DOI 10.5935/0034-7280.20170012

ORIGINAL ARTICLE

Study of asphericity coefficient and longitudinal spherical aberration surface corneal

Estudo do coeficiente de asfericidade e aberração esférica longitudinal da superfície corneana

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ABSTRACT

Objective: *To correlate the asphericity coefficient (Q) with longitudinal spherical aberration (LSA) of the corneal surface, also correlating each of these variables with the average keratometry* ***Methods:*** *An observational study was conducted by collecting preoperative data from the medical records of individuals candidate cataract surgery, i.e., patient sex and age, as well as Q, LSA of the corneal surface and mean keratometry (Km). Patients who had been subjected to any corneal surgical procedure who would alter Q, LSA and Km measuements were excluded. The corneanl topograph selected, fixedly, a 4.5 mm area of the anterior surface of the cornea for the measurement of Q and LSA, having the pupillary axis as the central point, since the occurrence of LSA is relevant in dim environments in individuals with a pupil wider than 3 mm* ***Results:*** *The sample consisted of 70 eyes of 35 individuals, 24 of them women (68.6%) and 11 men (31.4%) ranging in age from 48 to 89 years (mean: 69.97 ± 8.29). Km ranged from 41.00 to 46.50 D, with a mean of 43.94 ± 1.48D, and mean Q of the corneal surface was -0.15 ± 0.15. Six corneas showed a spherical design (Q= 0.0) and only one showed an aspheric design with Q = -0.50, generating an LSA of 0.0. Mean LSA of the corneal surface was +0.33 ± 0.14 µm. Only one eye showed an LSA equal to 0.0µm, and five showed an LSA of +0.10 to +0.30µm. No eye showed a negative LSA of the corneal surface. There was no correlation between Km and Q (r = -0.005 / p = 0.965) or between Km and LSA (r = 0.167 / p = 0.170). A correlation (r = 0.962 / p = 0.000) was observed between Q and LSA* ***Conclusion:*** *There was a correlation between Q and LSA of the corneal surface. There was no correlation between the sphericity coefficient or longitudinal spherical aberration with the average keratometry.*

Keywords: *Corneal topography; Cornea/physiology; Ocular physiological phenomena; Keratometry*

RESUMO

Objetivo: Correlacionar o coeficiente de asfericidade com a aberração esférica longitudinal na superfície corneana, correlacionando também cada uma dessas variáveis com a ceratometria média **Métodos:** Realizou-se um estudo observacional através da coleta de dados pré-operatórios nos prontuários de indivíduos candidatos a facectomia. Os dados coletados se referiam ao sexo e idade, além do Q, LSA da superfície corneana e ceratometria média (Km). Foram excluídos do estudo os pacientes que realizaram qualquer procedimento cirúrgico corneano, por alterar as medidas da Q, LSA e Km. O topógrafo selecionou, de maneira fixa, uma área 4,5mm da superfície anterior da córnea para medida do Q e da LSA, tendo como ponto central o eixo pupilar. A ocorrência da LSA é relevante em ambientes de penumbra, em indivíduos com pupila maior que 3mm. **Resultados:** A amostra foi composta por 70 olhos de 35 indivíduos: 24 (68,6%) mulheres e 11 (31,4%) homens. A idade variou de 48 a 89 anos (média de 69,97 ± 8,29). A Km variou de 41,00D a 46,50D com média de 43,94 ± 1,48D. Na avaliação do Q da superfície corneana se observou uma média de -0,15 ± 0,15. Seis (8,57%) córneas apresentaram desenho esférico com Q= 0 e apenas uma córnea apresentou desenho asférico com Q= -0,50, gerando LSA= 0,0µm. Em relação a LSA da superfície corneana se observou média de +0,33 ± 0,14 µm. Quarenta e dois olhos (60,0%) apresentaram LSA entre +0,31 a +0,64µm e 19 (27,15%) entre +0,16 a +0,30µm. Não houve correção entre a Km e o Q (r= -0,005 / p= 0,965), assim como entre Km e a LSA (r= 0,167 / p= 0,170). Observou-se correlação (r= 0,962 / p= 0,000) entre as variáveis Q x LSA. **Conclusão:** Foi observada correlação entre o Q e a LSA da superfície corneana. Não foi observado correlações entre o coeficiente de asfericidade ou aberração esférica longitudinal com a ceratometria média.

Descritores: Topografia da córnea; Córnea / fisiologia; Fenômenos fisiológicos oculares; Ceratometria

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The authors declare no conflicts of interest.

