Management of pellucid marginal corneal degeneration with simultaneous customized photorefractive keratectomy and collagen crosslinking

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A 34-year-old woman had simultaneous photorefractive keratectomy and corneal collagen crosslinking with riboflavin–ultraviolet-A irradiation for the treatment of progressive pellucid marginal corneal degeneration in both eyes. No intraoperative or early postoperative complications occurred. Twelve months postoperatively, the uncorrected visual acuity was assessed at 20/40 in both eyes compared with counting fingers preoperatively. The corrected visual acuity also improved from 20/50 and 20/63 to 20/25 and 20/32 in the right eye and left eye, respectively. Corneal topography revealed a significant improvement in both eyes. Despite the encouraging results, longer follow-up is necessary to confirm the stability of the results.

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Pellucid marginal corneal degeneration (PMD) is a progressive noninflammatory ectatic corneal disorder.[1] Proposed treatments are spectacle correction, rigid gas-permeable (RGP) contact lenses,[2] and intrastromal corneal ring segments.[3] In advanced cases, lamellar or penetrating keratoplasty is the latest treatment option when other choices have failed to provide functional visual acuity and the deformation of the cornea has advanced. In these cases, the approach necessitates large, eccentrically placed grafts because of the peripheral thinning of the cornea.[1] However, these grafts are technically difficult and susceptible to rejection due to their proximity to the limbus and its vascularization.[4]

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Corneal collagen crosslinking (CXL) is a new technique that induces collagen crosslinking using the photosensitizer riboflavin (vitamin B2) and ultraviolet-A light (UVA).[5,6] By modifying corneal stromal structures[7] and increasing corneal strength and stability, CXL provides a new approach that, combined with techniques that improve visual acuity, may offer a comprehensive treatment for patients with corneal ectatic disorders. We present a patient with progressive PMD who had simultaneous customized photorefractive keratectomy (PRK) and CXL.

CASE REPORT

A 34-year-old woman with PMD presented to the Institute of Vision and Optics at the University of Crete because of progression of the ectatic disorder. At the time of examination, the uncorrected distance visual acuity (UDVA) was counting fingers in both eyes and the corrected distance visual acuity (CDVA) was 20/50 (manifest refraction –2.00 − 8.00 × 75) in the right eye and 20/63 (manifest refraction +0.50 − 8.50 × 125) in the left eye. A trial with RGP contact lenses demonstrated improvement in visual acuity to 20/32 and 20/40, respectively. The topographic findings (Technomed C-scan) (Figure 1, *top left*; Figure 2, *top left*) showed the presence of PMD in both eyes. Keratometric readings were 42.63 @ 74/51.00 @ 164 in the right eye and 42.75 @ 108/52.00 @ 18 in the left eye.

To assess the corneal thickness, a pachymetric measurement (Corneo-Gage Plus, Sonogage) was performed in both eyes. This revealed peripheral inferior nasal and temporal corneal thinning compared with the central cornea:

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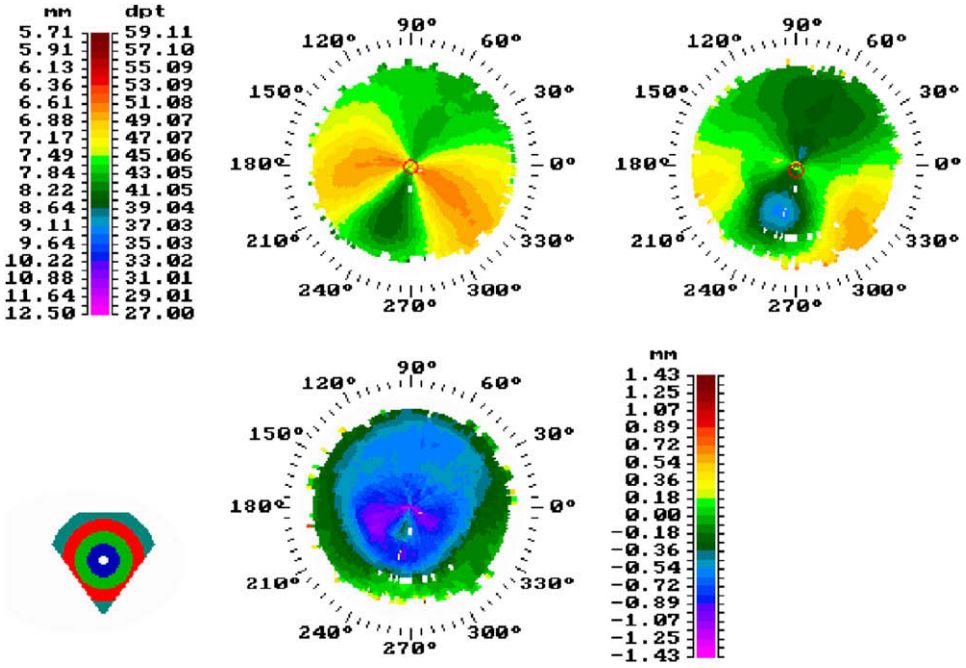

