THE LITERATURE

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INTRAOPERATIVE ABERROMETRY VERSUS STANDARD PREOPERATIVE BIOMETRY AND A TORIC IOL CALCULATOR FOR BILATERAL TORIC IOL IMPLANTATION WITH A FEMTOSECOND LASER: ONE-MONTH RESULTS

Woodcock MG, Lehmann RL, Cionni RJ, et al[1]

ABSTRACT

In a prospective cohort study involving 12 sites, the researchers enrolled 130 patients (260 eyes). For 124 of them (248 eyes), the initial operative eye was randomized to aberrometry measurement with the ORA System with VerifEye+ (Alcon) or standard preoperative biometry and the use of the Alcon Online Toric IOL Calculator. The contralateral eye was automatically assigned to the other group. One hundred twenty-one patients (242 eyes) completed the trial. The primary endpoint was the percentage of eyes with 0.50 D of astigmatism or less at 1 month. The authors reported that 89.2% of the intraoperative aberrometry group achieved this endpoint compared to 76.6% in the standard biometry with manual marking group.

Patients were excluded from the study if they had limbal relaxing or arcuate incisions created manually or with a femtosecond laser or if they had complications during surgery unrelated to the study device, lens/zonule instability, or any anterior segment or ocular pathology that could otherwise influence postoperative astigmatism. Patients were also excluded if they required excessive sedation, iris hooks, and insertion of a capsular tension ring or if they were unable to maintain adequate fixation for image capture with the investigational device.

Vector analysis of the test group found that the mean centroid was 0.61 ±1.97 D at 94.43° preoperatively, showing that this group tended toward with-the-rule astigmatism. One month postoperatively, the mean centroid was 0.05 ±0.04 D at 11.77° or very slightly against the rule (ATR). The control group's mean centroid was 0.68 ±1.92 D at 83.85° preoperatively, again tending toward with the rule. One month postoperatively, the mean centroid was 0.20 ±0.45 D at 179.22° or very slightly ATR as well, although with a greater overcorrection in this group.

DISCUSSION

As discussed by the investigators, few studies thus far have evaluated the performance of the ORA System with VerifEye+. A recent, relatively large, retrospective study evaluated eyes that had previously undergone keratorefractive surgery for the treatment of myopia.[2] Those researchers found that using the biomechanical waveform analyzer resulted in a significantly lower mean absolute value of the prediction error than the other methods, with 67% within 0.50 D and 94% within 1.00 D of the predicted outcome. The results in these eyes were similar to those in eyes without previous refractive surgery in which conventional methods were used.

Importantly, the investigators cited another study that pointed out several potential flaws of current intraoperative aberrometry that might contribute to unreliable results.[3] Erratic differences in cylinder readings caused by a tight speculum, eye squeezing by the patient, surgically induced astigmatism, wound hydration, and over- and underinflation of the anterior chamber can all influence measurements taken with the ORA System with VerifEye+. Despite these pitfalls, intraoperative aberrometry and toric IOL alignment with VerifEye+ appear to improve refractive results when placing one of these lens implants compared with standard biometry and manual marking.

ACCURACY OF TORIC INTRAOCULAR LENS AXIS ALIGNMENT USING A 3-DIMENSIONAL COMPUTER-GUIDED VISUALIZATION SYSTEM

Montes de Oca I, Kim EJ, Wang L, et al[4]

ABSTRACT

The researchers presented a retrospective case series of patients who underwent laser cataract surgery using the TrueVision 3D Visualization System (TrueVision Systems) versus a manual marking method. Initially, manual ink marks were placed at 3 and 9 o'clock on the limbus while the patient was sitting upright. Intrastromal marks were then created with the femtosecond laser at the intended toric meridian. Intraoperatively, the 3-D system was used to align the IOL and measure the angular position of the laser marks relative to the IOL meridian. Manifest refraction, corrected distance visual acuity, and toric alignment were recorded 3 weeks postoperatively. All data were acquired through a retrospective chart review. Exclusion criteria included more than 5° of IOL rotation from the intended meridian, a corrected distance visual acuity worse than 20/30, cataract incisions greater than 2.5 mm, corneal relaxing incisions, and a history of previous ocular surgery or trauma. Preoperative evaluation included assessment with the Lenstar LS900 (Haag-Streit), Galilei Dual Scheimpflug Analyzer (Ziemer Ophthalmic Systems), and Cassini (i-Optics).

The underlying rationale for the study was the fact that

1° of off-axis rotation results in a loss of up to 3.3% of the intended cylindrical correction. Thirty degrees of toric IOL rotation would leave the magnitude of preoperative astigmatism unchanged but at a different axis.[5,6] The TrueVision 3D Visualization System is a stereoscopic high-definition device that displays in real time the surgical field views on a 3-D flat-panel display in the OR. This system used simulated keratometry values of the anterior corneal surface measured by the color light emitting diode topographer. The best vessel-quality image assessed by the surgeon was used to create an optimized plan for the main incision's location, toric IOL alignment, and predicted residual astigmatism. The angular difference between the position of the laser marks and the final IOL axis was measured intraoperatively using the 3-D system and recorded. Postoperatively, to accurately measure the meridional position of the laser marks and the toric IOL's angular orientation, a 1° scale was attached to the BM900 slit lamp (Haag-Streit). Error attributed to the 3-D system was defined as the difference between the laser marks' orientation as determined intraoperatively by the 3-D system compared to their position at the slit lamp at the visit 3 weeks postoperatively.

