EXCIMER LASER CORRECTION OF HYPEROPIA, HYPEROPIC AND MIXED ASTIGMATISM: PAST, PRESENT, AND FUTURE

Adrian Lukenda[1], Željka Karaman Martinović[1] and Miro Kalauz[2]

[1]Opto Centar Eye Clinic; [2]University Department of Ophthalmology, Zagreb University Hospital Center, Zagreb, Croatia

SUMMARY – The broad acceptance of "spot scanning" or „flying spot" excimer lasers in the last decade has enabled the domination of corneal ablative laser surgery over other refractive surgical procedures for the correction of hyperopia, hyperopic and mixed astigmatism. This review outlines the most important reasons why the ablative laser correction of hyperopia, hyperopic and mixed astigmatism for many years lagged behind that of myopia. Most of today's scanning laser systems, used in the LASIK and PRK procedures, can safely and effectively perform low, moderate and high hyperopic and hyperopic astigmatic corrections. The introduction of these laser platforms has also significantly improved the long term refractive stability of hyperopic treatments. In the future, further improvements in femtosecond and nanosecond technology, eye-tracker systems, and the development of new customized algorithms, such as the ray-tracing method, could additionally increase the upper limit for the safe and predictable corneal ablative laser correction of hyperopia, hyperopic and mixed astigmatism.

Key words: *Hyperopic astigmatism; Hypermetropia; Astigmatism; Excimer laser; Laser in situ keratomileusis (LASIK); Photorefractive keratectomy (PRK); Spot scanning; Flying spot; Laser*

Introduction – The Past

Three decades after the first experimental treatment with argon fluoride excimer laser in 1983, corneal ablative laser surgery has become one of the most popular surgical treatment modalities for the correction of refractive errors, such as myopia, hyperopia and astigmatism[1]. The 193-nm ultraviolet excimer laser beams have an exceptional property – they are able to ablate very small amounts of tissue with an almost negligible thermal effect and minimal damage to the surrounding tissue.

Until the advent of the modern "slit scanning" and "spot scanning" excimer lasers, the results of the earlier corneal surgical procedures for correcting hyperopia, hyperopic and mixed astigmatism were unsatisfactory[2]. One of the earliest methods was keratomileusis, as proposed by Barraquer, which involved performing central lamellar keratectomy. The resected disk was shaped using the cryolathe and sutured back in place. A less demanding procedure was keratophakia, where the reshaped donor corneal lenticule was inserted intrastromally[3,4]. The procedure was later abandoned because of the unsatisfactory results. Further developments led to the emergence of epikeratoplasty, in which the donor lenticule was sutured on the mostly intact Bowman layer and corneal stroma[5]. Due to the poor predictability, this technique was also abandoned. Despite initial promising results, hexagonal keratotomy, named after the six paracentral corneal incisions used to make central cornea steeper, was later abandoned due to the glare, photophobia, fluctuating vision and

Correspondence to: *Adrian Lukenda, MD*, Opto Centar Eye Clinic, Vlaška 64, HR-10000 Zagreb, Croatia
E-mail: alukenda@opto-centar.hr

Received February 22, 2012, accepted June 1, 2012

polyopia that often caused irregular astigmatism[6,7]. In the automated lamellar keratoplasty, steepening of the cornea was achieved with a deep microkeratome cut, leaving behind a thin corneal bed and consequently a small amount of ectasia and steepening. This technique is not used any more because of the poor predictability and the development of progressive ectasia in some patients[8].

Other corneal surgical procedures for the correction of hyperopia and hyperopic astigmatism are still being used and additionally developed. Corneal relaxing incisions, such as astigmatic keratotomy and limbal relaxing incisions, are generally used to treat hyperopic astigmatism in combination with lenticular procedures[9,10]. The intracorneal artificial lenses that are implanted intrastromally have the advantage of being reversible. However, in the initial trials some intracorneal lenses had to be removed because of significant regression and/or formation of epithelial cysts[11,12]. Over the past decades, there were many attempts to treat hyperopia and hyperopic astigmatism by heating the peripheral cornea. In laser thermal keratoplasty, heating is achieved through the use of light from the holmium:YAG or continuous-wave diode laser to induce collagen shrinkage in the stroma[13,14]. Shrinkage can also be achieved through transfer of the radiofrequency energy into the stroma, as in conductive keratoplasty[15]. Despite the excellent safety profile, the stability of these methods has yet to be assessed in long term studies. Other viable options for surgical correction of hyperopia that are beyond the scope of this review include implantation of phakic intraocular lenses and lens exchange modalities[16,17].

