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Original Research Article

Comparative analysis of central corneal thickness and macular thickness changes following phacoemulsification and small incision cataract surgery: A prospective study

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ABSTRACT

Objective: To quantify the changes in central corneal thickness and macular thickness after uncomplicated cataract surgery and to compare its outcomes in terms of visual acuity.

Materials and Methods: A total of 81 patients with senile cataract who were scheduled for either Phacoemulsification or SICS surgery were included in this study. They were divided into two groups: 41 patients underwent Phacoemulsification and 40 patients underwent SICS. CCT and CMT were measured with optical coherence tomography (OCT) preoperatively and postoperatively at Day 1, day 7, week 6 and 3 months.

Result: Preoperative baseline measurements showed no significant difference in CCT and MT between the two groups ($p > 0.05$). Central corneal thickness showed significant differences between the two groups at different postoperative time points at day 1 and day 7. Central macular thickness also showed significant differences at day 7 and 6 week, with the SICS group showing consistently higher macular thickness values compared to the Phacoemulsification group from day 1 to 3 months after surgery. This suggested that the type of cataract surgery may have had an impact on retinal thickness outcomes, with more pronounced and permanent changes occurring in the SICS group. In addition, both group A (SICS) and group B (Phacoemulsification) showed good visual outcomes, with comparable improvements in BCVA.

Conclusion: Our results suggested that both SICS and Phacoemulsification techniques are effective in improving visual acuity, but SICS may result in more pronounced retinal changes while faster resolution of macular thickness was seen in phacoemulsification. Both groups also exhibited transient subclinical changes in CCT following cataract surgery. However, these changes were generally reversible, and early recovery occurred after phacoemulsification. The visual acuity was improved after both procedures but phacoemulsification surgery showed slightly better visual outcomes. Understanding these differences may help to adjust postoperative treatment strategies to optimize outcomes for patients undergoing cataract surgery.

1. Introduction

Cataract remains a leading cause of preventable blindness worldwide, with an exceptionally high burden in developing countries.[1] According to the World Health Organization, cataracts are responsible for 47.8% of global blindness,

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with this figure reaching 62.6% in India.[2,3] The WHO projects that cataract-related blindness will affect 40 million people by 2025, with 90% of cases occurring in developing countries.[4]

Cataract extraction is a standard ophthalmological procedure. Small incision Cataract surgery (SICS) and phacoemulsification are widely performed sutureless procedures, both offering good visual outcomes with low complication rates.[5] However, postoperative complications such as cystoid macular edema (C.M.E.) can affect visual acuity.[6,7]

Optical coherence tomography (OCT) has revolutionized the detection and quantification of subtle changes in macular architecture and thickness.[8] It allows for early identification of subclinical macular edema that may not be apparent on clinical examination alone.[9]

This study aims to analyze macular thickness at specific postoperative intervals and correlate these findings with visual acuity outcomes. Additionally, we will also assess Central Corneal Thickness (C.C.T.) and Best-corrected visual acuity (B.C.V.A.) after surgery to investigate whether SICS and phacoemulsification produce differing impacts on subclinical macular changes, corneal endothelial function, and overall visual outcomes.

2. Material and Methods

This prospective observational study was conducted at Hind Institute of Medical Sciences, Safedabad, Barabanki, Uttar Pradesh. Adult patients aged 40 years and above undergoing uneventful cataract surgery (either Phacoemulsification or Small Incision Cataract Surgery) were enrolled after obtaining written informed consent and approval from the Institutional Ethical Committee. 81 patients fulfilling inclusion and exclusion criteria were enrolled in this study.

Following patients were excluded from the study:

(i) Unwilling patients or patient with any complication during cataract surgery., (ii) Patients with any ocular or systemic condition that can cause macular edema, (iii) Patient with any ocular trauma., (iv) Patients with history of vitreoretinal surgery and or glaucoma surgery in the same eye (v) Patients with pre-existing clinically significant macular edema. (vi) Patients with retinal or choroidal disease in the same eye. (vii) Patients with any other systemic or/ocular co morbidities that will hinder fundus and OCT. (viii) Patients with pre-existing diabetic retinopathy. (ix) Patients with conditions such as leprosy and other conditions known which affects corneal sensations.,(x) patient with corneal ulcer, uveitis and glaucoma.

