Fact Sheet - Refractive laser surgery

Terminology and Techniques

The techniques for reducing or removing the need for corrective glasses and contact lenses are summarised in Table 1. Some are much more commonly used than others.

SITE OF TREATMENT	TECHNIQUE	PROCEDURE NAME	INDICATIONS
Corneal techniques	Excimer laser	PRK – Photo-Refractive Keratectomy	Low to high: myopia, astigmatism Low and moderate: hyperopia
		LASEK – LASer Epithelial Keratomileusis	
		LASIK – LASer In situ Keratomileusis	
	Excimer laser – non-refractive PTK–	Photo-Therapeutic Keratectomy	Removing scarring and smoothing
	Thermokeratoplasty (TK)	Holmium laser (LTK) Conductive Keratoplasty (CK)	Low hyperopia
	Microsurgical techniques	RK – Radial Keratotomy	Low and moderate myopia
		AK – Arcuate Keratotomy	Moderate and high astigmatism
		ICR – IntraCorneal Rings	Low myopia
Lens techniques	Microsurgical techniques	Cataract extraction & IOL	Clouding of the lens by cataract
		Clear lens extraction & IOL	Moderate and high myopia hyperopia
		ICL (Intraocular Contact Lens or Phakic IOL)	

Table 1.1. Refractive surgery techniques (IOL = intraocular lens. Low = 0 - 3D (dioptres), Moderate = 3 to 6D, High = 6 to 10D, Extreme = more than 10D)

Changing the eye's focus by surgery (refractive surgery)

The cornea is the transparent surface of the eye in front of the coloured iris. The extent to which it is curved determines its focusing power.

Excimer Laser Techniques

Excimer lasers reshape the cornea:
- In Short-sightedness (Myopia): the centre is made flatter by removing more tissue from the centre than the edge
- In Long-sightedness (Hypermetropia): the centre has to be more curved by removing more tissue from the edge than the centre as in a ring doughnut shape
- In Astigmatism: the curve has to be evened out (ie: the cornea converted from a rugby ball shape to a football shape).

The benefit of corneal laser surgery is that instruments do not need to enter the eye itself, so damage or infection inside the eye is very rare. Corneal surgery can only correct short-sightedness up to -14D and long-sightedness up to +6D. Any surgery on the cornea can induce clouding or distortion, which may reduce visual acuity.

Photorefractive keratectomy (PRK)

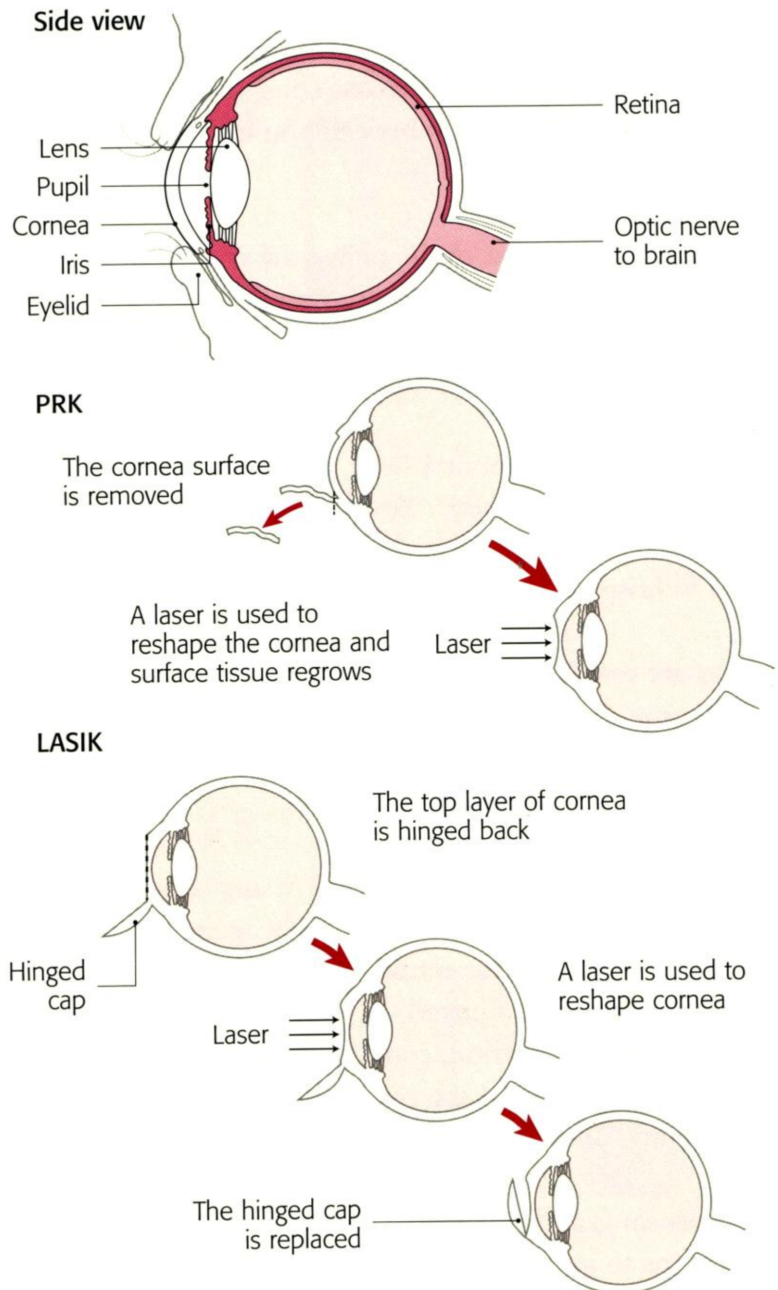
PRK has been widely performed since the late 1980s. With the development of LASEK and LASIK, it is now mainly used for low refractive errors. Since little corneal tissue is removed, the remaining cornea is strong. The eye may be sore for about 48 hours after surgery. The healing process continues for several months and can vary between patients. During this time the refraction slowly changes due to the healing process. There is usually a period of corneal haze which can cause blurring of vision and glare. In some patients (particularly those with higher refractive errors) these symptoms can persist to a greater or lesser extent.