Since the first photorefractive keratectomies (PRK) were performed on human eyes by McDonald *et al.* and Seiler *et al.* in 1987 and 1988, the excimer laser treatments of myopia have become the mainstream of refractive surgery[18,19]. The PRK treatment has become a representative of all the corneal surface ablation procedures. Depending on how the epithelium is removed, these procedures include laser-assisted subepithelial keratectomy (LASEK), transepithelial PRK and Epi-LASIK. The positive trend in laser ablative procedures was further facilitated by the introduction of laser-assisted in situ keratomileusis (LASIK) by Ioannis Pallikaris and colleagues in 1990. Today, LASIK is the most common corneal refractive surgery for the correction of myopia[20].

Obstacles to successful ablative laser correction of hyperopia, mixed and hyperopic astigmatism

Until recently, the corneal ablative laser correction of hyperopia, mixed astigmatism and hyperopic astigmatism has lagged behind that of myopia[2]. The reasons for that are numerous.

Unlike myopia, the effect of hyperopia on visual acuity depends on the available accommodative amplitude, which varies between different age groups[21]. In younger patients, between the ages of 22 and 39, the mean difference in refraction, measured before and after the pharmacologically induced cycloplegia, is greater than the difference in older patients[22]. Thus, the exact dioptric power that should be treated is much more difficult to determine in a hyperope than it is in a myope. In addition, translating the correction from the spectacle plane onto the cornea makes the retinal image smaller, which can cause a loss of 2 to 4 letters on the Snellen chart in a +5 hyperope[23].

Visual acuity can be influenced by the multifocality of the eye optics. Along with the spherical aberration and pupil size, astigmatism can also contribute to the multifocality. With the ability of today‘s excimer lasers to correct not only astigmatism but also higher order aberrations, laser treatments should be carefully chosen to suit each eye.

There is still no consensus among refractive surgeons about the amount and axis of astigmatism that should be treated if there is a significant discrepancy between the corneal and total astigmatism. Methods that include vector analysis of astigmatism of the cornea and total refractive correction can help in outcome analysis and improve the results of refractive surgeries[24]. In addition, the current, simplified formulas from paraxial optics also fail to take into consideration the multiple lens structure of the eye, which could be addressed by the laser ablation profiles based on optical ray-tracing algorithms[25].

Technical obstacles

The laser ablation treatment profiles for hyperopia, mixed and hyperopic astigmatism are more complex than the myopic profiles. The tissue is removed from the midperipheral area, thus creating a steeper central area with the increased optical power. For the simple hyperopic treatment, the ablation is performed in annular fashion. For the compound hyperopic and mixed astigmatism, reduced ablation depths can be achieved by hyperopic cylindrical and/or combined cylindrical treatment strategies. Older laser systems which use treatment strategies with the minus cylinder ablation profile should be avoided in the treatment of hyperopic astigmatism because of the greater ablation depths[26].

Optical zone and treatment zone sizes are critical for the efficacy of the treatment. The designs of the optical zone and two transitional zones should avoid abrupt steps on the corneal surface, which could lead to the regression due to epithelial hyperplasia, especially in treatments with smaller optical zones[27]. The corneal eccentricity should be kept within physiological limits. Highly positive eccentricity values of more than 1.2 following hyperopic laser ablation could lead to corneal scars at the point of maximal corneal curvature[8]. In contrast to the hyperopic PRK treatment, the corneal flap in LASIK does not fully follow the shape of hyperopic treatment, thus reducing the risk of scarring and regression due to epithelial hyperplasia. Treating corneas with high eccentricity values and inadequate transition zones can cause symptoms of glare and halos in people with wider pupils. Therefore, hyperopic treatments should be performed with the optical zones of more than 5.5 mm and with transition zones of 9 mm, which can be achieved with more advanced laser systems and creation of larger diameter flaps[2,28].

