REFRACTIVE SURGERY - THE FUTURE IN SIGHT?

In Part 2 David Harris discusses recent techniques in refractive surgery and post-LASIK contact lens fitting options

In the first part of these articles we learnt something of the excimer laser, the history of refractive surgery and why a technique that produced fast, predictable results with minimal post-operative discomfort was required. Laser assisted in-situ keratomileusis (LASIK) is the term given to a procedure in which a shaving, or flap, of cornea is created, the flap is folded back to expose the stroma and an excimer laser is used to change the corneal shape so that a given degree of ametropia may be corrected. This seemed to be the perfect answer – higher prescriptions than could reliably be attempted with PRK achieved excellent results, the visual recovery was very fast (in some cases, almost instantly achieved functional vision) and post-operative recovery could reasonably be described as painless – especially after the first few hours.

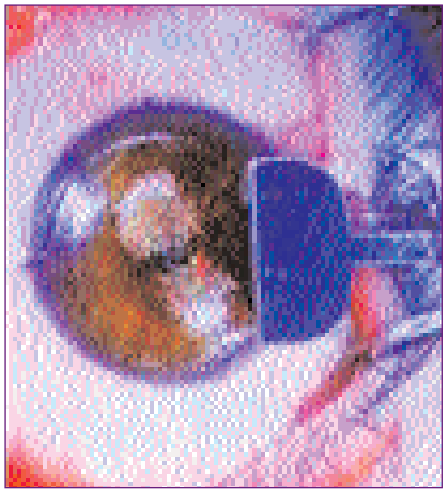
LASIK is the combination of microsurgery to create the flap and PRK. The flap is created with an instrument known as a micro-keratome, which cuts at a pre-determined depth across the corneal plane whilst resting on a base plate, which is held in position by suction against the sclera **(Figure 1)**. The flap that is created is not normally complete and remains attached at the hinge. Once the flap has been created it may be lifted and folded back: the laser then performs exactly the same treatment as would be used to perform PRK – the difference is in the level of cornea that it is applied. With PRK the ablation takes place at the level of the anterior limiting lamina (Bowman's membrane), which is vapourised, and in LASIK the flap is created in the stroma (typically at a depth of between 160µ - 180µ), thus preserving the anterior limiting lamina **(Figure 2)**. Following ablation the flap is returned to its original location, aided by markings which are made prior to use of the micro-keratome, where it heals without the need for sutures. It is seen as important that sufficient 'untouched' residual corneal depth is allowed, following creation of the flap and ablation by the laser, to prevent corneal ectasia (iatrogenic keratoconus) from the intra-ocular pressure pushing against the thinned cornea. As a rule of thumb, ablation of each Dioptre removes approximately 12 microns of corneal tissue. A residual bed of 250 microns is most often allowed for, although in the UK the Royal College of Ophthalmologists guidelines specify a minimum corneal bed of 200 microns. The issue is further compounded by the fact that creation of the flap by mechanical means is not exact and the thickness actually created may vary, although most flaps are actually slightly thinner than the targeted thickness.

Keratomileusis (which involves the creation and lifting of a corneal flap prior to further mechanical surgery) was originally performed in the mid 1960's[1]. LASIK simply represents its combination with PRK but allows a much faster visual recovery as the epithelium remains intact, which also provides for minimal post-operative discomfort. Additionally, the healing response to LASIK surgery from the cornea is much less aggressive than with PRK and therefore more predictable outcomes are possible, which allows a wider range of pre-operative prescriptions to be treated. Similarly, corneal haze is extremely rare in LASIK, in comparison to an extremely high incidence in PRK.

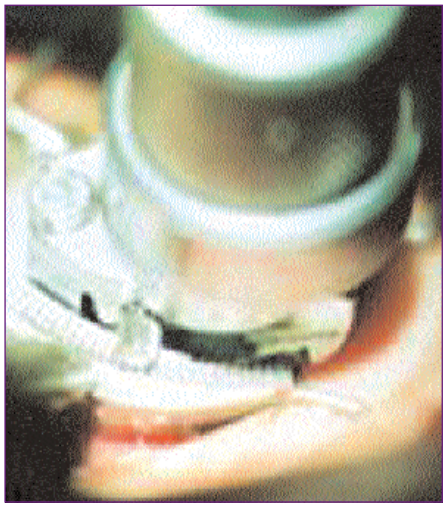
LASIK represents a major step forward in the perception of laser surgery by the public. In the initial days of private excimer laser treatment provision (from the early 1990s) many patients may have justifiably regarded the procedure as relatively new and perceived themselves very much as 'guinea pigs' although they might regard the surgery as worthwhile if their dependence on spectacles or contact lenses was reduced. With the advent of LASIK an almost exponential growth in patient interest has occurred[2,3], as confidence and availability have increased. Public confidence may well have increased with the advent of large multiple optical practices becoming involved in refractive surgery and in the fact that popular and well-known celebrities such as Courteney Cox, Richard Branson and Cilla Black have also elected for LASIK surgery.

