Anterior segment parameters: Comparison of 1-piece and 3-piece acrylic foldable intraocular lenses

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PURPOSE: To compare anterior segment parameters between 1-piece and 3-piece acrylic foldable intraocular lenses (IOLs).

SETTING: Farabi Eye Hospital, Tehran, Iran.

DESIGN: Prospective randomized comparative case series.

METHOD: Eyes scheduled for phacoemulsification were randomized into 2 equal groups to receive a 1-piece (AcrySof SA60AT) or 3-piece (AcrySof MA60AC) foldable acrylic IOL. Scheimpflug imaging (Pentacam) was used to measure anterior segment parameters, including anterior chamber depth (ACD), anterior chamber angle (ACA), and anterior chamber volume (ACV), preoperatively and 1 week and 3 months postoperatively.

RESULTS: The study evaluated 125 eyes (123 patients). There was a statistically significant postoperative increase in ACD, ACA, and ACV at 1 week and 3 months in both IOL groups. Although the mean ACD was significantly higher in the 3-piece group at 1 week, there was no significant between-group difference in ACD, ACA, or ACV at 3 months. There was no significant change in anterior segment parameters from 1 week to 3 months in the 1-piece group; however, the 3-piece group had statistically significant decreases in ACD, ACA, and ACV. Refraction remained stable throughout the follow-up in the 1-piece group but showed a significant myopic shift from 1 week to 3 months in the 3-piece group.

CONCLUSIONS: After phacoemulsification, the 1-piece acrylic foldable IOL showed little axial movement and provided stable refraction throughout the follow-up. The 3-piece IOL had significant forward movement and led to a myopic shift within 3 months postoperatively. Results indicate that spectacles can be prescribed earlier in eyes with a 1-piece IOL.

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Cataract surgery with foldable intraocular lens (IOL) implantation is one of the most frequently performed ophthalmic surgical procedures. In addition to improving vision, the surgery changes the anatomy of the anterior segment. It has been shown that cataract extraction with IOL implantation deepens the anterior chamber and widens the anterior chamber angle (ACA).[1,2] However, it remains largely unknown how and why IOL position, and thus anterior chamber depth (ACD), change over time after surgery. We believe this is the reason for the varying results in the literature, which reports increases,[2,3] decreases,[1,4] or no change[5–7] in ACD over time postoperatively.

The characteristics of the IOL implanted during cataract surgery may play a role in determining the postoperative configuration of the anterior segment, and the design of the IOL (ie, whether it is 1-piece or 3-piece model) may be the most important characteristic. The optic and haptics of 1-piece foldable acrylic IOLs are foldable and acrylic, while 3-piece foldable acrylic IOLs consist of an acrylic optic and poly(methyl methacrylate) haptics. Today, both types of IOLs are widely used in phacoemulsification, with good clinical results.[8] However, it is not entirely clear whether the 2 types of IOLs change the anterior segment configuration in a similar manner.

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Previous studies comparing postoperative changes in ACD between 1-piece IOLs and 3-piece IOLs[1,8,9] found that 3-piece IOLs shifted forward significantly after surgery but 1-piece IOLs did not. However, none of the studies evaluated other anterior segment parameters, such as ACA or anterior chamber volume (ACV).

Recent studies[7,10–12] have used rotating Scheimpflug imaging to accurately and quantitatively evaluate anterior segment parameters. To our knowledge, no study has used this technology to compare the postoperative changes in anterior segment parameters between 1-piece IOLs and 3-piece IOLs. Therefore, we used Scheimpflug imaging to compare these parameters in eyes having phacoemulsification with implantation of a 1-piece or 3-piece foldable acrylic IOL. To ensure the clinical relevance of the results, we also evaluated the changes in the patient's refractive status.

PATIENTS AND METHODS

This prospective randomized clinical trial included consecutive eyes with age-related cataract scheduled to have phacoemulsification with IOL implantation from April through August 2008. The Institutional Review Board, Farabi Eye Hospital, Tehran, Iran, approved the study's research protocol. All patients provided informed written consent before surgery.

