Today's Peripheral Corneal Relaxing Incisions

The surgeon determines the magnitude and the axis of astigmatism and consults a nomogram.

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Not only do patients presenting for cataract surgery anticipate improved vision, but they also desire spectacle independence. Their high expectations have increased the demands on surgeons to minimize postoperative refractive errors. Ophthalmologists correct spherical error by choosing the correct IOL power based on the accurate determination of axial length and corneal power. Astigmatism must also be minimized to achieve postoperative emmetropia. For true spectacle independence, patients require 0.50 D or less of astigmatism after surgery. This article describes the incisional approach of peripheral corneal relaxing incisions (PCRIs) for the correction of corneal astigmatism during cataract surgery.

Up to 95% of eyes have some amount of astigmatism, and approximately 15% to 30% of the adult population has more than 1.00 D of cylinder.[1] The prevalence of astigmatism increases with age and changes from with-the-rule to against-the-rule or oblique astigmatism. Because more than 0.50 D of astigmatism after the cataract procedure can lead to complaints of ghosting and shadows, the surgeon should to try minimize cylinder intraoperatively.[2]

Although toric IOLs provide excellent visual results, PCRIs continue to have a significant role in reducing astigmatism. These incisions can be useful in patients with very small and very large degrees of astigmatism outside the range of toric lenses, those whose eyes cannot support a toric lens in the capsular bag, patients with asymmetric and nonorthogonal astigmatic axes where the incisions can be placed on each arm of the steep axis, and individuals who cannot afford the additional cost of both the premium toric IOL and the surgeon's fee. PCRIs can be performed intraoperatively or postoperatively as a separate office procedure.[3] These incisions do not change the refractive spherical equivalent and therefore do not alter the spherical lens implant power.

PREOPERATIVE PLANNING

The first step in managing corneal astigmatism is to accurately assess the magnitude and axis of astigmatism. Total refractive astigmatism is best identified by the manifest or cycloplegic refraction and is composed of both corneal and lenticular astigmatism. Because the lenticular component is removed with the cataract, the surgeon must accurately assess corneal astigmatism to reduce postoperative astigmatism.[3] Corneal astigmatism is measured with manual keratometry, IOLMaster keratometry (Carl Zeiss Meditec) or Lenstar keratometry (Haag-Streit), corneal topography,

Cataract With-The –Rule Astigmatism (steep meridian at 90 degrees)

Pre-OP Astigmatism	Age	Number of incisions	Length of incisions
0.75 – 1.00 D	<65	2 1	45 deg = 4.5 mm 60 deg = 6.0 mm
0.75 – 1.00 D	>65	1	45 deg = 4.5 mm
1.01 – 1.75 D	<65	2	60 deg – 6.0mm
1.01 – 1.75 D	>65	2 1	50 deg = 5.0mm 60 deg = 6.0 mm
>1.75 D	<65	2	80 deg = 8.0 mm
>1.75 D	>65	2	60 – 70 deg = 6 – 7 mm

Combined with a 3.0 mm corneal temporal wound

A

Cataract Against-The–Rule/Oblique Astigmatism (steep meridian at 180 degrees)

Pre-OP Astigmatism	Age	Number of incisions	Length of incisions
1.00 – 1.25 D	N/A	1	35 – 40 deg = 3.5 – 4.0 mm
1.00 – 1.25 D	N/A	2	30 deg = 3.0 mm
1.26 – 2.00 D	N/A	1	45 deg = 4.5 mm
1.26 – 2.00 D	N/A	2	40 deg = 4.0 mm
>2.00 D	N/A	2	45 deg = 4.5 mm

Combined with a 3.0 mm corneal temporal wound

B

Figure 1. Koch limbal relaxing incision nomograms: with the rule (A) and against the rule (B).

