# Preoperative anterior segment optical coherence tomography as a predictor of postoperative phakic intraocular lens position

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**PURPOSE:** To evaluate anterior segment optical coherence tomography (AS-OCT) in the preoperative simulation of postoperative iris-fixated phakic intraocular lens (pIOL) position in the anterior chamber.

**SETTING:** Farabi Eye Research Center, Department of Ophthalmology, Tehran University of Medical Sciences, Tehran, Iran.

**DESIGN:** Case series.

**METHODS:** Using AS-OCT, the pIOL position was simulated preoperatively in 2 ways and compared with the actual postoperative pIOL position. For preoperative evaluations, the simulator was placed on the posterior pigmented epithelium of the iris. Then, the simulation was performed with the simulator placed in the middle of the iris tissue. The following distances were measured: from the center of the pIOL to the endothelium, from the edge of the pIOL to the endothelium, and from the posterior surface of the pIOL to the crystalline lens.

**RESULTS:** The study examined 26 eyes (16 patients). Although all distances in both simulation methods (except the lens vault in the first method of simulation) were highly correlated (all $P<.009$), only the results with the simulator placed in the middle of the iris tissue were not statistically different from the corresponding postoperative measurements ($P=.209$ and $P=.564$ for distance from endothelium to the center and the pIOL edge, respectively).

**CONCLUSIONS:** Using the pIOL template of the AS-OCT system for preoperative simulation of iris-fixated pIOLs improved the criteria for patient selection for implantation of these pIOLs. The simulator should be placed in the middle of the iris tissue for preoperative simulation.

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Phakic intraocular lenses (pIOLs) have been used as a safe alternative to correct ametropia.[1–3] Introduced in 1991, Artisan iris-fixated pIOLs (Ophtec BV) have been shown to have predictable results in the correction of myopia.[4–6] An important issue regarding implantation of these IOLs is to select patients for whom this type of surgery would not induce damage to intraocular structures. In the case of iris-fixated pIOLs, the major concern continues to be endothelial cell health,[7,8] although cataract formation has been reported after implantation of these pIOLs.[9,10]

Regarding endothelial cell health, an endothelial cell count of more than 2000 cells/mm$^2$ and anterior chamber depth (ACD) of more than 2.8 mm have been reported to be criteria for implantation of iris-fixated pIOLs.[11] In the case of the myopic Artisan pIOLs, the peripheral endothelial clearance (distance from endothelium to peripheral edge of the Artisan) seems to be more important than the ACD, and it has been suggested that it should be more than 1.5 mm.[11]

Anterior segment optical coherence tomography (AS-OCT) is a useful imaging technique for internal biometry of the anterior chamber. The Visante OCT AS-OCT system (Carl Zeiss Meditec AG) has a software tool (pIOL template) to simulate the postoperative position of iris-fixated pIOLs and can be useful in evaluating its position preoperatively. This

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simulation increases the safety of pIOL implantation by allowing proper patient selection. The purpose of this study was to evaluate this AS-OCT system in the preoperative simulation of the postoperative iris-fixated pIOL position in the anterior chamber.

## PATIENTS AND METHODS

In this prospective study, patients referred to the Cornea Clinic, Farabi Eye Hospital, Tehran University of Medical Sciences, were enrolled from January to September 2012. The study was performed in accordance with the Declaration of Helsinki, and all patients provided informed consent preoperatively.

Inclusion criteria were an endothelial cell density greater than 2000 cells/mm$^2$, internal ACD more than 2.8 mm, mesopic pupil less than 6.0 mm, age greater than 21 years, stable refraction with less than a 0.5 diopter (D) change in the previous 6 months, and crystalline lens rise of less than 600 μm. Crystalline lens rise is the forward protrusion of the crystalline lens. It is measured as the distance between the anterior pole of the crystalline lens and the line joining the 2 iridocorneal angles along the horizontal corneal diameter. Patients with a history of glaucoma, retinal detachment, retinopathy, uveitis, or autoimmune disease were excluded from the study.

