

MANAGEMENT OF ASTIGMATISM IN CONJUNCTION WITH CLEAR CORNEAL PHACO SURGERY

***Louis D. “Skip” Nichamin, M.D.
Medical Director
Laurel Eye Clinic, Brookville, PA***

Improved spherical and astigmatic outcomes are now well-recognized benefits of modern small incision cataract surgery. In fact, the term “refractive cataract surgery” no longer simply engenders a shift in philosophy, but rather has come to represent a reality for our cataract patients. An increasing number of refractive surgical patients may in fact fare better with refractive lensectomy surgery than they might with “standard” keratorefractive procedures.

Incision Decisions

During the early and mid 1990’s, a great deal of effort was directed toward the study of the astigmatic effects of various cataract incisions. By manipulating incision parameters (size, location, and shape) surgeons could, with a reasonable level of accuracy, “tailor” their astigmatic outcome according to the patient’s preexisting astigmatism. This on-axis, variable incisional approach does, however, require effort rotating about the operating room table, a dynamic mindset, and to some degree varying instrumentation. Although effective, recent advances in incisional technique and implant technology have led to a different approach in managing astigmatism during phacoemulsification (phaco) surgery. Specifically, the temporal clear corneal phaco incision, as popularized by Dr. Howard Fine, has now proven itself to be safe, effective, and remarkably reproducible. Additionally, as a result of improvements in foldable

intraocular lens (IOL) delivery systems, implantation may now be routinely performed through incisions of 2.8-3.2 mm.

Well-documented studies now support the clinical impression that incisions of this size behave in an essentially astigmatically neutral fashion^{1,2}. Thus, an incision may now be easily and reproducibly crafted that yields all of the wonderful benefits of the clear corneal approach, yet is astigmatically neutral. If a patient has enough preexisting astigmatism to warrant reduction, then additional surgery may be superimposed, concurrently or at a later time, upon this temporal clear corneal phaco incision. Today, this most commonly takes the form of (intra-) limbal peripheral arcuate astigmatic relaxing incisions or “LRI’s.” Other options include toric implants or a “bioptics” approach utilizing excimer or other non-laser technology to enhance the refractive outcome (please see following handout).

The use of *peripheral* arcuate astigmatic relaxing incisions or “LRIs” has been shown to be extremely safe and reliable.³ In the setting of concomitant lens surgery, our data indicate that this technique provides for more predictable astigmatic outcomes as compared to the use of conventional (smaller) astigmatic keratotomy (A.K.) optical zones, and yields more consistent results than when relying solely upon a “tailored” phaco incision.⁴

Our use of LRIs originated from the work of Dr. Stephen Hollis. With refinement of his nomogram, we found this approach to astigmatic management to be considerably more forgiving with less induced shift of resultant cylinder axis, greater predictability, and perhaps most importantly, less tendency to induce irregular corneal flattening and hence irregular astigmatism. Admittedly, these more peripheral incisions are less powerful than conventional corneal relaxing incisions; however, in treating cataract and presbyopic-aged patients, more effect may be achieved in this older population and one

must keep in mind that the goal is to reduce preexisting astigmatism without overcorrecting or shifting the axis. In fact, many refractive surgeons now prefer use of longer intralimbal arcuate incisions in all astigmatic keratotomy candidates irrespective of age.

Another advantage gained by moving out to the limbus involves the “coupling ratio” which describes the amount of flattening that is induced in the incised meridian relative to the amount of steepening that occurs 90° away. LRIs exhibit a very consistent 1:1 ratio, and therefore negligible change in spheroequivalent occurs obviating the need to adjust the IOL power. Finally, this form of intralimbal keratotomy seems to logically dovetail with the trend toward clear corneal phaco incisions. In summary, we start with the amazingly simple but elegant single-plane, temporal (neutral) clear corneal phaco incision, and then add on to the steep meridian, the necessary nonbeveled (perpendicular to the corneal surface) limbal arcuate relaxing incisions. This makes for a facile, logical and esthetic approach to astigmatism management.

