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Article

Role of Air Bubble in Cornea after Phaco-Emulsification Surgery

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Abstract

Introduction: *Phacoemulsification is the most commonly performed procedure for cataract removal and has revolutionized modern cataract surgery due to its rapid visual recovery and minimal complications. However, postoperative corneal edema and delayed visual rehabilitation remain concerns. This study aimed to evaluate the role of an intracameral air bubble in improving early postoperative corneal outcomes.*

Methods: *This prospective comparative study was conducted in the Department of Ophthalmology from July 2024 to July 2025 and included 86 eyes of 86 patients undergoing uncomplicated phacoemulsification with posterior chamber intraocular lens (PCIOL) implantation. Patients were randomly assigned into two groups: Group A (n=43), where the anterior chamber was reformed with a small intracameral air bubble (20–25% fill) at the end of surgery, and Group B (n=43), where balanced salt solution (BSS) was used without air. Data were analyzed using SPSS version 26.0.*

Result: *In 86 eyes, intracameral air bubble significantly reduced early postoperative corneal thickness (Day 1: 560.1 μm vs 589.7 μm; Day 7: 545.4 μm vs 563.2 μm) and improved early corneal clarity (65.1% vs 39.5%) compared to BSS, with minimal endothelial cell loss (~3.7% vs 3.6%) and only transient Day 1 IOP elevation (16.1 vs 14.7 mmHg). Persistent oedema beyond 1 week was lower in the air group (4.7% vs 13.9%).*

Conclusion: *The use of an intracameral air bubble at the end of phacoemulsification surgery provides significant early benefits, including reduced central corneal thickness, faster recovery of corneal clarity, and decreased incidence of persistent postoperative oedema, without causing additional endothelial cell loss. Although a transient elevation in intraocular pressure may occur on the first postoperative day, it resolves spontaneously and does not compromise safety.*

Keywords: Phaco-Emulsification, Cornea, Air Bubble, Descemet Membrane

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Introduction

Intracameral air has become an adjunctive manoeuvre in modern cataract and anterior segment surgery with multiple proposed roles related to corneal health and early postoperative recovery. Immediately after phacoemulsification, a small air bubble placed in the anterior chamber can act as a mechanical tamponade that opposes and re-apposes detached Descemet membrane, speeds deturgescence in localized corneal oedema, and temporarily alters the fluid-stroma equilibrium at the posterior corneal surface[1–3]. Descemetopexy with 100% air is a widely used first-line intervention for surgically induced Descemet membrane detachment (DMD): case series and cohort studies report high anatomic reattachment rates and rapid clearing of corneal oedema after air descemetopexy, often avoiding keratoplasty when performed early[1,2,4]. For occult or focal DMD presenting as persistent pseudophakic corneal oedema, timely recognition and air tamponade have been shown to restore corneal clarity and visual function in many reported cases[5]. Physiologically, intracameral air influences corneal thickness and endothelial pump-function kinetics. Recent ex vivo and donor-eye experiments indicate that an anterior chamber air bubble can accelerate corneal deturgescence and reduce central corneal thickness (CCT) rapidly, thereby improving intraoperative and immediate postoperative visualization when stromal swelling is limiting the view[6]. These findings support earlier clinical observations of reduced day-one oedema where an air bubble was used to reform the chamber. Mechanistically, the air interface reduces the height of the aqueous column contacting the posterior stroma and may transiently limit influx of fluid into the corneal stroma until the pump functions recover[3,6]. However, safety and endothelial effects remain areas of active investigation. Comparative clinical studies and controlled cohorts have produced mixed results: several larger clinical series found no clinically relevant difference in endothelial cell count or long-term morphometry when anterior chamber reformation was performed with air versus balanced salt solution (BSS)[3], whereas more focused morphometric and experimental studies (including after DALK microperforation) have documented alterations in cell shape (polymegathism) and warned of potential damage with prolonged or large air exposure[7,8]. A 2016 morphometric series suggested that short-term intracameral air for limited indications can be well tolerated, though measures of pleomorphism and polymegathism warrant monitoring[7]. A narrative review of predictors for endothelial cell loss after phacoemulsification highlights that multiple perioperative factors (energy, time, viscoelastic use, and surgeon factors) interact with any intracameral intervention to determine net endothelial outcome[9]. Clinically relevant complications of an intracameral air bubble include transient intraocular pressure spikes, pupillary block, and the theoretical risk of endothelial trauma if large bubbles contact the endothelium or remain for prolonged periods; experimental work has also documented important bubble-size dynamics with altitude/pressure changes (relevant for travel counselling after surgery)[10]. In practice, short controlled fills (small-to-moderate bubble, patient supine, prompt monitoring of IOP and anterior chamber depth) and selective use for DMD, visualization issues, or controlled deturgescence represent the current balance between benefit and risk[1–4,6]. This study aimed to evaluate the role of an intracameral air bubble in improving early postoperative corneal outcomes.

