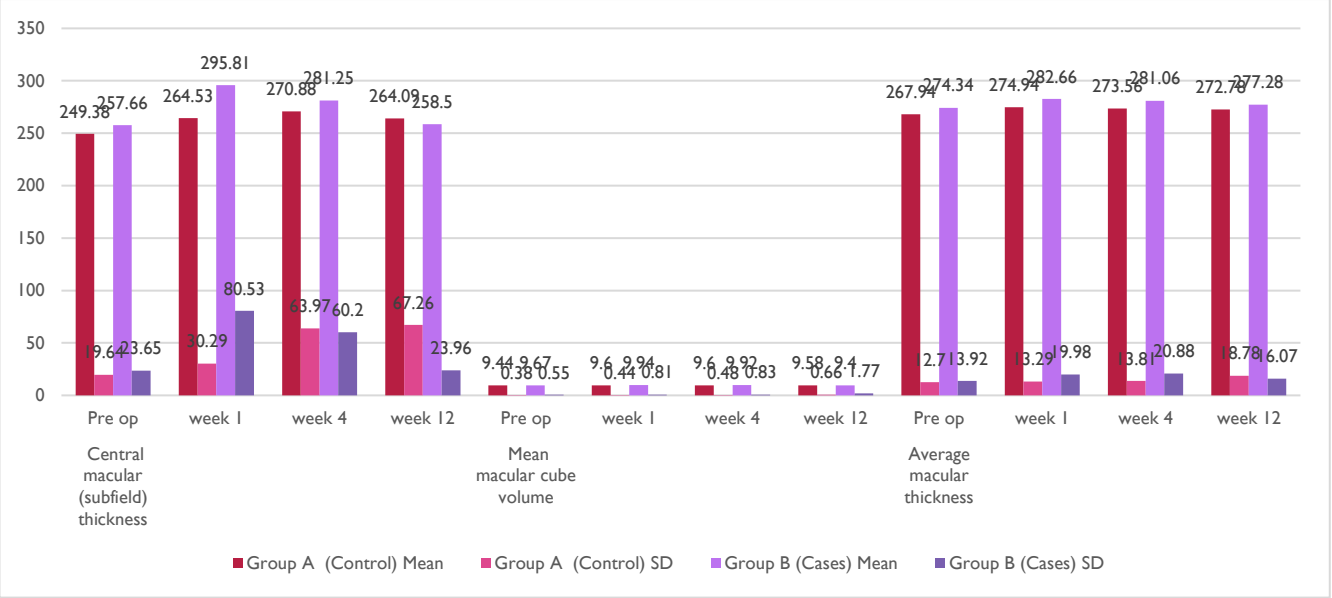

Figure 6- Comparison of mean macular thickness between the twoGroups over three months follow up

5. DISCUSSION

In our study, the mean fasting blood sugar (FBS) was 90.91 mg/dL (±11.31 mg/dL) in Group A and 98.77 mg/dL (±115.25 mg/dL) in Group B(Table no.1).This finding is consistent with previous research by **Wang et al.**[6],which reported greater fluctuations in fasting glucose levels in diabetics with variable insulin resistance. Poor fasting glucose regulation has been linked to increased oxidative stress and vascular endothelial dysfunction, both of which contribute to delayed post-operative recovery.

The mean post-prandial blood sugar (PPBS) levels were significantly higher in Group B (174.82 ± 231.22 mg/dL) compared to Group A (140.53 ± 45.96 mg/dL).A study by **Lobo et al.**[7] found that patients with post-prandial hyperglycemia exhibited prolonged macular thickening surgery. Post-prandial hyperglycemia has been identified as a major contributor to diabetic complications due to the increased production of advanced glycation end products (AGEs), which exacerbate retinal inflammation.

In our study the mean HbA1C level in Group B was 6.70% (±2.03%)(Table no.2), with a range from 5.2% to 14.1%. Higher HbA1C levels indicate poor long-term glycemic control and are associated with an increased risk of post-operative complications. A study by **Kim et al.**[8]demonstrated that diabetic patients with HbA1C > 8% had a significantly higher incidence of post-phacoemulsification cystoid macular edema (CME) compared to those with HbA1C < 7%. The findings suggest that maintaining HbA1C levels below 7% is crucial for minimizing inflammation and optimizing visual recovery post-surgery.

Macular findings of diabetic patients classified into two groups: controlled DM (HbA1c <6.5%) and uncontrolled DM (HbA1c ≥6.5%). The results indicate that all OCT parameters,were significantly higher in the uncontrolled diabetes group ($p<0.05$).

Central Subfield Thickness (CST) was significantly higher in the uncontrolled diabetes group (286.93±79.29 µm) compared to the controlled diabetes group (279.95±76.60 µm), with a statistically significant p-value of <0.001 (Table no.3). This suggests that poor glycemic control contributes to increased retinal thickness, likely due to persistent vascular leakage and inflammatory changes in the macula.