The Surgical Plan

In creating a surgical plan, it is generally agreed that mild residual with-the-rule astigmatism is desirable (when using monofocal IOL's), overcorrection (axis shift of 180°) is undesirable, and that the refractive plan must take into account the status of the fellow eye. With this in mind, surgery is planned according to the nomograms as illustrated (Tables I & II). Unfortunately, preoperative measurements—keratometry, refraction, and topography—do not always agree. Lenticular astigmatism may account for some of this disparity; however, our experience supports the notion that traditional measurements of astigmatism, particularly those obtained with standard keratometry (only 2 points measured in each meridian) do not always adequately quantitate the

amount of astigmatism present. We have found that keratometry generally provides an accurate determination of axis and that refraction, presuming that the cataract is not extremely dense, provides a more reliable indicator of the quantity of cylinder. When confounding measurements do arise, one can compromise and average the disparate readings, or simply defer the relaxing incisions until a stable postoperative refraction is obtained since this technique lends itself nicely for in-office “touchups.” We have come to increasingly rely upon corneal topography, particularly when measurements do vary and in complex cases. Once the amount of astigmatism to be corrected has been determined, the nomogram is used by aligning the age and preop cylinder columns. Incisions are typically paired to optimize symmetric corneal flattening and expressed in degrees of arc rather than millimeters since corneal diameter may significantly impact the relative length of the arcuate incision and its resultant effect (Fig. 1).

These nomograms may be used in conjunction with any modern phaco incision including scleral tunnels, but one must know the exact astigmatic effect of the cataract incision and factor this into the surgical plan. As mentioned, it is our preference to perform surgery through a 2.5 mm. to 2.8 mm temporal clear corneal incision, depending upon the tip and sleeve combination, and it is then enlarged to 2.8 to 3.2 mm to accommodate the particular foldable IOL. This single plane, paracentesis-style temporal incision is placed at or just anterior to the vascular arcade. If a larger incision is to be used (to accommodate a particular IOL), increased against-the-wound drift (with-the-rule, given temporal incision location) must be anticipated and factored into the amount of cylinder to be corrected. As seen in the nomogram, for patients with negligible preexisting astigmatism, the single plane phaco incision alone is employed. For patients with minimal against-the-rule astigmatism, a nasal peripheral arcuate relaxing incision is placed opposite to the temporal clear corneal phaco incision. As the amount of against-

the-rule cylinder increases, a temporal arcuate incision is paired with the nasal incision to create symmetric flattening in the horizontal meridian. The temporal cut, in essence, becomes a deep groove such that the incision architecture resembles the Langerman Hinge⁵ with the extent or length of the groove determined by the nomogram).

For with-the-rule astigmatism, the surgeon has two choices. There is varying opinion regarding the use of superior clear corneal incisions. Many leading surgeons fully advocate their use. One must keep in mind that these superior incisions will drift against the wound more than temporal incisions, as noted by Dr. Harry Grabow and others. In nearly all cases of with-the-rule astigmatism, I personally prefer to keep the phaco tunnel situated temporally, maintain an incision size of 3.5 mm. or less for neutrality, and apply LRIs over the steep vertical axis. In my experience, the latter approach has yielded more consistent results with less corneal edema, particularly in those patients who have short eyes with small corneal diameters, are deeply set, or those who have compromised endothelium. A final planning note for patients who have with-the-rule astigmatism, the side-port incision location may need to be adjusted so as not to interfere with the intralimbal relaxing incision.

Surgical Technique

When?

It is reasonable to place all relaxing incisions at the conclusion of surgery, in the event that a complication necessitates a modification to the phaco incision. For routine cases, however, I prefer to place these incisions at the outset in order to avoid epithelial disruption. One exception would be in the case of high against-the-rule astigmatism wherein the nomogram calls for a temporal arcuate incision of greater than 40°. Since this incision or “deep groove” will be superimposed upon the phaco tunnel, if it is

extended to its full arc length at the start of surgery, significant gaping and edema may result secondary to intraoperative manipulation. In this situation, the temporal incision is made by first creating a two-plane, grooved phaco incision (600 micron depth), which is then extended to the full arc length, as determined by the nomogram, at the conclusion of surgery. The nasal arc may be extended to its full arc length at the beginning of the case. Note that the keratome used for the phaco tunnel is inserted through the temporal LRI by pressing the bottom surface of the blade downward upon the outer or posterior edge of the LRI, and then advancing the keratome at an iris-parallel plane. This angulation will allow the keratome to enter at mid-stromal depth.

Where?