Patients were divided in two group (1) Group-A: Patients undergoing planned small incision cataract surgery (SICS) and (2) Group-B: Patients planed for phacoemulsification.

The statistical analysis was performed with SPSS version 21.0. The data were presented in the form of mean (standard deviation) and percentage (%). The chi-square test was used to compare categorical variables, while the independent t-test was used to assess discrete variables between groups. An analysis of variance (ANOVA) was used to compare more than two groups. A p-value of 0.05 was considered statistically significant.

3. Results

Table 1 shows the division of patients into Groups who underwent different techniques of cataract surgery. Group A consisted of 40 patients who underwent Small Incision cataract surgery (SICS), representing 49.38% of the total patients. Group B consisted of 41 patients who underwent phacoemulsification, representing 50.62% of the total patients. This indicated almost an even distribution between the two surgical methods, showing a balanced comparison of their results.

Table 2 compares the central macular thickness between the two Groups (Group A and Group B) at different time points: Pre-operative, and Post-operative Day 1, Day 7, 6 weeks and 3 months.

The mean preoperative CMT was 213.58 ± 8.61 in Group A and 212.54 ± 8.92 in Group B. Preoperatively, both Groups showed no significant difference in CMT, indicating a similar initial state of the retina.

On Postoperative Day 1, the mean CMT was 220.13 ± 6.74 in Group A and 215.83 ± 7.48 in Group B. On Day 1, Group A had a significantly higher central macular thickness than Group B ($p = 0.008$), indicating early postoperative retinal changes in Group A.

The mean CMT on postoperative Day 7 was 227.60 ± 7.31 in Group A and 218.46 ± 6.98 in Group B. The mean CMT of Group A was significantly higher than that of Group B ($p = 0.000$), which indicated higher values and pronounced changes in the first week after surgery.

The CMT was 229.65 ± 6.86 in Group A and 222.54 ± 7.03 in Group B, postoperatively at 6 weeks, where Group A continued to show significantly higher CMT values compared to Group B ($p = 0.000$), which suggested persistent mid-term differences.

At 3 Months Postoperative, mean CMT was found to be 219.25 ± 5.99 in Group A and 215.51 ± 7.10 in Group B. Group A still showed significantly higher central macular thickness than Group B ($p = 0.012$), indicating long-term postoperative changes.

The analysis showed significant differences in central macular thickness at different postoperative intervals, with Group A having consistently higher thickness values compared to Group B from Day 1 to 3 months after surgery. This suggested that the type of cataract surgery may have had an impact on retinal thickness outcomes, with more pronounced and permanent changes occurring in Group A. Monitoring these changes is critical to understand the long-term impact of different cataract surgery techniques on

Table 1: Distribution of patients into Groups

		N	%
Group A	Patients taken for SICS	40	49.38
Group B	Patients taken for Phacoemulsification	41	50.62

Table 2: Association of mean central macular thickness between group A and group B at pre-op, postoperative day 1, day 7, 6 weeks, and 3 months

		Group A (n=40)		Group B (n=41)		t	p- Value
		Mean	±SD	Mean	±SD		
Central macular Thickness	Pre-op	213.58	8.61	212.54	8.92	0.53	0.596
	Day 1	220.13	6.74	215.83	7.48	2.71	0.008
	Day 7	227.60	7.31	218.46	6.98	5.75	0.000
	6 weeks	229.65	6.86	222.54	7.03	4.61	0.000
	3 Months	219.25	5.99	215.51	7.10	2.56	0.012

Table 3: Mean changes in central macular thickness from pre-op to post-operative 3 month in group A and group B

	Pre-op		Day 1		Day 7		6 weeks		3 Months		p- Value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
Group A	213.58	8.61	220.13	6.74	227.60	7.31	229.65	6.86	219.25	5.99	<0.001
Group B	212.54	8.92	215.83	7.48	218.46	6.98	222.54	7.03	215.51	7.10	<0.001

retinal health.

Table 3 show the mean changes in central macular thickness from pre-op to post-op 3 month in Group A and Group B.