Laser epithelial keratomilieusis (LASEK)

LASEK is similar to PRK but the surface layer (epithelium) of the cornea is retained as a flap. A special soft contact lens is kept on the eye for 3-4 days to allow the surface to heal. The eye is much more comfortable than following PRK. Retaining the epithelium is thought to prevent later complications of haze and speed up healing

Laser in situ keratomilieusis (LASIK)

LASIK has been widely performed since the mid 1990s. Most types of refractive error may be corrected with LASIK but it may not be suitable for extreme corrections as the procedure may make the cornea too thin and unstable. It differs from PRK as a cut is made across the cornea by a special machine (microkeratome) to raise a flap of the cornea (like cutting the top off a boiled egg, and leaving the shell attached at one side). The exposed surface is then sculpted in the same way using the excimer laser and the flap is replaced. This results in tissue being removed from the middle layers of the cornea (stroma). LASIK does not usually causes much pain, and vision tends to recover quickly. The wound healing process is less pronounced. However, the surgical technique is more involved, and if complications do occur, they may be more serious than after PRK.



Wavefront

There are natural irregularities (aberrations) of the structural components of the eye, which can cause light rays to focus incorrectly. Wavefront analysers can detect such aberrations. Laser treatment can also cause ocular aberrations. These aberrations have been reduced with newer lasers, e.g. the use of larger diameter treatment zones. Customised ablations calculated from preoperative Wavefront analysis are becoming available but it remains to be seen whether customised ablations will make a significant difference to the average refractive surgery patient.

Thermokeratoplasty and conductive keratoplasty

Applying a ring of small spots of heat in specific locations, using a holmium laser in Laser Thermokeratoplasty (LTK) or using an electrically heated wire in Conductive Keratoplasty, alters the front shape of the cornea by contraction. The coagulated tissue within the spot contracts resulting in steepening of the cornea. Thermokeratoplasty will only correct low degrees of long-sightedness and the effect of the surgery may gradually reduce over time resulting in the return of the long-sightedness.

Radial Keratotomy (RK)

Radial keratotomy was one of the earlier methods of treating short sight. Shallow radial cuts were made into the cornea around the pupil. The technique has now been almost completely replaced by excimer laser surgery.

Are you suitable?

Those suitable for treatment

- ✓ Age 21 years or over
- ✓ Stable prescription i.e. less than 0.5D change over the preceding 2-3 years

- ✓ Healthy eyes
- ✓ Good general health
- ✓ People with reasonable expectations

Those unsuitable for treatment

- X Pregnancy / breast feeding
- X Significant keratoconus, cataract or glaucoma, herpes eye infection. (These should be discussed further with your surgeon).
- X Patients on certain prescription drugs, such as oral steroids.
- X Excimer laser surgery may not be suitable for patients with medical conditions such as diabetes, rheumatoid arthritis, systemic lupus erythematosus. These should be discussed with your surgeon.

