Anterior segment optical coherence tomography evaluation and comparison of main clear corneal incisions in microcoaxial and biaxial cataract surgery

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PURPOSE: To use Fourier-domain anterior segment optical coherence tomography (AS-OCT)) to evaluate the main clear corneal incisions (CCIs) in microcoaxial and biaxial cataract surgery, the effects of incision enlargement, and the probable reasons for problematic healing.

SETTING: Atatürk Training and Research Hospital, 2nd Ophthalmology Department, Ankara, Turkey.

DESIGN: Cohort study.

METHODS: Eyes that had microcoaxial cataract surgery through a 1.8 mm CCI or biaxial cataract surgery through a 1.2 to 1.4 mm trapezoidal CCI were divided into 2 equal subgroups based on incision enlargement. All surgeries were completed by stromal hydration. Incisions were evaluated 1, 8, and 30 days postoperatively.

RESULTS: The CCIs in the microcoaxial group were longer, thinner, and more slanted than those in the biaxial group, with no statistical difference. The microcoaxial incisions had significantly more arcuate configuration at 1 day ($P=.003$); however, the configuration became linear in the following days in both groups. The endothelial gap rates were less and Descemet membrane detachment rates greater than reported in the literature. In eyes with enlarged CCIs, the endothelial gap rate was higher in the microcoaxial group and the Descemet membrane detachment rate was higher in the biaxial group (both $P=.05$). At 1 day, the intraocular pressure (IOP) was significantly lower in Descemet membrane detachment and endothelial gap cases ($P=.006$ and $P<.001$, respectively).

CONCLUSIONS: Although closure was reliable in both groups, the microcoaxial group had slightly fewer undesirable effects on the incision site. Low postoperative IOP seemed to be a significant factor in problematic healing.

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Sutureless self-healing clear corneal incisions (CCIs) have been in wide use since they were described by Fine[A] in 1992; however, it has also been debated whether CCIs increase the risk for endophthalmitis. Various studies have found CCIs to have adequate reliability, while others have found them to be inadequate.[1–6] Many other studies[7–10] evaluated the correlation between healing and wound morphology, such as size and angle. The relatively recent availability of anterior segment optical coherence tomography (AS-OCT) has allowed in vivo evaluation of CCIs in high definition; this has resulted in more detailed and positive findings.[8–12] In the past, time-domain AS OCT technology was the most commonly used method of evaluating CCIs. Fourier-domain OCT technology, which has been in use since 2002, has a higher scan rate and is affected less by eye movement, thus producing images with fewer artifacts and a higher resolution.[13,14]

Another advance in phacoemulsification surgery is that it can be performed thorough incisions smaller than 2.0 mm using a microcoaxial technique or a biaxial technique. The very small incisions used with these techniques mean that the reliability of CCIs should be reassessed. In particular, studies of CCIs used in the biaxial technique[15–19] have evaluated the single-

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plane paracentesis and the probable mechanical and thermal injury that can arise during phacoemulsification with a sleeveless tip; the reliability results in these studies vary from good to poor.

We performed a study with 3 objectives. First was to determine the differences in wound structure and the dynamic healing process between the microcoaxial and biaxial surgical techniques. Second was to assess the effects of enlargement on incisions. Third was to determine the probable reasons for problematic healing. We used Fourier-based AS-OCT in our assessments.

PATIENTS AND METHODS

In this prospective randomized study of uneventful small-incision cataract surgery, eyes were equally randomized to have microcoaxial surgery (Group 1) or biaxial surgery (Group 2), respectively. Each group was divided into 2 subgroups. In subgroup 1A and subgroup 2A, the incisions were not enlarged. In subgroup 1B and subgroup 2B, the incisions were enlarged before intraocular lens (IOL) implantation. The study was in accordance with the tenets of the Declaration of Helsinki,[B] and all patients provided informed consent.

Patients who had a history of ocular disease, intraocular surgery, laser treatment, diabetes requiring medical control, or glaucoma were excluded. The inclusion criterion was age-related cataract.

