ARTICLE

Effect on refractive outcomes after cataract surgery of intraocular lens constant personalization using the Haigis formula

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PURPOSE: To quantify the effect on refractive outcomes after cataract surgery of personalization of Haigis intraocular lens (IOL) constants for a given surgeon–IOL combination.

SETTING: Institute of Eye Surgery and Institute of Vision Research, Whitfield Clinic, Butlerstown North, Waterford, Ireland.

METHODS: Personalization of Haigis IOL constants was performed using a series of 248 suitable eyes after biometry by partial coherence interferometry (IOLMaster) and IOL prediction based on optimized IOL constants derived from pooled data from the User Group for Laser Interference Biometry web site. A mean error of prediction and a mean absolute error were then calculated using the personalized IOL constants and compared with those derived using optimized IOL constants, allowing evaluation and quantification of the maximum realizable refractive benefits (if any) of personalization.

RESULTS: There was no statistically significant difference between personalized and optimized Haigis IOL constants in absolute error or the proportion of eyes within $\pm$1.00 diopters (D), $\pm$0.50 D, or $\pm$0.25 D of the target postoperative refraction in all eyes, short eyes (axial length [AL] <22 mm; n = 19), average eyes (AL $\geq$22 mm and <24.5 mm; n = 149), or long eyes (AL >24.5 mm; n = 46) (all P>.05, McNemar test). Ten eyes with a short AL had a smaller absolute error (by $\geq$0.30 D) in association with personalized IOL constants.

CONCLUSION: Personalized Haigis IOL constants showed marginal, but statistically nonsignificant, refractive advantages over optimized Haigis IOL constants, but only in eyes with a short AL.

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Modern cataract surgery can be regarded as a refractive procedure,[1,2] and patients have high expectations of their cataract surgeon and low tolerance for less than perfect results.[1,A] Indeed, the most common cause of litigation arising from cataract surgery is implantation of an intraocular lens (IOL) of inappropriate power.[1]

Refractive outcomes after cataract surgery have improved significantly over the past few years. The percentage of eyes with a postoperative refraction within $\pm$1.00 diopter (D) of the target refraction has increased from 65%[3] to more than 95%, and even to 100% in some series.[4–8] A recent multicenter prospective electronic audit of more than 4000 cataract operations[8] collected data in 3 cycles over a 3-year period; results suggest that the current and minimally acceptable standard for clinical audit should be as follows: 85% postoperative refractive results within $\pm$1.00 D of the target postoperative refraction and 55% within $\pm$0.50 D. The authors also concluded that continuous customization and optimization of IOL A constants is important to achieve the proposed benchmark standards in postoperative cataract refractive outcomes.

The reason for the improvement in refractive outcomes after cataract surgery is that the variables used to predict postoperative outcomes can now be validly and reliably measured before surgical intervention by immersion ultrasound biometry or partial coherence interferometry (PCI).[2,10–11] In other words, the impact of the major contributors to postoperative

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refractive error has been substantially reduced by improvements in measures of biometric parameters.

Furthermore, for almost 30 years now, many have been advocating personalizing IOL constants to the individual surgeon. This is an important step if further improvements in refractive outcomes after cataract surgery are to be realized.[2,12–16,B,C] Personalization of IOL constants can be performed for all currently used formulas, including third-generation 2-variable formulas (Hoffer Q,[14] Holladay 1,[16] SRK/T[17]), 3-variable formulas (Haigis[18]), and 7-variable formulas (Holladay 2).

The IOL power prediction curve of third-generation 2-variable formulas is mostly fixed and is moved up or down depending on the IOL constant. The larger the IOL constant, the more IOL power each formula will recommend for the same set of biometric measurements. The smaller the IOL constant, the less IOL power the same formula will recommend for the same set of biometric measurements. Those formulas do not take into account the individual geometry of each IOL model. They also assume that anterior chamber dimensions are related to axial length (AL). They assume that short eyes have shallower anterior chambers and that long eyes have deeper anterior chambers. However, 80% of short eyes have large crystalline lenses but a normal anterior chamber anatomy in the pseudophakic state.[C] Another erroneous assumption is that eyes with steep corneas have deep anterior chambers and eyes with flatter corneas have shallow anterior chambers.

