Alterations in the anterior chamber angle after implantation of iris-fixated phakic intraocular lenses

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PURPOSE: To evaluate anterior chamber angle alterations after phakic intraocular lens (pIOL) implantation using the Pentacam rotating Scheimpflug camera (Oculus) and the effect on intraocular pressure (IOP) and anterior chamber inflammation.

SETTING: Department of Ophthalmology, Keio University School of Medicine, Tokyo, Japan.

METHODS: Twenty eyes of 11 patients with high myopia who had implantation of pIOLs (Artisan/Verisyse, model 204, Ophtec BV) were included. All pIOLs were fixated on the iris near the 3 o'clock and 9 o'clock positions. Angles at the 2, 3, 4, 8, 9, and 10 o'clock positions, IOP, and postoperative flare were evaluated retrospectively.

RESULTS: The mean angle degree at 2, 3, 4, 8, 9, and 10 o'clock was 40.3 degrees ± 3.3 (SD) preoperatively and 36.5 ± 5.8 degrees postoperatively; the postoperative angles were significantly narrower than the preoperative angles ($P<.001$). The mean angles at 3 o'clock and 9 o'clock were 39.8 ± 3.7 degrees and 40.6 ± 3.5 degrees, respectively, preoperatively and 32.7 ± 6.0 degrees and 31.3 ± 5.4 degrees, respectively, postoperatively. The postoperative angles at 3 o'clock and 9 o'clock were narrower than the preoperative angles ($P<.001$). There was no significant difference between preoperative IOP and postoperative IOP ($P = .22$). The flare at 1 month ($r = 0.573$, $P = .0071$) and 1 year ($r = 0.700$, $P = .004$) was significantly correlated with the angle change.

CONCLUSION: Partial localized narrowing of anterior chamber angles that occurred after pIOL implantation induced acute and chronic anterior chamber inflammation in patients with large angle alterations.

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Recently, the implantation of iris-fixated intraocular lenses (IOLs) in phakic eyes has been shown to be an effective and predictable refractive technique for treatment of high myopia, especially high myopia in patients who are not candidates for excimer laser refractive surgery.[1–6] Surgical correction of myopia with iris-fixated phakic IOLs (pIOLs) causes less postoperative higher-order aberration than laser in situ keratomileusis,[7] and overall postoperative patient satisfaction is excellent.[8] Although the pIOL procedure has become standard to correct high myopia, severe postoperative complications have been reported. These include retinal detachment,[9,10] traumatic aniridia,[11] IOL dislocation,[12,13] pigment dispersion syndrome,[14] endothelial cell loss,[15] and glaucoma.[16] One concern is that pIOLs that are fixated to the iris inevitably cause postoperative intraocular structure alterations such as pupil ovalization,[17] pupil size change,[18] anterior chamber depth (ACD) change,[19,20] and crystalline lens rise.[14] Although anterior segment analyses after pIOL implantation have been performed,[14,17,19,20] to our knowledge, the change in the anterior chamber angle has not been reported. In this study, we evaluated anterior chamber angle alterations

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after pIOL implantation and their effect on intraocular pressure (IOP) and anterior chamber inflammation.

PATIENTS AND METHODS

Twenty eyes of 11 patients who had implantation of an Artisan pIOL (Ophtec BV) for high myopia at Keio University Hospital were included in this study. Signed informed consent describing the risk and benefits of the procedure was obtained from each patient before surgery.

The inclusion criteria were minimum age 20 years, ACD 2.8 mm or greater, and endothelial cell count 2000 cells/mm^2 or higher. Patients were excluded if they had a history of uveitis, diabetic retinopathy, glaucoma, or pathologic myopic macular degeneration.

Slitlamp examination, fundus evaluation, axial length measurement, endothelial cell count, videokeratography, and pupil diameter were performed before and after surgery. The amount of postoperative aqueous flare was measured 1 month and 1 year after surgery using laser flarimetry (FC-2000, Kowa).