Received for publication: 19/06/2016 - Accepted for publication: 07/12/2016.

INTRODUCTION

The technical evolution in cataract surgery and the improvement in the design of intraocular lenses brought improvements in the visual quality of the individuals submitted to a facectomy.

The coefficient of asphericity (Q) is defined as the curvature variation rate in a lens as it moves away from its center. Normally, the cornea has a proton design, that is, it decreases its curvature as it approaches the periphery, thus being aspherical with a negative Q.[1] But spherical lenses have a curvature radius anywhere on their surface, thus having a Q of zero.[2]

The longitudinal spherical aberration (LSA) is an optical phenomenon generated when the wavefront tangentially reaches the periphery of a spherical lens, enhancing its convergence effect, producing a second focus (positive LSA) anterior to the main focus. The measurement of LSA is made by the difference in diopters between the rays incident on the periphery of the lens and the rays of the paracentral region[2]. It is a high-order, physiological aberration, but very symptomatic in individuals with pupils larger than 3mm, generating halos around the lights, inducing glare and low contrast sensitivity. In youngsters, it is naturally neutralized by a negative LSA generated by the lens.[3,4]

Intraocular lenses (IOLs) may be spherical, generating positive LSA[5], and aspheric. The latter is divided into neutral aspheres, which do not induce any type of LSA, and negative aspheres, which induce a negative LSA. The existence of these IOLs gives the surgeon the opportunity to manipulate the patient's corneal LSA with the implant, improving their quality of vision.[6,7]

The aim of the present study was to correlate the coefficient of asphericity to the longitudinal spherical aberration on the corneal surface, also correlating each of these variables to the average keratometry.

Patients who underwent some kind of corneal surgical procedure (refractive surgery, corneal transplant, facectomy, pterygium surgery, etc.) were excluded from the study because they changed the measurements of asphericity, spherical aberration and keratometry.

The topographer fixedly selected 4.5 mm of the anterior surface of the cornea to measure Q and LSA, which corresponds to the physiological mesopic diameter of the elderly individuals.[8] The central point was the pupillary axis. The occurrence of LSA is relevant in shadowy environments, in individuals with a pupil greater than 3mm.[9]

The data were treated using descriptive and analytical statistical techniques with the SPSS program. The Shapiro-Wilk test was used to evaluate the normal distribution of continuous quantitative variables. For the correlation analysis to be considered significant, p = 0.01 was adopted. The significance level for the rest of the analyzes was 0.05.

Table 1

Distribution of the coefficient of asphericity (Q) of the corneal surface by eyes

Q-value	Amount	%
-0,47 a -0,50	02	2,84
-0,40 a -0,30	15	21,42
-0,29 a -0,20	15	21,42
-0,19 a -0,10	17	24,28
-0,09 a 0,0	12	17,14
+0,01 a +0,09	07	10,00
+0,13 a +0,14	02	2,85
Total	**70**	**100**

Table 2

Distribution of the longitudinal spherical aberration (LSA) of the corneal surface by eyes

Value of LSA (μm)	Amount	%
+0,0 a +0,15	09	12,85
+0,16 a +0,30	19	27,15
+0,31 a +0,64	42	60,00
Total	**70**	**100**

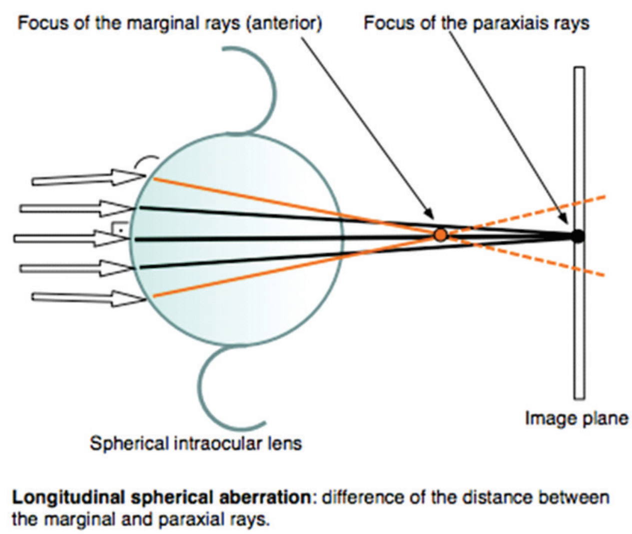

Figure 1: Longitudinal spherical aberration (LSA)