The Haigis formula is different from the 2-variable formulas. It uses 3 constants (a0, a1, and a2) to set the position and the shape of a power prediction curve. The a0 constant moves the power prediction curve up or down. The a1 constant is tied to the measured anterior chamber depth (ACD) and the a2 constant, to the measured AL. All 3 IOL constants are derived by multivariable regression analysis from a large sample of surgeons and IOL-specific outcomes for a wide range of ALs and ACDs, and they are published on the User Group for Laser Interference Biometry (ULIB) web site.[B] These optimized IOL constants are based on pooled data from multiple surgeons. Similarly, an individual surgeon can submit IOL-specific outcomes to Haigis[D] and acquire a set of a0, a1, and a2 IOL constants that are specific to that particular surgeon–IOL combination, thereby personalizing the IOL constants.

To our knowledge, the extent of the practice of IOL constant personalization is not known. We sent an anonymous survey to cataract surgeons in the United Kingdom and Republic of Ireland to ascertain the proportion of surgeons who incorporate optimized and/or personalized IOL constants into their practice, the methods used to do so, and the reasons some surgeons choose not to incorporate them. In the survey and in this paper, the term *optimization* is used for IOL constants derived from multisurgeon pooled data and the term *personalization* for IOL constants derived from single-surgeon data.

We also designed a study to analyze the refractive effect of personalizing IOL constants. In the study, we compared the mean error of prediction and mean absolute error generated using personalized Haigis IOL constants and nonpersonalized (but optimized) Haigis IOL constants for a series of eyes operated on by the same surgeon using the same IOL model.

PATIENTS AND METHODS

Survey

In June 2009, a postal survey was sent to all consultant ophthalmologists in the database of the Royal College of Ophthalmologists in the UK and of the Irish College of Ophthalmologists in the Republic of Ireland. The mailing comprised a 2-page anonymous questionnaire with a cover letter and a stamped, addressed envelope for return.

Ophthalmologists were asked a series of questions about IOL constant optimization and personalization in relation to their practice of cataract surgery. Specifically, they were asked whether they personally perform cataract surgery (if the answer was no, they were not required to answer additional questions); whether they use published optimized IOL constants (derived from pooled data) from the ULIB web site[B]; whether they personalize their IOL constants by analyzing their own postoperative refractive data and if so, which method of personalization they use; and finally, if they opt not to personalize their IOL constants, to offer reasons for their decision.

The completed questionnaires were returned to the lead investigator. The responses were manually entered into a purpose-designed database for analysis.

Study of Refractive Effect of Personalizing Constants

Preoperative, intraoperative, and postoperative data were prospectively collected from consecutive cases of

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phacoemulsification cataract surgery performed by the same surgeon (S.B.). Exclusion criteria included preoperative ocular comorbidity that would affect vision, previous intraocular surgery, intraoperative complications, use of a posterior chamber IOL (PC IOL) other than the Tecnis ZA9003 (Abbott Medical Optics Inc.), insufficient biometry data, inability to perform optical coherence biometry, insufficient postoperative refractive data, and postoperative corrected distance visual acuity (CDVA) worse than 0.5 by subjective refraction performed 6 to 8 weeks after surgery by the patient's optometrist.

Preoperative Data Partial coherence interferometry was performed with an IOLMaster biometer (version V, Carl Zeiss Meditec AG). The same experienced operator took all measurements using a standard technique. When doubt existed, readings were repeated and were accepted only when their reproducibility was shown. The following parameters were measured: AL, keratometry, ACD, and the white-to-white distance. The Haigis formula was used in each case to calculate IOL power to achieve the minus postoperative refraction closest to emmetropia. The Haigis a0, a1, and a2 constants for the PC IOL were downloaded from the ULIB web site[B] onto the software of the PCI device. When PCI measurements were not possible, immersion ultrasound biometry was performed and the cases were excluded from the study.

Intraoperative Data The surgeon performed all cataract and IOL implantation procedures using topical anesthesia and a standard technique. After a clear corneal incision was created superiorly, the PC IOL was placed in the capsular bag. A 10-0 nylon suture was placed in the corneal incision when the surgeon was not satisfied with wound integrity after stromal hydration.

Postoperative Data Patients were reviewed 2 weeks postoperatively, consistent with the unit's protocol.[19] The uncorrected distance visual acuity (UDVA) and CDVA were recorded at this visit. In addition, the ophthalmologist evaluated patient-reported symptoms or problems. If a corneal suture was in place, it was removed.

After the 2-week review, refraction for a new spectacle correction was arranged with a local optometrist. The results were forwarded to the practice. All refractions reported here are from an examination performed at least 6 weeks after surgery (and therefore can be considered stable) and at least 4 weeks after removal of the corneal suture, if present.