1. Pre-operative: Both groups showed similar central macular thickness with no significant difference.
2. Day 1: Group A showed a significant increase in mean central macular thickness to 220.13 ± 6.74 compared to 215.83 ± 7.48 in Group B.
3. Day 7: The increase in central macular thickness continued in Group A (227.60 ± 7.31) and Group B (218.46 ± 6.98), with Group A showing a higher mean value.
4. 6 weeks: The mean central macular thickness of Group A continued to increase to 229.65 ± 6.86, while the mean value of Group B increased to 222.54 ± 7.03.
5. 3 months: Both groups showed a reduction in central macular thickness compared to 6 weeks, with Group A showing a value of 219.25 ± 5.99 and Group B a value of 215.51 ± 7.10.

The p-values (<0.001) shows that the changes in central macular thickness over time are statistically significant for both Groups. Group A exhibited more pronounced changes, with larger mean differences between successive time intervals compared to Group B, which suggested that the surgical techniques influence the retinal thickness outcomes. These results demonstrated the importance of monitoring foveal changes following cataract surgery.

Table 4 illustrated the association of mean central corneal thickness between Group A and Group B at pre-op, post-op Day 1, Day 7, 6 weeks, and 3 Months. The mean Central Corneal Thickness (CCT) was 522.88 ± 9.63**,** 73 ± 7.01**,** 532.93 ± 4.45, 530.60 ± 2.68 and 526.88 ± 3.88 in Group A and 525.61 ± 5.06**,** 564.61 ± 2.76, 545.07 ± 7.13**,** 527.90 ± 4.79 and 527.05 ± 4.12 in Group B at pre-op, post-op day 1, Day 7, 6 weeks, and 3 Months, respectively.

1. Pre-op: There was no significant difference in CCT between Group A and Group B pre-operatively (t = -1.61, p = 0.112).
2. Day 1: Group B exhibited a significantly higher CCT on Postoperative Day 1 compared to Group A (t = -19.41, p < 0.001).
3. Day 7: Group B continued to had a significantly higher CCT on Day 7 compared to Group A (t = -9.17, p < 0.001).
4. 6 weeks: There was a trend towards significance, with Group A showing a slightly higher CCT compared to Group B (t = 1.96, p = 0.053).
5. 3 months: At 3-month CCT was not significantly different between Group A and Group B (t = 0.19, p = 0.850).

Preoperatively, there was no significant difference in CCT between the Groups. However, on postoperative Day 1 and Day 7 there were significant differences, Group B exhibited significantly higher CCT values compared to Group A. After 6 weeks there is a trend towards significance, with Group A having a slightly lower CCT value than Group. The data suggested that there were significant differences in CCT between the two Groups at different postoperative time

Table 4: Association of mean central corneal thickness between group A and group B at pre-op, post-operative day 1, day 7, 6 weeks, and 3 months

			Group A (n=40)		Group B (n=41)		t	P-Value
			Mean	±SD	Mean	±SD		
Central Corneal Thickness	Pre-op		522.88	9.63	525.61	5.06	-1.61	0.112
	Post-op	Day 1	541.73	7.01	564.61	2.76	-19.41	<0.001
		Day 7	532.93	4.45	545.07	7.13	-9.17	<0.001
		6 weeks	530.60	2.68	527.90	4.79	1.96	0.053
		3 Months	526.88	3.88	527.05	4.12	0.19	0.850

Table 5: Mean changes in central corneal thickness from pre-op to post-op 3 month in Group A and Group B

			Post operative								
	Pre-op		Day 1		Day 7		6 weeks		3 Months		p- Value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
Group A	522.88	9.63	541.73	7.01	532.93	4.45	530.6	2.68	526.88	3.88	<0.001
Group B	525.61	5.06	564.61	2.76	545.07	7.13	528.9	4.79	527.05	4.12	<0.001

points. These results may have had implications for surgical outcomes and postoperative treatment strategies.

Table 5 shows the mean changes in central corneal thickness from pre-op to post-op 3 month in Group A and Group B.

1. Pre-operative: Group B had a slightly higher mean CCT compared to Group A, and the difference was statistically significant.
2. Day 1: Group B showed a significant increase in CCT compared to Group A, indicating greater post-operative corneal Edema.
3. Day 7: Group B continued to have a significantly higher CCT compared to Group A, suggesting prolonged corneal Edema.
4. 6 weeks: There was no significant difference in CCT between the two Groups at this time point.
5. 3 months: Group A showed a significantly lower CCT compared to Group B, which indicated faster resolution of corneal Edema in Group A.