Most surgeons advocate placing an orientation mark at the 12:00 or 6:00 limbus before adopting the supine position. This is particularly important when utilizing injection anesthesia. In either event, to help identify the steep meridian (plus cylinder axis) intraoperative keratoscopy is highly recommended. The steep meridian over which the incisions are centered corresponds to the shorter axis of the corneal mire as reflected by the keratoscope. A simple hand-held device such as the Maloney (Katena, Storz and others) works well, or a more elaborate microscope-mounted device may be employed such as the Mastel Ring of Light. The steep meridian may also be identified by aligning a Mendez Ring or similar degree gauge with the previously placed 12:00 or 6:00 limbal orientation marks.

The LRIs are placed at the most peripheral extent of clear corneal tissue, just inside of the true surgical limbus, irrespective of the presence of vessels or pannus. If bleeding is encountered, it may be ignored and will stop spontaneously. Care must be taken not to place the incisions out at the true (gray-to-blue) surgical limbus in that a significant reduction in effect will occur. An empiric blade depth setting of 600 microns

is used in the setting of concomitant cataract surgery. Prior studies employing pachymetry and adjusted blade settings yielded negligible benefit in this older population, as opposed to younger refractive surgery patients where variable blade depth settings are justified along with a slightly more aggressive nomogram (see NAPA Nomogram, Table I). Diamond blade style and configuration may require an adjustment in depth settings; in my experience, a triple-edged 15° Thornton Arcuate Diamond set at this depth has yielded excellent results with no perforations. My personal preference is for a new diamond blade solely dedicated to this technique (Mastel). A single arced footplate improves visibility and the diamond extends to the appropriate (600 micron) preset depth (Fig. 2). Similar designs are available from Rhein Medical, ASICO and other companies.

The extent of arc to be incised may be demarcated in several different ways. My preferred method makes use of a specially designed Fine-Thornton Fixation Ring that both fixates the globe and allows one to delineate the extent of arc by visually extrapolating from the limbus to the adjacent marker (Mastel Precision, Rhein Medical and Storz). Each incremental mark is 10° apart, and bold hash marks (180°) apart serve to align with the steep axis. This approach avoids inking and marking of the cornea. If desired, a two-cut R.K. marker may be used to mark the exact extent of arc to be incised in conjunction with the fixation ring/gauge (Fig. 3). Alternatively, various press-on markers are available, such as those made by Rhein Medical (Nichamin-Kershner LRI Markers or the Dell Marker).

Increased Comfort for Patient and Doctor

Interestingly, one of the most common patient complaints following contemporary phaco surgery is that of a foreign body sensation. Intralimbal relaxing incisions, as compared to more central corneal incisions (smaller optical zones),

definitely improve patient comfort. With the addition of a postop topical NSAID, this problem is virtually eliminated. Upon examination, these incisions appear to heal quickly and are nearly unidentifiable within several days.

Potential Complications

As previously noted, LRIs are proving to be a safer and more forgiving approach to treating astigmatism as compared to more central corneal incisions. Nonetheless, potential for problems will always exist, and several are listed in Table III. Of these, operating upon the wrong axis is likely to be the most common error experienced. When this complication is encountered, it typically takes the form of a 90° mistake with the incisions being centered upon the opposite, flat meridian. This, of course, leads to an increase and probable doubling of the patient's preexisting cylinder. Compulsive attention is needed in this regard, with safety checks such as clear written plans being available within the OR for reference. Incisions are placed upon the plus (+) cylinder axis, and opposite to the minus (-) cylinder axis.

Conclusion

Our experience utilizing peripheral, intralimbal arcuate relaxing incisions over the past decade has paralleled that of many other surgeons, and serves to substantiate this technique as being a safe, effective and reproducible means by which both congenital and surgically induced astigmatism may be treated.

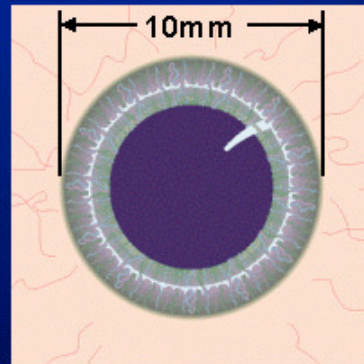
Once again acknowledgment is given to Dr. Stephen Hollis of Columbus, Georgia whose original work provided the platform for this technique, and to Dr. Spencer Thornton who has contributed so much to astigmatism surgery and whose modifiers are incorporated into our current nomograms.

