

Original research

Intracameral air injection after completion of phacoemulsification cataract surgery: Evaluation of corneal incisions with optical coherence tomography

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Abstract

Purpose: To evaluate the effects of air bubbles on clear corneal incision (CCI) in patients who had phacoemulsification surgery, and to compare this type of CCI architecture with patients who had no air bubbles after phacoemulsification surgery, using anterior segment optical coherence tomography (AS-OCT).

Methods: Eyes which had undergone uneventful phacoemulsification cataract surgery with implantation of a posterior chamber intraocular lens (IOL) were equally randomized into two groups. Group 1 comprised patients with anterior chamber air bubble injection after phacoemulsification, and Group 2 comprised patients who had undergone phacoemulsification surgery without anterior chamber air bubble. Postoperative evaluation included AS-OCT (Heidelberg Engineering, Germany) and pneumatic tonometry (Nidek NT-1000 Pneumatic Tonometer, Japan) in the 2nd hour, then at 1 week, and 1 month. Astigmatic changes assessed with corneal topography after phacoemulsification cataract surgeries were noted.

Results: Evaluation was made of 40 eyes of 28 patients (10 female, 18 male) as 20 eyes in Group 1 and 20 eyes in Group 2. On the first postoperative day, the endothelial gap rate was 13.3% in Group 1 and 57.1% in Group 2 ($P = 0.02$), and this continued until the 1-month follow-up examination. The Descemet's membrane detachment (DMD) rate was 0% in Group 1 and 42.8% in Group 2 on postoperative day 1 ($P = 0.006$), and this continued at the 1-month follow-up examination. At 1 month postoperatively, the rates of optical coherence tomography (OCT) parameters were similar. There were no significant differences between preoperative astigmatism and postoperative astigmatism in the group analyses.

Conclusion: In this study, air bubbles decreased the rate of DMD and of endothelial and epithelial gap during the early postoperative period. Copyright © 2019, Iranian Society of Ophthalmology. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Keywords: Air bubbles; Anterior segment optical coherence tomography; Phacoemulsification surgery; Clear corneal incision; Descemet membrane detachment

Introduction

Cataract is the most common cause of reversible blindness in the world, and surgical treatment has been shown to be highly effective in visual rehabilitation.¹ Clear corneal incision (CCI) was first described in 1992, and with recent surgical advances, the incision can now be made smaller and is more stable.^{2,3} However, the question of whether CCI increases the risk of endophthalmitis is controversial.⁴ In vivo studies have shown that air bubbles in the anterior chamber

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decreased the risk of *Staphylococcus epidermidis* endophthalmitis, reduced inflammation, and prevented the inflow of ocular surface fluid into the anterior chamber after CCI.^{5–7} Moreover, anterior chamber air bubbles have been used in the management of Descemet's membrane detachment (DMD) after cataract surgery and in Descemet membrane endothelial keratoplasty as a crucial tamponade.^{8,9} However, the effects of air bubbles on CCI architecture and the healing process are not well understood. In recent years, with the development of anterior segment optical coherence tomography (AS-OCT) technology, cataract surgeons have been able to make detailed in vivo evaluations of CCI.^{5,10} The ultrastructure properties of CCI such as epithelial and endothelial gaping of the wound, misalignment of the roof and floor of the incision on the endothelial side, DMD, and loss of coaptation along the stromal tunnel can all be evaluated using AS-OCT.¹¹

In the present study, it was aimed to evaluate the following using AS-OCT: 1) The effects of air bubbles on the healing processes of CCIs (in terms of wound gaping, misalignment, wound configuration, and DMD) in patients who had undergone phacoemulsification surgery, 2) The comparison of healing processes of CCIs with patients who had no air bubbles after phacoemulsification surgery, 3) The effects of air bubble on astigmatic changes after phacoemulsification cataract surgery, and the comparison of this technique with patients who had no air bubbles after phacoemulsification surgery in terms of astigmatic changes.

Methods

This study was approved by the Local Ethics Committee of Istanbul Education and Research Hospital. The tenets of the Declaration of Helsinki were followed in all steps of the study, and all patients were informed about the benefits and potential risks. Informed consent was obtained from each patient.

A total of 40 eyes of 28 patients (10 female, 18 male) who had undergone uneventful phacoemulsification cataract surgery with implantation of a posterior chamber intraocular lens (IOL) were equally randomized into two groups. Group 1 comprised patients applied with anterior chamber air bubble injection after phacoemulsification, and Group 2 comprised patients who had phacoemulsification surgery without anterior chamber air bubble. Of the 28 patients, both eyes of 12 patients were included, one side in Group 1 and the other in Group 2. In these patients, randomization was determined by a coin flip before the cataract surgery.

The patients included in the study were those with age-related cataract and oblique, or with-the-rule astigmatism. Exclusion criteria included a history of ocular disease, intraocular surgery, laser treatment, diabetes requiring medical control, glaucoma and preoperative against-the-rule astigmatism, and anterior segment disease or degeneration.

