Case Report

Corneal Ectasia after Laser-Assisted Small-Incision Lenticule Extraction: The Case for an Enhanced Ectasia Risk Assessment

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Abstract

Purpose: To present a case of asymmetric progressive corneal ectasia following femtosecond laser-assisted small-incision lenticule extraction.

Methods: After obtaining a patient's consent, preoperative and postoperative findings were represented in this case report.

Results: A 29-year-old woman presented with normal preoperative Placido disk-based corneal topography and tomographic findings. The corrected refractive error was −4.00 and −4.50 −1.00 × 177 in the right and left eye, respectively, with a maximal lenticule thickness of 87 and 115 μm OD/OS. Twenty months postoperatively, the patient presented with decreased vision in the left eye and mild ectatic changes in corneal shape in both eyes. The retrospective evaluation of the integrated rotating Scheimpflug tomography (Pentacam; Oculus, Wetzlar, Germany) and corneal biomechanical (Corvis ST) assessment revealed moderate susceptibility for corneal ectasia in the right eye and a significant corneal ectasia in the left eye.

Conclusion: This case corroborates the need for an enhanced multimodal approach to characterize the risk for postoperative corneal ectasia after laser vision correction.

Keywords: Biomechanics, Corneal ectasia, Small-incision lenticule extraction

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Submitted: 01-Mar-2022; **Revised:** 26-Mar-2022; **Accepted:** 05-Apr-2022; **Published:** 30-Nov-2022

Introduction

Excellent safety and efficacy have been reported for the small-incision lenticule extraction (SMILE) technique as a flapless procedure.[1] Although the SMILE procedure may theoretically reduce the risk of corneal ectasia, it is not eliminated due to corneal alterations by tissue removal and biomechanical weakening of the cornea.[2,3] This report describes a case of asymmetric progressive corneal ectasia following femtosecond laser-assisted SMILE.

Access this article online

Quick Response Code:

Website: www.jcurrophthalmol.org

DOI: 10.4103/joco.joco_79_22

Case Report

A 29-year-old woman seeking refractive surgery presented in our clinic in 2019. Baseline refractive characteristics are presented in Table 1. An informed consent was obtained from the patient. The patient had no ocular disease and no family history of keratoconus. The corrected distance visual acuity (CDVA) was 20/20 in both eyes. A full ophthalmologic assessment and diagnostic imaging including Placido

How to cite this article: Zarei-Ghanavati S, Hassanzadeh S, Ambrósio Jr R. Corneal ectasia after laser-assisted small-incision lenticule extraction: The case for an enhanced ectasia risk assessment. J Curr Ophthalmol 2022;34:357-63.

disk-based topography (TMS-4N, Tomey Corp.), tomography using Pentacam HR (Oculus; Wetzlar, Germany), and corneal biomechanical assessment by Corvis ST was performed preoperatively.

Preoperative topography-based keratometry was 45.54 @1°/46.84 @91° diopters (D) in the right eye and 45.75 @3°/47.69 @93°D in the left eye. The cornea in both eyes was steep, but there was no SRAX or significant inferior steepening. The surface asymmetry index was abnormal in the right eye (1.67). No keratoconus pattern was detected by Klyce/Maeda and Smolek/Klyce classifications [Figure 1]. Pentacam imaging showed no significant abnormal finding. The ART-Max was 350/355 µm for OD/OS. In Belin/Ambrósio enhanced ectasia map, the average progression index was borderline in both eyes (1.16 and 1.19 for the right and left eye). As a result, a borderline thickness distribution map and Belin/Ambrósio deviation of 2.02 D in the right eye and 2.09 D in the left eye was found [Figure 2]. In KC/staging map, no abnormal indices were found for both eyes. The thinnest corneal thickness was 513 and 514 µm in the right and left eye. Preoperative anterior/posterior elevation was +3/+11 µm OD and +6/+11 µm OS, which were in the normal range [Figure 2]. In the Corvis biomechanical/tomographic assessment map, four Corvis ST indices (DA ratio, ARTh, stiffness parameter

