LASIK Hyperopia

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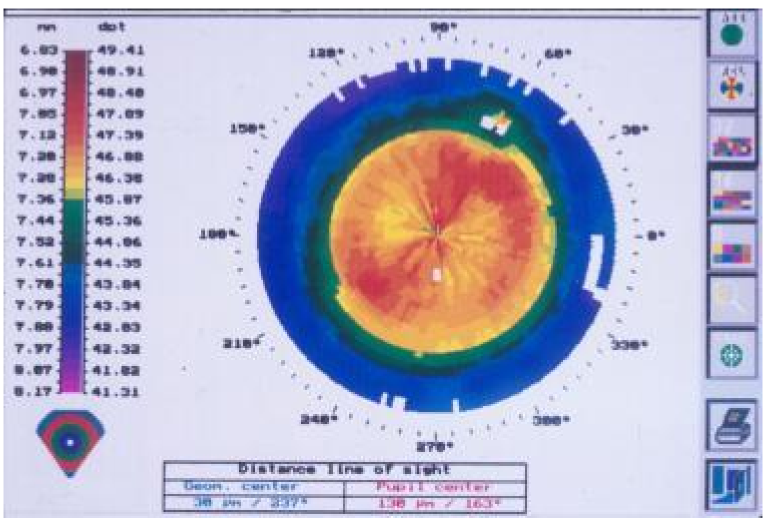
Overview

Background

The surgical reduction of hyperopia is an evasive but worthy pursuit since hyperopia affects both distance vision and near vision and is compounded by presbyopia at a time when patients are in the prime of their vocational and personal life. A wide spectrum of refractive surgeries has been applied over the years in the relentless pursuit of hyperopia correction.

With the introduction of the excimer laser, the possibilities of carving a positive lenticule into the cornea were investigated.[1, 2, 3, 4] To steepen an untreated corneal center, it is necessary to have a relatively deep peripheral ablation, with a progressive steepening of the transition of zone 1.

See the image below.



Corneal topography with central uniform steepening following hyperopic LASIK.

The argon fluoride 193-nm excimer laser corrects refractive errors by sub–micron-precision tissue removal from the cornea.[5] Photorefractive keratectomy (PRK) has been used successfully for hyperopia but has problems of regression, induced astigmatism, and corneal haze, thereby limiting its usefulness to the correction of mild hyperopia only.[6, 7, 8, 9] Excimer laser in situ keratomileusis (LASIK) overcomes many disadvantages of surface ablation (PRK) and has become the procedure of choice for treating hyperopia up to +6.00 diopters (D).[10, 11]

See related CME at Highlights of the American Society of Cataract and Refractive Surgery Symposium.

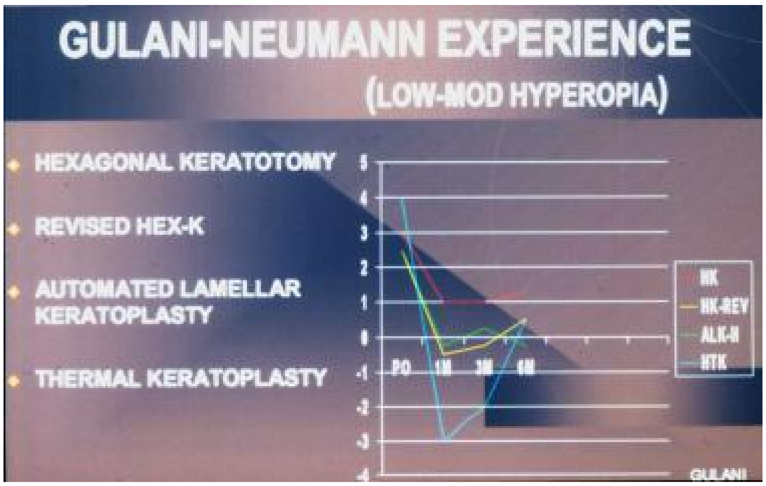
History of the Procedure

The technique routinely used for hyperopic LASIK uses a 110- to 160-µm thick corneal flap and a wide ablation with a peripheral blend zone.[12] With different output systems and configurations unique to each excimer laser system, the conceptual ablation pattern results in a relative central steepening to correct the hyperopia.[2]

When using a broad beam laser, the central cornea could be protected from the laser ablation, while the periphery would ablate, resulting in central steepening. The author had been practicing this technique to correct low hyperopia with good results but was finding patient fixation and surgeon control to be an obstinate problem.[12]

