Hyperopia Treatments

Surgeons discuss their preferred approaches to treating hyperopia.

BY MARIA CLARA ARBELAEZ, MD; LEOPOLDO SPADEA, MD; AND DAMIAN B. LAKE, MB ChB, FRCOphth

Hyperopia-Correcting Laser Surgery

By Maria Clara Arbelaez, MD

Hyperopia-correcting laser surgery can be broadly categorized into intrastromal and surface ablation techniques. Of intrastromal approaches, LASIK is the most popular for the correction of hyperopia. In surface treatments such as PRK, LASEK, and transepithelial PRK, mitomycin C is applied in the majority of cases. Due to differences in epithelial healing, a transepithelial approach is not recommended.

The main problems associated with hyperopic LASIK include decentration, decrease in BCVA, high rate of retreatment, frequent residual refractive error, and induction of astigmatism and high levels of corneal aberrations, specifically spherical aberration. The conventionally accepted limits for hyperopic LASIK are lower than those accepted for myopic LASIK, one reason being that the induction of aberrations per achieved diopter of correction is higher in hyperopic treatments than in myopic treatments.[1]

Proper centration of refractive treatments remains controversial. The offset between the corneal vertex and pupil center is larger in hyperopic eyes, in the nasal direction in most cases, and this must be taken into account.[2] Hyperopic eyes usually have short axial length, resulting in higher values for angles alpha, kappa, and lambda. This also causes an offset between the corneal vertex and pupil center that is of higher magnitude than in myopic eyes, making it difficult to determine where to center the refractive procedure.

The broad goals of hyperopic LASIK are to increase corneal curvature without inducing aberrations and ensure that the change remains stable over time. The improved stability of hyperopic laser treatments using enhanced ablation profiles and larger optical zones (about 6.7 mm) has been detailed in the scientific literature. Better registration and centration techniques using pupil centroid shift compensation contribute to these improvements.

My upper limit for hyperopic treatment is a maximum 5.00 D of spherical equivalent with a maximum postoperative keratometry (K) reading of 49.00 D. Consequently, this can lead to a preoperative K reading of less than 44.50 D in high hyperopia treatments. Modern algorithms take into account the amount of regression associated with a given refractive correction. For example, a treatment of 1.00 D at a 6.7-mm optical zone leads to an ablation depth of 17 µm. The transition zone further expands the ablation zone to 7.3 mm. Assuming a 5.00 D treatment at the same optical zone, an ablation depth of 103 µm is required, which is more than 5 x 17 µm (85 µm). Thus, an ablation depth of 100 µm is another limit in my treatment planning.

CLINICAL DATA

My colleagues and I evaluated 100 eyes (50 patients) with preoperative hyperopia or hyperopic astigmatism up to 5.00 D. Patients underwent LASIK using the Amaris laser system (Schwind eye-tech-solutions).[3] All ablations were noncustomized, based on aberration-free profiles, and calculated using the Schwind ORK-CAM software module. Mean manifest refraction spherical equivalent (MRSE) was 3.02 ±2.06 D (range, 0.13–5.00), and mean manifest astigmatism magnitude was 1.36 ±1.61 D (range, 0.00–5.00).

At 6 months postoperative, 90% of eyes achieved a UCVA of 20/25 or better, 44% achieved 20/16 or better (Figure 1), and 74% and 89% had spherical equivalents within ±0.25 and ±0.50 D, respectively (Figure 2). Additionally, 94% had astigmatism of 0.50 D or less. Mean spherical equivalent was -0.12 ±0.51 D, and mean astigmatism was 0.50 ±0.51 D. BCVA improved in 52% of eyes and decreased in 19%. The predictability slope for refraction was 1.03 and for intercept value was 0.01 D. On average, negative spherical aberrations were significantly increased by the treatments, and no other aberration terms changed from pre- to postoperative values.

RETREATMENTS

In this series, no retreatments were performed during the first 6 months of follow-up. After this time, five retreatments were performed due to under-correction or hyperopic regression. Even with today's technology, retreatments are more frequent in hyperopia.

