Anterior chamber depth, iridocorneal angle width, and intraocular pressure changes after uneventful phacoemulsification in eyes without glaucoma and with open iridocorneal angles

Cigdem Altan, MD, Sukru Bayraktar, MD, Tugrul Altan, MD, Hakan Eren, MD, Omer Faruk Yilmaz, MD

Purpose: **To investigate the influence of uneventful phacoemulsification on anterior chamber depth (ACD), iridocorneal angle (ICA) width, and intraocular pressure (IOP) in nonglaucomatous eyes with open ICA preoperatively.**

Setting: **Beyoglu Eye Education and Research Hospital, Istanbul, Turkey.**

Methods: **Fifty-three eyes of 49 patients were evaluated for 6 months postoperatively. The nonparametric Wilcoxon signed rank test was used to compare preoperative and postoperative IOP, ACD, and ICA width. Univariate and multivariate regression analyses were used to evaluate the relationships between IOP, ACD, and ICA width and between preoperative patient characteristics.**

Results: **The mean preoperative IOP of 15.1 mm Hg ± 2.8 (SD) dropped postoperatively to 13.4 ± 3.4 mm Hg at 1 day, 13.3 ± 2.6 mm Hg at 1 week, 13.2 ± 3.1 mm Hg at 1 month, 13.3 ± 2.7 mm Hg at 3 months, and 14.1 ± 2.5 mm Hg at 6 months (P<05). The mean preoperative ICA grade of 2.97 ± 0.72 increased to 3.55 ± 0.48 at 1 week and 3.68 ± 0.45 at 1 month (P<.05). The mean preoperative ACD of 3.06 ± 0.49 mm increased to 3.57 ± 0.47 mm at 4 weeks, 3.69 ± 0.32 mm at 1 month, and 3.70 ± 0.36 mm at 3 months (P<.05). The IOP decrease was not correlated with the changes in ICA width or ACD. Multiple regression analysis showed preoperative IOP was the single predictor of the postoperative IOP drop (P<.001).**

Conclusions: **In nonglaucomatous eyes with an open ICA preoperatively, uneventful phacoemulsification reduced IOP, increased ACD, and widened the ICA. The changes were statistically significant over 6 months.**

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It is well known that changes in the anterior chamber depth (ACD), iridocorneal angle (ICA) width, and intraocular pressure (IOP) occur after cataract extraction. Some researchers suggest that cataract surgery alone can reduce IOP in the long term in patients with and without glaucoma.[1-8]

In patients with coexisting chronic angle-closure glaucoma and cataract, cataract surgery alone has been suggested as an initial surgical option for the treatment of glaucoma. This procedure usually leads to widening of the ICA and a drop in IOP.[8,9] In eyes with wide and/or open angles preoperatively, an approximate 2 to 5 mm Hg IOP decrease has been reported after phacoemulsification surgery alone. However, the mechanism and the long-term course of the changes have not been thoroughly investigated.

This prospective study evaluated the influence of uneventful phacoemulsification through a clear corneal incision with in-the-bag foldable intraocular lens (IOL) implantation on IOP, ICA width, and ACD in nonglaucomatous eyes during the first 6 postoperative months.

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Reprint requests to Cigdem Altan, MD, Hukukcular sitesi, C/4 Blok No:18, 4. Levent 34331, Istanbul Turkey. E-mail- taltan@isbanknet.tr.

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Patients and Methods

Patient Selection Criteria

Fifty-three eyes of 49 patients who had cataract surgery with phacoemulsification and in-the-bag foldable IOL implantation between January and July 2001 were enrolled in this prospective study. Patients who had previous exfoliation syndrome, eye trauma, uveitis, glaucoma, previous intraocular surgery, or corneal refractive surgery and those using topical or systemic medications that might influence IOP measurements were excluded from the study. Six patients with intraoperative complications (eg, incomplete capsulorhexis, iris prolapse, posterior capsule perforation, zonular dialysis, corneal burn) and 3 patients with' postoperative complications (eg, fibrin reaction, endophthalmitis) were also excluded. No eye had glaucoma preoperatively, and the ICA was at least grade 2.

Preoperative Evaluation

A complete ocular examination was performed before cataract surgery. The uncorrected (UCVA) and best corrected (BCVA) visual acuities were measured with the Snellen chart and converted to logMAR values. Under biomicroscopy, nuclear grading (from I to 4) was performed using a cobalt blue filter and the type of cataract (cortical, nuclear, posterior subcapsular, mature) was noted. Keratometric values were measured with a Javal keratometer, and the mean of the 2 values taken from the main axis was calculated. The lens chickness and axial length were measured with A-scan ultrasonography (Axis II, Quantel Medical), and IOL power calculation was by the SRK II formula. Fundoscopy was done with a +90.0 diopter lens in eyes without dense cataract. When fundoscopy was not possible, the posterior segment was evaluated with B-scan ultrasonography.

An ICA examination was performed using a Goldmann 3-mirror lens I day before and I week and I month postoperatively. The ICA was graded from I to 4 according to the Shaffer classification as follows: 4 = all elements visible; 3 = Schwalbe's line, trabeculum, and scleral spur visible; 2 = only Schwalbe's line and trabeculum visible; 1 = only Schwalbe's line and, in some cases, the upper part of the trabeculum visible. The ICA examinations were done by the same examiner (A.C.). All 4 quadrants were graded, and the mean of the quadrant values was calculated.

The IOP was measured with a Goldmann applanation tonometer and topical anesthesia the day before surgery and I day, 1 week, and 1, 3, and 6 months postoperatively by rhe same examiner *[Q.K.).*

The ACD was measured by A-scan ultrasonography (Axis II) the day before surgery and I day, I week, and 1 and 3 months postoperatively by the same examiner (C-A.). The average of the 10 consecutive measurements was calculated and used in the study.