Surgical Technique

The same surgeon (İ.C.) performed all operations using topical anesthesia. In the microcoaxial group, incisions were made with a 1.6 to 1.8 mm laser-edge steel trapezoidal knife (E7600, Bausch & Lomb) through the steepest sites of the cornea. Later, 2 side ports were created 90 degrees from the main port with a 20-gauge paracentesis knife. In the biaxial group, 2 incisions were created 90 to 110 degrees away using a 19-gauge steel knife (EdgeAheadT #585240, BD Medical); the 1.2 to 1.4 mm incisions were trapezoidal. The Stellaris phacoemulsification system (Bausch & Lomb) and the half-moon supracapsular phacoemulsification[20] technique were used in both groups. The phaco parameters in the groups were similar (Table 1). The Chang Micro Finger chopper (Katena Products, Inc.) was used in Group 1 and a 20-gauge Fine-Nagahara irrigating chopper (Micro Surgical Technology) in Group 2. Sleeved 1.8 mm C-MICS tips (Bausch & Lomb) were used in Group 1 and sleeveless 1.4 mm B-MICS tips (thin) (Bausch & Lomb) in Group 2. The irrigation/aspiration (I/A) procedure was completed with bimanual Buratto I/A set tips (#170.12, Alcon, Grieshaber) in Group 1 and bimanually with Duet set cannulas (MicroSurgical Technology) in Group 2. In subgroup 1A, the IOL was implanted without enlarging the main incision. In subgroup 1B, the incision was enlarged to 2.2 or 2.8 mm depending on the type of IOL to be implanted. In subgroup 2A, the IOLs were implanted through a third incision or through a side port that was enlarged without enlarging the main incision. In subgroup 2B, the main port was enlarged to 1.8 mm, 2.2 mm, or 2.8 mm. Incision widths were measured with a Tsuneoka microincision gauge (American Surgical Instruments Corp.) before and after IOL implantation. All incisions were sealed by stromal hydration and checked for leakage with a microsponge. Before surgery was completed, 1 mg/mL of cefuroxime (Multicef 750 mg) was injected into the anterior chamber for endophthalmitis prophylaxis. The effective phaco time (EPT) was recorded at the end of the procedure.

Patient Examinations

All patients had an extensive examination preoperatively. Cataract hardness was evaluated and recorded according to the Lens Opacities Classification System III method.[21] Preoperative corneal pachymetric maps were also evaluated.

Postoperatively, the corneal incisions were analyzed using the RTVue-100 Fourier-domain AS-OCT system (Optovue, Inc.) at 1, 8, and 30 days. The system's anterior module (CAM L) was used to image the cornea.[22] During the process, the patients were asked to look straight ahead to the opposite of the corneal incisions. A complete transverse scan was taken, and the high-definition images were recorded. The following were analyzed on the image: (1) incision angle (angle between the line that joins the epithelial and endothelial ends of the incision and the tangential line on the corneal surface); (2) incision chord length; (3) incision configuration; (4) epithelial side closure of the incision or the existence of a gap; (5) endothelial side closure, endothelial gap, and if present, the proportion of the gap length to the whole incision; (6) Descemet membrane detachment; (7) corneal thickness at the incision site; (8) thickness at 2.0 to 5.0 mm and 5.0 to 6.0 mm from the central cornea; (9) central corneal thickness (CCT).

Statistical Analysis

Statistical analysis was performed using chi-square, Student *t*, and Mann-Whitney *U* tests and SPSS for Windows software (version 16.0, SPSS, Inc). A *P* value less than 0.05 was considered statistically significant.

RESULTS

The study enrolled 60 eyes of 51 patients. Table 2 shows the preoperative patient characteristics and Table 3, the intraoperative characteristics. There were no statistically significant differences in preoperative or intraoperative data between the 2 groups.

There were no statistically significant between-group differences in postoperative visual acuity, spherical or cylindrical refraction, or intraocular pressure (IOP). None

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Table 1. Surgical parameters.

Parameter	Microcoaxial Group (1.8 mm)	Biaxial Group (1.2–1.4 mm)
Pump	Venturi	Venturi
Phaco tip		
Type	30-degree flat, proprietary design	30-degree flat, thin
Diameter external/internal (mm)	0.95/0.79	0.90/0.67
Sleeve (external diameter, mm)	Yes (1.4)	No
Settings		
Quadrant removal		
Vacuum (mm Hg)	350 linear	350 linear
Power (%)	50	50
Mode	Micropulse (20 ms on, 40 ms off)	Micropulse (20 ms on, 40 ms off)
Bottle height (cm)	130	130
Irrigation/aspiration		
Vacuum (mm Hg)	400 linear	400 linear
Bottle height (cm)	130	130
Epinucleus		
Vacuum (mm Hg)	150 linear	150 linear
Power (%)	15	15
Bottle height (cm)	130	130

of the cases had clinically significant anterior chamber reaction, flare, corneal edema, or positive Seidel tests.

Anterior Segment Optical Coherence Tomography

Table 4 shows the results of the AS-OCT evaluation of the incision sites.

Incision Angle The mean incision angle was smaller in the microcoaxial group than in the biaxial group 1 day postoperatively, although the difference was not statistically significant ($P = .179$) (Figure 1). All incisions became more slanted with smaller angles over time.

Incision Length The chord lengths were shorter in the biaxial group than in the microcoaxial group, although the difference was not statistically significant ($P = .179$). The incisions became shorter over time in both groups.

Incision Configuration On the first postoperative day, an arcuate configuration was more common in the microcoaxial group and a straight configuration was more common in the biaxial group ($P = .003$) (Figure 2). Although the arcuate configuration generally changed to a linear configuration over time (Figure 3), an arcuate configuration was detected

Table 2. Preoperative patient characteristics and follow-up duration.