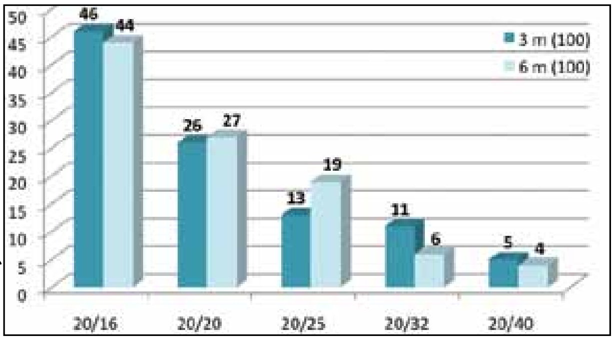


Figure 1. Efficacy plot of UCVA at 3- and 6-month follow-up.

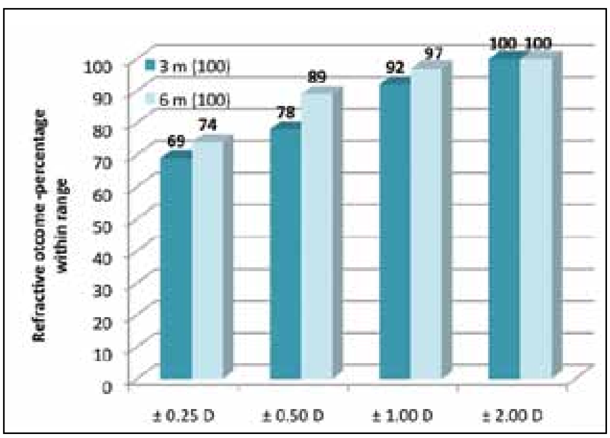


Figure 2. Refractive outcome plot of residual refraction within range at 3- and 6-month follow-up.

The low retreatment ratio may be attributed to several factors. First, I do not base corrections on the manifest or cycloplegic refractions. I use the objective refraction provided by the aberrometer, analyzed for subpupil of 4-mm diameter, as the starting refraction. This is particularly useful for determining the magnitude and orientation of astigmatism. I then push the refraction to the most positive spherical equivalent consistent with the highest BCVA achieved by the patient. Second, I center treatments not on the pupil or the first Purkinje image, but on an objective assessment of the corneal vertex as determined by videokeratoscopy. This offset for the treatment is based on the vectorial mean of four well-acquired topographies per treated eye.

Hyperopic aberration-free treatments with the Amaris laser are safe and predictable. Longer follow-up is necessary to evaluate long-term stability; however, de Ortueta et al[4] found good refractive and topographic stability after hyperopic LASIK, with little to no regression occurring at up to 36 months.

The improved results in our series may be due to treatment centration and to the Amaris technology. The ablation patterns, which minimize induced aberrations, allow surgeons to perform hyperopic LASIK safely and more predictably and may make it possible to treat higher hyperopia. To achieve this, one must consider the limits of steepness of the central cornea with regard to quality of vision and tear film stability.

CONCLUSION

Alternative options for treating hyperopia beyond the upper limit of corneal refractive surgery include phakic IOLs and add-on lenses. For treating hyperopia below the upper limit, LASIK has been shown to be an effective approach.

Maria Clara Arbelaez, MD, practices at the Muscat Eye Laser Center, Muscat, Sultanate of Oman. Dr. Arbelaez states that she is a consultant to Schwind eye-tech-solutions. She may be reached at tel: +96 824691414; fax: +96 824601212; e-mail: drmaria@omantel.net.om.

1. Yoon G, Mac Rae S, Williams DR, Cox IG. Causes of spherical aberration induced by laser refractive surgery. *J Cataract Refract Surg*. 2005;31:127-135.
2. Wachler BS, Korn TS, Chandra NS, Michel FK. Decentration of the optical zone: centering on the pupil versus the coaxially sighted corneal light reflex in LASIK for hyperopia. *J Refract Surg*. 2003;19(4):464-465.
3. Arbelaez MC, Vidal C, Mosquera SA. Six-month clinical outcomes after hyperopic correction with the SCHWIND AMARIS Total-Tech laser. *J Optom*. 2010;3:198-205.
4. de Ortueta D, Arba Mosquera S. Topographic stability after hyperopic LASIK. *J Refract Surg*. 2010;26:547-554.

