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Overview of Refractive Surgery

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A more recent article on LASIK is available (https://www.aafp.org/afp/2017/0515/p637.html).

See patient information handout on refractive surgery (https://www.aafp.org/afp/2001/1001/p1193.html), written by the authors of this article.

Patients with myopia, hyperopia and astigmatism can now reduce or eliminate their dependence on contact lenses and eyeglasses through refractive surgery that includes radial keratotomy (RK), photorefractive keratectomy (PRK), laser-assisted in situ keratomileusis (LASIK), laser thermal keratoplasty (LTK) and intrastromal corneal rings (ICR). Since the approval of the excimer laser in 1995, the popularity of RK has declined because of the superior outcomes from PRK and LASIK. In patients with low-to-moderate myopia, PRK produces stable and predictable results with an excellent safety profile. LASIK is also efficacious, predictable and safe, with the additional advantages of rapid vision recovery and minimal pain. LASIK has rapidly become the most widely performed refractive surgery, with high patient and surgeon satisfaction. Noncontact Holium: YAG LTK provides satisfactory correction in patients with low hyperopia. ICR offers patients with low myopia the potential advantage of removal if the vision outcome is unsatisfactory. Despite the current widespread advertising and media attention about laser refractive surgery, not all patients are good candidates for this surgery. Family physicians should be familiar with the different refractive surgeries and their potential complications.

Extensive television, radio and newspaper advertising have promoted laser vision correction, and the public has a variety of refractive procedures from which to choose. Because of this media attention, many patients will be asking their family physician about these procedures. Family physicians

shou d be familiar th the ndicat ons and contraind cations of the refractive procedures, as well as the results, follo -up courses and potential complications.

Anatomy of the Cornea

The t ansparent cornea s about 0 5 mm thick, w th five d stinct laye s the epithelium Bowman's membrane, stroma, endothelium and Descemet's membrane The epithelium s the most exter or layer, prov ding the smooth refract ve s rface and serv g as a barr e aga st infection The function of Bowman's membrane wh ch lies beneath the epithelium and its basement membrane is unclear. The st oma, ade p of tertw ing la ellae of collage fibr s p ovides st uctu e to the cornea and accounts for 90 percent of the corneal thickness. The endothelium and its basement membrane (Descemet s me brane) form the inne most layers E dothelial cells, via an active sod m potassium–adenosine triphosphatase pump, are respons ble for the relative corneal dehydration necessary for co neal cla ity

Optics, Refract on and Refractive Error

Refract on is the bending of light rays as they pass from one transparent med um to another medium of a different dens ty; t is measured in diopters. The refract ve power of a lens is the reciprocal of ts foca ength measured in meters (e g., a one-diopter lens has a foca point of 1 m; a two-diopter lens has a focal length of 0.5 m). The cornea and the crysta ne lens refract light that enters the eye. The cornea is responsible for two thirds of the eye's total focus ng po er wh e the crystalline lens accounts for the remain ng one third The focusing power of the cornea is fixed whereas the focusing power of the crystalline ens is not Through a process ca ed accommodation, the lens changes its shape to br ng ob ects into focus.

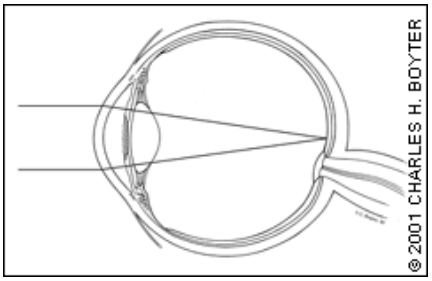
In emmetropia (an eye with normal vision , the focusing powers of the cornea and the lens are perfectly matched to the length of the g obe. When a person with normal vision acuity v e s an object the cornea and the lens focus the para e ght rays emitted from the object precisely on the retina (*Figure 1a*), and a clear mage s perceived. The eye's focal po nt is at nfinity.

Refract ve errors occur when the cornea and the ens do not properly focus the ght rays on the retina. In myopia (nearsightedness , the most common type of refractive error, the cornea is too curved or the ens too powerful for the length of the globe. D stant objects cannot be seen clear y because ght rays are focused in front of the retina (*Figure 1b*) however, near objects appear clear

Concave lenses with minus or divergent power correct this refractive error and refocus the light rays on the correct point on the retina.