Parameter	All Patients	Microcoaxial Group	Biaxial Group	P Value
Eyes (n)	60	30	30	—
Sex (M/F)	26/25	13/13	13/12	.555*
Laterality (right/left)	31/29	15/15	16/14	.796*
Mean age (y)	66.4 ± 12.8	69.1 ± 9.1	63.6 ± 15.5	.128†
Mean CDVA				
Snellen	0.34 ± 0.18	0.32 ± 0.15	0.37 ± 0.20	.249†
LogMAR	0.53 ± 0.31	0.55 ± 0.27	0.51 ± 0.36	.704†
Mean CCT (μm)	540.1 ± 40.3	538.5 ± 41.3	541.9 ±39.9	.750†
Cataract hardness (LOCS III)	2–4	2–4	2–4	—
Mean follow-up (d)	39.5 ± 9.4	40.5 ± 9.8	38.5 ± 9.0	.745†

Means ± SD
CCT = central corneal thickness; CDVA = corrected distance visual acuity; LOCS = Lens Opacities Classification System
*Chi-square test
†Student *t* test

Table 3. Intraoperative data.

Parameter	Microcoaxial Group	Biaxial Group	*P* Value*
Mean EPT (s)	6.38 ± 5.41	4.90 ± 3.95	.240
Total operation time (min)*	14.07 ± 2.60	14.16 ±3.08	.899
Mean fluid used (mL)*	99.03 ± 29.37	92.16 ± 33.90	.415
Main incision width (mm) at end of surgery (cases)			
Subgroup 1A	1.8 (15)	—	—
Subgroup 1B	2.2 (4)	—	—
	2.8 (11)		
Subgroup 2A	—	1.4 (15)	—
Subgroup 2B	—	1.8 (9)	—
		2.2 (1)	
		2.8 (5)	
Intraocular lens			
Akreos MI-60	16	14	
Alcon AcrySof IQ	14	16	

Means ± SD
EPT = effective phaco time
*Student *t* test

significantly more often in the microcoaxial group at all examinations.

Epithelial Closure Epithelial gaps were seen in 3 eyes in the microcoaxial group and in 1 eye in the biaxial group on the first postoperative day. ($P = .611$) (Figure 4 , *A* and *B*). At 8 days, epithelial closure was complete in all eyes.

Endothelial Closure There was no statistically significant between-group difference in the endothelial closure rate on the first postoperative day ($P = .536$) (Figure 4, *C* and *D*). All gaps were closed at 30 days except 2 cases (3.3%). The ratio of the gap length to the whole incision length was not more than 20% in any case.

Descemet Membrane There was no statistically significant between-group difference in the rate of Descemet membrane detachment. Figure 5 shows an AS-OCT image of a Descemet membrane detachment. All eyes with Descemet membrane detachment had a low IOP on the first postoperative day (Table 5); the difference in the mean IOP between eyes with Descemet membrane detachment and those without was statistically significant ($P = .006$). There was, however, no statistically significant difference in the incision parameters of thickness, angle, length, or configuration ($P < .05$).

Corneal Thickness Although there was no statistically significant difference in corneal thickness at the incision site between the 2 groups, the incision sites were thicker in the biaxial group at all examinations.

The mean CCT on the first day after surgery was 632.1 ± 75.3 μm in the microcoaxial group and 602.1 ± 67.2 μm in the biaxial group. Although the difference in the increase in thickness was not statistically significant between groups, it was at the limit of significance in favor of the biaxial group ($P = .055$).

There were no statistically significant between-group differences in corneal thicknesses in the zones 2.0 to 5.0 mm and 5.0 to 6.0 mm from the corneal center. However, the changes were less in the microcoaxial group from the center to the periphery.

Effect of Incision Enlargement The endothelial gap rate in the microcoaxial group and the Descemet membrane detachment rate in the biaxial technique were significantly higher in eyes with an enlarged incision (subgroups 1B and 2B) than in eyes in which the incision was not enlarged (subgroups 1A and 2A) on the first postoperative day. In the microcoaxial group, the endothelial closure rate was 93.3% in subgroup 1A (14 cases) and 66.7% in subgroup 1B (10 cases) ($P = .050$). In the biaxial group, Descemet membrane detachment was detected in 5 cases (33.3%) in subgroup 2A and 11 cases (73.3%) in subgroup 2B ($P = .050$). There were no statistically significant differences in other features (eg, incision angle, length, configuration, thickness) between the subgroups.

The mean IOP in eyes with endothelial gap was statistically significantly lower than in eyes without endothelial gap detachment in both groups ($P = .001$) (Table 5).

