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Refractive Surgery

Helen Wu, MD, Assistant Professor of Ophthalmology, Tufts University Medical School, Boston, Massachussetts

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Abstract

The standard visual aids used to correct refractive errors include glasses and contact lenses. Generally, these are safe, effective and predictable. For those individuals in whom these standard devices are not well-tolerated, however, a surgical alternative may be considered. Refractive surgery is an operation intended to change the refractive state of the eye, including intraocular lens implantation and scleral reinforcement for degenerative myopia. Refractive corneal surgery, on the other hand, refers only to operations on the cornea which are intended to alter the eye's refractive state. The majority of refractive surgery performed today is corneal surgery.

The three major categories of corneal surgery include incisional refractive surgery, (radial and astigmatic keratotomy), photorefractive keratectomy (excimer laser ablation), and lamellar surgery (keratomileusis). These procedures are generally used for the correction of myopia (nearsightedness) and astigmatism; the current surgical techniques for correction of hyperopia (farsightedness) have been unpredictable at best.

The primary goal of refractive surgery is to decrease dependence on visual aids. Professional, sports, or outdoor lifestyle considerations may also play a role in the decision to perform surgery. A good candidate for refractive surgery should be at least 21 years old and have a stable refractive error for at least 18 months. A history of herpes simplex keratoconus and keratoconjunctivitis sicca associated with autoimmune disease are all contraindications to surgery. Corneal surgery should not be performed on pregnant individuals as well. Glaucoma and proliferative diabetic retinopathy may also be contraindications. Patients should be fitted with glasses and contact lenses first before considering surgery.

The preoperative consultation should include a complete past ocular and medical history, as well as a thorough ophthalmologic examination, with a dilated funduscopic examination and cycloplegic refraction. Computerized corneal topography should be used to rule out early keratoconus which may be undetectable by slit lamp examination. Proper counseling is required so that patients understand that refractive surgery may not necessarily obviate the need for glasses. For example, if both eyes are corrected for good visual acuity in the distance, the patient will require reading glasses when he becomes presbyopic. Glasses for night driving may be required as well. Finally, an informed patient should understand the risks associated with refractive surgery, including under and overcorrection, infection, glare and potential loss of best corrected vision or loss of the eye.

Radial keratotomv consists of peripheral deep incisions in the cornea which weaken the paracentral cornea and secondarily flatten the central cornea, thus decreasing the refractive power of the cornea. Astigmatic keratotomy works by flattening the cornea in the steep axis of astigmatism, thereby creating a more spherical cornea.

The history of incisional surgery began in the late 1800's, when astigmatic incisions were performed to decrease postoperative astigmatism after cataract surgery. In 1898, Lans described radial corneal incisions which flattened the cornea centrally and noted that deeper incisions provided a greater effect.

In 1933 in Japan, Sato observed a patient with keratoconus who developed an acute break in Descement's membrane followed by spontaneous healing, flattening of the cornea, and subsequent improvement of vision. He then performed both anterior and posterior radial corneal incisions for astigmatism, keratoconus and myopia. Unfortunately, his patients with posterior incisions developed corneal edema 20 years later. In the 1970's in the USSR, Yenaliev performed 24 and 12 incision anterior radial incisions for myopia. In 1972, Fyodorov began to study anterior incisions, and developed a multifactorial predictive formula, varied the size of the clear zone and utilized 16 incisions across the limbus. Since 1976, Bores visited Fyodorov in the USSR and learned radial keratotomy. Later that year Fyodorov lectured at the Kresge Eye Institute in Detroit. In 1978, the equipment and techniques have improved, with ultrasonic pachymeters for more precise corneal thickness measurement and thinner diamond blades which may be calibrated with a micrometer. In addition, the usual number of incisions has decreased to four or eight. In 1980, three groups of ophthalmologists held meetings to study radial keratotomy. These included the National Radial Keratotomy Study Group, the Keratorefractive Society and the Workshop on Radial Keratotomy for Myopia, which later became the Prospective Evaluation of Radial keratotomy (PERK) Study. The PERK study was funded by the National Eye Institute in 1981 and was designed to evaluate the efficacy, safety, predictability and stability of RK over five years (now extended to ten years).

