

# THE ATHENS PROTOCOL: PRK AND CXL

Anastasios John Kanellopoulos, MD

A second procedure for visual rehabilitation may sometimes be needed after cornea collagen cross-linking (CXL) for treatment of progressive keratoconus or post-LASIK ectasia. Following many years of employing CXL for ectasia cases, we introduced the “Athens Protocol”: same-day topography-guided partial PRK and CXL.

Our findings support that simultaneous topography-guided partial PRK with cornea collagen cross-linking (CXL) offers a safe and effective approach for normalizing the cornea and enhancing visual function in eyes with ectatic conditions. The core importance of combining CXL in this technique is to address highly irregular astigmatism in the management of eyes with keratoconus and post-LASIK ectasia.

Our theoretical and clinical evidence supports the use of this “Athens protocol” where CXL and topography-guided surface ablation are performed in the same session rather than sequentially over time.

It is our experience that surface ablation using the topography-guided excimer laser platform (Allegretto, Alcon/WaveLight) effectively and predictably normalizes the corneal surface and improves functional vision, and we believe there is a synergistic effect when this procedure is performed simultaneously with CXL.

Safety with our combination approach has been favorable as well. Although postoperative haze and delayed epithelial healing have occurred, these have

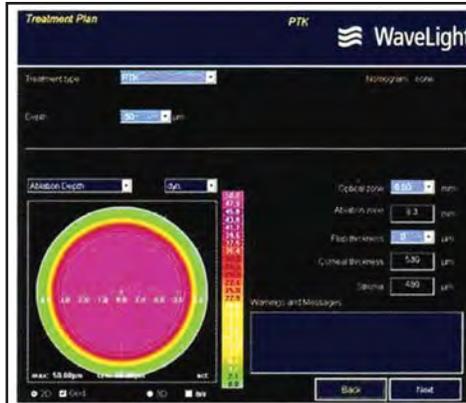
been minor complications in a small number of eyes within our large series. Out of the 400 eyes studied, just two required repeat CXL, and none needed to have a cornea transplant.

## Meeting Visual Rehabilitation Needs

Although the efficacy of CXL for stabilizing keratoconus is well-established and the procedure also causes some corneal flattening, significant residual astigmatism limiting contact lens wear may be a persistent problem for some patients. This situation creates an indication to perform topography-guided PRK.

While surface ablation in a keratoconic eye may sound unorthodox, the goal of our treatment using the topography-guided software is to normalize the corneal surface and improve best-corrected acuity. This is a therapeutic procedure, not a refractive one. In fact, some eyes turn out more myopic postoperatively, but have significant regularity and best spectacle-corrected visual acuity. We use surface ablation to remove no more than 50  $\mu\text{m}$  of stroma and typically treat only 2 D to 2.5 D of astigmatism and up to 1 D of myopia.

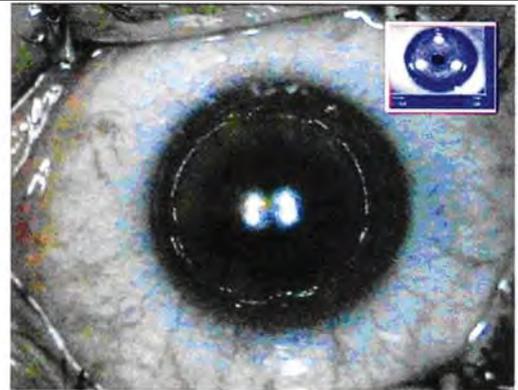
**Figure 8-1.** The basic steps of the Athens Protocol: Top left, The PTK treatment is planned on the Alcon/WaveLight platform. Top right, Following the PTK, areas of Bowman's have been ablated by the PTK, confirming that the epithelium over the cone is thinner. Bottom left, The treatment plans of the topography-guided partial PRK that is the core concept of this protocol. Bottom right, MC application prior to the riboflavin and CXL.