The Surgical Correction of Hyperopia

By Leopoldo Spadea, MD

Since the end of the 19th century, many attempts have been made to surgically correct refractive errors. Until the second half of the 20th century, these attempts were limited to the correction of myopia and myopic astigmatism. Only in the final decade of the 20th century were results reported for attempts to steepen the central cornea to correct hyperopia.

The surgical correction of hyperopia represents a great challenge. Most reported surgical approaches have had only limited success, with narrow range of correction, poor predictability and stability, and sight-threatening complications. However, newer surgical techniques such as LASIK and PRK are safe and effective forms of hyperopic correction.

HYPEROPIC CORRECTION TECHNIQUES

Earlier techniques. Several earlier techniques for treating hyperopia have been abandoned. Keratomileusis for hyperopia is no longer used because of its technical complexity and the long recovery time.[1] Automated lamellar keratoplasty was associated with high morbidity, long-term instability, and a high incidence of iatrogenic keratoconus,[2] and epikeratoplasty was unpredictable for hyperopia greater than 3.00 D.[3] Hexagonal keratotomy could be used to correct 1.00 to 3.00 D of hyperopia but is not recommended due to the high incidence of irregular astigmatism and poor results.[4]

CK and LTK. Conductive keratoplasty (CK) can be used to treat 0.75 D to 3.00 D of spherical hyperopia. Treatment penetration is deep and cylindrical in shape and does not damage the corneal endothelium. In one reported series, UCVA, predictability, and stability results were as good as or better than those obtained with other techniques, and CK was found to be safe, effective, and stable for correcting low to moderate spherical hyperopia in patients aged 40 years and older.[5]

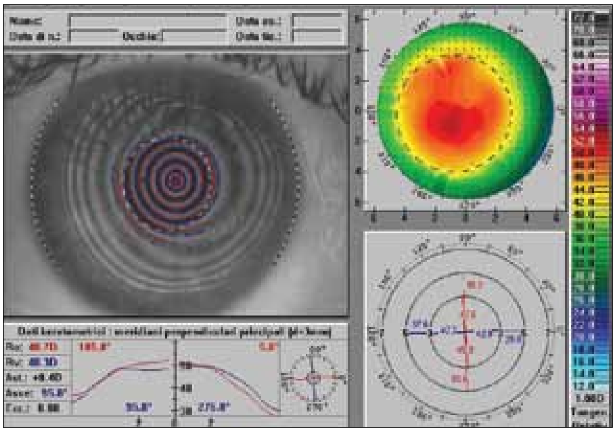
Holmium laser thermokeratoplasty (LTK) produces a central corneal steepening secondary to the shrinking of peripheral corneal collagen fibers at a temperature between 60° C and 70° C. Although immediate results with LTK were encouraging, Tassignon et al[6] found significant regression at 2 years, resulting in a final correction of 1.50 D, independent of the degree of hyperopia treated.

Phakic IOLs and RLE. The use of posterior chamber phakic IOLs to correct hyperopia carries risks of complications including anterior subcapsular cataract formation, pigment dispersion, and luxation or pupillary block glaucoma. The main complications of angle-supported anterior chamber phakic IOLs are glare and halos, pupil ovalization, and corneal endothelial cell loss. Those associated with iris-fixated anterior chamber phakic IOLs include chronic subclinical inflammation, corneal endothelial cell loss, and dislocation or pupillary block glaucoma. Refractive lens exchange (RLE) can produce cystoid macular edema and retinal detachment, and it becomes less accurate and predictable for more than 3.00 D of hyperopia.[7]

EXCIMER LASER TECHNIQUES

Although excimer laser techniques are accepted for hyperopic correction, some disagree on the degree of correction that can be achieved. Barraquer and Gutierrez suggest treating the total cycloplegic refraction for patients younger than 40 years and treating the manifest refraction for those older than 40 years.[8] Esquenazi and Mendoza maintain that cycloplegic refraction should be taken into account only if there is a difference of more than 0.50 D between the manifest and cycloplegic refractions.[9] In fact, in younger patients, residual latent hyperopia may result. This problem is less evident with more than 5.00 D of hyperopia, with which the latent component is lower.[8]

