

## Toric Artisan after transepithelial topography-guided photorefractive keratectomy for higher-order aberrations following intrastromal corneal ring segments in keratoconus – Trioptics

Gabriel de Almeida Ferreira<sup>1,2</sup>, Vinícius Coral Ghanem<sup>1,3</sup>,  
Renata Leite de Pinho Tavares<sup>1</sup>, Ramon Coral Ghanem<sup>1,3</sup>

Access this article online	
Quick Response Code:	Website: www.ijo.in
	DOI: 10.4103/ijo.IJO_73_20

<sup>1</sup>Department of Cornea, Sadalla Amin Ghanem Eye Hospital, Joinville, SC, <sup>2</sup>Master (MSc) in Ophthalmology at the São Paulo State University, Botucatu, SP, Brazil, <sup>3</sup>Doctorate (PhD) at the São Paulo University (USP), Sao Paulo, SP, Brazil

**Correspondence to:** Dr. Gabriel de A Ferreira, Sadalla Amin Ghanem Eye Hospital, 35, Camboriu Street. Joinville, SC, Brazil. E-mail: gaferreiramd@gmail.com

Received: 11-Jan-2020

Revision: 01-Apr-2020

Accepted: 20-Jul-2020

Published: 26-Oct-2020

We report a case of a 40-year-old female with keratoconus and high myopia who had previous ICRS implantation in both eyes (OU) and was intolerant to contact lenses. Manifest refraction was -8.50 -1.50 × 95 (20/25--) in right eye (OD) and -9.50 -2.50 × 60 (20/70--) in left eye (OS). A topography-guided transepithelial-photorefractive keratectomy (ttPRK) was performed to correct high-order aberrations on OS, resulting in corneal surface and coma improvement, and CDVA achieved 20/30. Correction of residual ametropia was performed with an iris-fixated toric phakic lens in OU. CDVA improved to 20/20- (Plano) in OD and 20/20- (Plano -1.00 90°) in OS. In conclusion, it is possible to rehabilitate a patient with keratoconus and high ametropia after intrastromal corneal ring segments (ICRS) implantation associating ttPRK and phakic lens ("Trioptics").

**Key words:** Keratoconus, phakic lens implantation, refractive surgery

Many patients with keratoconus present corneal distortions and refractive errors that are not fully corrected with spectacles,

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** WKHLRPMedknow\_reprints@wolterskluwer.com

**Cite this article as:** Ferreira GA, Ghanem VC, Tavares RL, Ghanem RC. Toric Artisan after transepithelial topography-guided photorefractive keratectomy for higher-order aberrations following intrastromal corneal ring segments in keratoconus – Trioptics. Indian J Ophthalmol 2020;68:2564-7.

contact lenses (CL), or surgical procedures, namely, intrastromal corneal ring segment (ICRS) or corneal transplantation.

The ICRS implant aims to regularize the corneal surface, improving the corrected distance visual acuity (CDVA). For correction of residual ametropia, there are spectacles, CL, and phakic lens implantation<sup>[1]</sup> or excimer laser treatment.<sup>[2,3]</sup> However, many patients remain unsatisfied with their CDVA after ICRS implantation.<sup>[4]</sup> Therefore, we describe a surgical alternative for those challenging cases.

## Case Report

A 40-year-old female presented with keratoconus (grade I in right eye [OD] and grade II in the left eye [OS], according to Amsler-Krumeich classification) and high myopia. The patient had a medical history of an ICRS implantation in both eyes 10 years ago in another service, without corneal crosslinking (CXL) associated. She had no medical history, however, at biomicroscopy a 160° ICRS was well-positioned, the cornea was clear, and the rest of the ophthalmological examinations were unremarkable. The patient was CL-intolerant and unsatisfied with spectacles.

The uncorrected distance visual acuity (UDVA) was counting fingers in both eyes (OU). The manifest refraction was  $-8.50 -1.50 \times 95$  (20/25-) in OD and  $-9.50 -2.50 \times 60$  (20/70-) in OS.