The exclusion criteria were previous ocular trauma or intraocular surgery, corneal disease, a narrow or closed ACA, uveitis, pseudoexfoliation syndrome, glaucoma, and high intraocular pressure (>22 mm Hg). Eyes with an intraoperative or postoperative complication were also excluded.

The same surgeon (H.H.) performed all cataract operations. The technique included phacoemulsification through a temporal clear corneal incision, a continuous curvilinear capsulorhexis with a diameter of approximately 4.5 to 5.0 mm, and foldable acrylic IOL implantation in the capsular bag. Patients were randomized to receive a 1-piece (AcrySof SA60AT) or 3-piece (AcrySof MA60AC) acrylic IOL (both Alcon, Inc.). Sutures were not used to close the corneal incisions.

One day before surgery and 1 week and 3 months after surgery, all patients had a complete ophthalmic examination, including corrected distance visual acuity (CDVA) measurement, manifest refraction, slitlamp biomicroscopy, applanation tonometry, and Scheimpflug imaging (Pentacam Comprehensive Eye Scanner, Oculus Optikgeräte GmbH). Masked examiners performed all measurements; the examiners were unaware of the type of IOL (ie, 1 piece or 3 piece). The Scheimpflug imaging was performed in dim illumination with the patient fixating on a black target over a blue background. The ACD was measured from the endothelium to the anterior surface of the IOL or crystalline lens.

Statistical analysis was performed using SPSS for Windows software (version 16.0, SPSS, Inc.). Differences between the groups were assessed using the independent sample *t* test. Preoperative and postoperative values were compared using paired *t* tests. Correlations between preoperative values and changes in values were calculated using the Pearson correlation test.

RESULTS

Of the 142 eyes of 140 patients (72 women) enrolled in the study, 125 eyes of 123 patients (66 women) completed the 3-month follow-up. The mean age of the patients was 68.7 years ± 9.5 (SD) (range 50 to 91 years). The 1-piece IOL group comprised 67 eyes of 28 men and 38 women and the 3-piece IOL group, 58 eyes of 29 men and 28 women. There were no statistically significant differences in preoperative patient or anterior segment parameters between the 2 IOL groups (Table 1).

The CDVA improved postoperatively in both groups. The means in the 1-piece group were 1.61 ± 0.78 logMAR preoperatively, 0.17 ± 0.22 logMAR 1 week postoperatively, and 0.08 ± 0.11 logMAR at 3 months. The means in the 3-piece group were 1.66 ± 0.82 logMAR, 0.23 ± 0.22 logMAR, and 0.13 ± 0.14 logMAR, respectively. There was no statistically significant difference in CDVA between the 2 groups preoperatively or postoperatively (Figure 1).

One week after surgery, the mean spherical equivalent (SE) refraction was −0.14 ± 0.90 diopter (D) in the 1-piece group and 0.17 ± 1.12 D in the 3-piece group (P = .5). The SE decreased to −0.24 ± 1.03 D and −0.08 ± 1.19 D, respectively, at 3 months. Although the change in SE in the 1-piece group was not

Table 1. Preoperative patient characteristics.

Parameter	1-Piece IOL (n = 67)	3-Piece IOL (n = 58)	*P* Value
Age (y)	67.42 ± 9.6	70.1 ± 9.3	.10
Axial length (mm)	23.09 ± 1.31	23.3 ± 1.55	.43
ACV (mm^3)	132.6 ± 37.2	126.6 ± 30.9	.36
ACA (degrees)	31.4 ± 7.3	30.1 ± 5.7	.30
ACD (mm)	2.72 ± 0.42	2.64 ± 0.38	.31

ACA = anterior chamber angle; ACD = anterior chamber depth; ACV = anterior chamber volume; IOL = intraocular lens
All values are mean ± SD

