Refractive surgery currently offers four surgical options for the reduction or elimination of high myopia. These include: radial keratotomy, myopic keratomileusis, myopic epikeratophakia, and lensectomy with implantation of a low or minus power intraocular lens. In this editorial, I summarize my experience with these various modalities and discuss some future options for the correction of high myopia.

**Radial Keratotomy** The advantages of RK include that it is a minimally invasive procedure with rapid visual recovery and little risk of complication when performed by an experienced surgeon. However, it is now well recognized that RK, although effective for treating low to moderate levels of myopia up to 8.0 diopters, has restricted effectiveness for treating myopia greater than 8.0 D in younger patients. However, in older patients, especially in men over 40, the Fyodorov multiple incision depth procedure can extend the upper limit to 12 D. Careful patient selection and counseling is necessary when considering RK as a surgical option for high myopia. Many patients choose RK over other surgical procedures, which have a greater likelihood of resulting in emmetropia, because of the lack of third-party reimbursement for refractive procedures. These patients will accept, for financial advantage, improved vision that approaches emmetropia but that may still require the use of optical aids for driving or reading.

Our results on 71 high myopes with preoperative myopia greater than −8.0 D (range −8.125 D to −14.75 D) and a mean follow-up of 22 months (range 12 to 84 months) indicates that a mean correction of 71% can be achieved, with 41% of these eyes obtaining an uncorrected vision of at least 20/40. In 21 eyes with myopia of 10 D or more, we achieved a mean correction of 62%. Thirty-eight percent of these eyes achieved an uncorrected vision of 20/40 or better, and 57% saw at least 20/200. Even though many of these eyes did not achieve emmetropia, the patients often were very satisfied with their improved unaided vision and, in some cases, improved best corrected vision.

**Myopic Keratomileusis.** For those patients with greater than 8 D of myopia and who are not candidates for RK, myopic keratomileusis is recommended. The advantages of this technique include its relative precision and stability. This procedure has a potential corrective limit of 15 to 24 D when homoplastic material is used. The disadvantages include the need for expensive equipment (a Barraquer cryolathe) and the need for extensive surgical skill and experience.

Although our experience with MKM has been limited to four eyes, our results have been good. Myopic keratomileusis was effective for reducing preoperative myopia (ranging from −8.8 to −12.1 D) by 77% to 94% in these four patients. All eyes were within 2 D of emmetropia at their final visit (14 months to 3 years) and two eyes were within 1 D of emmetropia. Uncorrected visual acuity was improved to 20/60 or better in all cases, and all eyes achieved their preoperative best corrected vision. Refractive and visual results appear stable and uniform for this procedure (Figure 1).

**Myopic Epikeratophakia.** The advantages of myopic epikeratophakia are that it is somewhat less invasive and easier to perform than MKM, it has a wide range of correction with a potential upper limit of 32 D, and it is claimed to be reversible. However, we and others (Neuman AC, McCarty GR, Sanders DR, Delayed Regression of Effect in Myopic Epikeratophakia Versus Myopic Keratomileusis and Radial Keratotomy for High Myopia, unpublished data) have found that there is an unacceptable incidence of delayed regression of effect associated with this procedure. Furthermore, one of our patients who had his epikeratophakia lenticule removed had higher myopia postoperatively.

Among the six myopic epikeratophakia procedures we have performed, only three of the six eyes obtained effective and stable results. Preoperative myopia in these three cases ranged from −13.5 to −15.25 D, was reduced 90% to 97% by 3 to 6 months after
surgery, and regressed slightly but remained stable thereafter at 82% to 90% correction. Two eyes were within 2 D of emmetropia. However, the three remaining eyes, which were within 0.38 D of emmetropia at the time of suture removal, experienced a regression of effect which resulted in myopia worse than their preoperative values (two eyes) or insignificant (30%) correction (Figure 2). Among the six eyes, uncorrected vision was improved 20/70 in one eye and 20/200 in a second eye. The remaining four eyes experienced 20/300 or worse uncorrected vision (Neumann AC, McCarty GR, Sanders DR. Delayed Regression of Effect in Myopic Epikeratophakia Versus Myopic Keratomileusis and Radial Keratotomy for High Myopia, unpublished data).