All patients in both groups were examined pre, per, and postoperatively. The preoperative examination included a complete systemic and ocular history, routine ocular

examinations such as slit-lamp biomicroscopy, pneumatic tonometer, and indirect ophthalmoscopy. The preoperative and postoperative corneal astigmatism findings were assessed using computerized corneal topography (Sirius 3D Rotating Scheimpflug Camera-Topography System, Costruzione Strumenti Oftalmici, Florence, Italy). The number of endothelial cells in the area of main entrance and central cornea was measured preoperatively and at 3 months postoperatively with Konan specular microscope (Konan Medical Inc., Hyogo, Japan). The Lens Opacities Classification System III was used to evaluate cataract hardness.¹²

The total ultrasonic time, mean cumulative energy, and surgery time were recorded preoperatively. Intraocular pressure (IOP) was measured with tonopen (Tono-Pen AVIA[®] Applanation Tonometer, Reichert Technologies, USA) at the end of each surgery.

Postoperative evaluation included AS-OCT (Heidelberg Engineering, Germany) and pneumatic tonometry (Nidek NT-1000 Pneumatic Tonometer, Japan) in the 2nd hour, then at the end of 1 week and 1 month. Astigmatic changes assessed on corneal topography after phacoemulsification cataract surgeries were noted.

Surgical technique

The same surgeon (E.Y.) performed all operations under topical anesthesia. The three-plane clear corneal tunnels of main incision were made with a 2.8 mm duval bevel slit knife (Clear cut HP, Alcon) through the steepest sites of the cornea. Then 2 side ports were created 90° from the main port with a 20-gauge paracentesis knife (A-OK[®] Corneal/Scleral V-Lance[®] Knives, Alcon, Switzerland).

The Infiniti[®] phacoemulsification system (Alcon, Switzerland) and the vertical chop phacoemulsification technique were used in both groups. The irrigation/aspiration (I/A) procedure was completed with bimanual Buratto I/A set tips (Alcon, Grieshaber, Switzerland). All incisions were sealed with stromal hydration and checked for leakage with a microsponge. Before surgery was completed, 1 mg/mL of cefuroxime (Aksef 750 mg Nobel pharma) was injected into the anterior chamber for endophthalmitis prophylaxis, and in Group 1, a 0.1 cc air bubble injection was applied to the anterior chamber. The patients were laid down in such a way that the head position was 45° vertical for the first postoperative day. IOP was measured with tonopen at the end of surgeries. To eliminate the effect of IOP on CCI, postoperative IOP was maintained within 15–18 mmHg. In patients with high IOP at the end of surgery, a side port drainage was performed.

The phaco parameters were recorded at the end of the procedure.

Specular microscopy was performed with an SP-2000P specular non-contact (Topcon America Corporation, Paramus, NJ, USA) microscope, and the endothelial cell density (cells/mm²) was calculated by analyzing 60 cells of the central cornea before surgery and after subsequent monitoring at 3 months, postoperatively.

The postoperative topical antibiotic and steroid treatments were the same in all patients. Hypertonic saline/NaCl 5% was not used in any case.

Anterior segment optical coherence tomography examination

The non-contact AS-OCT examination (Spectral Domain OCT, Heidelberg Engineering, Germany) was performed by the same examiner in all cases. The anterior segment module was used. The main corneal incisions were analyzed at 2 h, then 1, 7, and 30 days. During the process, the patients were asked to look straight ahead in the opposite direction to the corneal incision, and the optical coherence tomography (OCT) beam was as perpendicular to the incision as possible when the image was taken. Raster radial scans 6 mm in length were obtained.

All the images were exported and analyzed. High definition images were used for the analysis. CCI length and the corneal thickness at the site of the incision were measured with the device software (Fig. 1). During the AS-OCT measurements, the examiners (M.O.C.-K.S.) blinded to the groups, evaluated the healing process of CCI and the evidence of wound gaping (epithelial and endothelial gap), misalignment (misalignment of the roof and floor of the incision on the endothelial side), wound configuration (arcuate incision configuration Fig. 2, linear incision configuration), and DMD.

Statistical analysis

Statistical analysis for descriptive statistics was performed using SPSS version 16.0 statistical software. The data obtained from two procedures were analyzed with the Independent Samples t-test and the Paired Samples t-test. A value of $P < 0.05$ was considered statistically significant.

Results

The study enrolled 40 eyes of 28 patients (10 female, 18 male). The patient characteristics are shown in Table 1.

The phaco parameters were similar in both groups (Table 2).