Since CDVA in OS was below expected for ICRS implantation, but the ICRS was well-placed, the corneal topography showed an acceptable regularity [Fig. 1a], and an elevated corneal high-order aberration (HOA) was observed (Fig. 2a, preoperative corneal coma of 1,815  $\mu\text{m}$  [SCHWIND Corneal Wavefront Analyzer, SCHWIND eye-tech-solutions, Kleinostheim, Germany]), a topography-guided transepithelial photorefractive keratectomy (ttPRK) with mitomycin C 0.02% was proposed to correct the HOA with an optical zone (OZ) of 5 mm (ICRS optical zone), intending to regularize the cornea and improve the CDVA [Fig. 1]. The procedure was performed with the Corneal Wavefront-guided module on the Schwind Amaris® 1050RS (SCHWIND eye-tech-solutions, Kleinostheim, Germany), consuming 62  $\mu\text{m}$  centrally (from initial 451  $\mu\text{m}$ ) and 100  $\mu\text{m}$  at the periphery (from initial 395  $\mu\text{m}$ ) [Fig. 1d], values which include the 55  $\mu\text{m}$  of the epithelial thickness since it was a transepithelial treatment.

After 6 months, there was an improvement in the topographic pattern of the visual axis [Fig. 1b] with Surface Asymmetry Index (SAI) improving from 3.85 to 2.07. Besides, the HOA (especially coma) [Fig. 2] improved, and the epithelial pattern became more regular [Fig. 3]. The manifest refraction was  $-9.50 -3.00 \times 130$  with an improved CDVA of 20/30.

The surgical correction of the high residual ametropia was performed with an iris-fixated toric phakic lens (Artisan Toric, Ophthec, Netherlands) in OU. The preoperative endothelial cell count was 2,888 cells/ $\text{mm}^2$  in the OD and 2,863 cells/ $\text{mm}^2$  in the OS. The depth of the anterior chamber from the endothelium (Galilei G4, Ziemer Ophthalmic Systems AG, Port, Switzerland) was 2.89 mm in OD and 2.95 mm in OS.

After 4 months, the patient was very satisfied with a manifest refraction of Plano (20/20-) in OD and Plano  $-1.00 90^\circ$  (20/20-) in OS.

## Discussion

Treating keratoconic patients with low CDVA and CL intolerance is challenging. Most cases are submitted to ICRS implantation; however, frequently, the CDVA improvement is lower than desired.

In 2017, Coskunseven *et al.*<sup>[5]</sup> demonstrated the possibility of a quadruple procedure for keratoconic patients which combines CXL, ICRS, phakic lenses, and excimer laser ablation to correct residual ametropia. Unlike ours, his ablation, however, was associated with CXL and was not aimed at HOAs.

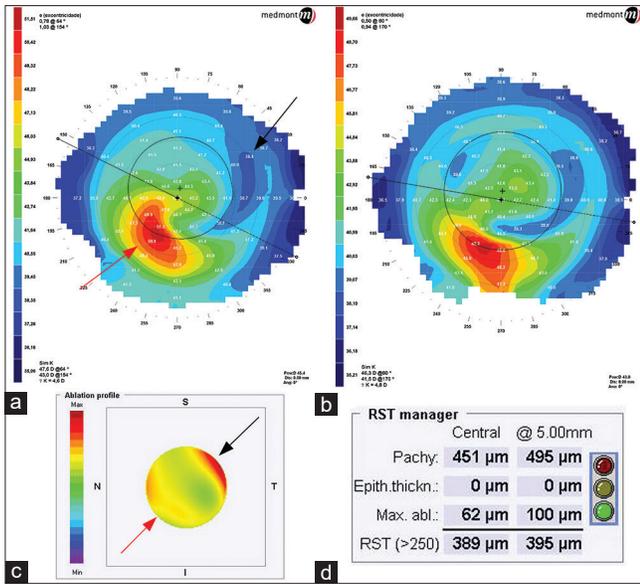
Despite being a common situation in referral eye-care centers, there are few studies about the surgical visual rehabilitation of patients with unsatisfactory CDVA after ICRS.<sup>[2,3]</sup> We propose that after initial corneal regularization with ICRS, ttPRK can be performed with a small OZ to exclusively correct HOA, improving CDVA with little corneal consumption. In the presented case, the CDVA improved from 20/70 to 20/30. If necessary, a phakic lens can be implanted, at least 6 months later, to correct the residual ametropia. In cases of keratoconus submitted to phakic lens implantation, astigmatism cannot be properly corrected by the incision, therefore, the use of toric lenses is frequently necessary.

The Athens and the Cretan protocols combine CXL with a transepithelial excimer laser to treat patients with keratoconus, using the epithelium as a masking agent for the cone apex. It is important to note that both protocols are intended for the excimer laser to partially correct the ametropia, which differs from our proposal to correct the HOA exclusively.

