Comparative Analysis Between Optical Coherence Biometry Using the Zeiss IOLMaster® and Ultrasonic Biometry

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I would like to share with you a fascinating journey that my office staff and I have taken over the last several years regarding axial length measurements and intraocular lens power calculations. The goal of this journey has been the best possible refractive outcome following cataract surgery.

Applanation A-scan Ultrasonography

In the mid-1990s, applanation A-scan ultrasonography, combined with a second generation intraocular lens calculation formula, was our routine method for intraocular lens power calculation. At that time, our results would generally have been considered acceptable, but were not as good as we would have liked to see.

Using optimized IOL constants, on average, the best overall accuracy we could obtain with standard applanation A-scan ultrasonography was between 0.75 and 0.50 diopters. A careful analysis of our results showed that only 25% of our patients had exact outcomes. (Fig. 1)

Approximately 35% of patients ended up –0.50 diopters more myopic than expected, which was felt to be due to varying degrees of corneal compression. Not a surprise, approximately 15% of patients also ended up +0.50 diopters more hyperopic than expected. A little more than 5% of our patients ended up –1.00 diopters more myopic than expected and approximately 10% of patients ended up +1.00 diopters more hyperopic than expected. My staff and I agreed that this was unacceptable and we began to look for other, more accurate, ways to do our IOL power calculations.

Fourth Generation IOL Calculation Formula

As a first step towards increased accuracy, we purchased the Holladay IOL Consultant and began using the highly accurate Holladay 2 formula. Almost at once, we began to notice our outcomes improving.

With the Holladay 2 formula (Fig. 2), 50% of our patients now had a refractive outcome exactly as predicted. However, we were still disappointed to see that 35% of patients ended up more myopic than expected and 15% of patients ended up more hyperopic than expected. Everyone in our office agreed that although better than before, this was still not as good as we thought possible.

