Assessment of Corneal Optical Quality for Premium IOLs with Pentacam

Naoyuki Maeda, MD

With the new advancements in cataract surgery, the safety and the efficacy of the procedures utilized have been more and more remarkable than ever. As a result, the indication of cataract surgery has been expanding, and the expectations of cataract patients to the post-surgical results have been raised.

The introduction of premium intraocular lenses (IOLs) or new technology IOLs such as multi-focal IOLs, toric IOLs, and aspherical IOLs enabled us to modify the optical property of the eye post-operatively with the tailor-made fashion. Although the choice of IOLs except for the power was not so critical from the patient's point of view in the days when only the spherical IOLs were available, the post-operative satisfaction of the patients can be currently altered not only by the IOL power but also by the optical characteristics of the IOL.

Therefore, it is important for cataract surgeons to understand the life style of each patient, the ocular pathology, and the optical quality of the eye before surgery.

In this article, the assessment of corneal optical quality with Pentacam for the selection of premium IOLs will be introduced as the example and the importance of the screening procedure with the corneal topographer before cataract surgery.

Corneal Topography for Selecting Premium IOLs

At clinics where new technology IOLs are available, surgeons have to select one particular IOL from at least four kinds of IOLs for each patient. It will be necessary to evaluate the optical quality of the cornea during the pre-operative evaluation because suboptimal optics of the cornea or post-operative refractive error may spoil the premium IOL implantation.

We have been proposing four steps in the interpretation of corneal topography before performing cataract surgery as shown in **Table 1**.

Table 1: Four Steps in the Interpretation of Corneal Topography.

Step 1: **Evaluation of corneal irregular astigmatism**	Check the irregular astigmatism with the refractive power map qualitatively, and with total HOA quantitatively. The current cut-off value of less than 0.3 µm (RMS, 4mm) for multifocal IOLs, and more than 0.5µm (RMS, 4mm) for the informed consent about significant irregular astigmatism is important.
Step 2: **Detection of abnormal corneal shape**	Check the abnormal corneal shape with the axial power map qualitatively, and with sagittal front-back ratio quantitatively. Determine whether to select the routine method or special method for IOL power calculation.
Step 3: **Evaluation of corneal spherical aberration**	Check the corneal spherical aberration. The tentative cut-off value of 0.1µm (RMS, 6mm) or higher for aspherical IOL and less than 0.1µm (RMS, 6mm) for spherical IOL.
Step 4: **Evaluation of corneal cylinder**	Compare the magnitude and axis of cylinder between K readings and wavefront. Consider surgical correction of regular astigmatism depending on the magnitude and axis.

Department of Ophthalmology, Osaka University Graduate School of Medicine , Japan.

The Pentacam HR (OCULUS, Germany) is one of the instruments categorized as slit scanning corneal topographer or Scheimpflug-based corneal topographer. We had a chance to develop a program with which the four steps of the screening procedure were easily performed.

Similar to the manual keratometer, it is very important for the interpretation of the topographic data to confirm the reproducibility of the data. Especial attention should be paid to very elder patients, patients with narrow palpebral fissure, or patients with poor fixation during measurement. If QS (quality specification) in the map is indicated with red color, the data should not be used. In doubt, the measurements should be repeated at least twice for each eye until reproducible topographic maps are obtained.

Figures 1, 2, 3 are the examples of the output. This program consists with 3 topographic maps, one Scheimpflug image, and one data box. The upper left is the axial power map using anterior surface data with keratometric refractive index (1.3375). This map is used to diagnose the abnormality in corneal shape. The upper center is the map of the total corneal refractive power. The total corneal refractive power (n=1.376 for cornea, n=1.336 for aqueous) is calculated from anterior and posterior refractive powers of the cornea and used for IOL power calculation for the patients with corneal shape abnormality such as post-LASIK, post-PTK, and post-keratoplasty. The upper right is the corneal pachymetric map. This map can be used to check the thickness at the main incision and at the side ports. The Scheimpflug image can be used to show the cataract to the