Centration and symmetry of the treatments are essential in preventing secondary astigmatism and higher-order aberrations, coma in particular. Steeper corneas are more affected by decentration. In order to avoid fixation loss during the treatment, the new laser systems utilize eye-tracker systems. There is still no consensus whether to use the entrance pupil center or the corneal vertex as a reference for the centration of laser treatment in hyperopic eyes[29]. To avoid the undercorrection in the eyes with mixed or hyperopic astigmatism, cyclotorsional movements should also be taken into account. The compensation of cyclotorsion can be static and/or dynamic, as with the iris-recognition based systems.

Excimer Laser Systems – The Present

Most of the excimer laser platforms in use today have overcome the drawbacks of the early broad beam lasers. The beam diameter of broad beam lasers ranged from 6 to 8 millimeters. These lasers were controlled by the aperture mechanisms and were not suitable for the complex hyperopic and astigmatic ablation profiles.

The more advanced scanning excimer lasers can be divided in two categories: the slit scanning and spot scanning lasers. The slit scanning lasers use a rotational device with the slitholes that enlarge. However, most of laser systems used for the correction of hyperopia are spot scanning lasers, often referred to as „flying spot“ lasers. These lasers use small beams of 0.8 to 2 millimeters. The beams are scanned across the cornea with a high repetitive rate creating a smoother ablation within a smaller amount of time, thus reducing the influence of a drying cornea on the final result. The spot scanning technology has significantly improved the outcomes for the more complex and customized ablation profiles for hyperopia and astigmatism.

Due to the limited number of randomized clinical trials and variations in study designs and protocols, such as different range of treatment, nomograms, follow-up periods and microkeratomes, it is difficult to compare the safety, efficacy, and refractive stability of hyperopia, mixed and hyperopic astigmatism treatments performed on different laser systems[2]. A brief overview of scanning excimer lasers approved by the U.S. Food and Drug Administration (FDA) from 2000 to 2011 is given in Table 1.

Scanning excimer lasers can safely and effectively perform low, moderate, and high hyperopic and hyperopic astigmatic corrections with the results comparable to the ones obtained when performing myopic corrections[30,31]. However, care must be taken with hyperopic treatments greater than +5.00 diopter with astigmatism of more than 1.00 diopter because of the lower predictability and greater risk of postoperative loss of one or more lines of the spectacle-corrected visual acuity[30,32]. In the high hyperopia/astigmatism group, there was also a significant increase in higher order aberrations. No significant change in higher order aberrations was noted in groups with low to moderate amounts of hyperopia and hyperopic astigmatism[30]. The introduction of new laser systems has

Table 1. Food and Drug Administration approved lasers for LASIK treatment of hyperopia, hyperopic and mixed astigmatism 2000-2011

Device name and type	Indication	Company	Year of approval
MEDITEC MEL 80 Excimer Laser System (scanning spot beam)	Hyperopia up to +5.00 D and astigmatism from +0.50 D to +3.00 D with a maximum MRSE of +5.00 D	Carl Zeiss, Inc.	2006, 2011
Star S4 IR Excimer Laser System with Wavescan System VISX Star Excimer Laser System (variable scanning spot beam)	Hyperopia up to +3.00 D and astigmatism up to +2.00 D Mixed astigmatism up to 5.00 D	VISX, Inc.	2001, 2003, 2004, 2005, 2007
Nidek EC-5000 Excimer Laser System (scanning slit beam)	Hyperopia +0.50 to +5.00 D and astigmatism up to +2.00 D	Nidek, Inc.	2000, 2006
Wavelight Allegretto Wave Excimer Laser System (scanning spot beam with gaussian profile)	Hyperopia up to +6.00 D and astigmatism up to +5.00 D with a maximum MRSE of +6.00 D Mixed astigmatism up to 6.00 D	Alcon, Inc. / Wavelight	2003, 2006
LADARVision 4000/6000 Excimer Laser System LADARVision Excimer Laser System (scanning spot beam)	Hyperopia and hyperopic astigmatism: up to +5.00 D	Alcon Laboratories, Inc.	2000, 2002, 2004, 2006
TECHNOLAS 217Z Zyoptix System TECHNOLAS 217A Excimer Laser System (scanning spot beam)	Hyperopia up to +4.00 D and astigmatism up to +2.00 D	Bausch & Lomb Surgical, Inc.	2000, 2002, 2003

D = diopter; MRSE = manifest refraction spherical equivalent. Source: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/SurgeryandLifeSupport/LASIK/ucm192109.htm, accessed February 5, 2012.

also significantly improved the long term refractive stability of hyperopic treatments[33].

