

Refractive Surgery Dilemma

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CASE PRESENTATION

A 33-year-old man seeking refractive surgery presented with refractive error of -1.75 $-4.0 \times 20^\circ$ in the right and -0.75 $-2.5 \times 170^\circ$ in his left eye in January 2009; best spectacle-corrected visual acuity (BSCVA) was 20/25+ and 20/20- respectively. All ocular examinations were unremarkable and family history for keratoconus was negative. He had previously obtained consultation for refractive surgery in 2000; at that time, intervention had been withheld due

to unspecified concerns. Previous refractive data was not available except for an Orbscan printout. Due to presence of asymmetric astigmatism, abnormalities on repeat Orbscan examination, and patient's interest in wavefront-guided (WFG) ablation, aberrometry (Zywave II, Bausch and Lomb, Rochester, USA) was obtained. Orbscan and Zywave printouts are shown in figures 1 through 3. Herein, we present the views of three experienced refractive surgeons in the approach to excimer surgery in this particular case.

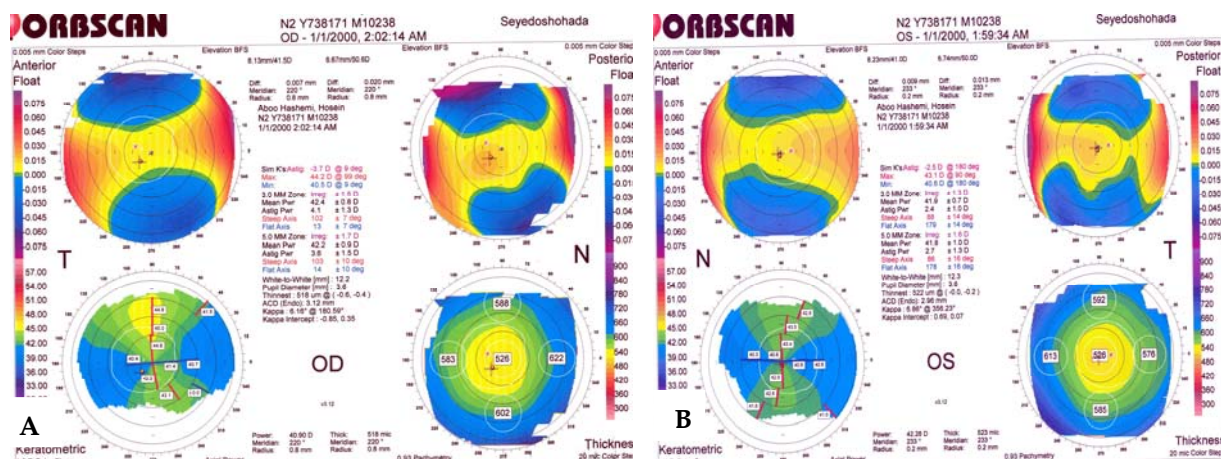


Figure 1 Orbscan printouts for the right (A) and left (B) eyes obtained in 2000.

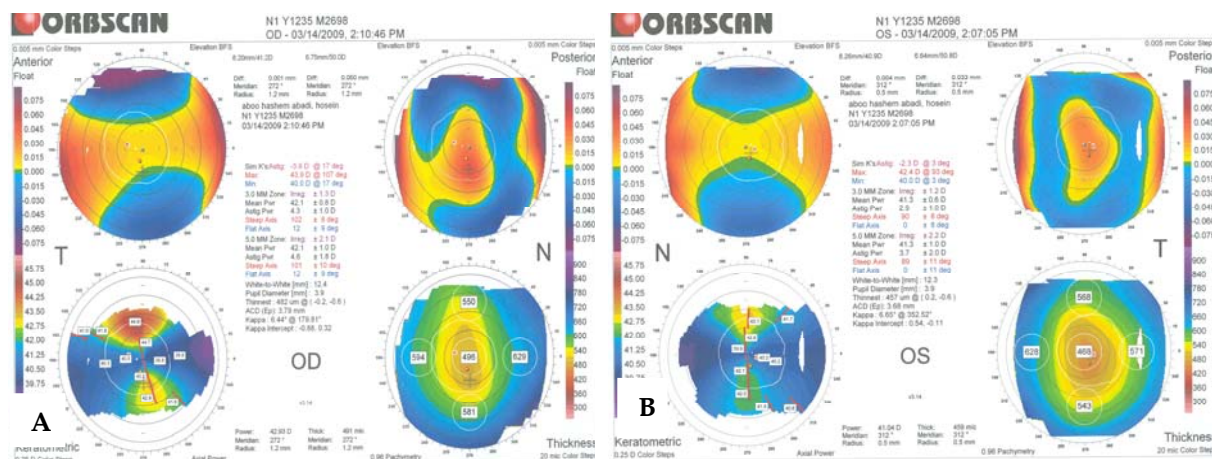


Figure 2 Orbscan printouts for the right (A) and left (B) eyes obtained in 2009.

