

Treatment of irregular astigmatism by topography-guided ablation

Tratamento do astigmatismo irregular por ablação guiada por topografia

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How to cite:

Toni AG, Martins LA, Colombo-Barboza GN, Colombo-Barboza LR, Moscovici BK, Colombo-Barboza MN. Treatment of irregular astigmatism by topography-guided ablation. Rev Bras Oftalmol. 2024;83:e0035.

doi:

<https://doi.org/10.37039/1982.8551.20240035>

Keywords:

Corneal topography;
Keratotomy, radial; Ablation
techniques; Keratoconus

Descritores:

Topografia da córnea;
Ceratotomia radial; Técnicas de
ablação; Ceratocone

Received on:
Apr 2, 2023

Accepted on:
Apr 2, 2024

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Conflict of interest:
no conflict of interest.

Financial support:
no financial support for this work.



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ABSTRACT

Topography-guided ablation was designed to improve corneal regularity throughout the correction of corneal high order aberrations. The present report described three cases with different indications for topography-guided ablation to correct irregular astigmatism. The patients were monitored in the immediate and late postoperative periods to evaluate long-term corneal stabilization. Surgery indications were based on the patient's complaint of poor quality of vision associated with previous radial keratotomy, corneal transplant, or keratoconus. In all three cases, the patients reported an improvement in the quality of their vision and expressed satisfaction with the procedure; however, the patient who had previously been submitted to crosslinking presented with keratoconus progression in the late postoperative period. Finally, topography-guided customized ablation appears to represent a safe and effective technique for reducing corneal irregularities.

RESUMO

A ablação guiada por topografia foi projetada para melhorar a regularidade da córnea durante a correção de aberrações de alta ordem da córnea. O presente relato descreveu três casos com diferentes indicações de ablação guiada por topografia para correção de astigmatismo irregular. Os pacientes foram monitorados no pós-operatório imediato e tardio para avaliar a estabilização corneana em longo prazo. As indicações cirúrgicas basearam-se na queixa do paciente de má qualidade de visão associada a ceratotomia radial prévia, transplante de córnea ou ceratocone. Nos três casos, os pacientes relataram melhora na qualidade da visão e manifestaram satisfação com o procedimento; entretanto, o paciente que já havia sido submetido ao crosslinking apresentou progressão do ceratocone no pós-operatório tardio. Finalmente, a ablação personalizada guiada por topografia parece representar uma técnica segura e eficaz para reduzir irregularidades da córnea em córneas não ectásicas.

INTRODUCTION

Conventional or aspheric corneal ablation corrects only low-order aberrations (LOA) such as defocus and regular astigmatism; however, its effectiveness diminishes in irregular corneas such as keratoconus (KC), transplanted corneas (PK), or previous incisional refractive surgery (RK).⁽¹⁾ In such cases, customized ablation should be considered.⁽²⁾

Some patients cannot achieve good visual acuity in irregular corneas with spectacles or soft contact lenses. Rigid contact lenses could improve their visual acuity, but some patients prefer a definitive solution. Since topography-guided ablation was designed to improve corneal high-order aberrations (HOA), this technique could be performed in these cases.^(3,4)

This paper reported three cases with different indications for topography-guided customized ablation treatment (TCAT) for correcting irregular astigmatism and HOA. The indications were based on patients' complaints of poor quality of vision associated with a previous radial keratotomy procedure, corneal transplant, or KC.

This report received approval from the institution's internal review board under reference CAAE: 34530720.7.0000.5509. The patients gave their written consent for the publication of the cases.

CASE REPORTS

Case 1

A 53-year-old white female teacher reported previous RK in both eyes. She complained of poor quality of vision in

the right eye (OD), particularly at night. She was using a contact lens in OD but was dissatisfied with it. Visual acuity is presented in LogMar in all cases. Examination showed UCVA of 0.5 in OD and 0.3 in the left eye (OS). Subjective dynamic refraction was +5.00 -1.00 x 77° (0.2) in OD and +2.00 -2.50 x 87° (0.1) in OS.

Corneal tomography was performed using a Scheimpflug camera (Pentacam® Oculus, Wetzlar, Germany). The anterior sagittal curvature map showed severe central cornea flattening, while the corneal thickness map was within normal limits, and the corneal elevation map showed irregularity in the anterior and posterior surfaces that are typical of RK (Figure 1). Topography-guided photorefractive keratectomy (TCAT PRK) combined with 0.02% mitomycin C with WaveLight® EX500 (Alcon, Fort Worth, United States) was performed in OD. Ablation was based on the WaveLight® Topolyzer® VARIO topographer (Alcon, Fort Worth, United States) profile. In all cases, we compensated defocus and spherical aberration in the Zernike list, trying to equalize Z4 and Z12.