Personalization of Intraocular Lens Constants Data from the eligible cases were entered into the Excel spreadsheet (Microsoft Corp.) zeiss-d2.xls on the ULIB web site.[B] Data in the spreadsheet included the unique patient identification number; preoperative AL, ACD, and corneal radii K1 and K2 measured by PCI; power of the implanted IOL; and the spherical and cylindrical components of the stable postoperative refraction. Additional information requested on the spreadsheet included the surgeon's name or identification number, the manufacturer and type of IOL, the serial number of the PCI device, and the method of determining stable refractive status.

The completed spreadsheet was e-mailed directly to Dr. Haigis.[D] Three-variable regression analysis was performed by calculating the personalized a0, a1, and a2 IOL constants for the PC IOL for the ophthalmologist who performed the surgeries. The outcomes of the analysis were subsequently posted on the ULIB web site per the agreement outlined on the site.[B]

Statistical Analysis

An error of prediction was derived for each eye to show the tendency of prediction performance by the Haigis formula in combination with optimized (but not personalized) IOL constants. The error of prediction is the actual postoperative spherical equivalent (SE) minus the target postoperative SE and tells how close the actual postoperative refraction in each eye is to the target postoperative refraction. The sign of the error of prediction denotes the direction of the departure from the target. In other words, a negative error of prediction value means that the patient had a postoperative refraction that was more myopic than intended, while a positive error of prediction value means that the patient had a more hypertropic refraction than intended. An absolute error was also derived for each eye. The absolute error is the absolute value of the error of prediction in each eye and denotes the distance of the refraction from zero, without taking into account whether the departure from zero was in the myopic or hyperopic direction.

The 3 personalized IOL constants for the surgeon and the PC IOL were subsequently entered into the software of the PCI device. Using the newly personalized IOL constants and the Haigis formula, the device calculated the putative postoperative target SE for the IOL power that had actually been implanted. This allowed comparison of the actual error of prediction using the optimized IOL constants (already calculated) with a putative error of prediction using personalized IOL constants (the latter calculated as the actual postoperative SE minus the target postoperative SE for the IOL implanted but derived using the personalized Haigis IOL constants). A putative absolute error in this series of eyes and personalized Haigis IOL constants were also derived. This allowed, in the context of each operated eye acting as its own control, the investigation, description, and quantification of the maximum realizable refractive benefits of personalization of IOL constants for the surgeon in terms of the error of prediction and absolute error.

Refractive outcomes using personalized Haigis IOL constants and nonpersonalized (but optimized) Haigis IOL constants were compared in terms of the mean absolute error (Student paired t test) in all eyes and in 3 subgroups: short eyes (AL $<$22 mm), average eyes (AL $\geq$22 mm and AL $<$24.5 mm), and long eyes (AL $>$24.5 mm). The performance of each group of IOL constants across AL subgroups was also examined (analysis of variance [ANOVA]).

The proportion of eyes achieving an error of prediction within $\pm$0.25 D, $\pm$0.50 D, and $\pm$1.00 D was calculated overall and in each of the 3 subgroups. In each case, agreement between the personalized IOL constants and optimized IOL constants was evaluated (McNemar test). Agreement between the absolute error for the personalized Haigis and nonpersonalized (but optimized) Haigis IOL constants was also represented using Bland-Altman plots for all eyes and for each of the 3 AL subgroups. For statistical purposes, eyes were analyzed independently in patients who had sequential bilateral cataract surgery during the study period because it has been shown that the correlation between fellow eyes is weak when evaluating refractive outcome after cataract surgery.[20] The PASW Statistics software package (version 18.0, SPSS, Inc.) and R statistical programming language[E] were used for the statistical analysis.

RESULTS

Questionnaire

The questionnaire was mailed to 943 members of the Royal College of Ophthalmologists and 65 members of the Irish College of Ophthalmologists; 561 responses (55.7% response rate) were received. Of the respondents, 55 (9.8%) did not personally perform cataract surgery; thus, their responses were excluded from further analysis. This left a study group of 506 respondents (90.2%) who personally performed cataract surgery.

Use of Published Optimized Intraocular Lens Constants Of the 506 respondents who performed cataract surgery, 201 (39.7%) reported using published optimized IOL constants (derived from pooled data) from the ULIB web site; 243 (48%) reported not using published optimized IOL constants, 58 (11.5%) did not know whether they were using published optimized IOL constants, and 4 (0.8%) did not answer the question.

Personalization of Intraocular Lens Constants More than 78% of cataract surgeons (396; 78.3%) reported that they did not formally personalize their IOL constants using a validated and recognized technique, while approximately 22% (110; 21.7%) said they did. Table 1 shows the methods of personalization.

Table 1. Method of IOL constant personalization (N = 198 surgeons).