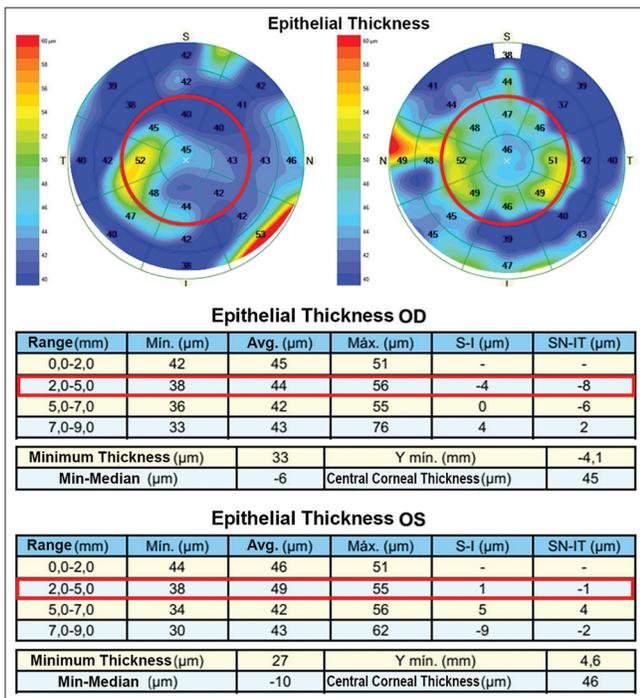
Two studies evaluated the use of conventional PRK in suspected keratoconus patients and verified the safety in these cases.<sup>[6,7]</sup> In keratoconus patients, the safety of PRK without CXL has already been demonstrated by some studies. Chelala *et al.*<sup>[8]</sup> assessed the results of PRK in 119 eyes with grade I or II keratoconus based on Amsler-Krumeich classification, with maximum ablation of 50  $\mu\text{m}$  and a residual stromal bed of 450  $\mu\text{m}$ . After a 5-year follow-up, 66.3% obtained a UDVA of 20/20, and only two eyes (1.7%) showed progression that required CXL. Khakshoor *et al.*<sup>[9]</sup> had similar results using PRK in 38 eyes of patients aged 40 years or older with grade I or II keratoconus. After a 3-year follow-up, 58% showed a UDVA of 20/20, and none progressed. On the other hand, Kasparova and Kasparov<sup>[10]</sup> observed progression in 8.57% out of 70 eyes with keratoconus submitted to PRK combined with PTK after a 6-year follow-up. We did not combine CXL in this case since the patient was already 40 years old and the tissue consumption was small.

Regarding PRK after ICRS, current studies also associate the treatment with CXL. Al-Tuwairqi *et al.*<sup>[3]</sup> studied 41 eyes submitted to topography-guided PRK with CXL after 6 months of ICRS implantation and verified that more than 60% of the eyes achieved a UDVA of 20/25 after 1 year, but 15% lost one or two lines of CDVA. Kremer *et al.*<sup>[11]</sup> performed a similar study with 45 eyes with a wavefront-guided PRK technique, showing an efficacy index of 0.948 and a safety index of 1.327 at the 1 year follow-up, without the loss of vision.

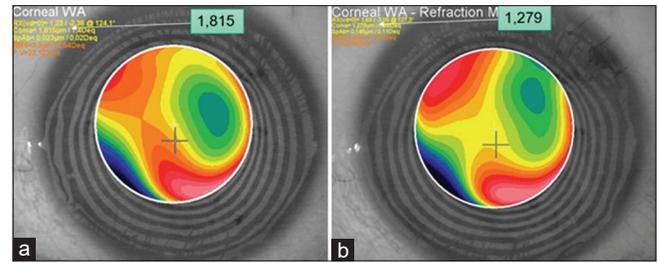
To our knowledge, this is the first case reported in literature combining ICRS followed by ttPRK for the correction of HOA and sequential phakic lens implantation to correct residual ametropia. We named this combination "Trioptics."



