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CASE REPORT

Combined Topography-Guided Trans-Epithelial PRK and PTK for Treatment of Calcific Band Keratopathy Unresponsive to EDTA Chelation Therapy

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Purpose: To report a case of Calcific Band Keratopathy (CBK) treated successfully with transepithelial Phototherapeutic keratectomy (PTK) combined with customized Photorefractive Keratectomy (PRK).

Methods: One case report.

Results: A 63-year-old man presented to our clinic with decreased visual acuity and ocular discomfort in both eyes. Clinical examination revealed a horizontal gray-whitish band across the central cornea in both eyes, supporting the diagnosis of CBK. Initially, an EDTA chelating procedure was attempted, but it had no effect on the deeper calcium deposits and on the irregular corneal morphology. In both eyes, a topography-guided trans-epithelial PRK with PTK was performed. Following PRK surface ablation, PTK was used to smooth the ablated area using 1% hydroxymethylcellulose as masking agent. The procedure was completed applying 0.02% Mitomycin C. At the 1-month follow-up, both eyes corneal opacities were resolved, and the LE visual acuity had improved to 20/63 and the RE to 20/20, which was maintained at the 3-, 6-, and 12-months follow-up. Furthermore, there was an improvement in spherical equivalent and corneal morphological irregularity index.

Conclusion: CBK may be successfully treated using a combined topography-guided trans-epithelial PRK and PTK.

Keywords: calcific band keratopathy, corneal degenerations, phototherapeutic keratectomy, topography-guided photorefractive keratectomy

Introduction

First described by Dixon in 1948, Calcific band keratopathy (CBK) is a relatively common, chronic corneal degeneration. CBK is characterized by band-shaped grayish to whitish fine deposits in the sub-epithelium, Bowman's layer and the anterior stroma.[1]

The deposits are composed of calcium hydroxyapatite and non-crystalline forms of phosphate and carbonate salts of calcium, along with mixed type materials.[2]

The presence of mixed type materials can account for the poor response to treatment with chelating agents such as ethylenediamine-tetraacetic acid (EDTA) in certain type of CBK.[3]

Although the cause of the calcium salts and the processes that cause them to accumulate are unknown, they are linked to a variety of different systemic and ocular conditions, like chronic ocular inflammation and hypercalcemia.[4] Among the causes, occupations with exposure to mercury vapor or calcium bichromate vapors can cause corneal degeneration leading to keratopathy.[5]

The progressive accumulation of calcium can lead to visual problems, when calcium crystals and the resulting opacity occupy the central zone of the cornea, resulting in significant glare and decreasing the visual acuity and ocular surface disruption, causing irritation, photophobia, or recurrent corneal erosions.[6]

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Restoring a smooth ocular surface and eliminating the calcium opacities are the objectives of therapy.

For this purpose, several treatments have been proposed for CBK: mechanical debridement, EDTA chelation therapy, Phototherapeutic Keratectomy (PTK) and Amniotic Membrane Transplantation (AMT).

Manual debridement of CBK by scraping with a blade is effective but has no effect on the irregularity of the corneal surface.[7]

By far the most widely used method is EDTA chelation, being an effective, simple, and inexpensive procedure. However, EDTA chelation therapy has some limitations. It primarily seeks to remove calcium plaques from the superficial layers of the cornea; as a result, some deposits from the deeper stroma may remain following treatment, contributing to the irregularity of corneal surface.[8] In addition, when there is a non-calcific material identified as elastotic degeneration of collagen, there is a poor response to treatment with such chelating agents.

Excimer laser ablation with PTK seems to be a safe and successful alternative to chelation therapy and seems to overcome its main limitations. In contrast to EDTA chelation therapy, PTK aims to remove calcium deposits in the deeper stroma and allows to treat cases where there is non-calcific material. Moreover, the PTK allows to obtain favorable ocular surface changes, such as a smoothing of the ocular surface and increased tear film stability probably through better mucin production by a healthier epithelium. It is possible that improvements in these parameters may reduce the likelihood of calcific band recurrence.[9,10]

This case documents the management of band keratopathy performing a ray-tracing customized transepithelial refractive photoablation and reports on its safety and efficacy.

