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CASE REPORT

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Bilateral Keratoconus: a Cataract Preoperative Assessment Incidental Finding. Role of Tomography in Biometry and Multifocality of Cone Effect

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ABSTRACT

Background: *Implantation of intraocular lenses (IOLs) for full refractive correction at all distances is the ideal goal for cataract surgery. A comprehensive examination is pivotal to identify corneal pathology such as keratoconus, in order to achieve optimal outcomes with selection of premium or monofocal IOLs.*

Case report: *A 57-year-old male presented for cataract surgery preoperative assessment. Ophthalmological examination indicated an unremarkable condition, while his files did not report any previous ocular pathology. The patient had high expectations for optimal refractive outcomes without spectacles and therefore, implantation of premium IOLs was considered. Preoperative biometric measurements using IOL Master 700 demonstrated a non-significant anterior corneal astigmatism in both eyes. The central corneal topography maps revealed an asymmetric colour appearance indicative of irregular astigmatism in the right eye, while colour gradation towards higher dioptres was present in the left eye. Despite not being pathognomonic for clinical ectasia, these visually relevant asymmetries warranted further investigation. Additional corneal tomography using Pentacam Scheimpflug imaging revealed an inferior symmetrical well-delineated mild keratoconus. Therefore, the selection of monofocal spherical IOL was decided. The patient had uneventful phacoemulsification bilaterally. At one month postoperatively, his unaided visual acuity at distance was 20/20 in both eyes, he could perform a Jaeger 2 scale for near vision, while subjectively had no complaints of unwanted photic phenomena.*

Conclusion: *Our case highlights that a detailed corneal evaluation may add value to appropriate decision making concerning the selection of IOL implant for optimal visual outcomes. In addition, an enhance depth of focus might be provided postoperatively in selected mild keratoconic cases.*

Keywords: IOL Master 700, Pentacam, premium IOL, enhanced depth of focus, keratoconus.

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BACKGROUND

Variable types of intraocular lenses (IOLs) are widely used to offer satisfactory visual outcomes and achieve spectacle independence after cataract surgery (1). Several types are available at present; conventional IOLs are monofocal, while premium IOLs have been designed to allow full refractive correction at near, intermediate and distance vision. Indeed, the ideal goal for cataract surgery would be implantation of IOLs that provide optimal outcomes to patients concerning their vision (2, 3).

Given the high sensitivity of premium IOLs to ocular aberrations, preoperative selection of patients is crucial to patient satisfaction. Corneal pathology such as keratoconus, peripheral corneal degenerations, corneal scarring, irregular corneal surface (Fuchs dystrophy), dry eye or macular dysfunction (epiretinal membrane, macular degeneration) are relative contraindications to premium IOL implantation because visual expectations may not be met. A comprehensive examination with corneal topography or tomography would contribute to clinical decision making for the optimal choice of IOL implant. Nonetheless, access to this equipment may be limited and, in that case, cataract surgery with premium IOLs may be compromised (2, 3).

IOL Master 700 (Carl Zeiss Meditec AG, Jena, Germany) has extensive application in preoperative assessment of cataract surgery. It has been recently upgraded to incorporate central corneal topography with a swept-source Optical Coherence Tomography (OCT) based algorithm and telecentric keratometry. Based on this, IOL Master 700 has capability to detect visually relevant asymmetries on central corneal shape along with the standard biometric measurements (4, 5). However, the captured area of corneal topography is more limited than that measured by Pentacam (Pentacam, Oculus Incorporation, Wetzlar, Germany) equipment. Indeed, a detailed corneal evaluation would add value to appropriate decision making concerning the selection of IOL implant (6, 7).

The purpose of this paper is to present a typically suitable patient-candidate for cataract surgery with premium IOL and the subsequent change in our management after comprehensive preoperative assessment with central topography technology and an additional Scheimpflug tomography exam; preoperative evaluation, choice of management and postoperative functional outcomes are described herein. ❑

CASE REPORT

A 57-year-old male presented to 251 Hellenic Air Force General Hospital for cataract surgery preoperative assessment. The patient was a retired fighter pilot previously flying combat F-16 aircrafts in Hellenic Air Force. This profession has high demanding visual requirements; therefore, as a part of a mandatory "fit to fly" waiver, fighter pilots undergo a regular annual comprehensive ophthalmic examination by the Hellenic Air Force Center of Aviation Medicine. Until that point, no remarks regarding any previous ocular pathology were written in his files.