The results of the PERK study at six years (328 of the original 435 patients) show 64% of patients younger than 40 years of age and 38% of those older than 40 wore no spectacles for distance or near vision. Nineteen percent of patients under age 40 and 17% of patients over 40 wore glasses for distance vision, while 4% of patients under 40 and 26% of patients over 40 wore reading glasses. Satisfaction was associated with having 20/20 visual acuity or better in at least one eye and not wearing glasses for distance vision, but 94% of patients said they would have the surgery again. The limitations of the PERK study were that each patient received eight incisions, regardless of age. It is now well-known that there is a direct association of age with response to incisional refractive surgery.

With the current incisional techniques, reports have shown success rates (as defined by 20/40 visual acuity or better) of 90% or better. Werbin recently published a series of 205 patients who had radial keratotomy with one year follow up. Ninety nine percent of his patients achieved uncorrected visual acuity of 20/40 or better (legal driving vision). Lindstrom has reported a technique known as minimally invasive radial keratotomy, or mini RK, which utilizes smaller incisions to reduce the risk of corneal instability and progressive hyperopia. Because progressive hyperopia may occur over several years, further longitudinal studies are required to fully assess the current incisional techniques.

All types of incisional refractive surgery share the inability to accurately predict the outcome due to variability in surgical technique and individual coneal wound healing. The development of laser surgery, however, allows the surgeon to control the first of these two variables.

There are two general types of laser corneal surgery; one type is refractive and the other is therapeutic. The pulsed excimer laser produces a photochemical effect, with the breaking of molecular bonds and resultant tissue fragments flying from the surface at supersonic speeds. The excimer laser was originally developed to sculpt polymers; it was first used to ablate corneal tissue in 1983 by Srinivasan and Trokel at Columbia University. The laser can be used to remove a graded amount of tissue from the central cornea or the steep axis of astigmatism. Photorefractive keratotomyyor PRK, refers to the removal of the central Bowman's layer and anterior stroma of the cornea. Phototherapeutic keratotomy, or PTK, indicates the ablation of anterior corneal tissue for superficial cornea scarring or recurrent corneal erosions secondary to corneal dystrophies or trauma. Potential side effects of the surgery include over or undercorrection, infection, glare, and central cornea "haze", or scarring. Because the laser ablates superficial tissue only, there is no risk of corneal perforation. Diurnal fluctuation of vision, seen after radial keratotomy, is not present after PRK.

Currently, the excimer laser is an investigational device regulated by the FDA, and clinical trials are in progress in the United States. Initial results with the excimer laser for decreasing myopia are promising; approximately 90% of patients with up to six diopters of myopia have achieved uncorrected visual acuity of 20/40 or better in studies with follow up of eighteen months. Summit Technology, as well as multiple other laser manufacturers, has lasers which are in use outside the United States, including mainland China, and are reporting similar results. The use of the excimer laser in higher myopia has been less satisfying due to greater regression of effect and central corneal scarring.

Lamellar refractive surgery involves removing a portion of the patient's corneal stroma to effect the refractive change. The term, "keratomileusis" was derived by Jose Barraquer from the Greek words for carving or chiseling the cornea. Cryolathe keratomileusis, in which a corneal cap is removed, frozen, reshaped and replaced on the corneal stromal bed, has been performed on thousands of patients since the 1960's. The results were highly variable depending on the skill of the surgeon. In situ keratomileusis is a variant in which a corneal cap is resected and a second lamella of tissue is removed, effecting the corneal flattening and subsequent refractive change. The initial cap is replaced on the stromal bed without the damage induced by the cryolathe in the original procedure. This technique is most useful for those individuals with high myopia. Because all of these techniques involve the use of a micro-keratome, more training and experience is required with these procedures. Possible complications include irregular astigmatism, decentration, and perforation of the anterior chamber.

More recent advances include the use of a flap technique in which the initial corneal cap is only partially resected, arid the use of the excimer laser to remove the stromal lamella ("flap and zap"). This technique combines the advantages of minimal corneal scarring associated with lamellar techniques and accuracy associated with excimer techniques.

Early reports have shown success rates (uncorrected visual acuity 20/40 or better and within one diopter of emmetropia) as high as 90% in individuals with up to 14 diopters of myopia.

In conclusion, refractive surgery presents a generally safe and effective alternative to conventional visual aids. Careful selection and education of patients, combined with a conservative and thoughtful surgical plan, are the keys to a successful outcome. As surgical techniques continue to evolve, precision and predictability should continue to improve.