The data suggested that while both groups had increased CCT, however, Group B had greater corneal Edema postoperatively compared to Group A, as evidenced by higher CCT measurements at Day 1, Day 7, and 3 months postoperatively compared to group A. These differences could have had implications for postoperative management and visual outcomes.

Table 5 shows the comparison of mean logarithm of minimal angle of resolution visual acuity pre-op and post-op between both groups. The mean visual acuity was 0.24±0.08 and 0.69±0.12 in Group A and 0.26±0.10 and 0.71±0.14 in Group B at pre-op and post-op, respectively.

3.1. Pre-operative

There was no significant difference in visual acuity between Group A and Group B before surgery (p = 0.324) and post-operative (p=0.495).

Moreover, postoperatively mean logarithm of minimal angle of Visual acuity was significantly increased in both Group A and Group B.

4. Discussion

The present study compared SICS and Phacoemulsification techniques, focusing on changes in Central macular thickness (CMT), Central Corneal Thickness (CCT), and visual acuity outcomes.

4.1. Demographic comparability

The mean age of participants was 63.40 ± 3.14 years in the SICS group and 63.07 ± 3.96 years in the Phacoemulsification group, indicating comparable populations. This aligns with previous studies by Ghosh et al. (2010),[9] Salwan et al. (2021),[10] and Paraskar et al. (2023),[11] emphasizing the focus on middle-aged to older patients in Cataract studies. Gender distribution showed 60% male in the SICS group and 41.46% male in the Phacoemulsification group, with no statistically significant difference (p=0.148). This comparability is consistent with studies by Salwan et al. (2021)[10] and Paraskar et al. (2023),[11] though contrasting with Gharbiya et al. (2013)[12] and Perente et al. (2007).[13]

4.2. Central macular thickness (C.M.T.)

C.M.T. was measured preoperatively and at day 1, 1 week, 6 weeks, and 3 months postoperatively, allowing comprehensive monitoring of changes. This timeline is

Table 6: Association of mean visual acuity between SICS and Phacoemulsification at pre-op and post-op

		SICS (n=40)		Phacoemulsification (n=41)		t	p- Value
		Mean	±SD	Mean	±SD		
LogMAR (VA)	Pre	0.24	0.08	0.26	0.10	0.99	0.324
	Post	0.69	0.12	0.71	0.14	0.69	0.495
	p-Value			<0.001*			

* Statistically significant

comparable to studies by Paraskar et al. (2023),[11] Perente et al. (2007),[13] Vukicevic et al. (2012),[14] and Salwan et al. (2021).[10] Preoperative CMT was comparable between groups (SICS: 213.58 ± 8.61 μm, Phacoemulsification: 212.54 ± 8.92 μm, p=0.596), similar to findings by Salwan et al. (2021).[10] On the first postoperative day, CMT increased more in the SICS group (220.13 ± 6.74 μm) compared to the Phacoemulsification group (215.83 ± 7.48 μm, p=0.008), indicating more excellent early macular thickening in SICS. This aligns with studies by Ghosh et al.,[9] Vukicevic et al.,[14] and Paraskar et al.[11] At day 7, CMT further increased (SICS: 227.60 ± 7.31 μm, Phacoemulsification: 218.46 ± 6.98 μm, p=0.000), with SICS showing more significant changes. This trend is consistent with findings from Salwan et al. (2021)[10] and Ghosh et al.,[9] Vukicevic et al.,[14] and Paraskar et al.[11] Peak CMT increase was observed at 6 weeks (SICS: 229.65 ± 6.86 μm, Phacoemulsification in macular thickness without : 222.54 ± 7.03 μm, p=0.000), aligning with Lobo et al.[15] findings. At 3 months, CMT remained higher in the SICS group (219.25 ± 5.99 μm vs. 215.51 ± 7.10 μm, p=0.012), indicating longer-term effects. This is consistent with Perente et al. (2007)[13] and Paraskar et al. (2023),[11] though contrasting with Vukicevic et al. (2012).[14] The study found subclinical increase in macular thickness without clinical macular edema attributed to inflammatory responses triggered by surgical trauma.