Personalization Method	Surgeons, n (%)
Informal methods of lens constant adjustment related to one's own surgical experience*	75 (37.9)
Electronic medical record system (Medisoft)	55 (27.8)
ULIB web site[B]/Warren Hill web site[C]	36 (18.2)
Partial coherence interferometry (IOLMaster)	7 (3.5)
Holladay IOL Consultant	6 (3.0)
Method not recognized by the authors†	3 (1.5)
Hoffer programs (EyeLab Inc.)	2 (1.0)
Okulix program package	1 (0.5)
Unknown/not specified/question left unanswered	13 (6.6)

*Not explicitly specified whether data from a single surgeon or multiple surgeons were used. The term *personalization* should infer a process specific to the individual surgeon, which represents a limitation of the questionnaire design.
†Back/Bates proportional method, IOL brain neural net software, London vision clinic optimization

Reasons for Not Personalizing Constants Of the 308 (60.9%) respondents who reported that they did not personalize their IOL constants by any means (even informal methods), 124 (40.3%) used optimized IOL constants from the ULIB web site, 139 (45.1%) used neither optimized nor personalized IOL constants; 43 (14.0%) did not know whether they used optimized IOL constants, and 2 (0.6%) did not answer the question.

Of the 124 respondents who used ULIB-derived (but not personalized) IOL constants, 31 (41.2%) reported that they believed their postoperative refractive results were satisfactory using the web site–optimized IOL constants and therefore did not feel the need to personalize them and 23 (18.5%) said they believed there was no good evidence to support personalization. Ten respondents (8.1%) did not explain why they did not personalize constants; 8 (6.5%) were preparing to start personalizing; 9 (7.3%) worked in a department in which the biometry machine is used by more than 1 surgeon, making personalization of IOL constants logistically difficult; 8 (6.5%) did not have the time to undertake such a process; 7 (5.6%) lacked the postoperative refractive results; and 3 (2.4%) performed low-volume surgery. One respondent did not know what the term *personalization of IOL constants* meant.

Study of Refractive Effect of Personalizing Constants

Postoperative Refractive Results After implementation of the exclusion criteria, 248 (195 patients) of 577 consecutive cases were deemed eligible for analysis. Patients were excluded because of lack of postoperative refractive data (115 cases; 19.9%), lack of biometric data in (112 cases; 19.4%), a postoperative CDVA that was worse than 0.5 (67 cases; 11.6%), an intraoperative complication (7 cases; 1.2%), lack of PCI biometry (3 cases; 0.5%), and implantation of an IOL other than the Tecnis ZA9003 (25 cases; 4.3%). The mean age of the 195 included patients (122 women, 62.6%) was 71 years ± 9.3 (SD). The ratio of right eye to left eye was 120:128. There were 21 eyes in the short AL subgroup, 180 eyes in the average AL subgroup, and 47 eyes in the long AL subgroup. The PCI-calculated putative postoperative target SE for the IOL power that had been implanted was available for 219 cases; the biometry for 29 eyes had been removed from the PCI device and this was not available for recalculation.

The Haigis optimized (but nonpersonalized) IOL constants were as follows: $a0 = -0.879$, $a1 = 0.252$, and $a2 = 0.220$ (based on 421 sets of postoperative refractive data and taken from ULIB web site). The mean postoperative SE derived using the optimized (but nonpersonalized) Haigis IOL constants was $-0.24 \pm$

Table 2. Mean error of prediction and MAE with Haigis optimized lens constants and with Haigis personalized lens constants and percentage of eyes with an error of prediction of ±1.00 D, ±0.50 D, ±0.25 D by AL.

	Optimized Haigis Lens Constants					Personalized Haigis Lens Constant				
	Mean (D) ± SD (Range)		% Eyes Within			Mean (D) ± SD (Range)		% Eyes Within		
Group	ME of Prediction	MAE	± 1.00 D	± 0.50 D	± 0.25 D	ME of Prediction	MAE	± 1.00 D	± 0.50 D	± 0.25 D
All eyes (n = 214)	−0.09 ± 0.48 (−1.78 to +1.53)	0.38 ± 0.31* (0.01 to 1.78)	96†	74†	43†	+0.01 D ± 0.47 (−1.72 to +1.50)	0.36 ± 0.30* (0.00 to 1.72)	96†	73†	44†
Short eyes (n = 19)	−0.37 ± 0.47 (−1.53 to +0.25)	0.45 ± 0.39* (0.10 to 1.53)	89†	68†	42†	−0.01 ± 0.48 (−1.19 to +0.57)	0.38 ± 0.28* (0.03 to 1.19)	95†	68†	37†
Average eyes (n = 149)	−0.11 ± 0.48 (−1.78 to +1.25)	0.38 ± 0.31* (0 to 1.78)	97†	74†	40†	+0.02 ± 0.46 (−1.72 to +1.50)	0.37 ± 0.30* (0 to 1.72)	96†	73†	42†
Long eyes (n = 46)	+0.08 ± 0.43 (−0.83 to +1.53)	0.32 ± 0.30* (0.01 to 1.53)	98†	78†	52†	+0.05 ± 0.41 (−0.83 to +1.48)	0.32 ± 0.29* (0 to 1.48)	98†	78†	52†