Table 1. Preoperative patient charactenstics.

Characteristic	Mean±SD	Range
Age(y)	66.6 ± 7.3	48-80
BCVA		
Decimal	0.3 ± 0.2	0.01-0.9
LogMAR	0.6 ± 0.7	2.0-0.04
K-value P)	43.4 ± 1.6	40-47
Nuclear opacity grade	1.8 ± 0.7	0-4
Lens thickness (mm)	4.2 ± 0.7	2.75-5.37

BCVA = best corrected visual acuity

Surgical Technique

Surgery was performed using topical or sub-Tenon's anesthesia. A 3-plane clear corneal incision was made in the temporal quadrant. In eyes with mature cataract, trypan blue dye was used to visualize the anterior capsule. A capsulorhexis of approximately 5.0 mm was made with a forceps, and cortical-cleaving hydrodissection was performed. The nucleus was emulsified using the stop-and-chop technique. After cortical cleanup, a foldable acrylic IOL with a 5.5 mm or 6.0 mm optic and 12.0 mm or 12.5 mm haptic diameter was implanted in the bag. An AcrySof® IOL (Alcon) was implanted in 29 eyes (54.7%), an Acryflex® IOL (Medical Developmental Research Inc.) in 15 eyes (28.3%), and an ACR 6D IOL (Corneal Laboratories) in 9 eyes (17.0%). The incisions were not sutured.

Postoperatively, patients were given topical antibiotics 4 times daily for 1 week and topical steroids 4 times daily for 1 month.

Statistical Analysis

Statistical analysis was done using SPSS for Windows 7. The nonparametric Wilcoxon signed rank test was used to compare preoperative and postoperative data from the same patient. Univariate and multivariate regression analyses were used to evaluate the relationships between the postoperative drop in IOP, increase in ACD and ICA width with the patient age, preoperative IOP, lens thickness, axial length, preoperative ACD, ICA grade, IOL type, and IOL power. Similar analyses were done to evaluate the relationships between the 3 outcome parameters (IOP, ACD, and ICA) postoperatively. A *P* value less than 0.05 was considered statistically significant.

Results

Patient Characteristics

Table 1 shows the patients' preoperative characteristics (means) including the BCVA, K-value, axial length, lens thickness, and nuclear opacity score. Twenty-five

Table 2. Intraocular pressure, ACD, and ICA width over time.

		Postop				
Parameter	Preop	1 Day	1 Week	1 Month	3 Months	6 Months
Mean IOP {mm Hg)	15.1 ± 2.8	13.4 ± 3.4	13.3 ± 2.6	13.2 ± 3.1	13.3 ± 2.7	14.1 ± 2.5
Mean ACD (mm)	3.06 ± 0.49	-	3.57 ± 0.47	3.69 ± 0.32	3.70 ± 0.36	-
Mean ICA width (grade)	2.97 ± 0.72	-	3.55 ± 0.48	3.68 ± 0.45	-	-

Means ± SD
ACD = anterior chamber depth; ICA = iridocorneal angle;. IOP = intraocular pressure

patients were men and 24, women. Twenty-four eyes (45.3%) were right and 29 (54.7%), left. The mean patient age was 66.6 years ± 7.3 (SD). The cataract was mature in 4 eyes (7.5%), nuclear in 11 eyes (20.8%), nuclear and posterior subcapsular in 17 eyes (32.1%), nuclear and cortical and posterior subcapsular in 6 eyes (11.3%), cortical in 2 eyes (3.8%), posterior subcapsular in 8 eyes (15.1%). cortical and posterior subcapsular in 4 eyes (7.5%), and nuclear and cortical in 1 eye (1.9%).

Change in Visual Acuity

After surgery, both the UCVA and BCVA improved. Preoperatively, the mean decimal UCVA was 0.1 ± 0.1(1.1 logMAR) and the mean decimal preoperative BCVA, 0.3 ± 0.2 (0.60 logMAR). Postoperatively, the means were 0.6 ± 0.2 (0.25 logMAR) and 0.9 ± 0.2 (0.07 logMAR), respectively.

Change in IOP

Table 2 shows the mean IOP and Figure 1, the change in IOP over time. The IOP was significantly lower at all postoperative examinations than preoperatively. There were no significant differences between the postoperative values (P^.05).

Change in ICA Width

Table 2 shows the mean ICA width and Figure 2, the change in the ICA over time. The preoperative width was statistically significantly lower than at 1 week and 1 month (P<.001). The difference in ICA width between 1 week and 1 month was also significant (*P* = .006).

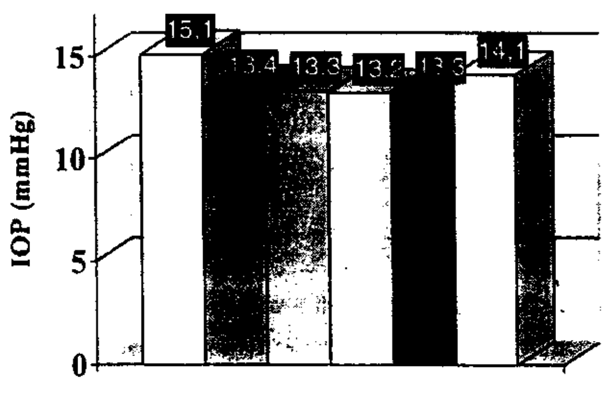
Change in ACD

Table 2 shows the mean ACD and Figure 3, the change in ACD over time. All postoperative measurements were significantly greater than preoperatively (*P*< .001). The ACD was significandy greater at 1 month than at t week (*P* = .019). There was no significant difference in ACD between 1 month and 3 months (*P* = .22).