Surgical Technique

All surgeries were performed by 1 of 2 experienced surgeons (K.T., K.N.). Pupils were constricted with pilocarpine 2% before surgery. A 6.0 mm corneoscleral tunnel was made at the 12 o'clock position under topical and subconjunctival anesthesia. The anterior chamber was filled with sodium hyaluronate 3.0%–chondroitin sulfate 4.0% (Viscoat) and sodium hyaluronate 2.3% (Healon5). The pIOL was introduced into the anterior chamber, rotated inside the eye, and fixated to the iris at 3 o'clock and 9 o'clock. A peripheral iridectomy was performed at the 12 o'clock position after the pIOL was fixated. The ophthalmic viscosurgical devices were removed, and the wound was closed with 10-0 nylon sutures. An Artisan/Verisyse IOL (model 204, Ophtec BV) with a 6.0 mm optic was implanted in all eyes. The IOL power was determined for emmetropia according to the power calculation using the Van Der Heijde formula.

Angle Evaluation

Preoperative and postoperative anterior segment examinations were performed using the Pentacam rotating Scheimpflug camera (Oculus). Anterior chamber angles at the 2, 3, 4, 6, 8, 9, and 10 o'clock positions on Scheimpflug photographs taken before surgery and 1 month postoperatively were retrospectively evaluated (Figure 1, *A*). Scheimpflug photographs were taken with natural pupil dilation in a dim room without instillation of cycloplegic agents. Anterior chamber angles were measured with a protractor (Figure 1, *B*) rather than with the automatic measurement system in the Pentacam device because the automatic measurement does not always recognize an accurate angle. All measurements were made by the same observer (T.Y.) at a later date. The alteration in anterior chamber angle was defined as the absolute value as follows:

$\Delta ACA = |$ (Mean preoperative anterior chamber angle) – (Mean postoperative anterior chamber angle) $|$ Degrees.

where ΔACA is the alteration in the anterior chamber angle. The relationship between the alteration in anterior chamber angle and aqueous flare 1 month and 1 year after surgery was evaluated.

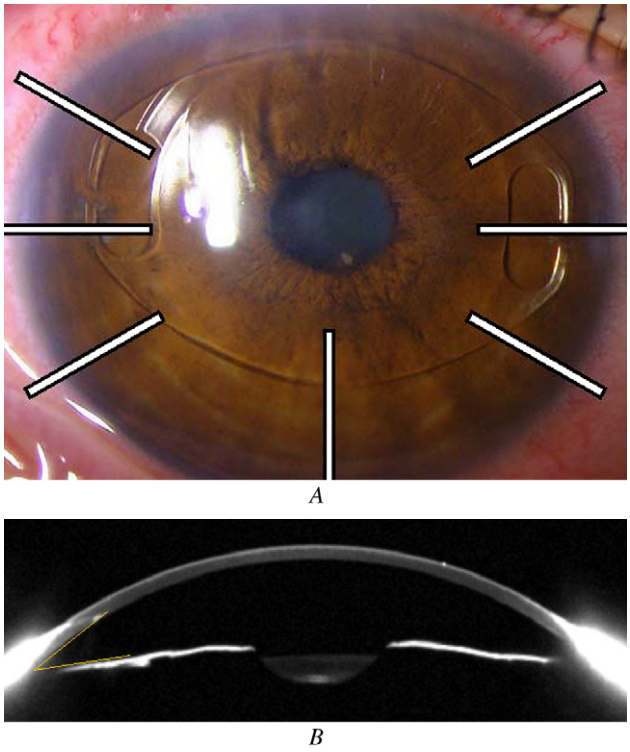

Figure 1. *A*: Example of anterior chamber angle measurement on Scheimpflug images at the 2, 3, 4, 6, 8, 9, and 10 o'clock positions. *B*: Anterior chamber angle measurement with a protractor using the Scheimpflug image of the Pentacam.

Statistical Analysis

Statistical analysis of the angle was performed by the paired Student *t* test for comparison of the preoperative and postoperative means. A *P* value less than 0.05 was considered statistically significant. All statistical analyses were performed with StatView computer software (SAS Institute Inc.).

RESULTS

The mean age of the 4 male and 7 female patients was 38.6 years ± 11.1 (SD) (range 26 to 58 years). Preoperatively, the mean refraction was −9.8 ± 4.5 diopters (D) (range −2.25 to −18.25 D), the mean ACD was 3.66 ± 0.20 mm, the mean pupil diameter in dim light was 6.16 ± 0.95 mm, and the mean endothelial cell count was 3139 ± 260 cells/mm^2.

The mean SE refraction 1 month after surgery was −0.50 ± 0.63 D (range −1.75 to +0.63 D). The SE refraction at 1 month was within ±1.00 D of the intended refraction in 16 (80.0%) of 20 eyes. No complications occurred during or after surgery in any eye. Postoperatively, the mean ACD was 3.13 ± 0.17 mm and the mean endothelial cell count, 3023 ± 367 cells/mm^2. The mean aqueous flare was 6.4 ± 1.8 photons/msec 1 at month and 6.9 ± 4.0 photons/msec at 1 year.

