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Original Research Article

Comparison of Corneal Endothelial Cell Count Changes in Patients Undergoing Phacoemulsification Vs Sics at Tertiary Care Hospital

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Conflict of interest: Nil

Abstract

Background: The corneal endothelium is essential for maintaining corneal transparency. Endothelial damage during cataract surgery can adversely affect visual outcomes, with Phacoemulsification and Small Incision Cataract Surgery (SICS) causing varying degrees of endothelial stress. Postoperative endothelial cell density assessment helps determine the relative safety of these techniques.

Aims: To evaluate and compare corneal endothelial cell count (ECC) changes following Phacoemulsification and SICS performed by a single experienced surgeon.

Settings and Design: Hospital-based longitudinal observational study.

Methods and Material: A total of 82 patients aged 41–80 years were enrolled, with 41 undergoing Phacoemulsification and 41 undergoing SICS. All participants received detailed preoperative ocular examinations. Endothelial cell density was measured using non-contact specular microscopy before surgery and at 2 and 6 weeks postoperatively.

Statistical analysis used: Chi-square test, unpaired t-test, ANOVA test.

Results: The mean preoperative ECC was comparable between the Phacoemulsification (2642.3 ± 171.6 cells/mm²) and SICS (2602.8 ± 184.3 cells/mm²) groups. Endothelial cell loss was significantly higher with Phacoemulsification at both 2 weeks (276.40 ± 54.25 vs. 195.60 ± 42.86 cells/mm²) and 6 weeks (394.70 ± 65.78 vs. 296.00 ± 57.42 cells/mm²) compared to SICS ($p < 0.001$).

Conclusions: SICS demonstrated lower endothelial cell loss and remains a safe, efficient, and cost-effective option, particularly in patients with advanced cataracts.

Keywords: Phacoemulsification, SICS, Endothelial cell count, Specular microscopy, Endothelial cell loss.

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Introduction

The corneal endothelium is essential for maintaining corneal transparency through active fluid regulation. Endothelial cells do not regenerate, making them highly susceptible to surgical trauma. Significant endothelial cell loss can result in corneal edema and visual impairment. [1] Cataract surgery, the most commonly performed ocular procedure worldwide, is a major cause of reversible blindness and is frequently associated with endothelial damage. [2,3]

Phacoemulsification and small-incision cataract surgery (SICS) are widely practiced techniques with distinct mechanisms that may differentially affect endothelial integrity. [4] This study aims to provide a comprehensive analysis of postoperative endothelial cell loss in both surgical techniques. Understanding these differences will help optimize surgical approaches and reduce endothelial damage for cataract patients.

Subjects and Methods

A hospital-based longitudinal study was conducted among patients with senile cataract undergoing manual small incision cataract surgery and phacoemulsification at GMERS Medical College and Hospital, Gandhinagar, in 1 year. A total of 82 Patients were randomly allocated into two groups, one undergoing SICS and the other undergoing phacoemulsification cataract surgery by a single surgeon.

Group A: 41 patients undergoing Phacoemulsification.

Group B: 41 patients undergoing SICS

Inclusion Criteria:

1. Patients providing written informed consent and willing to complete a 6-week follow-up.
2. Male or female patients aged 41–80 years with clinically diagnosed cataract.
3. Preoperative corneal endothelial cell count between 1500–3000 cells/mm².
4. Cataract grades NS 1–3 or PSC as per LOCS III classification.
5. Patients undergoing uncomplicated standard SICS or Phacoemulsification performed by the same surgeon.

Exclusion Criteria:

1. Patients with a documented history of diabetes mellitus.
2. Prior ocular surgery in the affected eye.
3. History of ocular trauma or presence of traumatic cataract.
4. Preoperative corneal endothelial cell density below 1500 cells/mm².
5. Evidence of pre-existing corneal pathology.
6. Known diagnosis of glaucoma.
7. Uveitic cataract.
8. Occurrence of any intraoperative complications, such as posterior capsular rent.

Methods

All patients underwent preoperative evaluation that included detailed demographic data, medical and ocular history, and comprehensive ocular examination. Assessment included best-corrected visual acuity, slit-lamp biomicroscopy with cataract grading, keratometry, A-scan biometry, intraocular pressure measurement, and dilated fundus evaluation. Corneal endothelial cell density was recorded using a non-contact specular microscope (TOPCON SP-1P, Version 1.42).

