Refractive Surgery – the answer to my visual problems?
C6449

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Refractive Surgery – the answer to my visual problems?

Shehzad Naroo presents an overview of current techniques and results, contraindications, complications and onward optometric management of refractive surgery.

Refractive surgery has now become sufficiently predictable and safe to be considered a viable option by a sizeable proportion of the ametropic population. Large numbers (70,000 last year in the UK alone), are undergoing some form of refractive surgery, usually corneal based and most commonly LASIK. The majority of these individuals are myopes with an average age of 37 years. Despite the best attempts of some surgeons and optometrists during preoperative counselling, few patients seriously consider the functional implications of presbyopia before it strikes, and the benefits of being myopic in older age.

Summary of excimer refractive surgery procedures for the correction of ametropia:

- Photorefractive keratectomy (PRK) – low myopia, low hyperopia and low astigmatism
- Laser epithelial keratomileusis (Lasek) – low myopia, low hyperopia and low astigmatism
- Laser in-situ keratomileusis (Lasik) –medium to high myopia and astigmatism, low to medium hyperopia

Photorefractive keratectomy (PRK)

Until about five years ago, PRK was the most commonly performed refractive surgery procedure. It has now been replaced in terms of popularity by Lasik but it remains a suitable technique for the correction of low degrees of myopia, hypermetropia and astigmatism. For the correction of ametropia between ±3D, there is little difference in predictability and final visual outcome, between PRK and Lasik [12]. Patients tend to prefer Lasik as they see it as a more modern procedure. There also tends to be less pain following Lasik and a more rapid return of functional vision. The advantage of PRK over Lasik is that it avoids the complications that can be associated with creation of a corneal flap, but it can lead to the development of corneal haze and regression, particularly when used to treat higher refractive errors.

Surgical method

Prior to any excimer laser procedure, beam homogeneity and calibration is checked. Topical anaesthesia is applied to the eye(s) to be treated.

Figure 1 shows a manual method of removing the epithelium in PRK, new epithelium will grow back over the ablated area

The treatment area is marked with a trephine (typically 6mm with modern lasers) and the epithelium is removed mechanically, chemically or with the laser itself **(Figure1).** The patient fixates the target in the laser and the instrument is run at the desired program. Treatment times vary according to the amount of ablation required as well as the instrument type. Modern, flying spot lasers which produce multiple laser burns typically take longer, around 60 to 120 seconds per eye. On completion of ablation, topical antibiotics and steroids are applied. Some surgeons insert a bandage lens for the first 24 hours, particularly in bilateral cases. The intense pain associated with PRK may necessitate the use of strong painkillers and/or sleeping aids. The patient is typically assessed the following morning, 1 week, 1, 3, 6 and 12 months post treatment.

Results

For low and medium degrees of myopia (<-6.00D), 88-99% achieve 6/12 or better (uncorrected vision), and 58-78% achieve 6/6 or better by 12 months post-PRK [13-16]. The post-operative refractive error tends to be slightly hyperopic initially, drifting towards emmetropia, or mild myopia as the cornea heals. By 12 months, 87-99% of low and medium myopes (<-6.00D), and 79-84% of high myopes are within ±1D of emmetropia. Enhancement procedures can be performed to correct residual refractive error but predictability is not as good as for the initial procedure. The treatment of astigmatism is less predictable since axis alignment is critical [17] and there are variations in meridional wound healing [18]. Hyperopic treatments are also slightly less successful than myopic treatments and can take longer for the refractive error to stabilse [19,20].

Complications

Diffuse stromal haze (backward light scatter) is very common following PRK and usually takes the form of a fine reticular subepithelial pattern that does not interfere with high contrast visual acuity. The haze corresponds to a corneal healing response after PRK, induced by activation and migration of keratocytes (fibroblasts) and newly synthesised collagen. Moderate to severe haze is usually associated with regression of the refractive error towards myopia. The haze usually fades within 12 to 18 months. Other complications include under or over correction, leaving the individual in need of an enhancement procedure or an optical correction.

Forward light scatter is known to increase following PRK, peaking around three months before returning to normal levels comparable to spectacle wearers and soft contact lens wearers by 12 months [21,22]. A more permanent consequence of excimer laser procedures including PRK, is the augmentation of aberrations such as spherical aberration and coma [21,23,24]. These irregularities are most commonly associated with an unwanted change in the eccentricity of the cornea (spherical aberration) – conventional laser algorithms correct spherical refractive error but alter the prolate shape of the cornea, reducing its optical quality. Irregularities can also be associated with central islands or decentration of the ablation (coma). The degree to which the aberrations of the eye increase as a result of surgery varies considerably between individuals. Since both forward scatter and aberrations cause a reduction in the retinal image contrast, low contrast acuity and contrast sensitivity are affected for the first three months for myopia below –6.00D, and six months for treatments greater than -6.00D [24-28]. A permanent reduction in visual performance occurs in a minority of individuals, associated with large induced aberrations or persistent scatter [29]. Studies indicate that visual performance under low illumination when the pupil is dilated (aberrations and scatter are greatest), may be compromised for a year or more, particularly for low contrast tasks [27,30]. Ocular integrity is not significantly compromised following PRK [31,32].

