

GLAUCOMA

Measuring IOP in the Unusual Cornea

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INTERVIEWING JOHN BERDAHL, MD, NATHAN P. RADCLIFFE, MD, ANGELO P. TANNA, MD,
AND WILLIAM B. TRATTLER, MD

The abnormal cornea poses special challenges for ophthalmologists measuring intraocular pressure (IOP). “Certain anomalies can render standard techniques to measure IOP inaccurate and inadequate,” said Angelo P. Tanna, MD.

A classic example of these challenges is an eye with very high central corneal thickness. “Such a cornea resists applanation, resulting in an artifactually high IOP reading when the true IOP may be normal,” said Dr. Tanna, at Northwestern University.

Corneal edema, keratoconus, prior corneal cross-linking treatment, and corneas that are thin, whether naturally or after keratorefractive surgery, are among the anomalies that can affect pressure readings. Another consideration may be low corneal hysteresis (see “Is Corneal Hysteresis a Factor?” at www.eyenet.org). “In all these situations, be aware that the measurement you have obtained may not be accurate,” said Dr. Tanna.

To get the best possible reading with irregular corneas, it can help to keep a few factors in mind.

Taking a Good Reading

Biomechanics. “When confronting the unusual cornea, you have to think about corneal biomechanics to accurately assess IOP and glaucoma risk,” said John Berdahl, MD, in Sioux Falls, S.D. He always considers the cornea’s thickness, as well as whether it is “particularly rigid” or “particularly

floppy.” These characteristics affect the cornea’s response to applanation and, in turn, the pressure reading. Specifically, thick and/or stiff corneas tend to yield artificially high IOP readings, and thin and/or soft corneas yield artificially low readings.

Tonometers. No single tonometer or method works best to gauge IOP across various corneal configurations; however, clinicians often prefer one type of device to another, depending on the circumstances. For many ophthalmologists, Goldmann applanation tonometry (GAT) remains the gold standard, but it is susceptible to error due to variations in corneal biomechanics, Dr. Tanna said.

All of the devices used to measure pressure inside the eye do so by pushing on the cornea, said Nathan P. Radcliffe MD, at New York University–Langone Ophthalmology Associates. “So if your cornea is somehow different from my cornea, even if we have the same pressure in the eye, you can imagine that these devices might not be able to distinguish differences in our corneas from differences in our pressures.”

Other factors. “Everybody wants a formula or a tonometer to accurately measure IOP in the eye with an unusual cornea. But we do not have a technique or a formula to achieve this goal in patients,” Dr. Tanna said. However, he closely follows patients with unusual corneas. “I measure the IOP and keep in mind that the underlying corneal abnormality may affect the ac-

Tonometry Challenges



It can be difficult to get accurate IOP readings in patients with (1) corneal edema and (2) keratoconus, among other conditions.

curacy of the pressure measurements,” he said. “In such cases, it is critically important to monitor the optic disc, the retinal nerve fiber layer, and the visual field to determine if the patient’s glaucoma is stable or deteriorating.”

The following is a guide to certain aberrations that can throw off pressure readings. In some cases, a physician may cite a particular tonometer as a good match for a particular condition. However, Dr. Berdahl said, “People will have their favorite tonometer, but there’s no evidence to back that up.”

Conditions Affecting IOP Readings
Band keratopathy. Calcific band keratopathy may lead to artificially high pressure readings when IOP is measured in the area of the cornea where the calcium deposition is present, Dr. Tanna said.

Tonometer. Tono-Pen, a small, handheld applanation device, may be useful, Dr. Tanna said, and be sure to take the measurement in an area of the cornea that is clear. But, he warned, an off-center measurement may also result in overestimation, since the peripheral cornea is thicker than the central cornea.

Corneal edema. “Edema makes the cornea thicker, so you would expect the pressure to be higher, but the cornea is also squishy and soft like a sponge,” Dr. Berdahl said, so GAT underestimates true IOP.