The main CCI was clearly evident on the AS-OCT examination, so all images from 40 patients were exported, examined, and measured. The corneal thickness at the site of the

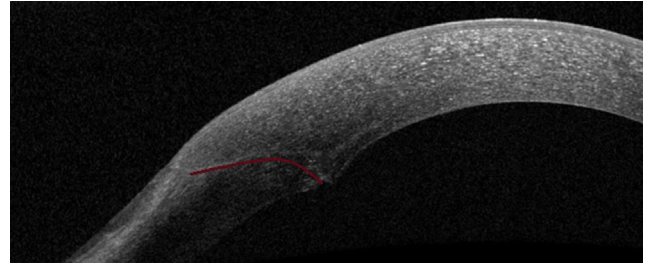


Fig. 2. Arcuate incision configuration (red line).

incision was $690 \pm 75.3 \mu$ in Group 1 and $716.2 \pm 63.4 \mu$ in Group 2, (Table 3) ($P = 0.03$). The mean incision length was $1675.2 \pm 135.1 \mu$ in Group 1 and $1666.2 \pm 171.4 \mu$ in Group 2, (Table 3), ($P = 0.65$). The mean IOP values are shown in Table 4. The postoperative mean IOP measured on the first day was similar in patients both with and without DMD, (13.6 ± 0.45 , 14.0 ± 0.52 mmHg, respectively, $P = 0.44$).

The results of the anterior segment examination are presented in Table 3 and Figs. 3–5. On postoperative day 1, the epithelial gap (Fig. 6) rate was 6.6% in Group 1 and 42.8% in Group 2; this difference was significant ($P = 0.03$) and continued until the first week follow-up. The DMD (Fig. 7) rate was 0% in Group 1 and 42.8% in Group 2 on postoperative day 1, and the difference was determined to be significant ($P = 0.006$). On postoperative day 1, the endothelial gap (Fig. 7) rate was 13.3% in Group 1 and 57.1% in Group 2; the difference was significant ($P = 0.02$) and continued until the first month follow-up (Fig. 5). This difference continued until the 1-month follow-up examination. At 1 month after surgery, the rates of OCT parameters were similar. The arcuate configurations of CCI were similar in all postoperative examinations (Table 3). Preoperative and postoperative specular microscopy analysis values were similar in both groups (Table 3).

No significant differences were determined between preoperative astigmatism and postoperative astigmatism in the group analyses of both groups, and postoperative astigmatic differences were similar in the two groups (Table 5).

Discussion

Cataract surgery is one of the most frequently performed surgeries in the world today, and CCI, which has many

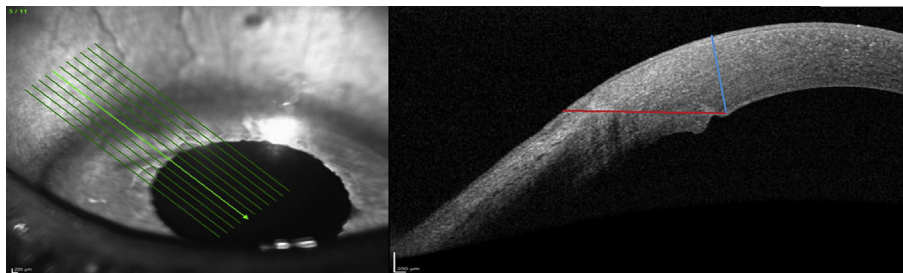


Fig. 1. Clear corneal incision (CCI) length (red line) and the corneal thickness (blue line) measured at the site of the incision.

Table 1
Preoperative characteristics of patients and the mean follow-up time.

Parameter	Group 1	Group 2	P
Eye	20	20	
Sex (M/F)	9/5	9/5	
Laterality (R/L)	11/9	10/10	
Mean age (y)	66 ± 12.2	65 ± 11.8	0.82 ^a
Mean CCT (µm)	540 ± 43.4	541 ± 42.8	0.79 ^a
Incision size (mm)	2.8	2.8	
^b Cataract hardness	3,15 ± 0.1	3,2 ± 0.12	0.84 ^a
Mean follow-up (D)	90	90	

Group 1: Phacoemulsification surgery with air bubble injection, Group 2: Phacoemulsification surgery without air bubble injection.

M: Male F: Female R: Right L: Left y: Year CCT: Central corneal thickness D: Day.

^a Independent Samples t-test.

^b Chylack LT Jr., Wolfe JK, Singer DM, et al. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. Arch Ophthalmol. 1993; 111(6):831-6.

advantages such as less bleeding, less surgically induced corneal astigmatism, and more stable anterior chamber, is the most common incision used by cataract surgeons.¹³ Despite the many advantages of CCI, some studies have suggested that it might induce postoperative endophthalmitis.⁴ With the recent development of high-speed AS-OCT, researchers have had the opportunity to evaluate CCI sites in vivo. Thus, epithelial and endothelial gaping of the wound and DMD, which cannot be detected postoperatively with routine slit-lamp microscopy, can be displayed easily on AS-OCT.¹¹ At the same time, it has been documented that injecting an air bubble after sutureless cataract surgery reduces inflammation, prevents the inflow of ocular surface fluid, and protects against the development of endophthalmitis.^{6,7,14} Air bubbles have also been used in the management of DMD after cataract surgery.⁸ However, the effects of air bubbles on the CCI wound after cataract surgery are not well known. In the present study, it was observed that air bubbles in the anterior chamber had a positive effect on CCI, and one of the positive effects was on DMD. Small and localized DMD at the CCI is common after cataract surgeries. Although the exact mechanism of DMD is not known, the possible explanation for the separation of Descemet membrane from the corneal stroma

Table 2
The peroperative surgical data.

