A 37-year-old woman was referred for refractive surgery evaluation. She has no ocular or medical history and no allergies. She occasionally wears contact lenses but does not tolerate them well. Spectacle dependence is her chief complaint. The corrected visual acuity for near and distance is 20/20 in both eyes. The manifest refraction is $-4.50 -1.75 \times 166$ in the right eye and $-3.75 -2.75 \times 8$ in the left eye. The slitlamp examination and the fundus retinoscopy showed no anomalies. The intraocular pressure is 13 mm Hg in the right eye and 16 mm Hg in the left eye.

Corneal topography was performed (Orbscan II, Bausch & Lomb); Figure 1 shows the maps. The corneal pachymetry is 531 $\mu$m in the right eye and 548 $\mu$m in the left eye.

Corneal hysteresis (CH) and the corneal resistance factor (CRF) were recorded using biomechanical waveform analysis (Ocular Response Analyzer, Reichert, Inc.). Figure 2 shows the curves.

What kind of refractive surgery (if any) would you recommend to this patient? What are the most important criteria in helping you make your decision? Would you perform refractive surgery if the patient were 22 years old instead of 37 years old?

Corneal ectasia is the most sight-threatening complication that can occur after laser in situ keratomileusis (LASIK). Thus, the main concern of refractive surgeons is to detect patients at risk for post-LASIK corneal ectasia.1 Keratoconus is a progressive, noninflammatory, localized thinning and elevation of the cornea that stabilizes after the age of 35 to 40 years. The diagnosis of keratoconus at advanced stages is made on the basis of a combination of clinical and corneal topographic signs. Corneas that share similarities

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**Figure 1.** Preoperative corneal topography (BFS = best-fit sphere).
with ectatic corneas (keratoconus or pellucid marginal corneal degeneration) are at higher risk for post-LASIK ectasia.

In this case, the patient is 37 years old, meaning that the shape of her cornea is probably stable and will not change over time. The corneal central thickness is normal in both eyes, and the thinnest point shown on Orbscan II maps is not decentered nasally. However, there is a significant difference in central pachymetry (16 μm) between the right eye and left eye, which we have reported as being a plausible risk factor for ectasia.2 The anterior elevation map shows an island pattern with normal keratometry readings in both eyes, and the posterior elevation map shows a relatively regular ridge pattern in both eyes. Inspection of the pachymetry maps with the Orbscan device would be interesting to eliminate the presence of a more rapid thinning progression toward the center in the right eye. Placido-derived curvature maps are not shown; however, the presence of any inferior/superior asymmetry would reinforce the suspicion of ectasia susceptibility.

Atopy, eye rubbing, and a family history of keratoconus are known risk factors for keratoconus. Regarding the medical history of this patient, it would have been interesting to know whether the patient has allergies, asthma, or atopy conditions. A family history of keratoconus would also be an element to check.

The Ocular Response Analyzer data shows decreased CH and CRF values, which indicate an abnormal cornea response to air pulse. In particular, the CRF values are clearly inferior to the CH values, which in our experience may indicate the presence of compromised corneal biomechanics. There is a marked reduction in the height of the peaks in the left eye compared with that in the right eye. These criteria have been described in keratoconus, supporting photorefractive keratectomy (PRK) instead of LASIK in patients with altered Ocular Response Analyzer curve profiles.2,3

Due to the difference in central pachymetry and Ocular Response Analyzer values and curve profiles, we would avoid performing LASIK in this case. We would perform PRK if the patient cannot tolerate contact lenses. If the patient were 22 years old, we would not perform corneal refractive surgery, neither LASIK nor PRK, and would follow her at 6 months and then at 1 year to monitor for corneal topography changes.

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This case illustrates the challenge refractive surgeons routinely face in identifying and properly addressing cases at risk for keratectasia.1
This is a 37-year-old contact-lens-intolerant woman with myopic astigmatism and an unremarkably normal eye examination. Considering that tear-film dysfunction is a leading cause of contact lens intolerance, it would be relevant to further examine the tear breakup time and perform ocular staining with trypan blue.

Orbscan II data are available (Figure 1), including axial curvature topography from the Placido-disk reflection and tomographic thickness and front and back elevation maps derived from horizontal slit scanning. It is critical to consider the contact lens history, determining which type of lens was used and when it was discontinued before the examination. The curvature maps are displayed with automatic 0.25 D scales, which augments color variability and thereby the sensitivity to detect irregularities. In such an approach, there is an adjustment on the color scale that is calculated for every examined cornea according to the keratometric values. This has produced slightly different scales between the right eye and left eye in this case. Both eyes have an asymmetric bowtie pattern with mild inferior steepening. The highest curvature reading in the image is 47.2 diopters (D) in the right eye and 47.8 D in the left eye. Central corneal pachymetry is 531 μm and 548 μm, respectively. It seems as though there is a relatively abrupt increase in thickness from the center outward in the left eye. Calculation of thickness profile graphs, as described from Orbscan data by Luz et al., would be of interest because this was shown to enhance the ability to detect ectasia patterns in subclinical keratoconus. The front and back elevation maps are relatively normal in both eyes.

Ocular Response Analyzer data are also available (Figure 2). The waveform signal is relatively low in the left eye, and there is a significant oscillation after the second applanation peak in both eyes. Both findings are consistent with relatively weak corneas. Corneal hysteresis and the CRF are lower than the cutoffs for detecting keratoconus in both eyes, according to studies by Fontes et al. that compared keratoconic corneas with healthy thin corneas (CH 8.95 mm Hg; CRF 7.4 mm Hg).