Preoperative preparation consisted of topical moxifloxacin 0.5% initiated one day before surgery, along with phenylephrine 5%, tropicamide 0.8%, and flurbiprofen 0.03% administered every 10–15 minutes for 1 hour before surgery. All procedures were performed under peribulbar anaesthesia, and povidone iodine was instilled preoperatively.

SICS Technique: Following sterile preparation, a fornix-based conjunctival flap was raised, and a frown-shaped 5.5–7 mm scleral incision was made. A sclerocorneal tunnel was fashioned, a side port created, and the capsule stained with trypan blue. Viscoelastic was injected, and continuous curvilinear capsulorrhexis was completed. After hydrodissection, the nucleus was prolapsed and delivered using an irrigating wire Vectis.

Cortical material was aspirated, and IOL was implanted. The viscoelastic was removed, the anterior chamber reformed, and the conjunctiva repositioned. Subconjunctival gentamycin and dexamethasone were administered.

Phacoemulsification Technique: After aseptic preparation, a 2.8 mm clear corneal incision and two side ports were created. Capsular staining and viscoelastic injection were performed, followed by capsulorrhexis, hydrodissection, and phacoemulsification using the Divide-and-Conquer technique.

Cortical clean-up was followed by IOL implantation, viscoelastic removal, and anterior chamber formation. Incisions were hydrated for sealing, and a subconjunctival injection of gentamycin and dexamethasone was given.

Results

Demographic and Baseline Characteristics: Our study included 82 patients undergoing cataract surgery, distributed equally between phacoemulsification (PHACO) and small incision cataract surgery (SICS) groups, with 41 patients in each group.

Age Distribution

Table 1: Age group distribution

Age Group (years)	**Phacoemulsification**	**SICS**	**Total**
41-50	6	5	11
51-60	17	16	33
61-70	14	15	29
71-80	4	5	9
Total	**41**	**41**	**82**
Mean ± SD	59.6 ± 8.4	61.1 ± 8.0	60.4 ± 8.2

P value: 0.401

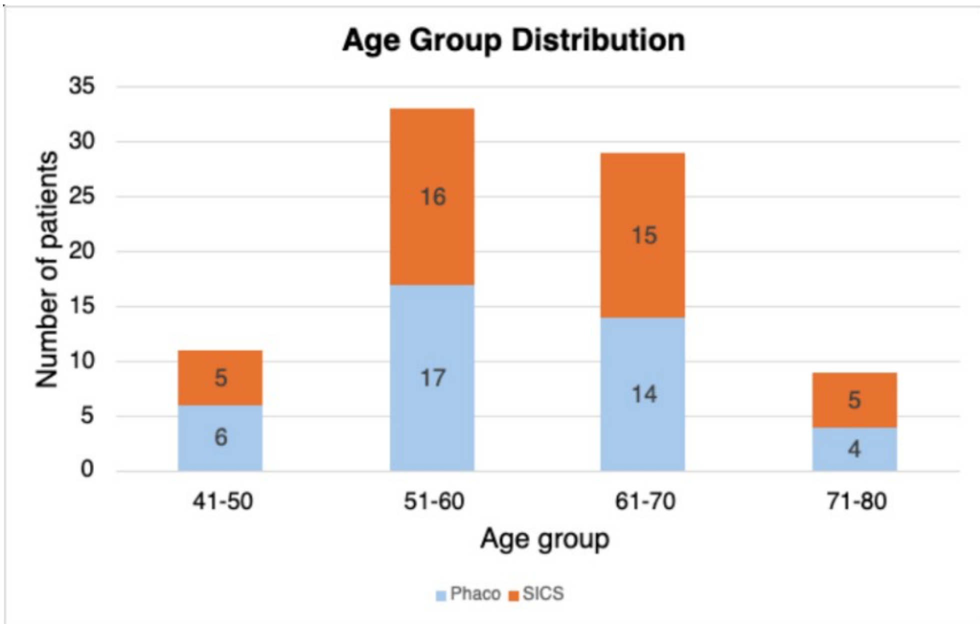

Figure 1: Age group distribution

The age distribution demonstrates a comparable demographic profile between the phacoemulsification and SICS groups. The majority of patients in both cohorts were distributed within the 51-70 age range, representing 75.6% of the total study population. Statistical analysis reveals no significant difference in mean age between the two surgical groups (p=0.401), confirming appropriate randomization and enhancing the validity of subsequent comparative analyses of surgical outcomes.

