

Corneal Relaxing Incisions

Louis D. “Skip” Nichamin, MD



I believe that managing preexisting astigmatism has become a requisite aspect of modern phaco surgery. In fact, it is safe to say that the dedicated implant surgeon must aspire to a level of accuracy that one would equate

with keratorefractive surgery. This procedure has demonstrated that astigmatism of as little as 0.75 D may leave a patient symptomatic with visual blurring, ghosting, and halos. A refractive goal of ± 0.50 D for both sphere and cylinder is therefore now the target.

The decision to use incisional surgery to correct preexisting astigmatism versus the insertion of a toric IOL or excimer laser ablation ought to be based upon a surgeon's comfort with each of the respective techniques, along with the specifics of the particular case and clinical situation. I began performing astigmatic keratotomy in conjunction with cataract surgery in 1989. I transitioned to limbal relaxing incisions (LRIs) in the mid 1990s. Given my experience with this technique, it remains my preferred method of addressing astigmatism at the time of implant surgery except under two circumstances: (1) the existing astigmatism is beyond the level that I consider treatable through an incisional approach alone or (2) there exists a contraindication to the use of LRIs.

CONTRAINDICATIONS

Contraindications for LRIs include eyes that have previously undergone RK for which further incisional surgery may destabilize the cornea and eyes with irregular astigmatism. For example, LRIs are not appropriate in eyes with keratoconus or other topographic abnormalities or those with peripheral corneal disease. One should also be circumspect when dealing with patients who suffer from advanced autoimmune or rheumatoid disease that might predispose them to healing problems after peripheral corneal incisions.

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THE LIMITS OF TREATMENT

I find that I am able to safely and reproducibly correct up to 3.00 D of astigmatism with LRIs based upon the patient's age. This contention is predicated upon several fundamental surgical principles (to be explained) and the use of high-quality, dedicated instruments for this particular technique. For greater amounts of astigmatism, one can combine the use of an LRI with a toric IOL or excimer laser ablation to correct up to 6.00 D of astigmatism. By using all three modalities, one can approach levels of 9.00 D of astigmatism!

CHOICE OF INCISIONAL INSTRUMENT

In my experience, crucial to achieving consistent results without regression when correcting up to 3.00 D of astigmatism is using a high-quality, modern diamond blade that is specifically designed for LRIs. I prefer to perform pachymetry and use adjusted blade depth settings (described later in more detail). I therefore utilize a diamond micrometer knife that also incorporates a single footplate to enhance visualization. Such instruments are available from Mastel Precision, Inc. (Rapid City, SD), Bausch & Lomb Storz (Rochester, NY), and other manufacturers. Other essential elements of the technique involve placing the incisions just inside the true surgical limbus (thus being literally intralimbal in nature) and maintaining a perpendicular orientation to the corneal surface to avoid a beveled result.

IDENTIFYING AND MARKING THE AXIS

Proper centration of the LRI over the steep meridian (plus cylinder axis) is the final key to success, and this

step starts with a reliable orientation mark. Rather than place a single orientation mark (eg, at 6 o'clock, as is commonly practiced), I prefer to use multiple radial lines. My approach can be executed with exquisite accuracy based upon surgeons' innate linear and Vernier acuity sense. Mastel Precision, Inc., makes a modified four-ray marker for this purpose that does not require ink. I then determine the steep meridian from these marks using a

modified Mendez ring gauge. Bringing a diagram or plan into the OR can be of great help in reducing astigmatic errors.