**Figure 1:** (a) Topographic map of the left eye 9 years after ICRS. The preoperative evaluation showed irregular and asymmetric astigmatism with inferior ectasia characterizing keratoconus. The red arrow indicates the area of higher curvature with 51.5D, and the black arrow indicates the flat area with 38.4D. (b) A postoperative topographic map presenting regularization of the central cornea area. (c) Ablation map of topography-guided profile for HOA correction: the red arrow indicates the ablation on the apical region that will be flattened, and the black arrow shows where deeper ablation will occur to steepen the flattest area of the central cornea. (d) Values of corneal ablation and residual stromal bed. Central ablation was 62 μm and peripheral ablation was 100 μm with an OZ of 5 mm. Since it is a transepithelial ablation, 55 μm of the epithelial thickness must be discounted to calculate the real stromal ablation



**Figure 3:** Epithelial map obtained through A-OCT (Cirrus HD-OCT Model 5000, Carl Zeiss Meditec Inc., Dublin, CA, USA) demonstrating greater epithelial regularity in the left eye (red circle). Both the SN-IT index and the S-I index show greater symmetry of the epithelial thickness in the central 5 mm of the left eye when compared to the untreated right eye



**Figure 2:** (a) Preoperative corneal HOA map of OS showing 1.815 μm of corneal coma and 0.023 μm of spherical aberration. (b) Postoperative corneal HOA map of OS showing 1.279 μm of corneal coma and 0.144 μm of spherical aberration. Both obtained through a Corneal Aberrometer (SCHWIND Corneal Wavefront Analyzer, SCHWIND eye-tech-solutions, Kleinostheim, Germany)

**Conclusion**

The present case demonstrates that it is possible to rehabilitate a patient with stable keratoconus and high ametropia by combining ICRS, tPRK, and phakic lens implantation. Thus, we believe that “Trioptics” is a viable option for patients with keratoconus, who are dissatisfied with their CDVA and unhappy with or intolerant to CL.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Ferreira TB, Guell JL, Manero F. Combined intracorneal ring segments and iris-fixated phakic intraocular lens for keratoconus refractive and visual improvement. *J Refract Surg* 2014;30:336-41.
2. Coskunseven E, Jankov MR 2<sup>nd</sup>, Grentzelos MA, Plaka AD, Limnopoulou AN, Kymionis GD. Topography-guided transepithelial PRK after intracorneal ring segments implantation and corneal collagen CXL in a three-step procedure for keratoconus. *J Refract Surg* 2013;29:54-8.
3. Al-Tuwairqi WS, Osuagwu UL, Razzouk H, Ogbuehi KC. One-year clinical outcomes of a two-step surgical management for keratoconus-topography-guided photorefractive keratectomy/cross-linking after intrastromal corneal ring implantation. *Eye Contact Lens* 2015;41:359-66.
4. Tognon T, Campos M, Wengrzynowski JP, Barella KA, Pasqualotti A, de Brito Martins LA, et al. Indications and visual outcomes of intrastromal corneal ring segment implantation in a large patient series. *Clinics (Sao Paulo)* 2017;72:370-7.
5. Coskunseven E, Sharma DP, Grentzelos MA, Sahin O, Kymionis GD, Pallikaris I. Four-stage procedure for keratoconus: ICRS implantation, corneal cross-linking, Toric phakic intraocular lens implantation, and topography-guided photorefractive keratectomy. *J Refract Surg* 2017;33:683-9.
6. Bilgihan K, Ozdek SC, Konuk O, Akata F, Hasanreisoglu B. Results

- of photorefractive keratectomy in keratoconus suspects at 4 years. *J Refract Surg* 2000;16:438-43.
7. Guedj M, Saad A, Audureau E, Gatinel D. Photorefractive keratectomy in patients with suspected keratoconus: Five-year follow-up. *J Cataract Refract Surg* 2013;39:66-73.
  8. Chelala E, Rami HE, Dirani A, Fadlallah A, Fakhoury O, Warrak E. Photorefractive keratectomy in patients with mild to moderate stable keratoconus: A five-year prospective follow-up study. *Clin Ophthalmol* 2013;7:1923-8.
  9. Khakshoor H, Razavi F, Eslampour A, Omdtabrizi A. Photorefractive keratectomy in mild to moderate keratoconus: Outcomes in over 40-year-old patients. *Indian J Ophthalmol* 2015;63:157-61.
  10. Kasparova EA, Kasparov AA. Six-year experience with excimer laser surgery for primary keratoconus in Russia. *J Refract Surg* 2003;19 (2 Suppl):S250-4.
  11. Kremer I, Aizenman I, Lichter H, Shayer S, Levinger S. Simultaneous wavefront-guided photorefractive keratectomy and corneal collagen crosslinking after intrastromal corneal ring segment implantation for keratoconus. *J Cataract Refract Surg* 2012;38:1802-7.
-