Surgical innovation in hyperopic LASIK - Design of masks

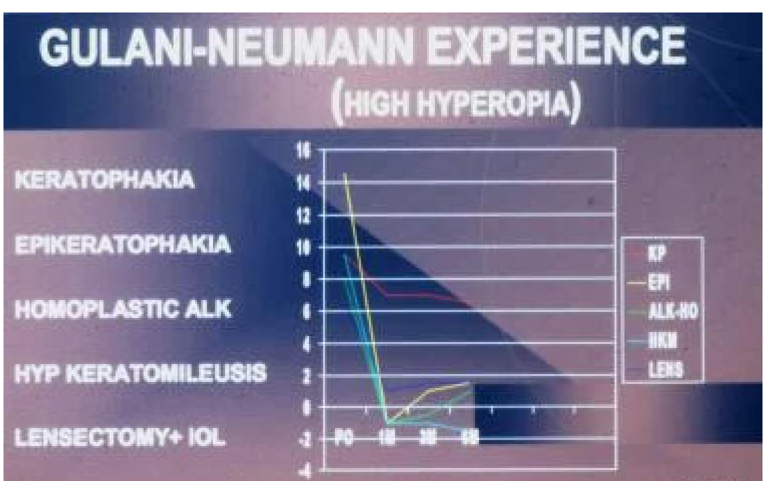
Three acrylate polymer masks of diameters 4.5 mm, 4 mm, and 3.5 mm, respectively, were designed and custom-made by Gulani as shown below. The surface of the masks was spherical, convex for hyperopia correction. The edges were thinned out evenly to a smoothly polished finish. These masks were centered on the exposed corneal stroma between the laser beam and the eye, successively starting with the 4.5-mm mask, followed by the 4-mm mask, and, finally, the 3.5-mm mask, to allow the final ablation pattern to reveal a central graduated steepening comprised of 3 concentric rings. The lenses were transparent with a green tint to allow for maximum light penetration by the green fixation light on the laser. Each lens was +2.5 D in power to aid fixation by the patient with hyperopia. See the image below.



Gulani-Neumann hyperopic surgery experience.

A specially designed triple zone marker and lens placement forceps (designed by Gulani) were used with these lenses during surgery. The principle behind designing these lenses stemmed from a desire to improve patient fixation and surgeon visibility of the ongoing procedure. Prior to the use of these masks, aluminum masks of the same base diameters, respectively, were used. Since these masks were not transparent, the patients could not see the fixation light and had a tendency to wander unless closely held by the globe fixator (designed by Gulani). Also, the surgeon could not see the corneal stroma under these masks; therefore, they had no active role to play in centration of the final concentric ring ablation pattern.

Making these lenses out of a transparent material helped both the surgeon and the patient and resulted in a well-controlled, supervised, and predictable hyperopic laser corneal sculpting as depicted below. Now, the surgeon could center these lenses and maintain direct observation during laser ablation. See the image below.



Gulani-Neumann hyperopic surgery experience.

These lenses were modified further to incorporate a green tint, with each powered to +2.5 D. These factors further enhanced patient fixation and centration in the following ways:

- Transparent lenses on the patient's corneal stroma allowed visualization of the fixation light.
- The green tint of the lenses maximized the unimpeded passage of the green fixation light into the patient's eye, helping the patient to visualize and fixate on this light in maintaining consistent centration.
- Patients with hyperopia have a difficult time visualizing the fixation light due to their farsightedness. Incorporating a spherical power of +2.5 D into these lenses dramatically improved their ability to clearly visualize and fixate.

All of the above features helped to improve patient fixation and to decrease anxiety, enabling a well-centered hyperopic corneal sculpting with consistent results.

Technology innovations and advances, chiefly in the field of laser technologies, flying spot applications, iris recognition, wavefront analysis, and custom ablations, will eventually pan out into a more dependable approach with laser vision surgery for hyperopia.[13, 14, 15, 16, 17]

Problem

Hyperopia generally is due to a shorter axial length or reduced corneal dioptric strength.

Epidemiology

Frequency

Various figures are given, but, generally, it is believed that hyperopia affects millions of individuals in the United States.

Etiology

Hyperopia may run in families.

Presentation

A primary finding is a reduction of vision. Near or distance vision can be affected depending on age and refractive error. With proper correction, the vision is good.

See the image below.

Clinical picture (retroillumination) showing the 3-ring ablation pattern following hyperopic LASIK.