Regression Analysis

Univariate analysis showed positive correlations between the preoperative ICA width and the ACD (*P* = .002) and axial length (*P* = .001). Patient age and preoperative ICA width were negatively correlated (P=.015).

Univariate regression analysis showed no significant correlation between the postoperative IOP drop and the ACD or widening of the ICA at any follow-up visit (P>.05). It also showed a significant correlation between the amount of IOP drop at the last visit (6 months) and the patient's age and preoperative IOP



- Preoperative
- U Postoperative first day
- Postoperative first week
- Postoperative first month
- •Postoperative third month
- Postoperative sixth month

Figure 1. (Altan) Change in IOP over time.

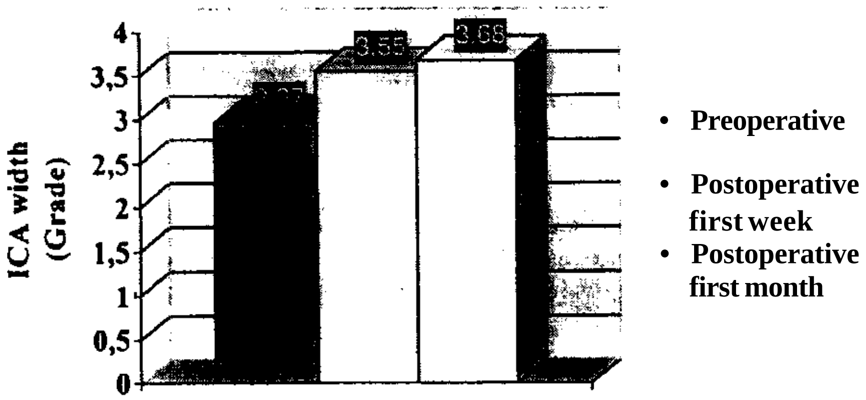


Figure 2. (Altan) Change in ICA width over time.

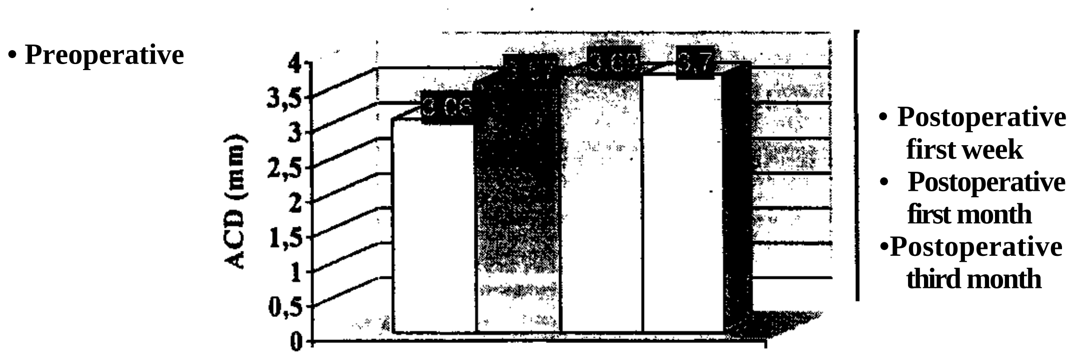


Figure 3. (Altan) Preoperative ACD and postoperative ACD over time.

level (*P* = .008 and *P*<.001. respectively). Multiple regression analysis revealed that preoperative IOP was an independent predictor of the postoperative IOP drop (*P*<.001), but age was not (*P*>.05).

Univariate regression analysis showed that postoperative widening of the ICA correlated negatively with the preoperative ACD (*P* = .008), axial length {*P* = .018), and preoperative ICA width {*P*<.001). Multiple regression analysis revealed that the preoperative ICA width was a predictor of postoperative widening of the ICA (P<.001). There was an inverse relationship between the 2 parameters; that is, the widening was more marked in eyes with narrow angles preoperatively.

Univariate analysis also showed that postoperative anterior chamber deepening was positively correlated with the patient's age (*P* = .006); however, there was an inverse correlation between the postoperative deepening and the preoperative ACD (P<.00I) and preoperative ICA width (*P* = .04). Multiple regression analysis showed that among these 3 parameters, only preoperative ACD had a significant correlation with postoperative anterior chamber deepening (P<.001). The IOL type and A-constant were not influenced by IOP, ACD, or ICA width (P>.05).

Discussion

Many studies of the long-term and short-term effects of cataract surgery on IOP have been published.[1-2-4-7-10-17] In this prospective study, we evaluated the influence of uneventful phacoemulsification through a clear corneal incision with implantation of a foldable IOL in the capsular bag on IOP levels in patients without any form of glaucoma. We also sought to determine the mechanism of IOP change by analyzing the concomitant changes in the ICA width and ACD.

Transient increases in IOP are common, especially during the first 6 to 8 hours after uneventful cataract surgery.[1,14] Inflammatory reaction from residual cortical material, blood elements, pigment, fibrin, free radicals, viscoelastic material, retrobulbar anesthesia, damage to aqueous veins, and pupillary block are reported to be responsible for the early IOP rise.[1,10,14] The rise is generally transient, and the IOP usually returns to a normal level within hours.

In our study, there was no early rise of IOP. Rather, the mean IOP decreased approximately 2 mm Hg on the first postoperative day. We believe that complete removal of cortical and viscoelastic materials, minimal iris trauma, and exclusion of eyes with posterior capsule rupture or vitreous loss may have contributed to this drop.