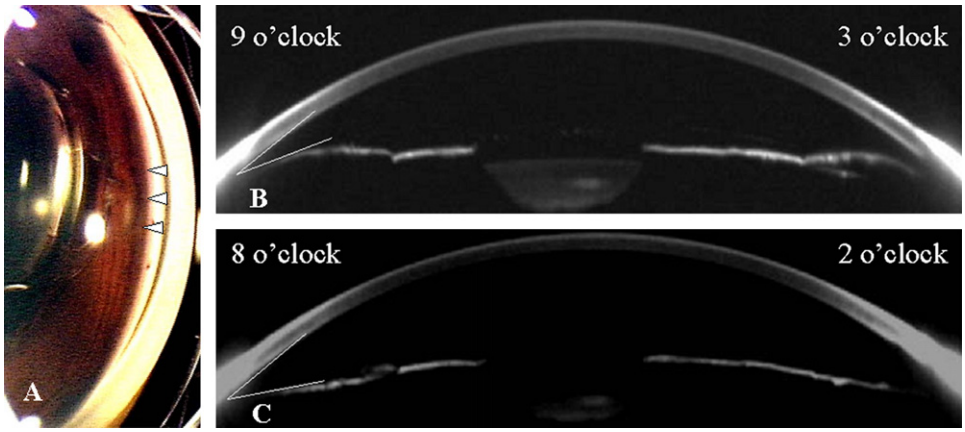

Figure 2. *A*: The peripheral iris in the area in which the pIOL haptics pinched the iris is vaulted and the angle narrower than in the other areas by Goldmann 3-mirror lens examination. The trabecular meshwork pigmentation is prominent. *B* and *C*: In this Scheimpflug image, the anterior chamber angle at 3 o'clock and 9 o'clock is narrower than at 2 o'clock and 8 o'clock.

The peripheral iris in the area in which the IOL haptics pinched the iris was vaulted, and the nasal and temporal angles were narrower than in the other areas by Goldmann 3-mirror lens examination (Figure 2, *A*). The anterior chamber angle at 3 o'clock and 9 o'clock was narrower than at 2 o'clock and 8 o'clock in the Scheimpflug photographs (Figure 2, *B* and *C*).

Table 1 shows the mean preoperative and postoperative anterior chamber angles. The postoperative mean of all angles was statistically significantly narrower than preoperatively ($P < .001$). The mean postoperative angles at 3 o'clock and 9 o'clock were also statistically significantly narrower than preoperatively ($P < .001$). There were no significant differences between preoperative and postoperative angles at 2, 4, 8, and 10 o'clock ($P > .05$). Narrowing of the anterior chamber angle of more than 10 degrees was frequently seen at 3 o'clock and 9 o'clock (Table 2). Not all Scheimpflug angle images at 6 o'clock were obtained due to obstruction by the lower eyelid. However, narrowing of the anterior chamber angle of 25 degrees was seen in 1 eye. There was no statistically significant difference between the mean preoperative IOP (13.2 ± 2.1 mm Hg) and the mean postoperative IOP (13.7 ± 3.0 mm Hg) ($P = .22$).

Table 1. Preoperative and postoperative angles in 20 eyes after implantation of iris-fixated pIOL.

	Mean Angle (Degrees) ± SD		
Parameter	Preoperative	Postoperative	*P* Value
All angles	40.3 ± 3.3	36.0 ± 3.8	<.001
Angle at 2 o'clock	40.2 ± 3.3	38.2 ± 5.5	.087
Angle at 3 o'clock	39.8 ± 3.7	32.8 ± 6.0	<.001
Angle at 4 o'clock	40.5 ± 3.2	39.0 ± 3.9	.096
Angle at 8 o'clock	40.5 ± 3.3	39.6 ± 3.5	.22
Angle at 9 o'clock	40.6 ± 3.5	31.3 ± 5.4	<.001
Angle at 10 o'clock	40.6 ± 3.0	39.3 ± 4.2	.097

There were significant correlations between the alteration in anterior chamber angle and aqueous flare 1 month and 1 year after surgery (Figure 3).