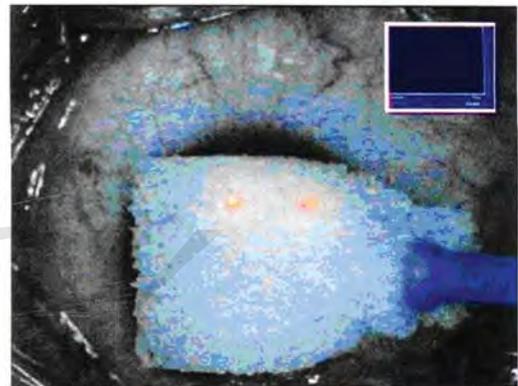
**Figure 4.1:** Epithelium removed with 50 micron PTK



**Figure 4.2:** TCat treatment plan



**Figure 4.3:** Topography-guided PRK to correct part of the refractive error (TCAT treatment plan) maximal thickness removal 50 microns



**Figure 4.4:** MMC solution 0,02% for 20 seconds

The protocol begins with a 6.5-mm phototherapeutic keratectomy (PTK) to remove 50  $\mu\text{m}$  of epithelium. Then, the topography-guided partial PRK is performed followed by mitomycin C application (0.02% for 20 seconds) and the CXL procedure. The excimer laser ablation resembles part of a hyperopic treatment. It is performed using a 5.5-mm effective optical zone and targets steepening of the area adjacent to the cone in an attempt to regularize the corneal surface (Figure 8-1).

We believe our rationale for performing the two procedures simultaneously with the ablation first has several advantages. We have reported data showing that the corneal epithelium and Bowman's membrane can act as barriers to UVA light penetration into the stroma. As these tissues are removed with the PTK/PRK procedure, it seems intuitive that the efficacy of the CXL procedure would be increased. This concept is supported by clinical findings outlined below.

For example, in a patient who had CXL alone in one eye and the Athens protocol in the other, inspection of OCT maps for hyper-reflectivity, which we recently described as a sign of the extent of cross-linking,

shows the area of cross-linking is much broader and denser in the latter eye.

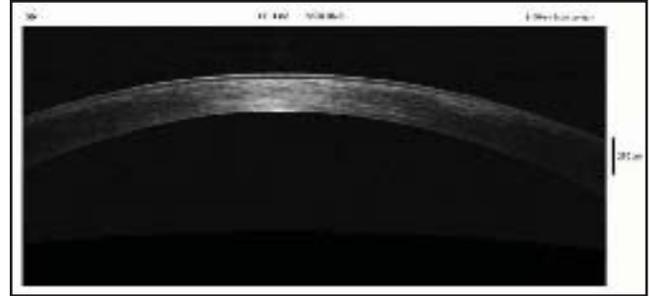
We additionally introduced the theory that the PRK-treated eye represents a better biomechanical model for performing the CXL procedure. In theory, an eye with a more regularized surface from CXL as opposed to an irregular untreated cornea would be better able to handle ongoing strain from IOP and eye rubbing over the cone peak and would more likely remain more stable.

We believe redistribution of corneal strain by remodeling the cornea with surface ablation is a significant factor in the synergistic effect achieved when performing the two procedures together. The simultaneous procedure also avoids removing cross-linked cornea, which occurs when performing CXL first followed by the laser treatment.

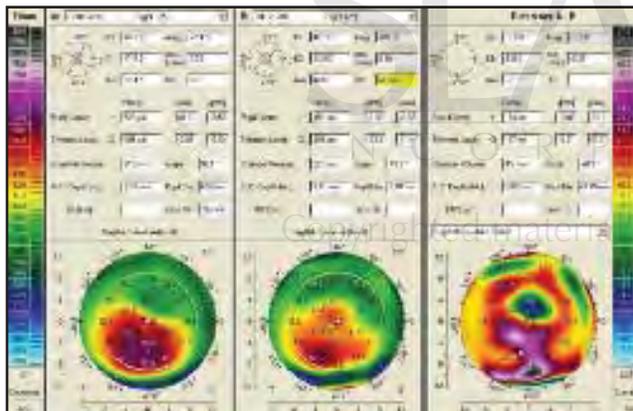
Results from a comparison of two large, consecutive series of eyes treated at the same session or with CXL first followed 1 year later by a topography-guided surface ablation showed statistically significant differences in a number of outcome parameters favoring the same-day procedure. The study, which



**Figure 8-2.** A clinical picture of the right eye of a 27-year-old man with advanced KCN. Preop BSCVA was 20/50 with -2.5 -5 @80. The patient underwent the Athens Protocol and is now UCVA 20/30 and BSCVA 20/20 with -1 -1.5 @85. The slit-lamp photo shows the corneal clarity and the ground-glass appearance typical of CXL.



**Figure 8-3.** Cornea OCT of the same eye 7 months postop Athens Protocol. One can appreciate the anterior cornea hyper-reflectivity consistent with CXL and the demarcation line at about 300  $\mu\text{m}$  depth depicting (as we have introduced and published) the depth of effective CXL. Those clinicians familiar with findings following CXL alone may appreciate the enhanced depth and diameter of the CXL effect noted on OCT supporting the advantage on the eye with the Athens Protocol.



