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Using the Pentacam™ for IOL Power Calculation

Because of advances in surgical technique and IOL design, patients are more and more demanding of excellent uncorrected postoperative vision acuity. Achieving this goal requires a very complete preoperative evaluation, precise measurements, the use of appropriate IOL power calculation formulas, the selection of the most appropriate IOL for each individual patient, and a flawless surgical technique.

Advances in Technology

With the introduction of the IOL Master™ for the measurement of axial length, many physicians and their staff incorrectly assumed that a near perfect axial length measurement would also produce near prefect postoperative refractive outcomes. Disappointingly, this was not the case. This is due to the fact that IOL power calculations are a multi-part process and perfecting only one part of several parts does not produce perfection.

Presently, with axial length by the IOL Master™ being nearly perfect, other issues in the process of IOL power calculations have become unmasked, such as the central corneal power, which has been shown to currently be the single most common measurement error resulting in the need for an IOL exchange [1]. So, with increasing technology, the focus for improving the accuracy of our IOL power calculations has shifted away from the measurement of axial length to the measurement of central corneal power.

Where this becomes even more important is for eyes with unusual clinical situations, such as prior ocular trauma, infections or inflammatory events, keratoconus, pellucid marginal degeneration and the various forms of keratorefractive surgery, such as LASIK, PRK and radial keratotomy.

Many Options

Recent advances in IOL design, combined with the availability of different amounts of negative spherical aberration on aspheric platforms, astigmatic correction with sophisticated toric IOLs, accommodative or multifocal correction and the future possibility of combinations on these features require that the preoperative evaluation and patient discussion be very comprehensive.

No longer do we simply have to pick the correct dioptric power of the IOL to be implanted but rather, we must also take into consideration the aberration profile of the cornea, viewing the eye as a whole. With ever emerging technology, the objective has shifted from the correct spherical equivalent to the best uncorrected situation for each individual patient, ranging from spectacle independence at distance, the best unaided near and distance acuity, or simply the highest possible contrast sensitivity.

And if these new, more demanding requirements were not enough, in a busy clinical environment, we also need technology that is able to obtain this information in both a precise and efficient way that is also comfortable for the patient.

Refractive Cataract Surgery

In my practice I consider all cataract patients as refractive surgery cases. All cases are examined with the Pentacam to determine possible corneal abnormalities or irregularities, corneal asphericity and at the same time to detect possible refractive surgery procedures performed elsewhere.

During a single two second examination, we are also able to document the density of the lens nucleus to objectively support the diagnosis of cataract diagnosis, which could be required for insurance or medico legal purposes. (**Appendix 1**).

Selecting an IOL Type

As soon as we started routinely evaluating our cataract patients with the Pentacam™, we noticed a tendency towards irregularities of curvature and a steepening of the corneal periphery as the patients became older

Appendix 1

Pentacam™: Clinical Application or Scheimpflug Principles

The Oculus™ Pentacam™ is a rotating Scheimpflug video camera that generates images from the anterior surface of the cornea to the posterior surface of the lens. It acquires a total of 50 images in approximately two seconds, extracting 2,760 true elevation points from these images which in turn generates 138,000 true elevation points for both the corneal front and back surfaces, from limbus to limbus, including the center of the cornea, a major advantage over keratometers and Placido-based corneal topographers.

We can obtain reports on anterior and posterior corneal topography and elevation maps, corneal pachymetry maps, as well as several options of anterior segment imaging that are not relevant to this subject. The Scheimpflug principle [3] corrects optical aberrations that are inherent to other slit-based instruments and the system integrates advanced software that compensates for minor eye movements that may occur during the test.

The Pentacam™ measures both the anterior and posterior corneal surfaces, calculating the power of the anterior surface using the difference between the refractive index of air (n=1) and the refractive index for corneal tissue (n=1.376). The power of the posterior surface is calculated using the difference between the refractive index for corneal tissue (n=1.376) and the refractive index for aqueous humor (n=1.336). This provides us with a map of the True net corneal power that can differ quite significantly from Placido-based topographic values which use a refractive index of 1.3375 and do not consider posterior surface, especially in patients with previous refractive surgery.

