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Surgical Correction of Hyperopia

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Abstract. Surgical attempts to correct hyperopia have yielded varying results over the last 130 years. These techniques include the reshaping of the cornea through incisions, burns, or lamellar cuts with removal of peripheral tissue; the addition of central inlays; laser ablations; and the replacement of the crystalline lens. By examining the success of each surgical technique, the refractive surgeon may be able to make an informed decision on its indications and limitations, based on the specific patient's characteristics. Reporting the outcomes and complications of hyperopic surgery will help refine our approach to the management of an increasingly hyperopic and presbyopic population. (**Surv Ophthalmol 51**:381–418, 2006. © 2006 Elsevier Inc. All rights reserved.)

Key words. conductive keratoplasty • hyperopia • intraocular lenses • LASIK • phakic IOLs • photorefractive keratectomy • presbyopia • refractive surgery • thermokeratoplasty

Introduction

According to the United States Census Bureau, approximately 22% of the U.S. population is hyperopic. We will soon see many millions of baby boomers entering their late 40s and 50s, and can expect the incidence of hyperopia to increase to almost 50% in this group.[316] Despite these figures, the surgical correction of hyperopia has lagged behind the surgery of myopia, in part because it is much more difficult to surgically steepen the cornea to correct hyperopia than to flatten it to correct myopia.[189,246,248,310,324,349,360] Over the past century, since Lans demonstrated that the cornea can be reshaped by incisions or thermal means, many procedures have been proposed, used, and then abandoned because of complications or poor long-term stability (Fig. 1).[405] Even now, despite recent remarkable advances in refractive surgery, there is still no general agreement on the best surgical procedure to treat the different degrees of hyperopia. In this article, we will review the indications, techniques, outcomes, and complications of the different surgical procedures for the correction of hyperopia.

Incisional Surgery

HEXAGONAL KERATECTOMY

Hexagonal keratotomy (HK) is an incisional surgical technique that relies on mid-peripheral, partial-thickness, anterior corneal incisions to

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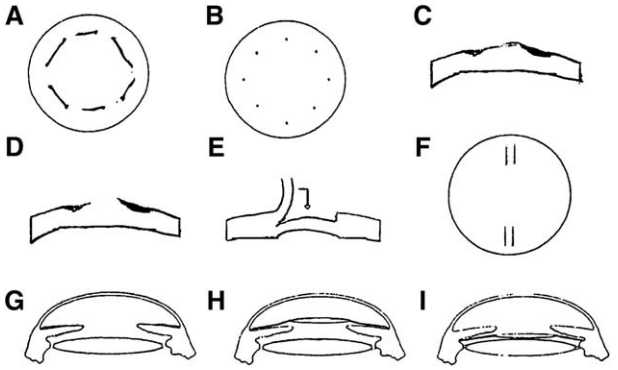

Fig. 1. Surgical alternatives for the treatment of hyperopia. *A:* hexagonal keratotomy. *B:* Thermokeratoplasty. *C:* Hyperopic photorefractive keratotomy. *D:* Hyperopic laser assisted in situ keratomileusis. *E:* Hyperopic automated lamellar keratoplasty. *F:* Intrastromal corneal inserts. *G:* Lens extraction and intraocular lens implantation. *H:* Anterior chamber phakic lens fixated to angle or iris. *I:* Posterior chamber phakic intraocular lens. (Reprinted from Primack and Azar[310] with permission from *International Ophthalmology Clinics.*)

steepen the central cornea.[330] In HK, six connecting incisions of approximately 90% depth are placed in a hexagonal pattern around a 5- to 6-mm optical zone. These incisions are sometimes coupled with transverse keratotomies placed peripheral to the initial cuts. This procedure results in flattening of the para-central cornea with concurrent steepening of the central cornea. In 1986, Mendez presented clinical data from 46 eyes using an apical intersecting hexagonal pattern with optical zones of 5.0, 5.5, and 6.0 mm (Mendez A: Hyperopia Reduction With Hexagonal Keratotomy. Presented at the Keratorefractive Society Symposium. 1988). He reported reductions of 1.5 to 3.5 D of hyperopia. In 1988, he reported results from 102 eyes using the same normogram (Mendez A: Advances in the Hyperopia Correction With Hexagonal Keratotomy. Presented at American Society of Cataract and Refractive Surgery Meeting; Los Angeles. 1996). He observed overcorrection in 7.8% of eyes and induced irregular astigmatism in 20% that he believed was secondary to non-uniform incision depth and irregularly shaped hexagon.

In 1989, Neumann and McCarty presented their results on 15 eyes using the original Mendez technique with a follow-up of 9.5 months. They reported a 93% improvement in uncorrected visual acuity, with 60% of the eyes having an uncorrected visual acuity of 20/40 or better.[269] Astigmatism increased a mean of 0.02 D, and no serious complications were mentioned.

The original Mendez technique definitely reduced hyperopia. However, the intersecting incisions tended to isolate the central cornea, producing persistent epithelial defects, poor wound healing, and frequent unpredictable results.[41] Some patients were left with irregular astigmatism, and some required suturing for wound gapes.

In order to improve the predictability of the results, Jensen altered the technique to avoid intersecting incisions.[178] He reported better outcomes with 483 eyes between 1987 and 1990. He found that a 5 mm optical zone resulted in an average hyperopic correction of 2.91 D, whereas 5.5 and 6.0 mm optical zones resulted in 2.07 D and 1.56 D of correction, respectively. However, he presented little data on complications. In 1994, Hollis reported his results using the modified Jensen technique in a series of 900 eyes. He noted a 10% undercorrection rate and a 1% induction of irregular astigmatism responsible for loss of best corrected visual acuity (BCVA).[162]

In 1990, O'Dell performed an HK 7 years after cataract surgery for an intraocular lens miscalculation in a 67-year-old woman.[278] He reported an uncorrected visual acuity of 20/25 postoperatively.

The nonconnecting incision technique, however, reduced the surgical effect of the procedure. In order to increase its effectiveness, Mendez further modified the technique, using six non-intersecting incisions with extension of one at each apex. Tamura et al reported that small improvements in the induced astigmatism rate were found with this new modification[372] and suggested that a transverse incision of 2.5 to 3.0 mm in length outside of each apex would be of additional benefit. He termed this technique a T-Hex and reported favorable results in a series of 46 eyes. He advocated treatment of astigmatism with astigmatic keratotomy, followed by hyperopic correction with the T-Hex technique at least 6 months later (Fig. 2). Casebeer in 1993 reported an uneventful cataract extraction using phacoemulsification in a patient that had a previous T-Hex surgery.[62]

In 1995, a new modification of the technique, called Spiral HK, was described in which arcuate incisions were used outside of the hexagon in order to reduce postoperative astigmatism.[395] Grandon reported his results on 199 eyes with a follow-up of 11.9 months using this technique.[150] The mean reduction in spherical equivalent was $+0.5 \pm 0.9$D. Uncorrected acuity improved 3.2 lines whereas BCVA decreased by -0.26 lines. Loss of two or more lines of BCVA was noted in 0.5–4.0% of eyes. Finally, suture-circling techniques have been developed with uncertain success.[204,218]

Weblin in 1996 showed his results with 12 patients who underwent HK in 1993,[402] reporting 14 enhancements in seven eyes for both astigmatism