Original Article

Determination and Comparison of Corneal Endothelial Cell Changes in Phakic and Pseudophakic Patients Undergoing Vitrectomy with Silicone Oil Tamponade

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ABSTRACT

Purpose: To determine and compare corneal endothelial cell changes between phakic and pseudophakic patients undergoing vitrectomy with silicone oil tamponade.

Study Design: Quasi-experimental study.

Place and Duration of Study: Retina Eye Clinic, POB Eye Hospital, from December 2024 to May 2025.

Methods: Fifty-six patients aged 18 to 65 years undergoing pars plana vitrectomy (PPV) with silicone oil tamponade were included. They were divided into phakic and pseudophakic groups. Pars Plana Vitrectomy was done with 1000 centistoke silicone oil. Endothelial cell density (ECD) was measured using specular microscopy preoperatively and postoperatively on day 1, at 1 month, and at 3 months.

Results: The mean preoperative ECD was 2554.20 ± 127.36 cells/mm². On postoperative day 1, it decreased to 2495.25 ± 134.41 cells/mm², further declining to 2422.16 ± 141.22 cells/mm² at 1 month, and 2334.11 ± 152.09 cells/mm² at 3 months. Repeated measures ANOVA indicated a statistically significant effect of time on ECD ($F(3,52) = 1083.86$, $p<0.001$), as well as a significant interaction between time and lens status ($F(3,52) = 61.23$, $p<0.001$). Pseudophakic eyes exhibited a greater degree of endothelial cell loss compared to phakic eyes. Stratified analysis showed that age significantly influenced ECD loss, with older pseudophakic patients experiencing greater damage. Gender did not significantly modify the trend.

Conclusion: Pseudophakia is associated with greater endothelial damage. This highlights the importance of lens status in surgical planning and postoperative management, particularly in elderly patients.

Keywords: Corneal Endothelium, Endothelial Cell Loss, Pars Plana Vitrectomy, Pseudophakia, Phakia, Specular Microscopy, Silicone Oil.

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INTRODUCTION

During the last several years, vitreoretinal surgery has undergone remarkable progress, enabling ophthalmologists to effectively manage retinal disorders that were once considered incurable. A pivotal element in this surgical field is silicone oil, a dense, transparent, and biologically compatible substance that has proven to be vital in the treatment of various complex retinal conditions.[1] Its indications include retinal detachment, macular hole and advanced diabetic eye disease, especially in cases where standard gas tamponades fail to provide sufficient long-term support.[2,3]Once injected, silicone oil provides an internal tamponade by gently pressing retina against underlying retinal pigment epithelium (RPE), aiding in the anatomical restoration. Depending on individual case requirements, the oil may

be retained within the eye for several weeks, months, or indefinitely. Despite the high anatomical success rates and therapeutic value of silicone oil, it is not without complications.[4] One significant concern is the toxic or mechanical damage to the corneal endothelium, potentially leading to corneal edema and visual deterioration.[5]

Corneal endothelium is vital for preserving corneal clarity by continuously pumping excess fluid out of the corneal stroma. However, these cells have minimal regenerative capacity.[6] A decrease in endothelial cell count below a certain threshold compromises the transparency, eventually resulting in pseudophakic bullous keratopathy (PBK) or persistent corneal edema.[7] Consequently, preserving endothelial integrity during intraocular procedures involving silicone oil is of utmost importance.

A crucial anatomical factor affecting endothelial integrity is the status of the lens.[8] In phakic eyes, silicone oil movement into the anterior chamber is restricted.[9] Conversely, in pseudophakic, especially those with damaged posterior capsule or history of posterior capsulotomy, silicone oil can more readily migrate into anterior chamber, increasing the likelihood of direct interaction with the endothelium.