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Indications

In this study, LASIK was used to treat 4 different groups of hyperopia, as follows:[18]

- Hyperopia with astigmatism of less than 0.75 D
- Hyperopia with astigmatism of greater than 0.75 D
- Overcorrected radial keratotomy
- Overcorrected automated lamellar keratoplasty

This article is limited to a discussion of LASIK for virgin eyes with hyperopia of less than 6.00 D and coexisting astigmatism of less than 0.75 D and the impact of the new intra-ablative lenses on the same eyes.

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Relevant Anatomy

With hyperopia, the axial length is generally shorter or the corneal dioptric strength is weaker.

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Contraindications

Contraindications for LASIK include lupus erythematous and rheumatoid arthritis.

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Treatment

Preoperative Details

This study included the first consecutive 49 eyes with preoperative hyperopia ranging from +1.25 D to +6.25 D with less than 0.75 D astigmatism and followed for 6 months postoperatively.[19] A Lambda Physik 193-nm argon fluoride excimer laser at a fluence of 130 mJ/cm² was used for these cases.[5]

Every patient underwent protocol preoperative ophthalmic tests that included a thorough slit lamp biomicroscopy, manual keratometry and autokeratometry, corneal topography, corneal pachymetry, specular microscopy, cycloplegic refraction, and recorded uncorrected and best-corrected visual acuity.[19]

Intraoperative Details

All eyes were operated on under topical anesthesia. The corneal flap was created using the Chiron automated corneal shaper after making an epithelial mark with the Gulani LASIK marker and checking the intraocular pressure with the Barraquer tonometer. The flap was deliberately decentered nasally. The flap was gently lifted and reflected on itself nasally.

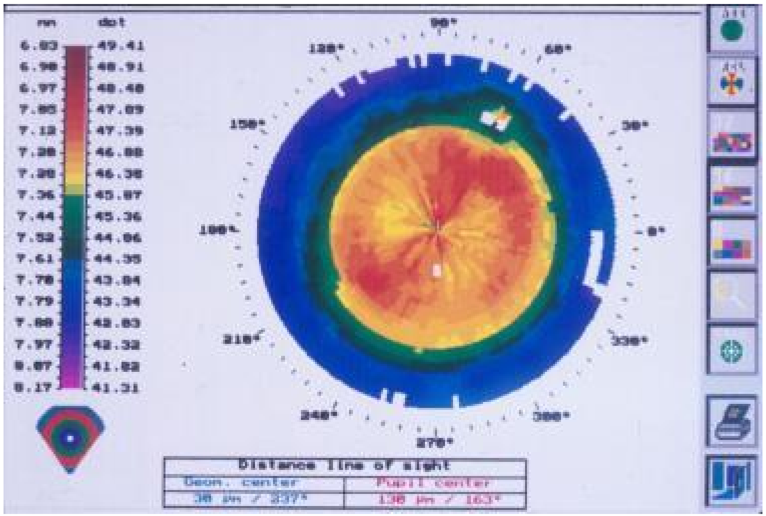
With the patient fixating at the fixation light, the Gulani triple lens marker was used to mark the anterior stroma with 3 concentric rings of 4.5-, 4-, and 3.5-mm diameters, respectively. Using a specially designed cupped lens forceps, the 4.5-mm lens was placed onto the stomal bed on the 4.5-mm mark and gently tapped into place as shown below. See the image below.

Gulani LASIK lenses.

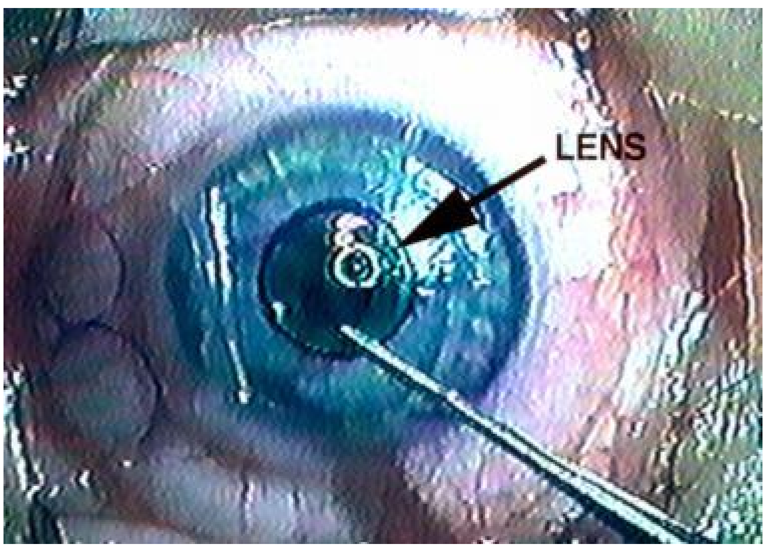
The flap hinge protector was used to prevent inadvertent ablation of the corneal flap hinge. In some cases, the globe stabilizer was used for apprehensive patients with excessive eye movements despite good visibility of the fixation light.[20] The pretested and calibrated laser performed nomogram-directed ablation with a beam diameter of 7 mm.