Fifty-eight percent (15) of eyes had residual refractive cylinder of 0.25 D or less, 77% (20 eyes) had residual refractive cylinder of 0.50 D or less, and 92% (24 of 26 eyes) had 0.75 D of residual cylinder or less. The mean refractive astigmatism at 3 weeks was 0.18 ±0.33 @ 170°. The mean predicted preoperatively using the color light-emitting diode topographer was 0.35 D ±0.28 @ 97°. The mean difference between the two techniques was 0.51 ±0.39 at 1°, indicating an ATR error in the preoperative predictions that were based on anterior corneal power alone.

DISCUSSION

The accuracy of intended toric IOL alignment at the intended meridian is crucial to achieving effective astigmatic correction and satisfying patients. The investigators did not find a statistically significant difference between the 3-D system and manual method for marking toric alignment. When compared to the study presented by Woodcock et al[1] discussed earlier, these results are similar to the standard biometry measurements (76.6% 0.50 D) and inferior to the toric IOL alignment results based on intraoperative aberrometry (89.2% 0.50 D). The investigators in this study noted that it would be desirable to have a system that fully automates the entire process, including measurement of the anterior and posterior cornea, provision of algorithms for the IOL selection, and intraoperative guidance of the IOL alignment.

NEW REGRESSION FORMULA FOR TORIC INTRAOCULAR LENS CALCULATIONS

Abulafia A, Koch D, Wang L, et al[7]

ABSTRACT

In this retrospective case series, the investigators used a new regression formula (Abulafia-Koch) on 78 eyes to estimate total corneal astigmatism based on standard keratometry measurements. Error in the predicted residual astigmatism was calculated by the Alcon and Holladay toric calculators with and without adjustments by the Abulafia-Koch formula. These results were compared with those of the Barrett toric calculator. The Alcon Online Toric IOL Calculator and Holladay toric calculator had a higher proportion of eyes within ±0.50 D of the predicted residual astigmatism with the Abulafia-Koch formula (76.9% and 78.2%, respectively) than without it (both 30.8%). There was no significant difference between the results of the Abulafia-Koch–modified Alcon Online Toric IOL Calculator and Holladay toric calculators and those of the Barrett toric calculator.

The authors pointed out several factors that might contribute to unexpected residual astigmatism. They include corneal surgically induced astigmatism[8]; errors in the alignment of the toric IOLs,[9] the measuring of corneal astigmatism,[10-12] and the method used to predict the required toric IOL; and residual astigmatism after surgery.[10-12] Traditionally, standard keratometry and Placido disk corneal topography measurements have been used to determine the correct axial and cylindrical power needed for a toric IOL based on the assumption that the posterior cornea induces minimal refractive astigmatism and can therefore be ignored.

Development of the Abulafia-Koch formula involved estimating the total corneal astigmatism, as calculated by subtracting the toric IOL power at the corneal plane from the cylindrical power of the postoperative manifest refraction adjusted to the corneal plane. A linear regression was derived between the estimated net corneal astigmatism and the astigmatism measured by the Lenstar LS900.

DISCUSSION

Unexpected residual astigmatism following toric IOL placement continues to be an issue despite advances in preoperative corneal biometry. The investigators suggested that none of the existing online toric calculators accounts for posterior corneal astigmatism, which results in ATR prediction errors when using radii measurements based on the anterior corneal surface alone. The Barrett toric calculator, which uses a mathematical model to estimate posterior corneal astigmatism, was shown to be better than standard toric calculators that use anterior cornea-based keratometry and those that use direct measurements of the posterior cornea by the Scheimpflug camera device (Pentacam; Oculus Surgical). In the Abulafia-Koch regression analysis, the x component (estimated net corneal astigmatism = 0.508 +0.926 × measured corneal astigmatism) plays a pivotal role by expressing a predicted pattern of deviation between the estimated net and the measured corneal astigmatism, whereas the role of the y component (estimated net corneal astigmatism = 0.009 +0.932 × measured corneal astigmatism) is almost negligible. When comparing the

Holladay 1 and Alcon toric calculator, the investigators saw no difference whether or not the Abulafia-Koch formula was used, thereby suggesting that the Holladay 1 calculator model may be limited to ordinary eyes. A toric IOL calculator that takes into account the effective lens position and IOL power, however, is beneficial for eyes with an unusual effective lens position and/or extreme IOL/toric powers.

Finally, the researchers determined equivalency between the Barrett toric calculator without any adjustments and anterior cornea-based keratometry measurements adjusted by the Abulafia-Koch formula for significantly reducing the errors in predicted residual astigmatism. Although the investigators claimed that the Abulafia-Koch formula can easily be integrated into any toric calculator as an add-on option to improve toric IOL calculation accuracy, it is important to note that this formula was derived from a retrospective review. The authors pointed out that they did not use direct measurements of the net corneal astigmatism from the Pentacam or Cassini. Nor did they compare results to those of intraoperative aberrometry. Thus, further prospective studies that evaluate the actual refractive outcome of the clinical application of the formula are warranted. ■

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