eFocus
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PACIFIC VISION INSTITUTE
Life in Focus

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A NEW ERA

in screening refractive surgery candidates, monitoring corneal health, and measuring true IOP

At Pacific Vision Institute, we recently added Ocular Response Analyzer (ORA) to our screening process for patients interested in refractive surgery. Until now, the biomechanical properties of the cornea could be inferred from its thickness, contour, and appearance at the slit lamp. With ORA, we can measure the corneal biomechanics directly, by measuring its elastic properties, called corneal hysteris and corneal resistance factor. In addition, with ORA, we can measure the true IOP that is independent of corneal factors such as thickness, curvature, and rigidity.

How does it work?

Just as with the noncontact tonometry (NCT), the ORA uses a brief puff of air to apply pressure to the cornea. Unlike NCT, however, the air pressure is not as strong and is better tolerated by the patient. The patient is seated in front of the machine and fixates on the green light. An automated alignment system positions an air tube in front of the corneal apex (Figure 1). An air puff is applied to the cornea. The air pulse causes the cornea to move inward into slight concavity before returning to the normal curvature. Infrared detection system records corneal movement. A graph is created that has two parts: a green curve and a red curve (Figure 2, page 2). The green curve corresponds to the air pulse pressure and the red curve corresponds to the corneal movement. The first peak on the red curve coincides with the pressure it takes to applanate the cornea inward (P1). This is analogous to an NCT measurement. The second peak on the red curve coincides with the pressure exerted by the cornea as it moves out, under the decreasing pressure of the air pulse (P2). Four measurements are done for each eye. If the cornea is irregular or moves abnormally, the peaks may be lower, wider, or otherwise irregular. Patients with keratoconus and other corneal thinning pathologies not only have lower peaks, but the peaks look irregular.

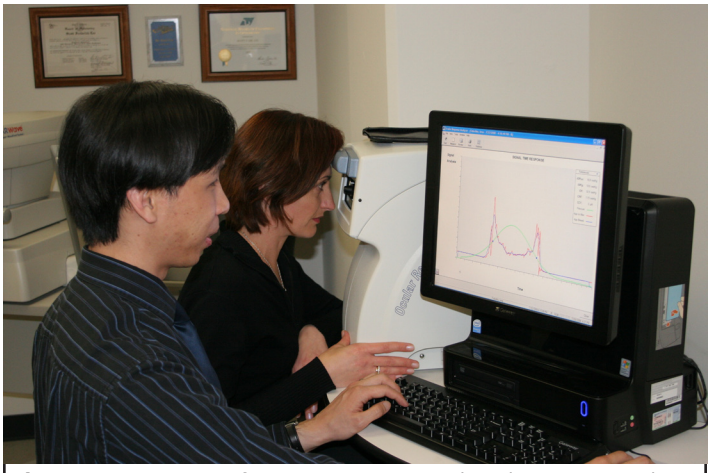


Figure 1. Dr. Scott Lee performing measurements with Ocular Response Analyzer

What does it measure?

Corneal Biomechanics – screen refractive surgery candidates, monitor progression of corneal conditions, such as corneal thinning disorders, corneal dystrophies and degenerations

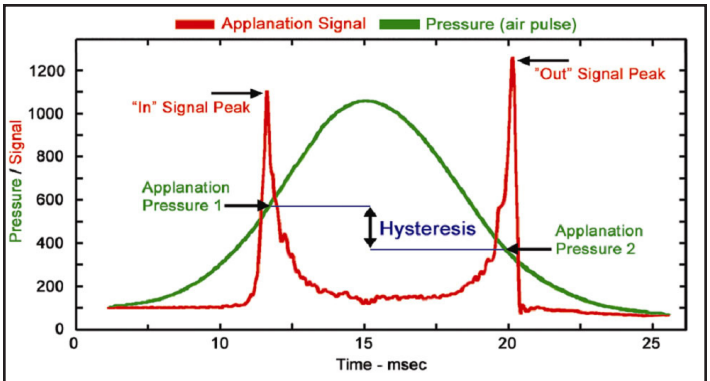


Figure 2. A graph generated by ORA. Corneal hysteris (CH) is the difference between the pressure it takes to applanate the cornea inward (P1) and the pressure the cornea exerts when it rebounds outward (P2).