Silicone oil related injury to the endothelium can result from multiple mechanisms.[10] The most direct is mechanical, when silicone oil accumulates within the anterior chamber, it physically contacts and impairs endothelial cells.[11] Additionally, the oil alters the intraocular environment by trapping inflammatory cytokines, blocking oxygen diffusion, and affecting the chemical composition of the aqueous humour. Over time, silicone oil may emulsify into microdroplets, which are more likely to migrate anteriorly, physically abrading and further damaging endothelial cells.

Eyes with preexisting ocular diseases are especially prone to endothelial complications following silicone oil tamponade.[12] Conditions like glaucoma[13], prior intraocular surgeries, and endothelial dystrophies compromise endothelial reserves. In such patients, even minor additional trauma can precipitate irreversible corneal decompensation. PPV with silicone oil is also associated with endothelial cell loss.[14]Therefore, preoperative assessment using tools like specular microscopy is essential for quantifying endothelial cell density (ECD), analysing cell morphology, and anticipating potential postoperative risks.

There is a need to deepen our understanding of how lens status influences postoperative endothelial outcomes. This study was designed to investigate and compare changes in corneal endothelial cell density between phakic and pseudophakic patients undergoing vitrectomy with silicone oil tamponade. Through specular microscopy, we aim to quantify the degree of endothelial damage and evaluate the role of anatomical and procedural factors in influencing endothelial outcomes.

METHODS

This quasi-experimental study was conducted at the Retina Eye Clinic of POB Eye Hospital for six months. Patients undergoing PPV with silicone oil tamponade at the vitreoretinal department of POB Eye Hospital were included by non-probability convenient sampling technique. Sample size estimation was carried out through OpenEpi, based on an anticipated mean endothelial cell loss of 30.48 ± 25.78,[15] with a power of 80%, confidence interval (CI) of 95%, and a margin of error of 7%. The resulting sample size was 56 Patients.

Patients of either gender, 18 - 65 years of age, undergoing PPV with silicone oil (1000 centistoke), either phakic or pseudophakic were included and followed up for a minimum of three months. Patients with a history of previous retinal surgery, coexisting ocular comorbidities such as glaucoma or other anterior/posterior segment diseases, any intraoperative or postoperative complications, including but not limited to silicone oil migration into the anterior chamber were excluded.

Following ethical approval from the Institutional Ethical Review Committee **(ERB-POB-002/2025),** patients meeting the inclusion criteria were enrolled after obtaining written informed consent. Each patient underwent a complete preoperative ophthalmic assessment including, detailed medical and surgical history, slit lamp examination and baseline corneal endothelial cell density via non-contact specular microscopy. All patients underwent standard three-port pars plana vitrectomy with 1000 centistoke silicone oil tamponade. Patients were followed postoperatively at specified intervals (1st day, 1st month and 3rd month), during which endothelial cell counts were recorded again using the same specular microscope to evaluate changes over time. All data were recorded in a predesigned structured proforma. SPSS version 27.0 was employed for data management and analysis. Continuous variables such as age and endothelial cell density were summarized using mean, median, standard deviation, and range. Categorical variables, including gender and lens status, were presented as frequencies and percentages.

The Shapiro-Wilk test was applied to assess normality. Repeated measures ANOVA was used to

compare the endothelial cell density changes between

Table 1: *Descriptive Statistics.*

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	56	39	26	65	50.75	11.556
Pre-op ECD	56	528	2253	2781	2554.20	127.357
Post-op Day 1	56	550	2199	2749	2495.25	134.409
Post-op Month 1	56	587	2127	2714	2422.16	141.221
Post-op Month 3	56	617	2044	2661	2334.11	152.088
Valid N (listwise)	56					