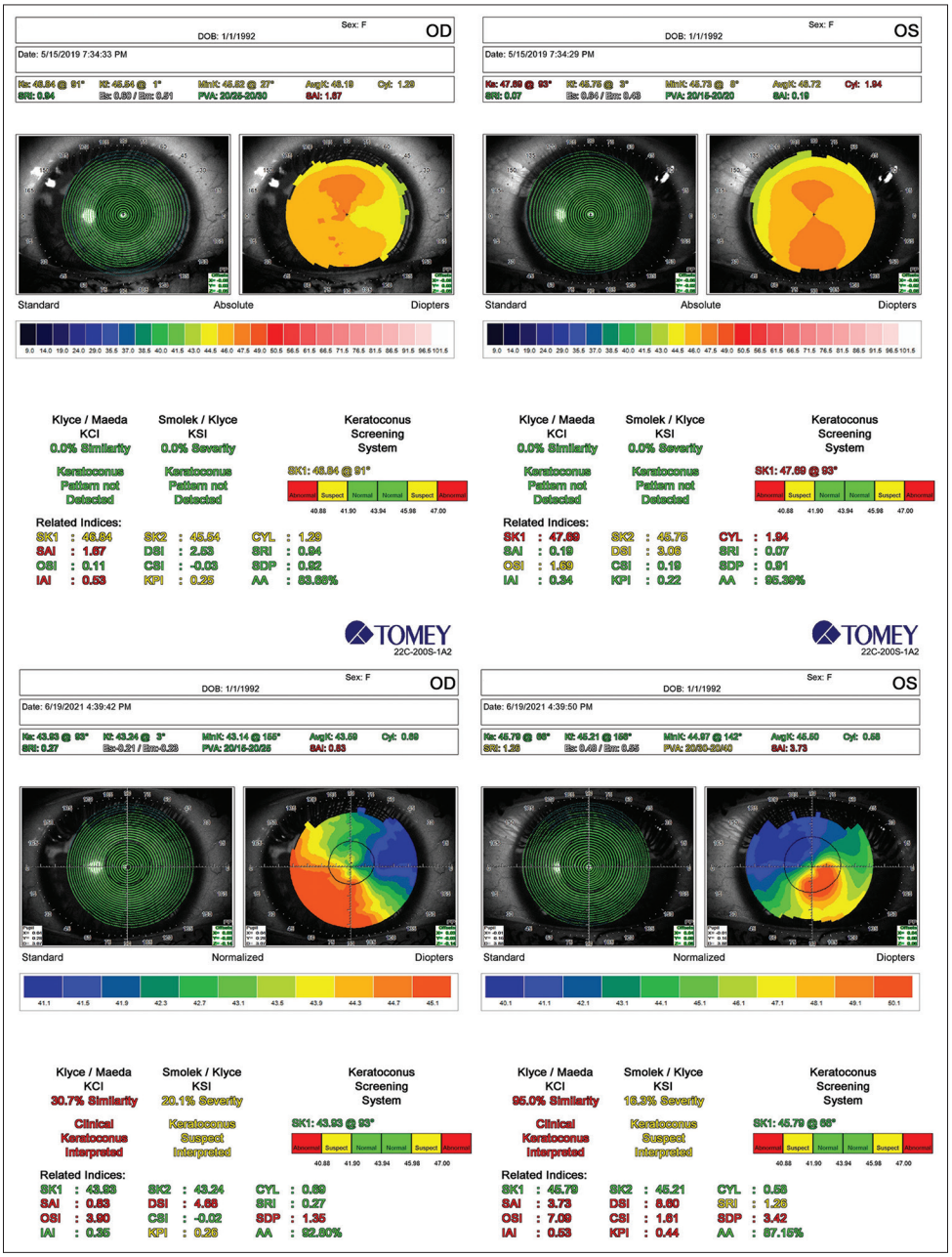

Figure 1: Preoperative (top) and 20 months postoperative (bottom) Placido disk-based topography images with keratoconus screening indices. Figure shows normal preoperative topographic findings in both eyes