• **Corneal hysteresis (CH)** is the difference between inward and outward pressure of the cornea. CH is a function of corneal viscous damping properties, i.e. energy absorption capabilities. Patients with keratoconus have low CH values, typically less than 8. Values above 10 are considered normal. A high value in a patient with obvious keratoconus on topography indicates the weak spot in the cornea is not where the measurement was taken. In these eyes, the irregular appearance of the peaks on the ORA graph will be noted. In normal eyes, right and left eye values are highly correlated. Corneal radius and astigmatism are not correlated with CH. Central corneal thickness (CCT) correlation with CH is weak. CH is age-independent.1,4

• **Corneal resistance factor (CRF)** is calculated by the machine using P1 and P2 values. The equation puts more emphasis on P1 than P2. CRF is, therefore, more heavily weighted by the corneal elastic properties. Normal values for CRF are similar to those for CH. In weaker corneas, such as keratoconus, for example, CRF values are depressed more than CH values. In patients with glaucoma, CRF values are close to normal, but CH values are lower.1

• **CH – CRF** difference is another parameter for analyzing corneal strength. Touboul D et al demonstrated that patients with keratoconus had CH values higher than CRF values (CH-CRF difference was positive), while this finding was rare in normal patients and in patients with glaucoma. This parameter could be used as a sensitive screening tool.

IOP – measuring true IOP, regardless of corneal characteristics.

• **Corneal compensated IOP (IOPCC)** is calculated using a combination of P1 and P2 (IOPcc = P2 - (0.43*P1). It is a measurement that is designed to reduce the effect of corneal thickness and its other properties on IOP measuring process. This IOP value has been reported to remain constant after refractive surgery.5 It is perhaps a more accurate measure of true IOP than CCT-adjusted IOP. CRF shows to be more of a factor in IOP testing than corneal thickness. There isn't always a direct correlation between CCT and CRF. A thick cornea doesn't necessarily mean the CRF is high as well.

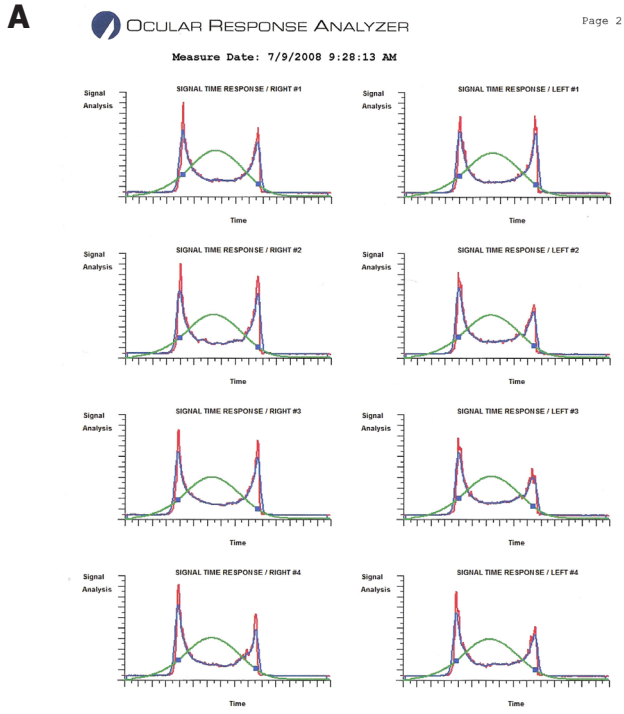
• **Goldman correlated IOP (IOPG)** is the average of P1 and P2. It is higher than IOPcc in more rigid corneas and lower than IOPcc in more flexible corneas.

Clinical applications in screening refractive surgery candidates

Normal ORA (Figure 3)

Normal graphs, normal CH and CRF values, and the difference between CH and CRF is minimal.