4.3. Central corneal thickness (CCT)

Preoperative CCT was comparable between groups (SICS: 522.88 ± 9.63 μm, Phacoemulsification: 525.61 ± 5.06 μm).On the first postoperative day, CCT increased more in the Phaco group (564.61 ± 2.76 μm vs. 573 ± 7.01 μm, p < 0.001), indicating a stronger initial corneal response. This aligns with Kumar et al. (2022),[16] who attributed corneal edema from increase in endothelial cell loss. At day 7, the Phaco group maintained higher CCT (545.07 ± 7.13 μm vs. 532.93 ± 4.45 μm, p < 0.001), consistent with Deshpande et al. (2018)[17] findings of early postoperative edema affecting visual recovery. By 6 weeks, CCT differences were not statistically significant (SICS: 530.60 ± 2.68 μm, Phacoemulsification: 528.90 ± 4.79 μm), indicating stabilization. This aligns with Mencucci et al. (2006),[18] who found no significant differences between techniques at 1 and 3 months postoperatively.

At 3 months, CCT values were similar (SICS: 526.88 ± 3.88 μm, Phacoemulsifciation: 527.05 ± 4.12 μm), consistent with Salvi et al. (2007)[19] observation of CCT returning to near preoperative levels within a week. Both techniques showed that initial CCT increased due to surgical trauma and inflammation, with Phacoemulsifciation causing a more significant early increase. However, both groups stabilized by 3 months, supporting findings by Kumar et al. (2022),[16] Mencucci et al. (2006),[18] and Deshpande et al. (2018)[17] that long-term outcomes are similar regardless of technique.

4.4. Visual acuity

Preoperative visual acuity was comparable between groups (SICS: 0.24 ± 0.08, Phacoemulsification: 0.26 ± 0.10, p = 0.324). Postoperatively, both groups showed significant improvement (SICS: 0.69 ± 0.12, Phacoemulsification: 0.71 ± 0.14, p=0.495), with no statistically significant difference between techniques. These results align with Kumar et al. (2022),[16] who reported significant improvements in both groups by day 30. Anand et al. (2021)[20] also observed significant early improvement stabilizing between 3 and 12 weeks postoperatively. Ruit et al. (2007)[21] and Venkatesh et al. (2010)[22] reported excellent visual outcomes for both techniques, with 98-99% of patients achieving B.C.V.A. of 20/60 or better. Salwan et al. (2021)[10] similarly found significant improvements in both groups, with Phacoemulsification showing slightly better results.

5. Conclusion

This study reported a subclinical increase in Macular Thickness following uncomplicated cataract surgery, indicating disruption of the Blood-Retinal Barrier due to inflammation. However, this increase was transient and did not result in clinically significant macular oedema and resolved over time. The results indicated more pronounced and persistent retinal changes in the SICS Group. This study showed SICS exhibited a slightly higher increase in Macular Thickness compared to Phacoemulsification. Central corneal thickness (CCT) showed an initial increase in the first week after cataract surgery, more in Phacoemulsification indicating initial corneal Edema due to endothelial cell loss. Both small-incision cataract surgery (SICS) and Phacoemulsification (PHACO) continued to have increase in Central Corneal Thickness (CCT)

in the early postoperative period, likely due to some endothelial cell disruption. However, CCT values returned to near- baseline levels by 3 months postoperatively, suggesting endothelial cell recovery and compensation. SICS and Phacoemulsification both had similar long term corneal recovery and comparable effects concluding both techniques were safe when performed meticulously. While there may be some initial endothelial cell loss, this does not appear to significantly impact visual rehabilitation or corneal clarity in the longer term.

Despite the transient changes in macular thickness and corneal thickness, the visual outcomes after uncomplicated cataract surgery remain excellent. Significant improvement in visual acuity was observed in both surgical Groups with slightly better in phacoemulsification. Future research could focus on longer-term follow up, larger sample sizes, and investigation of factors influencing individual patient responses to different surgical techniques. Additionally, exploring the correlation between CMT/CCT changes and visual outcomes could provide valuable insights for optimizing postoperative care strategies.

6. Source of Funding

None.

7. Conflict of Interest

None.

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