PRK. PRK appears accurate for up to 3.00 to 4.00 D of hyperopia, with poor predictability for moderate and high hyperopia (Figure 3). To obtain good postoperative results, the final corneal curvature must be less than 48.00 D. One study showed that preoperative keratometry, even in eyes with a postoperative K reading of more than 48.00 D, did not significantly influence postoperative results when the attempted correction was less than 4.00 D.[10]

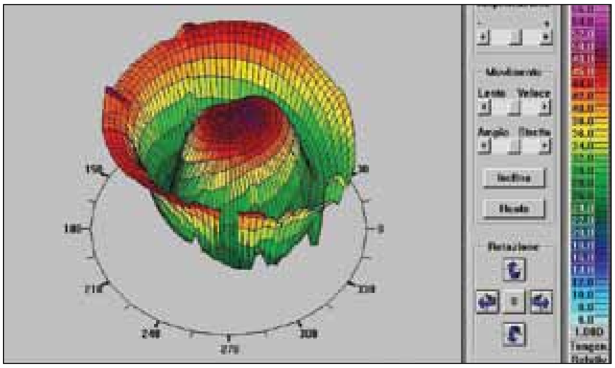


(Courtesy of Leopoldo Spadea, MD)

Figure 3. PRK appears accurate for up to 4.00 D of hyperopia, with poor predictability for moderate and high hyperopia.

(Courtesy of Leopoldo Spadea, MD)

Figure 4. The overlying flap appears to prevent strong epithelial regression after LASIK for hyperopia.



(Courtesy of Leopoldo Spadea, MD)

Figure 5. In patients with a mean preoperative MRSE of 4.49 ±1.20 D, the refractive hyperopic error was reduced to 0.24 ±0.60 D 3 months after LASIK. This result was stable at 2 years.

My colleagues and I evaluated a group of patients with a mean preoperative MRSE of 2.58 ±1.10 D who underwent PRK. At 3 months, a temporary myopic overshoot (-0.19 ±1.00 D) was observed; however, at 2 years, the mean MRSE was 0.34 ±0.92 D. This hyperopic regression was statistically significant (P<.01) and may be related to the healing process, which is ongoing for several months after PRK.[11]

It should be noted that, no matter whether hyperopia, myopia, or astigmatism is being treated, a normal tear film is fundamental for success in PRK.

LASIK. Hyperopic LASIK is gaining popularity because it is possible to ablate the corneal mid-periphery with stromal photorefractive ablation, and the presence of the overlying flap prevents strong epithelial regression (Figure 4).[12] LASIK appears to be accurate for up to 5.00 to 6.00 D of hyperopia, with poor predictability for high hyperopia. Tabbara et al[13] reported that LASIK was safe and effective for the treatment of up to 11.50 D of hyperopia.

My colleagues and I evaluated a group of patients with a mean preoperative MRSE of 4.49 ±1.20 D who underwent LASIK. We found that the refractive hyperopic error was reduced to 0.24 ±0.60 D at 3 months, and the result was stable at 2 years (0.29 ±0.60 D; P = .50; Figure 5).[11] Transient and slight discomfort in the LASIK group was reported in the first few hours after surgery, whereas pain was frequently reported after PRK.

It is important to make an accurate preoperative assessment of the sensory and binocular fusion conditions of hyperopes. Especially in patients with unilateral high refractive errors, a comprehensive study of extrinsic ocular motility and binocular cooperation should be performed after having the patient use contact lenses for 30 days to simulate the proposed postoperative vision.[14]

CONCLUSION

In my experience, PRK and LASIK are safe and effective for the correction of hyperopia. PRK was associated with initial and transient myopia with pain and late regression, and LASIK resulted in minimal pain and was associated with rapid refractive stability.

Leopoldo Spadea, MD, is an Associate Clinical Professor of Ophthalmology, Chief of Corneal and Refractive Surgery - Eye Clinic, S. Salvatore Hospital, University of L'Aquila, Italy. Professor Spadea states that he has no financial interest in the products or companies mentioned. He may be reached at tel: +39 0862 319671; e-mail: lspadea@cc.univaq.it.