Concerning the accuracy and repeatability of the exam, there are several studies that confirm this technology as highly reliable. [4] [5] [6]

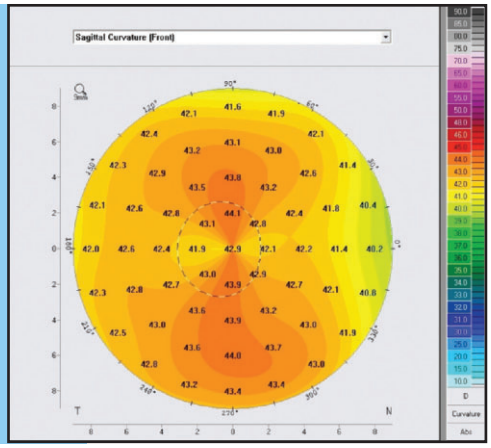

Figure 1. Sagittal curvature corneal map of a young patient: Symmetrical and steeper at the center and flatter at the periphery.

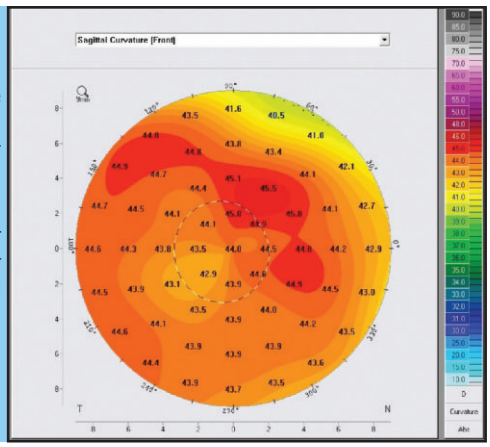

Figure 2. Sagittal curvature corneal map of a 74 year old patient: Irregularities in the mid-periphery with steepening in the periphery.

(**Figures 1 and 2**). These changes appear to be quite common, but they vary in severity from case-to-case, with some patients preserving their corneal shape with minimal, or no changes.

The recent availability of IOLs with different aspheric profiles has made the Pentacam™ indispensable for measuring asphericity of the cornea. Most eyes have positive anterior corneal spherical aberration (**Figure 3**) and will do better with an aspheric IOL that adds negative spherical aberration.

However, in some cases, where the central cornea is quite steep, an aspheric IOL without the addition of negative spherical aberration is the better choice. Conversely, those patients with Keratoconus or previous hyperopic LASIK (**Figure 4**) may have improved post-operative contrast sensitivity following the implantation of a spherical IOL that adds a small amount of positive spherical aberration.

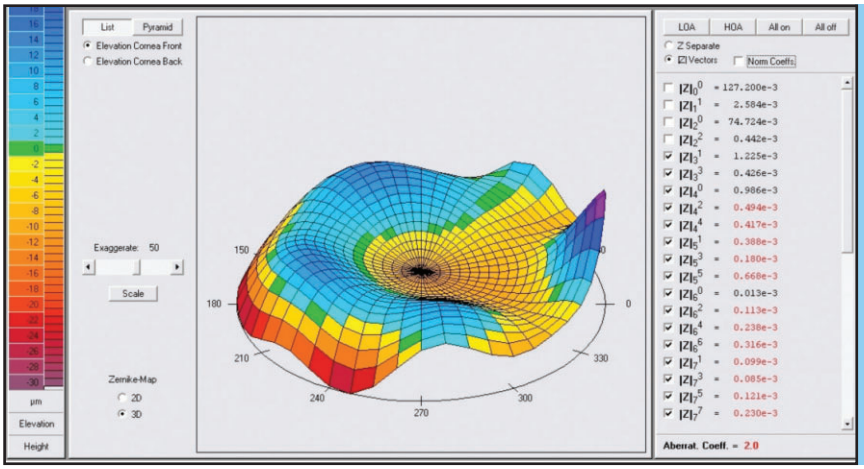

Figure 3. Zernike Analysis obtained with the Pentacam from the anterior corneal surface of the same patient whose topography is shown in Figure 2. The cornea presents a positive spherical aberration and an AcrySof™ IQ™ IOL was chosen to be implanted. The information is derived from the same exam that gave the topographic map and at the lower right corner presents a global corneal aberration coefficient.