DISCUSSION

Clear corneal incisions are the most commonly used incisions by cataract surgeons around the world.[23,24] However, there is debate about the reliability of CCIs and whether they increase the risk for endophthalmitis.[22–25] Because of the small size of these incisions, there may be an increased risk for undesirable thermal

Table 4. Results of AS-OCT incision site evaluation.

Incision Parameter	All Patients	Microcoaxial Group	Biaxial Group	*P* Value*
Mean angle (°)				
1 day	40.48 ± 7.4	38.79 ± 7.8	41.92 ± 7.8	.149†
8 days	40.05 ± 7.3	39.87 ± 7.6	40.21 ± 7.1	.874†
30 days	34.49 ± 6.7	34.43 ± 6.4	34.53 ± 7.1	.964†
Mean length (μm)				
1 day	1591.4 ± 289.8	1674.6 ± 290.2	1532.9 ± 283.6	.179†
8 days	1510.0 ± 296.7	1527.3 ± 297.8	1491.2 ± 300.6	.169†
30 days	1434.1 ± 187.2	1436.7 ± 211.2	1431.9 ± 169.2	.938†
Configuration, n (%)				
1 day				.003‡
Arcuate	22 (36.7)	17 (56.7)	5 (16.7)	
Linear	38 (63.3)	13 (43.3)	25 (83.3)	
8 days				.001‡
Arcuate	21 (35.0)	17 (56.7)	4 (13.3)	
Linear	39 (65.0)	13 (43.3)	26 (86.6)	
30 days				.039‡
Arcuate	16 (26.7)	12 (40.0)	4 (13.3)	
Linear	44 (73.3)	18 (60.0)	26 (86.6)	
Epithelial closure, n (%)				
1 day	56 (93.3)	27 (90.0)	29 (96.7)	.611‡
8 days	60 (100.0)	30 (100.0)	30 (100.0)	—
30 days	60 (100.0)	30 (100.0)	30 (100.0)	—
Endothelial closure, n (%)				
1 day	46 (76.7)	24 (80.0)	22 (73.4)	.536‡
8 days	49 (81.6)	24 (80.0)	25 (83.3)	.748‡
30 days	58 (96.7)	29 (96.7)	29 (96.7)	1.00‡
Endothelial gap, n (%)				
1 day	14 (23.3)	6 (20.0)	8 (26.6)	.536‡
8 days	11 (18.3)	6 (20.0)	5 (16.6)	.748‡
30 days	2 (3.3)	1 (3.3)	1 (3.3)	1.000‡
Mean % endothelial gap/incision length				
1 day	12.2 ± 6.9	9.6 ± 7.65	14.3 ± 5.7	.198‡
8 days	8.7 ± 1.5	7.9 ± 1.0	9.7 ± 1.6	.160‡
30 days	9.2 ± 1.1	8.4	10.0	—
DM detachment, n (%)				
1 day	36 (60)	20 (66.6)	16 (53.3)	.328‡
8 days	23 (38.3)	11 (36.66)	12 (40.00)	.786‡
30 days	1 (1.6)	1 (3.3)	0 (0.0)	.312‡
Mean Increase in CCT (μm)				
1 day	80.0 ± 64.4	96.4 ± 70.1	60.7 ± 52.1	.055†
8 days	26.9 ± 40.4	29.3 ± 26.7	24.0 ± 53.0	.641†
30 days	6.1 ± 25.6	5.4 ± 25.4	6.7 ± 26.3	.867†
Mean increase in 2–5 mm corneal zone (μm)				
1 day	94.0 ± 85.5	97.6 ± 87.7	90.0 ± 85.0	.771†
8 days	35.3 ± 46.1	36.0 ± 33.6	34.4 ± 58.3	.909†
30 days	10.0 ± 33.7	10.4 ± 33.7	9.5 ± 26.4	.920†
Mean increase in 5-6 mm corneal zone (μm)				
1 day	100.6 ± 94.0	100.8 ± 84.4	100.3 ± 105.5	.987†
8 days	39.7 ± 45.8	38.7 ± 42.4	40.9 ± 69.3	.894†
30 days	18.7 ± 45.0	19.2 ± 39.2	18.2 ± 52.4	.942†

(*continued on next page*)

Table 4. (Cont.)

