Effect of plateau iris configuration on effective lens position and intraocular lens power calculation: Report of 3 cases

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We report the cases of 3 patients with plateau iris configuration who had bilateral phacoemulsification with posterior chamber intraocular lens (IOL) implantation. A standard IOL power formula—Holladay 2 or Hoffer Q—was used to select IOL power preoperatively to achieve emmetropic refractive outcomes. The surgeries were uneventful, but the postoperative outcomes were more myopic than calculated, deviating from the preoperative targets by $-0.350$ to $-1.175$ diopters. To counteract this effect in 2 of the eyes, the IOL power was adjusted to a more hyperopic target, resulting in the desired emmetropic outcome.

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The refractive effect of an intraocular lens (IOL) is dependent not only on its power but also on its anatomic position in the eye, the effective lens position (ELP). Many modern IOL power formulas, such as the Hoffer Q, Holladay 2, and SRK/T, use estimations of postoperative anterior chamber depth (ACD) or the distance between the corneal epithelium and the anterior surface of the IOL as a correlate to ELP in their calculations. However, if an eye does not exhibit the assumed normal anatomy, this correlation may not be completely valid.

One condition in which intraocular anatomy may not conform to assumptions in IOL power calculation formulas is plateau iris configuration. This phenomenon is characterized by a flat iris plane with an iris root that angles forward and ciliary processes that are displaced anteriorly. The anatomy of plateau iris configuration is understood, but to our knowledge there have been no reports of how it affects the IOL position following cataract surgery. Although the central ACD may be normal in plateau iris, the more anterior insertion of the iris on the ciliary body may result in anterior displacement of the ELP that is not anticipated by standard IOL formulas, leading to a myopic surprise after IOL implantation.

We report 3 cases of plateau iris configuration in which the power of the IOL selected preoperatively using standard calculations led to myopic postoperative outcomes. In eyes with plateau iris configuration, a more hyperopic refractive target may be required.

CASE REPORTS

Three patients between the ages of 50 years and 66 years presented for evaluation of bilateral plateau iris and cataract. On slitlamp examination, all 3 patients had narrow angles by van Herick assessment and $1^\circ$ to $2^\circ$ nuclear sclerotic cataracts with mild to moderate visual significance. A laser peripheral iridotomy had been performed in 1 or both eyes of the patients in an attempt to widen the anterior chamber angle. However, gonioscopy of the 6 eyes revealed persistently occludable angles with only the anterior trabecular meshwork visible in at least half the angle. Darkroom ultrasound biomicroscopy (UBM) was performed and confirmed plateau iris configuration (Figure 1).

The 3 patients elected to have cataract extraction with IOL implantation for visual rehabilitation and/or prophylaxis against acute angle closure. The preoperative refractive
errors; optical biometry values including axial length (AL), keratometry, horizontal corneal diameter, preoperative ACD, and lens thickness; IOL powers with their estimated refractive targets measured by the Holladay 2 or Hoffer Q formula; and postoperative refractive outcomes are summarized in Table 1. In Cases 2 and 3, the ACD was normal despite the diagnosis of plateau iris configuration and anatomically narrow angles. In all eyes, cataract surgery was uneventful and the IOL was implanted in the capsular bag. Postoperative gonioscopy confirmed widening of the anterior chamber angles such that the angles were no longer considered occludable.

Case 1

A 66-year-old white woman with plateau iris and cataracts was targeted for emmetropia. A Tecnis multifocal ZMB00 24.5 diopter (D) IOL (Abbott Medical Optics, Inc.) was selected for the right eye. Using the Hoffer Q formula, the estimated refractive outcome with this IOL was $-0.20 \text{ D}$. At 1 month postoperatively, the manifest refraction was $-2.00 +1.25 \times 152$, a difference of $-1.175 \text{ D}$ from the preoperative target. Optical biometry and IOL calculations were repeated and confirmed consistent results. Given this significant refractive error, the patient requested an IOL exchange to improve spectacle independence. After uneventful IOL exchange using a lower-powered Tecnis multifocal ZMB00 22.5 D IOL (calculated using Previze software formulas), the uncorrected distance visual acuity (UDVA) was 20/20. Based on the refractive outcome in the right eye, an adjustment was made to the IOL choice for the left eye. A seemingly underpowered Tecnis multifocal ZMB00 22.0 D IOL was selected, with an estimated hyperopic refractive outcome of $+0.60 \text{ D}$ using the Hoffer Q formula. With this adjustment, the UDVA in the left eye was 20/20 with a manifest refraction of plano ($0.00 \text{ D sphere [DS]}$).