Previous studies, including those by **Kim et al.**[9]demonstrated a positive correlation between high HbA1c levels and increased macular thickness, even in patients without clinically significant diabetic macular edema (DME).

Cube Volume (CV), representing the total volume of the macular region, was also significantly higher in the uncontrolled diabetes group (11.31±1.92) compared to the controlled diabetes group (10.99±1.80), with a p-value of <0.001..

Central Average Thickness (CAT) was also significantly elevated in the uncontrolled diabetes group (317.80±54.63 µm) compared to the controlled group (306.10±68.08 µm), with a p-value of <0.001.

Present study shows the pre-operative values showed no significant differences, week 1 post-operative findings revealed a statistically significant increase in CMT and MCV in diabetics compared to non-diabetics (p=0.046 and p=0.042, respectively). However, the differences in CMT, MCV, and AMT at weeks 4 and 12 were not statistically significant

(p>0.05), suggesting resolution of post-operative inflammation over time.

In Group B diabetic patients, cube volume (CV) was significantly higher in previously diagnosed cases compared to newly diagnosed (10.06 ± 1.06 mm³ vs. 9.80 ± 0.00 mm³, p = 0.017), (Table no.4) indicating progressive retinal thickening with longer diabetes duration. Central subfield thickness (CST) was also higher in previously diagnosed patients (213.71 ± 37.36 µm vs. 196.00 ± 0.00 µm), but not statistically significant (p = 0.094). These findings suggest subclinical retinal changes with disease progression.**Sadda SR**[10]

Phaco power was significantly higher in Group B (49%) compared to Group A (37%). This suggests that diabetic cataracts tend to be harder and require increased ultrasound energy for effective emulsification.**Kim et al**.[11]have reported similar findings, indicating that diabetic cataracts are denser and require greater phaco power.

The duration of phacoemulsification was longer in Group B (0.9 seconds) compared to Group A (0.6 seconds) (Table no.5), reflecting increased resistance to fragmentation. This prolonged Phaco time in diabetics correlates with greater cataract hardness and nuclear opacification, as observed in previous studies by **Zhang et al.**[12]

The central macular thickness (CMT) showed slight variations between the two groups at different time points. Pre-operatively, CMT was comparable between Group A (249.38±19.64 µm) and Group B (249.66±23.65 µm) (Table no.6), with no statistical significance (p=0.133). This suggests that diabetic patients without pre-existing DME have a relatively normal baseline macular thickness.

At week 1, a statistically significant increase in CMT was observed in Group B (295.81±80.53 µm) compared to Group A (264.53±30.29 µm), p=0.046. This finding indicates that early post-operative macular thickening is more pronounced in diabetics, likely due to increased vascular permeability and inflammation.

Lobo et al.[12]reported similar findings, showing that early post-operative macular thickening is more significant in diabetic patients due to impaired blood-retinal barrier (BRB) integrity and prolonged inflammatory response.

By week 4 and week 12, the differences in CMT were not statistically significant (p=0.507 and p=0.66, respectively), indicating that retinal recovery progresses similarly in both groups after the initial post-operative period. Pre-operatively, the mean macular cube volume (MCV) was comparable between the two groups (Group A: 9.44±0.38 mm³, Group B: 9.51±0.55 mm³, p=0.062). At week 1, MCV was significantly higher in Group B (9.94±0.81 mm³) compared to Group A (9.60±0.44 mm³), p=0.042. This increase aligns with the early inflammatory response in diabetics, leading to transient macular thickening.

Williams et al.[13]noted that diabetic patients with MCV values above 10.0 mm³ had a higher risk of post-operative macular edema. Although this study did not observe extreme MCV elevations, the statistically significant difference at week 1 reinforces the importance of post-operative monitoring in diabetics.

By week 4 and week 12, the differences in MCV were no longer statistically significant (p=0.067 and p=0.59, respectively). This further supports the observation that diabetic patients without pre-existing retinal pathology exhibit post-operative thickening that normalizes over time.

The average macular thickness (AMT) followed a similar trend, with no statistically significant differences at any time point (p>0.05 across all comparisons). The mean AMT values were slightly higher in diabetics, but the changes did not reach clinical significance. This suggests that while diabetic patients may have a tendency toward greater macular thickening post-operatively, this does not always translate into persistent edema or vision loss.

6. CONCLUSION

Diabetic patients exhibited greater changes in macular thickness following phacoemulsification in the early postoperative period underscoring the importance of baseline macular thickness evaluation by OCT, strict blood sugar control and close post-operative monitoring for tailored management aimed at optimum visual recovery following cataract surgery.

7. LIMITATION OF THE STUDY

Present study was conducted over a limited period of time with relatively small number of participant, it may be difficult to conclusively confirm the significance of the result.

Future studies with longer follow up and larger cohort would help to further validate the findings of our study.

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