Residual Astigmatism After Corneal Ablation

We use a customized ablation profile, which requires careful consideration.

BY LEOPOLDO SPADEA, MD

The objective of refractive surgery is to optimize optical performance, and today it has gained acceptance from professionals and patient alike. Each refractive surgeon should aim to help his patients obtain clear vision under various intensities of illumination and contrast.[1]

Before the surgeon can truly dedicate himself to improve his patients' refractive results, he must have an excellent understanding of optical terminology. Astigmatism occurs when the curvature of the cornea and the lens vary in different meridians. Regular astigmatism is produced when the steeper and flatter meridians are perpendicular to each other; irregular astigmatism occurs when orientation of the principal meridian changes from one point to another across the pupil or when the amount of astigmatism changes from one point to another. Vision is indistinct at every distance because the cornea, which should be dome-shaped, is shaped similarly to the back of a spoon (ie, out-of-round). In this instance, the curvature of the cornea is steeper in one direction, thereby creating two axes that are typically perpendicular to each other. Astigmatism starts to cause noticeably blurred vision at approximately 0.50 D; however, this marker is patient dependent and may be greater in some cases.[2]

ASTIGMATIC CORRECTION

Astigmatism may be measured by keratometry and computerized videokeratoscopy, the latter of which may also define irregular astigmatism. Laser surgery can correct corneal astigmatism by changing the shape of the central cornea (mainly the central 6 or 7 mm) to look more like a symmetrical soup bowl than the back of a lopsided spoon. To correct astigmatism surgically—which is more difficult than treating nearsightedness—tissue is selectively removed to create similar curvature along the steepest and flattest meridians (ie, the corneal curves of greatest and smallest refractive power, respectively). Undesirable results, including surgically induced astigmatism, astigmatic regression, and under-correction, may result from pre-, intra-, and postoperative elements of the refractive procedure. For instance, postoperative residual or induced astigmatism may limit UCVA and cause starbursts and glare. Irregular astigmatism can also cause loss of BCVA, monocular diplopia, and ghosting of images.[3]

During the excimer laser ablation, significant amounts of astigmatism are rarely induced. Rather, astigmatism is more commonly the result of a decentered ablation, drift, or tilt of the corneal bed. Although eye-tracking systems are becoming more advanced, the technology still inadequately calculates the x, y, and z orientation of the corneal bed.4

After PRK, residual astigmatism may occur based on the individual's surface healing; some may end up with a small amount of irregular astigmatism secondary to the molecular adjustment of epithelial cells and keratocytes set up the formation of astigmatism.

After LASIK, irregular astigmatism can be schematized into three categories: preoperative (preexisting), intraoperative (induced), and postoperative. Corneal warpage is one of the prominent causes of preoperative astigmatism. Therefore, patients must discontinue the use of contact lenses for at least 1 to 3 weeks prior to treatment. Intraoperative causes of astigmatism include poor laser optics; irregular hydration of the stromal bed; central islands; decentered ablations; flap-related complications, including flap decentration and poor flap alignment causing a buttonhole, lost flap, etc; and hinge ablation. Postoperative irregular astigmatism may result from corneal ectasia or as a result of flaps and wrinkles from flap displacement.

SURGICALLY INDUCED ASTIGMATISM

A significant percentage of patients undergoing LASIK may lose some lines of BCVA secondary to irregular astigmatism. The flap-creation method, flap thickness, and hinge location/width may significantly effect the reduction of absolute cylinder and the surgical induction of astigmatism. According to the literature, the lamellar corneal flap may induce astigmatism,[5,6] and corneal biomechanical response models indicate that creating the lamellar flap has refractive effects.[7] As a general rule, nasal hinge flaps appear to induce negative cylinder at 90º, and superior hinge flaps appear to induce negative cylinder at 180º. This effect is more pronounced with large, thick flaps and steep corneal curvatures with wider hinges.[8] Other lamellar possible causes of astigmatism include micro- and macrostriae and epithelial ingrowths. If a surgeon is contemplating a reoperation for surgically induced astigmatism, he must first rule out striae and epithelial ingrowth as possible etiologies. Additionally, decentrations and ablations—in spite of a partial flap—and inflammation, such as diffuse interlamellar keratitis and microbial keratitis, may lead to irregular astigmatism.[9]

Induced astigmatism associated with hyperopic treatments is multifactorial. In some instances, an inadequate clearance between the outer zone of the excimer treatment and the flap hinge induce astigmatism. In other cases, significant surgically induced astigmatism may occur in the axis of the hinge if the hinge is accidentally ablated. Manual and software-related hinge protection systems are available; however, induced astigmatism may still occur if reproduction of the ablation profile on the corneal stromal bed is incomplete. Additionally, interaction between the surgically induced biomechanical effects of large-diameter corneal flaps and poor-fidelity reproduction of the theoretical hyperopic ablation profile can also produce unpredictable and unstable astigmatic results. The higher-order optical aberrations created by a low-fidelity reproduction of the complex hyperopic ablation profile will also induced irregular astigmatism, which is associated with decreased BCVA and UCVA.[10]

BUILDING BLOCKS

Although surgeons use various flap-creation technologies, excimer laser platforms, and surgical techniques, the factors I outline in this article are the building blocks of all astigmatic corrections. As technology becomes increasingly sophisticated and the software of the laser—and not the surgeon—directs the surgical plan, it is imperative that surgeons use a cognitive approach to the unique pre- and postoperative assessment and surgical planning of each patient. Understanding the basics of excimer laser ablation profiles and techniques potentially maximizes the outcomes in both simple and complex astigmatic cases.