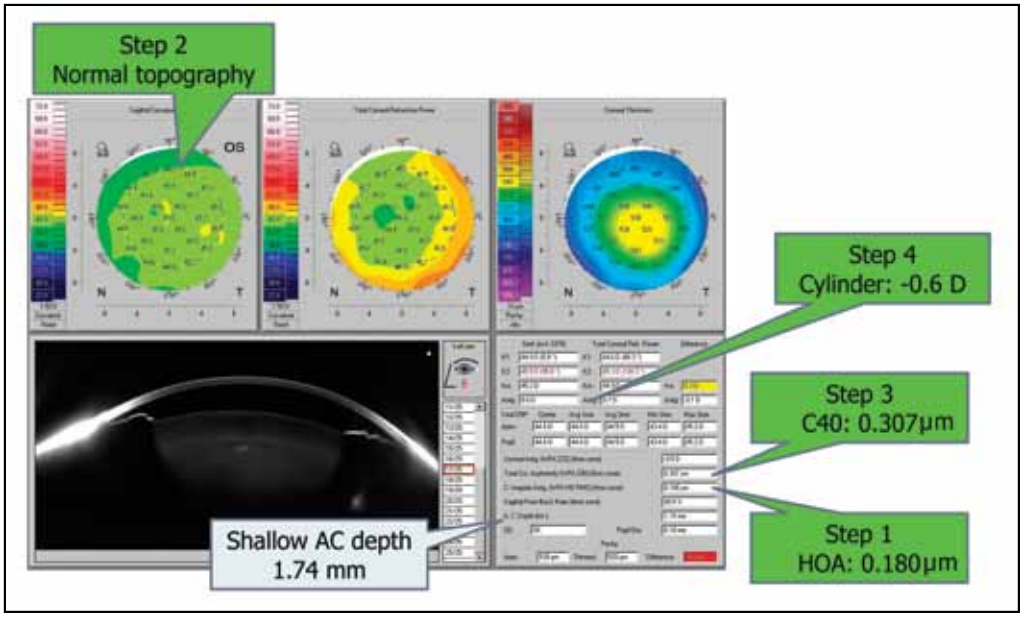

Figure 1: Normal cornea with shallow anterior chamber: Total HOA (0.180 µm), spherical aberration (0.307 µm), front-back ratio (80.5 %), and cylinder (-0.5 D) are within normal ranges. Either multifocal aspherical IOL or monofocal aspherical IOL is fine in terms of optical quality of the cornea although anterior chamber is shallow (1.74mm).

patients and also to check the anterior chamber depth. The data box shows topographic indices including total corneal refractive power, corneal irregular astigmatism (total higher-order aberration), corneal spherical aberration, and corneal cylinder. In addition, simulated K readings, anterior chamber depth, pupil diameter, corneal thickness and others are available.

Step 1: Evaluation of Corneal Irregular Astigmatism

Even if there were no problems for performing cataract surgery in patients with mild pterygium, subclinical keratoconus, or mild corneal scar, irregular astigmatism

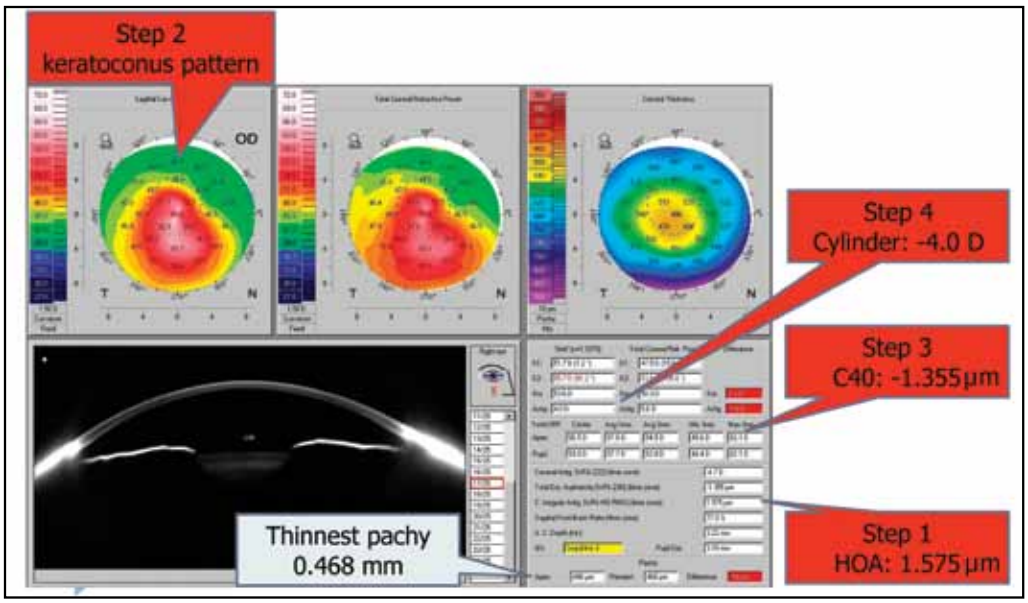

Figure 2: Moderate keratoconus: Total HOA (1.575 µm) is high and spherical aberration (-1.355 µm) is too low. Conventional spherical IOL is recommended with the informed consent for the effects of corneal irregular astigmatism on quality of vision.