With-The-Rule Astigmatism (steep axis 45 □ - 145 □)

Pre-op cylinder	Number of incisions	30 – 40 yo	41 – 50 yo	51 – 60 yo	61 – 70 yo	71 – 80 yo	81 – 90 yo	> 90 yo
1.00 – 1.50	2	50 □	45□	40□	35□	30□		
	2	60□	55□	50□	45□	40□	35□	30□
	2	70□	65□	60□	55□	50□	45□	40□
	2	80□	75□	70□	65□	60□	55□	45□

Degrees of arc to be incised

Combine with "neutral" temporal clear corneal incision

A

Against-The-Rule Astigmatism (steep axis 0-30□ / 150□-180□)

Pre-op cylinder	Number of incisions	30 – 40 yo	41 – 50 yo	51 – 60 yo	61 – 70 yo	71 – 80 yo	81 – 90 yo	> 90 yo
0.75 – 1.25 D	1 nasal						35□	
0.75 – 1.25 D	2	55□	50□	45□	40□	35□		
1.50 – 2.00 D	2	70□	65□	60□	55□	45□	40□	35□
2.25 – 2.75 D	2	90□	80□	70□	60□	50□	45□	40□
3.00 – 3.75 D	2	90□ at 8mm OZ	90□ at 9mm OZ	85□	70□	60□	50□	45□

Degrees of arc to be incised

Combine with "neutral" temporal clear corneal incision

B

Figure 2. Nichamin limbal relaxing incision nomograms: with the rule (A) and against the rule (B).

or corneal elevation mapping. In my experience, the magnitude of astigmatism is most accurately measured with manual keratometry, the IOLMaster, or the Lenstar, and the axis is best determined quantitatively with the IOLMaster or Lenstar using qualitative guidance from corneal topography and elevation mapping.[4]

Corneal topography and elevation mapping are also useful for identifying pathology such as keratoconus, occult ectasia, and subtle irregular astigmatism.[4] Patients with corneal pathology or irregular astigmatism may have unpredictable postoperative results and therefore may not be good candidates for PCRIs. Preoperatively, it is important to perform a careful slit-lamp examination of the corneal surface and the periphery. A poor-quality ocular surface from tear deficiency, epithelial basement membrane dystrophy, or Salzmann nodular degeneration may decrease the accuracy of the corneal astigmatic assessment. It is important to examine the specific area of the cornea where the peripheral incisions will be made. Pterygium, corneal thinning, furrows, corneal ectasia, scars, or limbal girdles may alter the accuracy of the PCRIs and increase the chance of perforation.

SURGICAL TECHNIQUE

After calculating the magnitude and axis of astigmatism, the surgeon consults a nomogram to determine the length and location of PCRIs.[5] In general, these incisions can correct between +0.75 and +3.00 D of astigmatism. Many nomograms are available for this purpose (Figures 1 and 2). Most depend upon the amount of preoperative cylinder, the axis of astigmatism, and the patient's age. Nomograms express the length of the PCRIs in degrees of arc, millimeters, or clock hours. Those that plan incisions based upon degrees of arc are thought to be most accurate.[5]

PCRIs can be single or paired depending on the amount of astigmatism that needs correcting. Incisions may be tailored to the astigmatic bowtie seen on corneal topography. For example, in asymmetric astigmatism, the PCRI can be longer in the larger arm of the bowtie and shorter in the smaller arm.

Before the procedure, surgeons mark the patient's eye while he or she is upright and looking straight ahead with both eyes open to avoid cyclotorsion. After the instillation of a topical anesthetic, the 6-o'clock position or the 3-, 6-, and 9-o'clock positions are marked on the limbus with a fine-tipped marking pen or an inked marker. Then, under the microscope, the steep corneal axis is marked with a fixation ring, astigmatic ruler, or arcuate axial marker centered on the previous 6-o'clock mark.[3]

The PCRIs are usually performed at the beginning of surgery. Some surgeons mark and perform the incisions before entering the eye. Others instill viscoelastic into the anterior chamber through a paracentesis to firm up the eye before creating the incisions. The PCRI should be placed at the most peripheral area of the clear cornea at a depth of approximately 90%. The effect of incisions that are too peripheral or too shallow will be reduced. A diamond blade with a footplate set to a depth of 600 µm is most often used. Some nomograms require intraoperative assessment of the corneal thickness at the site of the incisions and an adjustment of the blade based upon measured corneal thickness. It is important to use a single-footplate, double-cutting blade that provides full visualization of the blade during the cut. This configuration allows the surgeon to visualize the depth of the cut and to recognize a corneal perforation early if one occurs. The knife can be pulled or pushed to create the incisions, depending on the surgeon's comfort and the dimensions of the patient's nose and brow.