In recent years, another laser platform, not approved by the FDA, is showing promising results. Despite the increase in the postoperative ocular and corneal higher order aberrations, hyperopic LASIK treatments on the Esiris excimer laser (SCHWIND eye-tech-solutions) have been shown to be safe and effective[34].

The Future of Corneal Ablative Laser Surgery

The expansion of scanning laser delivery systems during the last decade enabled the domination of corneal ablative laser surgery over other refractive surgical procedures for correction of hyperopia, hyperopic and mixed astigmatism[35]. The development of customized wavefront-guided treatments has improved the results in the eyes with high preexisting higher order aberrations. However, a recent meta-analysis of randomized controlled trials showed no clear benefit in the efficacy, predictability and safety of wavefront-guided over the non wavefront-guided ablations[36].

The new generation of mechanical microkeratomes and femtosecond lasers enabled the creation of LASIK flaps, with a diameter of 9 millimeters or more, with excellent safety profiles. The femtosecond lasers could have the advantage over the mechanical microkeratomes in wavefront-guided LASIK because the planar flaps created by femtosecond lasers do not cause significant increase in higher order aberrations[37]. In the future, the femtosecond and nanosecond lasers could also be used to reshape the cornea and create hyperopic treatment profiles. Further contribution to the safety and predictability of hyperopic and astigmatic treatments could come from faster and more comprehensive eye-tracker systems[38].

The additional improvements in customized treatments could also prove beneficial, especially in the treatment of hyperopic and mixed astigmatism. The current customized treatments are based on a single diagnostic method, corneal topography or ocular wavefront, and depend on approximations[39]. The optical ray-tracing method uses data from ocular wavefront, topography and biometry measurements for every optically relevant structure of the eye. These data are then used to create an individual eye model from which the final custom ablation profile is derived. Recent studies report encouraging results of ray tracing-guided LASIK in the treatment of moderate to high myopic astigmatism[25]. In the future, similar algorithms could further increase the upper limits for the safe and predictable corneal ablative laser correction of hyperopia, hyperopic and mixed astigmatism.