A suction nozzle was held close to the eye by an assistant during ablation to address the plume and other unwanted products of the laser-corneal interaction. Following this first stage of hyperopic laser ablation, the 4.5-mm lens was lifted off the cornea and replaced by a 4-mm lens, which was then centered within the ablation edge of the previous laser-corneal interaction. Ablation is continued, followed by the final stage using the 3.5-mm lens.

After completing the hyperopic ablation using these 3 lenses successively, the surgeon can appreciate the concentric ring pattern of 3 rings with smooth edges under high magnification as shown in the images below. The stromal bed is now irrigated with balanced salt solution using the Gulani triple function LASIK cannula, while the corneal flap is floated back into position in alignment with the previously placed epithelial marks. Then, the flap is squeegeed gently using the bulbous tip of the cannula and air dried at the edges for 1 minute. The flap adherence is tested by applying the striae test, and, after speculum removal, it is tested by the blink test. See the images below.



Corneal topography with central uniform steepening following hyperopic LASIK.



LASIK lens on the corneal stroma during laser ablation.

A study of 60 eyes concluded that LASIK is an effective procedure for treatment of hyperopia. Pupil-centered and vertex-centered treatments provide similar visual and optical outcomes. However, in eyes showing large temporal pupil decentration, pupil-centered ablation seemed to produce a lower amount of coma and, as a consequence, a reduced loss of BCVA compared with vertex-centered patients.[21, 22, 23]

Postoperative Details

Dry eye is common after LASIK, and over-the-counter preservative-free lubricants are important.[24, 25]

Follow-up

Patients usually are seen the day after surgery, 2 weeks after surgery, and then as needed.[9]

For excellent patient education resources, visit eMedicineHealth's Eye and Vision Center. Also, see eMedicineHealth's patient education article Vision Correction Surgery.

Complications

Complications include displaced flap, corneal perforation, interface debris, and diffuse lamellar keratitis.[24, 26]

Outcome and Prognosis

The results of hyperopic LASIK have been encouraging and relatively stable at 6 months postoperatively.[27, 28, 29] Refractive stability occurred from 1-2 weeks postoperatively and remained stable at 6 months. The results with uncorrected visual acuity were similar, with vision stabilizing from 1-2 weeks postoperative.

In this study, patients who underwent LASIK had a mean preoperative sphere of +2.6 D. Ninety percent of the eyes attained 20/40 or better postoperative unaided vision, while 50% of eyes were 20/20. These results correlated with a hyperopic LASIK report of a similar preoperative hyperopic category of patients in which 95% of eyes achieved 20/40 or better unaided vision.[27, 30] No lines of best-corrected visual acuity were lost.

In this study series, no significant haze, decentrations, central islands, irregular astigmatism, or interface deposits/inflammation were observed.[31] Epithelial ingrowth did occur in 3 cases. This epithelial ingrowth was mild and restricted to the periphery. In these cases, the corneal flaps were uniform in thickness and well aligned as were the corneal topographies.[32, 33, 34] At the 8-month postoperative gate, one of these eyes underwent flap lifting and interface cleansing. A specially designed flap lifter was used to elevate the flap without eroding the surgically steepened stromal mound.

See related CME at Corneal Ectasia Following LASIK Surgery.[35, 36]

Future and Controversies

The surgical correction of hyperopia remains a challenge and a worthy pursuit in the field of refractive surgery.[24] The basic principle of corneal surgery for hyperopic correction remains in carving a lens shape that is steeper in the center by graded removal of tissue in the periphery.[31]

The possibility of regression will continue to be a concern in such a surgical profile because of the natural or sometimes hyperplastic healing response of the cornea to fill in this ablated step between the treated and untreated zones, thereby not only resulting in loss of effect over time but also inducing an astigmatic error in case of uneven fill-ins. With the surge of technological advances and the availability of smoother ablation systems, along with microkeratomes aiding larger corneal flaps, these concerns may be addressed.[13, 14, 15, 16, 17, 37] This author has no experience with piggyback intraocular lenses.[38]

In the author's experience, LASIK is presently the treatment of choice for this grade of hyperopia.[10] A welcome surprise in the results was a simultaneous improvement in near vision associated with this hyperopic LASIK technique. An investigation occurred to check if cylinder was being induced, thereby aiding the patient's presbyopia; the investigation revealed no significant induction of cylinder. Therefore, this improvement in presbyopia could be a direct result of the corneal multifocality that results from this work. Such postablation corneal multifocality has been previously observed and reported.