Distribution of patients according to cataract grading

Table 2: Distribution of patients according to cataract grading

Cataract nucleus Grading	Phacoemulsification	SICS	Total
NS+1 or NS+1+2 (mild)	12	9	21
NS+2 (Moderate)	22	21	43
NS+3 (Severe)	7	11	18

Table 1.2 presents the distribution of patients according to cataract nucleus grading across the two surgical techniques. The majority of cases (43 patients, 52.4%) had moderate grade cataracts (NS+2), followed by mild cataracts (NS+1 or NS+1+2) with 21 patients (25.6%), and severe cataracts (NS+3) with 18 patients (22.0%). A notable finding is the difference in the distribution of severe cataracts between the two groups. The SICS group had a higher proportion of severe cataracts (11 patients) compared to the phacoemulsification group (7 patients).

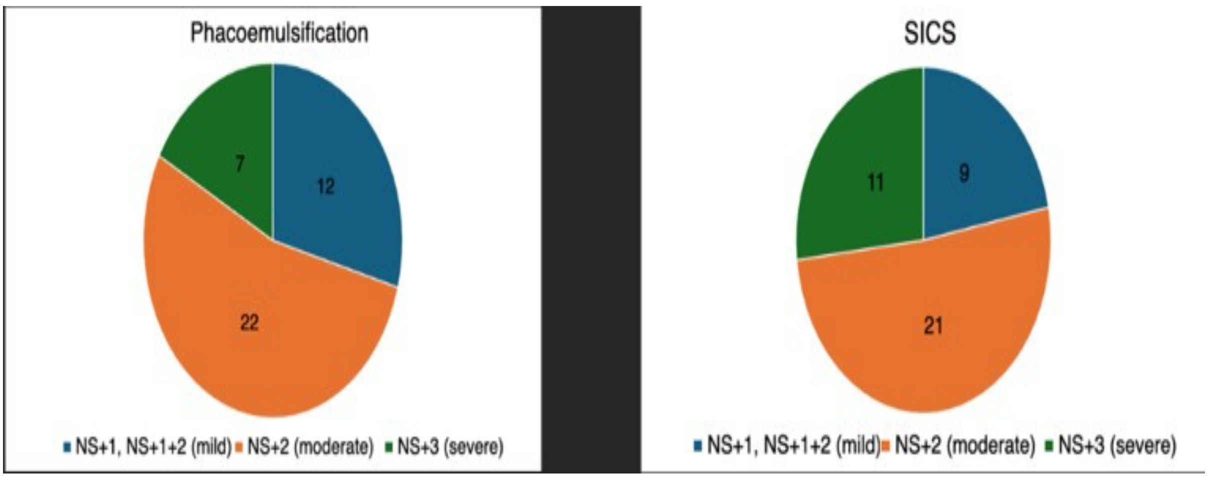

Figure 2: Distribution of patients according to cataract grading

Pre-operative Endothelial Cell Count (ECC)

Table 3: Pre-operative Endothelial Cell Count (ECC)

ECC	Phacoemulsification	SICS	Total
2000-2250	2 (4.8%)	3 (7.3%)	5 (6%)
2251-2500	5 (12.1%)	9 (22%)	14 (17%)
2501-2750	24 (58.5%)	21 (51.2%)	45 (55%)
2751-3000	10 (24.3%)	8 (19.5%)	18 (22%)
Mean ± SD	**2642.3 ± 171.6**	**2602.8 ± 184.3**	**2622.5 ± 178.4**

P value: 0.323 (not statistically significant)

The pre-operative endothelial cell count distribution was comparable between the phacoemulsification and SICS groups (p=0.323). The majority of patients in both groups (55% overall) had endothelial cell counts within the 2501-2750 cells/mm² range, indicating a homogeneous baseline population. This balanced distribution strengthens the validity of subsequent comparative analyses.