There may be other issues, but these will be discussed at the initial consultation.Much of the initial assessment may be undertaken by an optometrist (optician) but you should also be examined by an ophthalmologist who should be the person who will perform your surgery. This will also give you the opportunity to fully discuss any questions you may have with the operating surgeon. The surgeon will discuss with you about what to expect at each stage.

After surgery

It is common to protect the eye at night time for the first week or so with a plastic shield. Antibiotic, anti-inflammatory (steroid) eye drops and artificial tears are prescribed for use after surgery. The dosage and duration varies with each technique. Patients generally use the antibiotic and anti-inflammatory eye drops for a week or so while the artificial tears may be used for a longer period (often up to six months in patients with dry eyes after LASIK).

Most patients have a reasonably comfortable period after surgery and are back at work within a few days to a week. Depending on the vision correction attempted, driving may be unsafe for 1-2 weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

There are significant variations in the way patients recover from the three (PRK, LASIK & LASEK) laser techniques. The following table highlights these variations in cases where the surgery has been uneventful and free of complications.

Laser Technique	PRK	LASIK	LASEK
Pain	Moderate to severe with significant patient variability	Minimal if any	Mild for the first 24 hours or so light sensitivity
Recovery of useful vision	2-4 weeks	1-2 days	3-6 days
Stability of Vision	Usually 1-3 months, can take 6 months to a year in some cases	Usually 1 week to 1 month, in some complicated cases can take 3 to 9 months	1 week to 1 month, in some complicated cases can take 3 to 9 months
Contact lens	First 4-7 days	Usually not required. Used in cases where the surface epithelium is scratched.	Used for the first 3-4 days.
Return to work	Usually a week, can take longer	2-3 days	3-6 days

Table 2

Statistical results of Surgery

Myopia (PRK & PARK)

Studies between 1992 and 2002 show that for low to moderate degrees of myopia (-1.00 to -6.00D) the majority of patients achieve a very satisfactory result following surface based laser treatment (between 80% and 96% of patients obtained a result within 1.00D of the intended correction and see 6/6 unaided and all see 6/12 unaided). With higher corrections up to –10.00D, patients may have more visual side effects such as haloes. In this higher correction group, about 40% achieve 6/6 vision unaided and about 75% achieve 6/12 vision unaided. Correction of astigmatism is possible up to 4 dioptres and success is slightly less than results for myopia without astigmatism. Reduction of the original laser correction can occur with time. Newer excimer lasers produce

smoother treatment zones and more stable results so that fewer than 10% of eyes with low to moderate levels of myopia (-1.00 to -6.00D) will regress.

Longsightedness (HPRK & HPARK)

Results for treatment of hyperopia with PRK show less stability (compared to myopia results) with lessening of the effects after two years (regression). No more than 6 dioptres can be corrected as the visual quality is reduced if more is corrected.

Laser in situ epithelial keratomileusis (LASEK)

LASEK as an excimer laser technique has only been regularly practised in the UK since 1999 and at this time published data on the results of treatment is limited. At present it would appear the refractive and visual results of LASEK appear broadly similar to the results of PRK with possible reduction in corneal haze.

Laser in situ keratomileusis (LASIK)

LASIK has been practised in the UK since 1995. Initially it was used to treat the higher levels of myopia where it was thought likely that the result would be unsatisfactory using a surfaced based PRK treatment. In many centres in the UK, LASIK is being used as an alternative to PRK for corrections up to –12D. The refractive and visual results for treatment of patients with myopia, hypermetropia and astigmatism with the LASIK procedure are broadly similar to the results of treatment with PRK after one year. No statistical difference has been found between the results of the two procedures in randomised clinical trials published in English between 1994 and 2000 in International Specialist Journals. Occasionally there may be a permanent reduction in best-corrected visual acuity (BCVA). There is a risk (between 2.7% and 4.8%) of loss of two or more lines of BCVA after LASIK.

Complications of Excimer Laser Surgery

There is a wide range of the reported incidence of complications (from less than 1% up to 40%). Some complications, such as halo formation, were much more common with earlier laser machines using 3.5 to 4.5 mm diameter treatment zones than current lasers using 6.0 to 7.0 mm treatment zones. Since PRK, LASEK and LASIK utilise an excimer laser to produce the refractive correction many of the complications encountered are similar.

