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Corneal topography in cataract surgery

Topografia corneana na cirurgia de catarata

Topografía corneana en la cirugía de catarata

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ABSTRACT

Advancements in cataract surgery and intraocular lens (IOL) design have improved the quality of vision for patients subjected to cataract surgery. For the measurement of IOLs, the topographer can provide simulated keratometry, a parameter that simulates the keratometry of the automated refractor. In cases of corneal irregularities, the topography of semimeridians is used, disregarding the keratometric measurements of the ectatic area. Therefore, the measure of convergence of IOL will not be underestimated because the average keratometry obtained will be lower, avoiding the effect of postoperative hypermetropization. Corneal topography allows the quantitative determination of astigmatism and its classification into regular (symmetric and asymmetric) and irregular, guiding the cataract surgeon for the implantation of monofocal, multifocal, toric, or multifocal toric IOLs. Moreover, topography guides the surgeon while performing a corneal incision in the most curved axis to reduce postoperative astigmatism and allows the assessment of changes generated by corneal incision after cataract surgery. Therefore, topography has assumed an important role in surgical planning and preventing undesirable outcomes. This study presents the various applications of corneal topography in cataract surgery.

Keywords:
Corneal Topography;
Surgery;
Cataract

Palavras-Chave:
Topografia da Córnea;
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RESUMO

A evolução técnica na cirurgia de catarata e o aperfeiçoamento no desenho das lentes intraoculares trouxeram melhorias na qualidade da visão dos indivíduos submetidos à facectomia. Na medida da lente intraocular (LIO) o topógrafo pode fornecer a ceratometria simulada ou SIMK, parâmetro que simula a ceratometria do autorrefrator. Quando há irregularidades na córnea, utiliza-se o recurso topográfico de semimeridianos, desconsiderando as medidas ceratométricas da área ectásica; com isso a medida da vergência da LIO não será hipoestimada, pois a ceratometria média fornecida será menor, evitando-se efeito de hipermetropização no pós-operatório. Através da topografia corneana, a determinação quantitativa do astigmatismo e sua separação em regular (simétrico e assimétrico) e irregular orienta o cirurgião de catarata na indicação do implante das lentes monofocal, multifocal, tórica, ou multifocal tórica. A topografia orienta também o cirurgião na realização da incisão corneana no eixo mais curvo com intuito de diminuir o astigmatismo no pós-operatório. As modificações geradas pela incisão corneana após a facectomia podem ser avaliadas no pós-operatório através da topografia. Portanto, a topografia vem assumindo papel importante no planejamento cirúrgico prevenindo surpresas desagradáveis. Neste artigo são apresentadas as diversas formas de utilização da topografia corneana na cirurgia de catarata.

RESUMEN

La evolución técnica en la cirugía de catarata y el perfeccionamiento en el diseño de las lentes intraoculares han proporcionado mejoras en la calidad de la visión de los individuos sometidos a facectomía. En la medida de la lente intraocular (LIO), el topógrafo puede suministrar la queratometría simulada o SimK, parámetro que simula la queratometría del autorrefractor. Cuando hay irregularidades en la córnea, se utiliza el recurso topográfico de semimeridianos, desconsiderando las medidas queratométricas del área ectásica; con eso, la medida de la vergencia del LIO no será hipoestimada, pues la queratometría mediana suministrada será menor, evitándose el efecto de hipermetropización en el postoperatorio. A través de la topografía corneana, la determinación cuantitativa del astigmatismo y su separación en regular (simétrico y asimétrico) e irregular orienta el cirujano de catarata en la indicación del implante de las lentes monofocal, multifocal, tórica, o multifocal tórica. La topografía orienta también al cirujano en la realización de la incisión corneana en el eje más curvo con la finalidad de aminorar el astigmatismo en el postoperatorio. Las modificaciones que se generan por la incisión corneana después de la facectomía pueden evaluarse en el postoperatorio a través de la topografía. Por tanto, la topografía viene asumiendo un rol de importancia en la planificación quirúrgica, precaviendo sorpresas desagradables. En este artículo, se presentan las diferentes maneras de utilización de la topografía corneana en la cirugía de catarata.

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INTRODUCTION

Advancements in cataract surgery and intraocular lens (IOL) design have improved the quality of vision for patients subjected to cataract surgery. Topography has assumed an important role in surgical planning and preventing undesirable outcomes.

1. Measurement of IOL

For the measurement of IOL, the topographer can provide simulated keratometry, a parameter that simulates the keratometry of the automated refractor. Another use of topography in the measurement of IOL is in cases of corneal irregularities. In these cases, the surgeon can conduct a topographical analysis of the semimeridians (Figure 1), disregarding the keratometric measurements of the ectatic area. Therefore, the degree of convergence of IOL will not be underestimated because the average keratometry provided will be smaller, thereby avoiding the effect of postoperative hypermetropization[1,2,3].