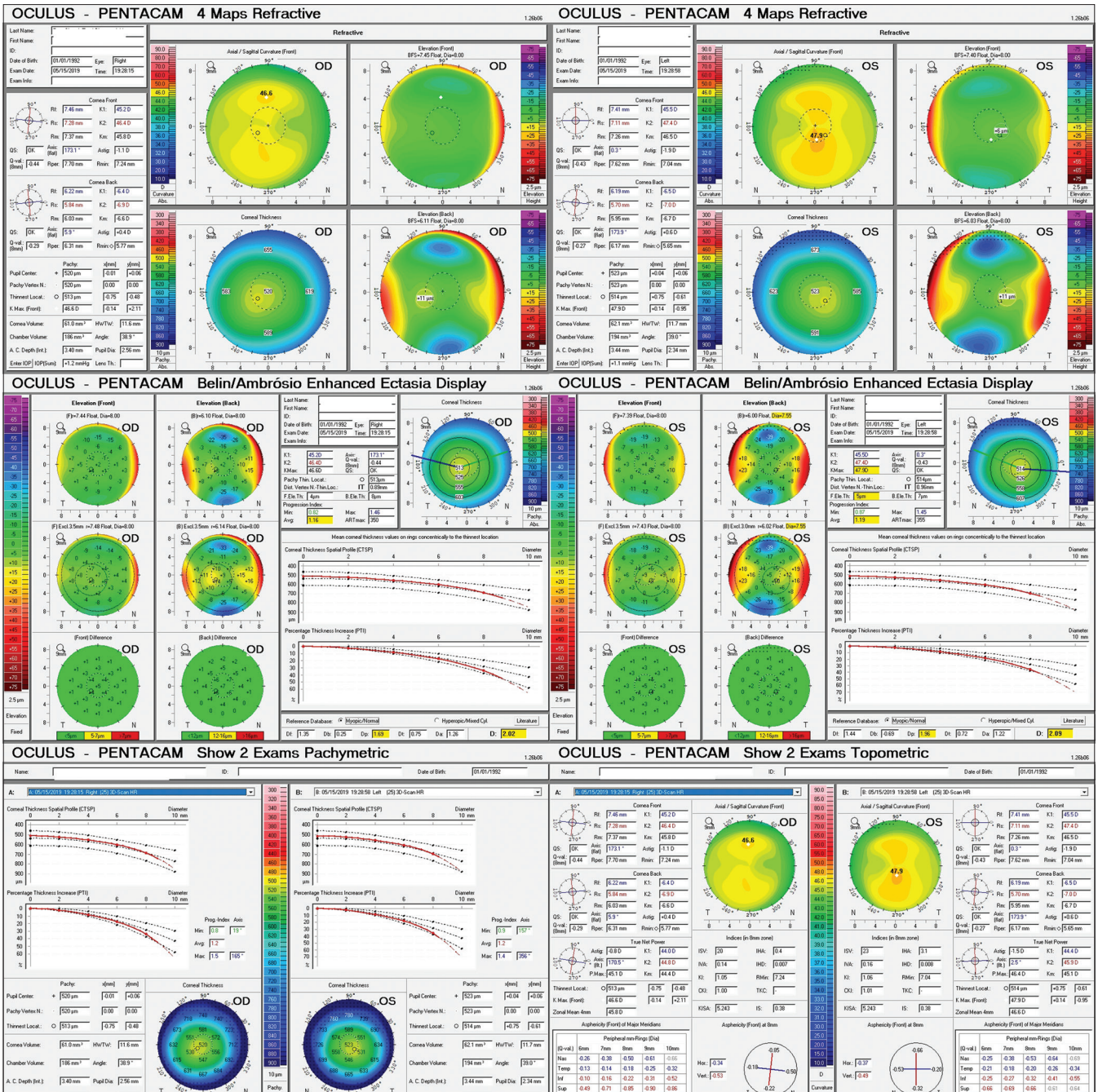

Figure 2: Preoperative tomography displays of Pentacam HR in the right and left eye do not show significant abnormalities