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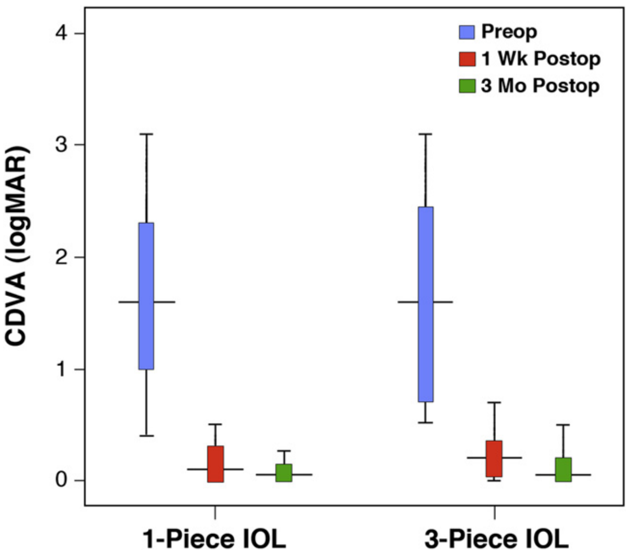

Figure 1. Preoperative and postoperative CDVA (CDVA = corrected distance visual acuity; IOL = intraocular lens).

statistically significant (P = .16), there was a statistically significant myopic shift (mean 0.23 ± 0.63 D) in the 3-piece group (P = .01).

Table 2 shows the mean anterior segment parameter measurements 1 week and 3 months postoperatively. Both IOL groups had statistically significant increases in ACD, ACA, and ACV at 1 week and 3 months compared with preoperative values (Figure 2). In the 1-piece group, the change in ACD, ACA, or ACV between 1 week and 3 months postoperatively was not significant. However, there was a statistically significant decrease in ACD, ACA, and ACV from 1 week to 3 months in the 3-piece group. At 1 week, the ACD was statistically significantly higher in the 3-piece group than in the 1-piece group (P = .01). There were no other significant differences in any other variable between the 2 groups at 1 week and 3 months.

The lower the ACV, shallower the ACD, and narrower the ACA preoperatively, the more significant the increases in ACV, ACD, and ACA postoperatively ($P<.001$, P = .002, and $P<.001$, respectively). There was no correlation between forward IOL shift and the preoperative ACD or axial length (AL) in either group.

Table 2. Preoperative and postoperative anterior segment parameters.

Parameter	Mean ± SD: 1-Piece IOL (n = 67)	Mean ± SD: 3-Piece IOL (n = 58)	P Value
ACD (mm)			
Preoperative	2.72 ± 0.42	2.64 ± 0.38	.31
Postoperative			
1 week	4.02 ± 0.74	4.33 ± 0.54	.01
3 months	4.12 ± 0.65	4.07 ± 0.58	.69
ACA (degrees)			
Preoperative	31.4 ± 7.3	30.1 ± 5.7	.30
Postoperative			
1 week	44.5 ± 6.9	45.3 ± 5.1	.48
3 months	44.6 ± 5.9	43.8 ± 5.2	.44
ACV (mm^3)			
Preoperative	132.6 ± 37.2	126.6 ± 30.9	.36
Postoperative			
1 week	174.2 ± 27.7	176.9 ± 27.5	.60
3 months	174.8 ± 28.3	172.3 ± 27.3	.62

ACA = anterior chamber angle; ACD = anterior chamber depth; ACV = anterior chamber volume; IOL = intraocular lens

DISCUSSION

Using Scheimpflug imaging, we found that the ACD, ACV, and ACA increased significantly after cataract surgery. Moreover, although eyes with a 3-piece foldable acrylic IOL had a deeper anterior chamber 1 week after surgery, the IOL shifted forward significantly during the first 3 postoperative months. In contrast, there was little axial shift of the 1-piece foldable acrylic IOLs, and the postoperative refraction was highly stable.

Several devices to evaluate the configuration of the anterior segment have been developed. They are based on ultrasound biomicroscopy (UBM), scanning peripheral ACD analysis, partial coherence interferometry (PCI), optical coherence tomography, scanning-slit topography, and Scheimpflug imaging. In the present study, we used the Pentacam Scheimpflug imaging device, which is a user-independent, automatic, and noncontact system. The device uses a rotating camera for quick acquisition of anterior segment measurements. Previous studies found that it accurately measures anterior segment parameters.[7,10–12] For example, Meinhardt et al.[12] found less intraindividual variability in ACD measurements with the Pentacam device than with the IOLMaster PCI device (Carl Zeiss Meditec) (variability 12.7 μm and 24.5 μm, respectively). The EAS-1000 (Nidek, Inc.), another Scheimpflug videophotography system, has been used to evaluate ACA after cataract extraction; however, for best accuracy, the values should be calculated manually.[6,13] Thus, more recent studies[14,15] have used the Pentacam device to evaluate changes in anterior segment parameters after cataract surgery.