CHOOSING AND REFINING A NOMOGRAM

For many years, I have been using an LRI nomogram specifically designed for IOL patients. The most recent refinement (Table 1) recommends adjusted blade depth

TABLE 1. THE NICHAMIN AGE- AND PACHYMETRY-ADJUSTED (NAPA) INTRALIMBAL ARCUATE ASTIGMATIC NOMOGRAM

WITH-THE-RULE

(Steep Axis 45° to 135°)

PREOPERATIVE CYLINDER, D	PAIRED INCISIONS IN DEGREES OF ARC					
	20- to 30-yo	31- to 40-yo	41- to 50-yo	51- to 60-yo	61- to 70-yo	71- to 80-yo
0.75	40	35	35	30	30	
1.00	45	40	40	35	35	30
1.25	55	50	45	40	35	35
1.50	60	55	50	45	40	40
1.75	65	60	55	50	45	45
2.00	70	65	60	55	50	45
2.25	75	70	65	60	55	50
2.50	80	75	70	65	60	55
2.75	85	80	75	70	65	60
3.00	90	90	85	80	70	65

AGAINST-THE-RULE

(Steep Axis 0° to 44°/136° to 180°)

PREOPERATIVE CYLINDER, D	PAIRED INCISIONS IN DEGREES OF ARC					
	20- to 30-yo	31- to 40-yo	41- to 50-yo	51- to 60-yo	61- to 70-yo	71- to 80-yo
0.75	45	40	40	35	35	30
1.00	50	45	45	40	40	35
1.25	55	55	50	45	40	35
1.50	60	60	55	50	45	40
1.75	65	65	60	55	50	45
2.00	70	70	65	60	55	50
2.25	75	75	70	65	60	55
2.50	80	80	75	70	65	60
2.75	85	85	80	75	70	65
3.00	90	90	85	80	75	70

Blade depth setting is at 90% of the thinnest pachymetry.

Abbreviation: yo, year-old.

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settings that are based upon 90% of the thinnest pachymetry readings found over the intended incision sites.

UNDER- AND OVERCORRECTIONS

For undercorrections, one should inspect the incisions and verify that they are of adequate arc length and depth. If not, one may lengthen or deepen them. I rarely encounter this problem, thanks to my use of the NAPA (Nichamin Age- and Pachymetry-Adjusted) nomogram and adjusted settings at the time of the incision's placement.

For overcorrections, I strongly recommend against creating additional incisions, which may produce unpredictable results and long-term instability. Rather, I use the excimer laser for further enhancements.

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Roger F. Steinert, MD



This article reviews 10 key elements of performing safe and successful astigmatism surgery beginning with your very first case. The steps are presented in the order in which they are performed.

NO. 1. OBTAIN CORNEAL TOPOGRAPHY PREOPERATIVELY

At the outset, only surgically treat symmetrical astigmatism. Asymmetrical axes or quantities of astigmatism may respond more variably than symmetrical astigmatism. Never perform astigmatic incisions on a highly irregular pattern such as mild keratoconus or pellucid degeneration; only a topographic map will detect mild cases.

Take a copy of the printed topographic map with you to the OR, where you will place the printout upside down or sideways, depending on your position, so that the map's orientation is the same as the eye's when the patient is supine. Triple-check the orientation of your incisions. The worst common mistake is to place the incisions on the flat meridian, 90° away from the correct orientation.

NO. 2. MARK THE CORNEA

Anatomical landmarks are often challenging to employ. Conjunctival and episcleral blood vessels may change appearance due to the vasoconstricting dilating drops. Iris

"Choose a nomogram that includes age as a variable in addition to the amount of astigmatism."

landmarks may be difficult to locate when the pupil is widely dilated. Before beginning the case, place orientation marks with a surgical marking pen while the patient is upright. Most surgeons do well with marks at the 3- and 9-o'clock positions. Vertical marks at the 6- and 12-o'clock positions pose difficulty in many patients due to coverage of the limbus above and below by the eyelids.

Cyclotorsion in the supine position is common and is compounded by the fact that, with the patient draped, precisely determining the horizontal meridian is very difficult. Errors exceeding 15° are frequent without accurate marks. When you stand back and observe, if you feel that your marks may be slightly off the horizontal meridian, place new ones.

NO. 3. PLAN TO TREAT CORNEAL ASTIGMATISM

Plan the surgery using the corneal—not the refractive—astigmatism. The cataract may significantly alter the amount of astigmatism measured on manifest refraction.

