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Interocular Axial Length and Corneal Power Differences as Predictors of Postoperative Refractive Outcomes after Cataract Surgery

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Purpose: To determine whether differences between eyes in axial length (AL) and corneal power (K) on optical biometry are predictive of refractive outcomes.

Design: Retrospective cohort study.

Participants: A total of 729 patients (1458 eyes) who underwent bilateral phacoemulsification at TLC (Mississauga, Ontario, Canada) from September 2013 to August 2015.

Methods: We compared the proportion of patients having >0.5 diopters (D) of refractive error from target stratified by interocular axial length differences (IALDs) and interocular K differences (IKDs) between eyes as measured by optical biometry (IOL-Master, Carl Zeiss Meditec, Oberkochen, Germany). Analysis was repeated for 0.25 D or 1.0 D targets and for patients with uncorrected visual acuity (UCVA) >0.3 logarithm of the minimum angle of resolution (logMAR) postoperatively.

Main Outcome Measures: Proportions, odds ratios (ORs), and corresponding 95% confidence intervals (CIs) were computed using generalized estimating equations to account for within-patient correlation.

Results: Some 79.1% of eyes were ≤0.5 D of refractive target, 47.0% were ≤0.25 D, and 97.2% were ≤1.0 D. The OR of having a refractive outcome >0.5 D from target for IALD cutoff of 0.2 mm was 1.4 (1.1−1.8), of 0.3 mm was 1.6 (1.2−2.1), and of 0.4 mm was 1.8 (1.3−2.5). This translates to 70.0% (63.5−75.7) within target for IALD of ≥0.4 mm versus 80.7% (78.4−82.9) for <0.4 mm. For a given patient with IALD, the chance of being off target was similar for the shorter and longer eye. Eyes outside of target were twice as likely to be <−0.5 D than >0.5 D. Interocular K difference was largely not associated with prediction error, yet larger IKD-flat, steep, and average were associated with increased odds of UCVA >0.3 logMAR postoperatively.

Conclusions: Interocular axial length difference of as little as ≥0.2 mm is associated with a higher chance of >0.5 D of refractive error from target and worse UCVA. Interocular K difference was not associated with worse refractive error from target, although a difference of ≥0.4 D was associated with worse UCVA. These cutoffs should be considered in preoperative planning and discussion with patients. Future study is required to assess whether repeating measurements, using adjunctive measurement devices, or attempting to separate true differences from artifact based on preoperative refractive characteristics reduces residual refractive error. *Ophthalmology 2018;■:1−10 © 2018 by the American Academy of Ophthalmology*

Ocular biometry is an integral part of preoperative assessment when evaluating a patient for cataract surgery. Patient and physician expectations of visual outcomes are increasing; cataract surgery is no longer exclusively performed as a medical procedure, but also as a refractive surgery, so both patient and physician strive to achieve the desired refractive target. Two important parameters measured for intraocular lens (IOL) power calculation are axial length (AL) and corneal power (K), present in essentially all formulas. Accurate measurement of these variables is paramount to ensuring good postoperative visual outcomes. An error in measurement of AL by only 0.10 mm results in 0.27 diopters (D) of refractive error in a standard eye[1]; this value can vary significantly in myopic and hyperopic eyes.[2] Likewise, deviation in the measurement of K by 1.0 D results in 0.9 D of refractive error.[1]

Newer technologies have enabled measurement of these parameters to a great degree of accuracy. Partial coherence laser inferometry enables measurement of AL with an error of only 0.03 mm.[1,3,4] Likewise, sophisticated corneal keratometry/topography equipment and formulas have enabled measurement of K accurately, even after corneal refractive surgery.[1,5]

To ensure accurate measurements, best practice is to compare ocular biometry between eyes and ensure that there are no interocular discrepancies. Currently, data on the impact of interocular differences between eyes are lacking. A large cohort study by Knox Cartwright et al[6] suggests that biometric measurements should be repeated if intra-individual asymmetry of AL exceeds 0.70 mm or mean K exceeds 0.90 D.[6] However, these estimates are simply based on the 95% distribution of a large sample of biometric measurements

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performed using the Zeiss IOLMaster (Carl Zeiss Meditec, Oberkochen, Germany) and do not consider associated postoperative refractive outcomes.[6]

Two studies exist looking at the impact of interocular AL difference (IALD) of visual outcomes in pediatric patients with cataract.[7,8] Lal et al[7] demonstrated a clinically important relationship between IALD and best-corrected visual acuity (BCVA) in a sample of 171 patients. Gochnauer et al[8] later performed a multiple logistic regression model of 96 patients in this same sample and confirmed that BCVA ≥20/40 (Snellen) was associated with lower IALD,[8] although these results may be confounded by anisometropic amblyopia. Rajan et al[3] performed the only related study in patients with age-related cataracts and found that increasing AL was associated with increased IALD and increased postoperative anisometropia, particularly in those with AL greater than 28.0 mm, without directly studying the relationship between IALD and refractive outcomes. To our knowledge, the effect of interocular differences in preoperative K on postoperative refractive error has not been reported.