This improvement is a welcome advantage in the presbyopic age group and has remained stable at the 6-month postoperative gate. Hyperopic LASIK using these intra-ablative contact lenses has been successful at the 6-month postoperative period with no loss of best-corrected visual acuity. The future of refractive surgery seems promising as a transition is predicted from corneafocused refractive surgery with its inherent variabilities toward intraocular surgery using multifocal lenses and phakic implants. [13, 14, 15, 39, 40]

At this time, the important issue is that hyperopia is finally receiving its due attention.

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References

1. Trokel SL, Srinivasan R, Braren B. Excimer laser surgery of the cornea. Am J Ophthalmol. 1983 Dec. 96(6):710-5. [Medline].
2. Waring GO 3rd. Development of a system for excimer laser corneal surgery. Trans Am Ophthalmol Soc. 1989. 87:854-983. [Medline].
3. Gulani AC. Excimer laser beam profile topography. Corneal Topography. Slack, Inc; 2005. 173-181.

4. L'Esperance FA, Taylor DM, Warner JW. Human excimer laser keratectomy: short-term histopathology. J Refract Surg. 1988. 1:118-24.

5. Seiler R, Kahle G, Kriegerowski M. Excimer laser (193 nm) myopic keratomileusis in sighted and blind human eyes. Refract Corneal Surg. 1990. 6:165-73.

6. Dausch D, Klein R, Schroder E. Excimer laser photorefractive keratectomy for hyperopia. Refract Corneal Surg. 1993 Jan-Feb. 9(1):20-8. [Medline].

7. Marshall J, Trokel S, Rothery S, Krueger RR. Photoablative reprofiling of the cornea using an excimer laser, photorefractive keratectomy. Lasers Ophthalmology. 1986. 1:21-48.

8. McDonald MB, Liu JC, Byrd TJ, et al. Central photorefractive keratectomy for myopia. Partially sighted and normally sighted eyes. Ophthalmology. 1991 Sep. 98(9):1327-37. [Medline].

9. Seiler T, Wollensak J. Myopic photorefractive keratectomy with the excimer laser. One-year follow-up. Ophthalmology. 1991 Aug. 98(8):1156-63. [Medline].

10. Ditzen K, Huschka H, Pieger S. LASIK for hyperopia. Burrato L, ed. LASIK Principles and Techniques. Slack, Inc; 1998. Vol. 22: 269-75.

11. Osama I. Laser in situ keratomileusis for hyperopia and hyperopic astigmatism. J Refract Surg. 1998. 14:181.

12. Gulani AC. Corneoplastique™. Techniques in Ophthalmology. 2007. 5(1):11-20.

13. Gulani AC. Future directions in LASIK. Corneal Refractive Surgery. Video Atlas of Ophthalmic Surgery. XLV. 2008.

14. Gulani AC. What's new in refractive surgery?. Review of Ophthalmology. 1997. 79-81.

15. Gulani AC, Holladay J, Belin M, et al. Future technologies in LASIK- Pentacam advanced diagnostic for laser vision surgery. Experts Review of Ophthalmology. London: In press; 2008.

16. Gulani AC. Pentacam technology in LASIK. Corneal Refractive Surgery. Video Atlas of Ophthalmic Surgery. XVII. (2). 2008.

17. Gulani AC, Probst L, Cox I, et al. Zyoptix: the Bausch & Lomb wavefront platform. Ophthalmol Clin North Am. 2004 Jun. 17(2):173-81, vi. [Medline].

18. Gulani AC. LASIK in four types of ametropia. Ann Ophthalmol. 1998. 30:135-6.

19. Gulani AC, Alio J, et al. Abnormal preoperative topography in refractive surgery complications. Cataract and Refractive Surgery Today. 2007. 7(2):37-42.

20. Gulani AC. Its a matter of control: The Gulani LASIK globe stabilizer and flap restrainer. Asico Vision News. 1998. 5:1:1-2.