Ophthalmological examination indicated an unremarkable anterior segment apart from the developing cataracts and fundoscopy showed a healthy appearance of retina, macula and optic disc. Optical coherence tomography (OCT) in the macular area indicated normal morphological structure of retinal layers, photoreceptors and retinal pigment epithelium. Given the patient's high expectations to achieve the best possible refractive outcome with restoration of vision for near and distance without spectacles after cataract surgery, implantation of premium IOLs was considered as an appropriate option. Following detailed counseling with the patient regarding types of IOLs and his requirement to 'enhance his range of vision', the use of extended depth of focus (EDOF) IOL was proposed. This option would provide him conceivable high level of satisfaction and enhanced depth of focus, as requested, by minimizing the effect of adverse optic phenomena (8). The patient agreed to proceed with cataract surgery and EDOF IOL implantation and therefore, subsequent further assessment was arranged.

Preoperative biometric measurements were obtained using IOL Master 700 (Carl Zeiss Meidtec AG, Jena, Germany) which is used as a gold standard in our department. In particular, IOL Master 700 K measurements demonstrated a non-significant anterior corneal astigmatism with the difference between Ks (?K) being -0.67 D in the right eye and -0.19 D in the left eye. Based on a fairly new software, central corneal topography mea-

surements for the anterior refractive powers, as well as the central corneal curvature data were displayed utilizing the swept-source OCT-based algorithm of the IOL Master 700 to detect visually relevant asymmetries on the central corneal morphology. The central corneal topography maps in the right eye raised suspicion for an asymmetric colour appearance indicative of an irregular astigmatism (Figure 1a), whereas the left eye image was categorised as normal; however, a colour gradation towards higher dioptres was also present (Figure 1b). Despite not being pathognomonic for specific clinical pathology or clinical ectasia cases, the asymmetry captured by the anterior axial power corneal topography map was a reason to proceed with an additional biometry in order to secure an accurate result and avoid any possible missing information from the cornea, given the fact that premium IOL was planned and the patient had a demanding nature, which both warranted further investigation.

Additional corneal tomography evaluation was performed using Pentacam Scheimpflug imaging (Pentacam AXL, Oculus Incorporation, Wetzlar, Germany). The Pentacam map revealed an inferior symmetrical well-delineated mild keratoconus, which was identified outside of the central zone that is typically evaluated by the standard central three-zone telecentric keratometry utilized by IOL Master 700 to calculate Ks (Figures 2a and 2b).

In view of the above findings, both the type and power of IOL implant had to be reconsidered. Given the diagnosis of keratoconus, the selection of a monofocal spherical IOL was considered from the perspective that it could provide satisfactory postoperative outcomes for vision. A spherically neutral IOL with uniform power throughout the lens compensating for common levels of decentration as well as reducing potential optical aberrations would optimize the outcomes due to the concomitant diagnosis of underlying keratoconus. Therefore, the decision was made for enVista (Bausch & Lomb, Rochester, NY, USA) IOL as the most suitable option (9). A number of IOL formulas were advised, which rendered similar IOL power numbers for an emmetropic towards the first myopic result.

Following an informed consent in view of our new findings and options, the patient had uneventful phacoemulsification with monofocal enVista IOL implantation bilaterally in a sequential order. At one month postoperatively, his vision was subjectively excellent with no complaints of unwanted photic phenomena such as glare, halos or dysphotopsia. His unaided visual acuity at distance was 20/20 in both eyes and, surprisingly, he could easily preform a Jaeger 2 scale during his near vision test. This outstanding and unanticipated near vision outcome may be possibly attributable to changes in refraction caused by the inferior corneal steepening secondary to keratoconus. ❑

