

# Fixed Immersion Shell Improves Axial Measurement

**Accuracy is more important than ever. Here are techniques to help.**

CATARACT SURGERY IS OFTEN referred to as the most successful surgery in medicine. To maintain that high standard, accuracy in preoperative measurements is paramount. Refractive surprises, defined as a 2-D difference in the predicted results, may occur in 5 percent of the cataract population.<sup>1</sup> This can lead to a diminished quality of life,<sup>2,4</sup> binocular diplopia, altered depth perception, possible lens exchange and/or loss of patient referrals.

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## Axial Length Errors

The greatest source of refractive surprise appears to arise from mistakes in measuring axial length, and may account for 54 percent of postop refractive error.<sup>1</sup> An inaccuracy of only 1 mm can result in a 3-D refractive error.

The contact technique or direct applanation on the eye is commonly used, but is fraught with problems. Even the skilled technician may have parallax difficulties in centering the

probe on the cornea, and there is always the potential of indenting the eye, especially in patients with lower intraocular pressures.

In contrast, the immersion technique utilizes a liquid interface between the eye and the ultrasound probe, eliminating these problems. Immersion may be performed with an open cylinder (Hansen Shell, Iowa City, Iowa) filled with Goniosol or with a fixed immersion shell (Prager Shell, ESI Inc., Plymouth, Minn. [eyesurgin.com](http://eyesurgin.com)). Compared to the open shell technique, I believe learning to use the fixed immersion shell, a one-handed procedure, is easier to master and does not require Goniosol, which may blur the vision and prevent additional testing that same day.

The immersion technique minimizes technician variables such as corneal compression, alignment of the ultrasound beam and probe insertion leading to more reproducible results. After practice, immersion biometry utilizing the Prager Shell has been reported to be faster than the contact method,<sup>5</sup> at least in part because it eliminates the considerable time to review the scans and delete those with corneal compression errors.

In the quest of greater accuracy in surgical outcome, there have been many comparisons between applanation and immersion techniques. An early study<sup>6</sup> reported that immersion scans consistently result in longer axial lengths and less variability than the



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contact technique. These findings have been replicated in numerous studies over the past 20 years.<sup>5-14</sup> Direct comparison of the Prager Shell and other immersion approaches to the non-contact interferometer method of axial length determination (Zeiss Humphrey IOLMaster, Dublin, Calif.) shows no clinical difference in precision between the two methodologies, despite a significant cost difference.<sup>5,8,15</sup> In a cohort of 253 patients, axial length measurements using the IOLMaster were unobtainable in 17 percent of the population due to low visual acuity and dense cataracts.<sup>16</sup> Thus, there always will be an important role for immersion biometry.

Simply utilizing an immersion shell, however, will not guarantee perfect results on every patient. There must be an understanding of the sources of error and a mental checklist when performing immersion biometry. An inexperienced technician who does not understand the basic principles underlying axial length scanning can undermine the efforts of the most skillful cataract surgeon.

**Prior to Measuring the Eye**

The majority of refractive surprises occur in unusual length eyes and more frequently in short eyes. Proportionately, a 1-mm mistake in a 21-mm eye has a greater postoperative refractive consequence than the same error in a 30-mm eye. Although staphylomas may make it more difficult to locate foveal spikes in a long eye, the smaller dimensions encountered in the short eye require greater measurement accuracy to maintain error tolerance. Thus, prior to measurement, the biometrist should determine if the eye is unusual in any way. A previous scleral buckle can change shape of the eye producing a significant axial length difference between the eyes.