Figure 1. Preoperative topography (*top left*), 12-month postoperative topography (*top right*), and difference map (*bottom*) of the right eye of PMD patient treated with simultaneous customized PRK and CXL using riboflavin and UVA irradiation.

inferior nasal—right eye, 501 µm, left eye, 493 µm; inferior temporal—right eye, 495 µm, left eye, 499 µm; central corneal—right eye, 527 µm, left eye, 533 µm. Slitlamp examination showed the presence of inferior nasal and temporal peripheral thinning only. The patient could not achieve functional visual acuity with spectacle correction because of the irregular shape of the cornea. She also had contact lens intolerance.

Photorefractive Keratectomy and Corneal Crosslinking Procedure

Both eyes were treated with a combination of customized PRK and CXL with riboflavin and UVA irradiation, with 15 days between eyes. The 15-day interval was chosen by the surgeon to minimize the discomfort and postoperative pain that occurs when both eyes are treated at the same time.

A solid-state laser with a 213 nm wavelength (Pulzar Z1, CustomVis) was used for the procedure. The wavelength was generated using a major neodymium:YAG laser system of 1064 nm; through special cultivated crystals, the 213 nm wavelength was achieved. The attempted correction was $-1.0 - 3.50 \times 74$ in the right eye and plano -5.0×110 in the left eye (both at a 5.0 mm treatment zone). The PRK customization was based on the corneal topography. The intended total ablation depth was less than 50 µm (right eye, 49 µm; left eye, 50 µm).

The surgical procedure was conducted under sterile conditions. The eyes were anesthetized with proparacaine 0.5% (Alcaine). The epithelium was removed with a rotating brush at the beginning of the procedure. Immediately after the PRK procedure, corneal pachymetry measurements were taken (central, temporal, and nasal; inferiorly and superiorly) using ultrasonic pachymetry to ensure adequate corneal stromal thickness remained to proceed with the CXL treatment. Next, the riboflavin 0.1% solution was instilled repeatedly for approximately 20 minutes. According to the protocol, 2 drops of riboflavin 0.1% were instilled in the center of the cornea every 5 minutes. Drops of pilocarpine (Isopto Carpine) were instilled in both eyes after photoablation to induce miosis of the pupil and obstruct the penetration of UVA radiation to the underlying tissues. Penetration of the cornea and presence of riboflavin in the anterior chamber (riboflavin shielding) was monitored by slitlamp examination. The UVA irradiation was performed using an optical system (UV-X illumination system version 1000) with a light source consisting of an array of UV diodes (365 nm) in conjunction with a potentiometer to allow intensity regulation. Before treatment, an intended 3.0 mW/cm^2 of surface irradiance (5.4 J/cm^2 surface dose) was calibrated using a UV light meter. Irradiance was performed for 30 minutes, corresponding to a dose of 5.4 J/cm^2. During treatment, the riboflavin solution was applied every 5 minutes to saturate the cornea.

After the treatment, a bandage contact lens (BCL) was applied until reepithelialization occurred. Topical antibiotic–corticosteroid drops (tobramycin 0.3%–dexamethasone 0.1% [Tobradex]) were used 4 times until removal of the BCL. After the BCL was removed, the patient received corticosteroid drops (fluorometholone 0.1% [FML]), tapered over the following 3 weeks, and was advised to use artificial tears 4 times daily for 3 months.

Both eyes were examined daily until the epithelium had completely healed. The BCLs were removed on the fifth postoperative day, and no signs of edema or inflammation were noted by slitlamp biomicroscopy. One month postoperatively, the UDVA was 20/50 and the CDVA was 20/40 in both eyes. At the 6-month examination, the UDVA was assessed at 20/40 and the CDVA at 20/32 in both eyes. Central corneal thickness was 454 µm in the right eye and 461 µm in the left eye. At 12 months, the UDVA was stable at 20/40 in both eyes, the CDVA was 20/25 in the right eye and 20/32 in the left eye, and the manifest refraction was $+2.50 - 2.50 \times 90$ and $-1.00 - 5.50 \times 135$, respectively. The slitlamp biomicroscopy revealed clear corneas with no signs of haze formation. Corneal topography showed a significant improvement in both eyes (Figures 1 and 2).