Laser epithelial keratomileusis (Lasek) / EpiLasik

Lasek is essentially a modification of the PRK technique and can be considered as an alternative technique for correction of low to moderate myopia. It results in less haze than PRK [33], and avoids the potential complications of Lasik associated with the creation of a corneal flap. Like PRK it has the advantage of conserving precious stroma in eyes with thin corneas or high myopia, which are unsuitable for Lasik. It may also be more appropriate for patients whose jobs or recreational activities put them at a higher risk of corneal trauma (Lasik flap damage). Lasek may also prove to be superior to Lasik in relation to wavefront-guided treatments since creation of the Lasik flap alone is known to modify the aberrations of the eye significantly. Although some surgeons believe that Lasek is simply a glorified version of PRK with few real benefits, others believe that Lasek will replace PRK completely within the next couple of years and also take over a portion of the Lasik market.

Surgical technique

Lasek involves the production of an epithelial flap using a solution of 20% alcohol. A trephine is placed on the cornea and the area flooded with the alcohol solution for approximately 20-30 seconds, before irrigating the eye profusely to wash away the alcohol. The alcohol breaks the hemidesmosome bonds between the basal epithelial cells and the basement membrane, but does not alter the bonds between epithelial cells, allowing the epithelium to be pushed aside as a complete circular flap or butterfly-style flap **(Figure 2)**. The underlying anterior stroma is ablated as in PRK **(Figure 3),** but the epithelial flap is then replaced, acting as a bandage lens to minimise post-surgical inflammation. EpiLasik employs a modified keratome to separate the intact epithelium from Bowman's membrane, rather than using alcohol.

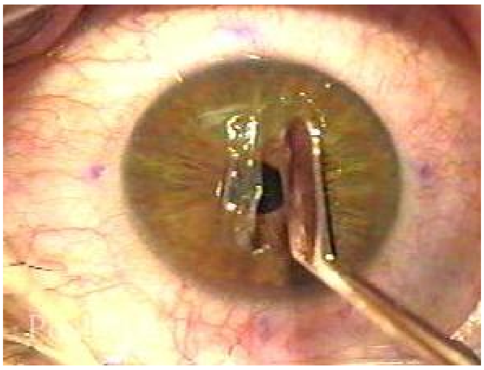


Figure 2 shows the epithelium being debrided in LASEK

Results

Vision recovers rapidly - in one recent study of 222 eyes ranging from –1D to –11D, 98% of eyes achieved 6/12 unaided vision within two weeks of Lasek and 63% achieved 6/6 unaided vision at one year [34]. The procedure appears to be safe since no eyes showed a reduction in best-corrected visual acuity despite the wide range of pre-operative myopia.

Complications

A study comparing Lasek with conventional PRK for the treatment of –3D to –6.5D, reported significantly less corneal haze following Lasek, although there was no significant difference in uncorrected vision or refractive outcome at three months post-surgery [35]. Complications associated with the laser such as aberrations, decentration and central islands are as common for Lasek as for PRK and Lasik.

Laser assisted in situ keratomileusis (Lasik)

In the last five years Lasik has superseded PRK as the method of choice for the treatment of myopia, myopic astigmatism, hypermetropia and hypermetropic astigmatism. There are many reasons why it has become the favoured treatment; from the patient's perspective, Lasik is less painful and gives an almost instantaneous result, whereas from the surgeon's viewpoint a greater range of refractive errors can be managed with this procedure. Although the magnitude of refractive correction that can be managed with Lasik will vary with surgeon, the range of myopic treatment is often in the region of –1.50D to –10D of myopia and +2D to +5D for hyperopia. The maximum treatable cylindrical power is usually in the region of 4DC. It is important to remember that the magnitude of refractive correction possible is governed by the available corneal thickness and the scotopic pupil size.

It is now accepted that in order to prevent corneal ectasia, 260µm of the corneal bed should be left untreated. Most flaps are in the region of 160µm thick, which means that for most Lasik procedures, 420µm of corneal tissue must be left untouched. Bearing in mind most corneas are between 500-550µm thick, this leaves between 80 and 130µm available for ablation. As a rule of thumb, for each dioptre of change in prescription approximately 12µm of tissue must be removed. Some surgeons have utilised thinner flaps (130µm) in order to manage a high refractive error, but thin flaps are associated with an increased risk of flap complications. Also where pupil size allows, the area of the treatment zone can be reduced from the normal 6mm to say 5.5mm allowing further reduction in a high prescription.