Six months after the procedure, UCVA improved to 0.1 and CDVA to 0.0 in OD. Postoperative topography showed an ablation pattern typical of hypermetropia (peripheral ablation and central elevation). Postoperative corneal tomography revealed better regularity on the anterior sagittal curvature map (Figure 2). Table 1 shows comparative data of the surgical results.

This patient reported an improvement in her quality of vision and satisfaction with the results. After 2 years

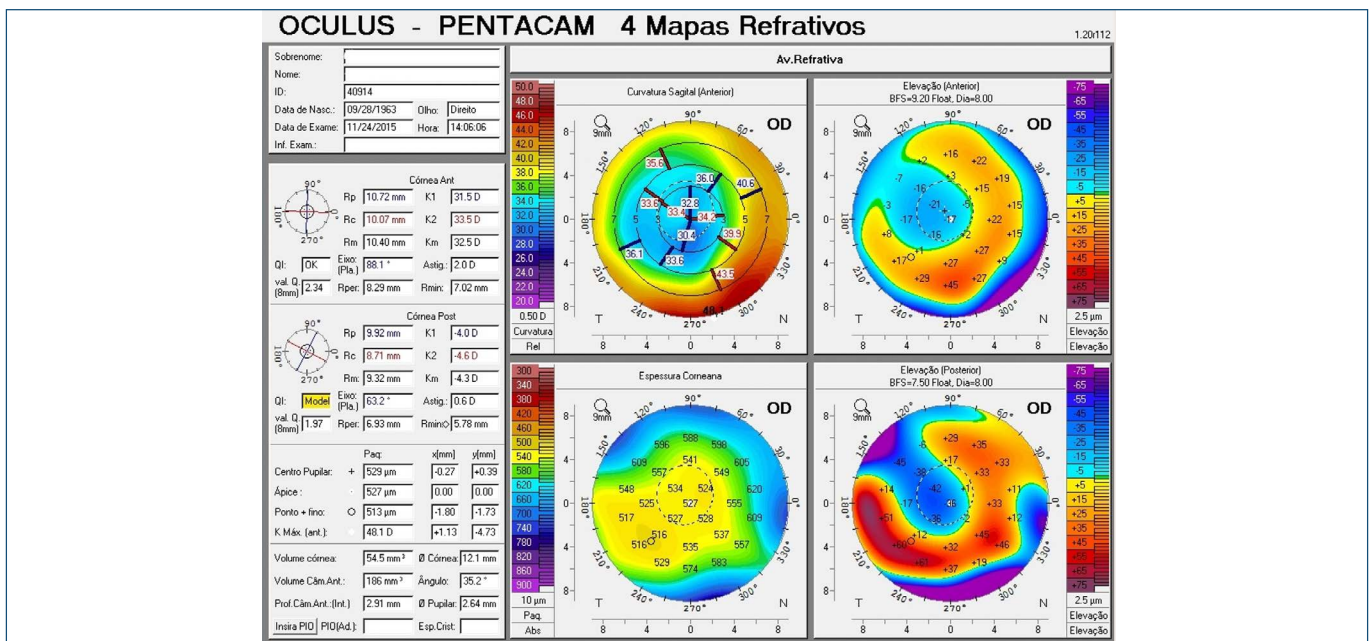


Figure 1. Preoperative corneal tomography of the right eye showing a sagittal curvature map with severe flattening in the central part of the cornea and elevation maps showing irregularities in the anterior and posterior surfaces typical of radial keratotomy.

