

Laser surgery for refractive errors

In this article, Lucy Titcomb examines refractive errors, the ways in which they can be treated by surgery and the drugs involved

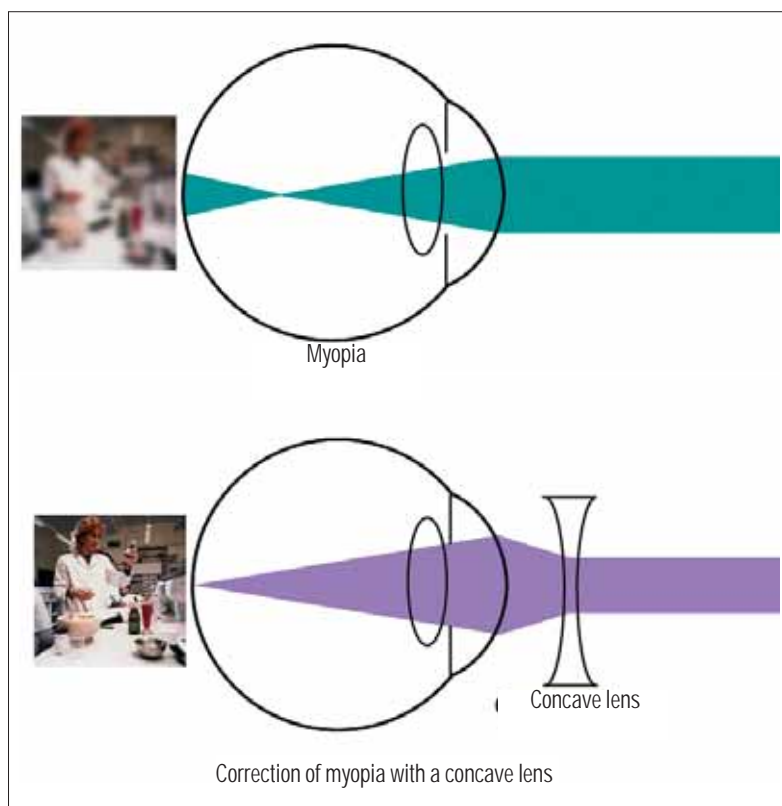
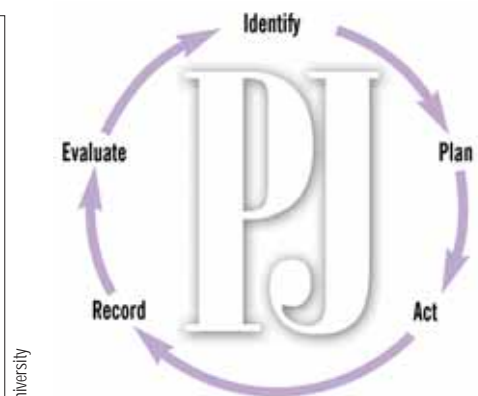


Figure 1: In myopia, light rays are focused in front of the retina

Estimates of the number of people world-wide with refractive error range from about 800 million to 2.3 billion. The British Society for Refractive Surgery states that between 68 and 79 per cent of the general population achieve 20/20 vision (in Britain, this is known as 6/6 vision) in at least one eye without any spectacle correction. A further 7 per cent of the population require a small refractive correction for distance vision but can manage without any correction for some visual tasks. The remainder have a larger degree of refractive error in the form of short-sightedness (myopia) or long-sightedness (hyperopia), with or without a degree of astigmatism and require a refractive correction to achieve good distance vision.

Myopia Lens power is measured in dioptres. Myopia is visually significant if the refractive correction required is greater than one dioptre ($>-1.00D$). This means that the person cannot clearly see an object that is more than 1m from the eye. Myopia affects approximately 25 per cent of the UK population although the prevalence is greater in some ethnic groups (eg, two-thirds of Japanese teenagers are myopic). Myopia occurs when the eye is too long for the strength of its refractive components, resulting in light rays focusing in front of the retina (see Figure 1). Distant objects are out of focus with the range of clear vision decreasing as the refrac-

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Identify knowledge gaps

1. What are the types of refractive error?
2. What methods of laser or lens surgery are used to correct these errors?
3. What drugs are used during and after laser eye surgery?