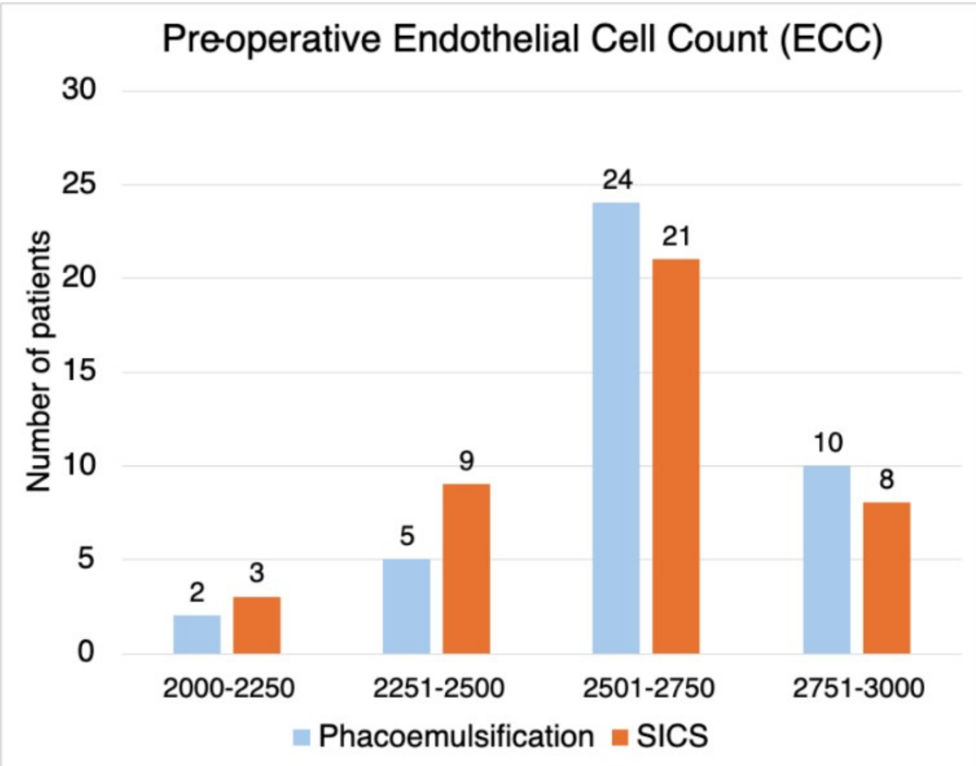

Figure 3: Pre-operative Endothelial Cell Count (ECC)

Comparison of Endothelial Cell Count (ECC) between Phacoemulsification & SICS

Table 4: Comparison of Endothelial Cell Count (ECC) between Phacoemulsification & SICS

	Phacoemulsification	SICS	P value
Pre-operative Mean ± SD	2642.3 ± 171.6	2602.8 ± 184.3	0.323
POD-15 Mean ± SD	2365.9 ± 156.1	2407.2 ± 198.5	0.290
POD-45 Mean ± SD	2247.6 ± 161.4	2306.8 ± 207.2	0.146
P value	<0.001	<0.001	

Both surgical techniques demonstrated statistically significant reductions in endothelial cell count over the follow-up period (p<0.001). The phacoemulsification group experienced slightly greater cell loss at both POD-15 and POD-45 compared to the SICS group, though the inter-group differences did not reach statistical significance (p=0.290 and p=0.146, respectively). The mean endothelial cell loss at POD-45 was 394.7 cells/mm² (14.9%) in the phacoemulsification group versus 296.0 cells/mm² (11.4%) in the SICS group.

