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Kappa and alpha angles in preoperative diagnostics of hyperopic patients qualified for multifocal lens implantation using iTrace™ analyser

Adam Cywiński, Olaf Szyja

Silesian Eye Treatment Centre, Poland
Head: Adam Cywiński, MD, PhD

HIGHLIGHTS

The values of the kappa (κ) and alpha (α) angles should be taken into account in the preoperative qualification for the implantation of premium class lenses, especially in hyperopic eyes.

ABSTRACT

The value and location of angles alpha (α) and kappa (κ) in the eyes diagnosed with hyperopia, qualified for premium class lens implantation were subject to evaluation. 67 patients, 101 eyes with hyperopia ranging from +0.5 Dsph to +10.62 Dsph were included into the study. For both angles, α and κ, their most common location is in the inferior temporal quadrant, followed by the superior temporal quadrant. A statistically significant correlation was observed between the value of angles alpha and kappa and the range of hyperopia. In each case the angle value was examined using the iTrace™ analyser.

Key words: angle alpha, angle kappa, hyperopia, cataract, clear lens extraction, iTrace™

INTRODUCTION

Preoperative evaluation of the value of angles kappa (κ) and alpha (α), along with the evaluation of the higher-order aberrations (HOA) generated by the cornea, is slowly becoming an inherent qualification standard for premium class lens implantation. It applies to both cataract patients and patients with a diagnosed refractive error who wish to eliminate it.

In the case of patients qualified for refractive lens exchange (RLE), the implantation of an "incorrect" premium class lens may turn out to be disastrous if you do not analyse the structural elements of the eye that can significantly affect the quality of vision and visual acuity parameters. Preoperative and postoperative quality of vision is a parameter that is rarely evaluated today, and the focus is placed mainly on the evaluation of visual acuity.

The documented influence of the value of the above angles on vision has been the subject of many articles and confirms their indisputable importance in the process of qualification for implantation of premium class lenses, both concentric and asymmetric in their structure [1–3].

The evaluation of HOA generated by the cornea is one of the stable elements of qualification for surgery using a premium class lens [4]. It is worth mentioning that the value of HOA generated by the cornea increases significantly in the eyes where laser correction procedures have been performed. It means that the possibilities of using complex intraocular lenses in such eyes are significantly reduced [5]. Greater eye tolerance with higher HOA values applies to the implantation of premium class lenses with a pure EDOF structure; however, an important qualifying factor in such cases is a sufficiently large pupil size [6].

People with hyperopia constitute a group of patients in the case of whom the values of angles κ, are statistically much higher than those in people with emmetropia or in patients with myopia [7].

An interesting observation has been made concerning patients who underwent implantation of lenses with a value above + 28.0 Dsph. In this group, changes in both, the refractive power (the lens power) and the value of optical aberrations that accompany the movements of the eyeball were observed [8]. These consequences can be considered as one of the reasons that may explain the authors' observation presented in this study. The observation is related to the ability to read to near distances from 30–40 cm without the need for additional correction despite implantation of a monofocal lens. This ability is acquired by some patients with preoperative high hyperopia, who after the procedure become emmetropic. Large preoperative angles α and/or κ are another likely cause of the above phenomenon.

High angles κ and α are also the cause of the intensification of halo and glare symptoms after premium class lens implantation, which significantly reduces the quality of postoperative vision and, in addition, if these parameters are omitted, it can cause many problems for the patient and the doctor.

OBJECTIVE

Evaluation of the value of angles κ and α and their axial location. The examinations were routinely performed using the iTrace™ analyser in patients qualified for lens exchange due to cataract or a diagnosed refractive error. The study group included patients with hyperopia and accompanying astigmatism in the process of qualification for premium class intraocular lens implantation.

The study included 67 patients, 101 eyes. Astigmatism over 0.75 D was observed in 36 eyes. Preoperative values of hyperopia ranged from +0.5 Dsph to +10.62 Dsph, corneal astigmatism ranged from -0.12 Dycl to -4.37 Dcyl. The above values were obtained in the examination conducted using an autorefractometer, which additionally provided keratometric indices.

EXAMINATION TECHNIQUE

Angles κ and α were evaluated 3 times in short time intervals using the already mentioned iTrace™ analyser. The device allows for, among others, separation of the HOA generated by the cornea from the HOA generated by the entire eye. It undoubtedly increases its attractiveness as a diagnostic device (fig. 1).

The author of this study, using this unique function, drew attention to the so far unknown disease entity, being the congenital dysfunction of the patient's own lens [9].