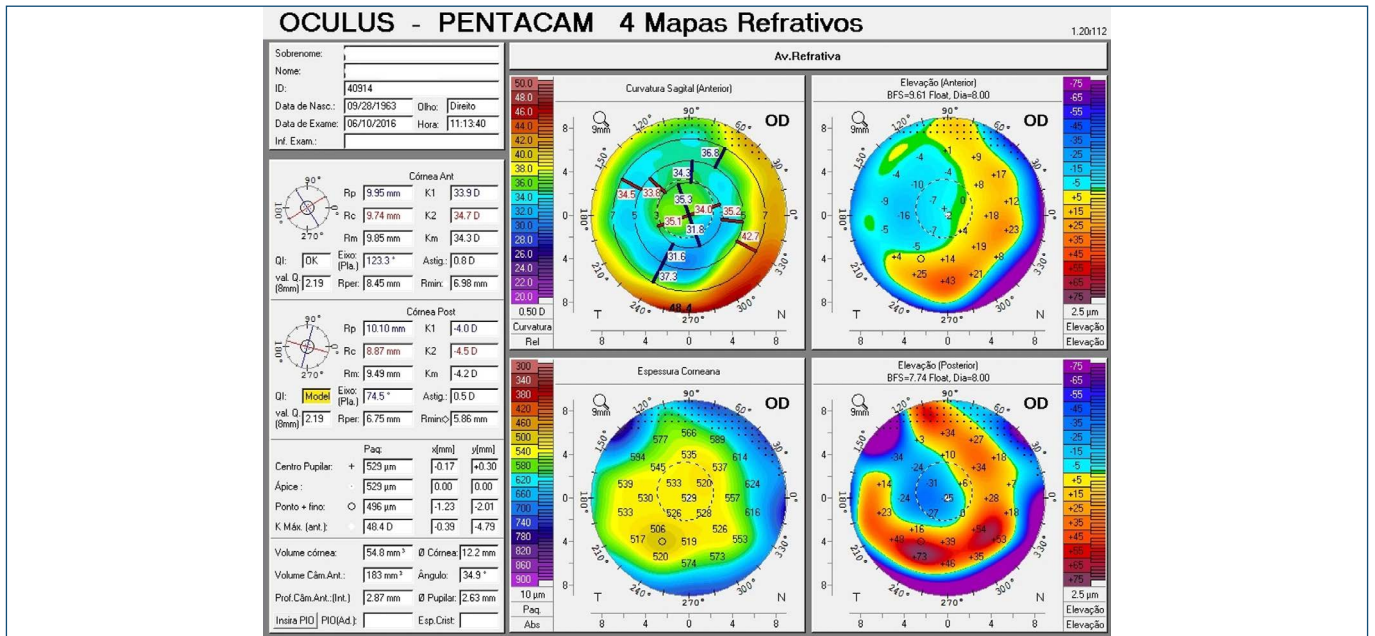


Figure 2. Postoperative corneal tomography of the right eye showing greater regularity in the anterior sagittal curvature map.

Table 1. Comparative data of the surgical results of case 1

	Before surgery	After surgery
Subjective refraction (Diopters)	+5.00 -1.00 (77°)	+1.50 -1.00 (25°)
Corrected visual acuity (logmar)	0.2	0.0
Average keratometry (Diopters)	32.5	34.3
Astigmatism (Diopters)	2.0	0.8

of follow-up, the topography showed that the ablation pattern of hypermetropia was still present even after this long time (Figures 3A and 3B).

Case 2

A 34-year-old white male mechanic reported previous PK (due to KC) in OS. He complained of poor quality of vision