Parameter	Group 1	Group 2	P
Pump	Peristaltic	Peristaltic	
Total ultrasonography time (second)	28.5 ± 11.6	27.9 ± 10.7	0.4 ^a
Mean cumulative energy	7.6 ± 3.4	7.9 ± 3.8	0.5 ^a
Quadrant removal			
Vacuum (mmHg)	400 linear	400 linear	
Power (%)	%30	%30	
Mode	Pulse	Pulse	
Bottle Height (cm)	85	85	
Surgery time (minute)	13.6 ± 3.2	13.1 ± 4.1	0.4 ^a

Group 1: Phacoemulsification surgery with air bubble injection, Group 2: Phacoemulsification surgery without air bubble injection.

^a Independent Samples t-test.

Table 3
Comparison of optical coherence tomography (OCT) and specular microscopy parameters.

OCT parameter	Group 1	Group 2	P
MIL µm	1675.2 ± 135.1	1666.2 ± 171.4	0.65
Endotelial gap 2. Hours	13.3%	71.4%	0.003
Endotelial gap 1. Day	13.3%	57.1%	0.02
Endotelial gap 1. Week	13.3%	42.8%	0.1
Endotelial gap 1. Month	0%	0%	–
Epitelial gap 2. Hours	66.6%	78.5%	0.68
Epitelial gap 1. Day	6.6%	42.8%	0.03
Epitelial gap 1. Week	0%	7.1%	0.48
Epitelial gap 1. Month	0%	0%	–
DMD 2. Hours	0%	42.8%	0.006
DMD 1. Day	0%	35.7%	0.01
DMD 1. Week	0%	35.7%	0.01
DMD 1. Month	0%	0%	–
CCT at CCI µm	690.15 ± 75.3	716.2 ± 63.4	0.03
CCT at Side ports µm	702.10 ± 72.2	715.10 ± 70.1	0.09
Arcuat configuration 2. Hours	66.6%	42.8%	0.55
Arcuat configuration 1. Day	42.6%	35.7%	0.6
Arcuat configuration 1. Week	13.3%	13.3%	–
Arcuat configuration 1. Month	6.6%	7.1%	0.7
Misalignment 2. Hour	13.3%	57.1%	0.02
Misalignment 1. Day	13.3%	57.1%	0.02
Misalignment 1. Week	13.3%	35.7%	0.2
Misalignment 1. Month	0%	0%	–
Preoperative specular mic. (cell per mm ²)	2091.0 ± 80.9	2096.5 ± 90.9	0.24
Postoperative specular mic. (cell per mm ²)	1740.2 ± 52.7	1738.5 ± 55.4	0.32

OCT: Optical coherence tomography, MIL: Mean insicion length, DMD: Descemet's membrane detachment, CCT: Central corneal thickness, CCI: Clear corneal insicion, mic: Microscopy.

includes mechanical forces that can be applied during surgery.¹⁵ DMD causes corneal edema, and this may lead to fibrosis, shrinkage of the corneal wound, and, eventually, corneal astigmatism.¹⁶ Therefore, prevention of DMD after cataract surgery may be important for corneal astigmatism. In the present study, DMD rates were 0% in Group 1 at 2 h, and on days 1 and 7, and the rates of DMD in Group 2 were higher at the same measurement times. It is possible that the push-up effect of an air bubble on the Descemet membrane can prevent detachment. On the other hand, this air bubble might lead to a false appearance of an attached Descemet membrane in AS-OCT images. To determine whether the air bubble affects the reattachment of DM, it is necessary to make an AS-OCT

Table 4
The mean postoperative intraocular pressure (IOP).

	Group 1	Group 2	P
Postoperative IOP ^a	16.4 ± 0.54	16.8 ± 0.29	0.6
Postoperative IOP 2. Hours	14.6 ± 0.63	13.8 ± 0.46	0.7
Postoperative IOP 1. Day	14.2 ± 0.55	13.3 ± 0.58	0.5
Postoperative IOP 1. Week	15.1 ± 0.32	14.7 ± 0.31	0.6
Postoperative IOP 1. Month	14.9 ± 0.32	14.6 ± 0.31	0.6

Group 1: Phacoemulsification surgery with air bubble injection, Group 2: Phacoemulsification surgery without air bubble injection.

IOP: Intraocular pressure.

^a Intraocular pressure at the end of surgeries.