In our study, Scheimpflug measurements showed significant increases in ACD, ACV, and ACA 1 week and 3 months after surgery compared with preoperative

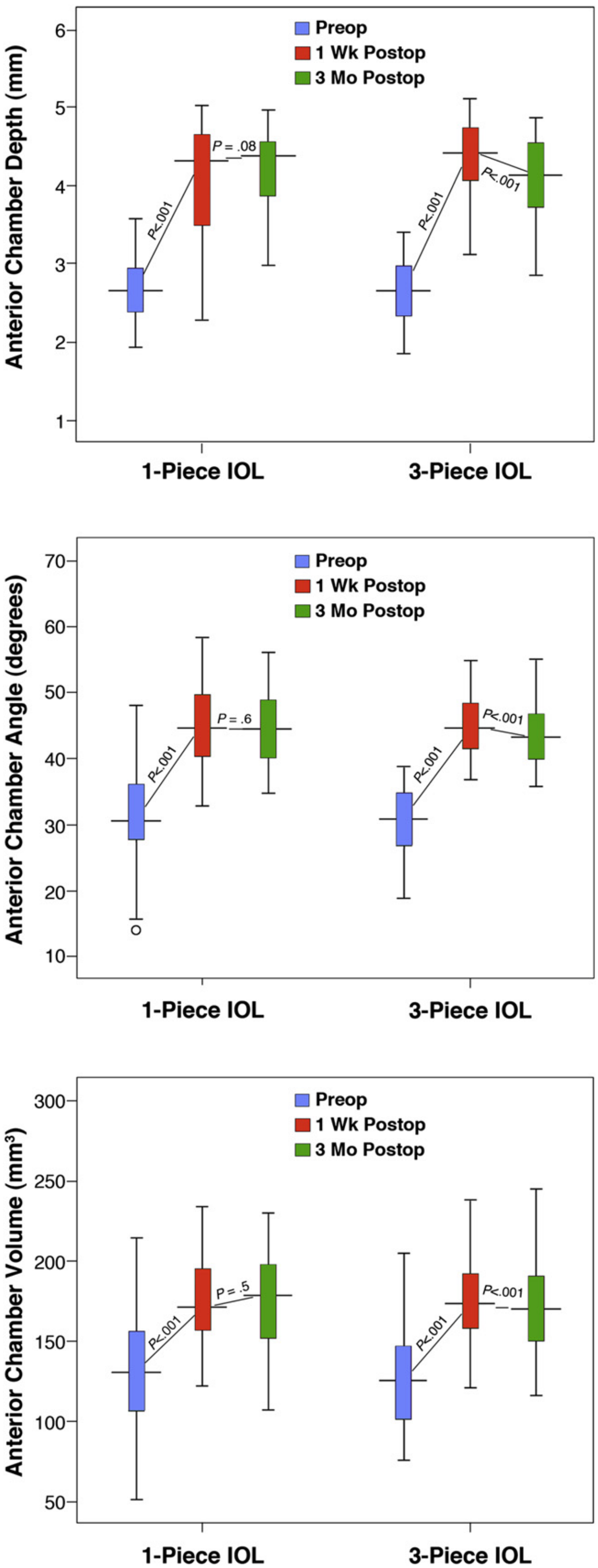

Figure 2. Anterior chamber parameters over time (IOL = intraocular lens).

values. In both IOL groups (ie, 1 piece and 3 piece), the ACD, ACV, and ACA increased by 53.4%, 34.8%, and 43.5%, respectively, at 3 months. Similar anterior segment changes have been reported after phacoemulsification with foldable IOL implantation in studies using A-scan ultrasonography,[3,16–18] UBM,[19–21] and Scheimpflug photography.[6] Doganay et al.[14] and Uçakhan et al.[15] used the same Scheimpflug imaging device we used and found similar increases in anterior segment parameters after phacoemulsification. The postoperative increases in ACD, ACA, and ACV values are because the IOL is much thinner than the crystalline lens.[17]

