Surgery for refractive defects

For those of us who only need weak spectacles on an occasional basis, it is perhaps easy to wonder what all the fuss is about when patients request surgery to do away with the need for glasses. Almost any refractive defect is correctable, and this article will discuss the indications for refractive surgery, the methods available and the results that can be achieved.

**Indications**

Theoretically, almost any refractive defect can be corrected using one of the surgical techniques now available. The long-term results of some of these techniques are not yet known, but, with increasing experience and follow-up, greater confidence will help to improve the quality of life for many more patients.

**Diagram 1**

Surgical procedures to correct refractive defects: part one

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**Epikeratophakia**

A donor cornea is cut into shape. The graft is performed onto the recipient cornea. The altered curvature of the anterior cornea corrects the refractive error.

**Keratomileusis**

A lamella of cornea is cut with a microkeratome. The lamella is shaped with a laser, or an ablator. The lamella is replaced. The cornea flattening can correct moderate to high myopia.

**Hydrogel keratophakia**

A donor full lamina of the cornea is cut with a microkeratome. A soft lens is shaped to place in the mid-stroma. The anterior surface of the cornea takes a new profile.
Figure 1a (top) Before epikeratophakia, the corneal contour of this patient with aphakia and high hypermetropia was normal. 1b (bottom) After epikeratophakia, the graft steepens the central cornea, as indicated by closer approximation of the photokeratoscope mires.

Unequal refraction Where there is a large difference in the refractive error of the two eyes (high anisometropia), it may be impossible to correct the vision in both eyes with glasses because of the disparity in image sizes produced by two widely dissimilar lenses (aniseikonia). Some patients may find that refractive surgery is the only way of restoring binocular function.

Childhood amblyopia Severe or unequal refractive errors can occur at any age, but take on a special significance in early childhood because of their potential to cause amblyopia – ‘lazy eye’.

It is not until the age of eight that visual ability is firmly established. Its development may be arrested, or may even regress, if optical defects are not corrected at this stage. Non-compliance with glasses or contact lenses cannot be tolerated without the risk of missing the once-only opportunity for visual maturation.

Other indications With increasing emphasis on health and safety standards, minimum visual standards have now been set for many careers. Where unaided acuity standards are specified, then refractive surgery is the only option.

Surgical techniques

In the past 10 years, technological advances have made it possible to correct surgically virtually any refractive defect of the eye. Some of the surgical techniques are now well tested, and of proven benefit, while many new ones are emerging which have yet to be established.

Extraocular and reversible There is one refractive procedure that stands alone in that it is readily reversible.

Epikeratophakia The specialised corneal on-lay graft used for this technique is lathed into shape from donor corneal tissue according to the patient’s refractive error (diagram 1a). The tissue is freeze-dried before concurrent topical medical therapy, may make contact lens use impossible or hazardous.

Excellent vision with minimal risk of ocular complications can be achieved with hard and ‘gas permeable’ contact lenses. Soft contact lenses, which can now correct most refractive defects, are more comfortable to wear. However, they are linked to a greater risk of serious ophthalmic complications, such as corneal ulceration or hypersensitivity reactions, that may preclude their use.

Contact lens technique cannot be acquired by the very old, the very young or the mentally retarded. Patients with physical disabilities may be unable to manipulate lenses, and a number of ophthalmic conditions, such as dry eyes, and the use of
2a Excimer laser phototherapeutic keratectomy

The Excimer laser is aimed at the central optical zone. Central thinning from ablation of tissue on both low myopic.

2b Radial keratotomy

Radial keratotomy incisions are made in the peripheral cornea, crossing the central optical zone. The incisions cause a change in shape of the cornea. Central thinning occurs in low myopic.