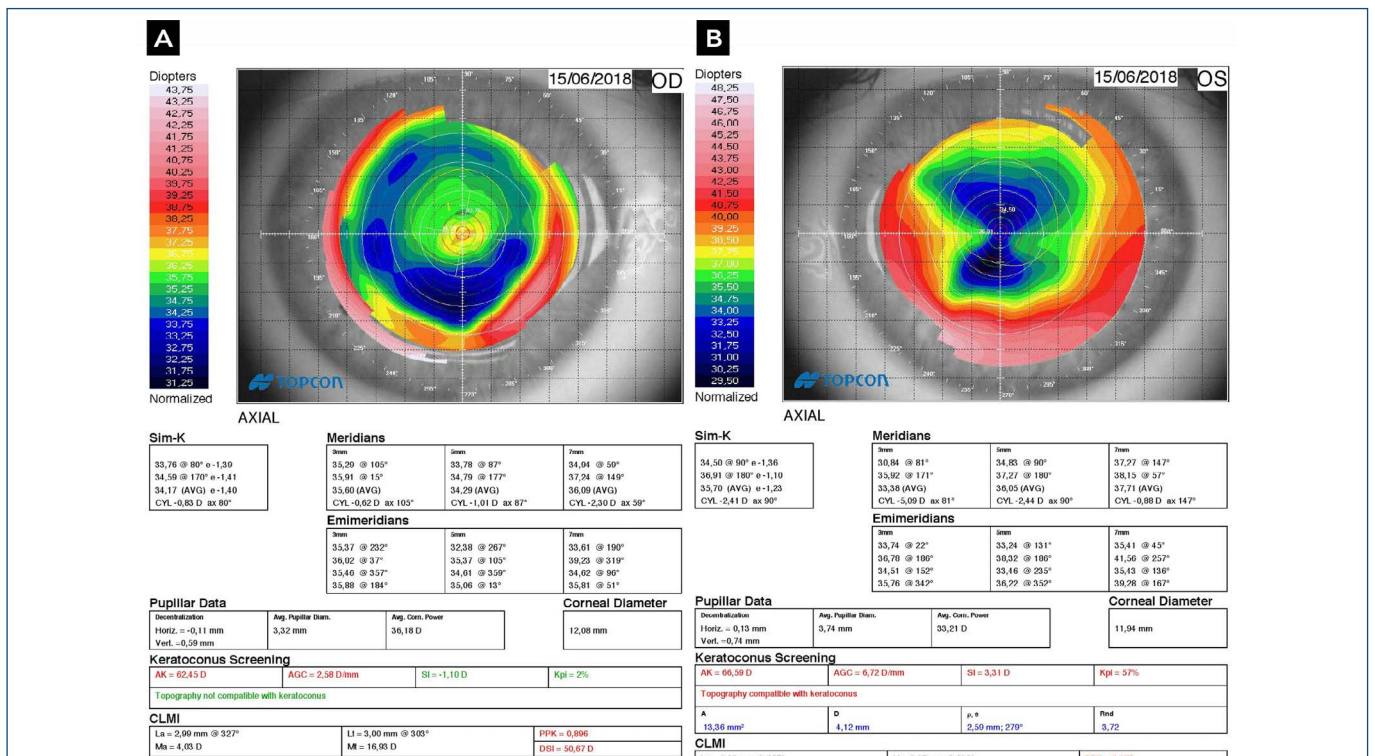


Figure 3. Corneal topography of both eyes after 2 years of follow-up showing that the ablation pattern in the right eye was maintained (3A and 3B).

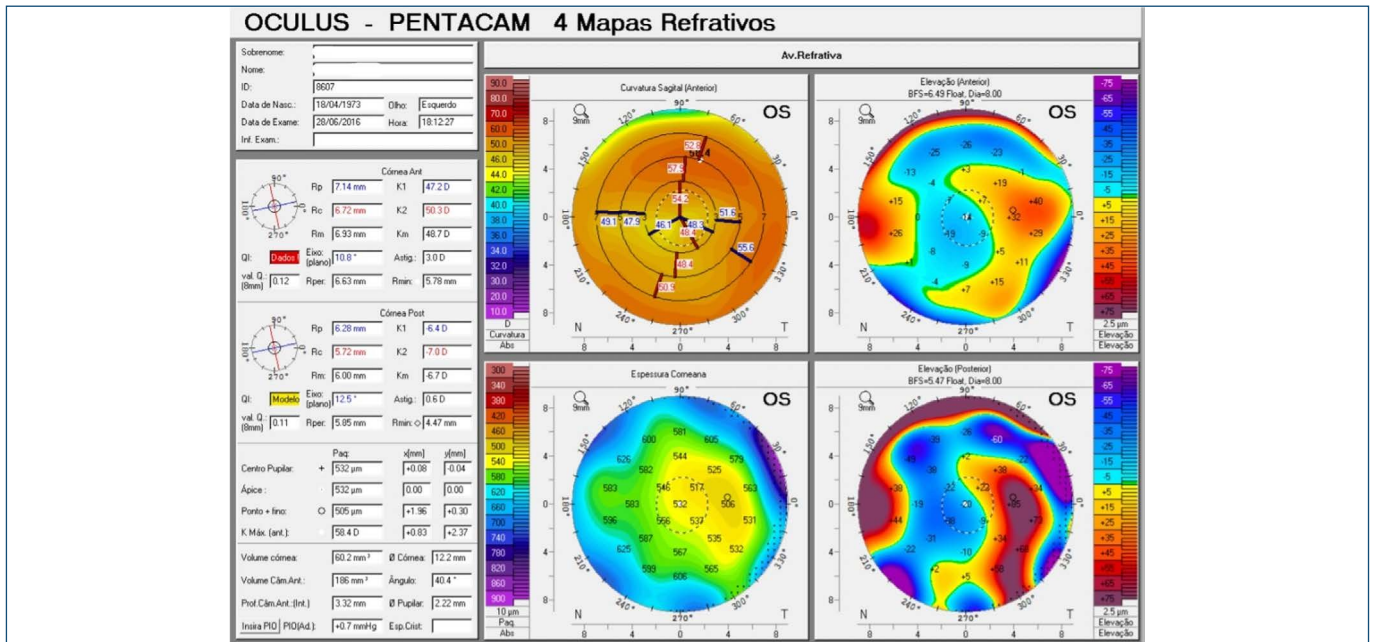


Figure 4. Preoperative corneal tomography of the left eye showing anterior sagittal curvature map with severe flattening in the central region and elevation maps with irregularities on the anterior and posterior surfaces of the cornea.

