The Effect of Air Bubble on Corneal Endothelium after Phacoemulsification

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Research Article

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Abstract

Purpose To investigate the effect of air bubble on the corneal endothelium at the end of the cataract surgery.

Methods In this prospective study, patients who underwent cataract surgery with phacoemulsification were separated into two groups. The study group comprised 60 patients with air bubble injected into the anterior chamber at the end of the operation and the control group was formed of 46 patients without air bubble. Endothelial cell density (ECD), coefficient of variation (CV), hexagonality rate (6A), and central corneal thickness (CCT) measurements were taken using non-contact specular microscopy (Tomey EM-4000, Nagoya, Japan) preoperatively and at 1 day, 1 week and 1 month postoperatively. The phacoemulsification parameters during the operation were noted.

Results No significant difference was determined between the groups preoperatively in respect of mean visual acuity, anterior chamber depth, ECD, CV, 6A, and CCT values ($p > 0.05$). The intraoperative average ultrasound power, effective phaco time, and ultrasound time values were similar ($p > 0.05$). The CCT value was lower in the study group than in the control group on postoperative day 1 ($p = 0.021$), but similar at 1 week and 1 month ($p = 0.208$, $p = 0.394$, respectively). No significant difference was determined between the groups in mean visual acuity, corneal edema, anterior chamber reaction, ECD, CV, and 6A values at 1 day, 1 week and 1 month postoperatively ($p > 0.05$).

Conclusion Although air bubble has no detrimental effect, there is also seen to be no protective effect on the corneal endothelium.

Introduction

Phacoemulsification is a cataract surgery technique with a low complication rate, which increases visual acuity in the early period due to a small incision and working in a closed system [1]. During this surgery, air bubble may be applied to the anterior chamber for various reasons. Air bubble is left in the anterior chamber at the end of surgery as a tamponade to prevent volume from shallowing [2]. It has also been demonstrated that air bubble tamponade for Descemet’s membrane detachment after phacoemulsification surgery is effective in relieving corneal clarity with Descemet membrane re-attachment [3, 4]. The addition of air bubbles to the anterior chamber at the end of sutureless cataract surgery has been shown to prevent inflow of wound leakage and ocular surface fluid with the positive and negative pressures caused by external forces [5]. In a previous study of 24 rabbits, Staphylococcus epidermidis was injected into the anterior chamber of one eye in each animal after draining the aqueous humor. After this injection of staphylococcus epidermidis, endophthalmitis developed in 1 of 12 eyes with air bubble, but in 7 of 12 eyes with serum (balanced salt solution). Air bubble in the anterior chamber was thought to have protective effects against the development of experimental Staphylococcus epidermidis endophthalmitis [6].

Anterior segment fluorophotometry has shown that cataract surgery can cause breakdown of the blood-aqueous barrier with protein leakage and cell reaction in the aqueous humor [7]. In a rabbit eye study, air bubble remaining in the anterior chamber after phacoemulsification was found to decrease the anterior chamber reaction and nitric oxide level, thus reducing inflammation [8].

The aim of this study was to determine whether air bubble applied to the anterior chamber at the end of surgery in phacoemulsification cases affects the corneal endothelium by reducing inflammation, and whether it is clinically important.

Materials And Methods

This prospective, cross-sectional study was conducted on adult patients undergoing cataract surgery at the University of Health Sciences, Ulucanlar Eye Training and Research Hospital, in Ankara, Turkey between August 2017 and September 2018.

Written informed consent was obtained from all patients.
The study was approved for prospective data collection by the University of Health Sciences, Numune Training and Research Hospital Human Research Ethics Committee and followed the tenets of the Declaration of Helsinki.

Demographic Data

A record was made for each patient of the preoperative findings of age, sex, systemic disease, routine ophthalmology examination findings (visual acuity measurement, biomicroscopic examination, fundus examination and intraocular pressure measurement), anterior chamber depth (ACD - measured with optical low coherence reflectometry-LenStar LS 900, Haag-Streit AG, Switzerland) and specular microscopy measurements. Cataract hardness was assessed with the Lens Opacity Classification System III [9].

