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Visual angles: Article on the importance of Multifocal Intraocular Lenses Implantation

Ângulos visuais: Artigo sobre a importância para o Implante de Lentes Intraoculares Multifocais

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Abstract

Objectives: *To measure the labral angle (LA) in individuals in the preoperative period of facectomies, correlating their presence with axial length and spherical equivalent of the eyes. Suggest conduits for the implantation of multifocal IOL according to the presence of the lambda angle.* **Methods:** *A cross-sectional study of 128 eyes of 74 individuals who were candidates for cataract surgery to record the presence of the lambda angle.* ***Results:*** *A positive correlation (r = 0.559 / p = 0.000) was observed for the angle of this angle by comparing the two eyes. There was no correlation between the size of the lambda angle and the spherical equivalent in the right eye (r = -0.027 / p = 0.840), but a positive correlation was observed for the left eye (r = 0.313 / p = 0.013). The presence of hyperopia correlated with small axial lengths, as did myopia with large ones. There was a negative correlation between the angle of the tongue and the axial length of the two eyes, with r = -0.249 for the right eye (p = 0.042) and = 0.281 for the left eye (p = 0.018).* ***Conclusions:*** *There was a correlation between the presence of a larger lambda angle and smaller axial lengths for both eyes. For the spherical hypermétrope equivalent, there was a correlation with the presence of a larger blunt angle only for the left eye. This work suggests parsimony in multifocal IOL implants in the presence of a significant lamella angle, based on the theory that the presence of this angle regulates the balance between corneal versus crystaline surface aberrations.*

Keywords: *Lambda angle; Spherical equivalent; Axial length, eye; Multifocal intraocular lenses*

Resumo

Objetivos: Medir o ângulo lâmbda (AL) em indivíduos no pré-operatório de facectomias, correlacionando a sua presença com o comprimento axial e o esférico dos olhos. Sugerir condutas para o implante de LIO multifocal de acordo com a presença do ângulo lâmbda. **Métodos:** Estudo transversal em 128 olhos de 74 indivíduos candidatos à cirurgia de catarata para registrar a equivalente presença do ângulo lâmbda. **Resultados:** Avaliando o ângulo lâmbda observou-se uma correlação positiva (r= 0,559 / p= 0,000) para o tamanho desse ângulo comparando-se os dois olhos. Não houve correlação entre o tamanho do ângulo lâmbda e o equivalente esférico no olho direito (r= -0,027 / p= 0,840), mas foi verificada correlação positiva para o olho esquerdo (r= 0,313 / p= 0,013). A presença da hipermetropia correlacionou com os comprimentos axiais pequenos, assim como a miopia com os grandes. Observou-se correlação negativa entre o tamanho do ângulo lâmbda e o comprimento axial para os dois olhos, sendo de r= -0,249 para o olho direito (p= 0,042) e r= -0,281 para o olho esquerdo (p= 0,018) **Conclusões:** Houve correlação entre a presença de ângulo lâmbda maior e comprimentos axiais menores para os dois olhos. Para o equivalente esférico hipermétrope houve correlação com a presença de um ângulo lâmbda maior apenas para o olho esquerdo. Esse trabalho sugere parcimônia nos implantes de LIO multifocal na presença de ângulo lâmbda significativo, baseado na teoria que a presença desse ângulo é reguladora do equilíbrio entre as aberrações da superfície corneana versus cristalineanas.

Descritores: Ângulo lâmbda; Equivalente esférico; Comprimento axial do olho; Lentes intraoculares multifocais

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Introduction

The visual angles lambda (λ) and kappa (κ) are clinically important when it comes to the surgical centralization of the cornea in the LASER refractive surgery [1], but they are not considered for multifocal intraocular lens (IOL) implantation.