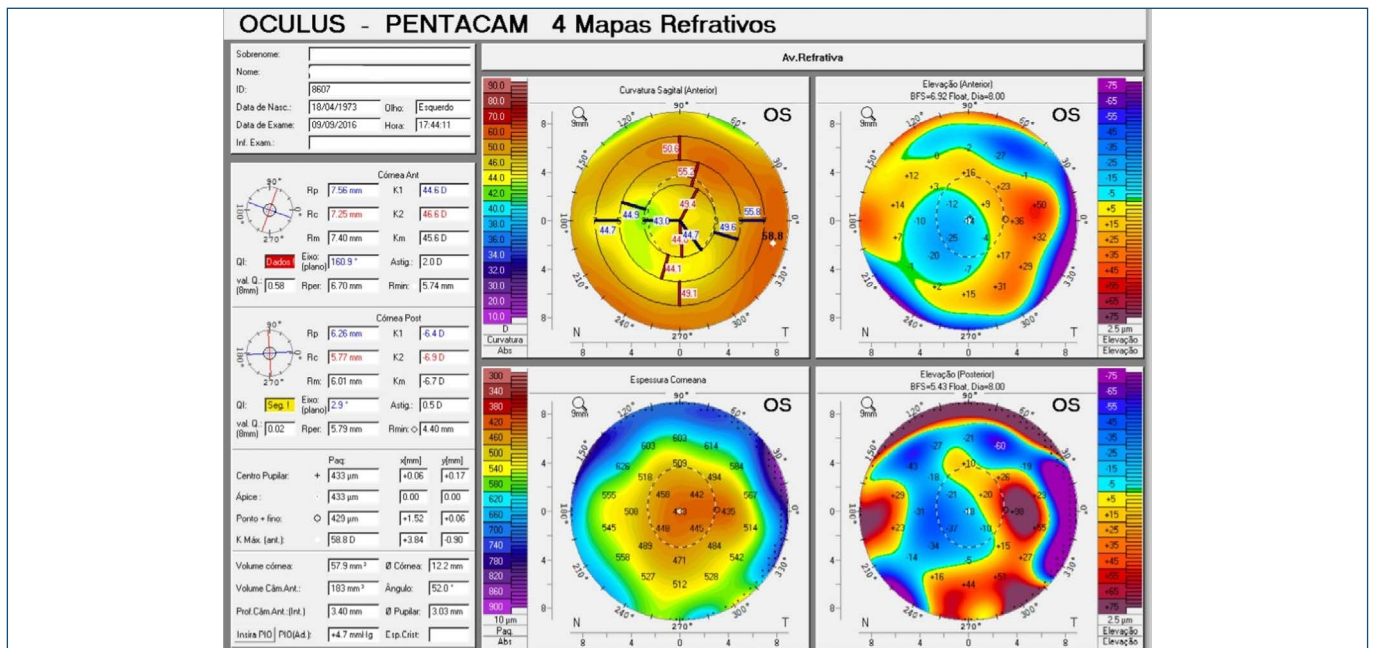


Figure 5. Postoperative corneal tomography of the left eye showing greater regularity on the anterior surface.

in OS for the past 6 years, particularly at night. Subjective refraction: right eye +0.50 -1.75 x 55° (0.2) in OD and -3.50 -4.50 x 13° (0.2) in OS.

Corneal tomography was performed. The anterior sagittal curvature map showed severe central cornea flattening, while the corneal thickness map was within normal limits, and the corneal elevation map showed irregularity in the anterior and posterior surfaces of the cornea

(Figure 4). Topography-guided photorefractive keratectomy was performed similarly to case one.

Six months after the procedure, the patient reported an improvement in his quality of vision. Subjective refraction in the OS following TCAT was -0.75 DC x 23° (0.0). Corneal tomography showed greater regularity on the anterior surface (Figures 5 and 6). Comparative data of the surgical results are found in table 2.