Incision Parameter	All Patients	Microcoaxial Group	Biaxial Group	*P* Value*
Mean corneal thickness at incision site (μm)				
1 day	1065.6 ± 113.5	1046.9 ± 125.7	1086.8 ± 96.2	.213*
8 days	1036.1 ± 151.1	1018.4 ± 149.2	1053.1 ± 153.6	.400*
30 days	931.3 ± 119.4	899.70 ± 129.5	963.0 ± 101.5	.072*

Means ± SD
CCT = central corneal thickness; DM = Descemet membrane
*Comparison between the 2 groups
†Student *t* test
‡Chi-square test

and mechanical effects of the phaco tip on the incision site. In addition to smaller incisions, there is debate over sleeved phaco tips versus sleeveless phaco tips. Recent studies of the biaxial technique with a sleeveless phaco tip[12,16–19] found that closure of the incision site is not adequate. The introduction of AS-OCT has given researchers the opportunity to evaluate incision sites in vivo. Using this noncontact noninvasive technique, patients can be examined within minutes after surgery with no risk. Anterior segment OCT systems display not only static parameters, such as the incision architecture (angle, length, thickness, configuration), but also the dynamic healing process.[9–13] With Fourier-domain OCT, images can be obtained with higher resolution and at higher scan rate than with time-domain OCT, which allows more accurate evaluation and results.[13,14]

Most recent studies of CCIs and AS-OCT evaluated the morphologic characteristics of incisions, such as the thickness, length, and configuration. In the present study, we had 3 objectives; that is, to evaluate incision configuration and healing with 2 small-incision phacoemulsification techniques, to assess the effect of incision enlargement, and to determine the probable reasons for poor incision closure. For standardization between groups, all cases had similar cataract hardness and the same surgeon performed all operations using the same phaco system and settings. The mean EPT, phaco power, and fluid consumption in the 2 groups were identical.

On the first postoperative day, the incisions tended to be longer and thinner in the microcoaxial group than in the biaxial group. In the biaxial group, the incision angles were larger and mostly linear. Although

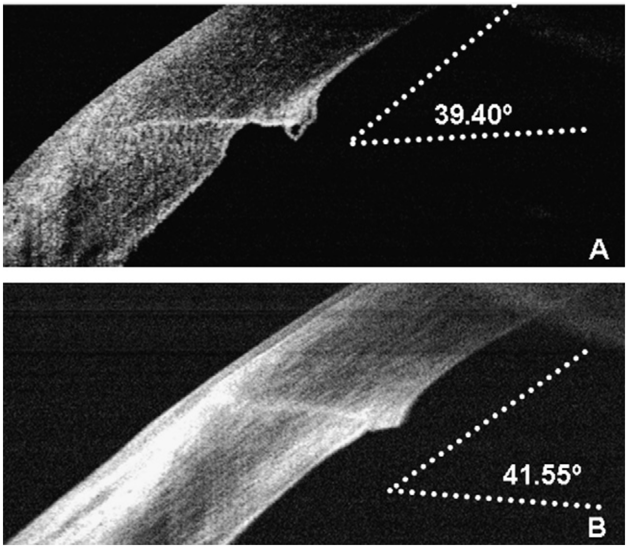

Figure 1. The incision angles measured with AS-OCT on the first postoperative day. *A*: Microcoaxial phacoemulsification case (39.40 degrees). *B*: Biaxial phacoemulsification case (41.55 degrees).

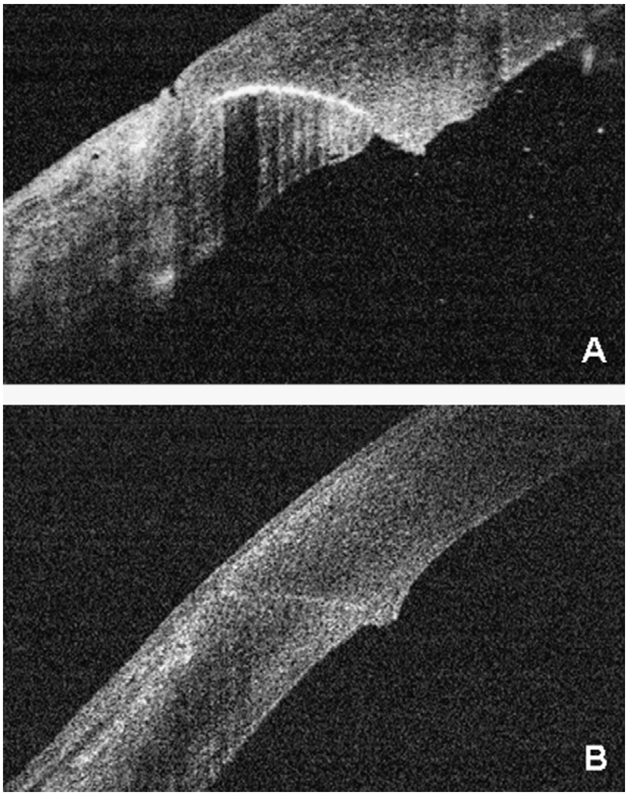

Figure 2. Incision configurations on the first postoperative day. *A*: Arcuate incision configuration in a microcoaxial case. *B*: Linear incision configuration in a biaxial case.