_Lensectomy._ Small incision phacoemulsification surgery and the availability of low or minus power intraocular lenses have made lensectomy a safer and remarkably accurate procedure. The disadvantages of this procedure include an increased risk of postoperative complications, specifically retinal detachment. Future polishing or cleaning of the posterior capsule may also be required postoperatively. Preoperative and regular postoperative retinal examinations also are necessary to minimize potential retinal problems.

Although we are not currently performing clear lens extractions for the treatment of high myopia, we do have some experience with correcting high myopia in cataractous eyes. The results of our first seven consecutive cataract procedures on eyes with greater than −15 D of myopia showed that the preoperative mean myopia of −21.48 D (range −15.5 D to −35.00 D) was reduced 81% to 116% (mean 99%) at 2 to 24 months postoperatively (mean 11 months). Four of the seven eyes were within 1 D of emmetropia and one eye was within 2 D. Preoperatively, all of the eyes had some degree of myopic retinal degeneration. One eye experienced an expulsive choroidal hemorrhage and underwent an anterior vitrectomy at the time of surgery. Postoperatively the eye developed a subretinal hemorrhage which was subsequently resolved with a loss of one line of best corrected vision (preoperatively VA = 20/50; postoperatively VA = 20/70). Overall, three of the seven eyes (43%) achieved an uncorrected visual acuity of 20/50 or better.

_Future Surgical Options for the Treatment of High Myopia._ Refractive surgery in general and specifically for high myopia requires greater precision and predictability than is currently available. Future requirements for new refractive surgical methods should include precision and predictability to within
0.5 D of the desired outcome. Our study (Enhanced Precision Is Necessary for Refractive Surgery Instrumentation, unpublished data) indicates the need for compensatory tables for depth markers and diamond knife blades because of lack of precision on the micron level. Manufacturers must increase industry-wide standards for refractive surgical instrumentation. Many new surgical methods are currently under development and may become available in the near future for the treatment of high myopia. These include synthetic corneal inlays or onlays, soft phakic intraocular lenses (intraocular spectacles), reshaping of the cornea with a laser, keratomileusis in situ, and the development of new products such as corneal mortar and epidermal growth factor to aid in corneal wound healing.

However, before these options become routinely available, some problems must be overcome. Intracorneal inlays must be manufactured in such a way that nutrients from the anterior chamber can traverse the inlay and reach the anterior corneal epithelium. Fenestrated inlays are now under investigation and may prove beneficial. Synthetic myopic corneal onlays must overcome the difficulties presented by the myopic peripheral wing (also a problem with current myopic epikeratophakia), including disruption of tear flow, resulting in dellen and troubles with re-epithelialization. The refractive laser holds considerable promise for enhancing the precision of refractive surgery. However, before this can be accomplished, systems for providing enhanced laser energy—homogeneity of mean energy—and for improving the current application and delivery systems must be perfected. The key to precision with this device lies in creating precise depth of incision or ablation feedback system which would provide an accurate titration of surgical effect.

Phakic intraocular lenses (intraocular spectacles) are also being developed in the USSR and the US at this time. These devices possibly could provide a very accurate high myopic correction, as is the case for intraocular lenses for aphakic eyes.

All of these new methods for treating high myopia are more invasive than incisional keratotomy. Therefore, the additional risks must be outweighed by significantly increased predictability and effectiveness. Technical problems will no doubt be overcome and new, precise methods for treating high myopia will become available. However, for the present time, myopic keratomileusis or, in select cases, radial keratotomy may be the best method for treating high myopia up to 15 D. Myopic epikeratophakia is not recommended at this time because of its unacceptable high incidence of delayed regression of effect. Lensctomy with implantation of a low or minus power intraocular lens is an effective and very precise
method for eliminating high myopia in those myopes with cataractous lenticular changes.

References


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