A1, and integrated radius) were borderline and in the overlap zone of the normal–abnormal area in both eyes. The corneal biomechanical index (CBI) was abnormal (more than 0.50) in both eyes. However, the tomographic biomechanical index (TBI) was in the normal range (0.20 in the right eye and 0.33 in the left eye). Furthermore, the Pentacam Random Forest Index was normal in both eyes (0.07 and 0.23) [Figure 3].

The patient had no other abnormality in terms of review of the system concerning sleep apnea, obesity, eye rubbing habit, allergies, etc., and was considered a low risk, suitable candidate for SMILE procedure using VisuMax femtosecond laser system (Carl Zeiss Meditec AG, Germany). The surgery was uneventful. Table 1 shows surgical characteristics.

Examinations were normal in 1-week, 1-month, 3-month, and 1-year follow-ups. After 20 months, the patients presented with decreased vision in the left eye (CDVA: 20/30). Imaging revealed corneal ectasia in the left eye and mild ectasia in the right eye. The ART-Max was 169 and 120 μm for the right and left eye, respectively. Post-laser vision correction CBI and

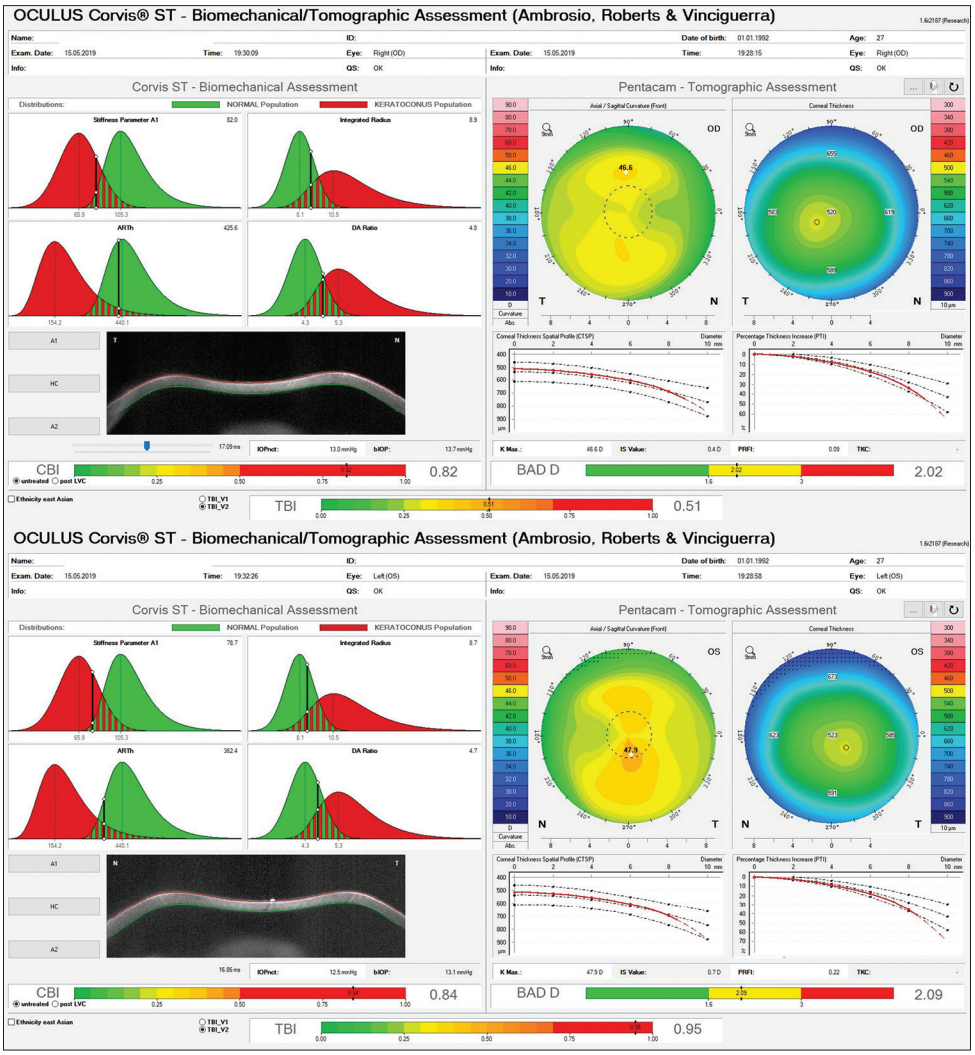