Case Presentation

A 63-old man presented to our Ophthalmology Unit of "SS. Annunziata" Hospital, Taranto, complaining of low visual acuity in both eyes and ocular discomfort for about two years.

His ophthalmic history was unremarkable. His uncorrected distance visual acuity (UDVA) measured with Snellen charts was 20/100 in the right eye (RE) and 20/200 in the left eye (LE), while his best corrected visual acuity (BCVA) was 20/50 in the RE and 20/100 in the LE. A history of amblyopia in his left eye was reported.

Slit-lamp examination revealed a horizontal gray-whitish band across the central cornea in both eyes, sparing the peripheral cornea and the limbus. No other pathological findings were observed (Figure 1).

He was diagnosed with CBK secondary to occupational exposure to mercury vapors, since he was a worker of steel industry.

Fundus examination was not possible. The anterior segment OCT (AS-OCT) showed a thickness corneal opacity of 150 um in both eyes (Figure 2).

This study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of the Ophthalmology Unit of "SS. Annunziata" Hospital Review Board. The patient provided informed consent for all procedures and their possible complications were explained. The patient gave informed consent for the publication of any case details and accompanying images. The IRB of the Ophthalmology Unit of "SS. Annunziata" Hospital, Taranto gave the approval for the publication of this case report.

The tomographic maps (Precisio2®, iVIS Technologies, Taranto, Italy) showed in both eyes an irregular corneal morphology due to the presence of the opacity (Figure 3).

Our first attempt was performing EDTA chelation procedure which removed the superficial calcium plaques. Two months after the procedure, the UDVA had improved to 20/80 in RE and to 20/100 in the LE, but the cornea was not completely clear, with residual stromal haze. The EDTA chelation procedure had no effect on the deeper calcium deposits and the tomographic maps showed irregular corneal surface. For this reason, a combined treatment with PRK and PTK was scheduled in both eyes in order to recover visual acuity and minimize surgical invasiveness.The customized treatment was determined by taking into account the following parameters: spherical error, some biometric data including anterior chamber depth, axial length; corneal morphological irregularity index (CMI) measured by tomographer (Precisio2®, iVIS Technologies, Taranto, Italy); pupillometry (pMetrics®, iVIS Technologies, Taranto, Italy).

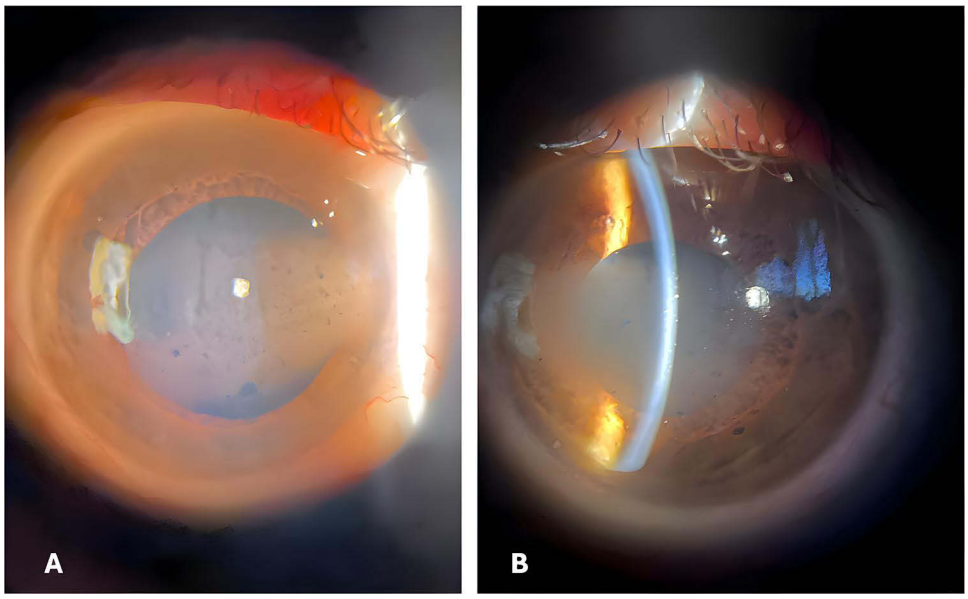

Figure 1 ((**A**), right eye; (**B**), left eye) Slit-beam photography demonstrating band-shaped grayish to whitish fine deposits in the sub-epithelium, Bowman's layer and the anterior stroma.