The best noninvasive option for managing irregular astigmatism is the use of a rigid contact lens (ie, hard, gas permeable, hybrid, and toric hydrophilic); however, this method is typically not the favored option for our refractive patients. Results indicate that contact lenses are a good, and sometimes the only, alternative for patients with induced irregular astigmatism. Rigid gas-permeable contact lenses provided the best visual performance and patient tolerance.[11]

CORRECTING REFRACTIVE ERRORS, RETREATMENTS

PRK and LASIK are safe and effective techniques to correct low to medium refractive errors. Unfortunately, regression toward the initial myopic or hyperopic state, overcorrection, and induced irregular astigmatism are serious complications that limit the predictability of the refractive outcome. An estimated 10% to 20% of patients require an enhancement after PRK, and approximately 5.5% to 28% require retreatment after LASIK.[6,7]

Retreatments after refractive surgery call for careful consideration. Possible causes of regression after PRK and LASIK not only depend on the patient abut also the type of instruments, parameters of treatment, and different postoperative therapy the surgeon uses. The surgeon should determine and consider any errors in evaluation and performance. Refraction, biomicroscopy, and videokeratography detect any changes in corneal curvature that might have occurred in response to postoperative pharmacologic therapy. If the initial refractive procedure was correctly conducted, the reason for failure is related to the individual's biological response—to either an abnormal healing process or biomechanical changes in the cornea.

Variability of stromal repair somewhat depends on the patient's general condition and age. Pathologies, including hyperglycemia or diabetes, can delay reepithelialization; even immune diseases may change the healing process. Additionally, adequate production in the

TAKE-HOME MESSAGE

- In most patients, astigmatism starts to cause noticeably blurred vision at 0.50 D.
- Residual astigmatism after PRK depends on the patient's surface healing.
- To avoid corneal warpage, patients must discontinue contact lens use 1 to 3 weeks before treatment.
- Surgeons should use a cognitive approach to the unique pre-and postoperative assessment and surgical planning.

quantity, and more importantly, quality of tear film is essential for correct lamination of the epithelium during the healing process.

Photoablative surgical procedures should create a quality surface ablation and a new corneal profile that does not induce epithelial hypertrophy. Additionally, the ablation should produce significant curvature variations, and postoperative topical therapy should modulate the evolution of refraction after PRK and minimize the appearance of corneal haze. Retreatments may be required if the original treatment was decentered, in the presence of a small optical zone (evaluated by computerized corneal topography), or after an overcorrection. The success rate of enhancements is generally lower than that of the primary procedure.[13,14] The risk factors for retreatment include degree of attempted correction, initial and residual astigmatism, age, and sex; however, a customized ablation may increase the success rate of retreatments.

In our own research, we found an improvement in the mean refractive spherical equivalent (MRSE) at 2 years for PRK and LASIK myopic retreatments (-2.54 to -0.05 vs -2.36 to -0.11, respectively) as well as PRK and LASIK hyperopic retreatments (2.23 to 0.03 vs 1.94 to 0.06).[12] All patients had a refractive error within ±0.75 D after the PRK enhancement and within ±1.00 D after the LASIK enhancement. Topography patterns significantly improved in all eyes for surface asymmetry index and surface regularity index topographic indices, and patients' UCVA results were 20/50 or better in the PRK retreatment group and 20/30 or better in the LASIK retreatment group. Results are better if compared with the results obtained using standard PRK and LASIK retreatments.

CUSTOMIZATION

Customized ablations for the correction of residual astigmatism, in our experience, are a safe and effective retreatment tool. Applying customized ablation to the mainstream of refractive surgery patients will require careful consideration of the issues I mention in this article.[13] We use a customized, transepithelial topography-guided PRK treatment. The choice of transepithelial ablation is secondary to the consideration that the epithelial layer might change, masking the corneal surface irregularity. Therefore, we produce an epithelium-inclusive videokeratography map, which uses the epithelium like a masking agent. Conversely, we accept the risk of creating a small, irregular ablation as a result of different ablation rates produced when the laser is applied to areas on the epithelium and stroma.

The choice to proceed with transepithelial PRK avoids chemical or mechanical removal techniques, which often cause the reemergence of stromal irregularity. Another advantage of transepithelial superficial ablation is that it promotes less epithelial damage with less stromal reaction.

Transepithelial topography-guided PRK for the treatment of an irregular cornea is valuable for several corneal pathologies and postsurgical conditions, including irregular astigmatism, corneal opacity therapeutical treatment, and LASIK complications. ■

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