1. Barraquer JI. The history and evolution of keratomileusis. *Int Ophthalmol Clin*. 1996;36:1-7.
2. Lyle WA, Jin GJ. Hyperopic automated lamellar keratoplasty: complications and visual results. *Arch Ophthalmol*. 1998;16:425-428.
3. Carney LG, Kelley CG. Visual performance after aphakic epikeratoplasty. *Curr Eye Res*. 1991;10:939-945.
4. Werblin TP. Hexagonal keratotomy—should we still be trying? *J Refract Surg*. 1996;12(5):613-617.
5. McDonald MB. Conductive keratoplasty: a radiofrequency-based technique for the correction of hyperopia. *Trans Am Ophthalmol Soc*. 2005;103:512-536.
6. Tassignon MJ, Trau R, Mathys B. Treatment of hypermetropia using the Holmium laser--laser thermokeratoplasty (LTK). *Bull Soc Belge Ophtalmol*. 1997;266:75-83.
7. O'Brien TP, Awwad ST. Phakic intraocular lenses and refractory lensectomy for myopia. *Curr Opin Ophthalmol*. 2002;13:264-270.
8. Barraquer C, Gutierrez AM. Results of laser in situ keratomileusis in hyperopic compound astigmatism. *J Cataract Refract Surg*. 1999;25:1198-1204.
9. Esquenazi S, Mendoza A. Two-year follow-up of laser in situ keratomileusis for hyperopia. *J Refract Surg*. 1999;15(6):648-652.
10. Cobo-Soriano R, Llovet F, Gonzalez-Lopez F, Domingo B, Gomez-Sanz F, Baviera J. Factors that influence outcomes of hyperopic laser in situ keratomileusis. *J Cataract Refract Surg*. 2002;28:1530-1538.
11. Spadea L, Sabetti L, D'Alessandri L, Balestrazzi E. Photorefractive keratectomy and LASIK for the correction of hyperopia: 2-year follow-up. *J Refract Surg*. 2006;22(2):131-136.
12. Ditzen K, Huschka H, Pieger S. Laser in situ keratomileusis for hyperopia. *J Cataract Refract Surg*. 1998;24:42-47.
13. Tabbara KF, El-Sheikh HF, Islam SM. Laser in situ keratomileusis for the correction of hyperopia from +0.50 to +11.50 diopters with the Keracor 117C laser. *J Refract Surg*. 2001;17:123-128.
14. Sabetti L, Spadea L, D'Alessandri L, Balestrazzi E. Photorefractive keratectomy and laser in situ keratomileusis in refractive accommodative esotropia. *J Cataract Refract Surg*. 2005;31(10):1899-1903.

Treatments for Hyperopia

By Damian B. Lake, MB ChB, FRCOphth

In the past, the surgical treatment of hyperopia has often been less satisfactory for refractive surgeons and patients than the treatment of myopia. The issues associated with hyperopic treatments have surrounded the relatively low levels of hyperopia that can be effectively treated with LASIK, the regression of effect, and the induction of aberrations such as negative spherical aberration. Additionally, hyperopic patients who have used spectacles are accustomed to a magnified image, but when hyperopia is corrected by contact lenses, laser vision correction, or RLE, the image size is reduced.

Hyperopia may be caused by short axial length (index hyperopia), a flat cornea (refractive hyperopia), or a mixture of both. The surgical treatment options include laser vision correction, phakic IOLs, and RLE. CK and intrastromal corneal implants are not considered viable options at this time due to reported poor effectiveness and/or regression.

SELECTING A TREATMENT

The decision-making matrix for selecting a hyperopic treatment includes patient age, presbyopia (hyperopes experience presbyopia earlier than nonhyperopes), corneal health (dry eye, endothelial cell count), corneal tomography (corneal shape, associated astigmatism, corneal thickness, K readings and their expected increase after laser vision correction), intraocular exam, and likely temporal gain of effect.