21. Soler V, Benito A, Soler P, et al. A randomized comparison of pupil-centered versus vertex-centered ablation in LASIK correction of hyperopia. Am J Ophthalmol. 2011 Oct. 152(4):591-599.e2. [Medline].

22. Antonios R, Arba Mosquera S, Awwad ST. Hyperopic laser in situ keratomileusis: Comparison of femtosecond laser and mechanical microkeratome flap creation. J Cataract Refract Surg. 2015 Aug. 41 (8):1602-9. [Medline].

23. Saib N, Abrieu-Lacaille M, Berguiga M, Rambaud C, Froussart-Maille F, Rigal-Sastourne JC. Central PresbyLASIK for Hyperopia and Presbyopia Using Micro-monovision With the Technolas 217P Platform and SUPRACOR Algorithm. J Refract Surg. 2015 Aug. 31 (8):540-6. [Medline].

24. Gulani AC, McDonald M, Majmudar P, et al. Meeting the challenge of post-RK patients. Review of Ophthalmology. 2007. 4(10):49-54.

25. Gulani AC, Probst L. Cons of presbyopic LASIK. LASIK: Advances, Controversies & Custom. Slack, Inc; 2004. 32B: 367-9.

26. Neumann AC, Gulani AC. Lamellar surgery: counterpoint and complications. Elander R, ed. Textbook of Refractive Surgery. WB Saunders; 1997. Vol. 24: 291-7.

27. Gulani AC, Neumann AC. LASIK gets good results with difficult hyperopia cases. Ophthalmol Times. 1997. 22:13.

28. Plaza-Puche AB, Yebana P, Arba-Mosquera S, Alió JL. Three-Year Follow-up of Hyperopic LASIK Using a 500-Hz Excimer Laser System. J Refract Surg. 2015 Oct 1. 31 (10):674-82. [Medline].

29. Schallhorn JM, Schallhorn SC, Ou Y. Factors that influence intraocular pressure changes after myopic and hyperopic LASIK and photorefractive keratectomy: a large population study. Ophthalmology. 2015 Mar. 122 (3):471-9. [Medline].

30. Zabel RW, Sher NA, Ostrov CS, et al. Myopic excimer laser keratectomy: a preliminary report. Refract Corneal Surg. 1990 Sep-Oct. 6(5):329-34. [Medline].

31. Gulani AC. Principles of surgical treatment of irregular astigmatism in unstable corneas. Irregular Astigmatism: Diagnosis and Treatment. Thorofare, NJ: Slack, Inc; 2007. 251-261.

32. Hersh PS, Schwartz-Goldstein BH. Corneal topography of phase III excimer laser photorefractive keratectomy. Characterization and clinical effects. Summit Photorefractive Keratectomy Topography Study Group. Ophthalmology. 1995 Jun. 102(6):963-78. [Medline].

33. Hersh PS, Shah SI. Corneal topography of excimer laser photorefractive keratectomy using a 6-mm beam diameter. Summit PRK Topography Study Group. Ophthalmology. 1997 Aug. 104(8):1333-42. [Medline].

34. Lin DT, Sutton HF, Berman M. Corneal topography following excimer photorefractive keratectomy for myopia. J Cataract Refract Surg. 1993. 19 Suppl:149-54. [Medline].

35. Mertens E, Gulani AC. Post-LASIK corneal ectasia. Mastering the Techniques of Customized LASIK. J.P. Publishers; 2007. 31: 284-293.

36. Gulani AC, Mertens E, Karpecki P. Indices for corneal ectasia in LASIK surgery. Corneal Topography. Slack, Inc; 2005. 173-181.

37. Gulani AC. Refractive tool time. LASIK flap instruments: the rush is on. Eyeworld. 1997. 2:38.

38. Gulani AC. Piggyback intraocular lenses. Ann Ophthalmol. 1998. 30:205-6.

39. Gulani AC. Intraocular phakic lenses in myopia. Nordan L, ed. Practical Atlas of Refractive Surgery. Raven Press (In press);

40. Gulani AC, Wang M. Future of corneal topography. Corneal Topography in the Wavefront Era. Thorofare, NJ: Slack, Inc; 2006. 26: 303-304.

41. Dierick FL, Missotten T. Is the corneal contour influenced by a tension in the superficial epithelial cells? a new hypothesis. Refract Corneal Surg. 1996. 8:54-9.

42. Gulani AC, et al. Innovative real-time illumination system for LASIK surgery. Journal of the Canadian Society of Cataract and Refractive Surgery. 2003. 1/21, 6:244-6.