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Methods

This prospective comparative study was conducted in the Department of Ophthalmology from July 2024 to July 2025 and included 86 eyes of 86 patients undergoing uncomplicated phacoemulsification with posterior chamber intraocular lens (PCIOL) implantation. Patients were randomly assigned into

two groups: Group A (n=43), where the anterior chamber was reformed with a small intracameral air bubble (20–25% fill) at the end of surgery, and Group B (n=43), where balanced salt solution (BSS) was used without air. Eligible participants were between 50 and 75 years of age, had nuclear sclerosis grade II–III cataract, and a preoperative endothelial cell count >2000 cells/mm². Patients with pre-existing corneal pathology, ocular trauma, glaucoma, uveitis, history of prior intraocular surgery, or those who developed intraoperative complications such as posterior capsular rupture or vitreous loss were excluded. All surgeries were performed by the same experienced surgeon using a standard clear corneal phacoemulsification technique under peribulbar anaesthesia. Preoperative evaluation included visual acuity, slit-lamp biomicroscopy, intraocular pressure (IOP) measurement, central corneal thickness (CCT), and endothelial cell count (ECC) using specular microscopy. Postoperative follow-up was done on Day 1, Day 7, and at 1 month, assessing CCT, corneal clarity grading, ECC, IOP, and postoperative complications. Data were entered into Microsoft Excel and analyzed using SPSS version 26.0, with continuous variables expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages; comparisons between groups were performed using an independent t-test or chi-square test, and a p-value <0.05 was considered statistically significant.

Results

Table 1: Baseline Demographic and Ocular Characteristics (N = 86)

Variable	Group A (Air) (n=43)	Group B (BSS) (n=43)	p-value
Age (years, Mean ± SD)	63.4 ± 8.2	62.1 ± 9.1	0.48
Male: Female (n)	24:19	26:17	0.67
Eye operated (Right: Left)	21:22	23:20	0.65
Pre-op CCT (µm, Mean ± SD)	542.8 ± 25.1	544.3 ± 24.9	0.72
Pre-op ECC (cells/mm²)	2410 ± 185	2395 ± 190	0.64
Pre-op IOP (mmHg)	14.6 ± 2.3	14.3 ± 2.5	0.58

Both groups were statistically comparable at baseline regarding age, gender distribution, eye operated, preoperative CCT, ECC, and IOP ($p > 0.05$).

Table 2: Postoperative Central Corneal Thickness (CCT) Changes

Time Point	Group A (Air) (Mean ± SD)	Group B (BSS) (Mean ± SD)	p-value
Post-op Day 1 (µm)	560.1 ± 28.3	589.7 ± 31.5	<0.001
Post-op Day 7 (µm)	545.4 ± 25.9	563.2 ± 27.8	0.002
1 Month (µm)	541.8 ± 24.7	542.9 ± 25.1	0.74

Group A had significantly lower CCT on Day 1 and Day 7, indicating faster resolution of corneal oedema. By one month, CCT was similar in both groups.

Table 3: Postoperative Corneal Clarity (Grading)

Clarity Grade (Day 1)	Group A (n=43)	Group B (n=43)	p-value
Grade 0 (Clear)	28 (65.1%)	17 (39.5%)	0.01
Grade 1 (Mild haze)	13 (30.2%)	18 (41.9%)	
Grade 2 (Moderate)	2 (4.7%)	8 (18.6%)	

A higher proportion of patients in Group A achieved a clear cornea on Day 1, while moderate haze was more common in Group B.

Table 4: Endothelial Cell Count (ECC) Changes			
Time Point	**Group A (Air) (Mean ± SD)**	**Group B (BSS) (Mean ± SD)**	**p-value**
Pre-op (cells/mm²)	2410 ± 185	2395 ± 190	0.64
1 Month	2320 ± 178	2308 ± 182	0.58
% Loss	3.7%	3.6%	0.91

Both groups had comparable endothelial cell loss at 1 month, with no statistically significant difference.