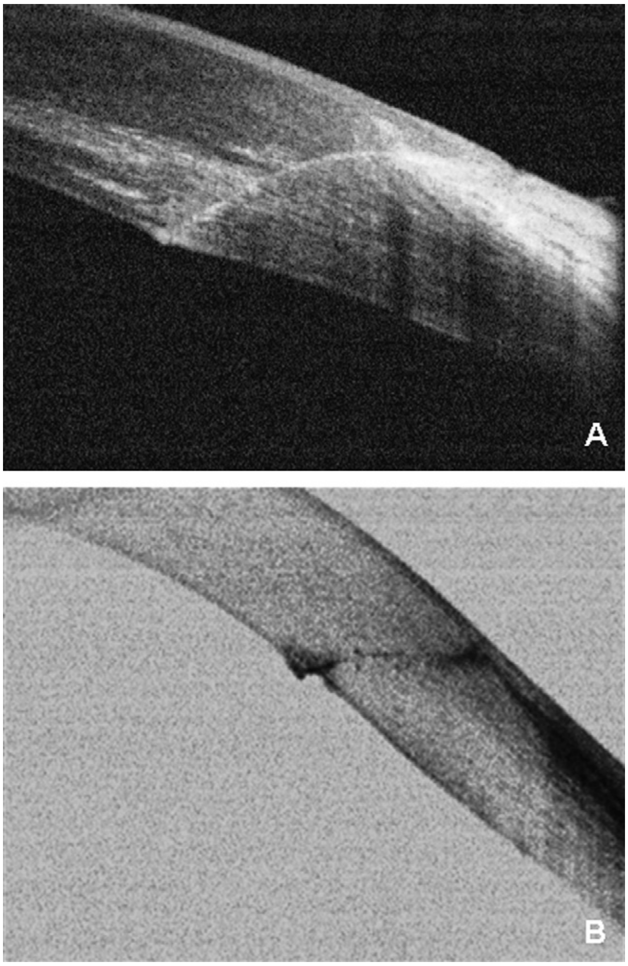

Figure 3. Alteration in incision configuration in the late postoperative period on AS-OCT. *A*: Arcuate configuration in a biaxial case on the first postoperative day. *B*: Linear configuration in the same case 30 days postoperatively.

the differences in incision length, angle, and width were not statistically significant, the difference in incision configuration was significant. The mean incision length was approximately 10% shorter than the intended length (1.75 mm) with both techniques.

Anterior segment OCT scans of the dynamic incision-healing process at 8 days and 30 days showed decreased incision length, thickness, and angle and more slanted incisions in both groups. Also, the arcuate incision configuration became linear over time. We believe that the CCIs in the microcoaxial group were more reliable in the early postoperative period because they were created with an angled blade. We believe the reason chord lengths were shorter than intended was that the cornea stretched under the force of advancing steel blades, which indicates the disadvantage of steel blades compared with diamond blades.

The main reason for the gradual alteration in wound architecture was likely the decrease in the surrounding edema and wound thickness. It can be expected that as the chord length shortens, the incision angle will increase and when the incision thickness decreases, the angle will become smaller. The gradual decrease in the incision angle with decreasing incision length and thickness in our cases shows the role of the diminishing edema at the incision site.

Fine et al.[10] found that stromal swelling lasts for at least 24 hours, and Calladine and Tanner[26] found that the chord lengths tended to be longer with stromal hydration. Incision site thickness is affected by mechanical and thermal trauma during surgery and the swelling caused by stromal hydration. Routine stromal hydration was performed in all our cases, and the gradual change in wound architecture was similar in the microcoaxial group and the biaxial group, indicating that the mechanical and thermal effects were not significantly different between the 2 groups. Even so, the incision thickness in the biaxial group was greater than in the microcoaxial group, although the differences were not statistically significant.

Recent studies of incision shapes report varied results. In an AS-OCT study by Fine et al.,[10] the incisions healed in an arcuate shape and the arch length of the incision was greater than the chord length. In a study by Elkady et al.,[27] the healing was arcuate in both biaxial and microcoaxial cases. However, Dupont-Monod et al.[12] report linear healing in biaxial cases and arcuate healing in standard and microcoaxial cases. The studies by Fine et al. and Dupont-Monod et al. were limited by the 1-day measurements and 1-day and 8-day measurements, respectively. In our study, the healing process at 1 day was mostly arcuate (56.7%) in the microcoaxial group and linear (83.3%) in the biaxial group. At 30 days, the appearance was linear in 60.0% of cases in the microcoaxial group and 86.6% of cases in the biaxial group. These data, including later term results, seem to support the results of Dupont-Monod et al. An arcuate healing configuration, which increases wound reliability, is an advantage of the microcoaxial technique; however, the positive effect disappeared over time in our study.