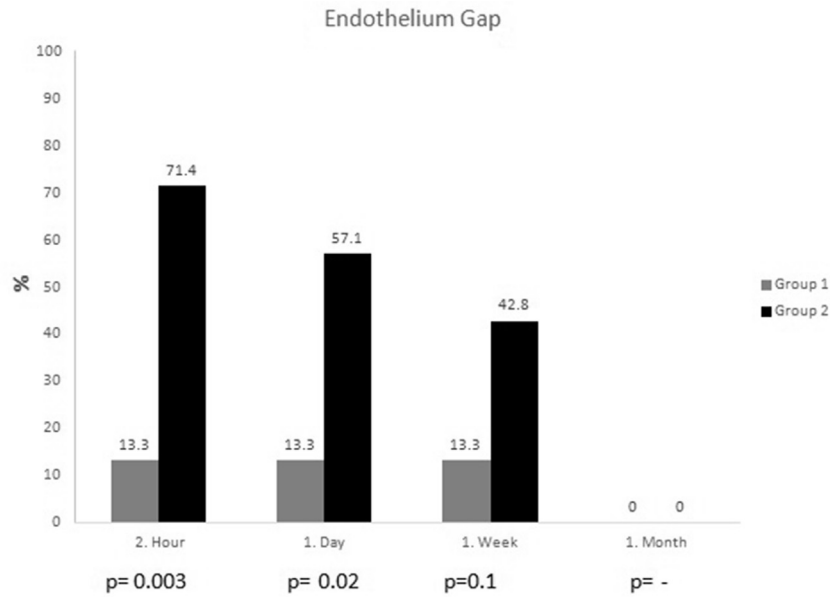


Fig. 3. Comparison of optical coherence tomography (OCT) parameters – endothelial gap formation.

examination with the head in different positions providing movement of the air bubble to another side of the anterior chamber. However, on the 7th day AS-OCT images, no air bubble was present, demonstrating no DMD in Group 1, which could indicate that the attached appearance of Descemet membrane is caused by the push-up effect rather than the falsely attached appearance of an air bubble. The results of DMD in Group 2 were comparable with the literature in the early and late follow-up periods (Table 3).^{5,10,17,18}

The second positive effect of air bubbles on CCI after cataract surgery is endothelial gap. The thermal and mechanical damage of ultrasound power and instruments on CCI

may cause endothelial gap. Low postoperative IOP may also play a role in endothelial gaping.^{5,10,19} Both endothelial gap and DMD are associated with edema and increased thickness in the CCI wound, and consequently, this may lead to alterations in the architecture of the wound.^{5,10} In the current study, lower endothelial gap rates were observed in Group 1 than in Group 2 and the published literature at 2 h, and 1 and 7 days (Table 3)^{5,10,11,17,18,20}; however, the rates were similar in the 2 groups at 1 month. As expected, the thickness of the corneal wound was also lower in Group 1 during the early period. The most important next step of research will be to determine whether all the changes after cataract surgery such as DMD,

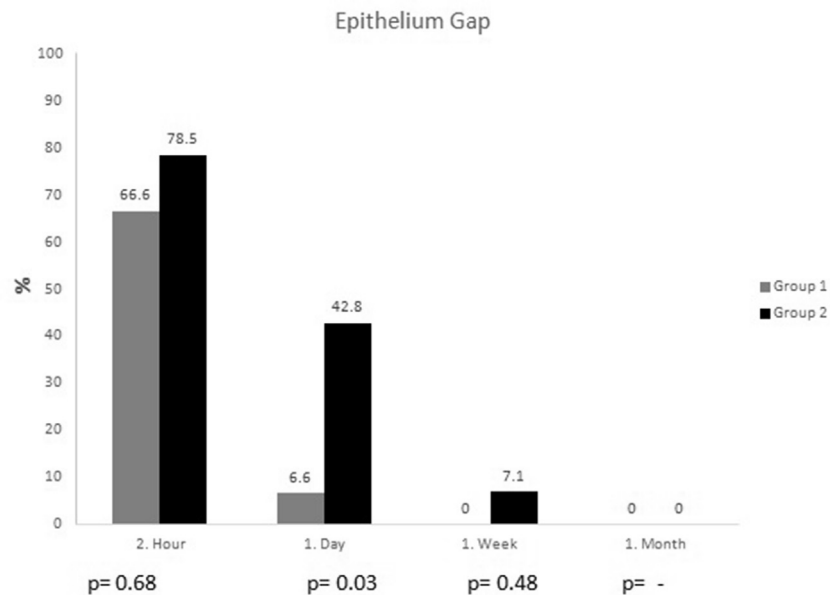


Fig. 4. Comparison of optical coherence tomography (OCT) parameters – epithelial gap formation.