SD = standard deviation; ECD = endothelial cell density

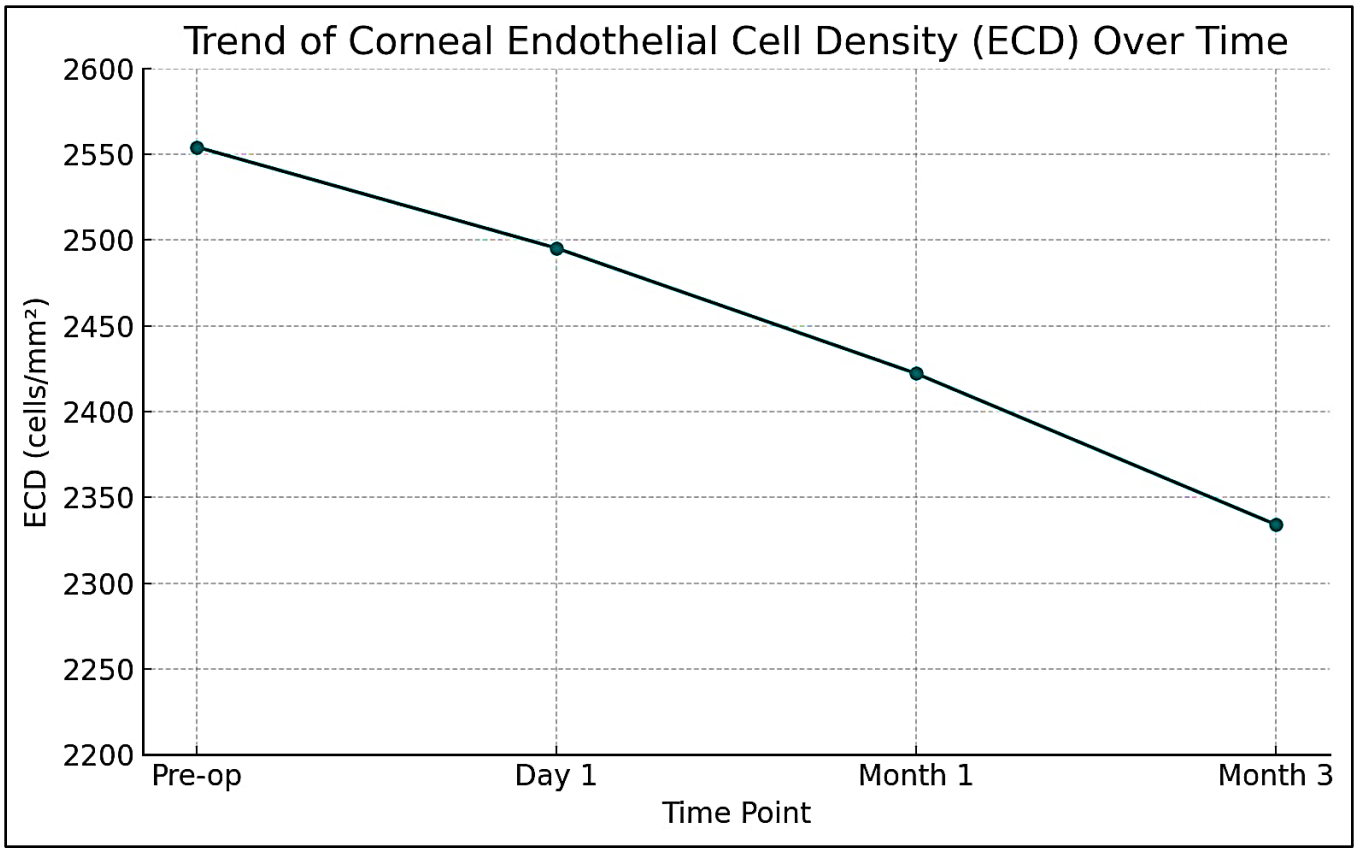

Figure 1: Trend of mean endothelial cell density (ECD) decline at baseline, day 1, month 1, and month 3 following vitrectomy with silicone oil tamponade.

phakic and pseudophakic groups over time. Stratification was performed to control for potential effect modifiers such as age and gender. Post-stratification differences were also conducted using independent sample t-tests based on the distribution of the stratified data. A p-value ≤ 0.05 was considered statistically significant for all analyses.