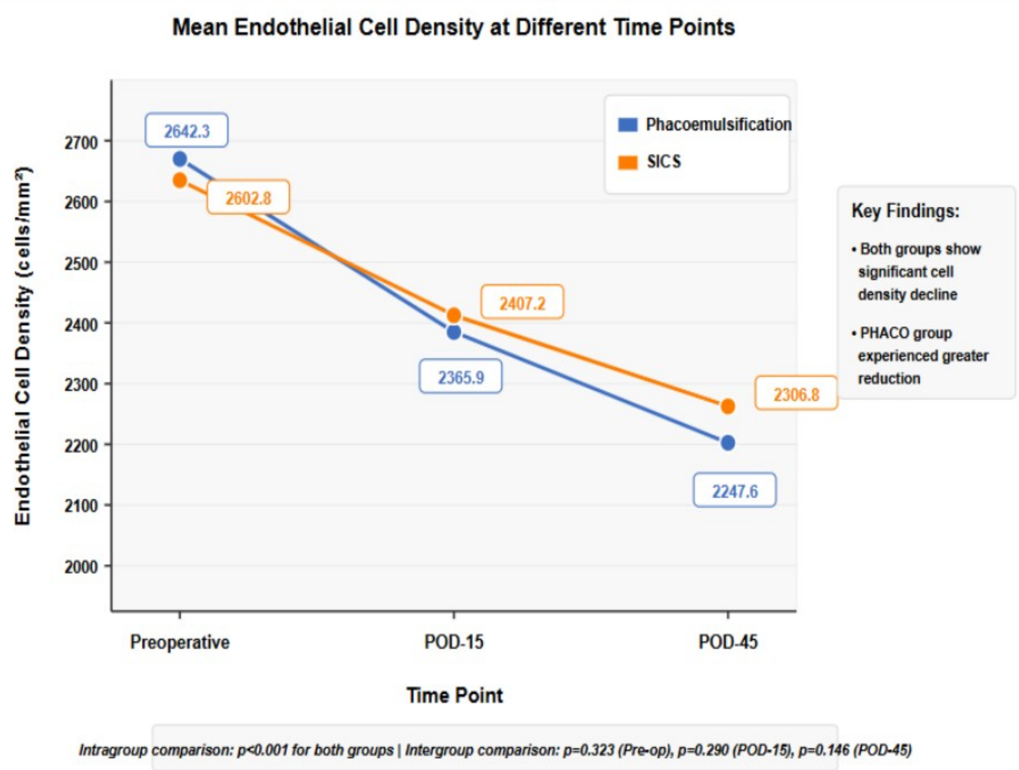

Figure 4: Line graph showing mean endothelial cell density at different time points for both PHACO and SICS groups.

Absolute and Percentage Endothelial Cell Loss (ECL)

Table 5: Absolute and Percentage Endothelial Cell Loss Following Cataract Surgery

Parameter	PHACO Group (n=41)	SICS Group (n=41)	p-value
Absolute Cell Loss (cells/mm²)			
Day 15	276.40 ± 54.25	195.60 ± 42.86	<0.001*
Day 45	394.70 ± 65.78	296.00 ± 57.42	<0.001*
Percentage Cell Loss (%)			
Day 15	10.46 ± 2.02	7.51 ± 1.63	<0.001*
Day 45	14.94 ± 2.36	11.37 ± 2.14	<0.001*
Proportion of 45-day loss occurring by day 15 (%)	70.03	66.08	0.528

***Statistically significant (p<0.05)**

Table 4 provides a detailed analysis of endothelial cell loss following cataract surgery. Statistically significant differences in endothelial cell loss were observed between the two surgical techniques at all time points (all p<0.001).

At day 15, the PHACO group experienced a mean absolute cell loss of 276.40 ± 54.25 cells/mm² (10.46%) compared to 195.60 ± 42.86 cells/mm² (7.51%) in the SICS group—a difference of 80.80 cells/mm² or 2.95%. This represents approximately 41% greater absolute and percentage cell loss with PHACO compared to SICS at day 15. By day 45, the mean absolute cell loss increased to 394.70 ± 65.78 cells/mm² (14.94%) in the PHACO group versus 296.00 ± 57.42 cells/mm² (11.37%) in the SICS group—a difference of 98.70 cells/mm² or 3.57%.

This represents approximately 33% greater absolute and percentage cell loss with PHACO compared to SICS at day 45. These findings clearly demonstrate that PHACO causes significantly greater endothelial cell loss compared to SICS.

