There will always be situations in which the original laser approach works best.

BY SUPHI TANERI, MD

I had the privilege of being trained in refractive surgery by Dimitri Azar, MD. This giant in ophthalmology was a key figure in refining the original excimer laser surface ablation procedure, PRK. He was the first surgeon to use alcohol to loosen an epithelial flap in such a gentle fashion that he could replace it after photoablation. He was the first to perform this procedure almost 20 years ago, although the term describing it, LASEK, was only later coined and popularized by Massimo Camellin, MD. Moreover, Dr. Azar meticulously examined the influence of alcohol on corneal epithelial cells in cell cultures and animal models to find the most effective and safe concentration of ethanol (18–20%).

In view of this background, my personal perspective on surface ablation may well be biased. However, the literature shows that, even in the early days, surface ablation had excellent and stable clinical outcomes.1–3

SURFACE ABLATION DRAWBACKS

Like many ophthalmologists, I love using new cutting-edge technologies and procedures such as small incision lenticule extraction (SMILE) and femtosecond LASIK, utilizing highly sophisticated eye-trackers and the latest ablation profiles. Surface ablation techniques have two major downsides compared with LASIK and SMILE: These newer procedures provide more comfortable and more rapid visual recovery for most refractive surgery patients.4

Historically, clinicians have tried to eliminate the disadvantages of surface ablation by introducing variations of the original PRK technique, including (1) LASEK,5,6 using alcohol to create an epithelial flap that is repositioned after photoablation (Figure 1A); (2) advanced surface ablation, using alcohol to remove the epithelium without replacing it (Figure 1B); (3) epi-LASIK, using a microkeratome equipped with a blunt blade to separate the epithelium from the basement membrane; and (4) epithelial Bowman keratectomy (EBK), in which a handheld instrument with a dull tip (Epi Clear; Orca Surgical) is used to remove the epithelium (Figure 1C; www.eyetube.net/?v=eeapos). We have evaluated all these modifications of surface ablation and found them to be comparable in terms of pain perception, speed of epithelial closure and visual recovery, haze formation, and final visual outcomes.2–9

Pain management after surface ablation has been improved dramatically with the introduction of innovations including cooling of the eye with ice-chilled balanced salt solution immediately after photoablation (Figure 2); the use of oral triptans, such as sumatriptan, a migraine medication; and the use of nonpreserved NSAID eyedrops.10 Still, patients continue to prefer the wow effects and comforts of LASIK and SMILE.

STILL INDISPENSABLE

However, there are good reasons why surface ablations are and will remain indispensable to my daily practice:

Reason No. 1: Surface ablation can provide simultaneous therapeutic treatment together with refractive correction. It can be used in recurrent erosion syndrome or for the removal of subepithelial opacities that either affect vision or make creation of a LASIK flap or SMILE procedure problematic.

Reason No. 2: Surface ablation makes a good retreatment procedure. In recent years, surface ablation on the LASIK flap has become my favorite choice for retreatment, rather than lifting the flap. The reason is that iatrogenic keratectasia has been strongly associated with reablation under the LASIK flap. At times, it may be impossible to determine whether a myopic undercorrection or regression is a stable condition or the beginning of ectasia formation. By ablating on top of the flap, we do not weaken corneal stability any further and avoid this potential pitfall. It is true that surface ablation after LASIK, and especially after SMILE, is more prone to cause haze formation;
however, this can be overcome by using mitomycin C 0.02% for 12 to 120 seconds (Figure 3).

**Reason No. 3: Surface ablation is gentler to the cornea.** In particularly young refractive surgery patients, it may be prudent to be old-fashioned and opt for surface ablation because their corneas may be susceptible to developing keratoconus later, and none of our current diagnostic tools are capable of detecting this genetically fixed precondition. Nevertheless, at present, I would not recommend performing surface ablation in a patient with forme fruste keratoconus in even one eye. On the other hand, there have been anecdotal reports of keratoconic patients with thin corneas who have had PTK or PRK with stable corneal topography for years thereafter. Some speculate that the reason for this observation may be the slight haze formation after uneventful surface ablation, which may represent some sort of strengthening crosslinking of collagen.