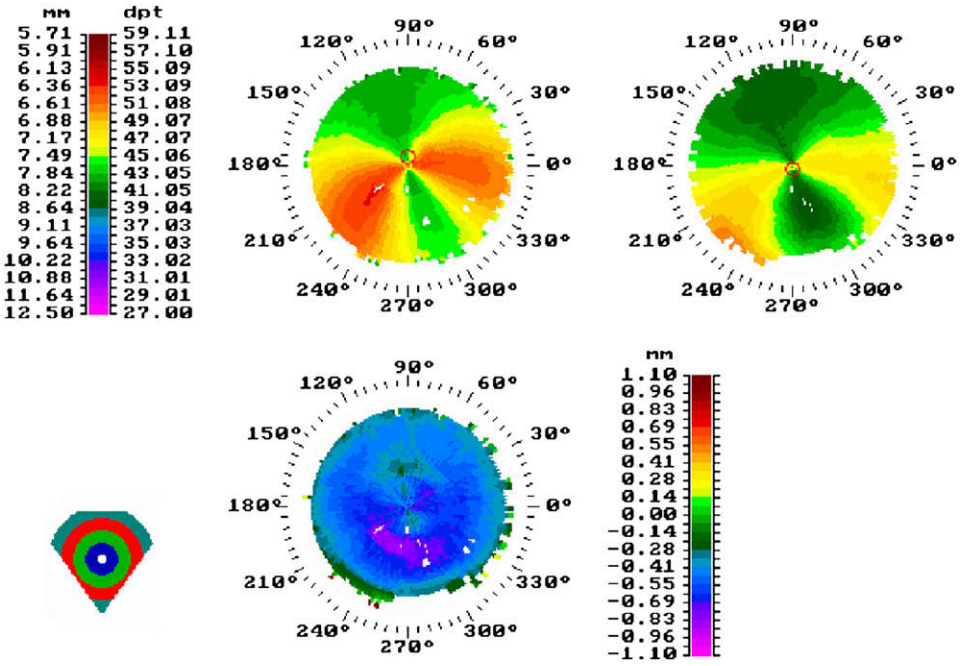

Figure 2. Preoperative (*top left*), 12-month postoperative (*top right*), and difference topographic map (*bottom*) in the left eye of PMD patient treated with simultaneous customized PRK and CXL using riboflavin and UVA irradiation.

DISCUSSION

Pellucid marginal corneal degeneration is an ectatic disorder of the cornea that affects a patient's life because of the poor quality of vision produced by the associated irregular astigmatism.[1] A new and less invasive technique, CXL with riboflavin and UVA radiation was adopted to arrest the progression of the ectatic character of PMD. Studies performed in rabbit and porcine eyes have shown that CXL increases the corneal rigidity.[6]

Kanellopoulos and Binder[8] have proposed a 2-step procedure with CXL first and PRK after 1 year. There are 2 potential limitations to this approach. First, the stiffened crosslinked corneal tissue is removed by the PRK (potentially decreasing the possible benefits of the CXL). Second, the corneal ablation rate could be different in crosslinked corneas than in the virgin cornea (leading to unpredictable refractive results).

In our case, simultaneous customized PRK and CXL with riboflavin and UVA irradiation were performed. During the preoperative examination, the patient complained of deterioration of visual acuity that could not be resolved with spectacles. The alternative of RGP contact lenses was not a solution because of contact lens intolerance. Penetrating keratoplasty with its potential risks was not a suitable choice considering the age of the patient and the marked ectasia. A procedure with CXL treatment alone would not have been ideal because of the contact lens intolerance and the inability to rehabilitate the vision with spectacles. Vinciguerra et al.[9] suggest that the improvement in visual acuity (both UDVA and CDVA) after CXL treatment alone is a result of apical keratometry reduction and consequent corneal regularization, but in this case it would probably not have been enough to provide functional visual acuity.

The aim of customized PRK was to remodel the irregular cornea to decrease the irregular astigmatism. Customization could be a percentage of the fully customized treatment for reducing the maximum depth of tissue removed over the corneal irregularity. A minimum ablation depth of 50 μm was chosen to achieve a decrease in astigmatism but avoid removing a significant amount of tissue that would jeopardize the biomechanical integrity of the cornea. An ablation depth up to 50 μm also minimizes the postoperative incidence of haze formation. We believe that the significant improvement in visual acuity after the 1-month postoperative examination in conjunction with topographic stability could be the result of the 1-step approach of customized PRK and the CXL procedure.

One limitation of this approach might be a decrease in corneal tissue from the laser keratectomy before CXL. This could increase the possibility of corneal damage from the irradiation.

Longer follow-up is necessary to evaluate the outcomes of this combined procedure in specific cases of ectatic corneal disorders such as PMD. Continued stability of the good visual outcome and lack of progression of corneal ectasia may make this combined therapy an effective alternative to other invasive techniques for the treatment of ectatic disorders of the cornea.

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