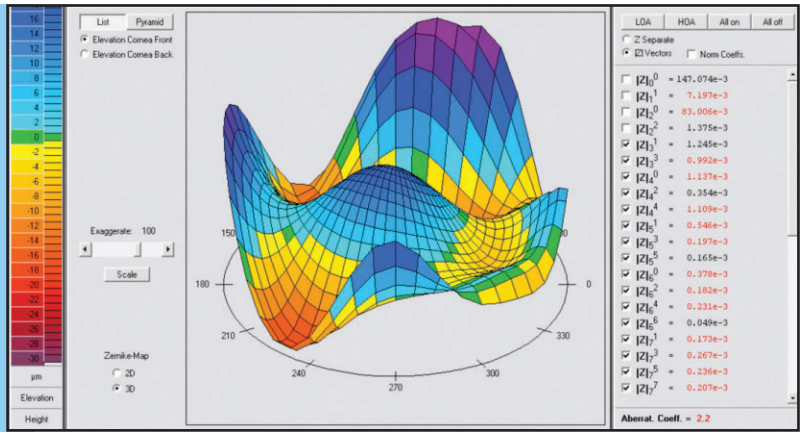

Figure 4. Zernike analysis of a case with previous hyperopic LASIK, presenting with a negative spherical aberration. The map is clearly the opposite than the case shown in Figure 3 and a spherical IOL was implanted, resulting in a decrease of total ocular aberration and better visual quality.

Patients with a high aberration coefficient, like the case presented in Figure 3, are more likely to have visual complains if a diffractive lens is implanted. These patients are told in advance about this possibility and also that a wavefront corneal ablation could be required to improve the quality of their vision, two to three months after the cataract surgery.

Soon-to-be-released Pentacam™ software versions will provide us with more complete information, such as consolidated anterior and posterior surface aberrations and a calculation of indexes that have a widespread acceptance, such as aberration values in RMS microns.

IOL Power Calculations Using the Pentacam™

If, prior to surgery, we have confirmed with the Pentacam™ that the patient does not have corneal pathology, or evidence of previous corneal refractive surgery, after deciding the IOL type to be implanted, in most of our patients we usually proceed with the IOL power calculation using the IOL Master™ K readings and the Haigis formula with all three lens constant optimized to determine the power of the IOL to be implanted.

However, in cases with previous refractive surgery (**Figures 4 and 5**) the keratometric readings based only in anterior corneal curvature, such as those obtained with a Placido-based topography or a keratometer, will give an erroneous value, because they are unable to measure the posterior corneal radius. These instruments also assume that the ratio between the posterior and anterior corneal radii is 82%, a relationship that is changed following all types of ablative procedures. In addition, topographers and keratometers are blind to the exact center of the cornea and must extrapolate this information. As explained in the Appendix, the Pentacam™ can do both and improves the accuracy of the corneal power measurement.

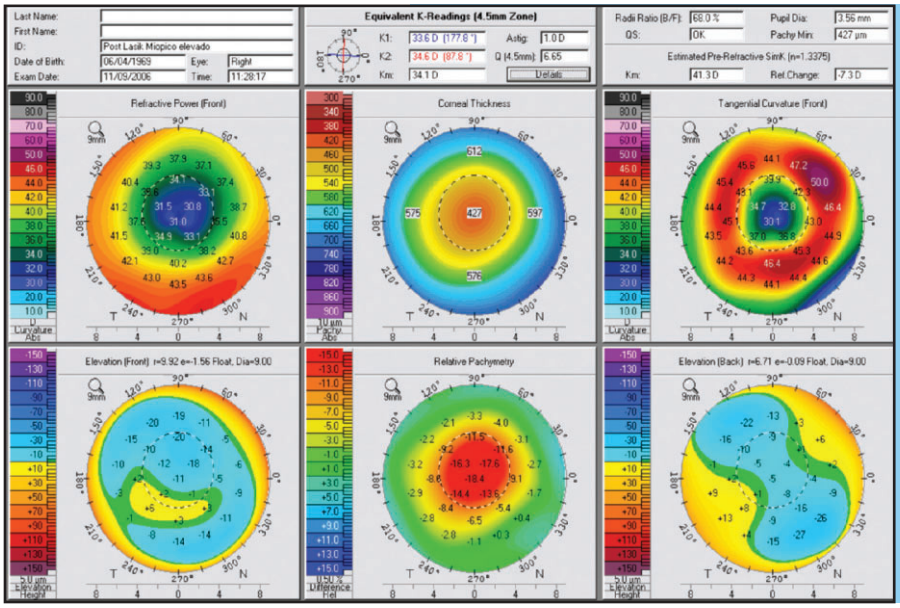

Figure 5. Holladay Report obtained from a case with previous myopic LASIK surgery. The Back to Front corneal radii ratio is 68% instead of the 82% assumed by all Keratometers and Placido based corneal Topographs. The central top panel presents Equivalent K-readings at the 4.5 mm central Zone, a value that can be used in the Holladay 2 IOL Formula (contained within the Holladay IOL Consultant™).