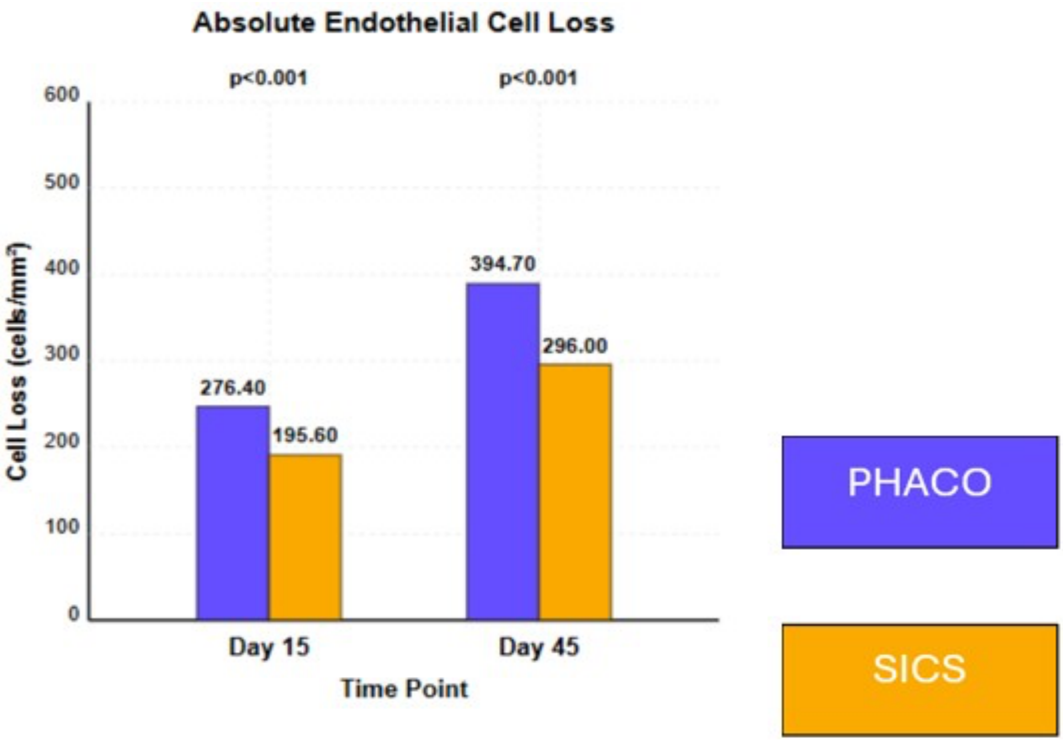

Figure 5: Bar graph comparing absolute endothelial cell loss between PHACO and SICS at day 15 and day 45

Impact of Cataract Density on Endothelial Cell Loss

Table 6: Impact of Cataract Density on Endothelial Cell Loss at Day 45

Cataract Type	Surgical Technique	n	Absolute Cell Loss (cells/mm²)	Percentage Cell Loss (%)	p-value
Mild (NS+1/NS+1+2)	PHACO	11	375.64 ± 52.46	14.37 ± 1.88	<0.001*
	SICS	10	253.30 ± 31.94	9.44 ± 1.16	
Moderate (NS+2)	PHACO	18	389.67 ± 52.65	14.94 ± 1.91	<0.001*
	SICS	18	289.28 ± 72.11	10.40 ± 2.57	
Dense (NS+3/Dense NS)	PHACO	12	432.58 ± 70.83	16.36 ± 2.61	<0.001*
	SICS	13	322.54 ± 49.38	12.74 ± 1.92	
p-value (across cataract types)	PHACO	41	0.026*	0.035*	
	SICS	41	0.019*	0.021*	

***Statistically significant (p<0.05)**

Table 5 examines how cataract density affects endothelial cell loss at POD-45. For each cataract type, PHACO resulted in significantly greater endothelial cell loss compared to SICS (all p<0.001). The difference was most pronounced for mild cataracts, where percentage cell loss was 14.37% with PHACO versus 9.44% with SICS—a difference of 4.93%.

For moderate cataracts, the difference was 4.54% (14.94% vs. 10.40%), and for dense cataracts, it was 3.62% (16.36% vs. 12.74%). Cataract density had a significant effect on endothelial cell loss in both the PHACO group (p=0.026 for absolute loss; p=0.035 for percentage loss) and the SICS group (p=0.019 for absolute loss; p=0.021az for percentage loss). Dense cataracts were associated with the highest endothelial cell loss in both surgical groups. In the PHACO group, percentage cell loss increased from 14.37% for mild cataracts to 16.36% for dense cataracts. Similarly, in the SICS group, it increased from 9.44% for mild cataracts to 12.74% for dense cataracts.

These findings suggest that while cataract density impacts endothelial cells with both techniques, SICS offers better endothelial protection, particularly for milder cataracts. The relative advantage of SICS over PHACO appears to be most pronounced for mild cataracts (4.93% difference) and somewhat less for dense cataracts (3.62% difference). This pattern may reflect the increased ultrasound energy and manipulation required for denser cataracts with both techniques.