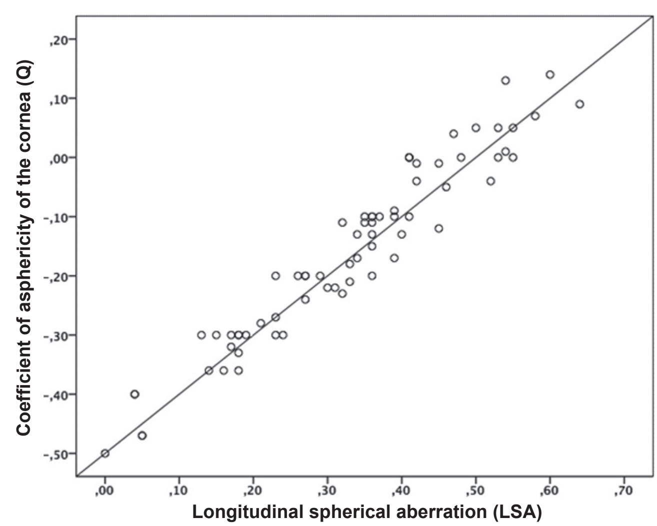

Figure 2: Corneal surface: Correlation between coefficient of asphericity (Q) x Longitudinal spherical aberration (LSA).

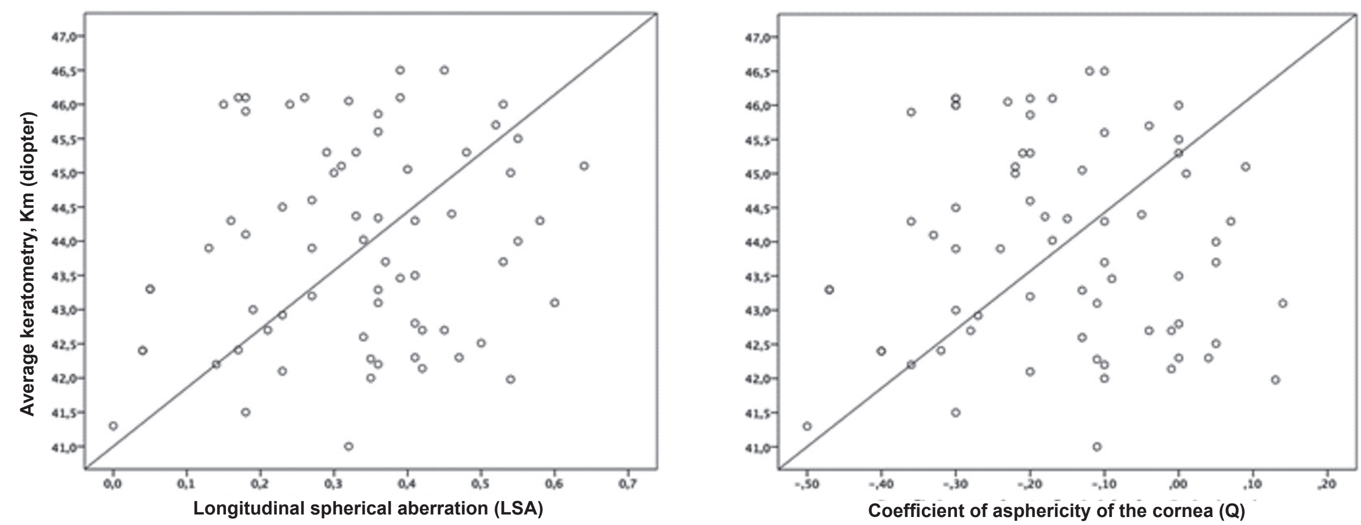

Figure 3: Average keratometry (Km): correlation between longitudinal spherical aberration (LSA) and coefficient of asphericity (Q).

Results

The sample consisted of 70 eyes of 35 individuals distributed as follows: 24 (68.6%) women, and 11 (31.4%) men. Age varied from 48 to 89 years, with an average of 69.97 ± 8.29.

In the evaluation of Q of the corneal surface an average of -0.15 ± 0.15 (95% CI = -0.19 to -0.12) was observed. Six (8.57%) corneas presented spherical design (Q = 0.0) and only one (1.42%) showed aspheric drawing with Q = -0.50 generating an LSA = 0.0 (Table 1).

Methods

An observational study was performed with the collection of preoperative data in the medical records of individuals who were candidates to facectomy at a reference service in Fortaleza, Ceará. The data collected referred to gender and age, as well as indexes provided by the CSO® topographer as: corneal surface coefficient of asphericity (Q), longitudinal spherical aberration of the corneal surface (LSA, Figure 1), and average keratometry (Km).