Table 5: Postoperative IOP Changes			
Time Point	**Group A (Air) (Mean ± SD)**	**Group B (BSS) (Mean ± SD)**	**p-value**
Day 1 (mmHg)	16.1 ± 3.2	14.7 ± 2.9	0.04
Day 7 (mmHg)	14.8 ± 2.6	14.3 ± 2.4	0.42
1 Month (mmHg)	14.5 ± 2.3	14.2 ± 2.1	0.53

Group A showed a transient rise in IOP on Day 1, which normalized by Day 7 and remained comparable at 1 month.

Table 6: Postoperative Complications			
Complication	**Group A (n=43)**	**Group B (n=43)**	**p-value**
Transient IOP rise	4 (9.3%)	1 (2.3%)	0.18
Persistent oedema >1wk	2 (4.7%)	6 (13.9%)	0.04
Pupillary block	0 (0%)	0 (0%)	—

Persistent oedema was significantly less frequent in Group A. Other complications were minimal and comparable between the two groups.

Discussion

In our prospective study of 86 eyes undergoing uncomplicated phacoemulsification, intracameral air bubble use resulted in a significant reduction in central corneal thickness (CCT) on postoperative Day 1 (560.1 µm) and Day 7 (545.4 µm) compared to the balanced salt solution (BSS) group (589.7 µm and 563.2 µm, respectively; $p < 0.001$ and $p = 0.002$), with convergence of values by 1 month (~541.8 vs 542.9 µm, $p = 0.74$). Early corneal clarity (Grade 0) was achieved in 65.1% of eyes in the air group versus 39.5% in the BSS group on Day 1 ($p = 0.01$), indicating a marked improvement in visual quality and patient comfort during the early postoperative period. Endothelial cell count (ECC) loss at 1 month was minimal and comparable between the two groups (~3.7% in air vs ~3.6% in BSS, $p \approx 0.91$), demonstrating that the air bubble did not contribute to additional endothelial damage. A transient elevation in intraocular pressure (IOP) was observed on Day 1 in the air group (16.1 ± 3.2 mmHg vs 14.7 ± 2.9 mmHg, $p = 0.04$), which normalized by Day 7 and Month 1, suggesting that moderate air volumes are generally safe and any pressure rise is self-limiting. Persistent corneal oedema beyond 1 week was less frequent in the air group (4.7% vs 13.9%, $p = 0.04$), reflecting faster corneal recovery. These findings are in agreement with Keles & Karaman[8], who reported Day 1 CCT of 555.6 µm in the air group versus 577.4 µm in controls, with convergence by 1 month and no significant endothelial loss, supporting our observations regarding early reduction of corneal swelling and endothelial safety. Yüksel et al.[11] demonstrated that air bubble injection reduces endothelial and epithelial gaps and decreases Descemet membrane detachment (DMD) in

the early postoperative period, which aligns with our improved early clarity and reduced oedema. Nascimento et al.[12] found no long-term difference in endothelial morphology between air and BSS groups, corroborating our findings of minimal ECC loss. Studies focusing on DMD, such as Kumar et al.[13] and Chaurasia et al.[1], reported that air tamponade significantly restored corneal clarity and reduced oedema, paralleling our high rate of early clear corneas, even though our cohort did not have pre-existing detachment. Sim et al.[14] observed only minimal IOP rise with air bubble use, similar to our transient Day 1 increase, indicating that the technique is generally safe regarding pressure dynamics. Overall, our study demonstrates that an intracameral air bubble after phacoemulsification provides measurable early benefits, including faster reduction of corneal thickness, improved early visual clarity, and minimal endothelial compromise, with only transient and self-limiting IOP elevation.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

Conclusion

The use of an intracameral air bubble at the end of phacoemulsification surgery provides significant early benefits, including reduced central corneal thickness, faster recovery of corneal clarity, and decreased incidence of persistent postoperative oedema, without causing additional endothelial cell loss. Although a transient elevation in intraocular pressure may occur on the first postoperative day, it resolves spontaneously and does not compromise safety.

Recommendation

It is recommended that surgeons consider the use of an intracameral air bubble at the conclusion of phacoemulsification, particularly in patients with healthy corneas undergoing uncomplicated cataract surgery, to enhance early postoperative corneal recovery and visual clarity. Careful monitoring of intraocular pressure on the first postoperative day is advised to ensure patient safety, although any elevation is generally transient and self-limiting.

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