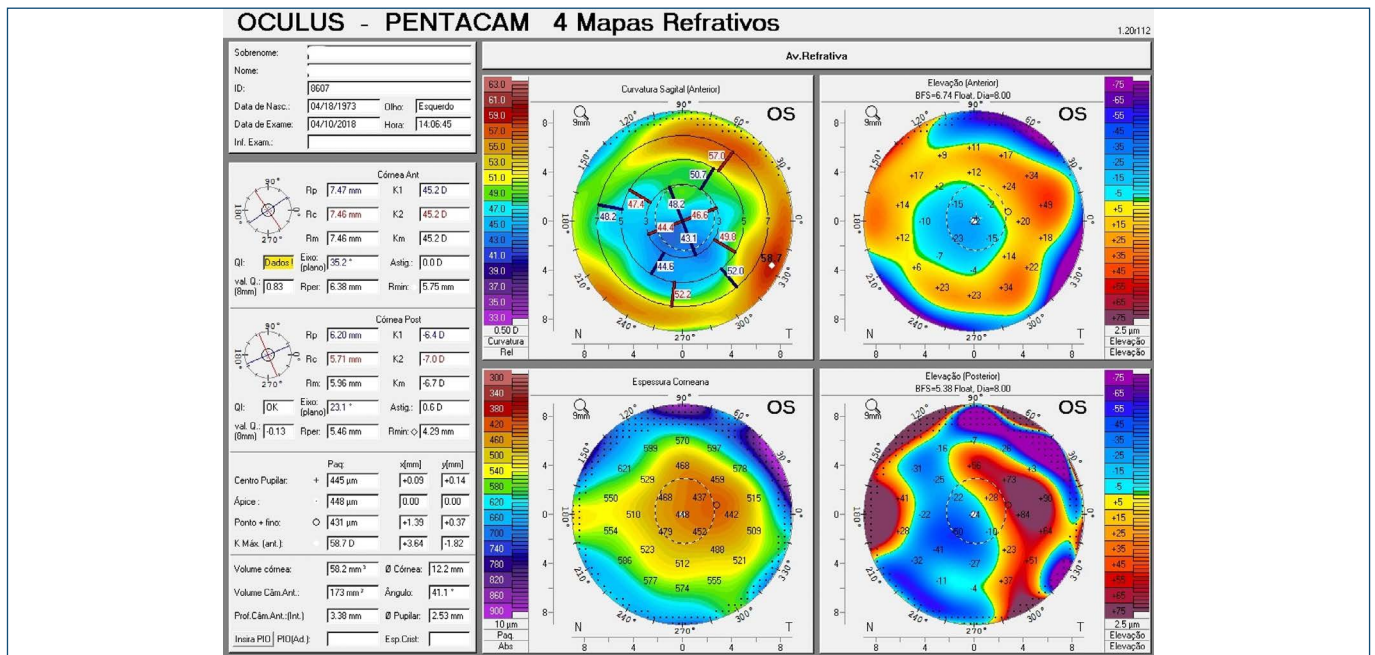


Figure 6. Corneal tomography of the left eye after 2 years of follow-up showing that the ablation pattern was maintained.

Table 2. Comparative data of the surgical results of case 2

	Before surgery	After surgery
Subjective refraction (Diopters)	-3.50 -4.50 (13°)	0.00 -0.75 (23°)
Corrected visual acuity (logmar)	0.2	0.0
Average keratometry (Diopters)	48.7	45.2
Astigmatism (Diopters)	3.0	0

Case 3

A 22-year-old white male salesman complained of blurred vision in his OS even using spectacles. He reported being unable to tolerate contact lenses. Ophthalmologic history included subclinical KC in OD and moderate KC in the OS; moderate allergic conjunctivitis (in use of olopatadine hydrochloride 0.2% ophthalmic solution). He had previously performed crosslinking (CXL) in 2014 in the OS (Dresden protocol). Subjective refraction: OD: plane -1.25 x 90° (0.0) and OS -3.00 -4.75 x 85° (0.5).

Corneal tomography was performed using a Scheimpflug camera. The anterior curvature map showed a significant steepening in the central region (K1 44.8 D, K2 48.3 D, Kmax 50.9) while the pachymetry map showed central thinning (496 µm). Topography-guided photorefractive keratectomy was performed similarly to previous cases.

The patient reported better vision quality after the procedure. Subjective refraction after 17 months of follow-up: OS -2.50 -0.50 x 85 (0.0), keratotomy: 42.70 (80°) x 44.60 (170°). Anterior sagittal map curvature showed greater regularity (Figure 7). Thirty months after the procedure, the central corneal thickness was 415 µm, the

subjective refraction in the OS was -2.00 -2.00 x 85° (0.3), and keratotomy was 47.99 (145°) x 48.90 (55°) (Figures 8A and 8B). Figure 9 shows the ablation profile. There was a KC progression in this case, with an increase in the central curvature and a reduction in UDVA and CDVA; however, until now, the patient has not presented progression after this appointment. Table 3 shows the comparative data of the surgical results.

DISCUSSION

The technique of RK began to be performed in the 1970s to treat myopia, with more than 1.2 million surgeries having been performed in the United States up to 1990.⁽⁵⁾ Although effective in many cases, the predictability of the outcome of this intervention was found to be limited and over the long term it often resulted in progressive hyperopia and corneal flattening. In a retrospective series, Filev et al. evaluated 16 eyes previously submitted to RK and treated with topography-guided PRK. There was an improvement in UDVA in all the eyes, while 56% had an improvement in CDVA. The technique was found to be an effective treatment method without any complications.⁽⁶⁾ In the first case described here, although CDVA was good, the patient complained of the quality of her vision and her inability to tolerate contact lenses, one of the main indications for customized treatment.