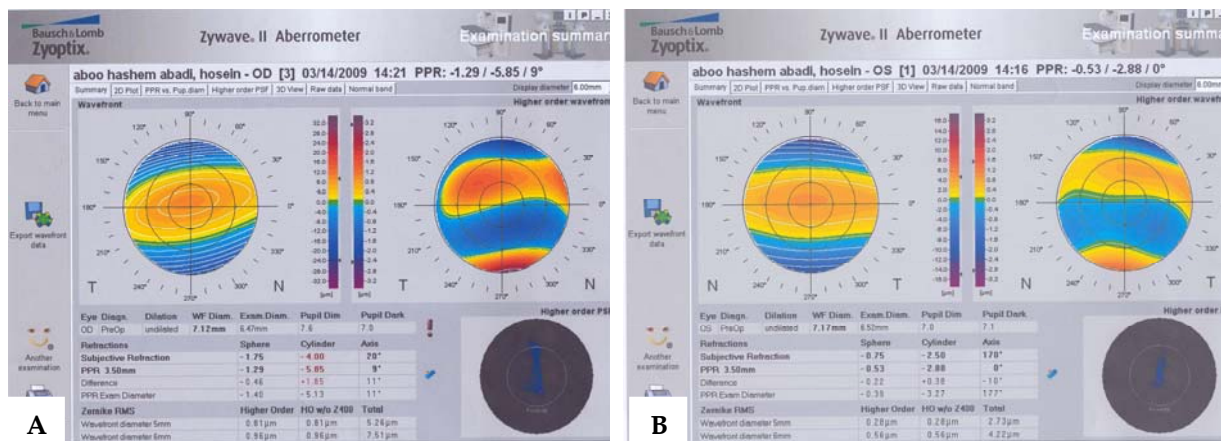


Figure 3 Wavefront printouts for the right (A) and left (B) eyes obtained in 2009.

Farid Karimian, MD

This 33-year-old man has highly asymmetric with-the-rule myopic astigmatism and 2 different Orbscan printouts 9 years apart. Dioptric axial keratometric steps in the first Orbscan (in 2000) had been 1 diopter (D) which is too large to reveal minor corneal changes. On the other hand, keratometric steps in the second Orbscan (in 2009) are 0.25 D which can exaggerate small corneal details and lead to an over-diagnosis of keratoconus. If the corneas are clear on examination and there is no history of rigid gas-permeable contact lens wear, superior steepening and asymmetric bow-tie pattern in both eyes might be a normal finding. These findings are noteworthy in the light that the patient has had stable refraction during this period. In 2009, posterior float elevation maps in both eyes show significant difference between the steepest point and best-fitted sphere. High posterior elevation in the right eye (50 microns) can be explained by the presence of high with-the-rule astigmatism; under these circumstances, the posterior corneal surface is artifactually shown steep which is one of the drawbacks of Orbscan. In 2000, the amount of corneal astigmatism based on Sim K had been 3.7 D and 2.5 D in the right and left eyes, respectively. Placido-based keratometric and refractive astigmatism are in accordance with each other and comparable on the Orbscan examinations. However, one should keep in mind that since different machines and dissimilar acoustic factors have been used, it is difficult to compare

the maps. Corneal irregularities in the 3 mm zone in both corneas are borderline which is not an important finding due to normality of other findings. In 2000, the thinnest corneal points had been 518 and 522 microns in the right and left eyes, respectively. Pachymetric maps in both eyes show 40-50 microns decrease in corneal thickness in 2009 which is not reliable because different acoustic factors have been employed in the first and second Orbscan machines (0.93 and 0.96, respectively).

Zywave II aberrometry maps show significant increase in higher order aberrations, particularly vertical coma. Wavefront root mean squares (RMS) for 5 and 6 mm pupil sizes are 0.81 and 0.96 microns and 0.28 and 0.56 microns in the right and left eyes, respectively. These figures, especially in the right eye, are higher than normal (0.25 to 0.3 microns). Correcting the effect of spherical aberration (Z400) does not change these figures; this means that correcting the spherical aberration of the optical system alone will not affect higher order aberrations and may lead to symptoms such as glare and ghost images following refractive surgery thereby reflecting the necessity of customized ablative correction of these aberrations.