Figure 3: Preoperative Corvis biomechanical properties of the right and left eye. Figure shows abnormal tomographic biomechanical index and corneal biomechanical index in the left eye

Table 1: Preoperative and postoperative characteristics of the patient and small-incision lenticule extraction surgical parameters

	Preoperative		Postoperative	
	OD	OS	OD	OS
Manifest refraction	-3.75	-3.75-1.00 X 177	-0.25	-1.25-1.00 X 101
UCVA	20/60	20/100	20/20	20/32
CDVA	20/20	20/20	20/20	20/30
Attempted refractive correction	-4.00	-4.50-1.00 X177	-	-
Cap diameter (mm)	7.80	7.80	-	-
Cap thickness (μm)	140	140	-	-
Optical zone	6.80	6.80	-	-
Lenticule thickness max (μm)	87	115	-	-
IOP (mmHg)	11	11	11	13
bIOP (mmHg)	13.7	13.1	13.1	13

UCVA: Uncorrected visual acuity, CDVA: Corrected distance visual acuity, IOP: Intraocular pressure, bIOP: Biomechanically-corrected IOP

the subtraction tomographic maps showed significant ectasia in the left eye [Figures 4-6]. Posterior elevation and best fit sphere 8-mm diameter considered the same reference for post- and preoperative calculation. Postoperative anterior/posterior elevation was +11/+8 μm in the right eye and +13/+25 μm in the left eye.

