

# The Literature

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## CONTRIBUTION OF POSTERIOR CORNEAL ASTIGMATISM TO TOTAL CORNEAL ASTIGMATISM

Koch DD, Ali SF, Weikert MP, et al<sup>1</sup>

### ABSTRACT SUMMARY

Koch et al conducted a retrospective analysis of 715 eyes of 435 consecutive patients who underwent keratometric analysis before cataract or refractive surgery.<sup>1</sup> The investigators calculated anterior, posterior, and total corneal astigmatism with the Galilei Dual Scheimpflug Analyzer (Ziemer Ophthalmic Systems). This device uses Placido disc and dual-channel camera technology to measure the topography of the anterior and posterior corneal surfaces. Total corneal astigmatism was calculated using a ray-tracing algorithm, which accounts for refraction at both the anterior and posterior surfaces using Snell's law over the central 1 to 4 mm of the cornea.

The mean total corneal astigmatism was  $1.10 \pm 0.70$  D, with  $-0.30 \pm 0.15$  D of posterior corneal astigmatism on average. Posterior corneal astigmatism was aligned vertically in 87% of patients and did not change with age, unlike anterior astigmatism, which became more horizontally aligned with age. Because posterior astigmatism has negative power, it may offset with-the-rule (WTR) astigmatism in younger patients and add to against-the-rule (ATR) astigmatism in older patients.

Although posterior corneal astigmatism measured less than 0.25 D in 43% of patients, 9% of patients had values greater than 0.50 D. The magnitude of posterior astigmatism showed a moderate correlation with anterior astigmatism when the anterior meridian was aligned vertically, a weak correlation when the anterior meridian was aligned obliquely, and no correlation when aligned horizontally. Overall, anterior corneal measurements underestimated total corneal astigmatism by 0.22 D @ 180, and only 5% of patients had a difference greater than 0.50 D.

### DISCUSSION

It has been known since the late 19th century that a difference of approximately  $-0.50$  D  $\times$  90 exists between keratometric astigmatism, which measures the anterior corneal

surface and total refractive astigmatism.<sup>2</sup> Until recently, this difference was thought to be primarily due to lenticular astigmatism. Studies have demonstrated the relationship in pseudophakic eyes, suggesting that the discrepancy may be a result of the posterior corneal surface's acting as a negative lens.<sup>3,4</sup> Unlike the anterior corneal surface, which refracts light from air (index of refraction,  $n = 1.0$ ) to the cornea ( $n = 1.376$ ), the posterior surface refracts light from the cornea ( $n = 1.376$ ) to the aqueous humor ( $n = 1.336$ ), yielding less refractive power.<sup>4</sup> Consequently, most keratometers (manual, automated, and Placido disc) only measure anterior astigmatism and use a fixed posterior:anterior curvature ratio to calculate the total corneal astigmatism.<sup>1</sup> The study by Koch et al provides evidence that posterior corneal astigmatism makes a clinically important contribution to total astigmatism.

## CORRECTING ASTIGMATISM WITH TORIC INTRAOCULAR LENSES: EFFECT OF POSTERIOR CORNEAL ASTIGMATISM

Koch DD, Jenkins RB, Weikert MP, et al<sup>5</sup>

### ABSTRACT SUMMARY

Koch et al prospectively enrolled 41 patients scheduled for cataract surgery with implantation of an AcrySof Toric IOL (SN6AT3-8; Alcon) to undergo preoperative measurements of corneal astigmatism using five different devices.<sup>5</sup> The instruments tested were the IOLMaster (Carl Zeiss Meditec), Lenstar LS900 (Haag-Streit), Atlas Corneal Topography System (Carl Zeiss Meditec), manual keratometer (Bausch + Lomb), and the Galilei Dual Scheimpflug Analyzer. To calculate the toric IOL's power required for each patient, the investigators used the Holladay 1 formula and all of the preoperative data they collected. The surgeon's discretion was used in combining measurements from the various modalities. Three weeks postoperatively, these preoperative measurements were compared to the actual corneal astigmatism, which was assumed to be the difference between the postoperative manifest refraction and the effective toric power implanted (calculated using the Holladay 2 software [Holladay Consulting]).

Patients with oblique astigmatism were excluded

**TABLE. EFFECTIVE IOL CYLINDER<sup>5</sup>**

Power at Corneal Plane (D)	WTR (D)	ATR (D)
0.00	≤ 1.69 (PCRI if > 1.00)	<0.39
1.00	1.70-2.19	0.40 <sup>a</sup> -0.79
1.50	2.20-2.69	0.80-1.29
2.00	2.70-3.19	1.30-1.79
2.50	3.20-3.79	1.80-2.29
3.00	3.80-4.39	2.30-2.79
3.50	4.40-4.99	2.80-3.29
4.00	5.00-	3.30-3.79

Abbreviations: WTR, with-the-rule; ATR, against-the-rule; PCRI, peripheral corneal relaxing incision.  
<sup>a</sup>Especially if spectacles have more ATR.

**Baylor toric IOL nomogram (target range up to 0.40 D WTR).** Values in the table are the vector sum of the anterior corneal and surgically induced astigmatism. Examples: (1) If the cornea has 3.70 D WTR and surgically induced astigmatism is 0.20 D WTR, use the value of 3.90 D to select IOL toricity. (2) If the cornea has 1.90 D ATR and surgically induced astigmatism is 0.20 WTR, use the value of 1.70 D to select IOL toricity.

from the study, and eligible patients were divided into two groups based on whether they had preoperative WTR (n = 17) or ATR (n = 24) astigmatism. The mean preoperative astigmatism for the WTR group was 1.78 @ 91 (IOLMaster) and 1.28 @ 1 (IOLMaster) in the ATR group. The mean postoperative refractive astigmatism was 0.08 × 11 for the WTR group and 0.12 × 148 for the ATR group.

The average corneal astigmatism prediction error between preoperative measurements and postoperative refraction was calculated for each device. Koch et al found that, for all devices, there were significant WTR prediction errors (0.50-0.60 D) for eyes with WTR astigmatism. Similarly, in the ATR group, there were significant, predominantly WTR prediction errors (0.20-0.30 D) for all devices except the Galilei Dual Scheimpflug Analyzer. In the ATR group, manual keratometry had oblique error but no significant WTR/ATR error. A nomogram was proposed to account for these errors when selecting a toric IOL (Table).<sup>5</sup> The goal is to reduce these errors and improve postoperative outcomes, and studies are currently underway to validate the nomogram's use.<sup>5</sup>

## DISCUSSION

The development of IOLs for astigmatic correction has raised patients' expectations of optimal refractive outcomes. Many diagnostic modalities are available to accurately measure corneal astigmatism for operative planning. Koch et al have quantified the contribution of posterior corneal astigmatism using multiple diagnostic modalities to explain the historical -0.50 × 90 discrepancy between keratometric astigmatism and total refractive astigmatism.<sup>1,5</sup> Although no single diagnostic modality can perfectly predict a refractive outcome, there exist trends in the type and magnitude of postoperative refractive error depending on the technology used. Using devices that measure only the anterior corneal surface, a WTR error of 0.50 to 0.60 D occurs in eyes with WTR astigmatism, and a WTR error of 0.20 to 0.30 D occurs in eyes with ATR astigmatism. It is important for the refractive cataract surgeon to keep in mind posterior corneal astigmatism when trying to optimize visual outcomes in patients with astigmatism so as to increase predictability and ultimately enhance refractive results. ■

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