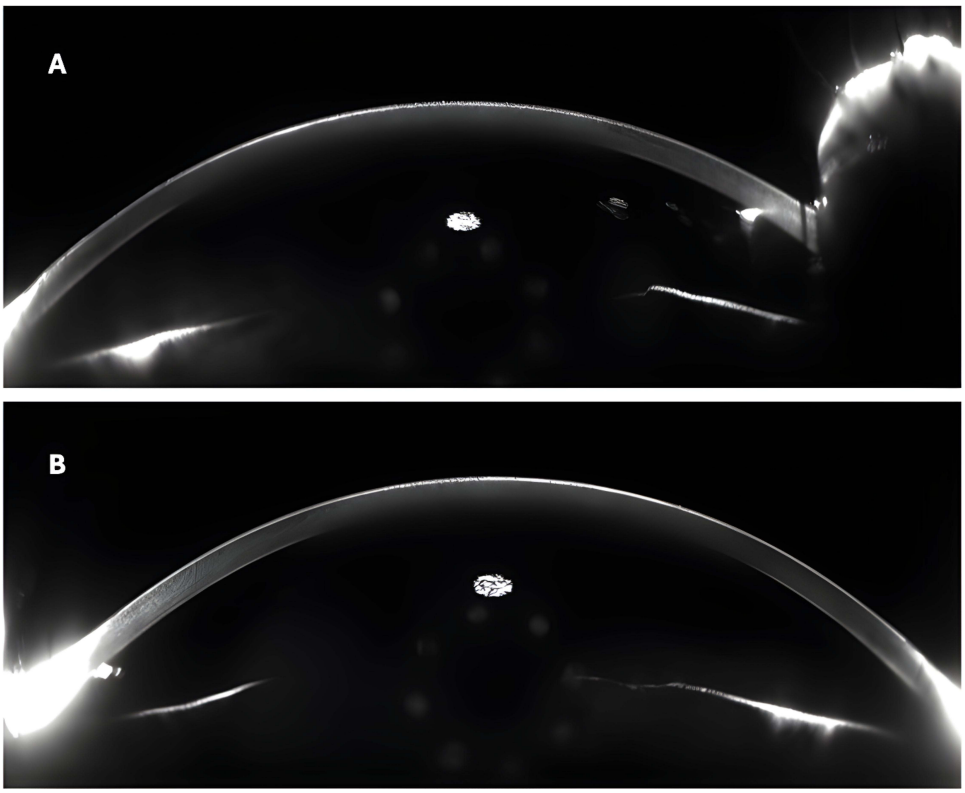

Figure 2 AS-OCT of the right (**A**) and left eye (**B**) showing hyperreflectivity due to the calcium deposits with a thickness of 150 um.