Before reading on, think about how this article may help you to do your job better. The Royal Pharmaceutical Society's areas of competence for pharmacists are listed in "Plan and record", (available at: www.rpsgb.org/education). This article relates to "providing advice" and "keeping abreast of issues affecting pharmacy".

tive correction increases (eg, a person with $-2.00D$ of myopia cannot clearly see any object more than 50cm from the eye). Myopia can be corrected by using a concave lens to produce a clear retinal image (see Figure 1).

Hyperopia Long-sightedness occurs when the eye is too short for the strength of its refractive components, resulting in light rays focusing behind the retina. Patients with a high degree of long-sightedness will require correction to achieve good distance vision, although some young patients may be able to accommodate (where the lens thickens to increase refraction) to overcome their long-sightedness. However, the ability to accommodate decreases with age and refractive correction is normally required for hyperopes over 35 years of age. Correction may be required from an earlier age depending on the degree of hyperopia and the accommodative ability of the individual.

Hyperopia can be corrected by using a convex lens to focus light rays on the retina.

Astigmatism An astigmatic eye has a different refractive power in each of its two perpendicular meridians. This may be due to the shape of the cornea or tilting of the crystalline lens, or both. In contrast to the normal eye (which can be described as football-shaped) the astigmatic eye is rugby ball shaped.

Panel 1: Disadvantages of traditional methods of refractive correction

Spectacles

- Lenses can become dirty, scratched, broken or fogged
- Glasses can become dislodged or knocked off
- Minification or magnification of image
- Frames or lenses can restrict the field of view

Contact lenses

- Reduced quality of vision compared with spectacles
- Lenses can fog
- Lenses can become dislodged
- Lens intolerance or discomfort
- Overwear can result in corneal neovascularisation, papillary conjunctivitis and chronic discomfort
- A high standard of hygiene is needed (poor hygiene increases the risk of bacterial keratitis and acanthamoeba keratitis)
- Expense of disposable lenses and contact lens solutions
- Allergy to components of contact lens solutions
- Discomfort in dry atmospheres (eg, air conditioned environments)
- Small particles can get trapped under lenses
- Reduced oxygen concentration in cornea can result in corneal swelling

Uncorrected astigmatism results in distortion and elongation of the image on the retina.

Astigmatism is usually combined with some degree of myopia or hyperopia. It can be corrected by using a lens with a different power in each of the two perpendicular meridians but precise alignment of the lens is critical and can present a challenge for contact lens fitting.

Presbyopia In presbyopia, the crystalline lens within the eye becomes harder as the eye ages and the ciliary muscle which constricts to alter the shape of the lens weakens. This reduces the ability of the eye to focus on close objects and near vision is blurred. Most people become presbyopic around the age of 45 years and require refractive correction for detailed close tasks, such as reading or sewing. Dependency on this correction increases with age. Presbyopia can be corrected simply by using reading glasses. However, if presbyopia is accompanied by another of the refractive errors described above, the patient may require bifocal or multifocal lenses.

Methods of refractive correction

Traditionally, refractive errors are corrected with spectacles or contact lenses. Although

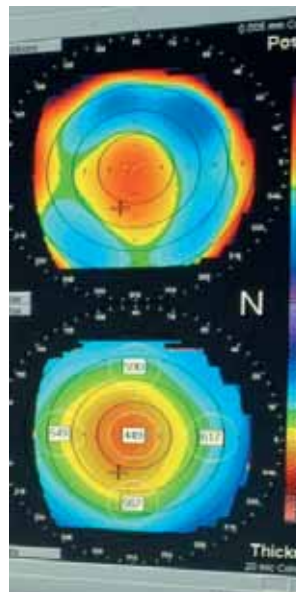


Figure 2: In a few centres a corneal map is used to individualise laser treatment for each patient

these options are acceptable to many patients they both have disadvantages (see Panel 1) and an increasing number of patients who wish to see well without spectacles or contact lenses are turning to surgical methods of refractive correction. Groups offering these services, such as Optical Express, Optimax and Ultralase, have become household names. The number of clinics offering refractive surgery has increased from 47 in 2001 to 95 in 2005. Optimax, one of the larger groups had conducted 198,000 procedures at the time of a 2005 survey.¹

The survey also highlighted the most frequently performed refractive procedures (see Panel 2). The two most frequently performed techniques, LASIK and LASEK, and the less popular PRK all involve laser reshaping of the cornea and are suitable for the correction of low to high myopia and astigmatism and low to moderate hyperopia. The laser used is the excimer laser, originally developed by IBM in 1976 for etching intricate patterns on to computer chips.