The influence of cataract extraction on intermediate- and long-term IOP measurements and the mechanism of change is usually different from the mechanisms responsible for the early IOP effect. Studies show that small-incision phacoemulsification usually leads to lower long-term IOP levels than extracapsular cataract extraction (ECCE). A larger incision, trauma during extraction, and suture damage to the anterior chamber angle structures after ECCE generally lead to higher IOP.[5] In-the-bag IOL implantation after phacoemulsification may also play a role in the long-term IOP-lowering effect.[18]

Shingleton et al.[10] report a significant decrease in IOP after phacoemulsification through a clear corneal incision during a 12-month follow-up in eyes without glaucoma. In contrast, the eyes with glaucoma required significantly fewer glaucoma medications without an accompanying decrease in IOP.

Kim and coauthors[19] found a significant decrease in IOP (from 18.1 to 15.2 mm Hg) in 31 eyes with glaucoma after phacoemulsification alone. They also found a decrease in the average number of glaucoma medications (from 1.7 to 0.7) after 16 months.

Jahn et al.[20] compared both eyes of 120 patients who had phacoemulsification with a scleral incision in 1 eye. They found significantly lower IOP levels in the operated eyes during a 17-month follow-up.

The exact physiopathologic mechanisms behind the lOP-reducing effect of phacoemulsification are not clear and require further study. The relationship between patient characteristics, such as age, sex, preoperative IOP (presence of glaucoma), ICA width, ACD, and the temporal characteristics of the response (whether IOP rises to preoperative levels with time), must also be addressed.

Many studies report that the IOP-reducing effect of phacoemulsification can be detected even after 10 years.[4,7,10] The maximum IOP drop usually occurs 3 to 6 months after cataract surgery, however.[2,11] In our study, the maximum IOP drop was in the first 3 months.

The size and placement of the cataract incision can influence IOP, at least theoretically. Tennen and Masker - compared the effect on IOP of a scleral tunnel incision with that of a clear corneal incision in phacoemulsification. They found that IOP was lower than the preoperative levels in both groups during a 6-month follow-up; however, the drop was statistically significant only in the clear corneal incision group. The 3-stepped clear corneal incision we used causes minimal damage to the trabecular meshwork. Other studies show no relationship between postoperative IOP and the type and size of cataract incision.[7] In our study population, the greatest IOP decreases were in patients with a higher preoperative IOP.

Hayashi and coauthors[8] evaluated the effect of phacoemulsification on ACD and ICA width in eyes with open-angle glaucoma or closed-angle glaucoma and in those without glaucoma. Significant increases were found in the ICA width and ACD and significant decreases in IOP in all 3 groups. There were no statistically significant differences between the groups.

Significant deepening of the anterior chamber has been reported after phacoemulsification.[2,21,22] Kurimato and coauthors[9] found that postoperative deepening was more prevalent in eyes with crowded anterior segments. Similarly, we found the only statistically significant predictor of postoperative anterior chamber deepening to be preoperative ACD (ie, the change was more obvious in eyes with a shallow anterior chamber).

In our study, the changes in the ICA width after phacoemulsification were similar to the changes in ACD. Most widening of the ICA occurred in eyes with narrow angles preoperatively, while the changes were minimal in eyes presenting with wider angles.

Using ultrasonic biomicroscopy, Kurimoto and coauthors[9] found that the position of the iris was different in phakic and pseudophakic eyes. In phakic eyes, the iris was in apposition to the crystalline lens, but there was no iris-IOL contact in pseudophakic eyes.

In eyes with narrow ICAs and shallow anterior chambers preoperatively, the mechanism of the IOP decrease is relatively simple to explain. Meyer and coauthors[1] report a significant increase in outflow facility after phacoemulsification and IOL implantation in eyes with diminished preoperative outflow facility. Marked improvements after phacoemulsification are common in the conventional outflow facility because the relative pupillary block in these eyes is relieved.

In our study, the magnitude of the IOP decrease did not statistically correlate with the amount of ICA widening or anterior chamber deepening. Also, temporal characteristics of the IOP curve over time were different from chose of the ICA and ACD. The IOP dropped approximately 2 mm Hg immediately after phacoemulsification and was relatively stable during the 6-month follow-up, whereas ACD and ICA width continued to increase. These findings suggest that pathophysiologic mechanisms other than improved conventional outflow facility are responsible, at least in pan, for the IOP decrease after phacoemulsification.

In our study, we purposely excluded eyes with closed or narrow angles and shallow anterior chambers and those with open-angle glaucoma based on the theory that the resistance to trabecular outflow in these eyes was normal before phacoemulsification. Three major mechanisms exist in a human eye to decrease IOP: blunting aqueous secretion, improving conventional outflow, and improving uveoscleral outflow. Precise measurement of the first 2 routes is possible in the living human eye; quantification of the third pathway can be accomplished only indirectly. Although we did not perform tonography or fluorophotometry, we believe the decrease in aqueous secretion, increase in uveoscleral outflow, or both were more important mechanisms in the IOP decrease after uneventful phacoemulsification in our series.

Some authors question the theory that there is hyposecretion of aqueous humor after cataract extraction. Most believe it is transient and diminishes with time. A unique complication of phacoemulsification, capsule shrinkage and phimosis, is not seen in ECCE and is a sequelae of the capsulorhexis. It occurs most frequendy in eyes with pseudoexfoliation, trauma, uveitis, and retinitis pigmentosa and in young patients with high myopia. The IOP is typically low in patients who develop this complication.