Two important caveats should be mentioned. First, if the patient has with-the-rule astigmatism, care must be taken to place the PCRIs slightly more centrally and the paracentesis incision slightly more peripherally in order to avoid crossing of the two. Second, if the PCRI is coincident

with the temporal clear corneal cataract incision, the former should be limited to the length of the cataract incision and only lengthened after the IOL is in place at the end of the case. This avoids tearing out of the cataract incision during phacoemulsification that can lead to a postoperative wound leak.

POSTOPERATIVE PERIOD

Postoperative results can vary based on the surgeon's technique, preoperative planning, and patient healing factors. Complications include undercorrection, overcorrection, perforation, wound leak, and infection.

Undercorrections usually result from variability in surgical technique. Inadequate depth of the incision is probably the most important cause. Undercorrections can be managed by slightly extending the PCRIs or by postoperative excimer laser refractive surgery. Overcorrections are best managed by postoperative excimer laser refractive surgery. Adding more incisions should be avoided.

Perforations usually occur secondary to a blade abnormality. They can also occur owing to unrecognized corneal thinning at the site of the incision.

If there is a significant intraoperative wound leak, a suture should be placed through the incision. A late wound leak can occur if the PCRIs connect with the paracentesis or if a temporal PCRI at the cataract wound extends secondary to the trauma induced by the phaco handpiece. Upon recognizing a late wound leak, the surgeon should place a suture.

Wound infections are rare. They should be cultured deep in the incision and treated with appropriately aggressive topical antibiotic therapy.

Patients with PCRIs may feel increased foreign body sensation for the first 24 hours until the epithelium heals. Extra lubrication with artificial tears can help.

NEW DEVELOPMENTS

New preoperative registration systems are being developed in order to align the astigmatic axis based upon preoperative landmarks on the eye. Examples include iris fingerprinting and automated limbal registration systems such as the Verion Image Guided System (Alcon), the Holos (Clarity Medical Systems), the TrueVision 3D Surgical system (TrueVision Systems), iTrace (Tracey Technologies), and Callisto Eye and Z Align (Carl Zeiss Meditec). These devices attempt to improve the accuracy of marking the astigmatic axis by bringing preoperative images to the OR. For example, the Verion can eliminate the use of manual markers. A reference unit in the office captures images and data such as keratometry, limbal anatomy, and pupillary location. This information is transferred to the unit in the OR via a USB memory stick. Real-time eye registration and tracking are generated in the surgeon's microscope view or on a flat-screen monitor. This technology helps to provide a consistent coordinate system for axial guidance when placing PCRIs or aligning toric IOLs.

Laser cataract surgery allows the strategic placement of PCRIs using the femtosecond laser.[6] Laser-created PCRIs may prove to be more effective in correcting astigmatism, because their length, location, and depth are better controlled.[7] Supporting data are being compiled. Another potential advantage of laser incisions is that they can be selectively opened postoperatively to titrate their effect.

Intraoperative aberrometry devices such as the ORA (WaveTec Vision) capture wavefront refractive information in real time during cataract surgery. The data help surgeons to select the spherical and cylinder power of the IOL, align a toric IOL, and place a PCRI. Packer successfully used intraoperative aberrometry to measure and enhance the effect of PCRIs at the time of cataract surgery.[8] More data are needed to evaluate the efficacy of aberrometry in PCRIs and to identify factors that may induce variability in measurements.

CONCLUSION

Advances in toric IOL technology may decrease the need for PCRIs, but many useful indications remain including intraoperative PCRIs used with multifocal lens implants; a low degree of astigmatism (+0.50 to +1.00 D); very high degrees of astigmatism beyond that which can be corrected with a toric IOL alone; and mild nonorthogonal astigmatism that makes it difficult to determine the axis location for a toric IOL. In these cases, PCRIs can be placed on the apices of the slightly asymmetric bowtie. When a toric lens cannot be implanted due to a lack of posterior capsule or zonular integrity, surgeons can reduce corneal astigmatism with PCRIs after implanting a three-piece lens in the sulcus.

A careful evaluation of preoperative cylinder and the accurate placement of PCRIs are likely to improve the result of astigmatic correction at the time of cataract surgery. ■

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