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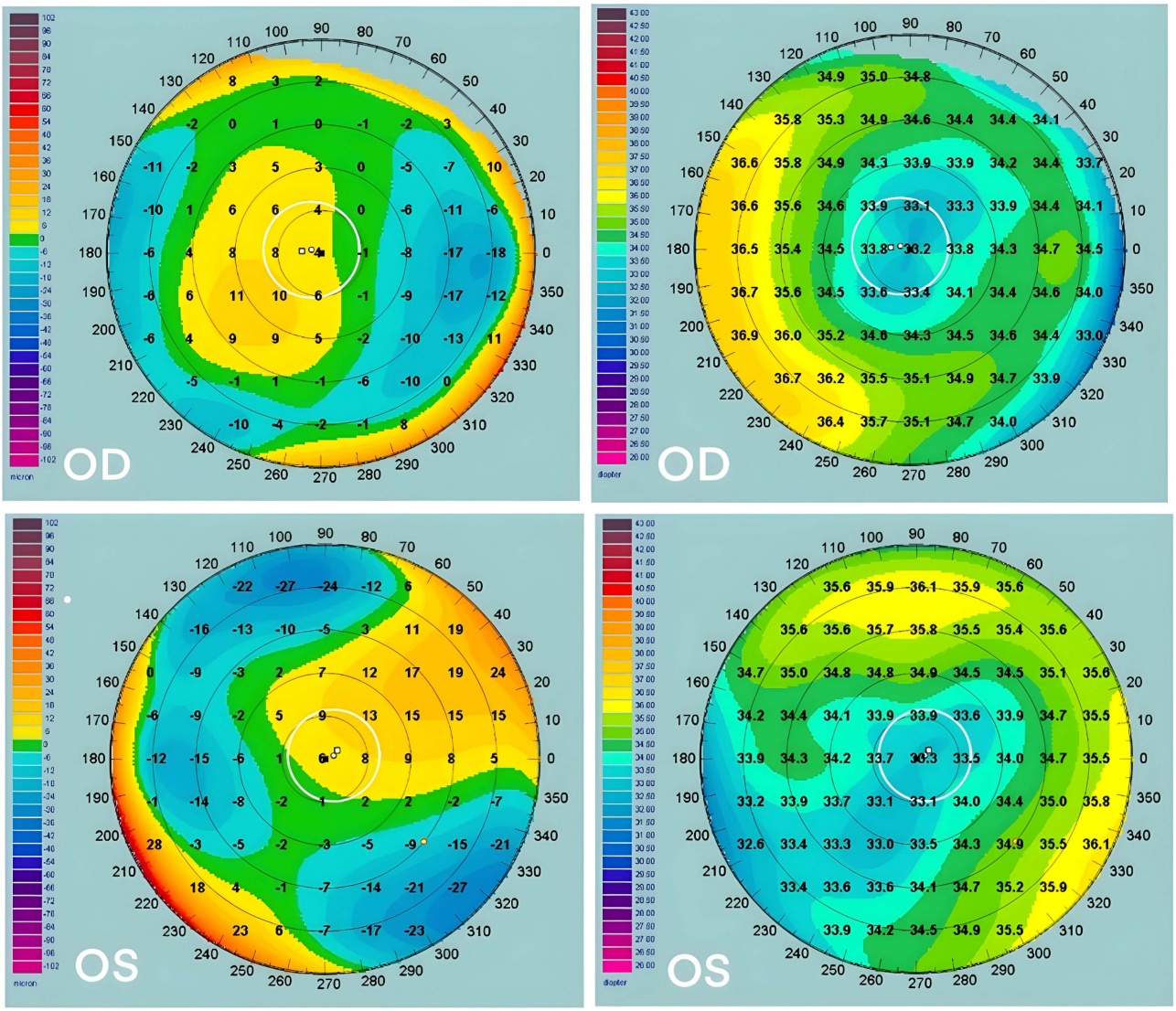

Figure 3 Anterior Elevation map and Anterior Ray Tracing Map of the right eye (upper image) and left eye (lower image) showing an irregular corneal morphology due to the opacity.

CMI, measured in μm, is a parameter which indicates the aberrations above the second order of the anterior and posterior corneal surface. It is strongly correlated to the quality of vision of the patient: the more the CMI, the worse the quality of vision.

The customized ablation is achieved using a ray tracing-based software. Ray tracing is based on the Snell law of refraction and allows the evaluation of the pathway of light rays after their passage through the eye from the anterior corneal surface to the retina. In this way, it is possible to know the exact refractive contribution of each surface and fully customize excimer laser ablation. This is achieved by not performing a full regularization of the anterior corneal surface; instead, a small amount of aberration on the anterior corneal surface is left to compensate for the posterior surface aberrations which are of opposite sign. In fact, the posterior corneal shape introduces posterior corneal morphological irregularities, which partially compensate for the anterior ones.

In this way, the ray tracing algorithm optimizes the quality of vision and at the same time minimizes the consumption of stromal tissue.