The obtained values of angles κ and α were analysed in terms of their axial location (fig. 2).

Another analysis concerned the evaluation of whether there is a correlation between the value of the angles obtained and the range of hyperopia. The analysis did not consider the spherical equivalent accompanying astigmatism of the optical system and corneal astigmatism of the eye. The two parameters of astigmatism in many cases differ from each other. The eye outline has been divided into four quadrants, two temporal (T) and two nasal (N), superior (S) and inferior (I) where the centre is the visual axis. The analyses were performed separately for the right and left eyes (fig. 3).

RESULTS

Angle κ

Its value determines the position of the pupil centre in relation to the visual axis. The values ranged from 0.924 mm to 0.103 mm, the mean value for all eyes was 0.415 mm. The mean values for both eyes examined separately were

FIGURE 1

A typical result of the HOA analysis of the entire eye in patients with diagnosed hyperopia and astigmatism (letter "E"). Corneal HOA are analysed separately from Internal HOA, which gives the doctor and the patient additional information about the state of the cornea and the lens.

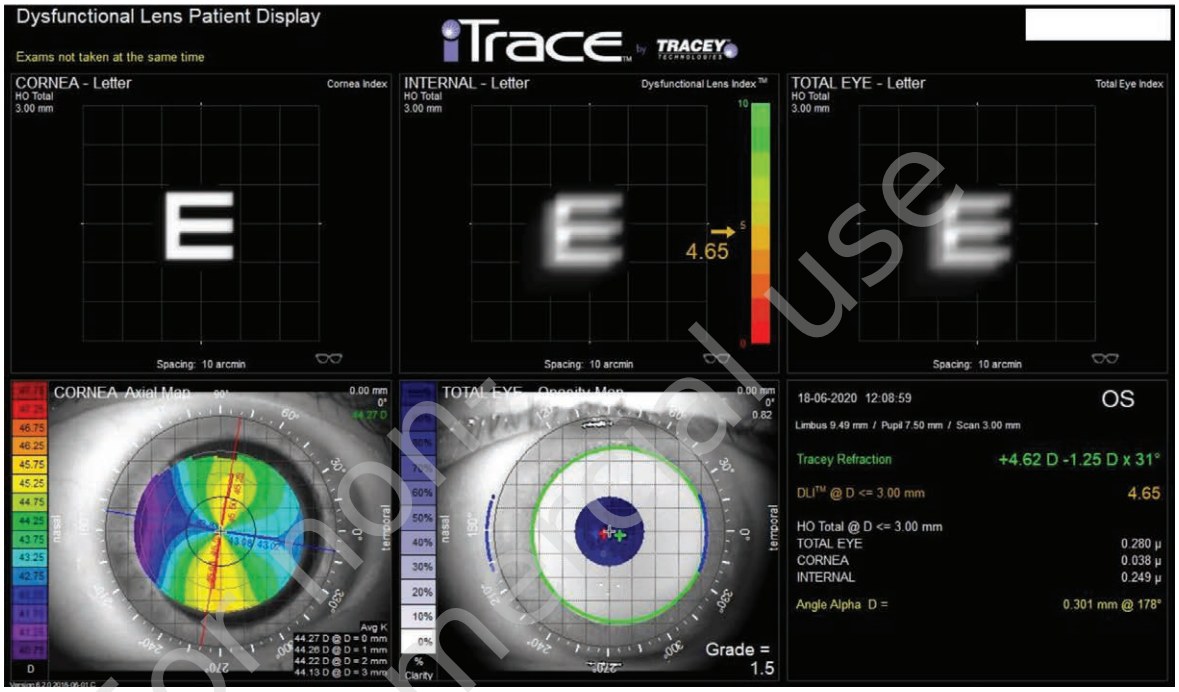


FIGURE 2

The analysis of the location of angle κ and angle α (bottom right). Additional information concerns axes of those parameters. Red colour concerns values which are higher than 0.5 mm, yellow concerns values 0.300–0.499 mm.