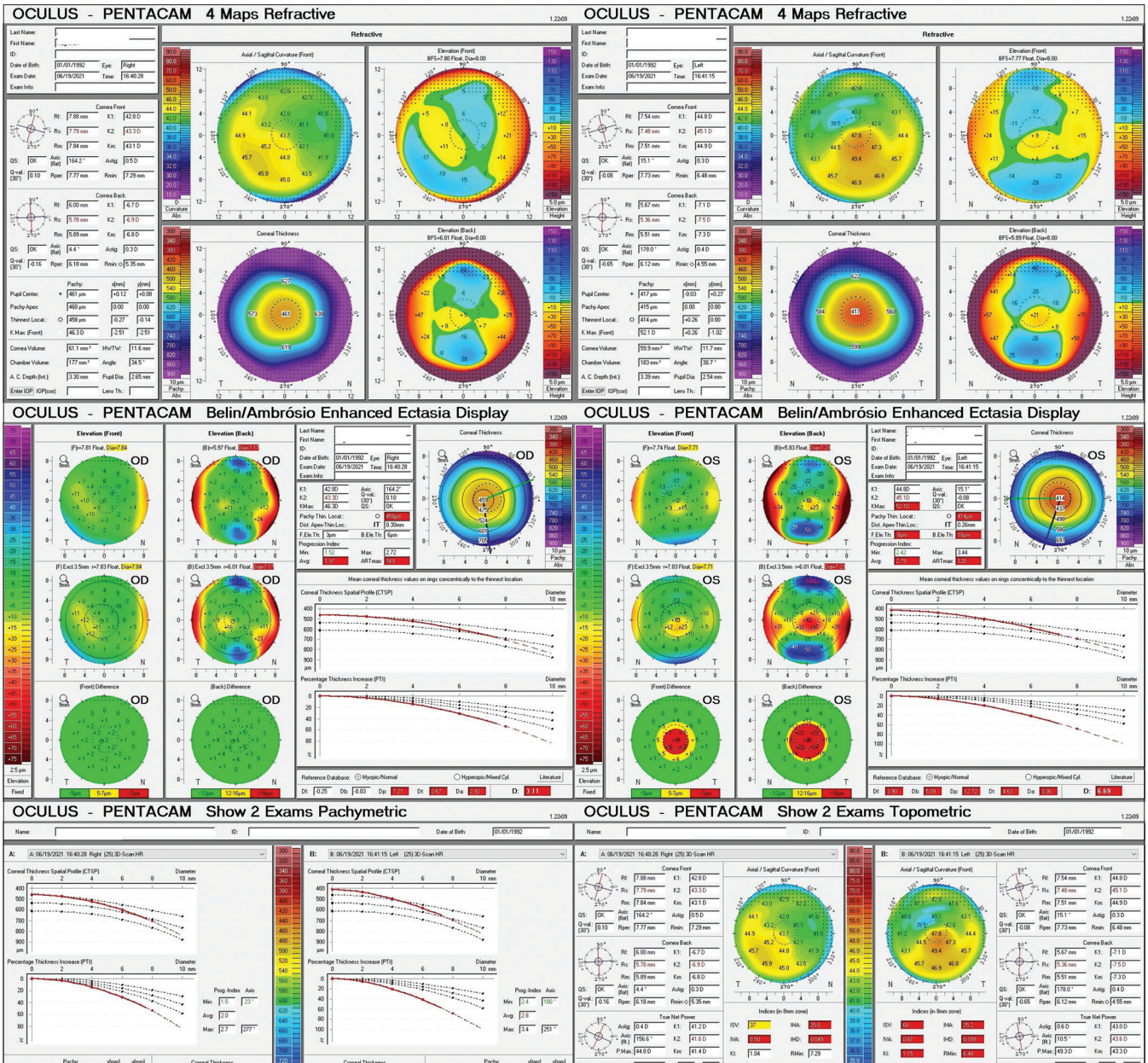

Figure 4: Postoperative tomography displays abnormal Pentacam parameters in the right and especially left eye

Corneal collagen cross-linking was performed on the left eye to arrest more ectasia progression, and the right eye was followed. The patient's consent was obtained to report her findings as a case representation.

Discussion

Histological studies on the ultrastructure of corneal stroma show that the collagen fibers network is denser in the anterior stroma. This unique geometry is responsible for stiffer biomechanical properties in the anterior part of the cornea.[4] In the SMILE procedure, the lenticule is extracted from within the stroma, and the anterior stroma remains intact. Randleman *et al*.[3] showed that the posterior 60% of the stroma is 50% weaker than the anterior 40% of the corneal stroma. A mathematical model created by Reinstein *et al*.[2] derived from depth-dependent stromal tensile strength data. This model theoretically showed that the SMILE procedure might leave the corneal with greater tensile strength than photorefractive keratectomy or laser *in situ* keratomileusis (LASIK) procedures.