Intra-operative and post-operative complications

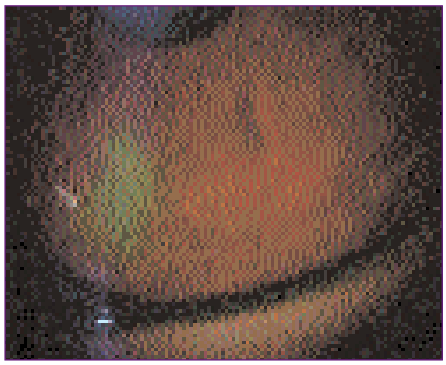
Although LASIK is regarded as a straightforward operation that is normally routine, it is a surgical procedure, which is not entirely without risks. It is therefore very important that patients do not undertake refractive surgery without undergoing suitable refractive counselling in order to ensure that they are in a position to make a fully informed choice. Intra-operative complications are rarely serious and are relatively uncommon[4]. These may include 'short' or incomplete



▲ Figure 1: The corneal flap is lifted aside and the exposed stroma is ablated by excimer laser.

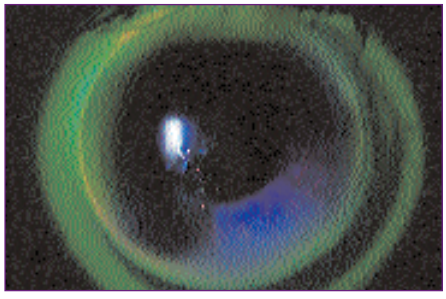


▲ Figure 2: A Bausch & Lomb, Hansatome keratome, used to create a corneal flap with a superior hinge.



▲ Figure 3: The corneal abrasion resulting from a patient's accident with a dropper bottle 20 days following LASIK. Note that the flap remains aligned.

▼ Figure 4: RGP lens fitted to post LASIK patient. A central tears pool that would normally be unacceptable is normal in these patients as a result of topographic changes to the cornea.



flaps in which suction is inadequate during the micro-keratome procedure, resulting in a shifting cornea while the flap is being cut.

A 'button-hole', in which a hole in the centre of the flap is created and a portion remains attached to the cornea, may also occur for the same reason. The action for both a short or button-hole flap is the same in each case and the flap is left alone so that it may heal with no ablation taking place. After a period to allow for healing of the partial flap (normally around three months) LASIK may be performed and an entirely new flap created.

Post-operatively displaced flaps may occur from trauma following the surgery. Patients may rub their eyes, especially in their sleep, which can cause dislocation or produce folds in the flap, although this is rare and only likely to occur in the first few days following surgery. Eye shields to be worn at night are routinely advised in order to prevent damage at night. Harris and Pillai have reported a case where a patient created a significant corneal abrasion with a dropper bottle only 20 days following LASIK[5]. Although the abrasion extended below the epithelium and across the flap edge into the peripheral cornea, the flap remained perfectly aligned **(Figure 3)**. Craig included an extremely unusual report of one patient who dislocated his flap within an hour of surgery by vigorously chewing a toffee[4]!

A potentially serious post-operative complication is Diffuse Lamellar Keratitis (DLK or 'Sand of the Sahara'). This is a non-infectious inflammation that usually presents within one week of surgery. Patients may have symptoms of reduced VA, foreign body sensation and photophobia. Signs seen at the slit-lamp are of a granular appearance to the interface, which does not extend into the stroma or the flap. The granular, undulating, shifting sands appearance results in the name of 'Sands of the Sahara' and varies in severity. Severe or untreated forms of DLK may result in flap melting[6] and is therefore considered a serious occurrence. The aetiology is unknown and likely to be multi-factorial.

Dry eye

Patient symptoms of dry eye are extremely common following LASIK[7]. This is 000likely to be a result of corneal denervation following creation of the flap[7] and the term 'Laser Induced Neutrophic Keratitis' has been used to describe it. In many cases the cornea does not have a dry appearance and the symptoms are disproportionate to the clinical signs. The creation of the flap, when severing corneal nerves, disrupts the feedback loop that exists between the eye and brain, which may result in a perception of dryness through a disrupted blink reflex or, in fact, when little dryness physically exists[7]. Symptoms are likely to resolve within months of surgery although lubricants[7] or punctal plugs normally give symptomatic relief until the corneal nerves have regenerated.

Contact lens fitting post-operatively

Although contact lens fitting for refractive purposes is not likely to be required post-operatively following LASIK because of the excellent visual results, there may be instances in which a contact lens is required. Corneal abrasions may occur during surgery where a contact lens provides smooth surface to disrupted epithelium, an improved visual result while the epithelium heals and pain relief if required. A plano high water content soft lens may be fitted for the initial 24 hours, which the patient may sleep in. It is seldom necessary to extend the wearing period beyond 24-48 hours.