Means ± SD
MAE = mean absolute error; ME = mean error
*$P > .05$ (paired t test comparing corresponding outcome measures for optimized and personalized lens constants)
†$P > .05$ (McNemar comparing corresponding outcome measures for optimized and personalized lens constants)

0.50 D (range −2.50 to +0.88 D). The mean logMAR CDVA postoperatively was 0.06 ± 0.12.

The Haigis personalized IOL constants for the PC IOL were as follows: a0 = −2.341, a1 = 0.278, and a2 = 0.276 (based on 248 sets of postoperative refractive data e-mailed to Dr. Haigis).

Table 2 shows the mean error of prediction and mean absolute error with the Haigis optimized IOL constants and the Haigis personalized IOL constants as well as the percentage of all eyes and eyes in each AL subgroup with an error of prediction within ±1.00 D, ±0.50 D, and ±0.25 D. There was no statistically significant difference in absolute error between personalized IOL constants and optimized IOL constants in any group (P = .275, ANOVA 1-way) (Figure 1). In the Bland-Altman plots, the variance in all eyes, average eyes, and long eyes was stable and positive and negative differences occur randomly moving across from left to right (ie, with increasing mean absolute error) (Figure 2, *A*, *C*, and *D*). The Bland-Altman plot for short eyes suggests that an increasing mean absolute error (0.7 or above) is associated with a mean difference in absolute error that is always negative in association with personalized IOL constants (Figure 2, *B*); however, this group had a small number of eyes (19), with only 4 having a mean absolute error of 0.7 or above.

Figure 3 shows the cumulative percentage of eyes (y axis) that achieved less than or equal to a given error of prediction. The performance of optimized and personalized IOL constants was similar except in the short AL group. In this group, the proportion of eyes achieving a postoperative refraction within ±1.00 D of the target was slightly higher with personalized IOL constants than with optimized IOL constants.

Ten eyes in the entire series had a smaller absolute error (by 0.30 D or more) with personalized Haigis IOL constants than with the optimized Haigis IOL constants; although all these eyes were in the short AL group, in no eye in the entire series was the absolute error 0.50 D smaller or more with personalized constants

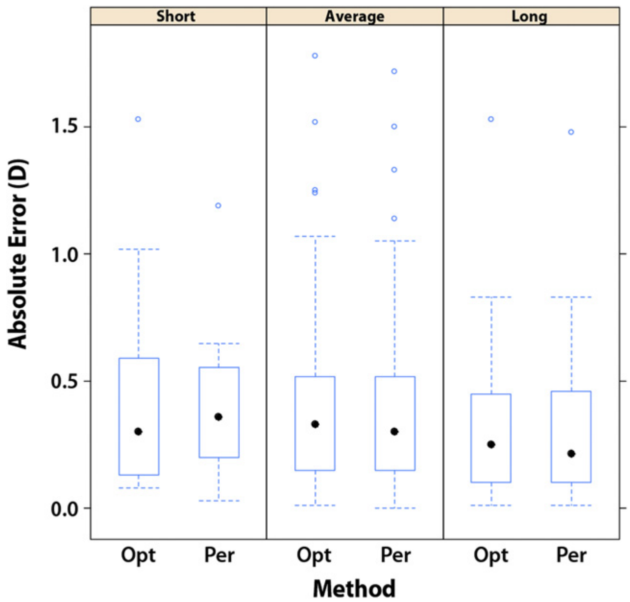

Figure 1. Box plot of the absolute derived using optimized Haigis IOL constants and personalized Haigis IOL constants by AL subgroup (AE = absolute error, Opt = optimized Haigis IOL constants, Per = personalized Haigis IOL constants).