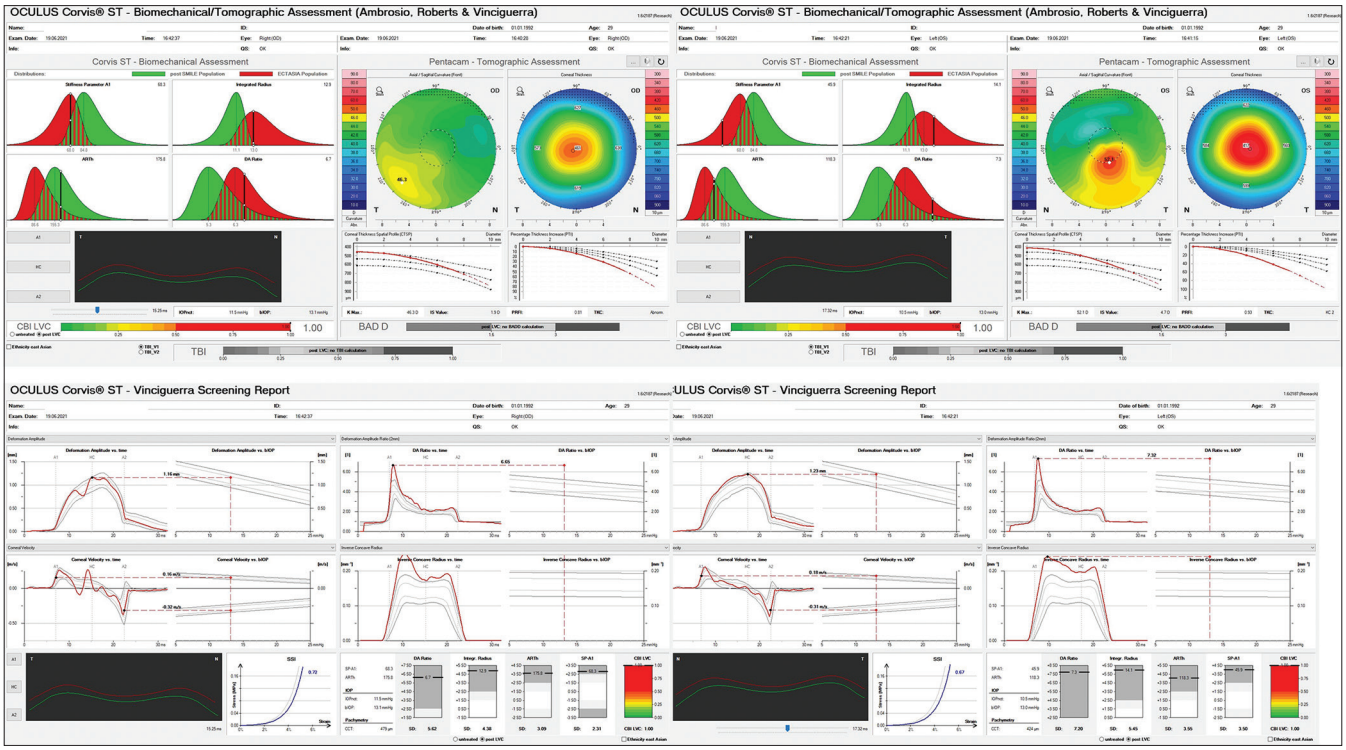

Figure 5: Twenty months postoperatively, Corvis biomechanical properties of the right and left eye