RESULTS

There were 56 patients, 30 (53.6%) phakic and 26 (46.4%) pseudophakic with a mean age of 50.75 ± 11.56 years (range: 26–65 years). Study population showed an equal distribution of gender (50% male, 50% female). Most patients (82.1%) were from rural areas, while 17.9% resided in urban settings. There were 53.6% right and 46.4% left eyes.

The mean preoperative corneal ECD was 2554.20 ± 127.36 cells/mm². Postoperative assessments revealed a progressive decline in ECD over time:

Table 1 demonstrates a gradual reduction in endothelial cell density following PPV with silicone oil tamponade. The overall decrease from baseline to three months postoperatively was approximately 220 cells/mm², corresponding to an 8.62% reduction from

baseline, suggesting a time-dependent endothelial cell loss in the initial postoperative period. (Figure 1).

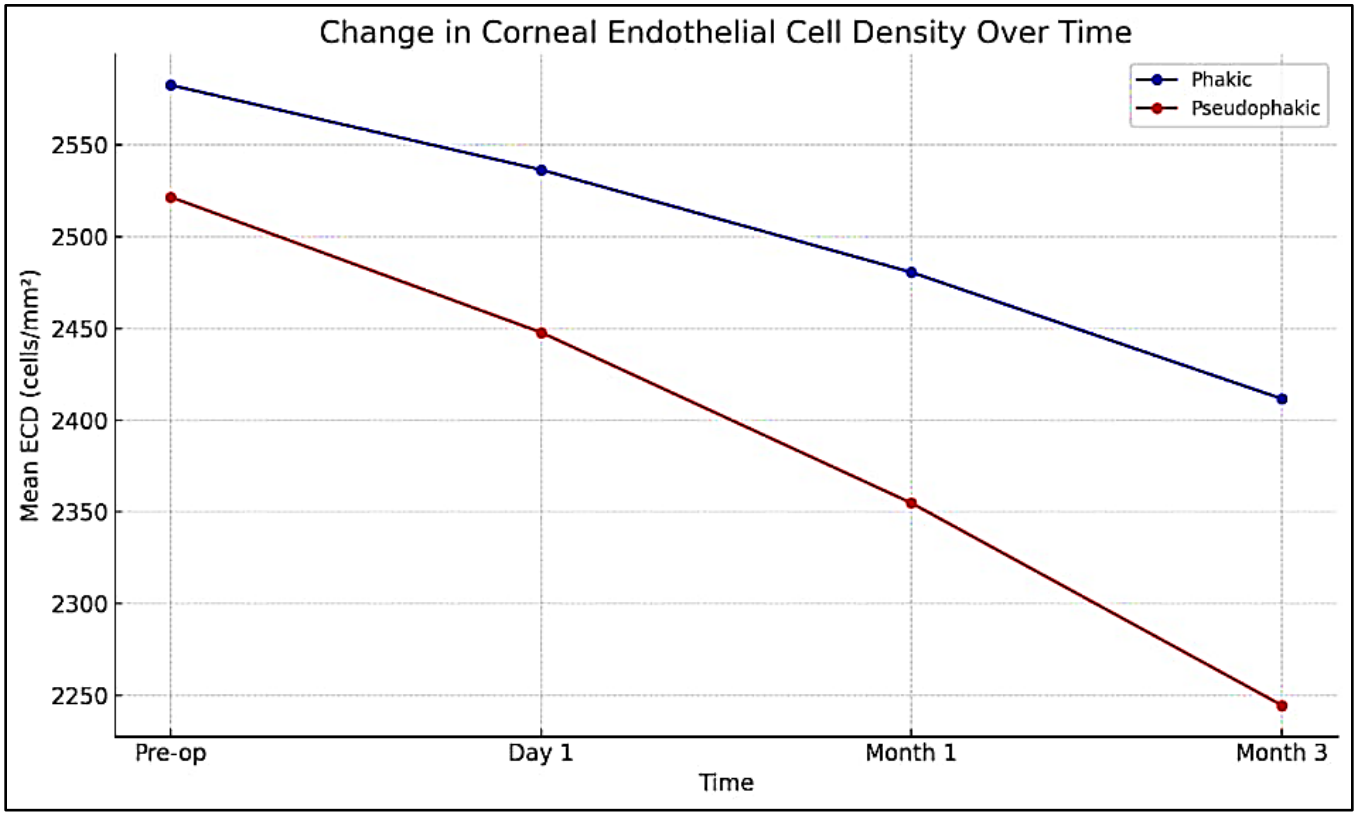

Figure 2: Change in corneal endothelial cell density (ECD) over time in phakic and pseudophakic patients. Both groups demonstrate progressive postoperative decline; however, pseudophakic eyes show a steeper and more pronounced reduction across the three-month follow-up period.

The distribution of the preoperative and postoperative ECD values were assessed for normality using the Shapiro–Wilk test. The results showed that all variables (Pre-op ECD and Post-op Month 3 ECD) were approximately normally distributed for both phakic and pseudophakic groups ($p > 0.05$), supporting the use of parametric tests for additional analysis.

Results showed a statistically significant main effect of time on ECD, $F(3, 52) = 1083.86$, $p < 0.001$, with a large effect size (Partial $Eta^2 = 0.984$), indicating a consistent decline in endothelial cell density following PPV with silicone oil tamponade. There was also a statistically significant interaction between time and lens status, $F(3, 52) = 61.23$, $p < 0.001$, Partial $Eta^2 = 0.779$, demonstrating that the pattern of endothelial loss varied significantly between phakic and pseudophakic patients. The between-subjects effect of lens status on average ECD across time points was also significant, $F(1, 54) = 10.68$, $p = 0.002$, Partial $Eta^2 = 0.165$ (Figure 2).

