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Intraocular Lens Power Selection after Radial Keratotomy

Topography, Manual, and IOLMaster Keratometry Results Using Haigis Formulas

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Purpose: To compare final spherical equivalent (SE) refractions in patients who previously underwent radial keratotomy (RK) undergoing routine cataract surgery using keratometry (K) values from the Tomey (Topographic Modeling System [TMS]; Tomey Corp., Phoenix, AZ) Placido topographer, manual keratometer, and IOLMaster (Carl Zeiss Meditec AG, Jena, Germany) keratometer using the Haigis formulas.

Design: Retrospective case series.

Subjects: A total of 26 RK eyes (20 patients) with a minimum of 3 months postoperative follow-up.

Methods: The following K values were evaluated: TMS topography (flattest K within first 9 rings, average K, minimum K), manual K, IOLMaster K. The final refractive goal was −0.50 diopters (D) for all eyes. The Haigis formula with target refraction −0.50 D was used. In addition, because of observed hyperopic overcorrections, IOLMaster K with the Haigis formula set to −1.00 D but with a final refractive goal of −0.50 D was also tested. The Haigis-L formula using IOLMaster K values was separately evaluated.

Main Outcome Measures: Mean final SE refraction, percent final SE within ideal (−0.12 to −1.00 D), acceptable (0.25 to −1.50 D), or unacceptable (<−1.50 or >0.25 D) range and within ±0.50 D and ±1.00 D of the intended result.

Results: Best results with minimal overcorrections were achieved with TMS flattest K (mean −0.68±0.60 D, 73% within ±0.50 D, and 88% within ±1.00 D of the surgical goal) and IOLMaster K set for target −1.00 D (mean −0.66±0.61 D, 69% within ±0.50 D, and 88% within ±1.00 D of the surgical goal). Other values produced more hyperopic (manual, IOLMaster K set for target −0.50 D, average topography) or higher myopic (minimum topography, Haigis-L) results.

Conclusions: For simplicity, using the IOLMaster K values combined with the Haigis formula set for target refraction −1.00 D produces acceptable results aiming for −0.50 D final SE refractions in former RK patients undergoing routine cataract surgery. *Ophthalmology 2015;■:1–6 © 2015 by the American Academy of Ophthalmology.*

Although radial keratotomy (RK) is hardly ever performed today, it was the most popular refractive surgical procedure in the United States from 1978 until 1996 when excimer laser technology was approved by the Food and Drug Administration in the United States and LASIK/photorefractive keratectomy gained ascendancy. Millions of patients who underwent RK will continue to present for routine cataract surgery in the years ahead. Numerous studies have documented the difficulty in determining the proper intraocular lens (IOL) power to avoid postoperative hyperopia due to overestimating the true central corneal power with manual office keratometers.[1–9] Several studies have recommended various corneal indices derived from computerized videokeratography, which measures more values closer to the corneal apex and within the pupillary zone.[4–6,8–15] The current study evaluates keratometry (K) values derived from 3 separate sources (topographer, manual office keratometer, and partial coherence interferometry), all using the Haigis equation for IOL selection in patients who previously underwent RK and are undergoing routine phacoemulsification surgery.

Methods

Patients who underwent RK presenting to the author for routine cataract surgery at the Virginia Mason Medical Center in Seattle, Washington, from April 2009 to May 2014, were retrospectively studied. The study was performed with the approval of the Virginia Mason Medical Center Institutional Review Board/Ethics Committee and in accordance with the U.S. Health Insurance Portability and Accountability Act and adhered to the tenets of the Declaration of Helsinki guidelines for human research. Data from 26 eyes (9 right) from 20 patients (14 female; mean age, 65 years; range, 48–82 years) were analyzed.

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Table 1. Final Spherical Equivalent Results for Each Study Method

	Mean ± SD (D)	Median Absolute Error (D)	Range (D)
Topography flat 1−9	−0.68±0.60	0.62	−2.11 to 0.62
Topography average	−0.04±0.68	0.36	−1.40 to 1.21
Topography minimum	−1.07±0.78	1.06	−2.53 to 0.59
IOLMaster (Carl Zeiss Meditec AG, Jena, Germany) −0.50 D	−0.20±0.63	0.43	−1.75 to 0.62
IOLMaster −1.0 D	−0.66±0.61	0.51	−2.11 to 0.25
Manual office	−0.24±0.75	0.38	−1.75 to 1.70
Haigis-L	−1.81±1.18	1.57	−4.80 to −0.12

D = diopters; SD = standard deviation.