In our study, the postoperative position of the 1-piece IOL and the 3-piece IOL varied over time. From 1 week to 3 months, the ACD, and hence the IOL position, remained stable in the 1-piece group (nonsignificant mean backward shift 69 μm); however, the 3-piece IOLs had a significant forward shift (mean shift 290 μm). Studies using devices based on other technologies report similar findings. Using PCI, Wirtitsch et al.[1] found that 1-piece IOLs had a mean backward shift of 14 μm and 3-piece IOLs had a mean forward shift of 213 μm during a 6-month postoperative follow-up. Most of the shift occurred from 1 day to 1 month. Hayashi and Hayashi[9] used Scheimpflug videophotography (EAS-1000) and found similar results; that is, the ACD did not change significantly in eyes with a 1-piece IOL but showed significant shallowing (approximately 120 μm) in eyes with a 3-piece IOL. Using the same Scheimpflug videophotography system as Hayashi and Hayashi, Nejima et al.[8] found no significant change in ACD in eyes with a 1-piece IOL but found significant shallowing of the anterior chamber (approximately 519 μm) and a myopic shift up to 1 month after surgery in eyes with a 3-piece IOL. There was no significant change in ACD in eyes with a 3-piece IOL from 1 month to 1 year. Although we did not measure the 1-month postoperative ACD in our study, other studies[8,9] report that most changes in ACD in eyes with a 3-piece IOL occurred during the first postoperative month, after which the ACD remained stable.

In our study, although the postoperative refraction was highly stable in the 1-piece group at 1 week and 3 months, there was a significant myopic shift (mean 0.23 ± 0.63 D) in the 3-piece group that was associated with the forward IOL movement. Myopic shifts of 0.30 to 0.40 D have been reported in eyes with 3-piece IOLs.[1,9] The absence of significant refractive change in eyes with the 1-piece IOL makes it possible to prescribe postoperative spectacles sooner than with the 3-piece IOL.

One week after surgery, the anterior chamber was significantly deeper in the 3-piece IOL group than in the 1-piece IOL group; however, there was no significant difference between the 2 groups at 3 months. Nejima et al.[8] found a significantly deeper anterior chamber in eyes with a 3-piece IOL than in eyes with a 1-piece IOL 2 days and 1 week after surgery but no difference at 1 month. In the study by Hayashi and Hayashi,[9] the difference was significant at 3 days but not at 1 month. The deeper anterior chamber in the 3-piece group can be attributed to the 10-degree haptic angulation relative to the optic of the 3-piece IOL we used; the 1-piece IOL has zero angulation. It appears that the haptic angulation of the 3-piece IOL gradually decreases after implantation in the capsular bag, causing the IOL to shift forward as well as a myopic shift. Loss of haptic memory, which affects haptic angulation, may be a cause of the postoperative forward movement of the optic of angulated IOLs.[22,23] Additional studies should be performed to determine the exact mechanisms of the different patterns of postoperative movement between 1-piece IOLs and 3-piece IOLs.

To our knowledge, our study is the first to compare the changes in ACA and ACV between 1-piece IOLs and 3-piece IOLs. In both groups, the ACA and ACV were significantly increased 1 week and 3 months postoperatively compared with preoperatively; however, there was no significant difference in the 2 parameters between the 1-piece group and the 3-piece group. Although eyes with a 1-piece IOL did not have significant changes in ACA and ACV from 1 week to 3 months postoperatively, eyes with a 3-piece IOL had a significant decrease in the 2 parameters during this time.

In this study, we tried our best to randomize the 2 groups in terms of preoperative factors that might affect postoperative IOL position, such as AL and anterior segment parameters. However, other unknown factors may affect anterior segment parameters. Furthermore, we excluded patients with conditions such as pseudoexfoliation syndrome or a closed or narrow ACA. It is not clear whether 1-piece or 3-piece IOLs in these eyes would behave in the same manner as in normal eyes. Further research is needed to determine which factors affect the postoperative position of these 2 types of IOLs.

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