**Reason No. 4: Surface ablation pairs well with CXL.** When performing CXL to treat ectatic eyes, I prefer laser ablation to manual abrasion for epithelial removal. To do this, we first obtain an epithelial thickness map with the Avanti OCT (OptoVue), showing the thinning of the epithelium over the apex and thickening around it. This enables us to smooth the stromal contour by using a limited surface ablation of homogeneous depth to remove the epithelium without sacrificing too much stromal tissue. Kanellopoulos and coworkers have published extensively on a more courageous approach, the Athens protocol, in which anterior corneal topography-guided surface ablations are used to flatten the cone before CXL.11-14

**Reason No. 5: Surface ablation can still be performed in the presence of an irregular flap.** Surface ablations have saved the day for me multiple times in the past when I created an irregular LASIK flap.15,16 These complications have included short flaps due to suction loss and buttonhole flaps. Instead of waiting several months for the cornea to heal and trying again, in these cases I did not lift the flap but instead performed surface ablation on the irregular flap, after carefully removing the epithelium with alcohol.

**CONCLUSION**

Clinicians will no doubt continue to refine LASIK and SMILE. No matter how successful these procedures become, however, I am convinced that there will always be good indications that can inherently be better addressed by the first-generation laser treat-

(Continued on page 72)
PRK PLUS CXL

PRK remains the only corneal refractive procedure with an established safety profile that allows its use in ectatic disorders of the cornea.

By Hatch Mukherjee, FRCOphth; and Ioannis Aslanides, MD, PhD

Even though the advent of CXL in the 1990s established it as an effective means of keratoconus stabilization, the evidence overall reveals minimal topographic regression and little visual improvement in keratoconus after treatment.

This has prompted several practitioners, ourselves included, to investigate means to retain the disease-stabilizing aspects of the CXL treatment and to obtain significant improvement in corneal irregularity and, hence, vision.

Several pioneering studies have evaluated visual rehabilitation in stable forme fruste keratoconus utilizing PRK alone, prior to the development of CXL.\(^1\)\(^-\)\(^3\) Despite initial fears, there was no evidence of progressive ectasia after PRK, and this laid the foundation for developing a synergistic CXL-plus-PRK therapy for more advanced progressive keratoconus.\(^4\)

It is important to distinguish among three distinct applications of combinations of CXL and PRK, all with differing therapeutic goals (Table 1); the discussion below is limited primarily to frank keratoconus. We have previously described our approach, which is to combine nontopographic transepithelial PRK without mitomycin C plus immediate CXL.\(^5\) While approaches vary, common to all is the finding of greater visual improvement than would be expected from CXL alone, as confirmed by recent comparative studies of PRK plus CXL versus CXL alone.\(^5\)

**ISSUES SURROUNDING PRK PLUS CXL**

The evolution of various approaches to combining these two therapies raises several issues.

**Issue No. 1: Sequential or simultaneous?** Kanellopoulos and Binder initially proposed CXL followed by delayed topographic PRK.\(^4\) Theoretically, this approach avoids superimposing the unpredictable CXL effect on the topographic correction. However, our experience,\(^6\) in keeping with subsequent work by the groups of Kanellopoulos\(^7\) and Kymionis,\(^8,9\) suggests that there is an additive effect when the two procedures are performed simultaneously. Thus, comparing sequential (CXL first and PRK later) versus simultaneous (PRK with immediate CXL), Kanellopoulos found superior results in UCVA, BCVA, keratometry, and haze with the simultaneous approach.\(^7\)

There are some clues to why this additive effect occurs when the procedures are performed simultaneously. PRK at an interval after CXL ablates the maximally crosslinked anterior cornea, and the ablation rate is also reduced, altering correction. The most important effect, in our opinion, relates to the potential enhanced crosslinking effect when CXL is applied immediately after ablation, as discussed below.