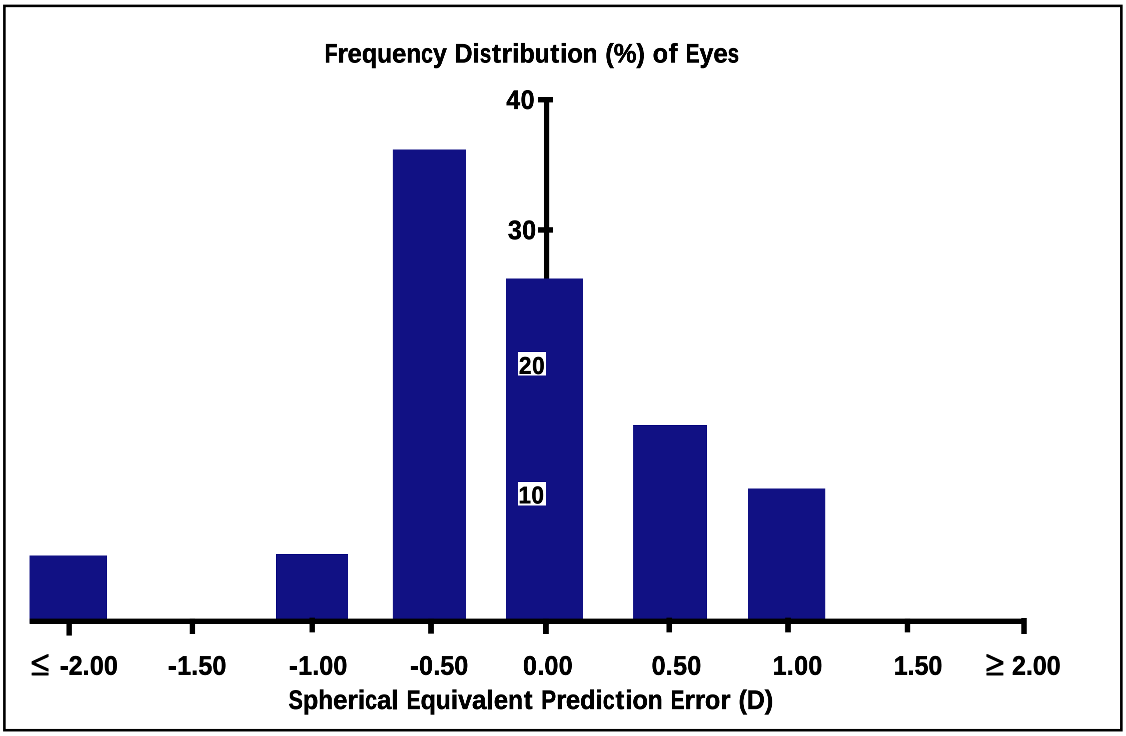

Fig. 1 Outcome with applanation A-scan ultrasonography

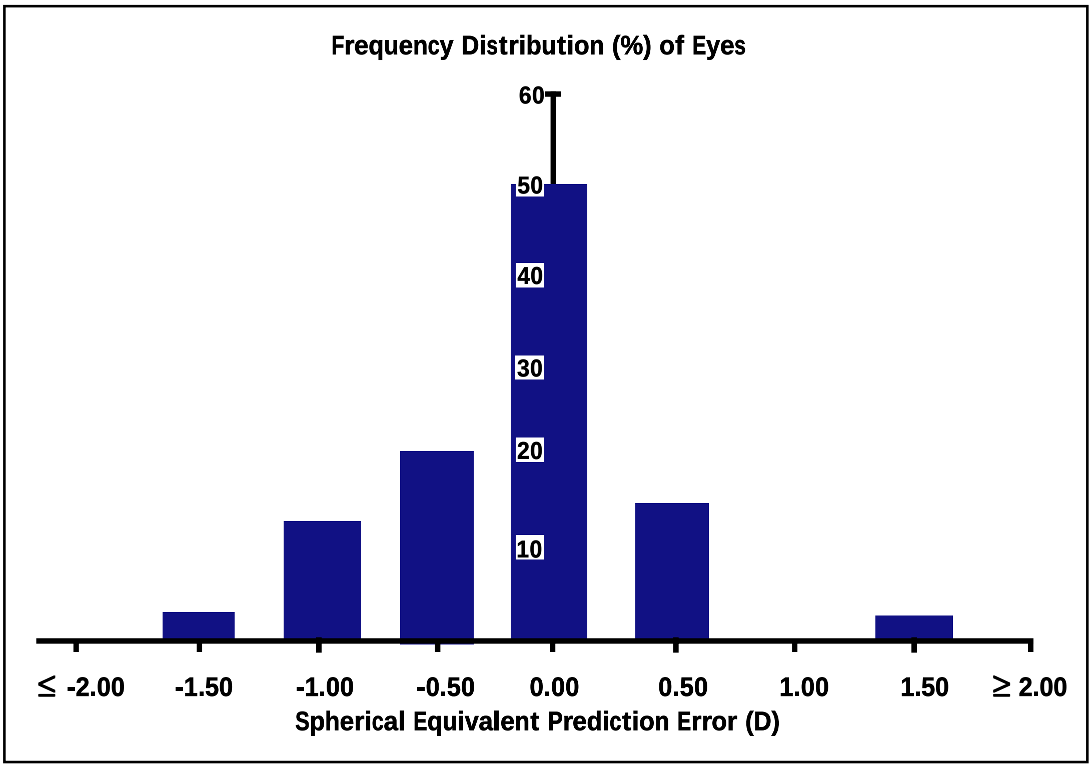

Fig. 2 Outcome with applanation A-scan ultrasonography and Holladay 2 formula

Immersion A-scan Ultrasonography

Several years ago, my friend Ken Hoffer explained to me how the accuracy of A-scan ultrasonography could be greatly improved by converting to the immersion technique. We followed Dr. Hoffer's advice and quickly found immersion A-scan ultrasonography to be more accurate, less operator dependent, and very reproducible.

After adjusting our IOL constants for this new technique, an analysis of our experience with immersion A-scan ultrasonography (Fig. 3) showed 64% of patients had exact outcomes, with 18% of patients being -0.50 diopters more myopic than expected, and a similar amount being +0.50 more hyperopic than expected. Again, this was a significant improvement, but we continued to look for ways to achieve even grater accuracy.

Immersion "B-biometry"

Not long ago, Alcon introduced their innovative UltraScan®, which measures axial length using a combination of simultaneous B-scan and vector A-scan, known as "B-biometry."

With the combination (Fig. 4) of an immersion technique, B-biometry, and the Holladay 2 formula, we now found that 85% of our patients showed outcomes that were exactly as predicted. However, 15% of patients were still either –0.50 diopters more myopic than expected or +0.50 diopters more hyperopic than expected. While this was yet another significant improvement, we continued to search for a method by which our outcomes could be close to perfect.