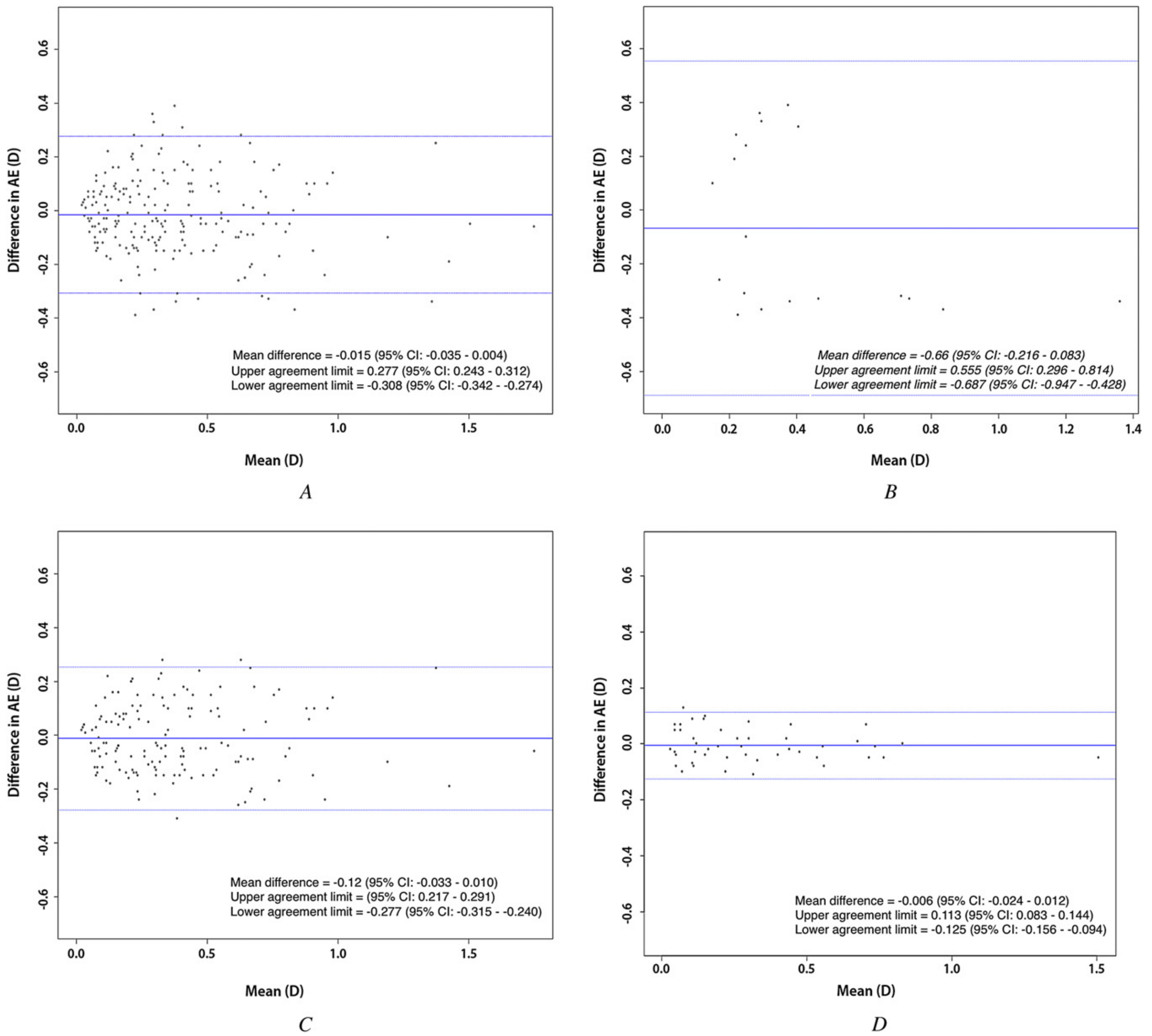

Figure 2. Bland-Altman plots showing agreement in the absolute error after cataract surgery between optimized Haigis IOL constants and personalized Haigis IOL constants. The solid horizontal lines represents the mean difference in the absolute error using the 2 techniques and the dotted lines, the upper and lower limits of agreement. A: All eyes (*A*), short eyes (*B*), average eyes (*C*), and long eyes (*D*). (Difference = AE using optimized IOL constants minus AE using personalized IOL constants; Mean = mean value of the AE using optimized IOL constants and the AE using personalized IOL constants).

than with the optimized constants. In contrast, 4 eyes had an absolute error that was 0.30 D smaller with optimized constants than with personalized constants; again, all the eyes were in the short AL group.