Further evaluation using ultrasonic pachymetry and machines employing Scheimpflug cameras (e.g. Pentacam and Gallilei) are recommended. Since refractive error has been stable during this nine-year period, provided that contact lens-induced corneal warpage is excluded and corneal thickness and elevation

problems are ruled out, wave-front guided customized ablation may be recommended after explaining the potential complications and outcomes of laser refractive surgery to the patient.

Mohammad-Ali Javadi, MD

The described patient has asymmetric compound myopic astigmatism. BSCVA in the right and left eyes are 20/25+ and 20/20- which may be due to mild degrees of amblyopia secondary to high astigmatism. On Orbscan images in 2000, refractive and topographic astigmatism are the same and demonstrate enantiomorphism, axial topographic maps show asymmetric bow-tie pattern and pachymetric maps reveal round central patterns. Although superior steepening may be a normal topographic finding in eyes with asymmetric bow-tie pattern, it may also be observed with contact lens induced warpage, superior keratoconus and superior corneal disorders. Taking a thorough ocular history and a careful slitlamp examination might be helpful in establishing the possible diagnosis. Axial topographic patterns are actually the same after 9 years, with hotter colors in 2009 due to closer topographic steps (1 D versus 0.25 D). However, raw corneal curvature figures are the same and topographic astigmatism has basically remained unchanged. All Orbscan indices are roughly within normal limits, posterior and anterior float maps show complete ridges with enantiomorphism and topographic skews are less than 20 degrees. However, it seems that over these 9 years, posterior corneal curvature has increased and the corneas have become thinner in both eyes. Despite the fact that anterior and posterior best-fitted spheres are similar in the maps of 2000 and 2009, posterior elevation has increased from 20 to 50 and from 13 to 33 microns in the right and left eyes, respectively. The corneas had been relatively thin in 2000 and have become thinner in 2009 (from 518 to 482 and from 522 to 457 microns, in the right and left eyes, respectively). Difference in thickness between the center of the cornea and the 7 mm zone is more than 100 microns in both eyes. The pattern of pachymetric maps in both eyes has changed from central round to vertical oval

which is suggestive of a true change in corneal shape. It is notable that Orbscan maps have been obtained at 2 different centers with 2 different machines using different acoustic factors; all of these factors make meaningful comparisons difficult. Performing Scheimpflug camera imaging with Pentacam or Gallilei may provide additional data, furthermore, confirming changes in corneal thickness with ultrasound pachymetry would also be helpful.

Total wavefront maps of both eyes are in accordance with subjective refraction and predicted phoropter refraction (PPR) (with-the-rule astigmatism). The RMSs for higher order aberrations (0.81 and 0.28 microns in the right and left eyes in the 5 mm zone) are greater than normal (0.25 to 0.30 microns) especially in the right eye. In addition, total aberrations in both eyes are also greater than normal (5.26 and 2.73 microns). Point spread function (PSF) shows vertical coma as the prominent higher order aberration in both eyes and spherical aberration (Z400) is actually 0 in both eyes. As shown in red figures, the difference between subjective and PPR astigmatism in the right eye is 1.85 D which is more than the acceptable limit (0.75 to 1 D). In case of discrepancy between subjective and PPR refractions, customized keratorefractive surgery is not recommended. If repeat aberrometry discloses closer PPR and subjective refractions, customized keratorefractive surgery could be suggested. One question is why refractive surgery was not performed back in 2000. Possible reasons are corneal thickness concerns in a 24-year-old patient especially in the right eye which needs 95 to 100 microns of ablation, suspicious findings such as scissor reflex on retinoscopy, and abnormal findings in the posterior surface of the cornea.

In summary, the presence of vertical coma, anisometropia and decreased BSCVA in the right eye are in favor of keratoconus. However, due to the absence of significant anterior corneal changes, it is difficult to definitely diagnose the condition. Considering Orbscan findings (provided that ultrasonic pachymetry and Scheimpflug imaging confirm them) and aberrometric results, subclinical or forme fruste keratoconus is suggested. On the other hand if Scheimpflug images suggest a normal cornea

and pachymetry is enough for the ablation (remaining stromal bed of at least 400 microns), surface ablation (conventional or customized according to new and more reliable aberrometry maps) could be considered after explaining the risks of surgery to the patient. One should keep in mind that even in the presence of normal Scheimpflug images but thin corneas, it is best to avoid surgery. New and more reliable aberrometric maps have no role in defining the indication for surgery; they only help in deciding the ablation profile (conventional versus customized). If Scheimpflug machines are not available, I would not suggest any type of keratorefractive surgery based on Orbscan data alone in this particular case. Performing ocular response analysis (ORA) and calculating corneal hysteresis (CH) and corneal resistance factor (CRF) may also add limited information, but due to significant overlap between normal corneas, subclinical keratoconus, and keratoconus, decision making cannot be based on their results.