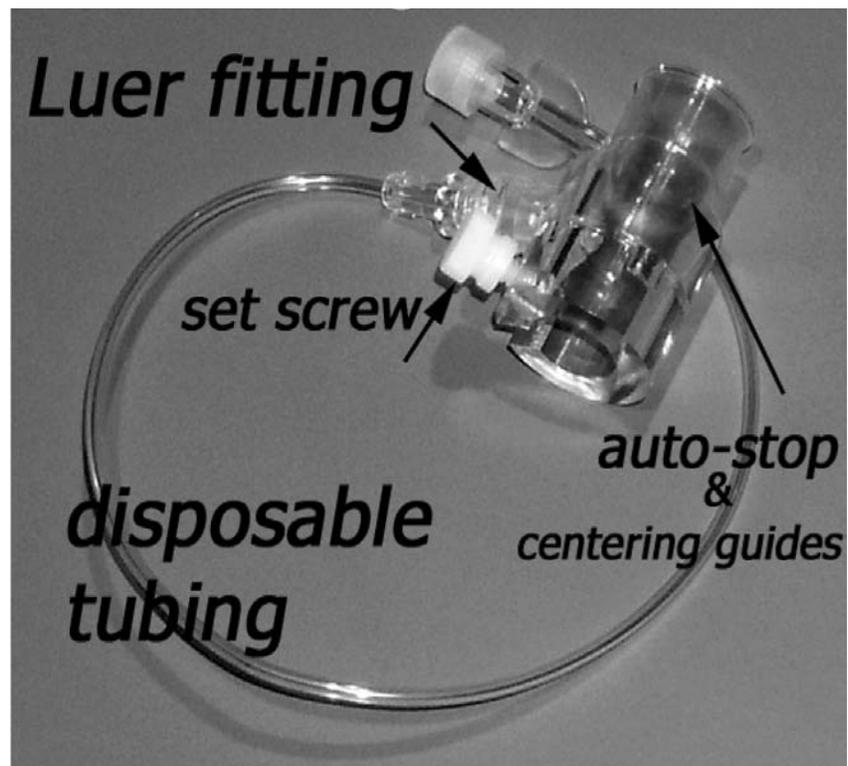
For the majority of patients both

eyes are approximately the same length, typically within 0.3 mm of one another. Replicate measurement findings several times and if a 0.3 mm or greater difference remains, note in the chart that the “measurements exceed normal physiological findings.” Determine if either eye is aphakic, as this will require a change in sound velocity to compensate for the missing lens.

Similarly, a pseudophakic eye will require a change in tissue velocity. Many instruments have settings for eyes with implanted IOLs, although an alternative method is to measure every

axial length measurements. Silicone oil in the eye, used to replace vitreous in eyes with retinal detachments, changes the speed of sound through the eye. To further complicate matters, the two most common types of silicone have different tissue velocities—1,050 or 980 meters/second—and the clinician must know which velocity to select or a small mistake in axial length will occur.

Each ocular component of the eye, anterior chamber, lens, and posterior vitreous cavity must be measured individually. The anterior chamber is measured at 1,532 meters per second and



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pseudophakic eye at the aphakic setting (1,550 meters/second), then add 0.4 mm to the anterior-posterior length if the lens is made of PMMA or subtract 0.8 mm if the IOL lens is silicone.

Measuring eyes that contain silicone oil in the posterior vitreous poses another difficulty in obtaining accurate

does not require a mathematical adjustment, but to obtain true values for the lens, use 1,641/1,532 X the measured lens thickness and 980 (most cases)/1,532 X the measured vitreous length. Final IOL power determination is made more confusing because the index of refraction differs in the eye

with silicone versus the normal eye and requires the addition of more refractive power.

For all patients, glean the chart for other information that potentially can affect the surgical outcome. What is the IOL power requested? If there is an anticipated 2-D difference or more in the final refraction and the other eye does not require cataract surgery, patients may not be able to tolerate the anisometropia. Look at the current glasses prescription to estimate the anticipated axial length. The average eye is 23.3 mm, so given 1 mm = 3 D, a 24-mm eye should be roughly myopic by 3 D. If the glasses have a hyperopic optical correction of +3 D and the axial length measurement is 26 mm, this should alert the biometrist that there could be a potential mistake.

### Practical Tips

Centers for Disease Control guidelines require that, prior to measuring the eye, the Shell and probe be thoroughly soaked in alcohol or hydrogen peroxide for at least five minutes. Allow the immersion Shell to completely dry and flush with BSS, as alcohol can compromise the cornea. To avoid transmitting pathogens from patient to patient, it is important to change the connecting tubing and BSS with each patient. A study (personal communication)<sup>17</sup> conducted at 33 ophthalmology clinics showed wide variability in probe cleanliness. Fungus was cultured from the shell in 12 percent of the samples and other organisms including coagulase-negative *Staphylococcus* grew in 33 percent of the specimens (Shell and tubing). While *Staphylococcus* is associated with conjunctival flora, its presence still indicates poor hygiene and fungus potentially puts patients at risk. This is especially true if the cornea has been compromised.

The Prager Shell has a Luer fitting to facilitate changing the tubing. A BSS

bottle can be attached directly to the tubing or BSS can be placed in a syringe. Tubing with a check valve minimizes fluid reflux, thus allowing continued use of the BSS bottle/syringe. Always soak the shell/probe and replace tubing after every patient. The minimal cost of new sterile tubing and BSS for each cataract patient represents less than 3 percent of the Medicare reimbursement for biometry and ensures that there is no patient cross-contamination. In terms of cost/benefit, having the biometrist clean and reuse the tubing is less efficient, with no guarantee of sterility, than using that time seeing other patients.

If there is a plastic sheath for appplanation, pull it away from the probe. Insert the biometry probe into the Shell. The software will capture scans only if the probe (and its main bang) is at the exact distance from the cornea specified by each ultrasound manufacturer. The Prager Shell has an auto-stop feature that seats the probe at the instrument manufacturer's specified distance from the cornea. This ensures the "corneal gate" on the biometer is positioned on the anterior cornea and not the posterior cornea, thus precluding the introduction of a 0.5-mm error. Note that internal centering guides hold the probe in place at six locations so perpendicularity is assured. Observe that the probe tip is placed at the scored line of the Prager Shell. Once the probe has been positioned to the score line/auto-stop, gently tighten the setscrew and seat against the probe.