DISCUSSION

The aim of this study was 2-fold. First, we sent a survey to cataract surgeons in the UK and Republic of Ireland to ascertain the attitudes toward and extent of the practice of IOL constant personalization. Second, we performed a study that evaluated and quantified the maximum realizable refractive benefits of personalized Haigis IOL constants over optimized Haigis IOL constants. We achieved the latter by comparing the error of prediction and absolute error between 2 groups; that is, a single-surgeon series in which optimized Haigis IOL constants were used to predict the IOL power required to achieve emmetropia and an identical theoretical series of eyes in which personalized Haigis IOL constants were used. The design of the study (comparing a series of eyes with an identical theoretical series) ensured that the maximum realizable refractive

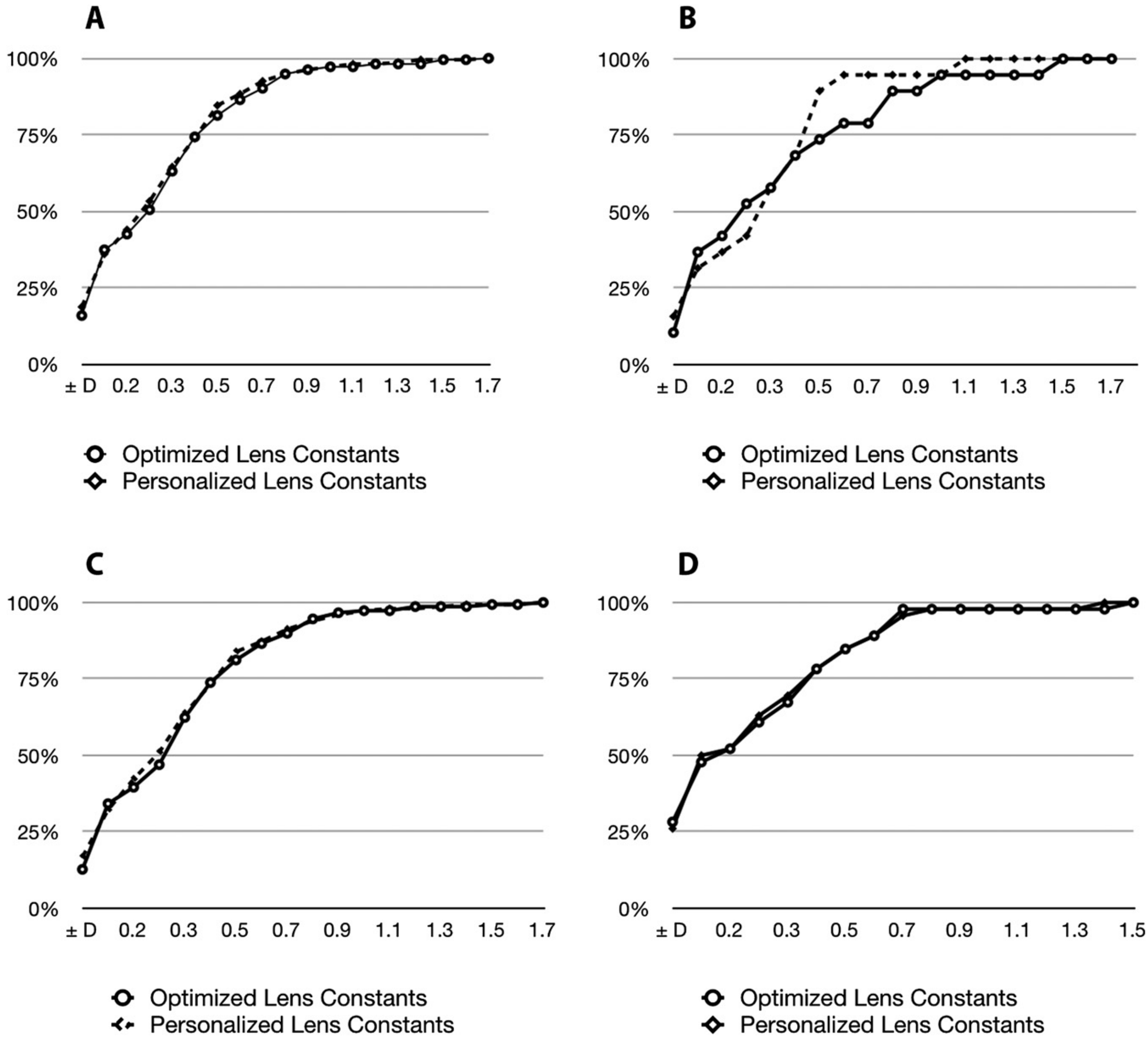

Figure 3. Cumulative percentage of operated eyes (*y* axis) that achieved less than or equal to a given error of prediction (*x* axis) using personalized (*solid line*) and optimized (*dashed line*) Haigis IOL constants in all eyes (*A*), in short eyes (*B*), average eyes (*C*), and long eyes (*D*) (AE = absolute error).

benefits of personalized Haigis IOL constants could be evaluated and quantified.