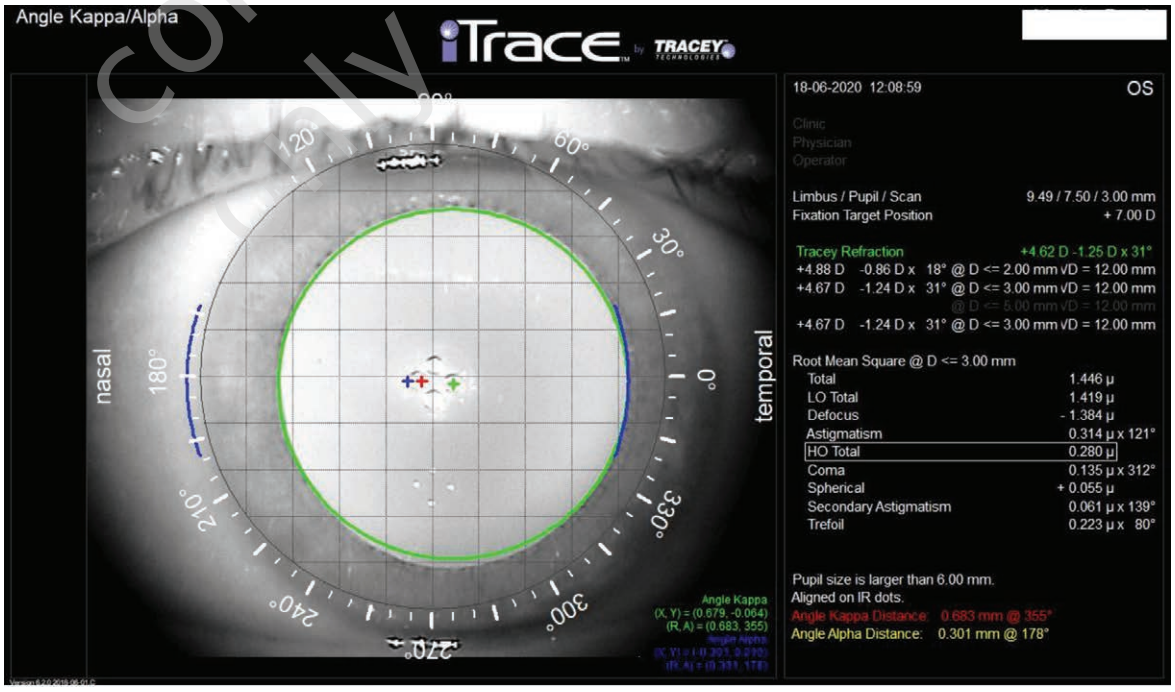
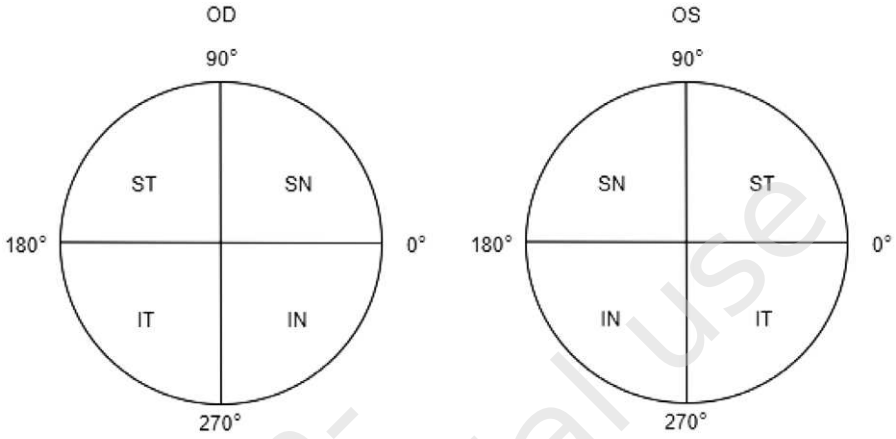


FIGURE 3

Diagram of the division of the eye into quadrants: OD – right eye, OS – left eye, ST – superior temporal, IT – inferior temporal, SN – superior nasal, IN – inferior nasal.



comparable and amounted to 0.410 mm for the right eye and 0.422 mm for the left eye.

A particular analysis of obtained results focusing on these four quadrants shows that the highest percentage of the obtained values was:

- for the right eye – 83.01% (39 eyes) in the inferior temporal quadrant, then in the superior temporal quadrant – 11.32% (6 eyes) and only 5.67% (2 eyes) in the inferior nasal quadrant
- for the left eye – 82.98% (44 eyes) in the inferior temporal quadrant and 17.02% (9 eyes) in the superior temporal quadrant.

The obtained results indicate that the pupil centre in hyperopic eyes is most often located peripherally (temporally) in relation to the visual axis, in most cases in the inferior temporal quadrant.