The angle λ is formed between the pupillary axis and the line of sight, and k is formed between the pupillary axis and the visual axis. The pupillary axis is a line perpendicular to the cornea passing in the center of the entrance pupil.[2-4]

The entrance pupil is the virtual image of the real pupil visualized when observing the eye of an individual, being about 14.0% larger than the real pupil, and 0.5mm anterior. It is the one to delimit the beams of light rays entering the eye.[5]

The line of sight (main ray) is the first part of the ray of light pathway, and attaches the fixation object at the center of the entrance pupil.[6,7] The visual axis is a line connecting the fixation object to the fovea, passing through the nodal point (intersection between the visual axis and the optical axis) of the eye.[8]

As seen, the pupillary axis and the line of sight invariably pass through the center of the entrance pupil, but in the path up to that point their lines may not coincide, thus forming the angle λ.[4]

The angle λ, as well as k, is positioned in the nasal direction to the pupil, decreasing as the individual grows, being on average 8,3° at birth and around 5,0° in adult life.[9,10]

The existence of these angles (λ / κ) in some individuals is justified as a slope compensating fixation of the eye to a specific target, responding to the eccentric position of the fovea (temporal) in relation to the geometric center of the pupillary axis.[11] Another hypothesis is that its presence works as a compensation for internal aberrations of the eye, i.e., a significant λ / κ angle1 generating an aberration on the anterior surface of the cornea and canceling an aberration of the crystalline.[12]

Objective

Measure the angle lambda in individuals in the preoperative period for facectomies, correlating their presence to the axial length and the spherical equivalent of the eyes.

Suggest procedures for the implantation of multifocal IOL according to the presence of the angle lambda.

Methods

A cross-sectional study was performed in 128 eyes of 74 individuals who were candidates for cataract surgery at a reference service in the city of Fortaleza, Ceará, to record the presence of the angle lambda.

Forty-one (54.4%) were female, and 33 (46.6%) were male. The average age was 65.9 ± 7.8 years, with a minimum of 42 and a maximum of 83 years. As the research was carried out with the collection of data in medical records, the term of fiduciary responsibility was signed by the legal researcher and director of the institution.

In addition to the angle lambda, data was collected on axial length (AL) and spherical equivalent (SE) of each eye.

In order to record the angle lambda, the pupil image was captured in its natural state, thus avoiding the displacement of its center by mydriatic eyedrops.[4] The device used was the corneal topographer of the Italian brand CSO®. While capturing of the image, the subject was asked to fix the gaze with the eyelids at maximum aperture at a central reference point (center of the innermost ring of the Placido's discs), making it possible to measure the distance between the center of the pupil and the center of said ring, thus having a good approximation of the angle λ.[13] (Figures 1 and 2).

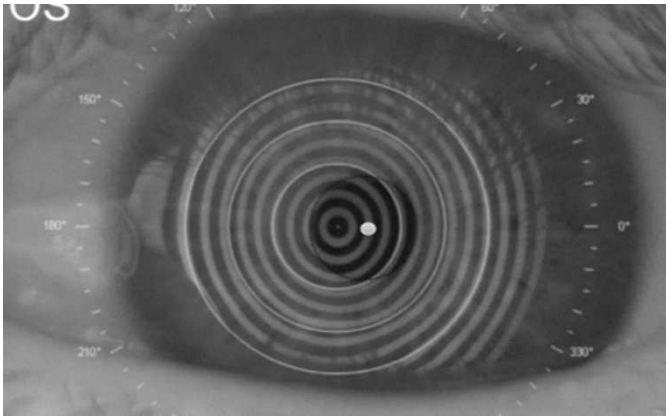

Figure 1: Angle lambda: distance between the pupillary center (orange point) and the center of the innermost ring (corneal vertex) of Placido's disc.

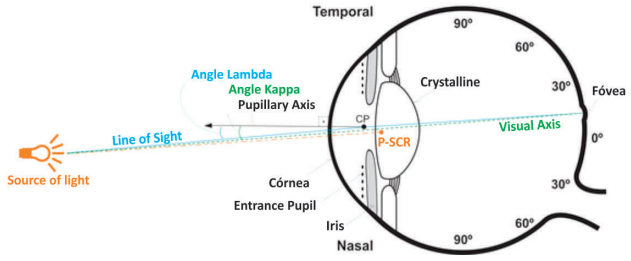

Figure 2: Description of the angle lambda, angle kappa, visual axis, line of sight, pupillary axis, pupillary center (PC) and Purkinge-Samso corneal reflex (P-SCR).

AL was measured by IOL Master® (Zeiss, Germany) and was collected in the subject's medical records. SE was defined considering the preoperative refraction.