Subgroup analysis stratified by age revealed thatpseudophakic patients experienced significantly greater endothelial cell loss than phakic patients in both younger and older age groups. The difference was particularly marked in older individuals, with a large effect size (Cohen's $d = 1.47$), indicating that advancing age may amplify the susceptibility of pseudophakic corneas to silicone oil-related damage.

Gender-stratified analysis revealed that within both male and female subgroups, pseudophakic eyes had significantly lower endothelial cell density at 3 months compared to phakic eyes. The magnitude of the difference was similar across genders, indicating no independent effect of gender on endothelial cell loss (phakic group: $p = 0.412$; pseudophakic group:$p = 0.356$).

DISCUSSION

We explored the association between lens status and changes in corneal endothelial cell density following

PPV using silicone oil as a tamponade. A significant time-dependent decrease in ECD was evident, with greater endothelial damage observed in pseudophakic eyes than in phakic eyes. These findings are consistent with existing literature and provide important clinical implications for vitreoretinal surgeons.[14,15] The trend highlights the cytotoxic potential of silicone oil on the corneal endothelium, particularly with prolongedintraocular retention.

A growing body of literature indicates that pseudophakic eyes are more susceptible to endothelial loss after silicone oil use compared to phakic eyes. For instance, Goezinne et al,[14] reported that within 12 weeks of surgery, pseudophakic patients showed approximately 19% loss compared to minimal change in phakic eyes. These findings have been corroborated by Shaheer[15] and Hannan[16]who emphasized the heightened vulnerability of pseudophakic eyes, particularly those with compromised posterior capsules. These insights have direct clinical implications in terms of surgical approach, tamponade selection, and patient monitoring.[17]

Literature shows that the effect of silicone oil on corneal endothelium depends on the lens status as well.[18,19]The impact of emulsification timing, and whether certain surgical techniques or IOL designs may mitigate endothelial damage in pseudophakic patients is also studied.[20,21] Moreover, as the population ages and the frequency of cataract surgery increases, the number of pseudophakic patients undergoing retinal surgery is likely to rise.[22] This makes it even more crucial to investigate how best to preserve corneal clarity in this growing patient population.