A complete ophthalmologic examination was performed preoperatively. The examination included manifest and cycloplegic refractions, corrected distance visual acuity (CDVA), slitlamp evaluation, Goldmann tonometry, fundoscopy, corneal topography and pachymetry (Pentacam, Oculus Optikgeräte GmbH), specular microscopy (SP-2000P, Topcon Corp.), and AS-OCT evaluation.

Phakic IOL power was calculated using the van der Heijde formula.[12] Preoperatively, pIOL simulation was performed using the pIOL template of the AS-OCT system. After the correct pIOL model and power were selected, pIOL simulation was performed in 2 ways. First, for the calculations, the Artisan simulator was placed on the posterior pigmented epithelium of the iris (Figure 1, *A*). In this type of simulation, the posterior surface of the haptic was aligned with the posterior pigmented epithelium. For the second calculation, the simulator was placed in the middle of the iris tissue (Figure 1, *B*). In this type of simulation, the posterior surface of the haptic was placed halfway between the anterior border of the iris (line passed anteriorly from thinnest portion of iris) and the posterior pigmented epithelium. Using the refractive tools of the AS-OCT system, central or maximum endothelial clearance (distance between the endothelium and the center of the pIOL), peripheral or minimum endothelial clearance (distance between the endothelium and the peripheral edges of the pIOL), and lens vault (distance between the posterior surface of the pIOL and the anterior surface of the crystalline lens) were measured.

All surgeries were performed by the same surgeon (R.S.M.). All patients were evaluated with the AS-OCT system 3 months postoperatively. In this postoperative evaluation, the central endothelial clearance, peripheral endothelial clearance, and lens vault were measured (Figure 1, *C*). They were then compared with the corresponding preoperative measurements.

Data analysis was performed using SPSS software (version 18, SPSS, Inc.). Preoperative and postoperative endothelial clearance and lens vault were compared with the paired *t* test, and the Pearson correlation coefficient was used to assess the relationship between them. The agreement between postoperative data and preoperative data was studied with the Bland-Altman method.[13]

## RESULTS

The study comprised 26 eyes of 16 patients. The mean age of the 6 men and 10 women was 27.5 years ± 4.4 (SD) (range 21 to 37 years).

In this study, the mean pIOL power was −13.71 ± 2.74 D (range −7.5 to −18.0 D). The ACD did not change significantly from before to after surgery (3.19 ± 0.17 mm versus 3.21 ± 0.12 mm) ($P = .21$).

Table 1 and Table 2 compare the mean preoperative simulated distances (with the simulator placed on the posterior pigmented epithelium of the iris and in the middle of the iris tissue, respectively) and postoperative distances and the correlation between them. There was a statistically significant difference between preoperative simulation and postoperative measurements when the simulator was placed on the posterior pigmented epithelium of the iris but no statistically significant difference when the simulator was placed in the middle of the iris tissue.

Figures 2 and 3 show the Bland-Altman plots of the agreement between the preoperative pIOL simulation and the postoperative measurements.

## DISCUSSION

In the correction of myopia with pIOLs, the health of important structures of the eye, especially the endothelium and lens, must be respected. This study was designed to improve the criteria for patient selection in pIOL surgery. Although an ACD of more than 2.8 mm has been reported to be safe for pIOL implantation, it is not just the ACD (distance between the endothelium and the center of the crystalline lens) that seems to be important in such surgeries. The thickness of iris-fixated pIOLs differs according to their power. The thickest portion of the Artisan pIOL is

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Maryam Kasiri, Imaging Unit, Farabi Eye Hospital, captured the anterior segment optical coherence tomography images.