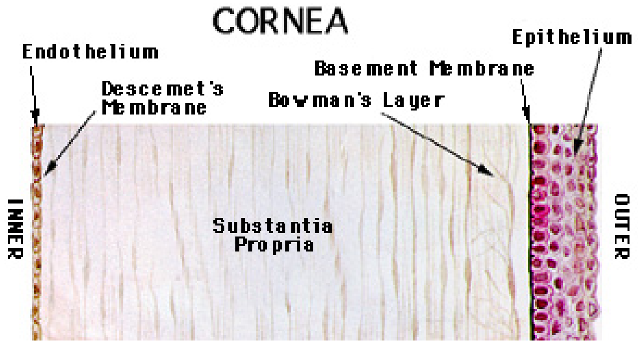
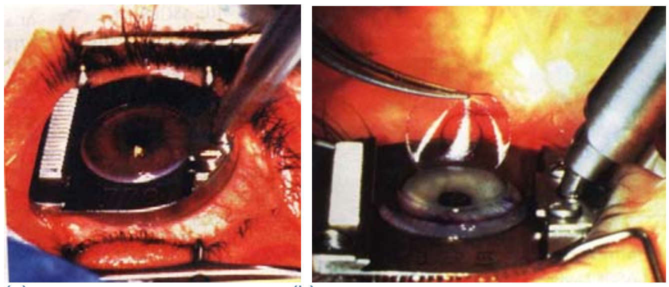


Figure 3 shows the layers of the cornea, in LASEK the epithelium is moved aside and then the underlying surface ablated and then the epithelium is replaced. In LASIK the microkeratome cuts into the anterior stroma and cuts a flap of approximately 160 microns that includes the epithelium, so that ablation occurs deeper in the cornea in LASIK

Surgical technique

Methods will vary according to surgeon idiosyncrasies however the following provides a useful guideline. The microkeratome used to make the Lasik flap is assembled and checked **(Figure 4)** . The patient is prepared for surgery by cleaning the eyelids with an iodine-based sterilising solution. The lids are clamped with an eyelid speculum to prevent blinking and the cornea is anaesthetised with topical eye drops. The cornea is marked with radial marks that will facilitate correct alignment once the flap is replaced after ablation. A suction ring **(Figure 5a)** is applied to keep the eye still and the microkeratome is then engaged. This splits the cornea into two lamellae, the outer flap (typically 160 to 180µm thick) being attached to the remainder of the cornea by a hinge. The flap is then reflected back on itself **(Figure 5b)** exposing the stroma. At this point the patient is asked to fixate the target on the laser.

Figure 4 shows the Hansatome, which is the most popular microkeratome used in LASIK



(a) (b)

Figure 5 (a) shows a suction ring being applied to the cornea; this raises the IOP to about 50-60mmHg causing transient visual blackout. The next step in LASIK would be to apply the blade part of the microkeratome and cut the flap. **(b)** shows the flap being lifted in LASIK

The laser is applied to the exposed stromal bed, not the flap **(Figure 3)**. With modern, flying spot lasers, ablation typically takes between 60 and 120 seconds. The flap is then replaced and floated onto a bubble of fluid to help alignment and sealing. The flap must be aligned in its original orientation and the surgeon must be careful to ensure no wrinkling or folding of the flap. The flap adheres via suction and surface tension to the underlying tissue spontaneously, resulting in no need for sutures. The flap being relatively thin will adopt the new shape of the underlying stroma; hence the contour of the flap becomes flatter in myopia and steeper in hypermetropia. On completion the surgeon checks the flap has sealed and topical antibiotics are applied. The eye is patched with a clear transparent shield. For bilateral cases the process is repeated. The amount of pain experienced post-operatively varies from patient to patient. Some will require no pain managing drugs while others will want some form of analgesia in addition to the prophylactic antibiotic and anti-inflammatory eye drops. The patient is then followed up in the clinic 1 day, 1 week and 1, 3, 6 and 12 months post-treatment.

Results

As with PRK and Lasek, the predictability and accuracy post-Lasik is greater for lower degrees of ametropia. The predictability of achieving 6/12 or better unaided is between 90-100% by six months for myopia up to –6.00D, but this figure drops to around 65% for myopia greater than –6.00D [36,37] An unaided vision of 6/6 or better is achieved by between 83-91% of eyes treated for <-6.00D [38,39]. The percentage of eyes achieving a residual refractive error within +/-1.00D of emmetropia at six months is between 81-100% for those treated for <-6.00D [37,39,40]. The refraction stabilises within 3-6 months [41] due to the limited stromal healing that takes place following the procedure. As with PRK and Lasek, treatments for astigmatism and hyperopia are less accurate and hyperopic treatments in particular tend to be associated with slow stabilisation of the refractive outcome and a greater loss of best corrected visual acuity [20,42]. Enhancements can be performed as early as 3 to 6 months post-Lasik. The flap can be lifted and a simple blunt dissection can be performed up to three years after the primary procedure.