Although generally successful, PK patients often present with high irregular astigmatism following surgery that prevents satisfactory visual acuity. Spectacles

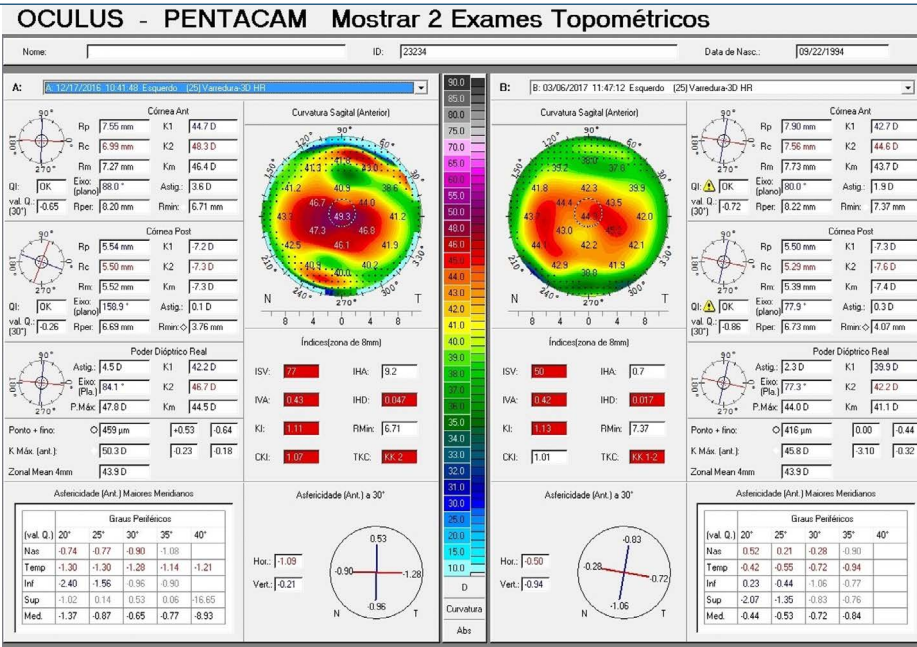


Figure 7. Corneal tomography of the left eye showing greater regularity on the anterior sagittal curvature map compared to preoperative findings.

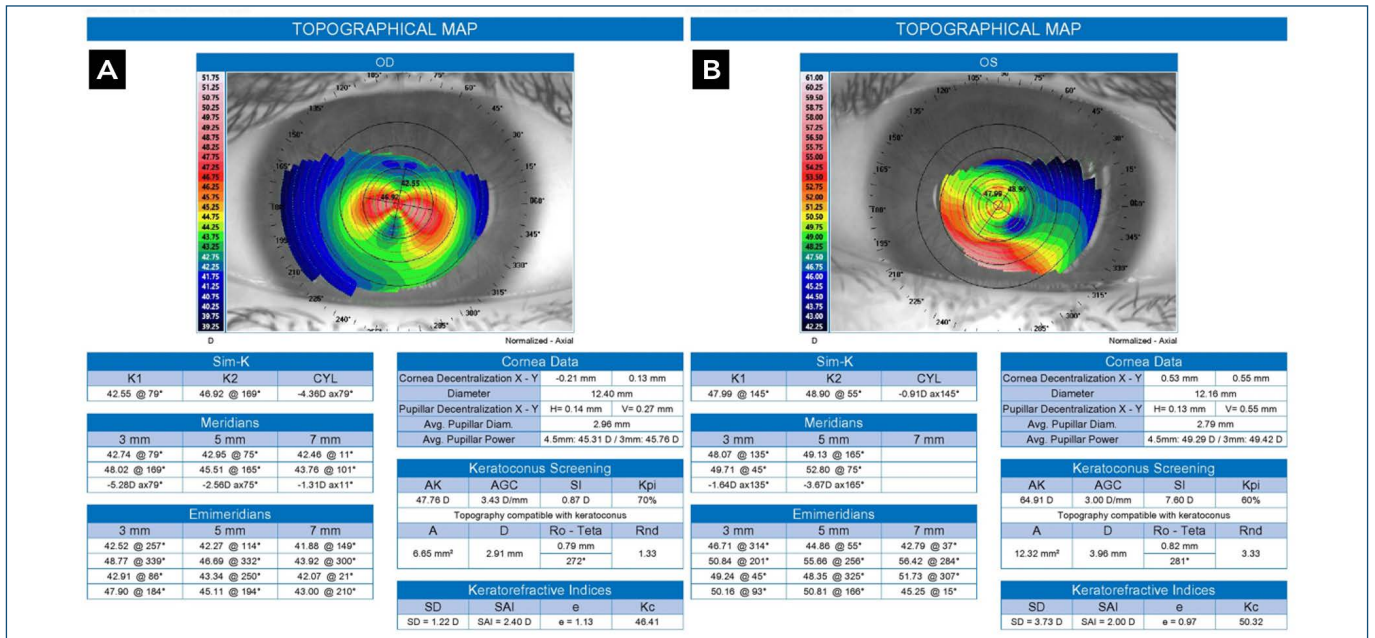


Figure 8. Topography of both eyes (8A and 8B) after 30 months of follow-up showing recurrence of increased curvature in the left eye. Keratometry of the left eye: 47.99 (145°) x 48.90 (55°).