Some investigators report an inverse relationship between capsulorhexis size and the amount of IOP decrease.[15,23] They suggest that capsule fibrosis after cataract surgery causes centripetal traction on the ciliary processes and probably reduces aqueous humor secretion to an extent.[2,11,15,23]

It is known that prostaglandin (PG) $F_{2\alpha}$ increases the outflow facility by a uveoscleral pathway and PGE increase it by the trabecular meshwork.[2,11,23-25] We believe that improvement in the uveoscleral pathway contributed to the IOP decrease after cataract surgery in nonglaucomatous eyes with open angles preoperatively.

Some studies report a greater drop in IOP in eyes with pseudoexfoliation syndrome than in those without.[13,26] This is because 1 source of pseudoexfoliative material and debris is removed from the anterior segment of the eye.[13] In our study, we excluded eyes with pseudoexfoliation syndrome.

In conclusion, uneventful phacoemulsification through a clear corneal incision and implantation of a foldable IOL in the capsular bag caused a statistically significant drop in IOP (approximately **2** mm Hg) in eyes without any form of glaucoma and with open IGAs preoperatively. The IOP drop occurred independent of changes in the ICA and ACD and appeared to be stable over a 6-month period. The only statistically significant predictor of the drop in IOP was preoperative IOP; that is, the decrease occurred more often in patients with higher preoperative IOP. We believe that the reason for the IOP decrease after uneventful phacoemulsification in our study was multifactorial. We think that diminishing aqueous humor secretion, improving uveoscleral outflow, or both were important mechanisms in the improvement of conventional trabecular outflow in our series. More studies using tonography and fluorometry to elucidate the exact contributions of the various mechanism(s) in the IOP decrease commonly seen after uneventful phacoemulsification surgery are needed.

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From the Beyoglu Eye Education and Research Hospital Istanbul Turkey.

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Conclusions: **In nonglaucomatous eyes with an open ICA preoperatively, uneventful phacoemulsification reduced IOP, increased ACD, and widened the ICA. The changes were statistically significant over 6 months.**

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Reprint requests to Cigdem Altan, MD, Hukukcular sitesi, CI4 Blok No:18, 4. Levent 34331, Istanbul, Turkey. E-mail: taltan@isbanknet.tr.

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Fifty-three eyes of 49 patients who had cataract surgery with phacoemulsification and in-the-bag foldable IOL implantation between January and July 2001 were enrolled in this prospective study. Patients who had pseudoexfoliation syndrome, eye trauma, uveitis, glaucoma, previous intraocular surgery, or corneal refractive surgery and those using topical or systemic medications that might influence IOP measurements were excluded from the study. Six patients with intraoperative complications (eg, incomplete capsulorhexis, iris prolapse, posterior capsule perforation, zonular dialysis, corneal burn) and 3 patients with postoperative complications (eg, fibrin reaction, endophthalmitis) were also excluded. No eye had glaucoma preoperatively, and the ICA was at least grade 2.

Preoperative Evaluation

A complete ocular examination was performed before cataract surgery. The uncorrected (UCVA) and best corrected (BCVA) visual acuities were measured with the Snellen chart and converted to logMAR values. Under biomicroscopy, nuclear grading (from 1 to 4) was performed using a cobalt blue filter and the type of cataract (cortical, nuclear, posterior subcapsular, mature) was noted. Keratometric values were measured with a Javal keratometer, and the mean of the 2 values taken from the main axis was calculated. The lens thickness and axial length were measured with A-scan ultrasonography (Axis II, Quantel Medical), and IOL power calculation was by the SRK II formula. Fundoscopy was done with a +90.0 diopter lens in eyes without dense cataract. When fundoscopy was not possible, the posterior segment was evaluated with B-scan ultrasonography.

An ICA examination was performed using a Goldmann 3-mirror lens 1 day before and 1 week and 1 month postoperatively. The ICA was graded from 1 to 4 according to the Shaffer classification as follows: 4 = all elements visible; 3 = Schwalbe's line, trabeculum, and scleral spur visible; 2 = only Schwalbe's line and trabeculum visible; 1 = only Schwalbe's line and, in some cases, the upper part of the trabeculum visible. The ICA examinations were done by the same examiner (A.C.). All 4 quadrants were graded, and the mean of the quadrant values was calculated.

The IOP was measured with a Goldmann applanation tonometer and topical anesthesia the day before surgery and 1 day, 1 week, and 1, 3, and 6 months postoperatively by the same examiner (C.A.).

The ACD was measured by A-scan ultrasonography (Axis II) the day before surgery and 1 day, 1 week, and 1 and 3 months postoperatively by the same examiner (C.A.). The average of the 10 consecutive measurements was calculated and used in the study.

Table 1. Preoperative patient characteristics.

Characteristic	Mean ± SD	Range
Age (y)	66.6 ± 7.3	48-80
BCVA		
Decimal	0.3 ± 0.2	0.01-0.9
LogMAR	0.6 ± 0.7	2.0-0.04
K-value (D)	43.4 ± 1.6	40-47
Nuclear opacity grade	1.8 ± 0.7	0-4
Lens thickness (mm)	4.2 ± 0.7	2.75-5.37

BCVA = best corrected visual acuity

Surgical Technique

Surgery was performed using topical or sub-Tenon anesthesia. A 3-plane clear corneal incision was made in the temporal quadrant. In eyes with mature cataract, trypan blu dye was used to visualize the anterior capsule. A capsulorhexi of approximately 5.0 mm was made with a forceps, and cortical-cleaving hydrodissection was performed. The nucleu was emulsified using the stop-and-chop technique. After cor tical cleanup, a foldable acrylic IOL with a 5.5 mm or 6.0 mm optic and 12.0 mm or 12.5 mm haptic diameter was im planted in the bag. An AcrySof® IOL (Alcon) was implanted in 29 eyes (54.7%), an Acryflex® IOL (Medical Develop mental Research Inc.) in 15 eyes (28.3%), and an ACR 6D IOL (Corneal Laboratories) in 9 eyes (17.0%). The incision were not sutured.