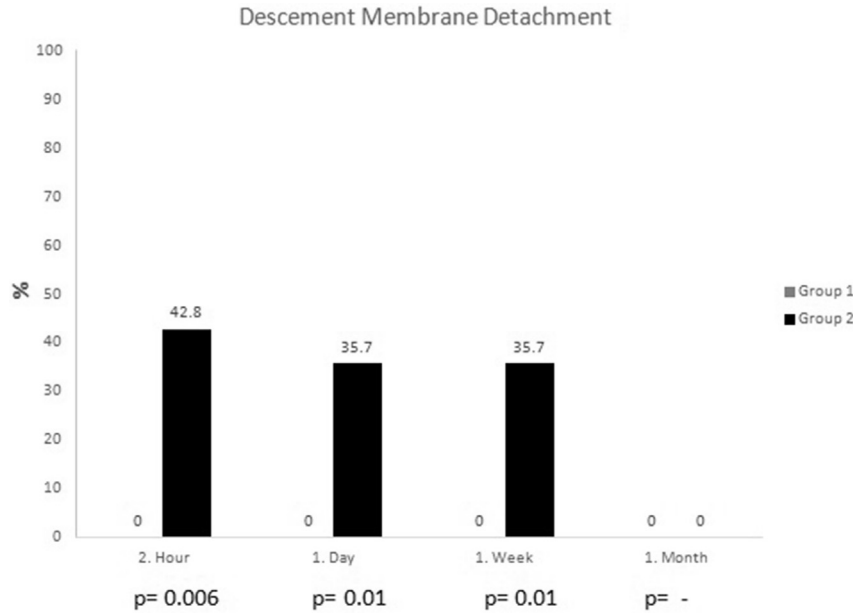


Fig. 5. Comparison of optical coherence tomography (OCT) parameters – Descemet's membrane detachment (DMD).

endothelial gap, and thickness of the corneal wound lead to corneal astigmatism, as there is insufficient knowledge in literature about this topic. In the current study, although air bubbles decreased the rate of DMD, and endothelial gap and thickness of corneal wound were lower during the early period, the changes of corneal astigmatism were similar in the two groups. A possible explanation for this is that the results became equal for both groups by the end of the follow-up period.

Another possible positive effect of air bubbles on CCI is the epithelial gap. The closure of the epithelium gap after cataract surgery is an important step in the prevention of endophthalmitis. McGowan theorized that the process of CCI closure started on the epithelial side, then suction occurred within the wound due to the pump function of the endothelial cells,

drawing together the wound margins.²¹ If the gaping in the epithelium does not heal, the suction within the wound fails and breaks the barrier mechanism, inviting risk for endophthalmitis. Therefore, the lack of epithelial gap may decrease the risk of endophthalmitis. In the current study, the epithelial gap was observed to be lower in Group 1 than in Group 2 at 2 h and on day 1. These results might be associated with the thicker corneal wound and higher endothelial gap in Group 2. The air bubble may decrease the risk of endophthalmitis, not only by decreasing the rate of epithelial gap, but also by preventing wound leakage and inflow of ocular surface fluid into the anterior chamber. Sim et al. demonstrated that if air bubbles were left after sutureless cataract surgery, this allowed the anterior chamber more compliance and prevented leakage of corneal wound and reflux of the contaminated material.¹⁴

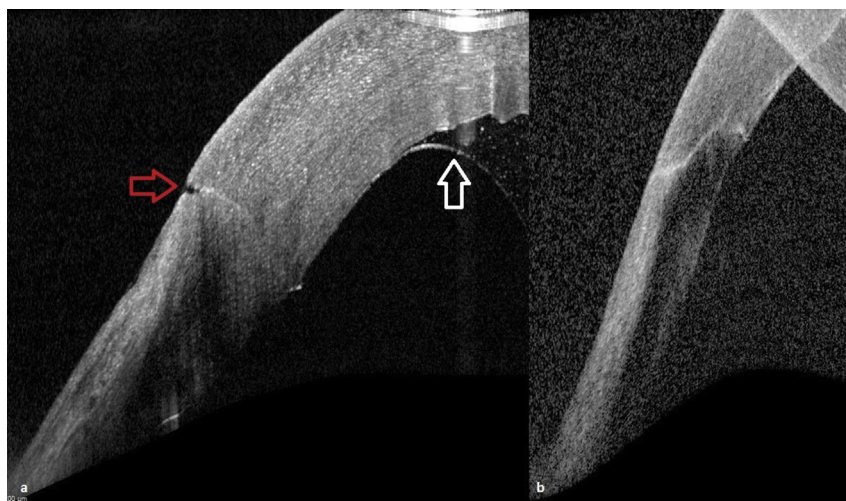


Fig. 6. a: The anterior segment optical coherence tomography (AS-OCT) of a patient in Group 1 on the first postoperative day. Epithelial gap formation (red arrow). Air bubble (white arrow). b: The AS-OCT of the same patient in the first postoperative month. The arcuate configuration at one-month.