In addition to the core data retrieved from the anonymous survey, it was apparent from the responses that there is considerable confusion regarding the terminology of IOL constant manipulation, with no universally accepted system of nomenclature. The terms *optimization*, *customization*, *personalization*, and *individualization* have all been used, sometimes interchangeably, to refer to different aspects of IOL constant manipulation.[4,9,21,22,B,C] We are proposing a system of nomenclature that is clear and unambiguous and that will help cataract surgeons understand the principles behind the methods described. We propose using the term *optimization* when IOL constants are derived from multisurgeon pooled postoperative refractive data (published pooled data or unpublished pooled data within a department) and the term *personalization* when IOL constants are derived from a single surgeon's postoperative refractive data.

Fewer than 22% of respondents to the survey said they perform IOL constant personalization. The most frequently cited reason for not personalizing constants was that the respondent chose to use published optimized IOL constants rather than personalized IOL constants.

The survey results also show the logistical difficulties inherent in IOL constant personalization. These are reflected in the reasons surgeons gave for not personalizing constants (eg, lack of time; use of the biometry machine by more than 1 surgeon, making isolation of single-surgeon data difficult; inadequate number of cases due to low-volume surgery; lack of postoperative refractive data) and by our experience collating appropriate data sets for personalization. For example, we had to prospectively recruit 577 consecutive cases of phacoemulsification by a single surgeon, a process that took approximately 12 months (even in a high-volume cataract surgery practice), to yield 248 data sets with which to personalize our IOL constants because of the stringent inclusion criteria required for a valid process of IOL constant personalization. Furthermore, given that rapid advances in IOL technology, a typical practice is likely to adopt a new IOL model at relatively frequent intervals (in our practice, approximately every 24 months); therefore, any refractive benefit of using personalized IOL constants will be short-lived.

Most authors measure refractive outcomes by the proportion of eyes achieving an error of prediction within $\pm$1.00 D of the target, within $\pm$0.50 D of the target, or both. Indeed, current proposed benchmark standards for postoperative cataract refractive outcomes are reported this way.[8,14,23–26] In our study, optimized Haigis IOL constants achieved postoperative refractive outcomes that compare favorably with currently proposed benchmark standards, with 96% of eyes and 73% of eyes achieving an error of prediction within $\pm$1.00 D and within $\pm$0.50 D of the target, respectively, with no statistically significant difference between optimized Haigis and personalized Haigis IOL constants.

Unprompted comments by survey respondents indicate that many surgeons remain unconvinced of the advantages of personalized IOL constants over published optimized IOL constants. In our study of the benefits of personalized Haigis IOL constants, the mean absolute error achieved with optimized IOL constants in the single-surgeon series was not statistically different from that achieved with personalized IOL constants. This finding held true regardless of the eye's AL. Also, there was excellent agreement between the mean absolute errors achieved with personalized and optimized IOL constants; again, this was not affected by AL. Notably, only 10 eyes (all with a short AL) benefited from a mean absolute error that was 0.30 D or more smaller with personalized IOL constants than with optimized IOL constants. In no case did personalization of IOL constants confer a refractive benefit (in terms of absolute error) of 0.50 D or more. Given that most IOLs come in increments of 0.50 D, it is difficult to argue strongly in favor of personalization of Haigis IOL constants. However, the validity of IOL constants, whether personalized or optimized, will relate to the size of the data set from which the IOL constants have been derived. In this study, databases of 421 eyes and 248 eyes were used to derive the optimized Haigis IOL constants and personalized Haigis IOL constants, respectively.

In conclusion, personalization of Haigis IOL constants resulted in a marginal but statistically nonsignificant improvement in refractive outcomes after cataract surgery, and only in eyes with a short AL. In real terms, however, 577 consecutive data sets by a single cataract surgeon were required to meet the inclusion criteria for the process of personalization, resulting in 248 data sets deemed eligible for the process and ultimately resulting in only 10 eyes in which the absolute error was more favorable using personalized IOL constants than using optimized IOL constants by a degree of 0.30 D or more. In addition, no eye had a refractive advantage of 0.50 D or greater. Although continuous audit is an essential component of modern cataract surgery, the refractive benefits of using personalized Haigis IOL constants over optimized Haigis IOL constants are probably not clinically meaningful unless the surgeon performs a very high volume of cases annually, and even then only as long as that surgeon continues to use the same IOL model that was used in the process of personalization.

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