**Issue No. 2: Does PRK potentiate the effect of CXL?** Our technique of nontopographic transepithelial PRK and immediate

---

**TABLE 1. THERAPEUTIC APPLICATIONS AND AIMS FOR COMBINATION PRK AND CXL**

<table>
<thead>
<tr>
<th>Application</th>
<th>Therapeutic Aim</th>
<th>Effect on Ectasia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frank keratoconus with visual disability</td>
<td>Improvement in functional vision rather than refractive correction</td>
<td>Stabilize progressive disease</td>
</tr>
<tr>
<td>Early/stable/forme fruste keratoconus</td>
<td>Refractive correction</td>
<td>Avoid inducing progression of preexisting stable ectasia</td>
</tr>
<tr>
<td>High-risk refractive surgery: no frank ectasia, but with risk factors for postoperative ectasia</td>
<td>Refractive correction</td>
<td>Avoid de-novo induction of postoperative ectasia</td>
</tr>
</tbody>
</table>
CXL is based on the clinical premise that the topographic effect is much greater than would be expected as the sum of the effects of a minimal ablation and CXL. A clinical example of our technique (Figure 1) illustrates far greater change than would be expected from adding the effect of CXL to a stromal ablation of less than 50 µm. This potentiation of CXL after surface ablation has been demonstrated by Kymionis et al in an approach termed the Cretan protocol. The authors showed an enhanced effect when PTK, rather than mechanical epithelial removal, was performed before CXL. Moreover, Kymionis et al also demonstrated a deeper demarcation line under the ablated area, suggesting enhanced CXL effect.

**Issue No. 3: Topographic or nontopographic?** It is our opinion that topographic planning based on the cornea’s pre-operative state before CXL is fraught with sources of unpredictability, particularly the effect of CXL itself. This is compounded by poor correlation between topographic and refractive findings and by the limited topographic correction obtainable when a limited ablation is performed. Our technique, thus, foregoes profile-based correction of higher-order aberrations. Notably, the visual acuity gains in our series do not vary greatly from those in series using topographic correction.

**Issue No. 4: Transepithelial or stromal treatments?** In several of the initial series cited above, alcohol or mechanical epithelial removal were used. However, like other more recent descriptions, our protocol incorporates a transepithelial treatment in order to obtain a topographic corrective effect based on the differential epithelial profile around the cone, which has been shown to have a so-called donut distribution; thus, the masking effect of the epithelium would tend to regularize the cone.

**Issue No. 5: Is mitomycin C beneficial?** Although mitomycin C has been used in keratoconic PRK, we theorized that CXL-induced keratocyte depopulation may offset a need for chemotherapy, particularly as the transepithelial treatment causes less haze. Our data and those of a similar study by Stojanovic both showed insignificant haze.

**CONCLUSION**

Approaches combining PRK or PTK and CXL for the management of frank keratoconus show encouraging results. We expect that further study and refinement of treatment parameters will yield further benefits. For the present, PRK remains the most well-established corneal refractive procedure and the only one with an established safety profile allowing its use in ectatic disorders of the cornea.

---


---

**Ioannis Aslanides, MD, PhD**
- Medical Director, Emmetropia Mediterranean Eye Institute, Crete, Greece
- i.aslanides@emmetropia.gr
- Financial disclosure: None

**Hatch Mukherjee, FRCPht**
- Consultant Ophthalmologist, Essex County Hospital, Colchester, United Kingdom
- hatch.mukherjee@gmail.com
- Financial disclosure: None
ment: surface ablation. In the long term, with enhanced control of corneal pain perception and improved promotion of epithelial healing, surface ablation may not only survive but thrive.


Suphi Taneri, MD
- Director, Center for Refractive Surgery, Eye Department, St. Francis Hospital, Muenster, Germany
- taneri@refraktives-zentrum.de
- Financial disclosure: None

(Continued from page 67)

Cover Focus

WATCH IT NOW

During the EBK procedure, the Epi Clear device is used to create clear and graduated borders for enhanced healing.

eyetube.net?v=eepos