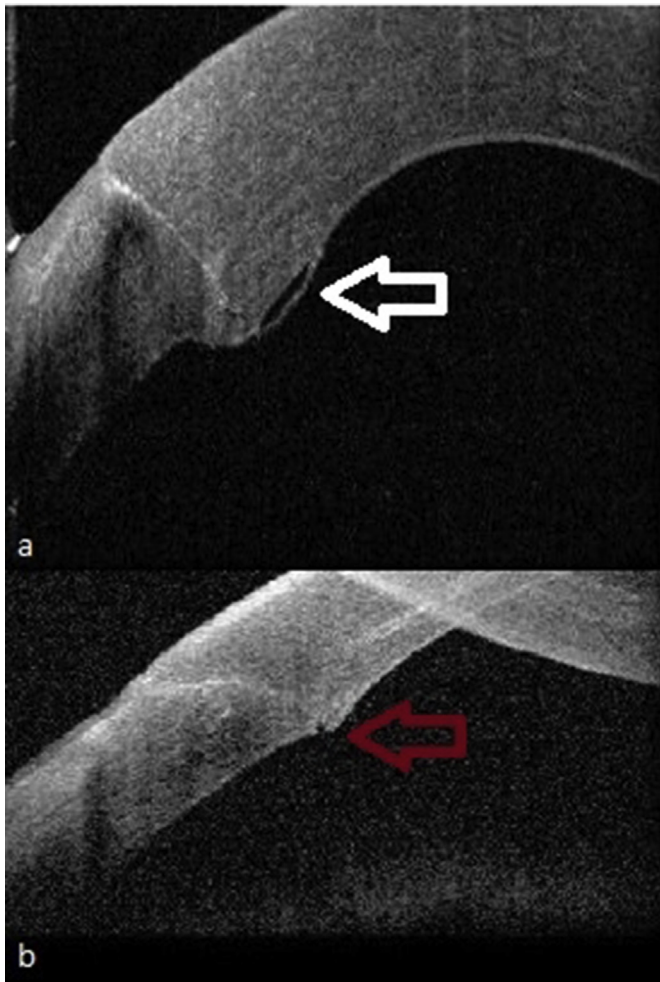


Fig. 7. a: The optical coherence tomography (AS-OCT) of a patient in Group 2 in the first postoperative week Descemet's membrane detachment (DMD) (white arrow) was noted. b: The AS-OCT of the same patient in the first postoperative week. Endothelial gap formation (red arrow) was noted.

Another advantage of air bubbles in the anterior chamber is prevention of *Staphylococcus epidermidis* endophthalmitis and reduction of inflammation.^{6,7} In addition to all the advantages of air bubbles in the anterior chamber after sutureless cataract surgery, one important concern is the possible toxic effect on corneal endothelium. Although Olson and Van Horn et al.

Table 5

The mean value of preoperative and postoperative astigmatism, and postoperative astigmatic differences.

Parameters of astigmatism	Group 1	Group 2	P
Mean value of preoperative astigmatism	1.1 ± 1	0.75 ± 0.54	
Mean value of postoperative astigmatism	1.2 ± 0.8	0.92 ± 0.38	
P value	0.5 ^a	0.1 ^a	
Mean value of preoperative axis of astigmatism	87.6 ± 40.2	89.7 ± 39.4	
Mean value of postoperative axis of astigmatism	91.4 ± 39.2	92.5 ± 41.4	
P value	0.41 ^a	0.46 ^a	
Mean value of postoperative astigmatic changes	0.1 ± 0.7	0.15 ± 0.4	0.8 ^b

^a Paired sample t-test.

^b Independent sample t-test.

showed air to have a toxic effect on corneal endothelium,^{22,23} in the current study, there were no differences between the two groups according to specular microscopy analysis at 3 months.

In the present study, the rate of DMD was relatively higher than findings in literature of current phacoemulsification practice. Ti et al.⁸ reported the incidence rate per year for visually significant DMD after phaco surgery to be 0.044%. However, mild cases only treated medically and cases with delayed diagnosis, resulting in irreversible corneal decompensation, were excluded from that study. The main cause of the higher rate in the present study can be considered to be the use of anterior segment OCT for the diagnosis of DMD. The current study patients with DMD were not clinically significant. Moreover, the wound size, wound hydration, and surgeon factor could influence the rate of DMD.

A limitation of the present study was that as the parameters normalized by one month and were only different in the first week, serial analysis at two and three weeks may provide a better idea of the healing stage. In addition, further studies with larger sample size and long-term follow-up could analyze the effect of anterior chamber air on the rates of postoperative endophthalmitis. There was also no analysis of the healing process of side ports.

In conclusion, to the best of our knowledge, this is the first study to evaluate the in vivo effect of air bubbles on CCI using AS-OCT after sutureless cataract surgery. These results have shown that air bubbles decreased the rate of DMD and of endothelial and epithelial gap during the early postoperative period. Although these effects became equal, and the changes in corneal astigmatism were similar between the two groups, larger sample size and long-term clinical studies are required to confirm these results.