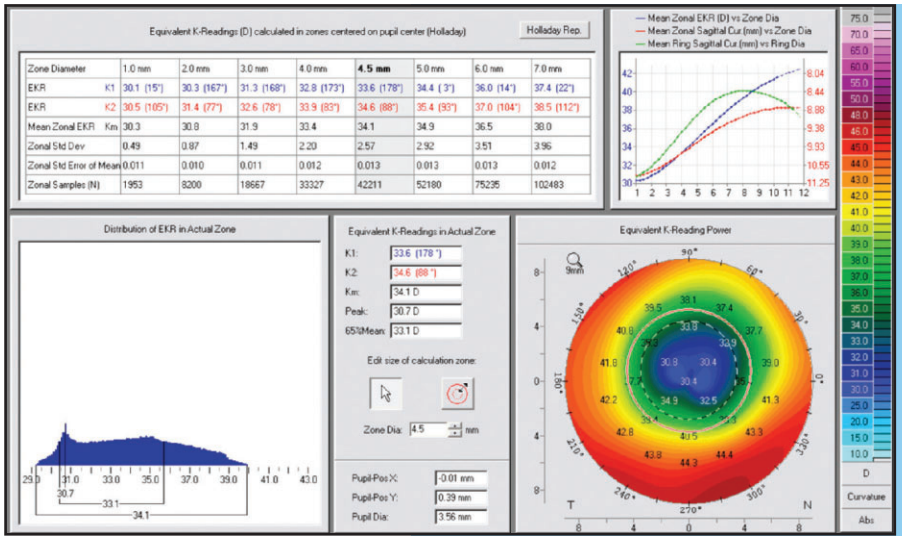

Figure 6. The detailed Holladay Report allows you to obtain Equivalent K-readings for different corneal areas, from 1.0 to 7.0 mm, either at the superior table in fixed steps or in a lineal mode at the central pane. The graph shows the distribution of EKR in the selected zone.

The Holladay Report, a module developed by Oculus with Dr. Jack T. Holladay, is presented in **Figures 5 and 6.** It gives the physician a realistic measure of the optical power of the cornea at different zones, as well as an estimation of the preoperative simulated K readings.

The ophthalmologist has to be aware that, although these values are more precise than those obtained with other instruments, they can only be used to calculate the IOL power in formulas that consider the origin of the data, like the BESSt or Holladay 2 formulas.

Calculation methodologies such as the Aramberri Double-K [2] method or the Haigis-L formula were developed using K readings obtained from keratometers and could give incorrect results a central corneal power from the Pentacam™ is used. Likewise, the physician will introduce additional error sources by violating the assumptions contained in most 3rd generation, 2-variable formulas, affecting the estimation of the postoperative effective lens position (ELP), which determines the effective power of the implanted IOL.

I have obtained excellent results using the free online service from the American Society of Cataract and Refractive Surgery (ASCRS), developed by Warren Hill, M.D., Li Wang, M.D., Ph.D. and Douglas D. Koch, M.D., that is available at: http://iol.ascrs.org/

This online calculator can be used to carry out IOL power calculations for eyes that have undergone myopic and hyperopic LASIK or PRK with the EKR measured at 3.7 mm. Depending on the ablation profile some surgeons prefer the 2.0 mm or the 3.0 mm EKR [3].

The estimation of IOL power after radial keratotomy has not been so precise in my cases and we are still working to find out what is the optimum corneal zone that correlates best with the IOL power and postoperative refractive result.

There are not yet many references in the literature regarding IOL power calculations for patients who present with ectatic corneal problems. They will become a more frequent and difficult challenge in the future. Calculations may be even more complex for patients who have had intracorneal implants placed and go on to develop cataracts. Here, the EKR at central zones may be very helpful. At the time I write this article I have patients who presented with posterior subcapsular cataracts and keratoconus. They received INTACS™ several months ago and are now waiting for the corneal curvature to become stable before they undergo phacoemulsification through a scleral incision, but the best method for performing an IOL power calculation in such a case has yet to be established.

Conclusions

The Pentacam™ provides us with a comprehensive, precise and valid measurement of corneal power and optical aberrations, that allows the ophthalmologist to make better decisions regarding the IOL design and power to be implanted in both cataract and refractive lens exchange patients, particularly in cases with abnormal corneas, either from ectatic conditions or previous keratorefractive surgery.

The measurement obtained from the Pentacam™ in abnormal corneas should be used in combination with formulas designed for this particular instrument, otherwise, the results may be inaccurate. Additional effort has to be made to improve these formulas and to determine the optimal EKR zone for specific cases.

REFERENCES

For detailed and complete References, please visit "Journal Bibliography Section" at our webpage: www.thehighlights.com

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