Excimer lasers are often described as "cold" lasers because their ultraviolet light beam breaks down molecular bonds without producing heat. This means that surrounding tissue is not damaged. Corneal topography, which produces a map of the corneal curvature by measuring light reflected from the surface of the eye, is used to determine whether or not patients are suitable for laser surgery. The map uses blue and green to identify flatter areas of the cornea, while steeper areas are represented by red and orange (see Figure 2). In a few centres the corneal map is used to individualise the laser treatment for each patient but, generally, the treatment plan is devised from the patient's refractive error, pupil diameter and corneal thickness.

For an extra payment, some centres offer wavefront aberrometry (measurement of tiny imperfections on the surface of the eye), which allows the laser treatment to be more precisely individualised. This aims to create a perfectly smooth cornea resulting in improved quality of vision especially at night (ie, reduction in glare and haloes around lights). The laser removes approximately 0.25 microns of tissue (1/200th of the thickness of a human hair) in a single pulse.

For myopia, the centre of the cornea is made flatter by removing more tissue from the centre than the edge. Hyperopia is corrected by removing more tissue from the edge than the centre and for the treatment of astigmatism, the curve is evened out, resulting in the conversion of a rugby ball-shaped cornea to a football shape. Laser surgery is undertaken in a clean room with air conditioning and temperature and humidity control.

PRK Photorefractive keratectomy (PRK) has been used since the late 1980s but has generally been superseded by laser epithelial keratomileusis (LASEK) and laser assisted *in situ* keratomileusis (LASIK) apart from for the treatment of low refractive errors (-1.00 to

Panel 2: Treatments offered by UK refractive surgery clinics in 2005*

Type of treatment	Percentage of clinics offering treatment
Laser <i>in situ</i> keratomileusis (LASIK)	97
Laser epithelial keratomileusis (LASEK)	97
Photorefractive keratectomy (PRK)	13
Clear lens extraction	23
Phakic intraocular lenses	20
Others	66

*61 respondents

Drugs currently used in laser surgery

Alcohol Eighteen per cent ethanol is applied to the cornea for 30 seconds to loosen the corneal epithelium in LASEK.

Antibiotics Ofloxacin 0.3 per cent eye drops are widely used as a prophylactic against infection pre- and post-operatively. A single drop is instilled pre-operatively and post-operatively (unlicensed). The patient continues with the antibiotic every four hours during the day for a week. Alternatively, neomycin or chloramphenicol is used (see also "Corticosteroids" below).

Corticosteroids The corticosteroid used depends on the surgeon's preference. During surgery, preservative-free eye drops, prednisolone 0.5 per cent or dexamethasone 0.1 per cent, are used. Post-operatively, the potent corticosteroids prednisolone acetate 1 per cent, dexamethasone 0.1 per cent or fluoromethalone 0.1 per cent are generally preferred although some surgeons use the betamethasone and neomycin combination rather than one of the above with ofloxacin. If the patient has reported allergy to eye drops or contact lens solutions, the surgeon may use prednisolone 0.5 per cent or dexamethasone 0.1 per cent with chloramphenicol 0.5 per cent as the antibiotic because these are available in a preservative-free form (Minims).

Local anaesthetics Proxymetacaine 0.5 per cent eye drops, which do not sting as much as oxybuprocaine 0.4 per cent or tetracaine 1 per cent, are preferred in most centres. However, for LASEK (where the

corneal epithelium is removed) the epithelial toxicity of tetracaine may assist epithelial removal. The eye drops are instilled at the beginning of the procedure and may be used post-operatively if the patient is in pain.