On the first postoperative day, even though the biomicroscopic findings and Seidel tests were normal, epithelial gaps were detected in 4 of the 60 cases, with 56 cases (93.3%) having normal epithelial closure. Three cases with epithelial gap were in the microcoaxial group. Epithelial closure was complete in all cases by 8 days postoperatively. The literature to date reports 100% epithelial closure on the first postoperative day.[9,11,12,26,27] The theory is that during the incision closure process, the epithelial side of the wound seals first. With the pump function of the endothelial cells, suction occurs within the wound, which opposes the wound margins.[28] The gaping in the epithelium counteracts the suction and barrier mechanisms and creates

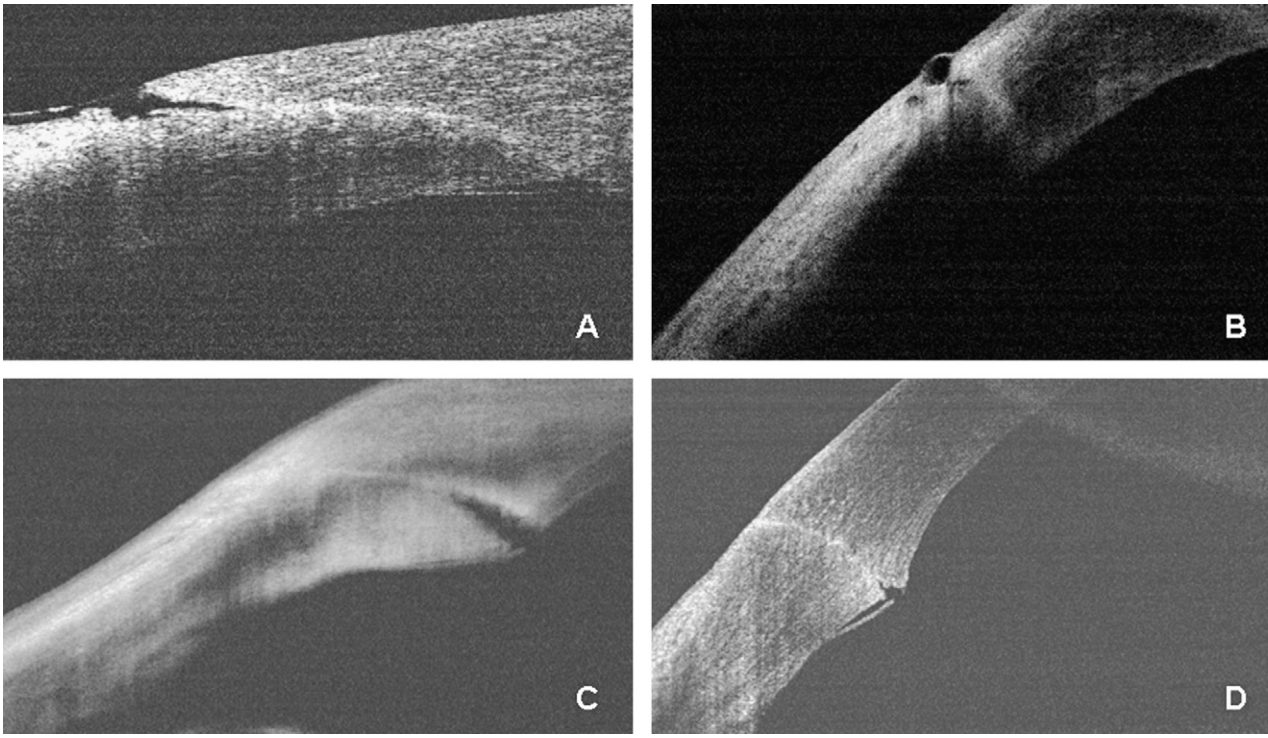

Figure 4. First postoperative day images show epithelial gap (*A* and *B*) and endothelial gap (*C* and *D*).

a risk for endophthalmitis. Based on our epithelial gap findings, we believe that a noninvasive noncontact technique, such as AS-OCT, should be used routinely, especially in the early postoperative period.

Endothelial gaps were detected in 20% in the microcoaxial group and in 26.6% in the biaxial group on the first postoperative day. The ratio between the endothelial gap length and the length of the entire incision did not exceed 20% in either group. At the 30-day examination, a gap was detected in 1 case in each group (3.3%). However, our endothelial gap rates are higher than in the published literature[9,12,27,29] (approximately 50% on first postoperative day). This better rate in our study may be because we routinely performed stromal hydration. Stromal hydration compensates for the suction inside the incisions that occurs as a result of the temporary breakdown of endothelial pump function after surgery. Fine at al.[10] and Calladine and Tanner[26] report that stromal hydration diminished the endothelial gap rate. In addition, Xia et al.[29] found the corneal thickness in cases with endothelial gap was significantly higher. Although some believe that endothelial closure problems arise from the thermal and mechanic damage to the incision and from corneal edema, recent studies[8,9,26,29–31] found that eyes with endothelial gaps also had low IOP; our findings agree. In our study, the mean IOP on the first postoperative day was 11.42 $\pm$ 2.73 mm Hg in eyes with endothelial gap and 16.31 $\pm$ 3.56 mm Hg in eyes with no gap; the difference was statistically significant ($P<.001$). However, unlike in the study by Xia et al.,[29] the incision thickness did not have an influence on endothelial gap in our study. Results in other studies support this.[9–13]

Figure 5. Anterior segment OCT image of a Descemet membrane detachment.