Given the gap in the literature, the purpose of this investigation was to determine the effect of preoperative interocular AL and K difference on refractive error; the goal was to establish cutoffs values for IALD and interocular K difference (IKD), beyond which physicians need to be aware of refractive uncertainty and communicate this with patients, and possibly for which operators should consider repeating measurements to reduce biometry prediction error.

Methods

Study Design

Charts of all patients who underwent sequential bilateral clear corneal phacoemulsification at TLC (Mississauga, Ontario, Canada) between September 2013 and August 2015 were retrospectively reviewed. This study was approved by the Research Ethics Board of Trillium Health Partners (ID no. 802) and was conducted in accordance with the tenets of the Declaration of Helsinki. Electronic patient records were obtained to collect all available demographic, clinical, and biometric data. Inclusion criteria were patients who underwent sequential bilateral cataract surgery. Patients were excluded as outliers if age was <25 or >90 years, AL was <20 mm or >30 mm, preoperative spherical equivalent refraction was <−15 or >10 D, preoperative mean K was <35 or >47 D, and astigmatic refractive error was <−3 or >5 D. Patients were also excluded if they did not undergo bilateral surgery or if AL was calculated using A-scan ultrasound biometry.

Data Collection

Data collected included patient demographics (gender, age), clinical history (diabetes, amblyopia, age-related macular degeneration), preoperative ocular measurements (uncorrected visual acuity [UCVA], BCVA, manifest refraction [sphere and cylinder], corneal tomography [from which keratometry was obtained], AL, and cataract grade), procedural details (procedure date, operated eye, refractive target, IOL power), and postoperative outcomes at 3 weeks (manifest spherical equivalent, UCVA, BCVA).

Clinical and Surgical Procedures

All patients underwent routine baseline preoperative clinical examination and bilateral biometry measurements. During this preoperative visit, patients underwent bilateral manifest refraction. Cataract density was rated on a scale ranging from 1 to 4+. The prediction error for the implanted IOL power was calculated using the third-generation Holladay 1 formula[9] with biometry data obtained from the IOLMaster 500 (Carl Zeiss AG). Only the biometry output deemed by the ophthalmic technologist to be the most accurate was used for analysis. For patients with myopic ALs (>24.8 mm), the Wang−Koch adjustment was applied to AL in calculating the Holladay 1 formula.

Patients underwent traditional manual cataract surgery or femtosecond laser-assisted cataract surgery (FLACS). Traditional manual cataract surgery was performed according to the standard of care. The procedure started with a clear corneal incision entering the anterior chamber. Capsulorhexis was then done using continuous curvilinear capsulotomy wherein the surgeon manually created the window into the anterior lens capsule wall. The lens was then hydrodissected from the capsule. The cataract was extracted using a nucleus-splitting phacoemulsification technique. The IOL was placed in the remaining lens capsule via the initial sutureless incision.[10,11] In FLACS, the femtosecond laser was used to create the clear corneal incision, capsulotomy, and initial lens fragmentation.[12,13] Manifest refraction was performed at 4 weeks postoperatively.

Primary and Secondary Outcomes

The primary outcome of interest was the incidence of biometry prediction error, defined as a difference between target refractive power and postoperative refractive power exceeding 0.5 D. Secondary outcomes were the difference between target refractive power and postoperative refractive power exceeding 0.25 D and exceeding 1.0 D, and postoperative UVCA exceeding 0.3 logarithm of the minimum angle of resolution (logMAR).

Primary Predictors

The primary predictors were the absolute value of the interocular axial length difference (IALD) and the absolute value of the interocular steep and flat K difference (IKD-steep, IKD-flat, and IKD-average). These were measured at baseline preoperatively using the IOLMaster.

Statistical Analysis

IBM SPSS Statistics (IBM Corp., Armonk, NY, Version 20) was used for statistical analysis. Normally distributed continuous variables are presented as means with standard deviations. Categoric variables are presented as frequencies as percentages with 95% confidence intervals (CIs). A P value of less than 0.05 was considered statistically significant throughout the study.

The association between the predictors, IALD, IKD-steep, IKD-flat, and IKD-average, and the outcomes, biometric prediction error and UCVA, was tested using generalized estimating equations accounting for within-patient correlation. This model produced adjusted odds ratios (ORs) and adjusted proportions after accounting for the relationship between the 2 eyes of each single patient. With a sample size of 1458 patients, an estimated proportion of patients within the target of 90% for IALD <0.4 mm and 85% for IALD >0.4 mm (5% effect size), and a type 1 error of 0.05, this study had 90% power.

The association between IALD and refraction prediction error was tested at 0.1 mm, 0.2 mm, 0.3 mm, and 0.4 mm cutoffs,