A



OCULAR RESPONSE ANALYZER

B

ID	Birth Date	Sex	Race
3	12/12/1965	Female	Asian

Measurement Date: 7/9/2008 9:28:13 AM

	#	IOPcc (mmHg.)	IOPg (mmHg.)	CRF (mmHg.)	CH (mmHg.)	CCT (uM.)
RIGHT	1	14.4	15.9	12.1	12.2	
	2	12.0	13.0	11.2	12.2	
	3	10.2	11.9	11.4	12.8	
	4	12.6	12.8	10.4	11.3	
	Avg.	**12.3**	**13.4**	**11.3**	**12.1**	0
LEFT	1	13.9	14.5	11.1	11.6	
	2	14.0	14.5	11.1	11.5	
	3	15.8	14.8	9.8	10.0	
	4	11.1	11.8	10.6	12.0	
	Avg.	**13.7**	**13.9**	**10.7**	**11.3**	0

Figure 3. Normal ORA. (A). ORA graphs; (B). CH, CRF, IOPcc, and IOPg

Keratoconus (Figure 4)

Topography demonstrates keratoconus, OD worse than OS. Right eye peaks in the ORA graph are more severely depressed than the peaks in the left eye. Some graphs demonstrate irregular appearance of the peaks, indicating abnormal corneal movement. Right eye CRF and CH values are lower than in the left eye, consistent with more severe keratoconus. CH values are significantly greater than CRF values, consistent with keratoconus.

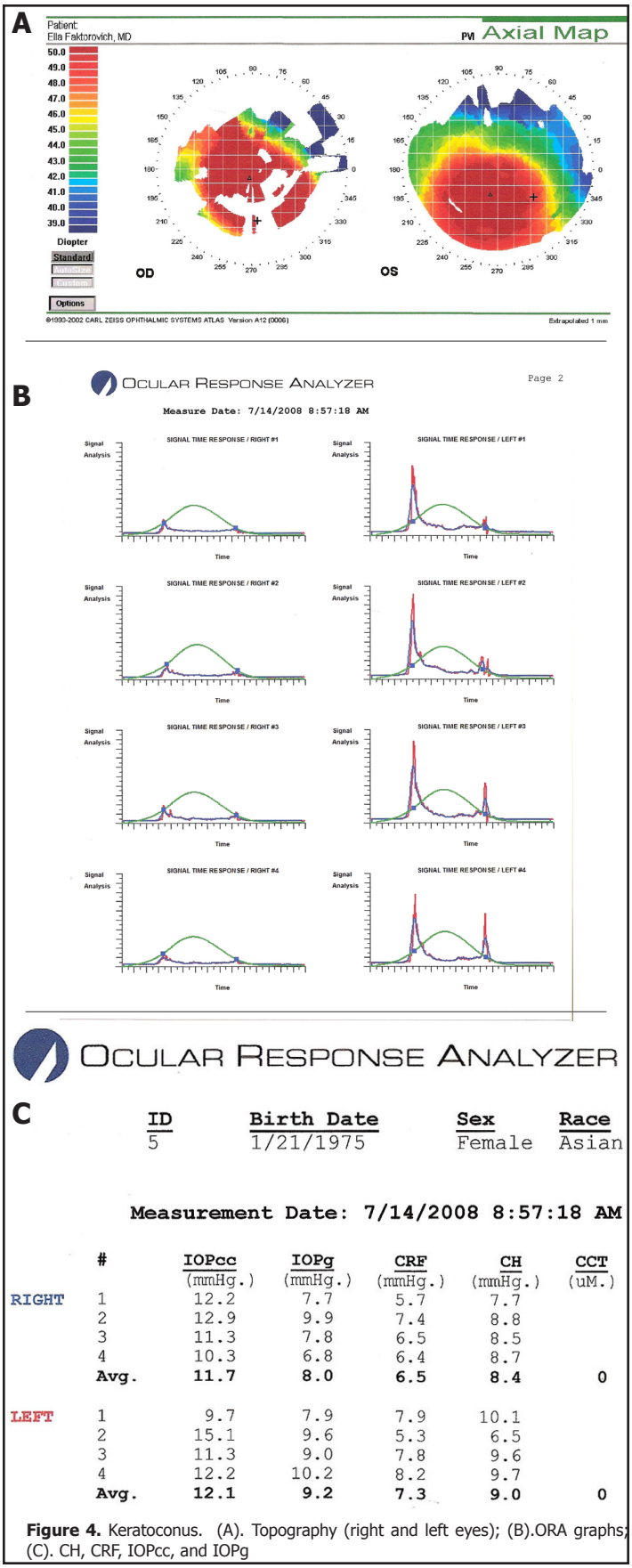


Figure 4. Keratoconus. (A). Topography (right and left eyes); (B).ORA graphs; (C). CH, CRF, IOPcc, and IOPg