Residual ametropia that requires correction following either PRK or LASIK may present more of a challenge. The corneal surface is changed centrally in curvature and soft lenses, while conforming to the new surface will not usually provide maximum improvements in visual acuity. This is because the flexibility of soft lenses allows corneal irregularity to be 'transmitted' through the lens itself in a similar way to corneal astigmatism. The solution is a rigid lens, which provides a smooth anterior surface and a tears lens to correct irregular astigmatism **(Figure 4)**.

Measurement of the central cornea by keratometry is likely to provide misinformation following laser surgery. This is because a central area, around 6mm in diameter, will have been flattened in myopic correction and steepened relative to the peripheral cornea in hypermetropic correction. Pre-operative keratometry, which may be obtained from the corneal topographies held at the operating clinic, will allow an appropriate trial lens to be selected.

A rule of thumb is that whatever BOZR is likely to have been appropriate from the pre-operative keratometry is likely to be suitable post-operatively. Patients may even successfully wear their pre-operative rigid lenses following surgery. This is because the BOZR and diameter are likely to be acceptable and, although the refraction may, at first sight, not seem to be appropriate following surgery the tears lens will compensate for the change in corneal curvature, providing acceptable visual acuity with little or no over refraction.

The change in cornea curvature will, however, result in unusual fluorescein patterns. In myopia the central cornea has been flattened and the resulting fluorescein pattern will strongly resemble an excessively steep rigid lens in an

untreated eye as the tears lens created by the flattened cornea against the steeper posterior surface of the lens produces a central tears pool. This is likely to be acceptable providing there is no trapped bubble. A flatter lens will be likely to provide poor centration so a compromise fit is required. Reverse geometry lenses, used in orthokeratology, where the central curvature is flatter than the lens periphery have been used in post-laser patients and these will provide good centration with an improved fluorescein pattern and tear exchange. The disadvantage of reverse geometry lenses is the cost, which is significantly higher than conventional lenses. Hybrid (rigid centre with soft skirt) or scleral lenses may provide an option in problematical cases where fitting with conventional lenses fails to produce an acceptable outcome.

The future

Whilst not exhaustive, this list provides an insight into promising developments in laser refractive surgery:

- Wavefront technology and the quest for 'Super Vision' (better than 20/20) has received much coverage in both the lay and professional press in recent years. In this technique, optical aberrations from the individual patient's eye is analysed by an aberrometer and the laser is then instructed by computer control to create a customised ablation that produces an aspheric surface capable of correcting higher order optical aberrations that should result in enhanced BCVA. The results, while promising, have been mixed and many clinics are awaiting further development before offering this to their patients, as the ideal wavefront configuration is not yet known. Indeed, some studies have questioned the advisability of removing optical aberrations at all. Testing of pilots in the United States Air force[8] (who can be expected to have extremely good unaided vision) has shown that the pilots had greater number of higher order aberrations than those in the 'normal' control population.
- Laser Epithelial Keratomileusis (LASEK). In this procedure the central cornea is bathed in alcohol, which softens the epithelium. After a 20 second period the alcohol is removed and the epithelium can be lifted intact to make an epithelial flap. This allows ablation at a more superficial level than LASIK but with a faster visual recovery and without the same degree of post-operative pain than can be expected from PRK. Whilst in its early stages of development, LASEK is regarded by some ophthalmologists as a promising procedure that allows ablation on a cornea that is otherwise too thin for LASIK and where wavefront ablation with LASEK might be expected to provide superior results.
- Femto-lasers. These are solid-state lasers that may be used to create the corneal flap. Whilst being cheaper to run than an excimer laser, especially because the solid-state electronics are easier to maintain, the refractive ablation must still be created with an excimer laser. However the flap may be cut at a precise depth and without the severe rise in IOP necessary to create a flap with a keratome.

Co-management

Laser procedures are often seen as a threat to opticians' business because they provide an alternative to spectacles or contact lenses. In the United States a different approach may be found and optometric practices can account for 25-30 per cent of laser clinic referrals . This symbiotic relationship, in which interested patients are referred for full assessment and initial aftercare then referred back to the initiating practice by the clinic when the critical aftercare has been completed has been championed in the UK by Maxivision who believe that working with opticians has greater benefits for all than engaging in 'turf battles'. Co-management of refractive surgery patients is now used by a number of laser clinics, in one form or another.

Studies have shown that, on average, a treated patient will refer five friends or relatives for spectacles, contact lenses, refractive advice or standard eye examinations to the practice undertaking their referral[8]. This might be expected as treated patients speak to their associates about the treatment. In the end, refractive surgery, in whatever form, is not going to disappear and it would be advisable for all professionals to see it as an opportunity, not a threat to business.

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