Routine topical anesthesia is administered to the patient's eyes. Have the patient seated with his head tilted slightly back against a counter or use an ordinary chair. Both patient and biometrist will benefit from the use of a regular reclining examination chair with a headrest. A fixation light on a flexible stem is crucial. Be sure that it is far enough from the patient's eyes that

the eyes are not stimulated to converge, thus increasing the difficulty of locating the fovea during biometry. The patient's attention is normally drawn to a fixation light, which is beneficial if you do not speak the patient's language and have difficulty communicating. When examining the one-eyed patient, it can be difficult to ensure proper fixation. A pearl is to have the patient extend his arm, make a fist and have him stare at his thumb. Even if the patient is blind, through proprioceptive feedback the eye will be able to locate and follow. Always support and move the arm to minimize fatigue.

### Exam Technique

Place a disposable towel on the patient's shoulder, rest the BSS bottle/syringe on the towel, and hold onto the probe/Shell in preparation for the insertion. Direct the patient to look downward, toward his feet; then lift the patient's upper eye lid and insert the flared rim underneath the lid (the upper portion of the Shell will make contact with the sclera while the lower part of the Shell will be held away from the eye); ask the patient to look straight ahead with the uncovered eye, toward the fixation light. Pull the patient's lower eyelid down and gently pivot the lower portion of the Shell into the lower fornix, making sure by close inspection that it is in the fornix and not sitting atop a fold in the conjunctiva. This pivotal motion avoids contact with the cornea and insures centration of the device around the limbus.

### How to Hold the Shell

The goal is to put minimal pressure on the eye. In fact, it is quite instructive for the biometrist to be the patient (at least once) and learn firsthand the benefits of a light touch. Note the Luer filler port is facing temporally. The left hand/palm is resting on the forehead (given the biometry instrument is to

your left), and is used to reduce Shell pressure on the eye. Try to keep the A-scan instrument in your direct line of sight. It is important to position the biometry screen so that it easily can be seen during the procedure. Moreover, the palm acts as the fulcrum or pivot point for the Shell. Sometimes the Shell can be stabilized with the right hand to make micro-movements. With practice, most practitioners usually will hold the Shell with just the hand resting on the forehead. The right hand is free to make instrument adjustments, if necessary. A facial tissue can be placed on the temporal canthus to catch any excess saline.



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To make a measurement, pick up the BSS bottle/syringe from its place on the patient's shoulder or keep the BSS bottle in your hand and slowly inject the saline into the Shell. As soon as the liquid fills the Shell sufficiently to reach the tip of the probe (about 2 cc), the characteristic waveforms of immersion biometry will be seen on the screen. Note when using tubing with a check valve, the BSS bottle may "pinch" slightly until the tubing is removed from the bottle.

The user may wish to review the waveforms by toggling through the list on the screen and deleting those that are less than perfect. By maintaining the Shell in the patient's eye during this review, any measurement that is delet-

ed will be immediately replaced with a new reading, which may in turn be either accepted or deleted. Optionally you can manually begin saving acceptable scans.

To remove the Shell from the eye, pivot the Shell upward, directing the patient to continue to look straight ahead. Then pull away from the eye without contacting the cornea. Upon the initial release, the remaining contents of the Shell (1-2 cc of liquid) will spill down the patient's cheek. Be prepared with a towel or facial tissue.

### Additional Biometry Tips

Although the Prager Shell completely eliminates corneal compression as a complicating factor, and greatly assists in the alignment of the probe with the macula, it is still necessary to review and analyze waveforms to insure a perfect reading. Be sure to accept only steeply rising retinal spikes. The corneal, anterior lens and retinal spikes should be of equal height. If the spikes demonstrate a downward trend or are stair stepped, this suggests that the scan is off axis. With dense cataracts, the tendency is to increase the gain, thereby elevating the spikes. If the tops of the spikes appear flattened, this may indicate that the amplifiers are saturated resulting in an inaccurate reading. With very long eyes such as in those with staphylomas, the macula may be located on the sloping portion of the staphyloma and the retinal spike may not rise to the same height as the corneal spikes. In normal eyes however, the retinal/scleral spikes equal the height of the corneal spikes. Detection of orbital fat spikes is a requirement.

A normal scan has a series of orbital fat echoes with descending amplitudes. If they are absent; or markedly attenuated, the probe may be misaligned and the biometrist may have directed the sound beam to the optic nerve instead of the fovea. The learning-to-learn

curve requires just a few patients and the immersion technique is easily mastered, but to gain confidence in your measurements follow the additional suggestions and be familiar with the sources of error. 

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