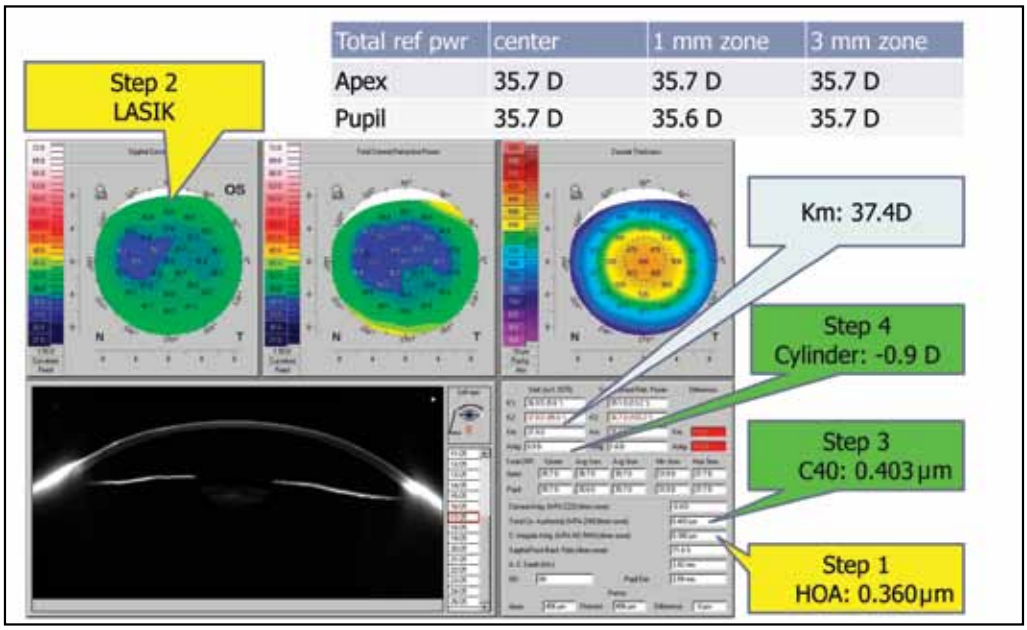

Figure 3. Post-LASIK: Total HOA (0.360 µm) shows mild irregular astigmatism and spherical aberration (0.403 µm) is relatively high but within normal range. Monofocal aspherical IOL is recommended with the aid of special IOL formulas for post-LASIK.

due to these corneal diseases might affect the quality of vision of the eye after surgery.[1] When cataract surgeries were only performed in the cataract patients with advanced visual loss, surgeons might not need to pay attention to such mild irregular astigmatism because of the remarkable improvement in their visual acuity. However, mild irregular astigmatism can be the cause of the dissatisfaction of the patients when post-operative visual acuity or contrast sensitivity was not improved as expected due to the irregular astigmatism in the patients with relatively mild cataract and in the patients with the premium IOL.

Pre-operative evaluation of corneal irregular astigmatism and the informed consent about the effects of corneal irregular astigmatism on quality of vision will be useful for avoiding the claims after surgery even for the candidates of conventional IOLs.

As show in the improvements of results following multi-focal IOLs by the aspherical design, mild increase of HOAs can be the cause of suboptimal results with the multifocal IOLs.

Currently, we set the cut-off value in total higher-order aberrations for 4mm diameter to 0.3 μm for mild irregular astigmatism, 0.5 μm for moderate irregular astigmatism.

Step 2: Detection of Abnormal Corneal Shape

After many years, Laser in Situ Keratomileusis (LASIK) has become popular and established a position in the correction of refractive errors. As the results, avoiding post-operative refractive errors following cataract surgery in the post-LASIK patients have been a subject of discussion. Although these patients are generally interested in the good uncorrected visual acuity following cataract surgery, it is well-known that the hyperopic shift in post-operative refraction is frequently seen with the conventional power calculation.

For preventing the post-operative errors in such patients, it is important to review the topographic map so as not to overlook the abnormal corneal shape. In the case of post-LASIK patients, special methods should be considered for the calculating IOL power,[2] and the total corneal refractive power can be used in the no history methods.

Step 3: Evaluation of Corneal Spherical Aberration

Aspherical IOLs are widely applied for correcting the average corneal spherical aberration.[3] However, the wide range of variation in corneal spherical aberration exists even in the normal population. In addition, higher positive spherical aberration in myopic LASIK[4] and lower negative spherical aberration in hyperopic LASIK and keratoconus are reported. It will be reasonable to measure the corneal spherical aberration while choosing aspherical IOL or spherical IOL. We set the cut-off value to 0.1 μm or higher for aspherical IOL at this moment.

Step 4: Evaluation of Corneal Cylinder

Toric IOL is effective to obtain good uncorrected visual acuity in patients with regular corneal astigmatism. However, implantation of a toric IOL for patients with severe irregular corneal astigmatism is considered as a contraindication. Therefore, it is critical to evaluate not only corneal regular astigmatism with manual keratometer but also corneal total higher-order aberration with corneal topographer. Also the comparisons of magnitude and axis of regular astigmatism between manual keratometer and wavefront derived value may be helpful to confirm the reproducibility of data.

Summary

As the optical quality of the cornea in candidates of cataract surgery is not always in good condition, it seems to be rational for cataract surgeons to screen the corneal topography in order to select the premium IOLs with the tailor-made fashion for optimizing the optical quality of the eye following cataract surgery. All the cut-off values written above are tentative, and the accumulations of the results and the verification of the usefulness will be necessary to establish the topographic screening system before cataract surgery.

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