Analysis of the correlation between the values of the angle and the range of hyperopia

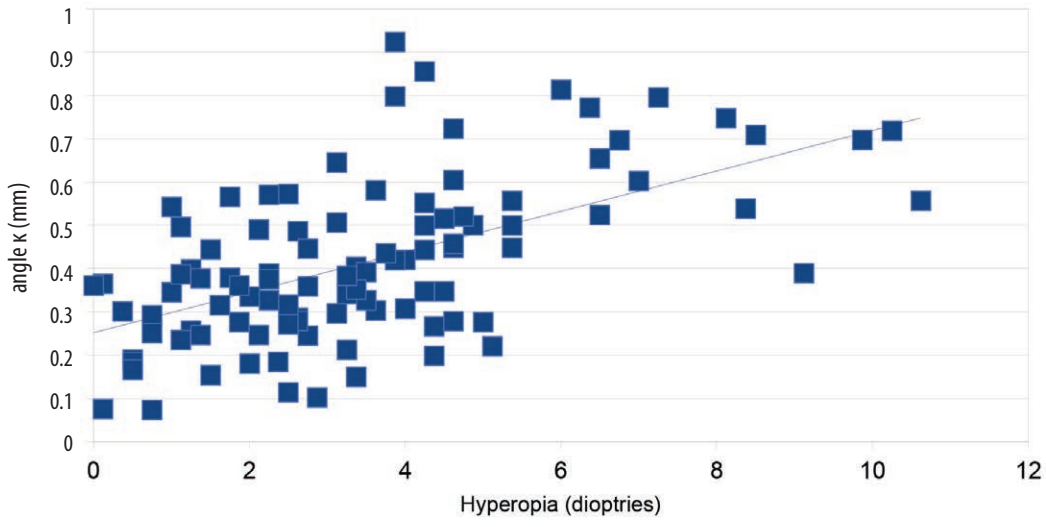
The correlation coefficient between the spherical defect and angles κ was 0.5798. With the significance level of 0.05, there are grounds to reject the hypothesis that the correlation coefficient between the variables is insignificant. This means that the correlation coefficient between these variables is statistically significant. The correlation is statistically significant.

In the case of hyperopia values above 6.0 spherical dioptres (Dsph), the angle values were higher than 0.5 mm. This group of patients accounted for approximately 15% of the examined eyes.

The correlation between the range of hyperopia and the value of angle κ is presented graphically (diag. 1).

DIAGRAM 1

Correlation between hyperopia and angle κ.



The number of eyes depending on the value of the angle is presented in table 1.

TABLE 1

Includes values of acquired angles κ and number of the eyes where there were achieved.

Angles κ (mm)	No. of eyes
0–0.200	12
0.201–0.400	44
0.401–0.600	29
0.601–0.800	13
more than 0.800	3
Total	101

Angle α

Its value determines the position of the optical axis of the visual system in relation to the visual axis. It could be said that the value of angle α indicates whether the eye is positioned in strabismus.

The mean value for the whole group is 0.478 mm, ranging from 1.063 mm to 0.130 mm. There were no statistical differences in the value of the angle for the right and left eyes. Its mean value for the right eye is 0.478 mm, and for the left eye is 0.476 mm.

As for localization, as in the case of angle κ, the axes of angles α were located mainly in the inferior, temporal quadrant. 83.01% of all examined eyes for the right eye, and 82.98% for the left eye. In other cases, the angles were located in the superior temporal quadrant: 11.32% for the right eye and 17.02% for the left eye.

Also, in the case of angles α, a statistically significant correlation was observed between the increasing values of the angle and the range of hyperopia. The correlation coefficient between the spherical defect and angles α was 0.4356. With the significance level of 0.05, there are grounds to reject the hypothesis that the correlation coefficient between the variables is statistically insignificant. This means that the correlation coefficient between these variables is statistically significant. The correlation is therefore statistically significant.

The correlation between the range of hyperopia and the value of angle α is shown graphically (diag. 2).

The number of eyes depending on the value of the angle is presented in table 2.