The Zeiss IOLMaster®

Earlier this year, we purchased the Zeiss IOLMaster®, which offered the promise of axial length measurements accurate to within 0.01 mm. Although limited by the fact that this is an optical device, we found it to be highly accurate, failing to give measurements only in the setting of axial PSC plaques, corneal scars, densely brunescent lenses, and vitreous hemorrhages. In our practice, this subset of patients comprises 10% to 15% of our cataract surgery population, requiring conventional immersion ultrasonography to obtain an axial length.
The Zeiss IOLMaster® uses partial coherence interferometry to measure the distance from the corneal vertex to the retinal pigment epithelium. An internal algorithm then approximates the ultrasonic axial length from the corneal vertex to the vitreoretinal interface. As long as the primary peak shows a signal to noise ratio of greater than 2.0, and preferably displays at least one set of secondary maxima, the measurement is considered valid. We have found that consistent measurements, with a signal-to-noise ratio as low as 1.3 are still usable and that the Zeiss IOLMaster® has an uncanny ability to find the correct reflection from the retinal pigment epithelium.

Accuracy Comparison: Applanation, Immersion, Partial Coherence Interferometry

In our hands, applanation A-scan ultrasonography, when compared to the true back calculated axial length, on average produces 0.28 mm of corneal compression. Immersion A-scan ultrasonography has better resolution, no corneal compression and an overall accuracy within 0.05 mm of the true axial length. The technique of B-biometry, employing a B-scan and combined vector A-scan, only slightly improves this accuracy, but has the added advantage of simultaneously imaging the posterior segment. Our experience with the Zeiss IOLMaster® has consistently shown axial length measurements accurate enough to use with IOLs in 0.25 diopter steps, if, in the future, intraocular lenses are manufactured to such tolerances.