Exclusion criteria included prior history of corneal opacities, glaucoma, uveitis, preoperative endothelial cell count < 1500 cells/mm^2, preoperative anterior chamber depth < 2.5 mm, degenerative myopia, proliferative diabetic retinopathy, intraocular surgery, eye trauma, intraoperative complication (zonular dialysis, posterior capsular opening, vitreous loss, nucleus drop etc.), and systemic autoimmune inflammatory disease.

Surgical Technique

All eyes were dilated using topical cyclopentolate hydrochloride 1% (Sikloplejin®, Abdi İbrahim, İstanbul, Turkey) and tropicamide 1% (Tropamid®, Bilim İlaç, İstanbul, Turkey). After topical anesthesia (Proparakain HCl 0.5%), two side ports were opened and anterior chamber stabilization was achieved with injected viscoelastic material (Healon GV®, AMO) and the anterior chamber was entered with a transparent 2.75 mm corneal incision by the same surgeon (SKK) in all cases. Following capsulorhexis

with a diameter of approximately 5.5 mm, the nucleus was emulsified with bimanual phaco chop and divide conquer techniques. After cortex cleaning, a foldable hydrophobic acrylic intraocular lens (Acrysof SA60AT®, Alcon) was implanted into the capsular bag. After viscoelastic clearance in the anterior chamber, 0.5%/0.1 mL moxifloxacin (Vigamox®) was injected into the anterior chamber following stromal hydration with no sutures. At the end of the operation, 0.2 cc air bubble was administered to the anterior chamber in patients of the study group and was not applied to the patients in the control group. After surgery, ofloxacin drops (Exocin® 5x1) and prednisolone acetate (Predforte® 4x1) were used for four weeks.

Average ultrasound power (AVG, %), effective phaco time using Ellips™ FX (EFX, seconds), and ultrasound time (UST, seconds) values of the phacoemulsification performed during the operation were noted using the AMOWhiteStar Signature® Ellips™ FX phaco system for all patients. The EFX is roughly the effective phaco time with a specific coefficient for the transversal movement expressed in seconds. Endothelial cell loss (ECL) was evaluated as follows: ECL = [(preoperative cell count-postoperative cell count)/preoperative cell count] × 100 %.

Main Outcome Measures

The cases were evaluated postoperatively on day 1, then at the end of the 1st week, and the 1st month with a slit lamp biomicroscope (Topcon SL-3G, Japan) for anterior chamber reaction (ACR), corneal edema intensity according to the Efron scale and the amount of air bubble in the anterior chamber (Fig. 1). The corrected distance visual acuity (CDVA) was examined on decimal charts preoperatively and on the 1st day, 1st week and 1st month postoperatively. Decimal visual acuity was converted to the logMAR scale for statistical analysis.

Endothelial cell density (ECD, cell/mm^2), the coefficient of variation (CV, polymygatism, %), hexagonality rate (6A, pleomorphism, %) and central corneal thickness (CCT, μm) were investigated using a reproducible and reliable non-contact specular microscopy (Tomey EM-4000, Tomey Corp., Nagoya, Japan) preoperatively and day 1, week 1, and month 1 postoperatively.[10] All measurements were performed at least 3 times using the “center” method by the same clinician. Subjects were asked to look at the central fixation target, and the automatic alignment function was used. All corneal endothelial cells were manually marked. More than 60 cells per eye were included in each assay.

Statistical Analysis

Data obtained in the study were analyzed statistically using SPSS vn. 22.0 software (Chicago, IL, USA). Descriptive statistics were stated as mean ± standard deviation values. The normal distribution of the variables was tested using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk test). The preoperative, intraoperative, and postoperative measurements of two groups were compared using the Independent Samples *t* test. Categorical variables were compared using the Chi-square test. A value of $p < 0.05$ was considered statistically significant.