Postoperatively, patients were given topical antibiotic 4 times daily for 1 week and topical steroids 4 times daily for 1 month.

Statistical Analysis

Statistical analysis was done using SPSS for Windows 7. The nonparametric Wilcoxon signed rank test was used to compare preoperative and postoperative data from the same patient. Univariate and multivariate regression analyses were used to evaluate the relationships between the postoperative drop in IOP, increase in ACD and ICA width with the patient age, preoperative IOP, lens thickness, axial length, preoperative ACD, ICA grade, IOL type, and IOL power. Similar analyses were done to evaluate the relationships between the 3 outcome parameters (IOP, ACD, and ICA) postoperatively. A P value less than 0.05 was considered statistically significant.

Results

Patient Characteristics

Table 1 shows the patients' preoperative characteristics (means) including the BCVA, K-value, axial length, lens thickness, and nuclear opacity score. Twenty-five

Table 2. Intraocular pressure, ACD, and ICA width over time.

Parameter	Preop	Postop				
		1 Day	1 Week	1 Month	3 Months	6 Months
Mean IOP (mm Hg)	15.1 ± 2.8	13.4 ± 3.4	13.3 ± 2.6	13.2 ± 3.1	13.3 ± 2.7	14.1 ± 2.5
Mean ACD (mm)	3.06 ± 0.49	–	3.57 ± 0.47	3.69 ± 0.32	3.70 ± 0.36	–
Mean ICA width (grade)	2.97 ± 0.72	–	3.55 ± 0.48	3.68 ± 0.45	–	–

Means ± SD
ACD = anterior chamber depth; ICA = iridocorneal angle; IOP = intraocular pressure

patients were men and 24, women. Twenty-four eyes (45.3%) were right and 29 (54.7%), left. The mean patient age was 66.6 years ± 7.3 (SD). The cataract was mature in 4 eyes (7.5%), nuclear in 11 eyes (20.8%), nuclear and posterior subcapsular in 17 eyes (32.1%), nuclear and corneal and posterior subcapsular in 6 eyes (11.3%), cortical in 2 eyes (3.8%), posterior subcapsular in 8 eyes (15.1%), cortical and posterior subcapsular in 4 eyes (7.5%), and nuclear and cortical in 1 eye (1.9%).

Change in Visual Acuity

After surgery, both the UCVA and BCVA improved. Preoperatively, the mean decimal UCVA was 0.1 ± 0.1 (1.1 logMAR) and the mean decimal preoperative BCVA, 0.3 ± 0.2 (0.60 logMAR). Postoperatively, the means were 0.6 ± 0.2 (0.25 logMAR) and 0.9 ± 0.2 (0.07 logMAR), respectively.

Change in IOP

Table 2 shows the mean IOP and Figure 1, the change in IOP over time. The IOP was significantly lower at all postoperative examinations than preoperatively. There were no significant differences between the postoperative values ($P>.05$).

Change in ICA Width

Table 2 shows the mean ICA width and Figure 2, the change in the ICA over time. The preoperative width was statistically significantly lower than at 1 week and 1 month ($P<.001$). The difference in ICA width between 1 week and 1 month was also significant ($P = .006$).

Change in ACD

Table 2 shows the mean ACD and Figure 3, the change in ACD over time. All postoperative measurements were significantly greater than preoperatively ($P<.001$). The ACD was significandy greater at 1 month than at 1 week ($P = .019$). There was no significant difference in ACD between 1 month and 3 months ($P = .22$).

Regression Analysis

Univariate analysis showed positive correlations between the preoperative ICA width and the ACD ($P = .002$) and axial length ($P = .001$). Patient age and preoperative ICA width were negatively correlated ($P=.015$).

Univariate regression analysis showed no significant correlation between the postoperative IOP drop and the ACD or widening of the ICA at any follow-up visit ($P>.05$). It also showed a significant correlation between the amount of IOP drop at the last visit (6 months) and the patient's age and preoperative IOP

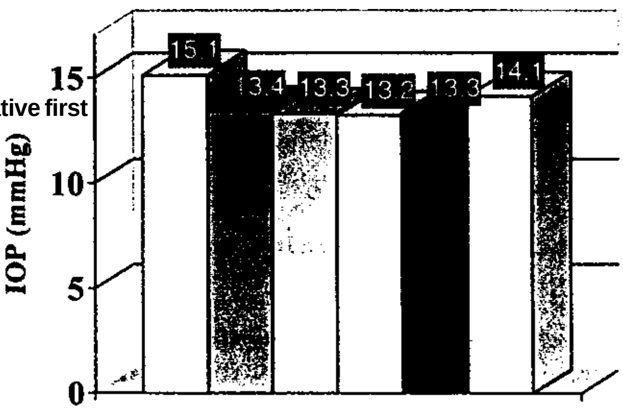

Figure 1. (Altan) Change in IOP over time.

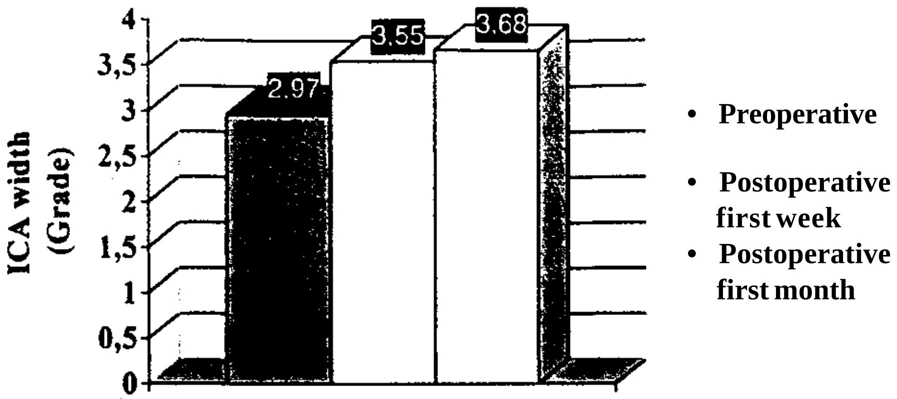

Figure 2. (Altan) Change in I(width over time.