Miscellaneous side effects occurring equally in surface treatments and LASIK

- **Minor over correction or under correction of refractive error**. Since all patients' eyes differ in the rate and manner of healing, the computer predicted result might not achieve the expected correction leaving some patient's over- or under- corrected. Some patients may be offered a second procedure (enhancement) but others may need spectacles or contact lenses for some tasks. Additional laser treatment is required in 5% to 15% of cases.
- **Presbyopia** is difficulty reading without glasses. This usually occurs when people reach their early to mid 40's. However, short-sighted people often do not require glasses for reading when they reach this age as removing their distance glasses allows reading unaided. A young myopic patient treated for distance vision will effectively become "normal sighted" for reading, but when a treated patient reaches 40-45 years of age, reading glasses will be required for near work. (See also Section 3.3 Monovision)
- **Difference in refractive error between the two eyes (anisometropia)** may occur if only one eye is treated and patients may need to continue using glasses or contact lenses to balance the two eyes.
- **Contact lens wear if needed** may be more difficult following laser treatment due to the changed shape of the cornea.
- **Ptosis (drooping of the upper lid)** may occur in the first few weeks following surface laser treatment but rarely persists.
- **Eye sensitivity**. The eye after surface laser treatment can be slightly more sensitive to touch. Minor symptoms are relatively common in the first few months but severe symptoms are rare. These problems are usually self-limiting and persist in less than 1% of patients.
- **Decreased night or low light vision** is characterised by symptoms such as glare, halos and starbursts seen around objects at night or in dim light conditions. Although visual acuity as measured on an eye chart may not be affected, for some patients these symptoms can interfere with daily activities and in particular with driving at night. Reduced night vision is often temporary lasting one month to six weeks. A few patients however continue to experience these symptoms on a long-term basis. Research has shown that the incidence of these symptoms is caused by increased light scatter and induced irregularities (higher order aberrations) in the eye. Such problems are more common in those with particularly large pupils.

- **Risk of Retinal Detachment**. People with Myopia (short-sightedness) have a greater risk of retinal detachment. It is important to remember that your retinal detachment risk remains after laser surgery.

Complications of surface based laser treatment (PRK, LASEK)

- **Instability of the cornea following PRK or LASEK**. The cornea is made 10%-20% thinner after surface based excimer laser treatment. The cornea is not significantly weakened and is therefore unlikely to be at risk from trauma.
- **Vision reduction from all causes**. The majority of scientific publications regard a reduction in visual acuity by two or more lines on the Snellen letter chart as being significant. This may occur in:
  - Less than 4% of patients with low to moderate myopia (-0.5 to -6.00 D)
  - 10% or more patients with high or extreme myopia (over –6.00 D).
- **Haze and scarring**. All patients develop at least a mild degree of corneal haze. The haze is worse during the first two to three months and in most cases will disappear within six to twelve months. Scientific publications indicate that the percentage of patients with haze and the degree of haze after laser treatment are related to the preoperative degree of myopia. With higher myopia it is more likely that haze will occur and will affect the vision. Haze may occur in:
  - 1-3% of patients with low to moderate myopia (less than –6.00D)
  - 5% or more patients with high or extreme myopia (over –6.00D).
- **Infection**. Since the surface of the cornea is removed during treatment it is possible that the eye may develop infection in the first week following laser treatment. Surface laser treatment infection is rare and occurs in less than 0.1% of treatments. (Severe infection can result in permanent corneal scarring, reduced vision and possible loss of the eye). Excimer laser treatment may result in reactivation of old herpes simplex virus corneal infection and the laser surgeon must be informed if a patient has had presumed herpes infection of the eye in the past.

Complications of LASIK

- **Instability of the cornea following LASIK**. Ectasia is the forward bulging of the centre of the cornea resulting in irregularity of the optical surface and poor quality vision. It results from weakening of the cornea due to removal of too much tissue. It is thought that 250 microns of untouched deep corneal tissue must remain to prevent ectasia following laser treatment. A LASIK procedure will create a corneal flap (usually between 160 and 180 microns depth) and the laser treatment is then carried out on the remaining corneal tissue. The untouched deep corneal tissue is, therefore, thinner following a LASIK procedure than a surface based laser treatment. Although the figure of 250 microns of untouched corneal tissue is generally taken as a safe level following LASIK treatment, there is relatively little scientific data to validate this figure, which is speculative, and still the subject of debate.
- **Corneal haze**. Due to cutting of the cornea, there is less healing after LASIK and a greatly reduced incidence of haze.
- **Reduction in visual quality from all causes**. There is a risk (between 2.7% and 4.8%) of loss of two or more lines of best corrected visual acuity after LASIK.
- **Problems specifically related to the LASIK surgical procedure**. Due to the creation of the hinged corneal flap in LASIK, complications related to the corneal flap are necessarily unique to the LASIK procedure. The following complications have generally been reported as occurring in between 0% and 4% of patients undergoing the LASIK procedure. All these complications may be associated with a permanent reduction of best-corrected vision. Other rare problems are:
  - Incomplete cut of the corneal flap (usually remedied by a repeat procedure after 2-3 months)
  - Loss or extensive damage to the corneal flap
  - Completely free corneal flap – which might require stitches to hold it in place
  - Debris or fibres under the corneal flap which may cause inflammation
  - Epithelial ingrowth under the corneal flap
  - Wrinkling of the corneal flap
  - Retinal haemorrhage or retinal artery or venous occlusion
  - Penetration of the eye by the microkeratome and possible loss of the eye because of haemorrhage or infection (very rare)
- **Dry eye**. The majority of patients complain of dry eye symptoms after LASIK because the surface nerves have been cut. (These nerves take six months to regrow). The use of artificial tears (lubricant drops) alleviate the sensation of irritation. Occasionally a temporary punctal plug is placed in the opening of the tear duct to slow the tear drainage from the eye.