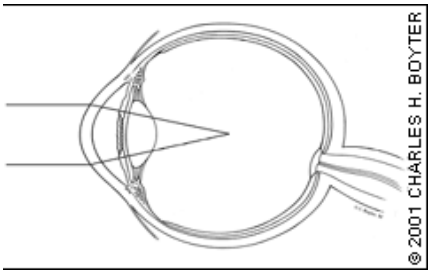
In hyperopia (farsightedness), the cornea is too flat or the lens too weak for the length of the globe. As a result, the cornea and lens focus the light rays behind the retina *(Figure 1c)*. The process of accommodation may bring a distant object into focus; however, near vision is unclear. Convex lenses with plus or convergent power correct this refractive error and refocus the light rays to the correct point on the retina.

FIGURE 1A.



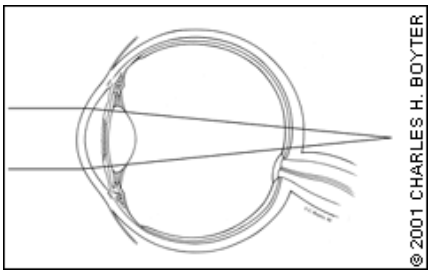
The emmetropic eye.

FIGURE 1B.



The myopic eye.

FIGURE 1C.



The hyperopic eye.

In astigmatism, the refractive power of the eye is different in different meridians. The cornea and the lens cannot bring the light rays to the precise point on the retina to provide clear vision; thus, objects will appear blurry at any distance. Astigmatism may occur with myopia or hyperopia.

Refractive Surgery

Radial keratotomy (RK), photorefractive keratectomy (PRK), laser-assisted in situ keratomileusis (LASIK), laser thermal keratoplasty (LTK) and intrastromal corneal rings (ICR) are the most common refractive surgeries presently performed in the United States in the treatment of patients with myopia, hyperopia and astigmatism. The object of these procedures is to change the refractive state of the eye by changing the shape of the cornea.

RADIAL KERATOTOMY

In the past, RK was performed to treat patients with myopia. The surgeon makes a number of microscopic corneal incisions in a radial or spoke-like pattern. This allows the outer cornea to relax so that the central cornea flattens (*Figure 2*). The new shape of the cornea is permanently retained as the cornea heals.

Potential serious complications include loss of best-corrected vision acuity, perforation of the cornea, infection and rupture of the globe. Some of the major concerns with this procedure relate to the significant corneal instability induced by the surgery, including diurnal fluctuation of refractive error, overcorrection, hyperopic shift and potential rupture of the globe with blunt trauma.[1] This procedure has declined in popularity since 1995, when the U.S. Food and Drug Administration (FDA) approved the use of the excimer laser, and because of the superior results of the other commonly performed refractive surgeries.

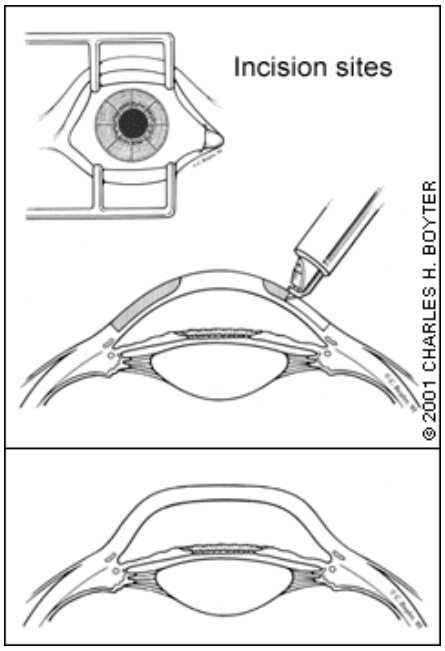
THE EXCIMER LASER

The excimer laser is used to perform PRK and LASIK procedures and works by changing the shape of the cornea. The excimer laser emits an ultraviolet beam that has sufficient energy to break intermolecular bonds within the cornea (photoablation). Because little or no thermal damage occurs to adjacent tissue, this is often referred to as a “cool” laser beam. A computer, programmed with the

patient's refraction and corneal topography, controls the laser beam to precisely remove corneal tissue.[2] With improving technology, the width of the laser beam has continued to decrease to less than 100μ. In addition, laser eye-tracking systems are now available that allow precision corneal ablation during eye movements.[3]

In myopia, the laser flattens the central cornea to decrease its focusing power. In hyperopia, the laser indirectly steepens the central cornea by removing tissue from the periphery, thus increasing the cornea's focusing power. Astigmatism is treated with an elliptic or cylindrical beam that flattens the steepest corneal meridian (*Figure 3*).

FIGURE 2.



Radial keratotomy. (Top) Partial-thickness incisions of the cornea. (Bottom) Compensatory flattening of the central cornea.

FIGURE 3.

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