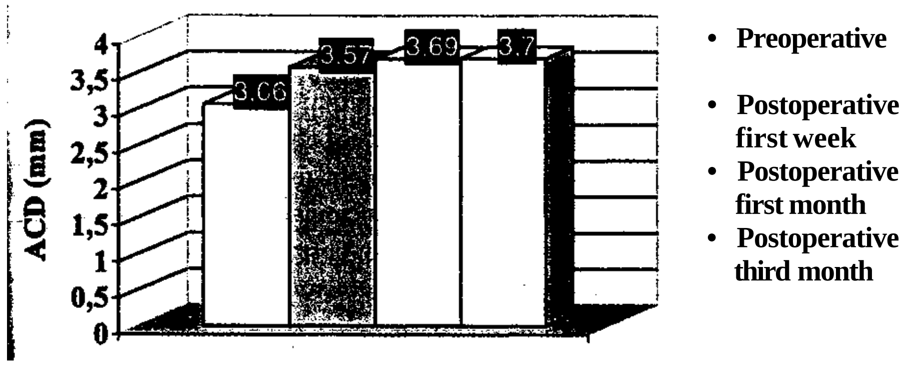

Figure 3. (Altan) Preoperative ACC and postoperative ACD over time.

level *(P* = .008 and P<.001. respectively). Multiple regression analysis revealed that preoperative IOP was an independent predictor of the postoperative IOP drop (P<.001), but age was not (P>.05).

Univariate regression analysis showed that postoperative widening of the ICA correlated negatively with the preoperative ACD *(P* = .008), axial length *{P* = ,018), and preoperative ICA width *(P*<.001). Multiple regression analysis revealed that the preoperative ICA width was a predictor of postoperative widening of the ICA (P<.001), There was an inverse relationship between the 2 parameters; that is, the widening was more marked in eyes with narrow angles preoperatively.

Univariate analysis also showed that postoperative anterior chamber deepening was positively correlated with the patient's age *(P* = .006); however, there was an inverse correlation between the postoperative deepening and the preoperative ACD (P<.001) and preoperative ICA width *(P* = .04). Multiple regression analysis showed that among these 3 parameters, only preoperative ACD had a significant correlation with postoperative anterior chamber deepening (P<.001). The IOL type and A-constant were not influenced by IOP, ACD, or ICA width CP>.05).

Discussion

Many studies of the long-term and short-term effects of cataract surgery on IOP have been published.[1,2,4,7,10-17] In this prospective study, we evaluated the influence of uneventful phacoemulsification through a clear corneal incision with implantation of a foldable IOL in the capsular bag on IOP levels in patients without any form of glaucoma. We also sought to determine the mechanism of IOP change by analyzing the concomitant changes in the ICA width and ACD.

Transient increases in IOP are common, especially during the first 6 to 8 hours after uneventful cataract surgery.[1,14] Inflammatory reaction from residual cortical material, blood elements, pigment, fibrin, free radicals, viscoelastic material, retrobulbar anesthesia, damage to aqueous veins, and pupillary block are reported to be responsible for the early IOP rise.[1,10,14] The rise is generally transient, and the IOP usually returns to a normal level within hours.

In our study, there was no early rise of IOP. Rather, the mean IOP decreased approximately 2 mm Hg on the first postoperative day. We believe that complete removal of cortical and viscoelastic materials, minimal iris trauma, and exclusion of eyes with posterior capsule rupture or vitreous loss may have contributed to this drop.

The influence of cataract extraction on intermediate- and long-term IOP measurements and the mechanism of change is usually different from the mechanisms responsible for the early IOP effect. Studies show that small-incision phacoemulsification usually leads to lower long-term IOP levels than extracapsular cataract extraction (ECCE). A larger incision, trauma during extraction, and suture damage to the anterior chamber angle structures after ECCE generally lead to higher IOP.[5] In-the-bag IOL implantation after phacoemulsification may also play a role in the long-term IOP-lowering effect.[18]

Shingleton et al.[10] report a significant decrease in IOP after phacoemulsification through a clear corneal incision during a 12-month follow-up in eyes without glaucoma. In contrast, the eyes with glaucoma required significantly fewer glaucoma medications without an accompanying decrease in IOP.

Kim and coauthors[19] found a significant decrease in IOP (from 18.1 to 15.2 mm Hg) in 31 eyes with glaucoma after phacoemulsification alone. They also found a decrease in the average number of glaucoma medications (from 1.7 to 0.7) after 16 months.

Jahn et al.[20] compared both eyes of 120 patients who had phacoemulsification with a scleral incision in 1 eye. They found significantly lower IOP levels in the operated eyes during a 17-month follow-up.

The exact physiopathologic mechanisms behind the IOP-reducing effect of phacoemulsification are not clear and require further study. The relationship between patient characteristics, such as age, sex, preoperative IOP (presence of glaucoma), ICA width, ACD, and the temporal characteristics of the response (whether IOP rises to preoperative levels with time), must also be addressed.