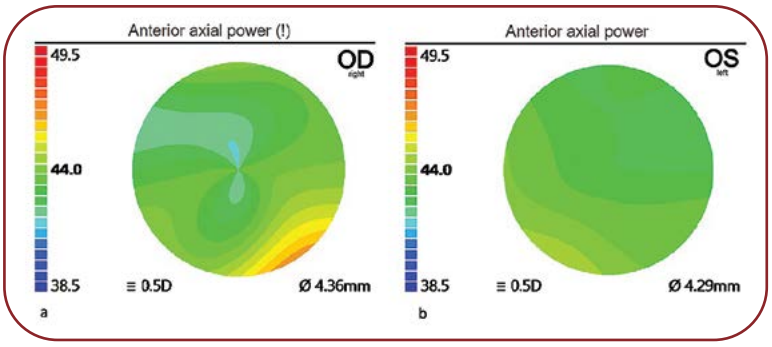

FIGURE 1. IOL Master 700 central corneal topography maps: (a) right eye asymmetric colour appearance indicative of an irregular astigmatism; (b) left eye image fairly normal with a colour gradation towards higher dioptres inferiorly

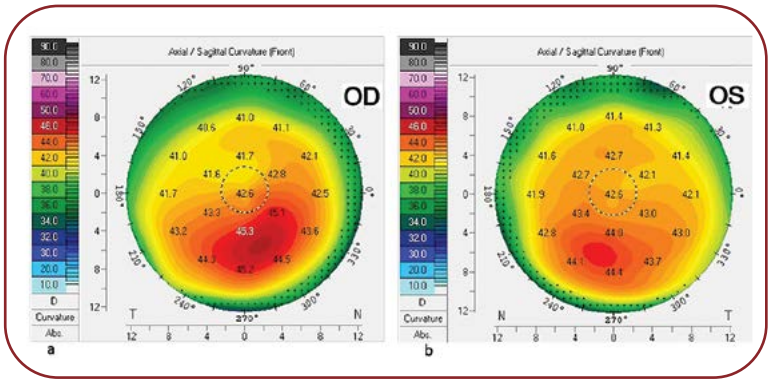

FIGURE 2. Pentacam axial maps. Inferior symmetrical well-delineated mild keratoconus in both eyes identified outside of the central zone typically evaluated by standard central three-zone telecentric keratometry utilized by IOL Master 700; good correspondence with central corneal topography maps from Figure 1: (a) right eye; (b) left eye

DISCUSSION

The ideal goal for cataract surgery would be implantation of IOLs that offer full refractive correction for variable distances to achieve the best outcomes for postoperative vision (1). Indeed, for clinicians, the practical utility of equipment for optimal decision making represents a challenging need (2, 3).

IOL Master 700 has been widely used in preoperative assessment for cataract surgery by providing biometric measurements for IOL power calculation. It also provides corneal curvature data obtained with telecentric keratometry from 18 reference points in hexagonal patterns at approximately 1.5, 2.4 and 3.2 mm optical zones around the center of the cornea, also incorporating a unique feature of color coded central corneal topography (10). The color scale and hues of the central topography provide a useful tool for optimal interpretation of the results. In particular, green represents 44 D, while the default color scale window for normal cornea ranges from 39 to 49 D in 0.5-D steps with 21 colors. In cases of very steep/flat corneas, as well as highly aberrated or irregular cases, the color scale might differ. A major benefit of this feature is that central topography may be obtained during biometry measurements with the same device (11). In our case, IOL Master 700 measurements indicated normal biometric and keratometric values, while the patient did not have any astigmatism preoperatively. Notably, astigmatism or refractive error had not been recorded previously during patient's annual thorough clinical evaluation as a fighter pilot as well. However, the central topography maps in preoperative assessment indicated corneal asymmetry, and therefore, it alarmed us to proceed with a more extensive corneal evaluation. Further imaging by utilizing the Pentacam AXL (Pentacam AXL, Oculus Incorporation, Wetzlar, Germany) tomography maps revealed the underlying bilateral keratoconus. After detecting the first Purkinje image, the rotating Scheimpflug camera of the Pentacam AXL (Pentacam AXL, Oculus Incorporation, Wetzlar, Germany) captures 138000 data points from the whole cornea and calculates the conventional keratometric values from the central 3 mm zone, also providing a total cornea tomographic imaging, being today the reference standard for diagnosis and monitoring ectatic diseases (12). In view of the findings, we reconsidered the selection of both the type and power of IOL.