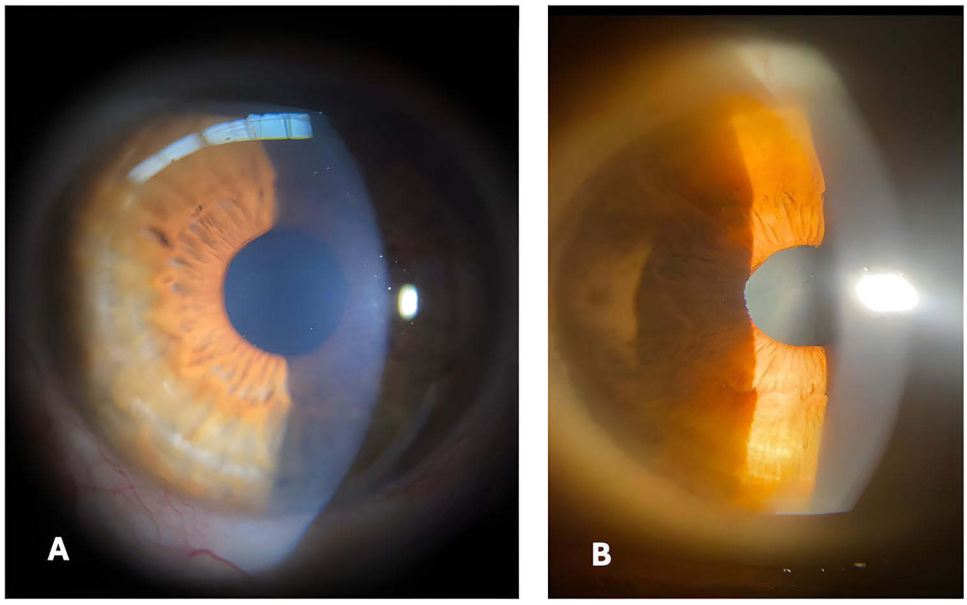

Figure 4 ((**A**), right eye; (**B**), left eye) After 3 months from combined excimer laser treatment, corneal clarity has been recovered with the resolution of opacities.

We decided to perform the surgery first on the right eye and then after 20 days on the left eye. The surgery was performed using topical anesthesia (oxybuprocaine eye drops, Benoxinato Cloridrato, Alfa Intes S.r.l). We decided to use a no-touch approach in order to have less postoperative pain and faster re-epithelialization. The surgery was executed with the iRes™ excimer laser, working with flying-spot of 650µm at 1000Hz (iVis Technologies S.r.l).

The customized ablation profile obtained had a refractive zone of 5.60 mm in RE and 5.50 mm in LE, and a connecting zone of 8.90 mm in RE and 9.60 mm in LE. The cumulative ablation stromal depth was 34 µm in both eyes.

Following surface ablation, PTK with a frequency of 10% was carried out with masking agents (1% hydroxymethyl-cellulose) to smooth the ablated surface, with a depth of 80 µm.

To avoid any kind of corneal haze, 0.02% Mitomycin C (MMC, 0.2 mg/mL, diluted in BSS®) was applied over the ablated area for 20 seconds. At the end of the procedure, a soft therapeutic contact lens was placed. The therapeutical postoperative regimen consisted in topical dexamethasone and amikacin eye drops given four times a day for a week. The patient was then put on 0.1% fluorometholone eye drops and artificial tears eye drops for 12 weeks, which were tapered gradually. The patient was examined the day following surgery, and additional follow-up visits were carried out at one week, two weeks, one, three, and six months, respectively.

At the 1-week follow-up visit the contact lens was removed, with a complete epithelial healing. On slit lamp examination the clarity of the ablated area was notably improved (Figure 4).

AS-OCT scans and topography were performed at 1 week, 1, 3 and 6 months after treatment.

At the 1-month follow-up the final uncorrected visual acuity (UCVA) improved from 20/200 to 20/20 in right eye and to 20/63 in the left eye.

CMI decreased from 15 µm to 3 µm in RE and from 21 µm to 11 µm in LE, and minimum corneal thickness was reduced from 567 µm to 533 µm in RE, and from 574 µm to 540 µm in LE.

The improved visual acuity was maintained at 3-month follow-up and 6-month follow-up, with the patient fully satisfied. The corneal clarity remained during the 6 months follow-up.

The postoperative follow-up was uneventful. The ablation map and topographic changes of both eyes were reported in Figures 3–6.