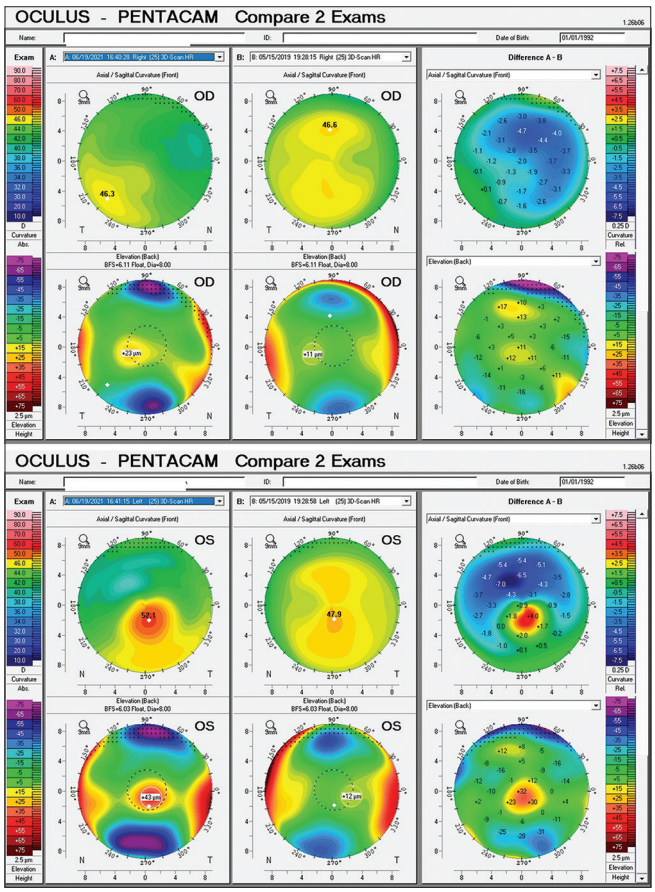

Figure 6: Tomographic subtraction maps of pre/postoperative data shows a significant postoperative corneal ectasia in the left eye

Excellent safety and efficacy have been reported to be achievable with SMILE as a flapless procedure.[5] Although the SMILE procedure may theoretically reduce the risk of corneal ectasia, it is not eliminated due to corneal alterations by tissue removal and biomechanical weakening of the cornea. Postoperative ectasia can be an inherent risk associated with the SMILE technique. Among all SMILE surgeries which have been performed worldwide, a few postoperative ectasia cases have been reported.[1,6-9] Although most of these cases occurred in patients with preoperative subclinical keratoconus or with an underlying corneal pathology,[10] rare cases with normal preoperative topography have been reported in the literature.[1,7] Moshirfar *et al*.[10] in their review of ectasia cases following the SMILE procedure, stated that abnormal topography might not be the only risk factor for postoperative corneal ectasia progression. They also evaluated four cases of post-SMILE ectasia using calculated percent tissue altered (PTA) as an ectasia risk assessment factor and introduced a modified PTA (mPTA) formula for SMILE cases. According to the traditional formula, the PTA of our patients' right and left eyes was 43.6% and 48.7%, which were more than the cut-off point of 40%. Moshirfar *et al*.[10] modified the PTA formula based on the weakening effect of SMILE vertical side cuts on the corneal structure and showed inaccuracy of traditional PTA formula for SMILE cases.[10] Based on the mPTA formula, the left eye of our patients was at high risk for SMILE surgery (more than 20%). Nevertheless, based on the PTA and mPTA formulae, increasing cap thickness increases the PTA and the ectasia risk. This is against the theory of saving the stronger

anterior cornea by using thicker caps. In other words, in the SMILE procedure, we can change the cap thickness from 110 μm to 140 μm to preserve the biomechanical properties of the anterior cornea without altering the visual outcome.[11-14] Still, it seems that the PTA formula needs further improvement for expressing the impact of the SMILE procedure, considering the positive effect of increasing cap thickness on corneal biomechanical properties, which is different from flap thickness in LASIK. However, in SMILE surgery, like other refractive surgery techniques, minimizing tissue removal is very important to lessen tissue alterations and lessen postoperative corneal biomechanical changes.

Today, preoperative detection of the mild and subclinical form of corneal ectasia has evolved to the characterization of ectasia susceptibility using a combination of tomographic–biomechanical diagnostic data. However, our case shows that post-SMILE corneal ectasia may happen, despite preoperative normal imaging, low refractive error correction, and considering a flap thickness of 140 μm for preserving anterior stroma. Future studies incorporating artificial intelligence and improving algorithms will detect very mild and susceptible ectasia diseases before refractive surgeries.[15,16] Furthermore, data from patients with preoperative normal cornea who had corneal ectasia after laser vision correction procedures on the cornea, is helpful for developing more accurate ectasia risk assessment strategies.

Declaration of patient consent

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

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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