Mohammad-Reza Sedaghat, MD

Some findings are in favor of performing refractive surgery in this case. All Orbscan indices (including elevations, pachymetry and placido-based topography) were within normal limits in 2000. Topographic astigmatism in the right and left eyes had been $-3.70 \times 9^\circ$ and $-2.50 \times 180^\circ$ in 2000, and are $-3.90 \times 17^\circ$ and $-2.30 \times 3^\circ$ in 2009, respectively; there is no significant change in the amount and axis of astigmatism in either eye. It seems that the topographic pattern has changed from symmetric bow-tie in 2000 to asymmetric bow-tie with superior steepening in 2009 in both eyes. Considering the topographic dioptric steps (0.25 D in 2000 versus 1.00 D in 2009), changes in placido-based topography colors are probably due to changes in dioptric steps which might be misleading at first glance. In fact, keratometric values and topographic patterns are the same and within normal limits.

On the other hand, certain findings point against performing refractive surgery. On Orbscan examination, posterior elevation has increased from 20 to 50 microns in the right eye

and from 13 to 33 microns in the left eye from 2000 to 2009. Corneal thickness has decreased by about 35 and 65 microns in the right and left eyes, respectively in 2009; the thinnest points are 482 and 457 microns in the right and left eyes, respectively while they had been about 520 microns in both eyes in 2000. Acoustic factors of 0.93 and 0.96 were applied in 2000 and 2009 respectively, therefore under similar circumstances corneal thickness should have been higher in 2009. However, the opposite has occurred and greater pachymetric changes in the left eye suggest an error in 2009. Six millimeter zone wavefront errors with and without spherical aberration (Z400) were 0.96 and 0.94 microns in the right eye indicating larger amounts of higher order aberrations (HOAs) such as coma which is also evident in PSF and higher order wavefront maps. A similar picture is seen in the left eye but with lower amounts of HOAs. Given the increase in posterior elevation, decrease in corneal thickness, and high amounts of coma, early ectasia could be considered as a probable diagnosis.

Elevation topography and pachymetry by Orbscan have been performed using different machines at two different centers 9 years apart; this limits comparisons. Imaging with Pentacam should be performed for better evaluation of anterior and posterior elevations, and corneal pachymetry. Corneal thickness should be compared using ultrasonic pachymetry, Orbscan and Pentacam. Despite stability in topographic patterns and astigmatism, changes in elevation maps and pachymetry should be considered as suspicious. ORA could be very helpful for evaluating corneal rigidity in this patient. If CRF and CH show acceptable amounts and Pentacam does not confirm Orbscan pachymetric results, chances for performing refractive surgery are increased.

Due to the aforementioned reasons and despite stability in refraction and topographic patterns, keratorefractive surgery is not recommended based on the available data in this case. If ultrasound pachymetry, Pentacam, and ORA do not confirm the Orbscan findings, keratorefractive surgery may then be considered. Due to significant difference in the amount of astigmatism between subjective ref-

raction and PPR, despite the presence of high amounts of HOAs, customized ablation is not recommended. Aberrometry should be repeated to have a new wavefront map. In the presence of high amounts of HOA and better concordance between subjective refraction and PPR, customized ablation could then be recommended.

Editor's Note

- Common indications for customized keratorefractive surgery include myopia >-3 D, astigmatism >1.5 D, mixed astigmatism, hyperopia (in the corrective range of the particular excimer laser machine), RMS $>0.3-0.5$ microns for higher order aberrations, large mesopic pupil size, need for good night-time vision, patient's interest in customized ablation, enhancement surgery following previous keratorefractive surgery including radial keratectomy, and sometimes following penetrating keratoplasty.
- The difference between PPR, cycloplegic, and manifest refraction should be acceptable before customized ablation. Discrepancy may occur due to following reasons: inaccurate aberrometry and refraction, accommodation during aberrometry and refraction,

and influence of higher order aberrations on manifest refraction. In the case of significant discrepancy between these refractions, the following measurements should be performed: (1) repeat manifest and cycloplegic refraction and (2) subjective refraction using PPR sphere and cylinder. In the case of improved BSCVA, this might reflect more precise aberrometric refraction compared to manifest refraction. In the case of persistent discrepancy between PPR, manifest and cycloplegic refractions, WFG ablation might not be a good option.

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