DISCUSSION

To our knowledge, this is the first report of changes in the anterior chamber angle after implantation of an iris-fixated pIOL. Our results show that partial narrowing of the anterior chamber angle near the fixation points was induced by implantation of the iris-fixated pIOL and that postoperative acute and chronic anterior chamber inflammation had a significant correlation with the amount of the alteration in the anterior chamber angle.

Recent studies[1–6] report excellent postoperative visual performance and refractive stability of iris-fixated pIOLs used to correct high myopia. Although the effectiveness and safety of iris-fixated pIOLs for high myopia have been shown, few studies have evaluated changes in intraocular structures after implantation. The complications of endothelial cell damage, IOP elevation, cataract, and pigment dispersion

Table 2. Change in anterior chamber angle before and after pIOL implantation (N = 20).

	Change	
ΔACA	5 Degrees or Less	5 Degrees or More
Angle at 2 o'clock	17	3
Angle at 3 o'clock	6	14
Angle at 4 o'clock	14	6
Angle at 8 o'clock	17	3
Angle at 9 o'clock	6	14
Angle at 10 o'clock	17	3
Angle at any area	1	19

ΔACA = (Mean preoperative ACA) – (Mean postoperative ACA) Degrees; ACA = anterior chamber angle

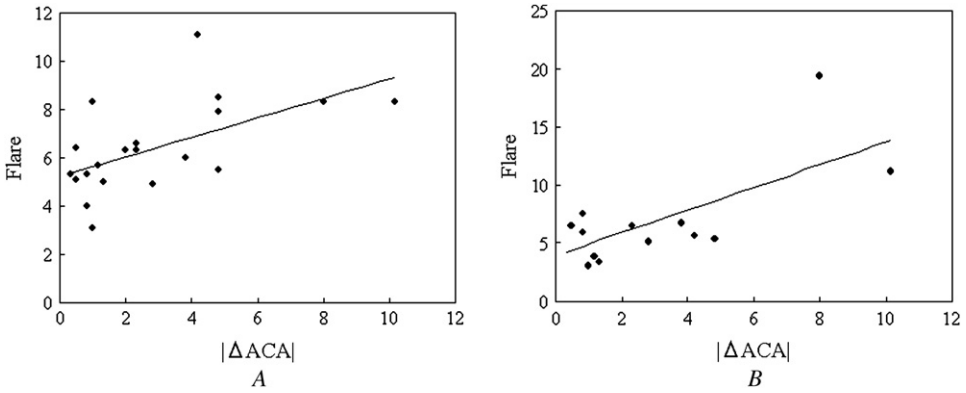

Figure 3. Correlation between the alteration in anterior chamber angle (|ΔACA|) and aqueous flare 1 month (*A*) and 1 year (*B*) after surgery (*A*: $r = 0.573$, $P = .0071$; *B*: $r = 0.700$, $P = .004$).

are caused by the close proximity of the pIOL to intraocular structures such as the angle, iris, crystalline lens, and corneal endothelium.[12,14,21] Thus, evaluation of changes in anterior segment structures is important to assess and prevent complications of pIOL implantation.

Technological analysis of the anterior segment, such as Pentacam photography, ultrasound biomicroscopy (UBM), and anterior segment optical coherence tomography, have made it possible to precisely examine the pIOL position in the anterior chamber, the distance between the pIOL and corneal back surface, crystalline lens vaulting, iris configuration, and angle configuration analysis.[19,20,22] Using Scheimpflug photography, Baumeister et al.[22] examined the postoperative positional stability of pIOLs for myopia including angle-supported pIOLs (NuVita, Bausch & Lomb), iris-fixated pIOLs (Artisan, Ophtec), and sulcus-implanted pIOLs (Staar ICL). They found that the iris-fixated pIOL had the best positional stability. Pop et al.[19] used UBM to evaluate ACD and the distance between the pIOL, corneal endothelium, and crystalline lens after implantation of iris-fixated pIOLs. They found the preoperative ACD was reduced by 28% to 34% after surgery. They also found that in hyperopic eyes, adequate space was maintained between the iris-fixated pIOL and the corneal endothelium, angle, and crystalline lens. In addition, they observed haptic indentation of the iris. Using the Pentacam device and UBM, Yu et al.[23] found that space was maintained between iris-fixated pIOLs and the corneal endothelium, angle, and crystalline lens in eyes with high myopia. In our study, the anterior chamber angle narrowed more than 5 degrees in 19 of 20 eyes (95%) after implantation of an iris-fixated pIOL. The maximum change in the anterior chamber angle was 20 degrees at 3 o'clock. Assessment of anterior chamber angle alteration is not generally included in the routine postoperative follow-up examination after iris-fixated pIOL implantation. Based on the results in our study, angle evaluation should be included in the routine examination before and after implantation of iris-fixated pIOLs. We also recommend that patients with large angle alterations be carefully observed over the long term.