Results

The demographic and preoperative clinical features of participants according to groups and intraoperative parameters are presented in Table 1. Patients who underwent cataract surgery by phacoemulsification were separated into two groups. In the study group of 60 patients, air bubble was applied to the anterior chamber at the end of the operation, and in the control group of 46 patients, no air bubble was applied. The mean age was 66.68 ± 11.35 years in the study group and 66.41 ± 10.78 years in the control group (p = 0.901). The male to female ratio was similar in both groups (p = 0.757). The best corrected visual acuity values on Snellen chart were 0.93 ± 0.62 in the study group and 0.93 ± 0.61 in the control group (p = 0.993). The mean ACD and cataract hardness of the two groups were similar (p = 0.691 and p = 0.778, respectively, Table 1).

Table 1
Comparison of Patients' Preoperative Characteristics and Intraoperative Parameters

	Air bubble (n = 60) (Mean ± SD)	**Control (No air bubble) (n = 46) (Mean ± SD)**	***p* value**
Age, years	66.68 ± 11.35	66.41 ± 10.78	0.901
Gender (Male/Female)	37/23	27/19	0.757
Preop CDVA (logmar)	0.93 ± 0.62	0.93 ± 0.61	0.993
ACD (mm)	3.41 ± 0.40	3.44 ± 0.33	0.691
Cataract Hardness	2.77 ± 0.85	2.72 ± 0.93	0.778
Preop ECD (cell/mm^2)	2395.13 ± 331.41	2464.26 ± 292.08	0.265
Preop CV (%)	40.35 ± 5.17	41.09 ± 7.18	0.541
Preop 6A (%)	45.22 ± 6.53	44.13 ± 6.33	0.392
Preop CCT (µm)	524.37 ± 32.81	530.96 ± 39.26	0.349
AVG (%)	6.52 ± 3.26	6.57 ± 5.12	0.953
EFX (s)	38.98 ± 26.03	30.22 ± 25.64	0.087
UST (s)	105.15 ± 58.87	92.78 ± 60.94	0.294
CDVA: Corrected distance visual acuity, ACD: Anterior chamber depth, ECD: Endothelial cell density, CV: Coefficient of variation, 6A: Hexagonality rate, CCT: Central corneal thickness, AVG: Average ultrasound power, EFX: Effective phaco time, UST: Ultrasound time.			

No statistically significant difference was found between the two groups in respect of the preoperative ECD, CV, 6A and CCT values (p = 0.265, p = 0.541, p = 0.392 and p = 0.349, respectively). There was no significant difference between the groups in terms of AVG, EFX, and UST values (p = 0.087, p = 0.294, p =

0.953 and $p = 0.963$, respectively), (Table 1). On postoperative day 1, 6 patients in the study group (10%) and 5 patients in the control group (10.9%) could not be measured due to corneal edema ($p = 0.884$). Measurements were obtained from all patients at the end of the postoperative 1st week and 1st month. Air bubble was completely reabsorbed on postoperative day 4 or 5. The mean CCT value on postoperative day 1 was lower in the study group compared to the control group ($p = 0.023$), but the mean CCT values were similar at the end of the postoperative 1st week and 1st month ($p = 0.208$, $p = 0.394$, respectively). There was no significant difference between the groups in respect of mean CDVA, corneal edema, ACR, ECD, CV and 6A values at postoperative day 1, week 1 and month 1 ($p > 0.05$ for all, Table 2).