Descriptive statistics techniques were used to evaluate the quantitative variables. Pearson's correlation was used to study the connections between the size of the angle lambda and the axial length and spherical equivalent. The Student t test for paired sample was used for the data normally distributed. The statistical program used was the SPSS, statistical package for social sciences, version 21.0.

Results

In the evaluation of the angle lambda (Ş, the right eye showed a value of +0.30 ± 0.15mm, and the left eye showed +0.29 ± 0.15mm. No statistically significant difference (p = 0.713) was found between the angle Şof both eyes. A positive correlation (r = 0.559 / p = 0.000) was observed for the size of this angle comparing both eyes (Figure 3).

The spherical equivalent (SE) of the right eye was -0.16 ± 2.66, and the left eye was +0.04 ± 2.48, with no statistically

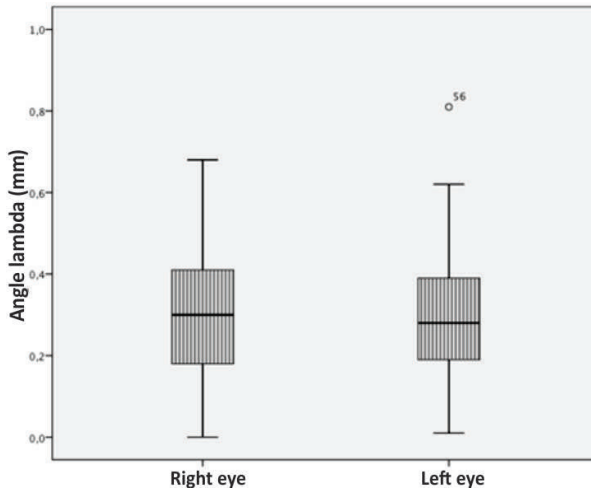

Figure 3: Distribution of the measures of the angle λ per eye.

significant difference between the two eyes (p = 0.360). There was no correlation between the size of the angle λ and the SE in the right eye (r = -0.027 / p = 0.840), but a positive correlation was found between the angle λ and the SE in the left eye (r = 0.313 / p = 0.013).

The presence of hypermetropia correlated to the small axial lengths (AL), as well as myopia to the large AL, both for the right eye (r = -0.667 p = 0.000) and the left eye (r = -0.757 / p = 0.000).

The AL of the right eye was 23.44 ± 1.50mm, and the left eye was 23.33 ± 1.62mm, with no statistically significant difference (p= 0.138) between the AL of two eyes. There was a negative correlation between the size of the angle λ and the AL for both eyes, with r = -0.249 for the right eye (p = 0.042) and r = 0.281 for the left eye (p = 0.018), (Figure 4).

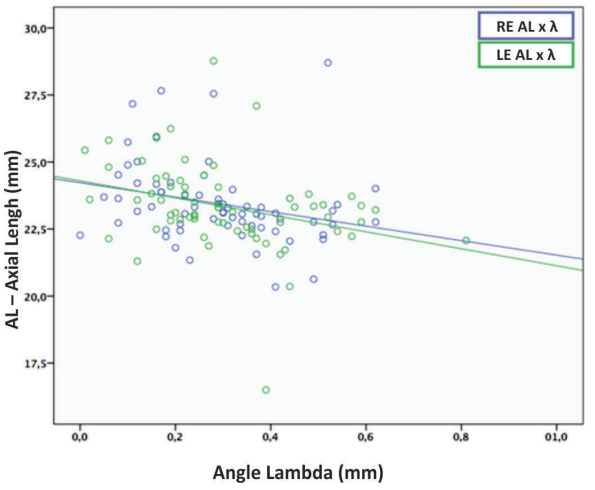

Figure 4: Correlation between the angle λ of the right and left eye versus AL.

Discussion

The literature suggests that the angles lambda (λ) and kappa (κ) are practically the same, as long as the point of attachment is sufficiently distant. The angles λ and k are conceptually different, but both are measured in videoceratography using the same reference points: the distance between the center of the pupil and the corneal vertex.[10,14,15] In the present research, the representation of the lambda angle was considered the angular formation between the corneal vertex (center of the innermost ring of Placido's disc or corneal reflex of Purkinge-Samso) and the pupillary axis.