TABLE 2

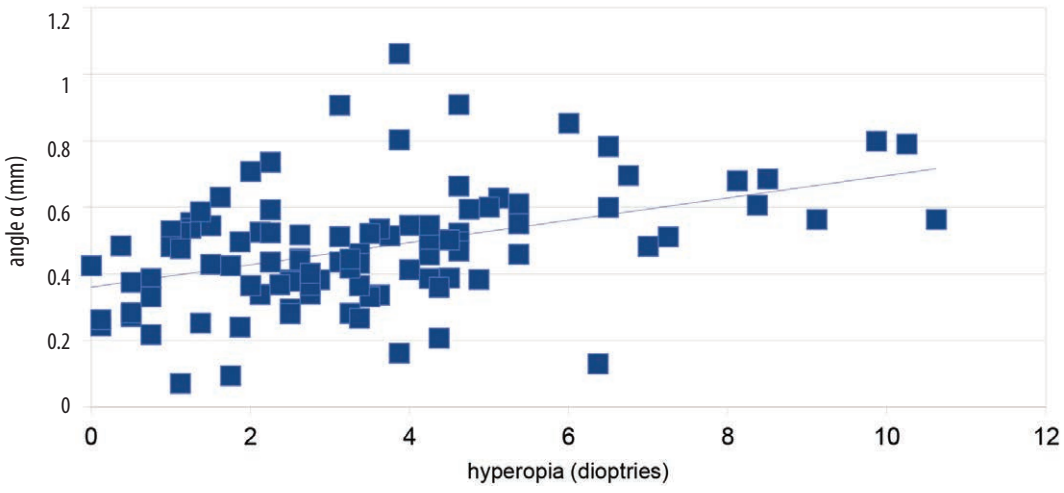
Values of the acquired angles α and the number of eyes where they were achieved.

Angle α (mm)	No. of eyes
0–0.200	4
0.201–0.400	30
0.401–0.600	48
0.601–0.800	14
above 0.800	5
Total	101

As in the case of angles κ, the number of eyes in which the angle value exceeded 0.6 mm accounted for approximately 15% of all patients.

DIAGRAM 2

Correlation between hyperopia and angle α.



DISCUSSION

What is the value of the obtained results? If you want to implant premium class lenses with a complex structure, such values are of great importance. About 15% of eyes have angles κ and α greater than 0.6 mm, which creates significant problems regarding the quality of postoperative vision, mainly due to the severity of side effects, including halo and glare symptoms. Approximately 50% of the eyes had α values greater than 0.4 mm. Considering that, many manufacturers of intraocular lenses indicate the value of 0.5 mm as a borderline value that should not be exceeded, this examination should be performed in hyperopic patients as a standard. In over 40% of patients, angle κ was greater than 0.4 mm.

Many articles have been written about the usefulness of the measurements of angles κ and α and their influence on the quality of vision. Angle κ is a value that cannot be ignored both in the qualification for laser correction procedures and for multifocal lens implantation [10, 11]. The location of angle κ in relation to the visual axis has already been described by other authors, and their position in relation to the visual axis was defined as positive if the reflex from the corneal surface was located temporally in relation to the pupil centre, and as negative if the reflex was located nasally from the pupil centre [12]. In the case of the studied group, the positive temporal location of angle κ occurred in each case, regardless of the examined eye. As with angle κ, angle α is also located in the inferior temporal quadrant. In both cases, a statistically significant correlation was observed between the increasing angles κ and α and the range of hyperopia. Significant asymmetry in the position of the pupil centre may affect the quality of vision not only in the case of multifocal lenses with a concentric structure, but mainly those with an asymmetric structure. In the case of implantation of lenses with an asymmetric structure, the information about the location of angle κ may be useful in the case of the lack of a visual acuity value accepted by the patient in the range of specified distances. Knowing the axis of angle κ, you can shift the artificial lens and thus slightly change the "exposure" of the part responsible for visual acuity to far and to near distances, which may be of importance, among others, in eyes with a very small pupil, the size of which is additionally reduced in the case of visual acuity to near distances [6]. Analysing the obtained values in the range of angles α, almost half of which reached a value greater than 0.5 mm, knowing the negative impact of large angles on the quality of vision, implantation of complex intraocular lenses is very risky in eyes with high hyperopia and, according to authors of this study, it should not be used.

Significant pupil asymmetry in combination with the non-axial position of the eyeball, observed in about 15% of eyes, may cause not only poor quality of vision, but also reduced visual acuity, mainly to far distances. If a patient with moderate and high hyperopia is willing to obtain a premium lens implant, preoperative examination of the value of both angles should be a required standard.

When evaluating vision, not only visual acuity, but also the quality of vision is emphasized with an increasing frequency. Visual acuity is mainly evaluated using optotypes, examining vision at different distances. The examination performed using the iTrace™ analyser allows for the evaluation of the quality of vision graphically presenting the HOA values separately for the cornea and the inside of the eye and their total value. The information in the graphic form allows both the patient and the doctor to realize that quite good visual acuity is sometimes accompanied by poor quality of vision, resulting from, among others, the presence of cataract (fig. 4).