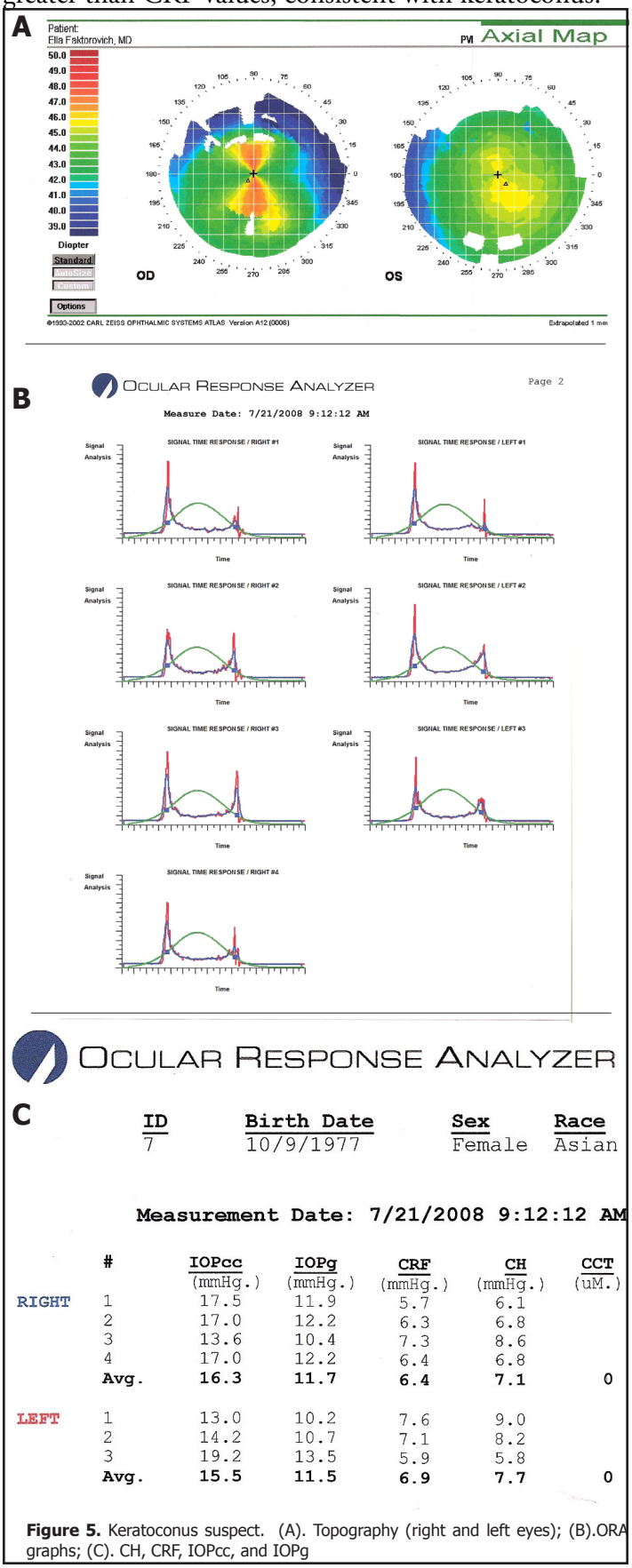


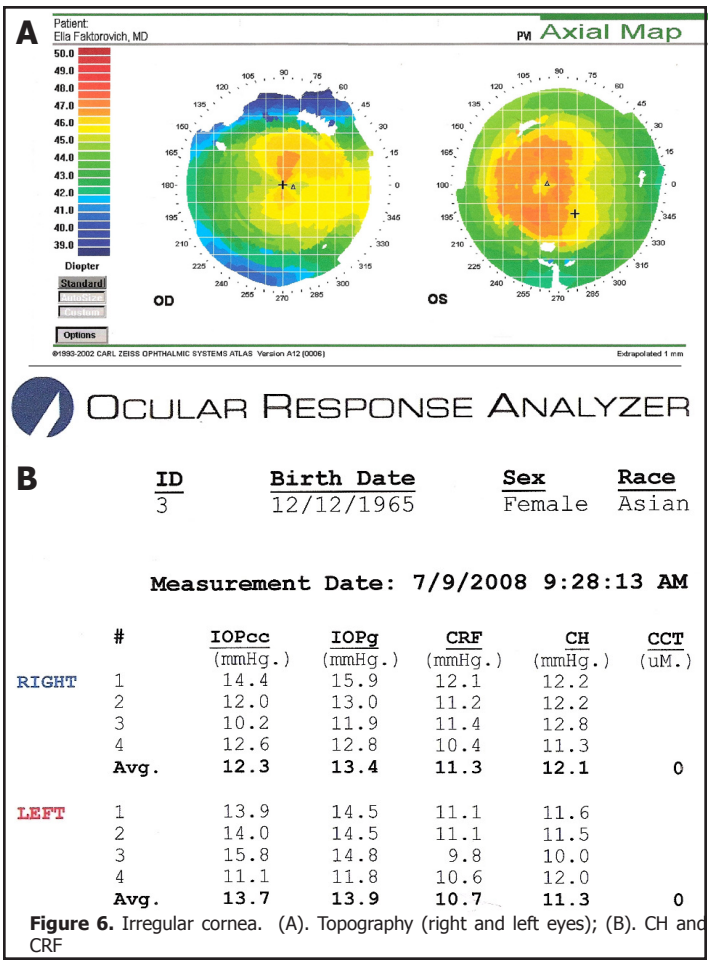
Figure 5. Keratoconus suspect. (A). Topography (right and left eyes); (B).ORA graphs; (C). CH, CRF, IOPcc, and IOPg

Keratoconus suspect (Figure 5)

Topography demonstrates symmetric astigmatism. The peaks in the ORA graph are somewhat depressed. CH and CRF values are low. CH values are significantly greater than CRF values.

Irregular cornea, not keratoconus (Figure 6)

The corneas are irregular, but the CH and CRF values are normal. The ORA graphs (not shown)



B

ID	Birth Date	Sex	Race
3	12/12/1965	Female	Asian

Measurement Date: 7/9/2008 9:28:13 AM

	#	IOPcc (mmHg.)	IOPg (mmHg.)	CRF (mmHg.)	CH (mmHg.)	CCT (uM.)
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	4	12.6	12.8	10.4	11.3	
	Avg.	**12.3**	**13.4**	**11.3**	**12.1**	0
LEFT	1	13.9	14.5	11.1	11.6	
	2	14.0	14.5	11.1	11.5	
	3	15.8	14.8	9.8	10.0	
	4	11.1	11.8	10.6	12.0	
	Avg.	**13.7**	**13.9**	**10.7**	**11.3**	0

Figure 6. Irregular cornea. (A). Topography (right and left eyes); (B). CH and CRF

References

1 Touboul D, Roberts C, Kerautret J, et al. Correlation between corneal hysteresis, intraocular pressure, and corneal central pachymetry. J Cataract Refract Surg 2008;34:616-622