Many studies report that the IOP-reducing effect of phacoemulsification can be detected even after 10 years.[4,7,10] The maximum IOP drop usually occurs 3 to 6 months after cataract surgery, however.[2,11] In our study, the maximum IOP drop was in the first 3 months.

The size and placement of the cataract incision can influence IOP, at least theoretically. Tennen and Masket[12] compared the effect on IOP of a scleral tunnel incision with that of a clear corneal incision in phacoemulsification. They found that IOP was lower than the preoperative levels in both groups during a 6-month follow-up; however, the drop was statistically significant only in the clear corneal incision group. The 3-stepped' clear corneal incision we used causes minimal damage to the trabecular meshwork. Other studies show no relationship between postoperative IOP and the type and size of cataract incision.[7] In our study population, the greatest IOP decreases were in patients with a higher preoperative IOP.

Hayashi ,and coauthors[8] evaluated the effect of phacoemulsification on ACD and ICA width in eyes with open-angle glaucoma or closed-angle glaucoma and in those without glaucoma. Significant increases were found in the ICA width and ACD and significant decreases in IOP in all 3 groups. There were no statistically significant differences between the groups.

Significant deepening of the anterior chamber has been reported after phacoemulsification.[2,21,22] Kurimato and coauthors[9] found that postoperative deepening was more prevalent in eyes with crowded anterior segments. Similarly, we found the only statistically significant predictor of postoperative anterior chamber deepening to be preoperative ACD (ie, the change was more obvious in eyes with a shallow anterior chamber).

In our study, the changes in the ICA width after phacoemulsification were similar to the changes in ACD. Most widening of the ICA occurred in eyes with narrow angles preoperatively, while the changes were minimal in eyes presenting with wider angles.

Using ultrasonic biomicroscopy, Kurimoto and coauthors[9] found that the position of the iris was different in phakic and pseudophakic eyes. In phakic eyes, the iris was in apposition to the crystalline lens, but there was no iris-IOL contact in pseudophakic eyes.

In eyes with narrow ICAs and shallow anterior chambers preoperatively, the mechanism of the IOP decrease is relatively simple to explain. Meyer and coauthors[1] report a significant increase in outflow facility after phacoemulsification and IOL implantation in eyes with diminished preoperative outflow facility. Marked improvements after phacoemulsification are common in the conventional outflow facility because the relative pupillary block in these eyes is relieved.

In our study, the magnitude of the IOP decrease did not statistically correlate with the amount of ICA widening or anterior chamber deepening. Also, temporal characteristics of the IOP curve over time were different from those of the ICA and ACD. The IOP dropped approximately 2 mm Hg immediately after phacoemulsification and was relatively stable during the 6-month follow-up, whereas ACD and ICA width continued to increase. These findings suggest that pathophysiologic mechanisms other than improved conventional outflow facility are responsible, at least in part, for the IOP decrease after phacoemulsification.

In our study, we purposely excluded eyes with closed or narrow angles and shallow anterior chambers and those with open-angle glaucoma based on the theory that the resistance to trabecular outflow in these eyes was normal before phacoemulsification. Three major mechanisms exist in a human eye to decrease IOP: blunting aqueous secretion, improving conventional outflow, and improving uveoscleral outflow. Precise measurement of the first 2 routes is possible in the living human eye; quantification of the third pathway can be accomplished only indirectly. Although we did not perform tonography or fluorophotometry, we believe the decrease in aqueous secretion, increase in uveoscleral outflow, or both were more important mechanisms in the IOP decrease after uneventful phacoemulsification in our series.

Some authors question the theory that there is hyposecretion of aqueous humor after cataract extraction. Most believe it is transient and diminishes with time. A unique complication of phacoemulsification, capsule shrinkage and phimosis, is not seen in ECCE and is a sequelae of the capsulorhexis. It occurs most frequently in eyes with pseudoexfoliation, trauma, uveitis, and retinitis pigmentosa and in young patients with high myopia. The IOP is typically low in patients who develop this complication.

Some investigators report an inverse relationship between capsulorhexis size and the amount of IOP decrease.[15,23] They suggest that capsule fibrosis after cataract surgery causes centripetal traction on the ciliary processes and probably reduces aqueous humor secretion to an extent.[2,11,15,23]

It is known that prostaglandin (PG) increases the outflow facility by a uveoscleral pathway and PGEi increase it by the trabecular meshwork.[2,11,23-25] We believe that improvement in the uveoscleral pathway contributed to the IOP decrease after cataract surgery in nonglaucomatous eyes with open angles preoperatively.

Some studies report a greater drop in IOP in eyes with pseudoexfoliation syndrome than in those without.[13,26] This is because 1 source of pseudoexfoliative material and debris is removed from the anterior segment of the eye.[13] In our study, we excluded eyes with pseudoexfoliation syndrome.

In conclusion, uneventful phacoemulsification through a clear corneal incision and implantation of a foldable IOL in the capsular bag caused a statistically significant drop in IOP (approximately 2 mm Hg) in eyes without any form of glaucoma and with open ICAs preoperatively. The IOP drop occurred independent of changes in the ICA and ACD and appeared to be stable over a 6-month period. The only statistically significant predictor of the drop in IOP was preoperative IOP; that is, the decrease occurred more often in patients with higher preoperative IOP. We believe that the reason for the IOP decrease after uneventful phacoemulsification in our study was multifactorial. We think that diminishing aqueous humor secretion, improving uveoscleral outflow, or both were important mechanisms in the improvement of conventional trabecular outflow in our series. More studies using tonography and fluorometry to elucidate the exact contributions of the various mechanism(s) in the IOP decrease commonly seen after uneventful phacoemulsification surgery are needed.

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From the Beyoglu Eye Education and Research Hospital Istanbul Turkey.

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