Table 5. Intraocular pressure in Descemet membrane detachment and endothelial gap cases.

	Descemet Membrane Detachment					Endothelial Gap				
	Yes		No			Yes		No		
Group	n	Mean IOP (mm Hg)	n	Mean IOP (mmHg)	*P* Value	n	Mean IOP (mm Hg)	n	Mean IOP (mm Hg)	*P* Value
All patients	36	13.80 ± 3.05	24	17.47 ± 4.55	.006*	14	11.42 ± 2.73	46	16.31 ± 3.56	<.001*
Microcoaxial	16	13.90 ± 2.80	14	17.14 ± 4.09	.061†	6	11.33 ± 1.75	24	15.71 ± 3.16	.003†
Biaxial	20	13.68 ± 3.41	10	17.70 ± 5.05	.044†	8	11.50 ± 3.42	22	17.05 ± 3.97	.003†

Means ± SD
*Student *t* test
†Mann-Whitney *U* test

Descemet membrane detachment usually cannot be detected under biomicroscopic evaluations, although it occurs in at least 50% of cases on the first day.[12,20,30,32] The rate in our study was higher, with AS-OCT showing Descemet membrane detachments in 66.6% of eyes in the microcoaxial group and 53.3% of eyes in the biaxial group 1 day postoperatively. Stromal hydration might be the reason for this. Because corneal stroma lamellae and Descemet membrane have different physical features, the former could become swollen with water while the latter could maintain its properties without swelling; tangential forces between these structures may lead to Descemet membrane detachment.[20] In a study by Calladine and Tanner,[26] Descemet membrane detachment was found in 63% of eyes with stromal hydration and 25% of eyes without stromal hydration. Our data indicate that low IOP also plays a role in Descemet membrane detachment and endothelial gap formation. However, there was no correlation between incision site thickness and Descemet membrane detachment.

In our study, the increase in CCT was significantly less in the biaxial group than in the microcoaxial group on the first postoperative day ($P = .055$). However, when measurements were performed in the periphery of the cornea, the increase in thickness was less in the microcoaxial group. The increase in corneal thickness arises from the corneal edema that occurs as a result of fluid turbulence, nuclear material impingement, the mechanical and thermal effects of the phaco tip, and the impact of the irrigation fluid on the corneal endothelium, which differs from the aqueous in pH, osmolarity, and ion composition. Stromal hydration also contributes to the increase. Bolz et al.[33] found that the postoperative increase in corneal thickness was greater in the vicinity of the incision site, which shows the impact of the phaco tip on the incision site. In addition, Lundberg et al.[34] found strong correlations between postoperative endothelial cell loss and corneal swelling resulting from surgical trauma. Based on our data, although the difference between groups was not statistically significant, we believe that although the biaxial technique is more compatible with the corneal endothelium because of its favorable fluidics, the microcoaxial technique provides safer incision sites because it uses sleeved phaco tips. These findings agree with results in our previous study.[35]

The endothelial gap rate in the microcoaxial group and the Descemet membrane detachment rate in the biaxial group were significantly higher in eyes in which the incision was enlarged than in eyes in which the incision was not enlarged. We attribute these findings to the different amount of balanced salt solution used for stromal hydration in the 2 techniques. In the biaxial technique, the incisions are perpendicular and shorter and more balanced salt solution might be needed to completely seal the incisions. In the microcoaxial technique, the incisions tend to be slanted and longer and less balanced salt solution may be required.

As discussed, stromal hydration is associated with a lower rate of endothelial gap formation and a higher rate of Descemet membrane detachment. Incision enlargement increases the area of the wound exposed to balanced salt solution, which may have led to the higher endothelial gap rate in the microcoaxial group. Less stromal hydration was needed in that group. It may have also led to the higher Descemet membrane detachment rate in the biaxial group, in which less stromal hydration may have been needed.

In conclusion, the wound architecture seemed to be more favorable with the microcoaxial technique, whereas the sleeveless biaxial technique had a greater affect on the thickness at the incision. This was especially true on the first postoperative day, when the risk for endophthalmitis and problems related to wound structure is higher. We found that although stromal hydration facilitated endothelial closure, it increased the rate of Descemet membrane detachment. Postoperative IOPs that were slightly over the mean values were associated with a decreased rate of Descemet membrane detachment and endothelial gap, whereas an increase in corneal thickness had no correlation with either problem. Nevertheless, reliable wound closure and healing occurred in both groups over time.

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