References

- Lansing VC, Carter MJ, Martens M. Global cost-effectiveness of cataract surgery. *Ophthalmology*. 2007;114(9):1670–1678.
- Lyle WA, Jin GJ. Prospective evaluation of early visual and refractive effects with small clear corneal incision for cataract surgery. *J Cataract Refract Surg*. 1996;22(10):1456–1460.
- Cavallini GM, Campi L, Torlai G, Forlini M, Fornasari E. Clear corneal incisions in bimanual microincision cataract surgery: long-term wound-healing architecture. *J Cataract Refract Surg*. 2012;38(10):1743–1748.
- McDonnell PJ, Taban M, Sarayba M, et al. Dynamic morphology of clear corneal cataract incisions. *Ophthalmology*. 2003;110(12):2342–2348.
- Can I, Bayhan HA, Celik H, Bostanci Ceran B. Anterior segment optical coherence tomography evaluation and comparison of main clear corneal incisions in microcoaxial and biaxial cataract surgery. *J Cataract Refract Surg*. 2011;37(3):490–500.
- Demirci G, Karabas L, Maral H, Ozdek S, Gulkilik G. Effect of air bubble on inflammation after cataract surgery in rabbit eyes. *Indian J Ophthalmol*. 2013;61(7):343–348.
- Mehdizadeh M, Rahat F, Khalili MR, Ahmadi F. Effect of anterior chamber air bubble on prevention of experimental *Staphylococcus epidermidis* endophthalmitis. *Graefes Arch Clin Exp Ophthalmol*. 2010;248(2):277–281.
- Ti SE, Chee SP, Tan DT, Yang YN, Shuang SL. Descemet membrane detachment after phacoemulsification surgery: risk factors and success of air bubble tamponade. *Cornea*. 2013;32(4):454–459.
- van Dijk K, Ham L, Tse WH. Near complete visual recovery and refractive stability in modern corneal transplantation: Descemet

- membrane endothelial keratoplasty (DMEK). *Contact Lens Anterior Eye J Br Contact Lens Assoc.* 2013;36(1):13–21.
10. Xia Y, Liu X, Luo L, et al. Early changes in clear cornea incision after phacoemulsification: an anterior segment optical coherence tomography study. *Acta Ophthalmol.* 2009;87(7):764–768.
 11. Calladine D, Packard R. Clear corneal incision architecture in the immediate postoperative period evaluated using optical coherence tomography. *J Cataract Refract Surg.* 2007;33(8):1429–1435.
 12. Chylack Jr LT, Wolfe JK, Singer DM, et al. The Lens Opacities Classification system III. The Longitudinal study of cataract study group. *Arch Ophthalmol.* 1993;111(6):831–836.
 13. Leaming DV. Practice styles and preferences of ASCRS members—2001 survey. *J Cataract Refract Surg.* 2002;28(9):1681–1688.
 14. Sim DA, Wong R, Griffiths MF. Injecting an air bubble at the end of sutureless cataract surgery to prevent inflow of ocular surface fluid. *Eye.* 2007;21(11):1444–1445.
 15. Nouri M, Pineda Jr R, Azar D. Descemet membrane tear after cataract surgery. *Semin Ophthalmol.* 2002;17(3-4):115–119.
 16. Mahmood MA, Teichmann KD, Tomey KF, al-Rashed D. Detachment of Descemet's membrane. *J Cataract Refract Surg.* 1998;24(6):827–833.
 17. Wang L, Dixit L, Weikert MP, Jenkins RB, Koch DD. Healing changes in clear corneal cataract incisions evaluated using Fourier-domain optical coherence tomography. *J Cataract Refract Surg.* 2012;38(4):660–665.
 18. Dupont-Monod S, Labbe A, Fayol N, Chassignol A, Bourges JL, Baudouin C. In vivo architectural analysis of clear corneal incisions using anterior segment optical coherence tomography. *J Cataract Refract Surg.* 2009;35(3):444–450.
 19. Torres LF, Saez-Espinola F, Colina JM, et al. In vivo architectural analysis of 3.2 mm clear corneal incisions for phacoemulsification using optical coherence tomography. *J Cataract Refract Surg.* 2006;32(11):1820–1826.
 20. Fukuda S, Kawana K, Yasuno Y, Oshika T. Wound architecture of clear corneal incision with or without stromal hydration observed with 3-dimensional optical coherence tomography. *Am J Ophthalmol.* 2011;151(3):413.e1–419.e1.
 21. McGowan BL. Mechanism for development of endophthalmitis. *J Cataract Refract Surg.* 1994;20(1):111.
 22. Van Horn DL, Edelhauser HF, Aaberg TM, Pederson HJ. In vivo effects of air and sulfur hexafluoride gas on rabbit corneal endothelium. *Investig Ophthalmol.* 1972;11(12):1028–1036.
 23. Olson RJ. Air and the corneal endothelium: an in vivo specular microscopy study in cats. *Arch Ophthalmol.* 1980;98(7):1283–1284.