References:

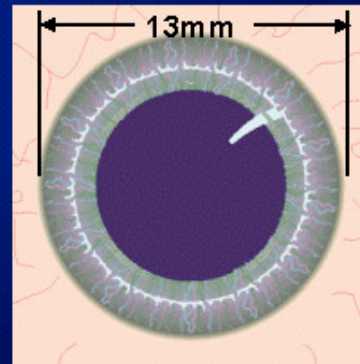
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Nomogram Design

- Degrees of arc vs Millimeters



$$2 \pi r = 31.4\text{mm}$$
$$90^\circ \text{ of arc} = 7.85\text{mm}$$



$$2 \pi r = 40.84\text{mm}$$
$$90^\circ \text{ of arc} = 10.21\text{mm}$$



Figure 1



Figure 2

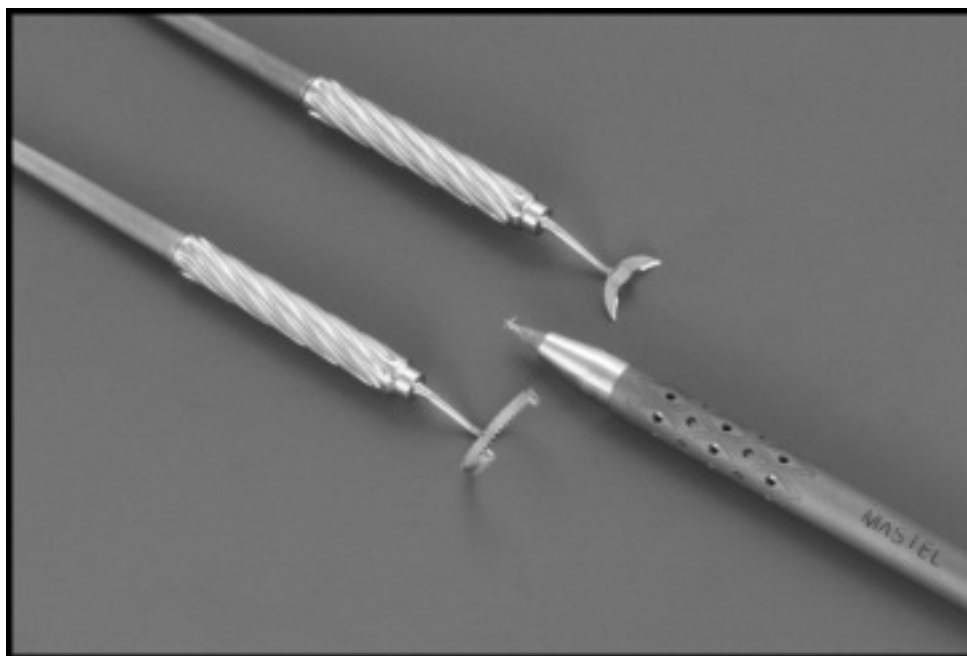


Figure 3

Table I **The “NAPA” Nomogram**

Nichamin Age & Pach-Adjusted Intralimbal Arcuate Astigmatic Nomogram

Louis D. “Skip” Nichamin, M.D.

“WITH-THE-RULE”

PREOP CYL (Diopters)	<i>Paired Incisions in Degrees of Arc</i>			
	20-30 yo	30-40 yo	40-50 yo	50-60 yo
0.75	40	35	35	30
1.00	45	40	40	35
1.25	55	50	45	40
1.50	60	55	50	45
1.75	65	60	55	50
2.00	70	65	60	55
2.25	75	70	65	60
2.50	80	75	70	65
2.75	85	80	75	70
3.00	90	90	85	80

“AGAINST-THE-RULE”

PREOP CYL (Diopters)	<i>Paired Incisions in Degrees of Arc</i>			
	20-30 yo	30-40 yo	40-50 yo	50-60 yo
0.75	45	40	40	35
1.00	50	45	45	40
1.25	55	55	50	45
1.50	60	60	55	50
1.75	65	65	60	55
2.00	70	70	65	60
2.25	75	75	70	65
2.50	80	80	75	70
2.75	85	85	80	75
3.00	90	90	85	80

**When placing intralimbal relaxing incisions following or concomitant*

with radial relaxing incisions, total arc length is decreased by 50%