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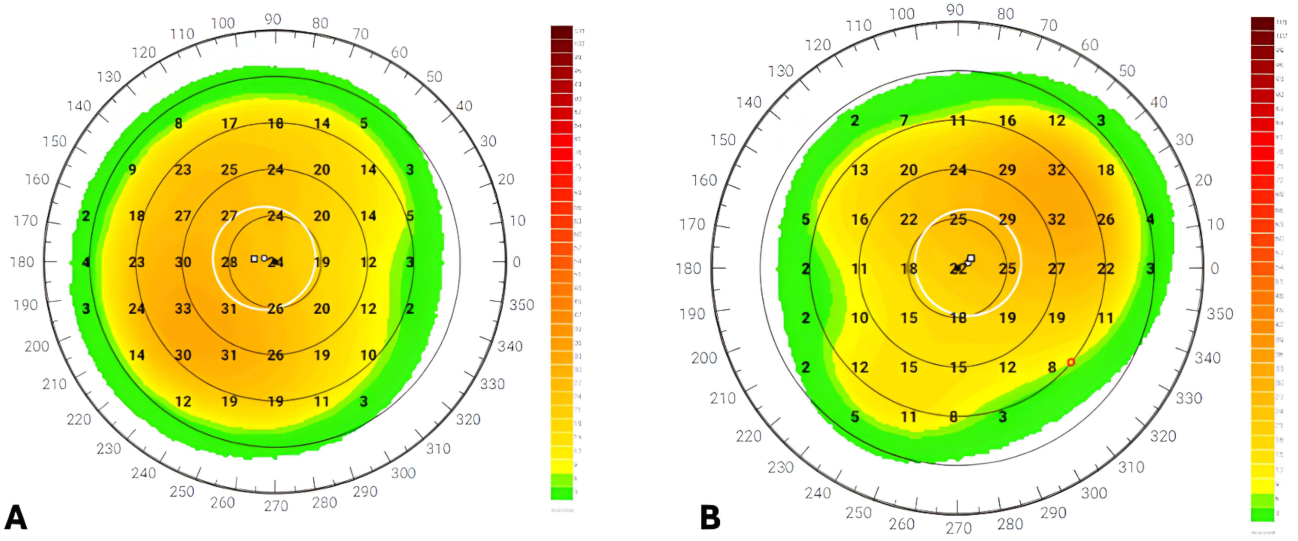

Figure 5 Ablation map of right (**A**) and left (**B**) eye.