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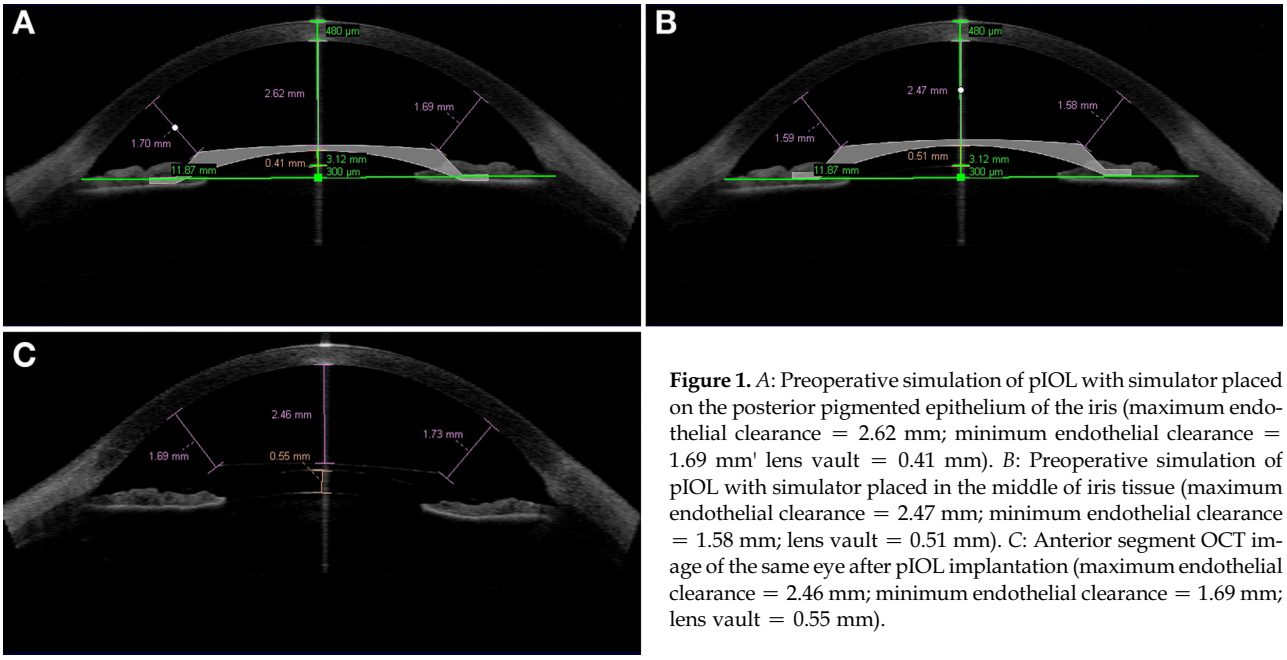


**Figure 1.** *A*: Preoperative simulation of pIOL with simulator placed on the posterior pigmented epithelium of the iris (maximum endothelial clearance = 2.62 mm; minimum endothelial clearance = 1.69 mm' lens vault = 0.41 mm). *B*: Preoperative simulation of pIOL with simulator placed in the middle of iris tissue (maximum endothelial clearance = 2.47 mm; minimum endothelial clearance = 1.58 mm; lens vault = 0.51 mm). *C*: Anterior segment OCT image of the same eye after pIOL implantation (maximum endothelial clearance = 2.46 mm; minimum endothelial clearance = 1.69 mm; lens vault = 0.55 mm).

the periphery (edge) of the optic; thus, endothelial clearance seems to be the most important distance when implanting iris-fixated pIOLs.

Scheimpflug photography has been used preoperatively to simulate the position of pIOLs in the anterior chamber. Tehrani et al.[14] used Scheimpflug photography for preoperative simulation of the pIOL position in the anterior chamber and reported the results in 1 case. The simulator was placed on the upper surface of the iris, and all actual postoperative distances from the pIOL to the endothelium were 50 µm higher than the corresponding distances in the simulation mode.

Doors et al.[15] evaluated the Visante AS-OCT system in a preoperative simulation of an Artiflex pIOL. All measurements showed highly significant correlations and small mean differences between preoperative measurements and postoperative measurements, although the distance from the nasal edge of the pIOL to the endothelium and the distance from the pIOL to the crystalline lens showed a statistically significant difference between the preoperative simulation and the actual postoperative measurements ($P=.045$ and $P=.001$, respectively). For simulation in their study, the pIOL simulator was placed in the middle of the iris tissue. The measured edge distances were smaller in the preoperative simulation than in the postoperative images; however, only the difference in the nasal edge distance was statistically significant.