Tonometer. William B. Trattler, MD, in Miami, said that he usually uses a Tono-Pen in the peripheral part of the cornea. He added that although GAT requires a fairly regular corneal shape to accurately determine IOP, the device can be useful in these cases. This is because corneal edema typically results in a mild underestimation of IOP—by only a few points. “If the true IOP is 19, GAT might measure 15 to 17. But that difference is not clinically significant,” he said.

High astigmatism. Dr. Berdahl noted that the irregular shape of highly astigmatic corneas may cause the applanation mires to differ from one direction to another when traditional GAT is used.

Tonometer. In eyes with high astigmatism, said Dr. Tanna, two GAT readings should be obtained: one with the prism oriented horizontally and the other with the prism oriented vertically. “The mean of those two measurements is a better estimate of true IOP,” he said.

Dr. Trattler prefers Tono-Pen because, he said, it is not influenced by the shape of the cornea in high astigmatism.

Keratoconus and other corneal ectatic disorders. In keratoconus or other ectasia, the cornea is thin, so the

tonometer might measure 14 mmHg when the correct measure might be 19 or 23 mmHg, Dr. Berdahl said. Of course, a keratoconic cornea that has been treated with cross-linking will be stiff, he said.

Tonometer. “In patients with irregular corneal shape, as in keratoconus, it can be difficult to determine the endpoint using Goldmann,” said Dr. Trattler who prefers Tono-Pen.

Dr. Tanna noted that you can use GAT by taking the average of measures in two perpendicular axes—much as with high astigmatism.

He also noted that there is evidence that the Pascal Dynamic Contour Tonometer provides more accurate IOP measurements in these eyes.^{1,2} “It is the tonometer that appears to be least impacted by corneal thickness, corneal curvature, and irregular astigmatism,” he said. “The problem is the device is difficult and time-consuming to use.”

Dr. Tanna pointed out that corneal cross-linking therapy seems to be associated with an approximately 1.5 mmHg increase in the GAT measurement, which, he noted, is almost certainly due to the increased rigidity of the treated cornea.

Penetrating keratoplasty or lamellar keratoplasty. Any eye with a transplanted cornea is anomalous, Dr. Tanna said, adding that the biomechanics of such corneas may be abnormal due to the presence of subclinical corneal edema, irregular curvature, and scarring at the host-graft interface.

Tonometer. “In eyes that have undergone penetrating keratoplasty, we know GAT pressure measurements are significantly lower than those obtained with the Tono-Pen. However, we do not know which tonometer more accurately reflects the true IOP in such eyes,” said Dr. Tanna.

Post-LASIK or post-PRK. In a cornea thinned by LASIK or PRK, Dr. Trattler said, the actual pressure will be higher than the measured pressure.

Tonometer. The devices available in Dr. Trattler’s office—both GAT and Tono-Pen—are suitable for these eyes, he said, as long as the clinician understands that the value of the IOP

from either device needs to be adjusted higher. This adjustment, he said, “is really more of a guess. In general, one has to be aware that the IOP could be underestimated. So, if the IOP measures 15, it might be 17 to 19. However, if the IOP measures 21, then we have to be suspicious that the real IOP may be in the mid 20s.”

Bottom Line

When taking measurements, keep the bigger picture in mind. “Don’t make too big a deal out of small variations in intraocular pressure, as those variations are as likely to come from measurement error as they are to come from real pressure variability,” Dr. Radcliffe said. “If we obsess over small variations in eye pressure that are likely to come from artifact, we will probably do our patients more harm than good.”

Dr. Trattler concurred, “You have to be cognizant of the fact that in some patients, the IOP measurement may not be perfectly accurate due to the cornea condition. What’s important is to follow the health of the optic nerve through direct exam and/or with OCT of the retinal nerve fiber layer.” ■

1 Mollan SP et al. *Br J Ophthalmol*. 2008; 92(12):1661-1665.

2 Papastergiou GI et al. *J Glaucoma*. 2008; 17(6):484-488.

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EXTRA MORE ONLINE. Read about corneal hysteresis in the Web Extra that accompanies this article at www.eyenet.org.