References

1. TROKEL SL, SRINIVASAN R, BRAREN B. Excimer laser surgery of the cornea. Am J Ophthalmol 1983;96:710-5.
2. VARLEY GA, HUANG D, RAPUANO CJ, SCHALLHORN S, BOXER WACHLER BS, SUGAR A; Ophthalmic Technology Assessment Committee Refractive Surgery Panel, American Academy of Ophthalmology. LASIK for hyperopia, hyperopic astigmatism, and mixed astigmatism: a report by the American Academy of Ophthalmology. Ophthalmology 2004;111:1604-17.
3. BARRAQUER JI. Keratophakia. Trans Ophthalmol Soc U K 1972;92:499-516.
4. BARRAQUER JI. Results of hypermetropic keratomileusis, 1980-1981. Int Ophthalmol Clin 1983;23:25-44.
5. WERBLIN TP, KAUFMAN HE, FRIEDLANDER MH, SEHON KL, McDONALD MB, GRANET NS. A prospective study of the use of hyperopic epikeratophakia grafts for the correction of aphakia in adults. Ophthalmology 1981;88:1137-40.
6. GRADY FJ. Hexagonal keratotomy for corneal steepening. Ophthalmic Surg 1988;19:622-3.
7. BASUK WL, ZISMAN M, WARING GO 3rd, WILSON LA, BINDER PS, THOMPSON KP, GROSSNIKLAUS HE, STULTING RD. Complications of hexagonal keratotomy. Am J Ophthalmol 1994;117:37-49.
8. ANSARI EA, MORRELL AJ, SAHNI K. Corneal perforation and decompensation after automated lamellar keratoplasty for hyperopia. J Cataract Refract Surg 1997;23:134-6.
9. MÜLLER-JENSEN K, FISCHER P, SIEPE U. Limbal relaxing incisions to correct astigmatism in clear corneal cataract surgery. J Refract Surg 1999;15:586-9.
10. BUCKHURST PJ, WOLFFSOHN JS, DAVIES LN, NAROO SA. Surgical correction of astigmatism during cataract surgery. Clin Exp Optom 2010;93:409-18. doi: 10.1111/j.1444-0938.2010.00515.x. Epub 2010 Aug 24.
11. BARRAQUER JI, GOMEZ ML. Permalens hydrogel intracorneal lenses for spherical ametropia. J Refract Surg 1997;13:342-8.
12. ISMAIL MM. Correction of hyperopia with intracorneal implants. J Cataract Refract Surg 2002;28:527-30.
13. THOMPSON VM. Holmium:YAG laser thermokeratoplasty for correction of astigmatism. J Refract Corneal Surg 1994;10:S293.
14. KOCH DD, KOHNEN T, McDONNELL PJ, MENEFEE R, BERRY M. Hyperopia correction by noncontact holmium:YAG laser thermal keratoplasty: U.S. phase IIA clinical study with 2-year follow-up. Ophthalmology 1997;104:1938-47.
15. McDONALD MB and the Conductive Keratoplasty United States Investigators Group. Conductive keratoplasty for the correction of low to moderate hyperopia: U.S. clinical trial one-year results on 355 eyes. Ophthalmology 2002;109:1978-89.
16. FECHNER PU, SINGH D, WULFF K. Iris-claw lens in phakic eyes to correct hyperopia: preliminary study. J Cataract Refract Surg 1998;24:48-56.
17. ROSEN E, GORE C. Staar Collamer posterior chamber phakic intraocular lens to correct myopia and hyperopia. J Cataract Refract Surg 1998;24:596-606.
18. McDONALD MB, KAUFMAN HE, FRANTZ JM, SHOFNER S, SALMERON B, KLYCE SD. Excimer laser ablation in a human eye. Case report. Arch Ophthalmol 1989;107:641-2.
19. SEILER T, BENDE T, WOLLENSAK J, TROKEL S. Excimer laser keratectomy for correction of astigmatism. Am J Ophthalmol 1988;105:117-24.
20. SUGAR A, RAPUANO CJ, CULBERTSON WW, *et al.* Laser in situ keratomileusis for myopia and astigmatism: safety and efficacy: a report by the American Academy of Ophthalmology. Ophthalmology 2002;109:175-87.
21. DUANE A. An attempt to determine the normal range of accommodation at various ages, being a revision of Donder's experiments. Trans Am Ophthalmol Soc 1908;11(Pt 3):634-41.
22. KRANTZ EM, CRUICKSHANKS KJ, KLEIN BE, KLEIN R, HUANG GH, NIETO FJ. Measuring refraction in adults in epidemiological studies. Arch Ophthalmol 2010;128:88-92.
23. SMOLEK MK, KLYCE SD. Basic optics of hyperopia and presbyopia. In: TSUBOTA K, WACHLER BS, AZAR DT, KOCH DD, editors. Hyperopia and presbyopia. New York, NY: Marcel Dekker, Inc., 2003:17-26.