I would be interested to evaluate Scheimpflug-based tomography and dynamic ultra-fast-speed biomechanical assessment. However, these findings are consistent with weak corneas, with the left eye more affected than the right eye. This is related to a higher susceptibility for ectasia progression, which may also be referred to as subclinical or forme fruste keratoconus.

Considering the patient is older than 27 years and that there is a history of refractive stability, I would consider this patient to be a candidate for custom advanced surface ablation. Topography-guided custom ablations would be indicated; however, wavefront-guided ablations could also be considered if a reliable ocular aberrometry examination were available. If the same presentation were to occur in a 22-year-old patient, I would advise documenting tomographic and biomechanical stability before proceeding with keratorefractive surgery.

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“Primum non nocere” should be our guiding principle when assessing for refractive surgery.
At first glance, the topography and biomechanical parameter patterns are normal. But, is it really so? To obtain the right answer, we must meticulously assess the small details.

1. The anterior float shows mild inferotemporal displacement of a cone-like elevation. The maximum anterior elevation is within normal limits in both eyes. However, the anterior elevation ratio is low in both eyes (0.33 right eye; 0.44 left eye), a finding very specific to keratoconic eyes.\(^1\)

2. The posterior float shows the maximum posterior elevation of 35 μm in the right eye and 30 μm in the left eye. Both are higher than would be expected in a healthy eye and very characteristic of keratoconus.\(^2\) The best-fit sphere (BFS) is also increased and suspicious for keratoconus (57.1 D right eye; 57.2 D left eye).

3. The corneal thickness is rather normal in both eyes, without displacement of the thinnest point.

4. The mean simulated keratometry values in both eyes are much higher than the reported normal 43.6 D (46.3 D right eye; 46.9 D left eye), further increasing our suspicions.\(^3\)

5. The irregularity indices in the 3.0 mm zone, and especially in the 5.0 mm zone, are borderline in the right eye and increased in the left eye.

6. The Ocular Response Analyzer presents graphs with normal pattern in the right eye but abnormally low amplitude signals in the left eye. The calculated mean CH is pathologically low in both eyes (7.7 mm Hg right eye; 6.6 mm Hg left eye) and typical of keratoconus.\(^3\)

7. The anterior chamber depth from endothelium is within normal limits in both eyes.

8. The irregular dilated left pupil requires additional clinical assessment.

Summarizing the above, I think laser refractive surgery is contraindicated for this patient. Intraocular lens–based refractive surgery is the preferred option. Whether it will be refractive lens exchange or phakic intraocular lens implantation depends on the endothelial cell assessment and then on the patient's preferences, considering her pre-presbyopic age.

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The scanning-slit elevation tomography seems normal. Although the asymmetric bowtie with inferior steepening is a concern, it is probably the result of selecting a low scale interval. Use of a sensitive, automated scale mode is sometimes misleading. The keratometric map of Orbscan II is Placido based. However, I would prefer to recheck it with another Placido-based topographer to obtain more valuable, conclusive data, especially in a borderline case. Regarding the other Orbscan II maps, the results are within normal limits. The posterior BFS is mildly steep (>55.0 D); however, the maximum elevation difference is less than 50 μm in both eyes. This pattern (including a mildly steep cornea with inferior steepening and borderline posterior elevation) is common in relatively small corneas, similar to this case (white to white = 11.0 mm).

The Ocular Response Analyzer result is a main concern. The low signal quality score indicates low reliability of the test; however, a low score is common in keratoconic patients. The CH and CRF values are below the normal (<5th percentile); however, studies report that some normal individuals have similarly low values.\(^1\) In addition, although eyes with subclinical and clinical keratoconus have significantly lower CH and CRF values, a large overlap exists between normal and keratoconic eyes.\(^2-4\)

The Ocular Response Analyzer waveform is also important. Asymmetry and lack of a sharp rise in the second peak are more common in pathologic corneas. New software (version 2) allows quantitative evaluation of the waveform, which might help distinguish different pathologies. However, our previous study\(^3\) showed that the Ocular Response Analyzer parameters are affected by several confounding factors (eg, central corneal thickness, keratometry, corneal irregularity).

 Debates exist on the sensitivity and specificity of Ocular Response Analyzer measurements.\(^5-7\) For example; it offers very low sensitivity and specificity for discriminating healthy thin corneas from keratoconic corneas.\(^5\) In addition, studies\(^6,7\) have shown that the Ocular Response Analyzer is not sensitive enough to detect an improvement in cornea biomechanics after collagen crosslinking.

In this case, I would recheck all measurements carefully and evaluate the patient using the Pentacam device (Oculus). If the Ocular Response Analyzer
results were the same and other measurements within normal limits, I would recommend surface ablation. I do not consider the low Ocular Response Analyzer parameters to be contraindications to PRK for a 37-year-old patient. If the patient were 22 years old, I would follow her for at least 6 to 12 months and reevaluate all the tests. I would prefer to be more conservative in a 22-year-old patient with the CH and CRF outside the 2 standard deviation range for the normal population.

In general, I think the agreement between the paraclinical tests and age is important in making a decision. I expect to see other alarming clinical or paraclinical signs for keratorefractive surgery in a 37-year-old patient in addition to the low CH and CRF values (if they truly are indicators of corneal biomechanics).

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