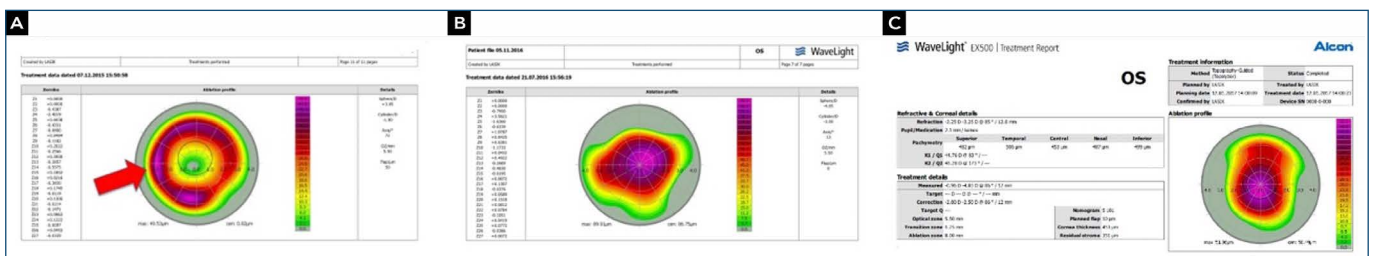


Figure 9. Topography-guided ablation profile in the 3rd case.

Table 3. Comparative data of the surgical results of case 3

	Before surgery	After surgery
Subjective refraction (Diopters)	-3.00 -4.75 (85°)	-2.00 -2.00 (85°)
Corrected visual acuity (logmar)	0.5	0.3
Average keratometry (Diopters)	46.4	43.7
Astigmatism (Diopters)	3.6	1.9

and contact lenses often fail to provide the necessary visual rehabilitation; therefore, excimer laser treatment emerged as an alternative.⁽¹⁾ Conventional ablation procedures correct only LOA, and their effectiveness in cases of more oblate corneas is broadly limited. In such cases, customized ablation should be considered.

Treatment with TCAT depends exclusively on topographical maps of the cornea to remodel irregularities, generating a more regular and symmetrical surface. A point of debate concerns the need for predictability concerning the final refractive outcome since the changes induced by correction are unknown, and a second refractive procedure may be necessary. Laíns et al. evaluated 31 eyes submitted to TCAT and reported a significant improvement in UDVA and CDVA in the postoperative follow-up. There was a gain of one line or more in UDVA. Most eyes (74.2%) gained at least one CDVA line of vision, and 12.9% gained five or more lines. In two eyes, loss of one and three CDVA lines was observed, related to postoperative central opacity and recurrence of herpetic keratitis.⁽⁴⁾

Kwitko et al. described a series of cases in which 60 eyes were evaluated in 48 patients. The study included patients with corneal irregularity due PK, RK, anterior lamellar keratoplasty and other diagnoses that result in poor visual acuity and dissatisfaction with the quality of vision, all confirmed by topography. That retrospective study showed an improvement in CDVA in 65% of the eyes.⁽⁷⁾ There was a significant reduction in manifest refraction, and follow-up confirmed the durability of the results, as in the cases presented here.

The third case referred to a patient with moderate KC submitted to TCAT PRK with previous CXL. Keratoconus is an ectatic disorder involving progressive cornea thinning, resulting in corneal protrusion, irregular astigmatism, fibrosis, and vision impairment. Corneal CXL alters the collagen matrix of the corneal stroma by forming additional covalent bonds, thereby improving corneal rigidity.⁽⁸⁾ In agreement with reports in the literature,⁽⁸⁾ the patient's vision in this case report improved; however, after 30 months, there was a change in keratometry readings, with a loss of two lines of vision. The procedure was found to be safe but with a possibility of recurrence over the long term. The surgery followed the Athens protocol,

developed for the combination of personalized PRK and CXL surgery to address the progression of KC and improve the corneal irregularity. Epithelial debridement with an associated excimer laser ablation (50 µm), aiming to improve corneal irregularity with smaller optical zones, has been documented with positive results in long-term follow-up.

Cassagne et al. compared the effectiveness of topography-guided CKL with the conventional procedure in patients with progressive KC. Sixty eyes were evaluated for at least one year following surgery. The topography-guided treatment was as safe as conventional treatment, with improved CDVA after surgery.⁽⁹⁾ Nattis et al. evaluated 62 eyes, with results showing significant improvements in corneal astigmatism and maximum and mean keratometry readings. These results reinforce the effectiveness and safety of the topography-guided method for improving visual acuity and reducing irregular astigmatism.^(10,11) Studies with longer follow-up periods after TCAT should be conducted in patients with KC to evaluate corneal stabilization. Cassagne et al. and Nattis et al. monitored patients for 1 year after surgery, while in the patient reported here, recurrence was found thirty months after surgery.

Topography-guided customized ablation treatment represents an interesting treatment option for cases of irregular astigmatism aiming to treat HOA and improve visual acuity.

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