Younger patients with healthy corneas and low hyperopia (up to 3.00 D) benefit most from laser vision correction. The treatment aim in hyperopic LASIK is a peripheral ablation profile inducing a central steepening of the cornea and a myopic shift. Patients with 3.00 to 5.00 D of hyperopia may still benefit from laser vision correction but must be aware that regression and the need for retreatment is more likely than for lower hyperopes; therefore, a healthy reserve of residual stromal bed and an expected postoperative K reading of less than 48.00 D is required, as is an adequate explanation to the patient of the additional risks. These are not absolutes but should be considered on a case-by-case basis. In patients with poor tear film quality, low tear film break-up time, high tear film osmolarity, high ocular surface disease index scores, and low Schirmer test score, the limits

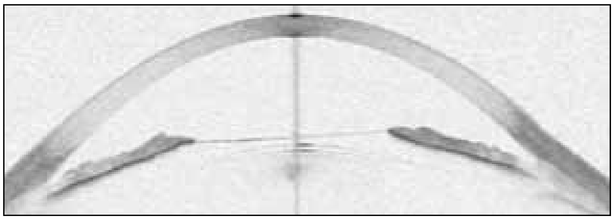

(Courtesy of Damian B. Lake, MB ChB, FRCOphth)

Figure 6. The V4c eliminates ICL-lens touch.

of refractive correction will be reduced and laser vision correction may even be excluded.

In prepresbyopes who have 3.00 to 5.00 D of hyperopia and are not suited for laser vision correction, treatment options are more limited. For those with a healthy corneal endothelium and an adequate anterior chamber depth of more than 2.8 mm from the corneal endothelium to the anterior lens capsule, one attractive option may be the Visian ICL (STAAR Surgical). Long-term studies have shown stability and safety of the ICL, with 86.5% of eyes within 0.50 D of refractive target at 10 years.[1] The latest version of the ICL (V4c) has a central aperture in the lens that allows aqueous circulation; therefore, a peripheral iridectomy is no longer required. The flow of aqueous to the anterior lens capsule with the V4c and the lack of ICL-lens touch (Figure 6) should reduce the previously reported incidence of 0.4% anterior subcapsular cataract at 36 months.[2]

Prepresbyopes and presbyopes who are younger than 50 years of age and have 3.00 to 5.00 D of hyperopia are not suitable candidates for laser vision correction or the ICL. I suggest waiting until RLE becomes a better option for these patients, unless gonioscopy suggests the potential for angle closure. Then, the case could be made for RLE at an earlier stage to deepen the anterior chamber and decrease this risk.

The treatment of presbyopic hyperopes can be relatively more straightforward. Patients older than 50 years of age generally benefit from RLE, with the option of an added-value lens to restore near vision. These patients depend on accurate biometry data with optimized A-constants and modern formulas for optimal outcomes. I use the Haigis formula, the efficacy of which has been confirmed.[3,4]

For patients who would rather avoid intraocular surgery and its added risks, I insist on a contact lens trial to demonstrate the loss of near vision after laser vision correction and explain the added complexity of future cataract surgery with respect to formula selection.

CONCLUSION

The best surgical treatment for hyperopia is heavily dependent on patient age, presbyopia status, corneal and tear film health, anterior chamber anatomy, lens status, and adequate understandings of the risks and benefits of each treatment option. Combination treatments are more likely in this patient group, as laser vision correction patients may require retreatments, and ICL and RLE patients may need laser vision correction optimization of their refractive outcomes. However, final results are often good with these approaches. ■

Damian B. Lake, MB ChB, FRCOphth, is a Consultant Ophthalmologist at The CorneoPlastic Unit and Eye Bank, Queen Victoria Hospital, and Centre For Sight, both in East Grinstead, United Kingdom. Dr. Lake states that he has no financial interest in the material presented in this article. He may be reached at e-mail: lakedamian@hotmail.com.

1. Pesando PM, Ghiringhello MP, Di Meglio G, Fanton G. Posterior chamber phakic intraocular lens (ICL) for hyperopia: ten-year follow-up. *J Cataract Refract Surg*. 2007;33(9):1579-1584.
2. Visian ICL FDA submission 2005.
3. MacLaren RE, Natkunarajah M, Riaz Y, Bourne RR, Restori M, Allan BD. Biometry and formula accuracy with intraocular lenses used for cataract surgery in extreme hyperopia. *Am J Ophthalmol.* 2007;143(6):920-931.
4. Terzi E, Wang L, Kohnen T. Accuracy of modern intraocular lens power calculation formula in refractive lens exchange for high myopia and hyperopia. *J Cataract Refract Surg.* 2009;35(7):1181-1189.