Non-steroidal anti-inflammatory drugs Diclofenac 0.1 per cent is indicated to control ocular pain and discomfort associated with corneal epithelial defects after excimer PRK surgery and is used during LASIK and before, during and after the more painful PRK and LASEK procedures. The dose is one drop twice in the hour before surgery, one drop twice, five minutes apart, immediately after PRK surgery and then post-operatively one drop every two to five hours while awake and for up to 24 hours. Voltarol Ophtha is the only NSAID licensed for this use.

Ocular lubricants Preservative-free ocular lubricant eye drops are used during surgery. Therapy with ocular lubricants generally continues for one to three months after surgery although some patients may require them for longer periods. Products used include carmellose 1 per cent, hypromellose 0.3 per cent and polyvinyl alcohol 1.4 per cent.

Other drugs Some clinics supply paracetamol or ibuprofen tablets for pain relief following surgery. Promethazine hydrochloride 25mg may be used as a sedative after LASEK and PRK. Povidone iodine 5 per cent may be used to disinfect the eye before laser surgery and mitomycin C 0.01–0.02 per cent may be applied to inhibit wound healing mechanisms that can lead to scarring and hazing of the stroma.

–6.00D). Following instillation of local anaesthetic eye drops, the corneal epithelium is removed and the cornea is reshaped with a computer-controlled excimer laser. A contact lens is placed on the eye and this is worn for four to seven days. Antibiotic, anti-inflammatory and steroid eye drops are instilled and a plastic eye shield, which is worn for 24 hours after the procedure, is placed over the eye.

Post-operative pain following PRK can be moderate to severe and recovery of useful vision takes between two and four weeks. Vision usually stabilises in one to three months but may take up to a year.

LASEK LASEK was originally used to correct mild to moderate short sight and astigmatism but, with time, its use has been extended to correct higher degrees of myopia sometimes above –12.00D. LASEK is now preferred to LASIK (see below) by some surgeons. LASEK is similar to PRK but the corneal epithelium, loosened with a dilute solution of alcohol after the application of local anaesthetic drops, is retained as a flap and replaced over the sculpted corneal tissue at the end of the procedure.

As with PRK, a contact lens is placed on the eye (but this is only needed for three to four days) and post-operative eye drops are instilled. Some post-operative discomfort is felt for about 24 hours and patients will experience light sensitivity. Some patients experience mild to significant pain around days 4 and 5, after the contact lens has been removed. Useful vision normally returns in three to six days and stabilises within a month, although this can take up to nine months. The average price for LASEK in 2005 was £744 per eye.¹



Pascal Goetheluck / SPL

LASIK: an anaesthetic is instilled to numb the eye before a flap of the cornea is cut open

LASIK LASIK has been in use since the mid 1990s and is used to treat myopia, hyperopia and astigmatism. It differs from PRK in that a flap of cornea is raised using a tool called a microkeratome before sculpting of tissue from the middle layer of the cornea occurs. After the laser treatment the corneal flap is replaced so no loss of corneal epithelium occurs. A transparent eye shield is used for 24 hours post-operatively to protect the eye but a contact lens is not needed.

LASIK may not be suitable for extreme corrections because the procedure may make the cornea too thin and unstable. Post-operative pain is minimal. Useful vision recovers after one or two days and, like LASEK, usually stabilises within a month although this can take up to nine months. The average price for LASIK in 2005 was £860 per eye.¹

Contraindications to excimer laser eye surgery include:

- Under 21 years of age (some clinics have a lower age limit of 18 years)
- Prescription change of 0.5D or greater over the past three years
- Significant keratoconus, cataract, glaucoma or herpes eye infection
- Diabetes, rheumatoid arthritis or systemic lupus erythematosus
- Concomitant medicines, such as oral steroids and other immunosuppressants
- Pregnancy or breast feeding

Complications of laser eye surgery are shown in Panel 3 (p514). Eyes that have undergone laser refractive procedures may have a lower measured intraocular pressure and ophthalmologists and optometrists meas-

Panel 3: Complications of excimer laser surgery

All excimer laser surgical procedures (PRK, LASEK and LASIK)