NO. 4. USE AN APPROPRIATE NOMOGRAM

Choose a nomogram that includes age as a variable in addition to the amount of astigmatism. Age has a large impact on the cornea's response to incisions: an 80-year-old responds twice as much as a 40-year-old to the same incision.

The nomogram should employ degrees rather than measurements of length such as millimeters. Using degrees to measure the distance around a circle is natural, whereas a straight linear measurement is awkward.

NO. 5. CHOOSE A SUITABLE MARKING SYSTEM

The marking instrument(s) must be understandable and convenient to you. There are probably 100 marking systems on the market. Some have a single adjustable marker, whereas others have multiple markers, each with a fixed size. Check out the products of several reputable manufacturers before making a purchase.

NO. 6. SELECT A WELL-DESIGNED KERATOME

Use a diamond knife with easy-to-use depth settings. Most peripheral corneal incisions are done at 600 μm, so a

micrometer-type adjustable blade is unnecessary and a source of error.

The keratome's footplates should allow you to see the blade under the microscope. The traditional orientation of diamond knives' footplates obscures the surgeon's view of the blade as he or she creates the incision. When you look down through the microscope, the handle of the blade should be perpendicular to the peripheral cornea, which means that the handle will be tilted away from the vertical meridian relative to the ceiling and floor (and the optical pathway of the microscope). The blade must be visible with the handle tilted.

NO. 7. PLACE INCISIONS IN THE NEAR-CLEAR AVASCULAR CORNEA

Technically best known as *peripheral corneal relaxing incisions* but widely called *limbal relaxing incisions*, their proper location is just central to the fine limbal vessels. Sometimes, a large peripheral vessel's ingrowth will force you to cut into limbal vessels, but the presence of blood vessels typically stimulates stronger wound healing and therefore less effect. Avoiding the vascular areas is desirable when possible.

Peripheral incisions are safer than more centrally located clear corneal incisions, because the former heal more reliably in elderly patients (more central incisions sometimes will remain unhealed for months). They are also safer because they are less likely to cause irregular astigmatism due to their maximum distance from the central visual axis.

NO. 8. MAKE THE ASTIGMATIC INCISIONS FIRST

Place the relaxing incisions at the beginning of the case on a dry cornea. They will influence the location of the cataract surgical incisions. If you place the cataract incisions first, the subsequent astigmatic incisions may intersect and cause major problems with the wound's sealing.

If the astigmatic incision and the main phaco incision or sideport incision are in the same zone, the operative-access incision can begin inside the astigmatic incision. Because the cornea is relatively dry when the incisions are made, if the astigmatic incision is too deep, you will recognize any perforation immediately by the appearance of a bead of aqueous humor and will be able to stop before you have a large leak that requires suturing.

NO. 9. WHEN IN DOUBT, DO LESS

An undercorrection is fixed by simply extending the initial incisions or adding new ones that are slightly more central in clear cornea. The repair of an overcor-

rection requires opening the incisions, debriding any epithelial plug, suturing, and removing the sutures after healing. The final refractive outcome will be much less predictable.

NO. 10. TIME YOUR POSTOPERATIVE DRUG REGIMEN APPROPRIATELY

Have patients use antibiotics until the incisions are healed, when fluorescein no longer enters them during testing. Otherwise, the incisions are potential sites for infectious keratitis that can severely damage the cornea and patients' subsequent visual acuity. Healing is usually complete within 1 week but, in elderly patients, occasionally continues for 1 month or longer.

Patients should administer topical corticosteroids and nonsteroidal anti-inflammatory drugs as after routine cataract surgery unless an under- or overcorrection has occurred. Corticosteroids reduce wound healing, so modifying the dosage can (mildly) influence the refractive outcome.