Poor quality of vision is also a possible consequence of the implantation of a premium class lens in eyes with high values of angles κ and α.

CONCLUSIONS

A statistical correlation between the increasing range of hyperopia was observed for increasing values of angles α and κ. In more than 15% of cases, the values of both angles exceeded 0.6 mm. Such values exclude the implantation of most complex intraocular lenses. In over 50% of the eyes, angle κ was greater than 0.4 mm. A large value of the angle has an impact on both the quality of vision and visual acuity to far and to near distances, if the central part of the lens in its structure is dominantly responsible for any of the above vision parameters. Information about the temporal inferior location for both angles in more than 80% of all examined cases may be useful when an asymmetric lens has been implanted, additionally in eyes with a narrow pupil.

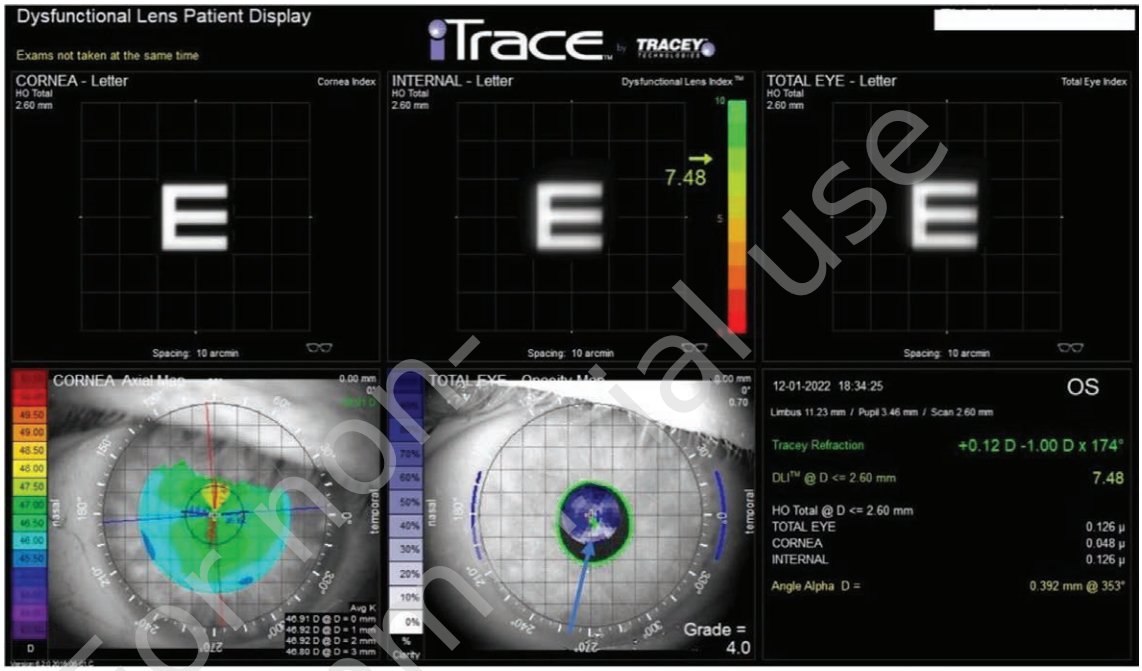
Figures: from the authors' own materials.

CORRESPONDENCE
Adam Cywiński, MD, PhD
Silesian Eye Treatment Centre
44-240 Żory, ul. Okrężna 11
phone: (+48 32) 469-60-31
e-mail: adam.cywinski@solcho.pl

ORCID
Adam Cywiński – ID – http://orcid.org/0000-0001-8732-7396
Olaf Szyja – ID – http://orcid.org/0000-0002-4510-073X

FIGURE 4

Male 56 y.o. He complained of significant loss of the quality of vision. Best visual acuity to far distances was 0.2 (logMar), but letter "E" (top, middle window) which represents HOA from the eye inside (also from the lens) is hazy like a HOA from the total eye (top right). This hazy "E" result is a consequence of cataract formation, which was also detected by iTrace™ analyser – bottom, middle window. Opacification is represented by white irregular colour (irregular cataract opacification).



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Adam Cywiński: idea of the manuscript, statistical compilation of data, writing the manuscript; Olaf Szyja: collecting data.

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The content presented in the article complies with the principles of the Helsinki Declaration, EU directives and harmonized requirements for biomedical journals.