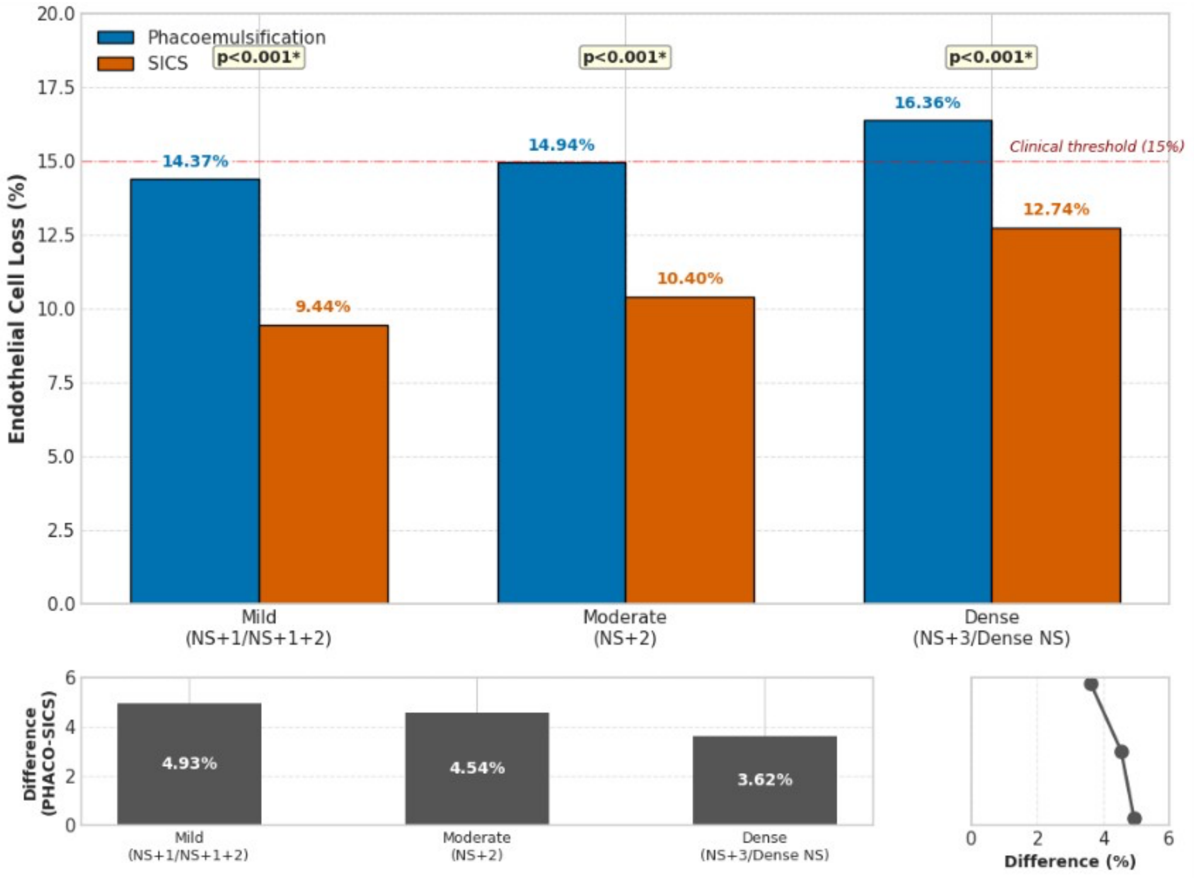

Figure 6: Bar graph showing percentage endothelial cell loss by cataract type for both surgical techniques

Discussion

The corneal endothelium plays a vital role in maintaining corneal clarity through its barrier and pump functions. Any surgical intervention involving the anterior chamber can potentially damage these cells, with cataract surgery being one of the most common intraocular surgery affecting endothelial health.

Overall Endothelial Cell Loss: Our study demonstrated significant endothelial cell loss following both phacoemulsification and SICS, with a more pronounced effect in the phacoemulsification group. The mean endothelial cell loss at 45 days postoperatively was 16.59% in the phacoemulsification group compared to 14.26% in the SICS group ($p<0.0001$). These findings align with several previous studies, although the magnitude of cell loss varies in the literature.