Royal College of Ophthalmologists guidelines for refractive surgery

Qualifications of the surgeon

There are no specific qualifications in refractive surgery and the only legal requirement for doctors performing laser eye surgery is that they are registered with the General Medical Council. However, the Royal College of Ophthalmologists recommends that refractive surgeons should be fully trained ophthalmologists and should have undergone additional specialist training in refractive surgery. Some refractive surgeons are also NHS consultants in ophthalmology. They have completed at least 8 years training, are Fellows of the Royal College of Ophthalmologists, have experience of a wide range of eye diseases and regularly perform intra-ocular microsurgical procedures. They have experience of a wide variety of eye diseases in addition to refractive problems.

Recommendations

- ✓ You should have an initial consultation with the doctor who is going to perform the refractive surgery.
- ✓ Surgery should not be performed within 24 hours of this consultation.
- ✓ Follow up after the procedure should be with the same doctor who performed the surgery.
- ✓ The doctor should maintain an outpatient service, either at the clinic/hospital where refractive surgery is undertaken, or elsewhere, such that he/she can provide routine and emergency follow-up care.
- ✓ Some clinics treat both eyes at the same time. Serious complications affecting both eyes are very rare, but can and do happen. If this happened to you, you would be left with permanently poor vision in both eyes, perhaps unable to work, read, or drive.

Glossary

Antibiotics	Drugs used to prevent or treat infection by bacteria
Antivirals	Drugs used to prevent or treat infection by a virus
Astigmatism	Oval shape of the eye or cornea
Conjunctiva	Loose sealing layer over the white sclera of the eye which keeps the eye moist and protected
Dominant	Lead eye
Excimer	A type of laser (EXCited dIMER)
Epithelium	Surface layer of the cornea
Endothelium	Cell layer on the inside of the cornea responsible for keeping the cornea dehydrated and clear
Haloes	Ring of light around a light
Haze	Loss of clarity of the cornea
HPRK	Hyperopic PRK
Hyperopia (hypermetropia)	Longsightedness corrected using plus (+) lenses
Keratectomy	Removal of corneal tissue
Keratome	Knife/blade for cutting the cornea
Keratomileusis	Making a flap of the cornea
LASEK	LASer Epithelial Keratomileusis
LASER	Light Amplification by the Stimulated Emission of Radiation
LASIK	LASer In-situ Keratomileusis
Microkeratome	Small mechanised blade for cutting the cornea
Monovision	Use of each eye for different distances, ie dominant eye for distance and other eye for near vision
Myopia	Short-sightedness corrected using minus (-) lenses
PARK	Photo-astigmatic Refractive Keratectomy
Presbyopia	Loss of accommodation with age (near focus)
PRK	Photo-refractive Keratectomy
PTK	Photo-therapeutic Keratectomy (smoothing of an irregular surface)
Refraction	Assessment using lenses of the focus of the eye
Retina	Light sensitive layer at the back of the eye containing rods and cones, similar to the film in a camera
Scatter	Spreading out of light inside the eye, resulting in a reduction in the quality of vision
Speculum	Clip used to keep the eyes open during surgery
Squint or Strabismus	Abnormal eye turn
Steroids	Drugs used to reduce the inflammatory reaction that occurs during the healing process
Stroma	The main bulk of the cornea
6/6	normal level of vision, measured in metres. It is the same as 20/20 which is measured in feet.
6/12	at this level of unaided vision many social activities are possible without glasses (equivalent to 20/40)
6/60	sufficient vision to see the top letter on a vision testing chart (equivalent to 20/200)

Produced in part from the Royal College of Ophthalmologists leaflets and website. This is a guide only and you should always use the consultation with the Ophthalmologist to confirm these procedures are correct. Remember things change.

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