Diagram 2 Surgical procedures to correct refractive defects: part two

surgery to remove any living cells, thereby preventing rejection. The freeze-dried graft tissue can be stored under vacuum at ambient temperature for three months. The patient's own corneal cells quickly repopulate the graft tissue to form a 'living contact lens'. The shape of the graft can be designed to correct either high hypermetropia or high myopia (figures 1a and 1b).

Extraocular and irreversible This group includes a wide variety of techniques which change the corneal curvature by direct modification of the patient's cornea. Again there is little risk of intraocular complications, but, rarely, problems with these techniques may leave corneal irregularity or scarring which can be reversed only by corneal transplantation.

Keratomileusis Here the surface of the cornea is thinned off with a motorised plane. Stromal tissue is then excised mechanically or with a laser, and the surface lamella is replaced (diagram 1b). This allows high myopia to be corrected without the risk of surface scarring and irregularity which may result from external laser keratectomy. The procedure is technically very difficult, and is not widely carried out.

Hydrogel keratophakia Here the anterior corneal profile is modified by inserting a small lens into the mid-stroma. The lens is made from donor corneal tissue or from permeable hydrogel, which is shaped to correct high hypermetropia or high myopia (diagram 1c). The technique is potentially reversible, as the lens insert can be removed or replaced, but irregular microradial keratectomy or interface scarring may cause irreversible changes to the cornea.

Excimer laser phototherapeutic keratectomy

With this new technique, direct removal of tissue from the surface of the central optical zone causes this area to be flattened (diagram 2a). The method will treat low spherical myopia, but it is as yet of unproven benefit in the treatment of myopic astigmatism or higher degrees of myopia. Since the laser treatment is superficial, there is no risk of perforating the globe and the corneal structure is not weakened, but there is a risk of scarring on the visual axis.

Radial keratotomy This procedure modifies the central 'optical zone' of the cornea by changing the curvature of the peripheral supporting cornea. Deep radial cuts in the peripheral cornea produce a general central flattening that corrects low myopia (diagram 2b), while transverse cuts can be used to correct astigmatism.

Many thousands of patients have been...
successfully treated with this procedure, and the predictability of results is good (figures 2a, 2b and 2c).

Intraocular procedures This group is set apart from the previous categories because of the significantly higher risks of serious intraocular complications, such as retinal detachment, glaucoma and endophthalmitis.

Anterior chamber lens implant It is possible to insert a negative power lens implant into the anterior chamber of a myopic eye between the cornea and the physiological lens. Although the optical predictability of this procedure is good, the long-term effects on the health of the eye are more doubtful.

Clear lens extraction with implantation This can be carried out in high myopia and, with selection of an appropriate intraocular lens implant, the refractive error can be neutralised. However, it is well recognised that complications such as retinal detachment are linked to lens extraction, and high myopes are also especially prone to this problem.

Presbyopia could similarly be treated by clear lens extraction and insertion of a multifocal intraocular lens implant, but it seems that it will be some time yet before the risks of intraocular surgery can be justified for the correction of presbyopia.

Refractive results

The chief difficulty in all refractive procedures is achieving an accurate refractive result. A small percentage error from predicted outcome in low myopia might leave a minimal refractive defect and good post-operative acuity, while a similar percentage error when correcting a higher defect may give a poor acuity. However, the incentive to achieve correction is often greater in high ametropia, and reduction rather than complete correction may still be appreciated by the patient.

The long-term results of some procedures, such as hydrogel keratophakia and excimer laser treatment, are not yet known. The stability of the

Figure 2b Radial keratotomy. The inclusion-free central optic zone is marked

cornea following keratomileusis seems good over many years, but degenerative myopia is sometimes progressive, and this must be kept in mind when recommending surgery.

Ophthalmologists now have a wide array of surgical techniques with which it is theoretically possible to correct virtually any refractive defect. With increasing clinical experience and long-term follow-up, these procedures will no doubt become more widely used improving the quality of life for many more patients.

Figure 2c Radial keratotomy. Incisions are made in the peripheral cornea to correct low myopia.