In relation to the LSA of the corneal surface, we observed an average of +0.33 ± 0.14 µm (95% CI = +0.29 to +0.36). Only one (1.40%) eye had LSA equal to 0.0, and no eye had negative LSA (Table 2).

A correlation was observed (r = 0.962 / p = 0.000) between the variables Q x LSA (Figure 2).

Km varied from 41.00D to 46.50D, with an average of 43.94 ± 1.48D (95.0% CI= 43.70D to 44.41D). There was no correction between Km and Q (r = -0.005 / p = 0.965), as well as between Km and LSA (r = 0.167 / p = 0.170), Figure 3.

Discussion

To evaluate the coefficient of asphericity (Q) and the longitudinal spherical aberration (LSA), a sample of individuals with a high average age in the cataract department was chosen. Thus, it would be possible to make projections of possible IOL implants according to the LSA generated for this age group of individuals.

The normal cornea does not have a perfect aspherical design. This "imperfection" can generate positive LSA in subjects with a pupil greater than 3mm, causing vision with glare halos and low in contrast sensitivity.[10] Considering an ideal height of the object at the line of sight level, optimized topographies will make it flatter towards the ends (negative asphericity), minimizing or correcting this positive LSA.[11] In the relevant literature, values of Q ranging from -0.18 to -0.30 are found, generating positive spherical aberration.[12,13] On the one hand this may be good, since this aberration, though deleterious for mesopic vision, generates a focus anterior to the retina, improving near-sight vision.[14,15] In this study, a proton design of the anterior surface of the cornea was found with an average Q of -0.15 and a positive LSA with a average of + 0.33µm. Any lens, and here the cornea is included, varying its curvature (not spherical) can be called aspherical. Commercially the term aspheric was associated to synonymous of lenses with high optical quality, non-generating of spherical aberration (LSA zero). However, not all aspherical lenses fit that profile. In this research, only one cornea presented LSA zero with Q -0.50, that is, a "perfect" aspheric design. All the rest generated some level of positive LSA. No negative LSA was found. This finding may be justified by the exclusion from the search of eyes that have undergone refractive surgery or presented corneal ectasia. Highly prolated corneas that have undergone LASER refractive surgery for hypermetropia or that have central keratoconus tend to have an elevated negative LSA because they have a hyperprolonged design (very negative Q). Especially for these cases, it is indicated spherical IOLs naturally having a positive LSA with an average of + 0.18µm.[16] In contrast, individuals who undergo refractive surgery for myopia usually have a cornea with positive Q and LSA, inducing glare halos vision and low sensitivity to contrast. In these, in order to minimize this exaggerated positive LSA, the implant of an aspheric IOL with the most negative LSA value (-0.27µm) is indicated.

The benefit of the neutral aspheric IOL implant is to improve sensitivity to contrast and obfuscation under mesopic conditions.[8] These IOLs have a negative Q, around -0.50, generating LSA zero. It is suggested that individuals with corneal LSA between -0.15 and + 0.15µm receive a neutral aspheric IOL (Q around -0.50), i.e., free of LSA. Those with corneal LSA between +0.16 and + 33.0µm may receive an aspheric IOL (most prolated with Q> -0.50) generating a negative LSA around -0.20µm. Those with positive corneal LSA above + 0.33µm should receive an aspheric IOL (even more prolated with more negative Q) generating LSA around -0.27µm.[17] In this survey, the majority of the eyes, 42 (60.0%) eyes, presented LSA greater than +0.30, and an implant of an aspheric IOL with negative LSA of -0.27µm was suggested. Nineteen (27.15%) eyes presented LSA between +0.16 and + 0.30µm, suggesting an aspheric IOL with negative LSA of -0.20µm. Nine (12.85%) eyes presented LSA between zero and + 0.15µm, and a neutral aspheric IOL was indicated.

In this sample, the average value of the anterior keratometry (Km) of the cornea was not correlated with Q nor with LSA, showing that the variation in Km does not modify the relation between the peripheral and paracentral curvatures of the cornea. Thus, the indication of the spherical aberration of the IOL according to the average keratometry has no real correspondence. The present study suggests not to indicate IOL implant, be it spherical or aspherical, based only on the Km, and the LSA generated by the Q of each individual should be routinely measured to indicate the most adequate IOL.

Conclusion

There was a correlation between the corneal coefficient of asphericity and longitudinal spherical aberration. No correlation was observed between the coefficient of asphericity or the longitudinal spherical aberration with the average keratometry.

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