Table 2
Comparison of Postoperative Parameters Between Groups

	Air bubble (n = 60) (Mean ± SD)	**Control (No air bubble) (n = 46) (Mean ± SD)**	***p* value**
Postop 1.day CDVA (logmar)	0.14 ± 0.13	0.17 ± 0.13	0.203
Postop 1.day Corneal edema	0.45 ± 0.62	0.54 ± 0.72	0.476
Postop 1.day ACR	0.80 ± 0.51	0.85 ± 0.56	0.648
Postop 1.day ECD (cell/mm^2)	2132.78 ± 434.35	2199.88 ± 408.18	0.446
Postop 1.day CV (%)	45.81 ± 10.13	46.39 ± 10.17	0.785
Postop 1.day 6A (%)	38.19 ± 8.22	39.8 ± 8.99	0.363
Postop 1.day CCT (µm)	553.63 ± 38.80	571.71 ± 36.69	**0.023***
Postop 1.day Misalignment (+/-)	6/54	5/41	0.884
Postop 7.day CDVA (logmar)	0.08 ± 0.11	0.08 ± 0.09	0.863
Postop 7.day Corneal edema	0.03 ± 0.18	0.09 ± 0.35	0.313
Postop 7.day ACR	0.10 ± 0.30	0.11 ± 0.31	0.886
Postop 7.day ECD (cell/mm^2)	2076.52 ± 455.26	2168.24 ± 465.76	0.311
Postop 7.day CV (%)	43.78 ± 5.54	44.5 ± 7.44	0.571
Postop 7.day 6A (%)	36.63 ± 7.20	38.76 ± 6.06	0.110
Postop 7.day CCT (µm)	541 ± 40.58	550.52 ± 35.17	0.208
Postop 30.day CDVA (logmar)	0.04 ± 0.06	0.03 ± 0.07	0.557
Postop 30.day Corneal edema	0 ± 0	0 ± 0	-
Postop 30.day ACR	0 ± 0	0 ± 0	-
Postop 30.day ECD (cell/mm^2)	2062.15 ± 438.93	2126.78 ± 464.93	0.466
Postop 30.day CV (%)	42.1 ± 5.44	43.8 ± 6.46	0.144
Postop 30.day 6A (%)	38.5 ± 5.92	38.98 ± 6.40	0.691

	Air bubble (n = 60) (Mean ± SD)	Control (No air bubble) (n = 46) (Mean ± SD)	*p* value
Postop 30.day CCT (μm)	526.18 ± 34.86	531.93 ± 33.56	0.394
ECL (%) 1st day	11.36 ± 13.69	11.38 ± 12.73	0.995
ECL (%) 1st week	13.15 ± 14.99	12.12 ± 15.14	0.729
ECL (%) 1st month	13.90 ± 13.60	13.85 ± 15.08	0.985

CDVA: Corrected distance visual acuity, ACR: Anterior chamber reaction, ECD: Endothelial cell density, CV: Coefficient of variation, 6A: Hexagonality rate, CCT: Central corneal thickness, ECL: Endotelial cell loss.

*Bold value indicates statistically significant result.

Discussion

The corneal endothelium is a mechanical barrier against fluid movement into the cornea and is an energy-dependent active pump to move fluid out of the cornea. The endothelium plays a critical role in maintaining corneal transparency by pumping fluid from the stroma into the aqueous humor. Disruption of the endothelial function brings about stromal swelling and corneal edema [11, 12]. Corneal endothelial cells can not regenerate, yet stretch to compensate for dead cells that decline the overall cell density of the endothelium and ultimately fluid regulation is affected. Therefore, to compensate for corneal damage, other healthy corneal cells migrate to the damaged area, which results in a reduction in their hexagonality [13, 14]. In the present study, the effects on corneal endothelial count and morphology were examined of air bubble applied to the anterior chamber at the end of the phacoemulsification.

Olson [15] and Van Horn et al. [16] reported that air bubble has a toxic effect on the corneal endothelium. However, Norn [17] applied air bubble to the anterior chamber in 86 of 135 patients who underwent cataract extraction, and concluded that air bubbles in the anterior chamber did not have any adverse effects on the corneal endothelium, as well as protected the endothelium from postoperative damage. Yuksel et al. [18] showed that the rate of Descemet's membrane detachment and of endothelial and epithelial gap decreased during the early postoperative period in patients who had been given with air bubble after phacoemulsification surgery compared to the control group. The endothelial cell density of the two groups was found to be similar preoperatively and at 3 months postoperatively [18]. Likewise, Alsmman et al. [19] studied air bubble versus balanced salt solution for anterior chamber reformation at the end of phacoemulsification and found similar endothelial cell count-morphology in both groups at 1 and 3-month follow-up visits. In contrast, Mataftsi et al. [20] compared intrastromal wound hydration with anterior chamber air tamponade to ensure waterproof closure of corneal incisions at the end of the phacoemulsification surgery and reported that air has a detrimental effect on endothelial cell count compared to balanced salt solution. In that study with an average age of patient age of 70 years, compared to a former study of patients aged 50–60 years, they interpreted that younger corneas may have a greater tolerance to the toxic effect of air on endothelial cells, and thus a lesser effect on the final

number and density [20]. In the current study, in which the mean age of the patients was approximately 67 years, there was no difference according to the specular microscopy analysis at the 1-month follow-up examination.