24. ALPINS NA, GOGGIN M. Practical astigmatism analysis for refractive outcomes in cataract and refractive surgery. Surv Ophthalmol 2004;49:109-22.
25. SCHUMACHER S, SEILER T, CUMMINGS A, MAUS M, MROCHEN M. Optical ray tracing-guided laser in situ keratomileusis for moderate to high myopic astigmatism. J Cataract Refract Surg 2012;38:28-34. Epub 2011 Oct 26.
26. AZAR DT, PRIMACK JD. Theoretical analysis of ablation depths and profiles in laser in situ keratomileusis for compound hyperopic and mixed astigmatism. J Cataract Refract Surg 2000;26:1123-36.
27. MALONEY RK, FRIEDMAN M, HARMON T, HAYWARD M, HAGEN K, GAILITIS RP, WARING GO 3rd. A prototype erodible mask delivery system for the excimer laser. Ophthalmology 1993;100:542-9.
28. VINCIGUERRA P, CAMESASCA FI. Surgical treatment options for hyperopia and hyperopic astigmatism. In: TSUBOTA K, WACHLER BS, AZAR DT, KOCH DD, editors. Hyperopia and presbyopia. New York, NY: Marcel Dekker, Inc., 2003:69-82.
29. SOLER V, BENITO A, SOLER P, TRIOZON C, ARNÉ JL, MADARIAGA V, ARTAL P, MALECAZE F. A randomized comparison of pupil-centered *versus* vertex-centered ablation in LASIK correction of hyperopia. Am J Ophthalmol 2011;152:591-599.e2. Epub 2011 Jul 2.
30. KANELLOPOULOS AJ, CONWAY J, PE LH. LASIK for hyperopia with the WaveLight excimer laser. J Refract Surg 2006;22:43-7.
31. WATSON SL, BUNCE C, ALLAN BD. Improved safety in contemporary LASIK. Ophthalmology 2005;112:1375-80.
32. ARBELAEZ MC, KNORZ MC. Laser in situ keratomileusis for hyperopia and hyperopic astigmatism. J Refract Surg 1999;15:406-14.
33. KEZIRIAN GM, MOORE CR, STONECIPHER KG; SurgiVision Consultants Inc. WaveLight Investigator Group. Four-year postoperative results of the US ALLEGRETTO WAVE clinical trial for the treatment of hyperopia. J Refract Surg 2008;24:S431-8.
34. ALIÓ JL, PIÑERO DP, ESPINOSA MJ, CORRAL MJ. Corneal aberrations and objective visual quality after hyperopic laser in situ keratomileusis using the Esiris excimer laser. J Cataract Refract Surg 2008;34:398-406.
35. DUFFEY RJ, LEAMING D. US trends in refractive surgery: 2003 ISRS/AAO survey. J Refract Surg 2005;21:87-91.
36. FARES U, SULEMAN H, Al-AQABA MA, OTRI AM, SAID DG, DUA HS. Efficacy, predictability, and safety of the wavefront-guided refractive laser treatment: meta-analysis. J Cataract Refract Surg 2011;37:1465-75.
37. TRAN DB, SARAYBA MA, BOR Z, GARUFIS C, DUH YJ, SOLTES CR, JUHASZ T, KURTZ RM. Randomized prospective clinical study comparing induced aberrations with IntraLase and Hansatome flap creation in fellow eyes: potential impact on wavefront-guided laser in situ keratomileusis. J Cataract Refract Surg 2005;31:97-105.
38. ARBA MOSQUERA S, ARBELAEZ MC. Use of a six-dimensional eye-tracker in corneal laser refractive surgery with the SCHWIND AMARIS TotalTech laser. J Refract Surg 2011;27:582-90. doi: 10.3928/1081597X-20110120-02. Epub 2011 Feb 1.
39. MANNS F, HO A, PAREL JM, CULBERTSON W. Ablation profiles for wavefront-guided correction of myopia and primary spherical aberration. J Cataract Refract Surg 2002;28:766-74.

Sažetak

ISPRAVLJANJE HIPEROPIJE, HIPEROPIČNOG I MIJEŠANOG ASTIGMATIZMA EXCIMER LASEROM: JUČER, DANAS I SUTRA

A. Lukenda, Ž. Karaman Martinović i *M. Kalauz*

Široka rasprostranjenost nove generacije „*spot scanning*“ excimer lasera, odnosno lasera s pomičnom točkastom zrakom, omogućila je u posljednjih deset godina dominaciju laserske ablacijske kirurgije rožnice u korekciji dalekovidnosti, dalekovidnog i miješanog astigmatizma nad drugim refrakcijskim kirurškim postupcima. U članku su navedeni najvažniji razlozi zbog kojih je laserska kirurgija rožnice u ispravljanju dalekovidnosti, dalekovidnog i miješanog astigmatizma niz godina zaostajala za laserskim ispravljanjem kratkovidnosti. Većina današnjih lasera temeljenih na navedenoj tehnologiji omogućuje sigurno i učinkovito ispravljanje niskih, srednjih i visokih dalekovidnosti i astigmatizama uz pomoć postupaka LASIK i PRK. Uvođenje ovih laserskih sustava također je unaprijedilo i dugoročnu stabilnost rezultata nakon tretmana. Može se očekivati da će daljnji napredak u femtosekundnoj i nanosekundnoj tehnologiji, sustavima za praćenje pokreta oka, te razvoj novih individualiziranih algoritama poput metode “*ray-tracing*” u budućnosti pomaknuti današnje granice sigurne i predvidljive ablacijske laserske korekcije dalekovidnosti, kao i dalekovidnog i miješanog astigmatizma.

Ključne riječi: *Hipermetropni astigmatizam; Dalekovidnost; Astigmatizam; Excimer laser; Laserska in situ keratomileuza (LASIK); Fotorefrakcijska keratektomija (PRK); Točkasta zraka; Laser*