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R. Bruce Wallace III, MD



Until recently, we cataract surgeons were able to ignore visually significant postoperative astigmatism. Our patients did not expect freedom from glasses, and Medicare helped to cover the cost of their postoperative spectacles. Because the popularity of refractive cataract surgery is rising rapidly, however, patients are now disappointed if they remain dependent on glasses after the procedure. An important factor in their satisfaction is effective astigmatic correction. In particular, this article focuses on peripheral corneal relaxing incisions, also called *limbal relaxing incisions* (LRIs). Although I am not fond of the latter term, it is omnipresent in the medical literature and our everyday discussions, so I will use it in this article.

Why are fewer than 30% of US surgeons currently using LRIs? Many do not think these incisions work or feel that they are unpredictable. Others believe that correcting astigmatism is not worth the expense and learning curve associated with LRIs. However, as a growing number of surgeons begin implanting presbyopia-correcting IOLs, many are adding LRIs to their lens surgery. After teaching courses on LRIs for more than a decade, I have found that surgeons are

likely to rely on these incisions when treating patients who want to reduce their need for glasses, once these ophthalmologists really believe that LRIs are safe and predictable and they have confidence in the instrumentation and the surgical technique.

GETTING STARTED: KEEP IT SIMPLE

A stumbling block in the adoption of LRIs is the confusing myriad of surgical planning protocols, instrumentation, and techniques. Determining which nomogram and set of instruments to use can be challenging, and unlike with phaco equipment, sales representatives for instrument manufacturers usually are not visiting our surgery suites to demonstrate the latest in LRI technology.

A few tips on how to choose the most user-friendly and least confusing instruments are to

- Keep the number of instruments to a minimum
- Look for a Mendez axis marker
- Recognize that the best LRI blades usually are diamond, are trifaceted, and feature a single footplate
- Remember that titanium lasts longer than stainless steel

Wet labs at major meetings, such as those of the AAO and ASCRS, are one way to “test drive” various LRI methods. One real advantage of LRIs is how quickly a surgeon can learn the procedure in this setting. The pig cadaver eye offers excellent simulation of an LRI on the human cornea. In just minutes, novice LRI surgeons can master the proper hand movements and instrument alignment.

SURGICAL TECHNIQUE

The goal for astigmatic control should be to leave cylinder of less than 0.75 D at any axis. Most patients enjoy good UCVA with this degree of astigmatism. One study suggested a benefit to leaving some residual against-the-rule cylinder to improve patients’ uncorrected near vision after cataract surgery.¹ Surgeons implanting presbyopia-correcting IOLs or using a monovision approach will not find this technique advantageous, because more than 1.00 D of cylinder compromises distance visual acuity.

One of the more challenging tasks that we face is deciding which preoperative astigmatic measurements to perform when planning a surgical correction. Do we

THE WALLACE LRI NOMOGRAM

The nomogram assumes that all cataract incisions are performed temporally and are relatively astigmatically neutral. When using this nomogram, if the patient’s age/astigmatism is at the dividing point

- Choose the shortest incision
- Select one incision over two

TABLE 1. THE SPECIFICS

FOR WITH-THE-RULE AND OBLIQUE ASTIGMATISM

Astigmatism, D	40- to 50-yo	50- to 60-yo	60- to 70-yo	70- to 80-yo	80-yo and older
1.00 to 1.50	60° (1)	50° (1)	50° (1)	40° (1)	30∞(1)
1.50 to 2.00	70° (1)	70° (1)	70° (1)	60° (1)	60∞(1)
2.00 to 2.50	60° (2)	60° (2)	60° (2)	70° (1)	70∞(1)
2.50 to 3.00	70° (2)	70° (2)	70° (2)	60° (2)	60∞(2)
3.00 to 4.00	80° (2)	80° (2)	80° (2)	70° (2)	70∞(2)

FOR AGAINST-THE-RULE ASTIGMATISM

Astigmatism, D	40- to 50-yo	50- to 60-yo	60- to 70-yo	70- to 80-yo	80-yo and older
1.00 to 1.50	60° (1)	50° (1)	40° (1)	40° (1)	30° (1)
1.50 to 2.00	70° (1)	60° (1)	60° (1)	60° (1)	40° (1)
2.00 to 2.50	60° (2)	80° (1)	80° (1)	70° (1)	60° (1)
2.50 to 3.00	70° (2)	70° (2)	70° (2)	60° (2)	60° (2)
3.00 to 4.00	80° (2)	80° (2)	80° (2)	70° (2)	70° (2)