One of the significant considerations during IOL choice in keratoconic eyes is the sphericity of both the cornea and IOL. Savini et al show that corneal asphericity can influence the refractive outcome following IOL implantation (13). Keratoconic eyes are steep and aspheric having a large negative Q value, hence adding an IOL with a negative Q value may not be the best option. Instead, adding an IOL with a Q value of 0 or with a positive Q value may have better refractive and visual outcomes. Patients with keratoconus and cataracts present also challenges to IOL calculations since accurate keratometry (K) and axial length measurements are difficult. Optical biometry in eyes with KCN typically overestimates the corneal power and underestimates the IOL target power resulting in postoperative hyperopia (14). As a result, estimating corneal power and selecting IOL power is sometimes inaccurate or unable to be performed. In our case, the K values were well within normal eye average limits, with any corneal tomographic abnormality being away from the central 4 mm from the visual axis optical zone. So, we used the actual K values that were provided by our biometries, which is the advised option for eyes with a mean K of ≤ 55 D (14), targeting a close to zero towards myopia with good results. In addition, the contour of the keratoconic cornea renders it multifocal, but the visual axis is not at the apex of the cornea, which commonly generates asymmetric astigmatism, a challenge for refractive surgeons. Interestingly, our choice of monofocal IOLs in this case indicates the optimal visual outcomes postoperatively, thus providing evidence that the location of the symmetrical bilateral mild inferior keratoconus might have given the patient an enhanced depth of vision.

A pivotal point to consider is that IOL Master 700 has demonstrated an excellent negative predictive value of 96% as a screening tool for selection of suitable corneas for premium IOLs (15). These results suggest that IOL Master 700 may be able to detect a 'normal cornea' and hence, one may be able to proceed with a premium IOL implantation with good reliability. However, the relatively average sensitivity of 73% may suggest that the instrument may not be 100% reliable in diagnosing all cases of corneal irregularity or ectasia, as suggested by comparisons with the Pentacam map (15). In our case, IOL Master 700 was able to detect a suspicious cornea and provided remarkable information for further evaluation that could lead to precise details about the underlying pathology. However, to the best of our knowledge, the fairly new feature of central corneal topography has not been evaluated in the screening of corneal pathology. Despite the fact that IOL Master 700 was not able to predict the accurate diagnosis of keratoconus, it provided

certain evidence for further investigation with a more thorough corneal assessment, where a Pentacam – in our case – enabled the diagnosis and guided further management. Indeed, additional preoperative assessment might be useful for selection of premium IOLs with instruments measuring more than the central 3 mm such as a number of biometry devices do. On the contrary, Pentacam has the capability to provide measurements outside the central 3 mm and might be able to diagnose mild, otherwise not seen, subclinical keratoconus. However, IOL Master 700 central topography color mapping may represent a reliable additional screening tool for patients with suspicious corneal characteristics that require further investigation for corneal pathology, ie, keratoconus. ❑

CONCLUSION

In conclusion, our case highlights a number of points that someone has to consider when assessing the suitability of patients for premium IOLs. IOL Master 700 central corneal topography seems to be a reliable device in both diagnosing appropriate corneas and identifying suspicious corneal morphological findings that require further investigation. Scheimpflug tomographic maps, especially in both the version with the combined biometry and Pentacam AXL, provides safe and reliable information for any corneal pathology that may influence premium IOLs outcomes. Additional data are warranted to establish the utility of IOL Master 700 as a screening tool for detection of suspicious corneal morphology and ectatic diseases. However, the central topography maps certainly provide an additional safety toll when evaluating patient's eligibility for premium IOLs. In addition, the potential multifocality of cone position merits a point in preoperative evaluation and type of IOL selection. Certainly, the prediction of potential beneficial effect of the cone in depth of focus remains difficult. However, in our case, the symmetrical off-visual axis and well demarcated cones provide a good clinical insight tool for future studies and routine evaluation. ❑

Data availability: All data are available from the corresponding author upon reasonable request.

Conflicts of interest: none declared.

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Patient written informed consent: obtained from the participant in our study, who agreed to the procedure/treatment and accepted that data could be used for research purposes or publication.

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