The greater endothelial loss in pseudophakic eyes may be explained by the absence of the crystalline lens as a protective barrier, facilitating silicone oil migration toward the anterior segment. Although silicone oil contact with the endothelium is a recognized cause of endothelial damage, it should be noted that eyes with anterior chamber silicone oil were excluded from our analysis; therefore, our findings specifically reflect uncomplicated posterior segment tamponade cases without anterior migration of silicone oil.

Age stratification further highlighted that older patients experienced significantly greater endothelial cell loss, particularly among pseudophakic individuals. This supports the notion that aging corneal endothelium has reduced regenerative capacity and resilience against stressors such as intraocular silicone oil. This finding is critical for surgical planning and postoperative monitoring, suggesting that older pseudophakic patients should be considered high-risk and may benefit from shorter durations of tamponade or alternative tamponade agents.

Gender-based stratification, however, did notshow a modifying effect on ECD loss. While both male and female patients exhibited significantly higher endothelial loss in pseudophakic eyes, the consistency of this pattern across genders indicates that gender does not significantly interact with lens status in influencing ECD outcomes.

Our study aligns closely with previous research in this field. Notably, Goezinne et al,[14] investigated the impact of silicone oil tamponade on corneal endothelial health following vitrectomy for retinal detachment. They assessed parameters such as ECD, cell morphology (hexagonality and coefficient of variation), and corneal thickness at3, 6, and 12-months post-surgery. The results demonstrated that prolonged exposure to silicone oil leads to a decline in ECD, increased cell size variability, and morphological distortion. The study stratified patients based on lens status and found that the greatest endothelial loss occurred in aphakic (39.2%) and in pseudophakic that had undergone cataract extraction during follow-up (19.2%). The authors emphasized the protective role of an intact lens–iris diaphragm in minimizing silicone oil-induced endothelial damage.

The findings of our study reinforce the importance of lens status in determining postoperative outcomes following PPV with silicone oil. Given that pseudophakic eyes are more vulnerable to endothelial damage, measures such as early silicone oil removal and careful patient selection are warranted. Additionally, surgeons should consider preserving the natural lens where feasible in younger patients or those at higher risk for corneal decompensation. In cases with visually significant cataract, lens extraction may be strategically timed at the stage of oil removal rather than during primary surgery to minimize endothelial exposure to silicone oil. This approach is particularly beneficial in patients with good visual potential or older age groups, thereby helping to maintain long-term corneal clarity and visual function.

The limitations of this study are the small number of participants, and the research was conducted at a single tertiary eye care facility, which may restrict the broader applicability of the results. Secondly, the follow-up period was three months, which did not allow for the evaluation of potential long-term endothelial cell recovery or progressive deterioration. Although endothelial cell density was assessed, other important indicators of endothelial health, such as pleomorphism and polymegathism were not included in the analysis, limiting a more comprehensive understanding of corneal

endothelial morphology. Future studies with larger samples, longer follow-up, and inclusion of anterior chamber migration cases are needed to better understand long-term endothelial changes and the influence of posterior capsule integrity.

CONCLUSION

Pseudophakic eyes are at a significantly greater risk of endothelial cell loss following PPV with silicone oil tamponade. The natural lens in phakic eyes appears to offer a protective barrier against silicone oil, mitigating endothelial damage. Age emerged as a significant effect modifier, with older patients, particularly those who are pseudophakic, experiencing the most substantial endothelial decline. Gender did not significantly influence outcomes. This highlights the importance of individualized surgical planning and postoperative management, especially in older, pseudophakic patients.

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Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(POB-ERB No. 002/2025)**.

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