2 Luce DA. Determining in vivo biomechanical properties of the cornea with an ocular response analyzer. J Cataract Refract Surg 2005;31:156-162

3 Luce DA. IOVS 2006;47:ARVO E-Abstract 2266

4 Kirwan C, O'Keefe M, Lanigan B. Corneal hysteresis and intraocular response analyzer. Am J Ophthalmol 2006;142:990-992.

5 Pepose JS, Feigenbaum SK, Qazi MA, et al. Changes in corneal biomechanics and intraocular pressure following LASIK using static, dynamic, and noncontact tonometry. Am J Ophthalmol 2006;141:868-875.

Calendar of PVI Grand Rounds

By invitation only:

08/28/08	Update on ocular diagnostics
08/08-09/08	Ocular Response Analyzer workshops (for PVI affiliated doctors)
10/23/08	Refractive Surgery
11/20/08	Glaucoma
12/11/08	PVI Holiday Dinner (Practice Management Pearls)
01/22/09	Retina
02/26/09	Binocular vision
04/23/09	8th Annual San Francisco Cornea, Cataract, and Refractive Surgery Symposium

Sight Gags *by Scott Lee, O.D.*

"Make a run for it! The stylist lost her glasses."

Scott F. Lee, O.D., Editor-in-Chief, eFocus.
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