Original RK surgeries had been performed from 1983 to 1996. Time between RK and IOL surgeries ranged from 15 to 29 years with a mean of 21 years. Five eyes had 4 radial incisions, 16 eyes had 8 radial incisions, 2 eyes had 16 radial incisions, 2 eyes had 12 radial incisions, and 1 eye had 6 radial incisions; 9 eyes had astigmatic keratotomy (AK) incisions also placed at the time of RK surgery (5 with 8 radial incisions, 1 with 4 radial incisions, and 1 with 12 radial incisions had 2 AK incisions; 1 eye with 12 radial incisions had 1 AK incision; and 1 eye with 6 radial incisions had 3 AK incisions). Average time of follow-up after IOL surgery was 17 months (range, 3−46 months; median, 16 months), well beyond the initial 3-month time period when the transient hyperopic shift induced by surgery has been documented to disappear.[3,5,7] All eyes achieved ≥20/25 best spectacle-corrected visual acuity. Scleral frown incisions (2.6 mm) placed between the largest gap between preexisting radial incisions were created. Any sutures were removed before data collection. Routine phacoemulsification with implantation of AcrySof IQ SN60WF IOLs (Alcon Laboratories, Fort Worth, TX) within the capsular bag was performed with the Alcon Infiniti system.

Spherical equivalent (SE) refractions before surgery were recorded for each eye. Preoperative axial length (AL) measurements were obtained with partial coherence interferometry (IOLMaster; Carl Zeiss Meditec AG, Jena, Germany) (mean, 25.67±1.09 mm; range, 23.70−27.74 mm). Preoperative K values were measured with the following instruments: manual office-based central K (Haag-Streit, Bern, Switzerland), IOLMaster (flattest of the 3 K readings if within 0.25 D of one another), or computerized videokeratography (Topographic Modeling System [TMS]-4, Tomey Corp., Phoenix, AZ). The flattest K value in rings 1 to 9 using the mean ring power function of the TMS machine was recorded along with the Sim-K average K and minimum K reading. Rings 1 to 9 measure the central cornea diameter from approximately 0.5 to 3.5 mm.

Final refractions and SE were recorded along with best spectacle-corrected visual acuity, number of original RK incisions, and presence or absence of astigmatic incisions. The final refractive goal was −0.50 D for all eyes. The Haigis formula value was calculated using the internal software of an immersion A scan instrument (Accutome, Inc., Malvern, PA) by inserting the recorded K reading and aiming for a final surgical result of −0.50 D (personalized IOL constants: A constant 119.16, Haigis a0 −1.03, a1 0.133, a2 0.238).[16] In addition, because of observed hyperopic overcorrections, IOLMaster K values with the Haigis formula set to −1.00 D but final refractive goal of −0.50 D were also tested. The Haigis-L formula using IOLMaster K values was separately evaluated using the American Society of Cataract and Refractive Surgery website (http://iolcalc.org/wbfrmCalculator.aspx) with the final target refraction set at −0.50 D.[17]

The strategy chosen for selecting the surgical IOL implant power for each patient was as follows using calculated Haigis values between 23.80 D and 24.70 D as an example:

23.80−24.20 D: 24.00 D
24.30−24.70 D: 24.50 D

If the IOL implanted did not match the IOL prediction for a given K value, the IOL printout stating the anticipated refractive outcome for each chosen IOL power determined the necessary diopter (D) correction to be added or subtracted from the patient's final SE power. For most cases, each 0.50 D difference represented 0.36 to 0.38 D SE correction. The mean arithmetic SE, standard deviation, median absolute SE, and range for each tested K value were determined. The goal was to achieve mild myopia (−0.50 D) to minimize both the risk of future progressive hyperopia and hyperopic overcorrection. The percent of eyes achieving ideal results (−0.12 to −1.00 D), acceptable results (0.25 to −1.50 D), and unacceptable results (<−1.50 or >0.25 D) of final SE refractions was calculated.

Results

Table 1 shows the final measured or estimated SE refractions. Topography 1−9 had only 1 case with hyperopia >0.25 D (0.62 D), and the IOLM −1.0 method had no eyes with >0.25 D final SE. The Haigis-L method also had no hyperopic overcorrections but had higher levels of mean myopia, which would not be satisfactory for most patients. Topography 1−9, IOLM −1.0, IOLM −0.5, and manual K methods had mean SEs approximately within 0.25 D of the intended result, with the first 2 more myopic and the latter 2 more hyperopic. The actual spread of the data is shown in Table 2. Topography 1−9 and IOLM −1.0 had higher percentages within the ideal intended result (final SEs, between −1.00 D and −0.12 D). The 2 outlying cases of high postoperative myopia (−1.96 and −2.11 D) with the topography 1−9 and IOLM −1.0 calculations came from 1 patient who had previous bilateral vitrectomies for numerous vitreous floaters, who subsequently underwent bilateral cataract surgery. IOLM −0.5, manual, and average topography K methods had higher levels of hyperopia >0.25 D. Table 3 shows the mean K results for the 5 different corneal measurements used in this study, and Table 4 shows the mean and range of IOL powers chosen by the Haigis formula for each testing method used. Although topography 1−9 and minimum topography K mean K results had the flattest values separated by 0.63 D, the former was steeper in 20/26 eyes (range, 0.01−1.76 D; mean, 0.60 D with 12 eyes >0.50 D steeper) and flatter in 6 eyes (range, −0.23 to −0.60 D; mean −0.40 D with only 2/6 eyes >0.50 D flatter). This difference led to higher powered IOLs being selected, producing