In our study, the simulation was performed twice. First, the simulator was placed on the posterior pigmented epithelium of the iris. Then, the simulation was performed with the simulator placed in the middle of iris tissue. Although all distances in both simulation methods were highly correlated (except lens vault in the first method of simulation), only the results with the simulator placed in the middle of the iris tissue were not statistically different from the corresponding postoperative measurements.

Although it seems that peripheral iridectomy may change the ACD and affect the simulated distances, studies evaluating the effect of peripheral iridectomy on anterior segment morphology[16,17] concluded that peripheral iridectomy results in an increase in angle

**Table 1.** Comparison of preoperative simulation with postoperative measurements when the simulator was placed on the posterior pigmented epithelium of the iris.

| | Mean (mm) ± SD | | | Pearson Correlation | |
|---|---|---|---|---|---|
| Variable | Preop | Postop | *P* Value | *P* Value | *r* Value |
| Maximum endothelial clearance | 2.61 ± 0.20 | 2.45 ± 0.14 | .000 | .000 | .886 |
| Minimum endothelial clearance | 1.81 ± 0.21 | 1.65 ± 0.12 | .000 | .000 | .691 |
| Lens vault | 0.46 ± 0.02 | 0.58 ± 0.01 | .000 | .285 | .158 |

**Table 2.** Comparison of preoperative simulation with postoperative measurements when the simulator was placed in the middle of the iris tissue.

| Variable | Mean (mm) ± SD | | *P* Value | Pearson Correlation | |
|---|---|---|---|---|---|
| | Preop | Postop | | *P* Value | *r* Value |
| Maximum endothelial clearance | 2.42 ± 0.21 | 2.45 ± 0.14 | .209 | .000 | .865 |
| Minimum endothelial clearance | 1.67 ± 0.21 | 1.65 ± 0.12 | .564 | .000 | .663 |
| Lens vault | 0.61 ± 0.10 | 0.58 ± 0.01 | .143 | .009 | .501 |

width, with no change in the ACD. In our study, the ACD did not change significantly from before to after surgery (3.19 ± 0.17 mm versus 3.21 ± 0.12 mm; $P = .21$); thus, it seems unlikely that peripheral iridectomy significantly affected the simulated measurements.