- Minor over-correction or under-correction of refractive error
- If laser surgery is performed in patients under 40 years of age presbyopia can still occur
- Anisometropia (difference in refractive error between the two eyes)
- Difficulty with contact lens wear (if still needed or if needed again in the future) due to changed shape of cornea
- Ptosis (drooping of the upper lid) in first few weeks following treatment but this rarely persists
- Increased eye sensitivity
- Decreased night or low light vision
- Risk of retinal detachment in patients with myopia

Surface-based treatments (PRK and LASEK)

- Instability of the cornea, which is 10–20 per cent thinner than before
- Reduction in visual acuity by two or more lines on the Snellen chart in < 4 per cent of patients with low to moderate myopia (–0.5 to –6.00D) and 10 per cent or more patients with high or extreme myopia (over –6.00D)
- Haze and scarring (in 1–3 per cent of patients with myopia < –6.00D and 5 per cent or more with myopia > –6.00D)
- Infection (< 0.1 per cent of treatments)
- Reactivation of herpes simplex virus

LASIK

- Instability of the cornea (the cornea is thinner than that resulting from a surface-based laser treatment)
- Corneal haze
- Reduction in visual acuity (the risk of loss of two or more lines on the Snellen chart is between 2.7 and 4.8 per cent)
- Problems relating to creation of a hinged corneal flap (0–4 per cent). These include: incomplete cut, loss or damage to the flap, completely free corneal flap (may require stitches), debris or fibres under the flap leading to inflammation, epithelial ingrowth under the flap, wrinkling of the corneal flap, retinal haemorrhage or retinal artery or vein occlusion and penetration of the eye by the microkeratome and possible haemorrhage or infection that can result in loss of the eye
- Dry eye

uring this parameter must be aware of the effect of reducing the corneal thickness on the results obtained with applanation tonometry (a technique to measure intraocular pressure).

For patients with moderate and high degrees of myopia or hyperopia, two lens techniques (clear lens extraction and phakic intraocular lens insertion) are available. However, both involve intraocular surgery in operating theatres so they are not as widely available as laser correction.

Clear lens extraction and its replacement with an intraocular lens may be suitable for patients who are not good candidates for laser eye surgery, such as those with a high refractive error (myopia > –12.00D or hyperopia or astigmatism > 5.00D), a thin cornea or other ocular problems, particularly in the early stages of cataracts. The procedure of lens removal and replacement is essentially the same as that in cataract extraction (see *PJ*, 27 August 2005, pp257–60). An accommodating or multifocal lens may be used if such a lens is available in a power suitable for the individual.

Insertion of a phakic intraocular lens involves putting an additional lens between the patient's iris and natural lens. The procedure is

NICE guidance

In March, the National Institute for Health and Clinical Excellence issued guidance on laser eye surgery for refractive errors. It states that current evidence suggests laser eye surgery is safe and works well enough for use in appropriately selected patients. However, NICE does not recommend that the treatment should be routinely offered on the NHS. The guidance is available at www.nice.org.uk

similar to the lens insertion that follows cataract or clear lens extraction except that the natural lens remains in the eye. In effect, the lens becomes an internal contact lens. The surgery is preceded by a procedure called peripheral iridotomy, one normally performed to prevent recurrence of closed angle glaucoma, where microscopic holes are made in the iris with an yttrium aluminium garnet (YAG) laser to facilitate the flow of aqueous humour. This procedure is most suitable for patients with high refractive errors who are not suitable candidates for laser surgery.

The average charge per eye for clear lens extraction and phakic intraocular lenses in 2005 varied between £995 and £2,500.¹

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Action: practice points

Reading is only one way to undertake CPD and the Society will expect to see various approaches in a pharmacist's CPD portfolio.

1. Do you stock any of the eye drops used during and around laser eye surgery? Familiarise yourself with the contents of their patient information leaflets.
2. Find out if there are any clinics in your area offering surgery for refractive errors.
3. Talk to patients who have had laser eye surgery and make notes on what medicines they were given post-surgery.

Evaluate

For your work to be presented as CPD, you need to evaluate your reading and any other activities.

Answer the following questions:

What have you learnt? How has it added value to your practice? (Have you applied this learning or had any feedback?) What will you do now and how will this be achieved?