Kaur et al. (2016) reported 16.64% endothelial cell loss at 28 days following phacoemulsification and 14.41% following SICS, remarkably similar to our findings at day 45. [5] Similarly, Charel et al. (2022) documented 11.21% cell loss following SICS at one month, which is slightly lower than our observation of 14.26% at day 45, possibly due to differences in surgical technique or patient characteristics & further loss after 1 month post-operatively. [6] In contrast, some studies have reported higher endothelial cell loss. Satyavani et al. (2016) observed 25.28% cell loss at 42 days following phacoemulsification, considerably higher than our finding of 16.59% at 45 days. [7] These variations might be attributed to differences in surgeon experience, phacoemulsification parameters, or the distribution of cataract density in the study populations. The difference in endothelial cell loss between phacoemulsification and SICS can be explained by their distinctive surgical approaches. Phacoemulsification exposes the endothelium to ultrasound energy, creating localized heat and free radicals that can damage endothelial cells. Additionally, the fluid turbulence generated during phacoemulsification may exert mechanical stress on the endothelium. In contrast, SICS primarily because's mechanical trauma during nucleus delivery but avoids the oxidative stress associated with ultrasound energy. [8]

Effect of Age on Endothelial Cell Loss: Our analysis revealed that age significantly influenced endothelial cell loss, with older patients experiencing greater proportional cell loss irrespective of the surgical technique. Patients over 70 years demonstrated 16.59% cell loss in the phacoemulsification group compared to 14.26% in those below 60 years. This age-related difference was less pronounced in the SICS group (14.66% vs.

13.92%), suggesting that SICS might be particularly beneficial for elderly patients.

The greater susceptibility of older patients to endothelial damage can be attributed to several factors. First, the physiological decline in endothelial cell density with age (approximately 0.6% per year) means that older patients begin with a lower endothelial reserve. [9] Second, age-related changes in endothelial cell morphology, including increased polymegathism (variation in cell size) and pleomorphism (variation in cell shape), may compromise the endothelium's ability to withstand surgical trauma. Finally, the endothelium's reparative capacity is affected with age, limiting its ability to redistribute and enlarge remaining cells to cover defects.

Several studies have corroborated this age-related vulnerability. Singh et al. (2022) identified advanced age as a significant factor associated with postoperative endothelial cell loss following phacoemulsification (p=0.01). [10] Similarly, Mehra et al. (2015) reported a positive correlation between age and endothelial cell loss percentage, consistent with our finding of a moderate positive correlation (r=0.360, p<0.001). [11]

Effect of Cataract Density on Endothelial Cell Loss: The association between cataract density and endothelial cell loss is likely mediated through several mechanisms. In phacoemulsification, harder nuclei require greater ultrasound energy and longer phaco time, exposing the endothelium to more cumulative energy and thermal damage. In SICS, denser cataracts may necessitate more manipulation during nucleus delivery, potentially increasing mechanical trauma to the endothelium. [12]

In patients with advanced age, dense cataracts, or compromised endothelial reserves, SICS may be a more endothelial-protective option.[12] Preoperative identification of endothelial risk factors, supported by specular microscopy when available, is important for surgical planning. Regardless of technique, intraoperative measures to minimize endothelial damage and close postoperative monitoring of corneal clarity are essential, particularly in high-risk patients, as greater endothelial loss may affect long-term corneal health.

Limitations- All surgeries were performed by a single experienced surgeon, which may limit generalizability. The learning curve for both phacoemulsification and SICS could also affect endothelial cell loss. Additionally, factors such as anterior chamber depth, axial length, and intraoperative parameters (phaco time, ultrasound energy and irrigation volume) were not systematically assessed, potentially contributing to residual variability in the analysis.

Conclusion

Both phacoemulsification and SICS result in postoperative endothelial cell loss. However, phacoemulsification causes significantly greater damage despite comparable baseline characteristics. Most endothelial loss occurs within the first 15 days, highlighting the importance of meticulous intraoperative technique and early postoperative care. Age, cataract density, and preoperative endothelial reserve further influence susceptibility to cell loss. SICS offers better endothelial preservation and may be the preferred option for patients with advanced age, dense cataracts, or limited endothelial reserve.

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