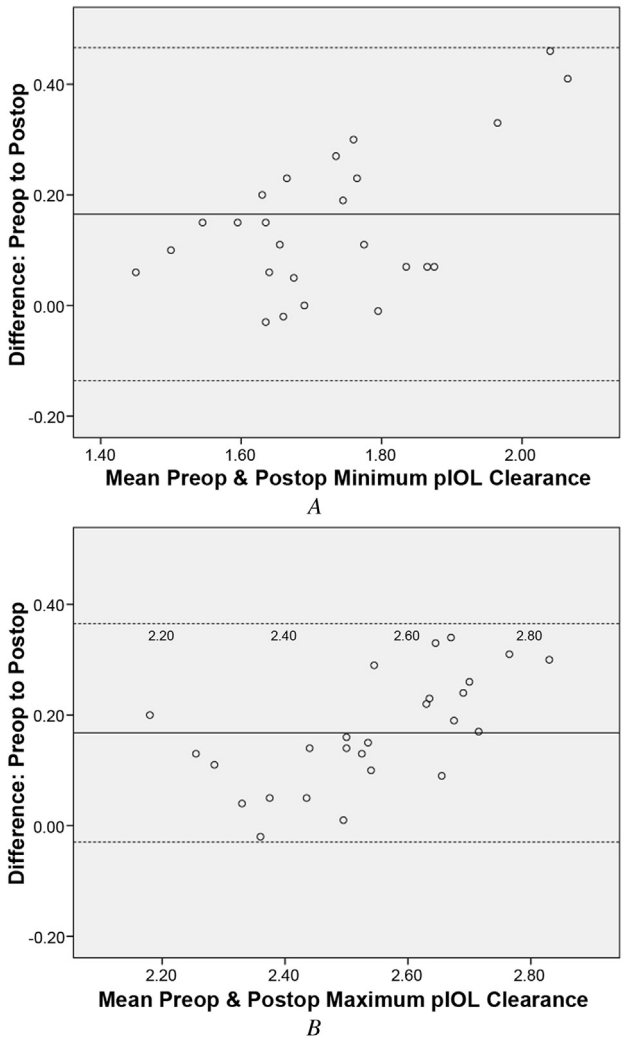


**Figure 2.** Bland-Altman plot showing the difference between the preoperative and postoperative measurements (mm) with the simulator placed on the posterior pigmented epithelium of the iris. The dotted lines enclose difference from −1.96 to +1.96 SD. *Top*: Minimum endothelial clearance (mm) (95% confidence interval [CI], 0.103-0.227). *Bottom*: Maximum endothelial clearance (mm) (95% CI, 0.127-0.208) (pIOL = phakic intraocular lens).

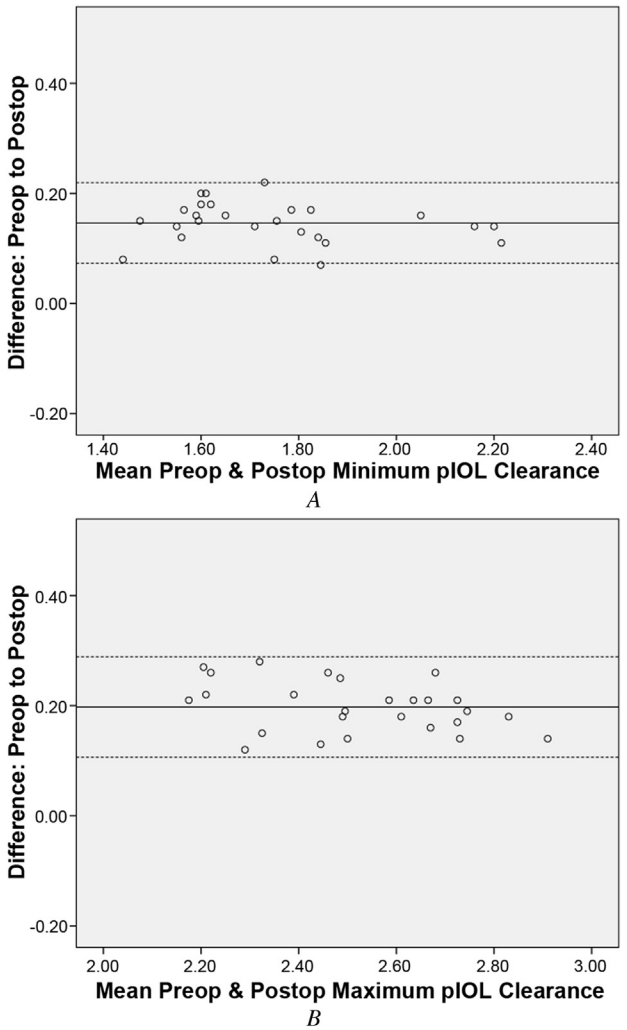


**Figure 3.** Bland-Altman plot showing the difference between the preoperative and postoperative measurements (mm) with the simulator placed in the middle of the iris tissue. The dotted lines enclose difference from −1.96 to +1.96 SD. *Top*: Minimum endothelial clearance (mm) (95% confidence interval [CI], 0.131-0.161). *Bottom*: Maximum endothelial clearance (mm) (95% CI, 0.178-0.216) (pIOL = phakic intraocular lens).

In conclusion, the pIOL template of the Visante AS-OCT system was useful in the preoperative simulation of the pIOL position in the anterior chamber, which increases the safety of pIOL implantation. We propose that the simulator should be placed in the middle of the iris tissue for preoperative simulation.

### WHAT WAS KNOWN

- In implantation of iris-fixated pIOLs, endothelial clearance is the most important distance.
- There are a few studies of the preoperative simulation of pIOLs using Scheimpflug photography or AS-OCT.

### WHAT THIS PAPER ADDS

- Results indicate that preoperative simulation using AS-OCT is useful in the selection of patients considering pIOL implantation. For simulation, the simulator should be placed in the middle of the iris tissue.

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