Complications

Complications can be associated with the flap or less commonly, the laser ablation itself. Flap complications that can occur during surgery include the creation of a buttonhole flap (more common with steep corneas), a free cap (more common with flat corneas) or an incomplete flap. All generally require the flap to be repositioned without ablation and the procedure is postponed for 3-6 months. Flap displacement occurs in less than 1% of cases, almost exclusively within 24 hours following surgery. Prompt recognition and early surgical intervention are crucial to achieve a good outcome. Flap wrinkles and folds can cause significant visual problems and result from improper positioning of the flap after the ablation. These are more common in eyes that have undergone treatment for large refractive errors since the flap no longer fits the stromal bed. Central wrinkles require prompt management, involving refloating of the flap. Interface debris is common, even with aggressive irrigation. Metal filings, sponge fibres, or meibomian secretions can become trapped in the interface. These particles rarely incite inflammation or affect vision. In cases with significant amounts of debris it may be necessary to lift the flap and irrigate the stromal bed. When inflammation does develop, it is known as Sands of the Sahara syndrome or diffuse lamellar keratitis (DLK). It is a non-infectious interface inflammation presenting 1 to 5 days after Lasik that usually responds well to prompt identification and treatment. Decreased visual acuity, foreign body sensation or photophobia may be reported. Slit lamp examination reveals fine granularity confined to the interface with no flap or stromal extension. Irrigation and intensive steroid therapy is required in severe cases. Epithelial defects occur occasionally after Lasik and are associated with an increased risk of DLK and epithelial ingrowth. Epithelial ingrowth occurs most commonly after enhancement surgery and after flap complications. The incidence of epithelial ingrowth is between 1.5%-3.5%. The majority of these cases are seen several weeks post surgery with mild in-growth at the edge of the flap. These do not require treatment if stable but should be referred back to the operating surgeon for review. Occasionally ingrowth may occur resulting in significant complications. In-growth toward the pupillary area may induce irregular astigmatism. Treatment of significant epithelial ingrowth involves lifting the flap and debriding both the stromal surface and under surface of the flap using a paton spatula. The most feared complication is surgically-induced keratectasia but this is rare as long as 200-250 microns are left untreated in the stromal bed. Complications associated with the ablation are the same as for PRK and Lasek – principally irregularity and increased aberrations, leading to a reduction in visual quality [43] Although high contrast visual acuity is rarely affected, on average, contrast sensitivity is reduced at high and middle spatial frequencies for up to three months post-operatively, [44,45]. Visual performance at low light levels is likely to be degraded for longer with permanent changes in some individuals [46].

Since the majority of patients opt for refractive surgery in the hope of eliminating their reliance on spectacles, it is not surprisingly that levels of satisfaction are lower in those who need reading glasses following surgery [47]. One group that can be particularly disappointed are the low myopes who have only just become presbyopic, and have previously been able to read by removing their spectacles. Satisfaction is also lower in individuals who have been accidentally overcorrected, leaving them slightly hyperopic and hastening the onset of presbyopia. This is more likely to happen in older patients since the healing of the eye is less predictable [48,49] and the laser ablation rate is augmented by age-related differences in stromal hydration and collagen fibril characteristics [50,51]. There is also evidence to suggest that there is a greater reduction in contrast acuity with increasing age, perhaps associated with a more substantial increase in aberrations for the same degree of refractive correction [46]. The ability to discriminate low contrast detail naturally reduces with age associated with an increase in forward light scatter, a reduction in the transmission of the crystalline lens, and neural degeneration. Further degradation of retinal image contrast as a result of corneal surgery can prove highly significant for more visually demanding tasks.

Lasik-induced dry eye is more likely in those with a poor quality tear film preoperative, i.e. older individuals, and post-operative contact lens fitting in problematic cases can also be hampered by dry eye.

Corneal refractive surgery has implications for intraocular surgery should a cataract develop later in life. Due to the alteration of the corneal topography, calculation of the power required for an intraocular lens to replace a patient's own cataractous lens, is less accurate. Surgeons presently base their calculations on the measurement of ocular axial length obtained by biometry, and the keratometry results. Keratometers give an estimate of corneal curvature based on two points from the paracentral cornea, assuming the cornea is a standard shape. The flattening of the central cornea that occurs following excimer laser treatment or radial keratotomy, leads to the wrong intraocular lens being inserted, causing a significant increase in refractive error post-cataract surgery. If a surgeon has access to the patient's pre-refractive surgery notes, a more accurate estimate can be made.

The deadline for responses is 2^{nd} April 2009
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