**Figure 8-4.** A comparison of preoperative and 7 months postoperative of Pentacam images showing the significant normalization of the cone and keratometric flattening and better symmetry.

has been published,<sup>1</sup> included 127 eyes in the sequential group and 198 eyes treated with the Athens protocol (Figure 8-2).

For the eyes in the sequential group, mean logMAR uncorrected visual acuity (UCVA) improved from 0.9 to 0.49, mean logMAR best spectacle-corrected visual acuity improved from 0.41 to 0.16, mean K decreased by 2.75 D and mean MRSE by 2.5 D, and the mean haze score was 1.2. For the eyes in the simultaneous group, there was a significantly greater improvement

in mean logMAR UCVA (from 0.96 to 0.3) and mean logMAR BSCVA (from 0.39 to 0.11) as well as a significantly greater mean reduction in MRSE (-3.2 D) and keratometry (-3.5 D) (Figures 8-3 and 8-4). The mean haze score in the simultaneous group was 0.5, and that was significantly lower than in the controls. Central corneal thickness decreased by 70  $\mu\text{m}$  after both procedures, and there was no significant change in endothelial cell count in either group. These findings demonstrate that performing the two procedures together offers advantages of less PRK-associated scarring and better riboflavin and UVA penetration to achieve a wider and deeper CXL effect with greater corneal flattening.

## Reference

1. Kanellopoulos AJ. Comparison of sequential vs same-day simultaneous collagen cross-linking and topography-guided PRK for treatment of keratoconus. *J Refract Surg.* 2009;25(9):S812-S818.

## Bibliography

- Kanellopoulos AJ. Cross-linking plus topography-guided PRK for post-LASIK Ectasia Management. In: Garg A, Rosen E, eds. *Instant Clinical Diagnosis in Ophthalmology Refractive Surgery.* New Delhi, India: Jaypee Brothers; 2008:258-269.
- Kanellopoulos AJ. Cross-linking plus topography-guided PRK for post-LASIK ectasia management. In: Garg A, ed.

- Mastering Advanced Surface Ablation Techniques*. New Delhi, India: Jaypee Brothers; 2007:204-214.
- Kanellopoulos AJ. Cross-linking plus topography-guided PRK for post-LASIK ectasia management. In: Garg A, Pinelli R, Brart DO, Lovisolo CF, eds. *Mastering Corneal Collagen Cross-linking Techniques (C3-CCL/CxL) with Video DVD Rom*. New Delhi, India: Jaypee Brothers; 2008:69-80.
- Kanellopoulos AJ. Crystalens HD: the accommodative IOL technique. In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:301-304.
- Kanellopoulos AJ. In-flap simultaneous collagen crosslinking (CXL) and topography-guided (tPRK) for early Post-LASIK ectasia: a novel technique. In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:233-236.
- Kanellopoulos AJ. Intralase-assisted LASIK, video V; Comparison of topography guided to standard LASIK for hyperopia, video VI; Limited topoguided PRK followed by collagen cross linking for keratoconus, video VII. In: Garg A, ed. *Video Atlas of Ophthalmic Surgery*. New Delhi, India: Jaypee Brothers; 2007
- Kanellopoulos AJ. PRK and C3-R. In: Boxer Wachler BS, ed. *Modern Management of Keratoconus*. New Delhi, India: Jaypee Brothers; 2007:219-228.
- Kanellopoulos AJ. Prophylactic collagen crosslinking in high risk femtosecond assisted-LASIK: a novel technique. In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:423-426.
- Kanellopoulos AJ. Simultaneous prophylactic collagen cross-linking (CXL) following high-risk topography-guided PRK (tPRK). In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:427-430.
- Kanellopoulos AJ. Simultaneous collagen cross-linking (CXL) and topography-guided PRK (tPRK) for keratoconus (KCN). In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:18-21.
- Kanellopoulos AJ. Simultaneous collagen crosslinking (CXL) and topography-guided PRK (tPRK) for keratoconus (KCN). In: Garg A, Alio JL, eds. *Surgical Techniques in Ophthalmology: Refractive Surgery*. New Delhi, India: Jaypee-Highlights; 2009:60-63.

SLACK  
INCORPORATED

Copyrighted material. Not for distribution.