On the postoperative first day, air bubble seemed to have no favourable influence on anterior chamber reaction, suggesting that air bubble is not clinically related to inflammation. A limitation of this study was that the quantitative anterior chamber reaction and flare values could not be measured due to the lack of anterior segment fluorophotometry.

The only statistically significant increase was observed in CCT data on the postoperative first day in the study group applied with air bubble compared to the control group. Corneal edema formation has been used as an indirect tool to assess surgically induced endothelial cell loss [21]. In previous studies, corneal endothelial loss was found to be correlated with increase in CCT on the first postoperative day [22]. However, endothelial loss between the groups was similar in the current study. The lesser increase in pachymetry in the study group is not explained by endothelial loss. Therefore, it can be considered that the lesser increase in pachymetry in the study group may be related to the reduction of fluid passage into the stroma due to the mechanical barrier effect of the air bubble.

In conclusion, there may be less corneal edema on the postoperative 1st day of cases terminated by leaving air bubble in surgery. As there was no significant difference between endothelial cell density and other parameters, it was concluded that air bubbles in the anterior chamber did not have any side-effects on the corneal endothelium, but there was no clinically protective effect against surgery-induced endothelial injury by reducing inflammation. There is a need for further comprehensive studies with large patient populations to determine the exact effect of air bubble.

Declarations

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Conflict of interests: The authors have no conflict of interests to declare.

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Contributors: Design of the study (AK and SKK); conduct of the study (AK and SKK); analysis and interpretation (AK and SKK); and literature search (AK and SKK).

Data availability: All data will be available upon request.

Consent to participate: All participants gave written informed consent for participation in the study.

Consent for publication: All participants gave written informed consent for their data to be published.

Ethics approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board/Ethics Committee of Numune Training and Research Hospital, Ankara, Turkey (protocol no: E-17-1453).

Language editing: The text was reviewed by a native English speaker.

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Figures

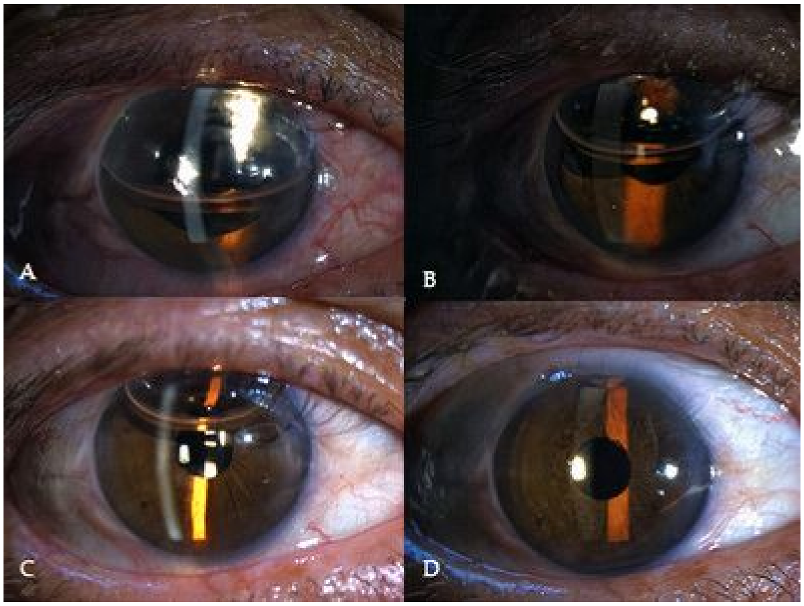

Figure 1

Images of the right eye of a patient with air bubble given at the end of surgery (Haag-Streit BQ 900 imaging, Koeniz, Switzerland). A. One hour after surgery B. One day after surgery C. Two days after surgery D. On postoperative day 5, the air bubble was completely reabsorbed.

Supplementary Files

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- Airbubbledata.xlsx