Abbreviation: yo, year-old. (1) denotes one incision, (2) denotes two incisions.

depend on the cylinder diopters and axis from the refraction, the keratometry readings, or corneal topography? One study showed that these three methods of measurement frequently correlate poorly, especially for less than 2.00 D of astigmatism.² Fortunately, unlike the correction of spherical refractive errors, astigmatic correction is more forgiving, especially when it addresses moderate-to-low levels.

One way to plan the surgical correction of astigmatism is to initially assess the refraction and the keratometry simultaneously. If the amount of cylinder and axis are strongly correlated, the surgical planning for astigmatic correction during cataract surgery will be fairly straightforward. If the correlation is poor (although keratometry should be more reliable), surgical correction can be less predictable, even with corneal topography. This is where the art of astigmatic correction applies. We must judge the relative reliability of the astigmatic information. If, after careful consideration, we doubt we can create a reasonable surgical plan, we should postpone correcting the patient's astigmatism until after cataract surgery is complete and the phaco incisions have healed.

My current LRI nomogram for lower levels of cylinder includes one LRI, due to the relative safety and long-term benefits of this approach (see *The Wallace LRI Nomogram*). The term *coupling* helps to explain the aftereffects of LRI procedures, including their impact on the postoperative spherical equivalent. A one-to-one steepening-flattening resulting from an LRI incision might not influence the keratometry value and therefore the IOL calculation in most cases. Longer incisions might induce an RK effect, and we

may need to increase the IOL's power in order to achieve a good spherical result.

"[LRIs'] user-friendliness, low risk, and rapid, stable results make them an excellent means of reducing many patients' dependence on spectacles."

THE PROCEDURE IN DETAIL

After a preoperative evaluation of the patient's refractive, keratometric, and corneal topographic cylinder, I "guess-timate" the best axis and length of incision(s) with the help of the Wallace LRI nomogram. Often, the axis of the LRI is the reading from the current IOLMaster version 5.0 keratometry (Carl Zeiss Meditec, Inc., Dublin, CA). I document the chosen axis and arc length of the incision in the patient's surgical chart.

The eye is prepped and draped, and the surgical microscope is brought into position. I hydrate the eye and ask the patient to look into the light of the microscope. The Mendez ring is placed on the eye with the handle at the lateral canthus. If I made reference marks preoperatively, I align them with the Mendez marker. I use a calibre 0.12-mm forceps to mark the cornea at the decided axis inside the Mendez ring, approximately 1.0 to 1.5 mm inside the corneal limbus. I then rotate the Mendez ring so that a hash mark on it is adjacent to the axial mark. Next, I mark the incision's borders on each side of the axial mark (see *Sample Limbal Relaxing Incision*).

CONCLUSION

Although toric IOLs are available, many cataract surgeons still use LRIs to correct astigmatism. Their user-friendliness, low risk, and rapid, stable results make them an excellent means of reducing many patients' dependence on spectacles. ■

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SAMPLE LIMBAL RELAXING INCISION

An example of a limbal relaxing incision (LRI) with a 60° arc at axis 83°:

- Place a Mendez ring
- Mark inside the ring at 83°
- Rotate the ring so that the 90° mark on the ring corresponds with the corneal mark at 83°
- Place marks on the cornea next to the 60° and 120° marks on the ring (or 30° on either side of the 83° mark)
- Remove the Mendez ring
- Dry corneal marks with a sponge spear
- Fixate the globe with the same calibre 0.12-mm forceps grasping conjunctiva distal to where the LRI is to be performed
- Initiate the incision at the far mark with the blade and handle of the LRI diamond knife perpendicular to the corneal surface (not the iris)
- Advance the LRI blade in an arcuate fashion by gently twirling the handle of the knife and following the template of the nearby limbus