Some authors say that it is impossible to measure the angle k as the optic system of the eye (cornea / crystalline) is not centralized, which would make it impossible to accurately capture the visual axis.[3,16] In fact, some considerations must be made about this statement, since the line of sight is also a measure having the Purkinge-Samso corneal reflex (P-SCR) or the corneal vertex as the approximate reference point. So why couldn't the visual axis also have its approximate measure through the P-SCR reference? Figure 2 shows that the P-SCR is closer to the visual axis than to the line of sight.

The search of the relation between SE and the angle λ was suggested in literature reports showing an increase in this angle in hypermetropic and its reduction in myopic patients.[17,18] The present study observed the SE and showed no correlation between the increase in λ and the increase in hypermetropia in the right eye. However, the same was not observed for the left eye, which presented a positive correction between the presence of an increasing λ and increased hypermetropia. The use of SE to replace the true sphero-cylindrical degree of the individual may have impaired the correlation between the presence of refractive defect and its relation to the size of the angle λ in the right eye. In order to reach an SE from hypermetropia associated to astigmatism, the negative degree of the cylinder is added to the positive degree of hypermetropia, resulting in an SE with a relative value smaller than the original spherical degree.

Literature has analyzed of the axial length (AL) of the eye, showing that the smaller its value, the greater the angular separation between the fovea and the intersection of the pupillary axis, generating a greater angle λ / κ.[19] In the present study, said finding was observed in the measurement of AL, and while the angle λ increased, the AL decreased, with a negative correlation for both the right eye and the left eye.

The findings regarding SE and AL suggest a profile for prescription of multifocal IOL implantation. Currently, the regular astigmatism barrier has already been overcome with multifocal toric IOLs. Thus, by ensuring that the crystalline sac is aligned with the pupillary axis, and taking into account the presence of the significant angle λ greater than 0.25mm[1] suggested as a generator of corneal surface aberrations and with higher frequency in individuals with lower AL, the implantation of multifocal IOL would make no sense in these individuals.

Considering that the two angles λ and k are practically identical, and avoiding only the classification conflicts in the literature,[14,20] we can consider a relevant fact in the pathway in the wavefront in the pseudophakic: following the line of sight in the presence of an insignificant angle λ, the image would go to the center of the entrance pupil where the "perfectly centered" multifocal IOL would allow the passage of this wavefront through the center of the innermost diffractive ring or very close to it without any visual damage to the individual. But in the presence of a significant angle λ the wavefront generated would be opened[12], and even with its path reaching the center of the innermost diffractive ring, it would cause impairments in the quality of sight.

In the current study of aberrometry, the wavefront is measured relative to the line of sight. Therefore, the optic axes of the cornea and crystalline should coincide with the line of sight in order to minimize aberrations. However, in most cases,

it does not happen.[21] The anterior surface of the cornea is the most important optical part in determining the refractive power and wavefront aberrations of the eye, and is generally off-center and inclined to the line of sight. In the presence of an important angle λ, the anterior cornea's optic performance in relation to the line of sight generates an eccentric image of a visual target, and therefore creates asymmetric aberrations.[22]

Last but not least, the presence of the angle λ/ κ in some individuals is justified as a compensation for the internal aberrations of the eye, that is, there are aberrations on the anterior surface of the cornea to neutralize the crystalline aberrations.[12] With the removal of the crystalline in cataract surgery there would be an imbalance of this "balance". Moreover, if the IOL implant is multifocal, the natural corneal aberration generated by the presence of the angle λ will induce low visual quality, especially in lenses with a small diameter of the innermost diffractive ring.

Future studies should be directed to verify the correlation between the presence of the value of angle lambda and the quantification of significant corneal aberrations.

Conclusion

There was a correlation between the presence of a larger angle lambda and the smaller axial lengths for both eyes. For the hypermetropic spherical equivalent there was a correlation with the presence of a larger angle lambda only for the left eye.

The present work suggests partiality in multifocal IOL implants in the presence of a significant angle lambda based on the theory that the presence of said angle regulates the balance between the aberrations of the corneal surface versus the crystalline.

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