Chun et al.[24] evaluated angle structure after implantation of a posterior chamber pIOL for high myopia by gonioscopy examination. They found that the anterior chamber angle was narrowed to within less than 20 degrees and the peripheral iris configurations were changed to steeply convex. They postulate that the cause of the narrow angle was anterior displacement of the posterior chamber pIOL resulting from an incomplete laser iridotomy opening. Abela-Formanek et al.[25] report that iris bulging was induced after implantation of a posterior chamber pIOL and that it was caused by anterior displacement of the iris level of the haptics. However, there was no effect on IOP. Dick et al.[18] found that the scotopic pupil diameter decreased by a mean of 1.1 mm in myopic eyes with iris-fixated toric pIOLs and that the smaller pupil diameter postoperatively was induced by the iris-supported fixation method. In our study, the narrow anterior chamber angle was thought to be caused by the claw of the pIOL pinching the iris. However, the amount of alteration in the anterior chamber angle varied between patients. This difference could be due to surgical factors such as the amount of iris that is pinched, the position of the pIOL, and individual patient factors such as iris hysteresis (stiffness of the iris). Because the amount of angle alteration was correlated with postoperative acute and chronic anterior chamber inflammation, further evaluation of iris changes is necessary in eyes with iris-fixated and other types of pIOLs.

In this study, we used the Pentacam device to measure the angle because it takes noncontact optical measurements, a method that is expected to lead to less mechanical measurement error than when the eye or lid is pushed during measurement. Congdon et al.[26] evaluated Scheimpflug angle measurements and found they were significantly associated with anterior chamber angle measurements by biometric

gonioscopy. Moreover, Pentacam measurements are not affected by cyclotorsion because they are performed with the patient in the sitting position; thus, the anterior chamber angle position is more accurate than with UBM. However, it is sometimes difficult to measure the upper and lower angles with the Pentacam device because of obstruction by the upper and lower eyelids. It is possible to assess the automatic angle measurement, although the angle position is mistakenly recognized. To avoid that, we measured the anterior chamber angles in the Scheimpflug photographs manually using a protractor to reduce measurement error.

The age range of most patients who have pIOL implantation is 20 years to the mid-50s. Thus, in most cases, the pIOLs will be used for several decades of life. It is possible that in the future, these patients will develop many types of eye disease such as angle-closure glaucoma, open-angle glaucoma, uveitis, and diabetic retinopathy. Angle-closure glaucoma occurs later in life, and its incidence increases with age. Angle-closure glaucoma in young adults is reported to be associated with structural ocular anomalies rather than with pupillary block.[27] There are several reports of angle-closure glaucoma after implantation of posterior chamber pIOLs.[28–31] Pineda-Fernandez et al.[28] report that angle-closure glaucoma occurred in 11.1% of patients with posterior chamber pIOLs. There are only 2 reports of angle-closure glaucoma after implantation of anterior chamber pIOLs; 1 is of pupillary block with an angle-supported pIOL[32] and the other, of an iris-fixated pIOL in a patient with Weil-Marchesani syndrome and a history of glaucoma.[33] Burakgazi et al.[33] reported nasal and temporal peripheral synechiae 10 years after implantation of pIOL, which induced angle-closure glaucoma in a patient with Weil-Marchesani syndrome. The anterior chamber angle at 3 and 9 o'clock was narrowed 1 month after surgery in eyes with high myopia in this study. Although localized narrowing of the anterior chamber angle itself is "clinically silent" and devoid of IOP changes, it can induce chronic anterior chamber inflammation and angle-closure glaucoma years after surgery. It is imperative that clinicians carefully evaluate anterior chamber inflammation as well as peripheral ACD.

In conclusion, after implantation of an iris-fixated pIOL, partial localized narrowing of angles occurred and was associated with acute and chronic anterior chamber inflammation in patients with large angle alterations. Although it did not affect postoperative IOP 1 month after surgery, it would be desirable to observe the change in the anterior chamber angle over the long term.

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