Case 2

A 67-year-old white woman with plateau iris and cataracts was targeted for emmetropia. An SN60WF 20.5 D IOL (Alcon Laboratories, Inc.) was selected for the right eye. Using the Holladay 2 formula, the estimated refractive outcome with this IOL was $-0.16 \text{ D}$. At 1 month, the manifest refraction revealed a refractive surprise of $-1.25 \text{ D}$, which was 1.09 D more myopic than expected. Biometry was repeated and confirmed the initial measurements. Based on the refractive outcome in the right eye, an SN60WF 19.0 D IOL was selected for the left eye, with a hyperopic refractive target of $+0.55 \text{ D}$ using the Holladay 2 formula. Postoperatively, the UDVA was 20/20.

Case 3

A 50-year-old African American man with plateau iris and cataracts was targeted for emmetropia. An SN60WF 29.5 D IOL was selected for the right eye. Using the Hoffer Q formula, the estimated refractive outcome was $-0.62 \text{ D}$. At 1 month, the manifest refraction was $-0.75 +1.00 \times 50$, which was $-0.85 \text{ D}$ more myopic than the predicted refraction. The same IOL was selected for the left eye; the estimated refraction was $+0.29 \text{ D}$ using the Hoffer Q formula. As in the fellow eye, the postoperative manifest refraction was $-1.00 +0.50 \times 105$, which was a myopic surprise of $-1.04 \text{ D}$. As the UDVA in both eyes was 20/20, the patient decided to address the residual refractive error with spectacles.

DISCUSSION

Patient expectations for cataract surgery have increased the importance of accurate IOL selection.
Thus, highly accurate IOL power calculation formulas that are specific to each individual are a necessity. The ELP, which is a theoretical construct that defines the principal plane position of the IOL, is important to establish as it affects the refractive target of an IOL. As the ELP is highly correlated with the postoperative ACD, the postoperative ACD is calculated and used as a proxy to the ELP in many modern IOL power formulas. The Hoffer Q formula assumes a directly proportional relationship between preoperative AL and postoperative ACD and uses the former value to estimate the latter. The Holladay 2 and SRK/T formulas use the Fyodorov method, which uses AL and keratometry to predict preoperative corneal height or the distance from the corneal endothelium and the iris plane. Predicted postoperative ACD is then calculated as the sum of corneal height, corneal thickness, and a surgeon factor (Holladay 2) or A constant (SRK/T).

Despite the improved performance of the newer formulas, estimating the postoperative ACD has been the major limiting factor in the accuracy of IOL power calculations, accounting for 35.5% of IOL power errors. In comparison, 17.0% of prediction errors result from errors in the measurement of AL and 2.5% from errors in the measurement of corneal power. One explanation for the high percentage of IOL power errors is that currently used IOL power calculation formulas assume that an eye exhibits normal anatomy, so the postoperative ACD can be calculated as directly proportional to the AL in the Hoffer Q equation or from the preoperative corneal height and corneal thickness in the SRK-T and Holladay 2 equations. If there is any irregularity in intraocular anatomy, such as in the configuration of the iris in plateau iris configuration, an estimation of postoperative ACD with the relationships in these formulas may not be accurate. Furthermore, the calculated postoperative ACD may not correlate directly with the ELP.

In patients with plateau iris configuration, AL and corneal height may be similar to those in patients with normal anatomy, allowing calculation of postoperative ACD as described above with the Hoffer Q, Holladay 2, and SRK/T formulas. However, the ciliary body processes and iris root in plateau iris configuration are anteriorly displaced, leading to a narrow peripheral angle but normal central ACD. It is this position of the ciliary body processes and iris root that determines the postoperative position of the IOL or the ELP. Thus, in patients with plateau iris configuration, the IOL may sit more anteriorly than it does in patients with normal anatomy. Modern IOL power formulas fail to capture this as they do not consider the location of the ciliary body and iris root when determining the ELP.
Although the anatomy of plateau iris configuration has been understood for some time, there have been no reports of refractive outcomes and IOL position following cataract surgery, perhaps because the disorder was thought to be rare. However, a recent multicenter cross-sectional study of subjects without glaucoma reports that the prevalence of plateau iris configuration may be between 21% and 25% in healthy white and Chinese eyes, suggesting that plateau iris configuration may be a more common variation of anterior chamber anatomy than previously realized. For patients with plateau iris, we postulate that forward rotation of the ciliary processes results in a more anterior displacement of the IOL than would be predicted by standard IOL power calculation formulas, which may result in myopic surprises. As demonstrated by the 3 cases of UBM-confirmed plateau iris configuration, standard IOL formulas are poor predictors of refractive outcomes in patients with this anatomic variant.

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