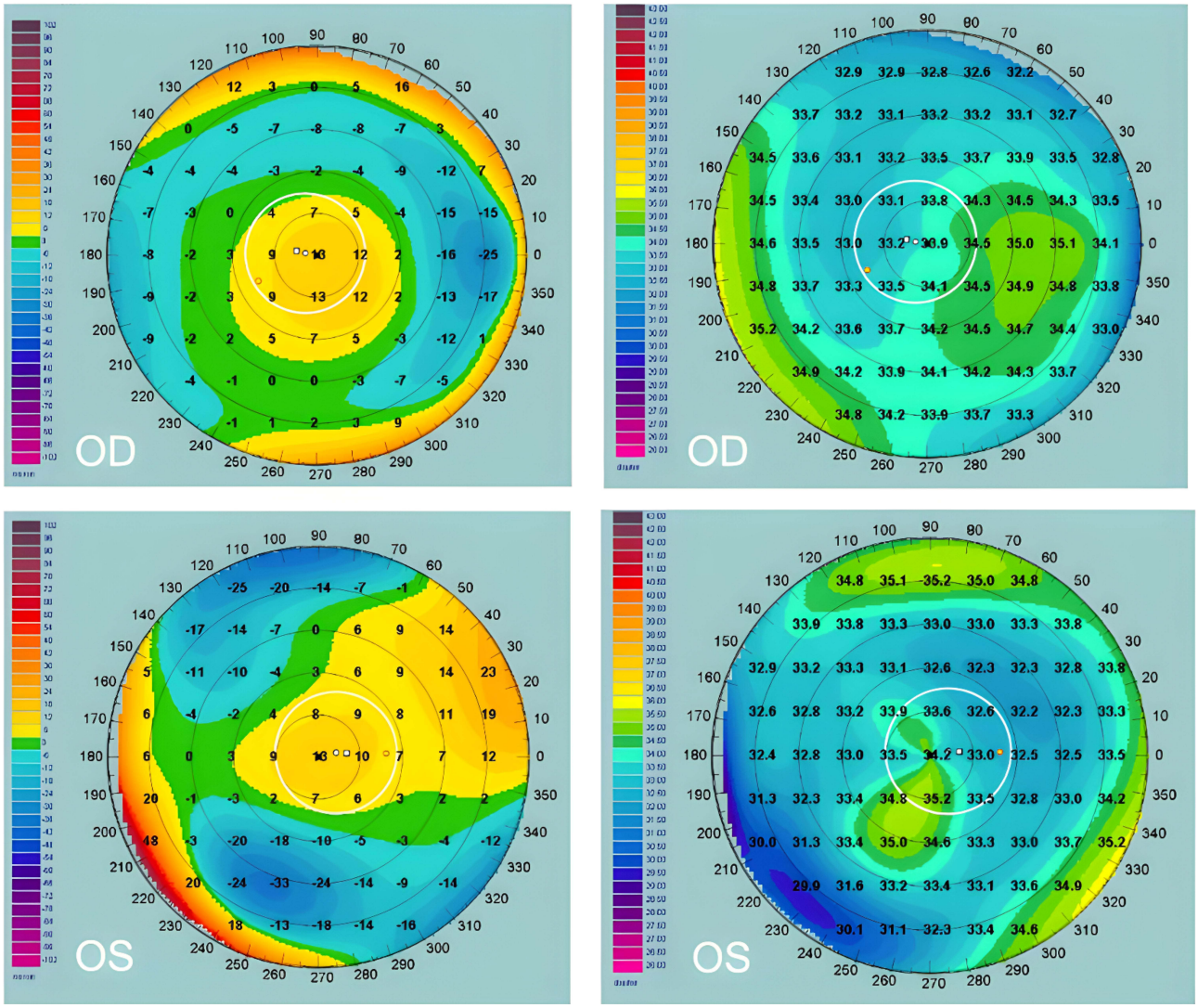

Figure 6 Post-operative Anterior elevation Map and Anterior Ray Tracing map of the right eye and left eye.

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Discussion

CBK may cause reduction of visual acuity and glare due to corneal opacification, along with symptoms of pain and discomfort if epithelial breakdown occurs.

The aim of CBK treatment is to remove the opacity and to achieve a regular corneal surface. The EDTA chelation procedure is by far the mostly used technique worldwide, since it is very simple and not requiring additional procedures.

Although initially effective, CBK tends to recur after EDTA. Najjar et al reported a recurrence rate of 17.8%, and their primary diagnoses associated with recurrence were uveitis and herpes simplex keratitis.[6]

In some cases, when the opacities are located deeper in the anterior stroma or when there is a non-calcific material identified as elastotic degeneration of collagen, there is a poor response to treatment with chelating agents.[3]

Hence the need to perform others procedure such as Phototherapeutic keratectomy (PTK), Amniotic Membrane Transplantation (AMT) or a combination of these.

In this paper we describe the use of a customized approach with combined topo-guided PRK and PTK, which allows to simultaneously obtain the corneal remodeling and the therapeutic removal of the opacities.

PTK has proven to be a successful treatment for several superficial corneal conditions, including bullous keratopathy, corneal opacity, and recurrent corneal erosion.

In a previous paper we already described the efficacy and safety of a combined topography-guided trans-epithelial no-touch PRK and PTK to treat epithelial erosions and stromal opacities in lattice corneal dystrophy.[11] Excimer PTK has been already described to be an effective procedure in the management of CBK whether it is performed for visual rehabilitation or for improvement of the ocular surface.[12] Spadea et al described the combined use of EDTA with PTK to treat efficiently two cases of CBK.[9]

To our knowledge, this is the first case of CBK unresponsive to EDTA successfully treated with a combined approach using a topography-guided trans-epithelial ablation with PRK and PTK. The major advantage of this approach is the possibility of removing in a single step epithelium and stroma according to the planned ablation profile. In addition, the smoothening of the ocular surface may increase ocular film stability and reduce the rate of recurrence.[1]

In conclusion, combining topography-guided trans-epithelial no-touch PRK and PTK seems to be a promising treatment for irregular corneal surface and stromal opacities in CBK not responsive to EDTA chelation treatment. This procedure needs a longer follow-up and further study to evaluate its efficacy and safety.

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Disclosure

The authors report no conflicts of interest in this work.

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