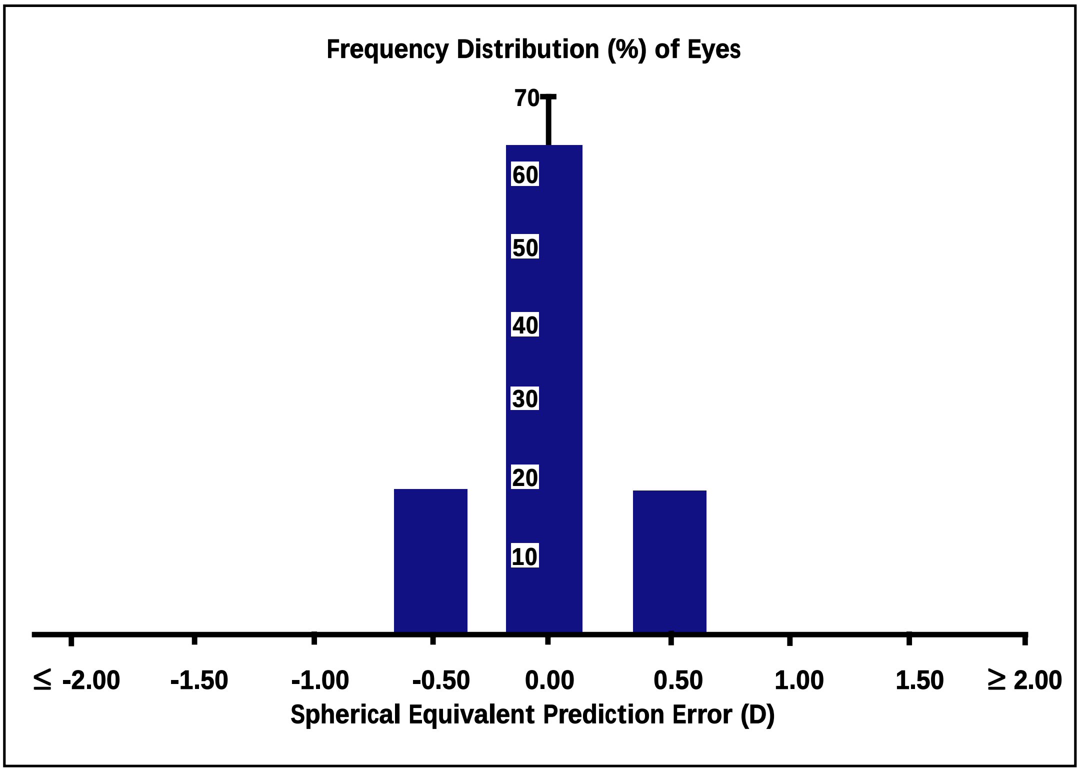

Fig.3 Outcome with immersion A-scan ultra sonography

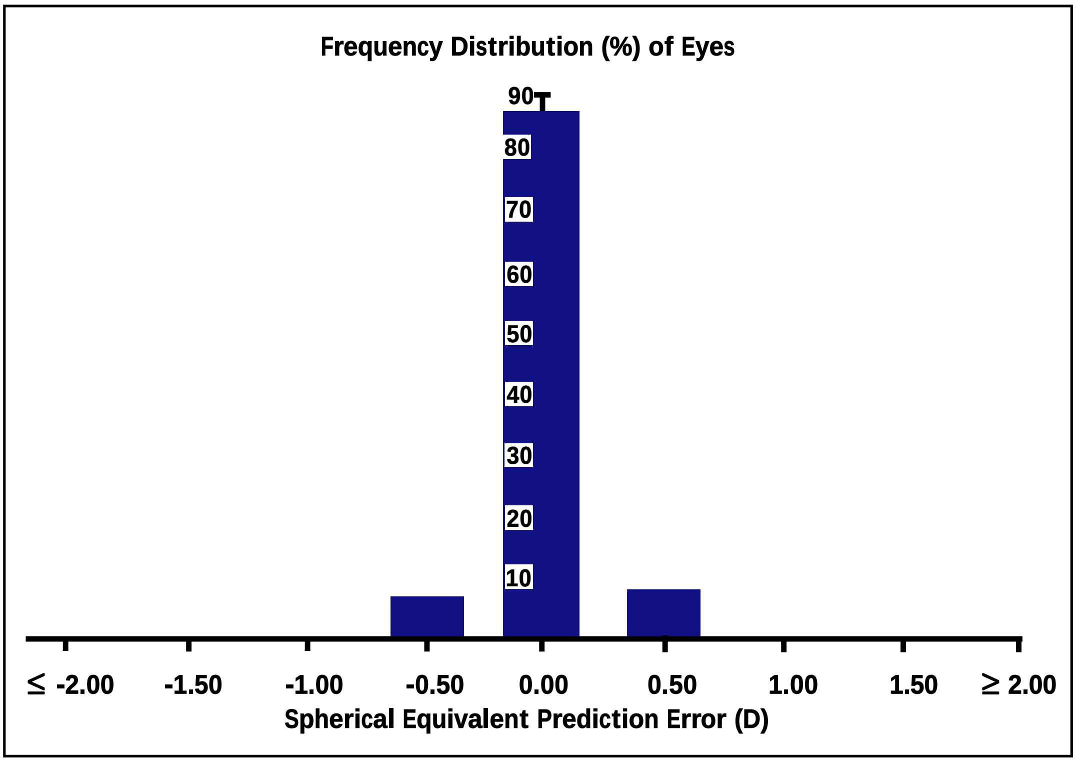

Fig. 4 Outcome with "B-biometry"

New IOL Constants Needed

The only initial surprise we had with the Zeiss IOLMaster® was that the IOL constants for our favorite intraocular lenses had to be recalculated. Dr. Wolfgang Haigis, at the University of Würzburg, has provided a simple and elegant method for calculating new A-constants for the Zeiss IOLMaster®. Dr. Haigis recommends subtracting the ultrasonic axial length from the Zeiss IOLMaster® axial length, multiplying this number by three, and then adding that number to the optimized ultrasound A-constant. We have found this method to work very well in establishing a place from which to begin. For example, let's say that your favorite intraocular lens has an ultrasound optimized A-constant of 118.9. The axial length of a particular patient, measured by your present ultrasound method, is found to be 23.81 mm, and the axial length is measured by the Zeiss IOLMaster® is found to be 23.96 mm. This difference is multiplied by three and then added to 118.9. The calculation would be:

$$A_{IOLMaster} = A_{Ultrasound} + 3 * (AL_{IOLMaster} - AL_{Ultrasound})$$

$$119.35 = 118.9 + 3 * (23.96 - 23.81).$$

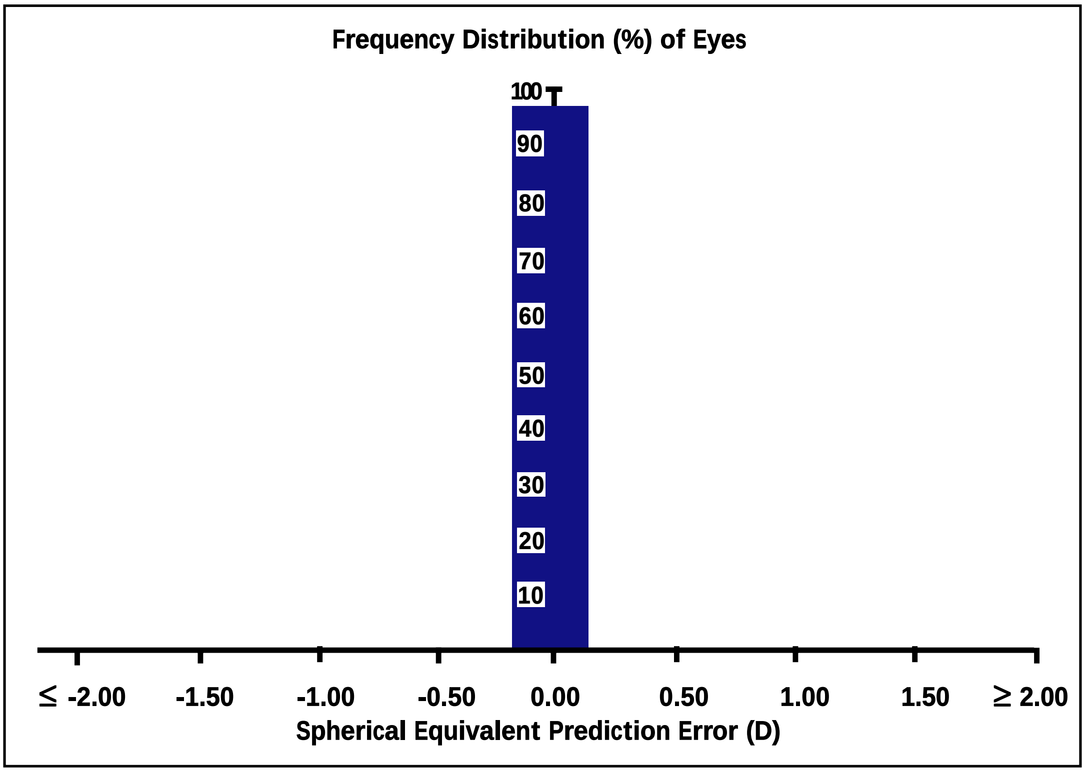

Fig. 6 Outcome with optical coherence biometry

The newly calculated Zeiss IOLMaster® A-constant would then be 119.35. This exercise is then repeated for at least 20 patients, and the results averaged. For even greater accuracy, we have used the Holladay IOL Consultant to fine tune our intraocular lens constants, based on the actual outcomes of several hundred patients.

Improved Office Efficiency

An unexpected, but much welcome, advantage of the Zeiss IOLMaster® is that it has dramatically increased our office efficiency. With manual keratometry, and immersion ultrasonography, the average time it takes to do axial length measurements, corneal power determination, and intraocular lens calculations in our office was typically 19 minutes. However, with the Zeiss IOLMaster®, this time has been reduced to 4.5 minutes. For any busy surgical practice, reducing the time needed to complete a common measurement by almost 25% (Fig. 5) would be an enormous benefit.

	Keratometry & Immersion Ultrasound	**Zeiss IOLMaster®**
Data Entry	1	1
Keratometry	4	1
Axial Length	12	1
ACD	0	1
IOL Calcs	2	0.5
Total Time	19 minutes	4.5 minutes

Fig. 5 Increased Office Efficiency

Limitations and Advantages

As mentioned above, because the Zeiss IOLMaster® measures axial length by partial coherence interferometry, it will not work in the presence of a significant axial opacity. A mature or darkly brunescent lens, dense PSC plaque, vitreous hemorrhage, or central corneal scar will preclude any type of meaningful measurement. On the other hand, very difficult immersion ultrasonography measurements, such as eyes with posterior staphylomata, or eyes with silicone oil, are very easy, and almost routine, with the Zeiss IOLMaster®.

Objective Finally Reached

With our IOL constants now optimized, over the last 100 eyes we have found 100% of our patients to be within 0.25 diopters of the predicted outcome when using a combination of the Zeiss IOLMaster® and the Holladay 2 formula. At long last our journey has come to an end and we have found a technique that is as close to perfect as possible.
The Zeiss IOLMaster® has allowed us to go from 50% of eyes matching our predicted outcome to a predicted accuracy of 100% (Fig. 6). With the introduction of the Zeiss IOLMaster®, it is now possible to achieve a level of accuracy that several years ago could only have been imagined. We are delighted with this device and look forward to further refinements in this exciting new technology.

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