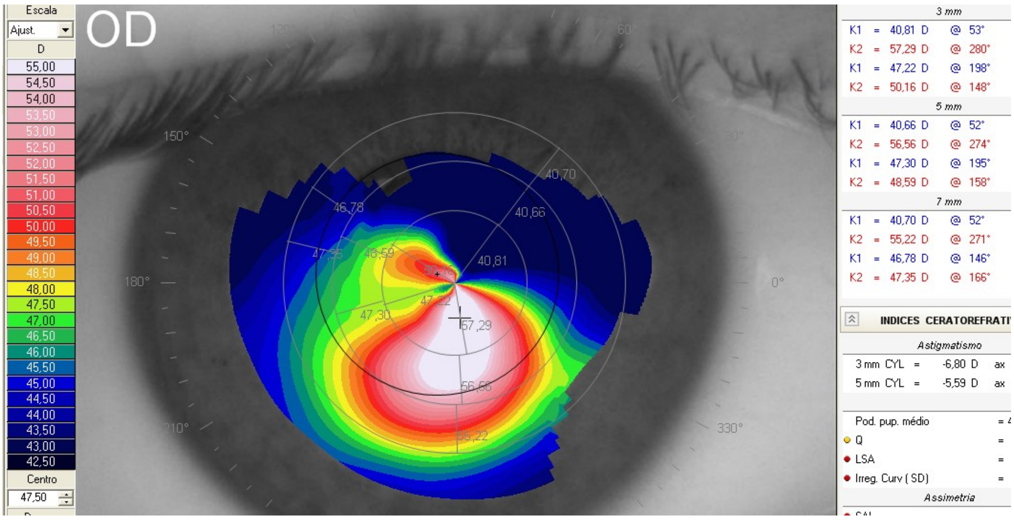


Figure 1. Analysis of the semimeridians showing a 3-mm area with optional curvatures of 47.22 × 50.16 instead of 40.81 × 57.29.

2. Diagnosis of corneal astigmatism

Corneal topography allows the quantitative determination of astigmatism and its classification into regular and irregular, guiding the cataract surgeon for the implantation of monofocal, multifocal, toric, or multifocal toric IOLs. Moreover, topography can guide the main incision of cataract surgery in the most curved corneal axis to reduce postoperative astigmatism[4]. and can assess the changes generated by corneal incision after cataract surgery [5].

The topographic pattern of the corneal surface allows the classification of the type and degree of astigmatism, when present. In the absence of significant astigmatism, the cornea is considered to have a spherical or oval topographic pattern[6].

Regular astigmatism occurs in cases in which the most planar and most curved corneal meridians form an angle of 90° with each other. Regular astigmatism is subdivided into symmetrical (Figure 2) and asymmetrical (Figures 3 and 4). The classification of symmetry is possible when the difference between the equidistant points of the most curved or most planar hemimeridians is smaller than 1.0 D. Stigmatism is asymmetrical in cases in which this difference exceeds 1.0 D[6,7,8,9].

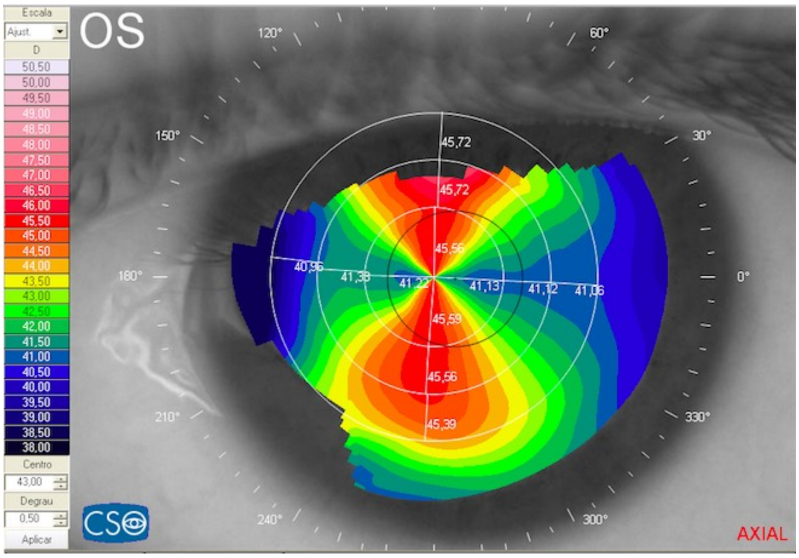
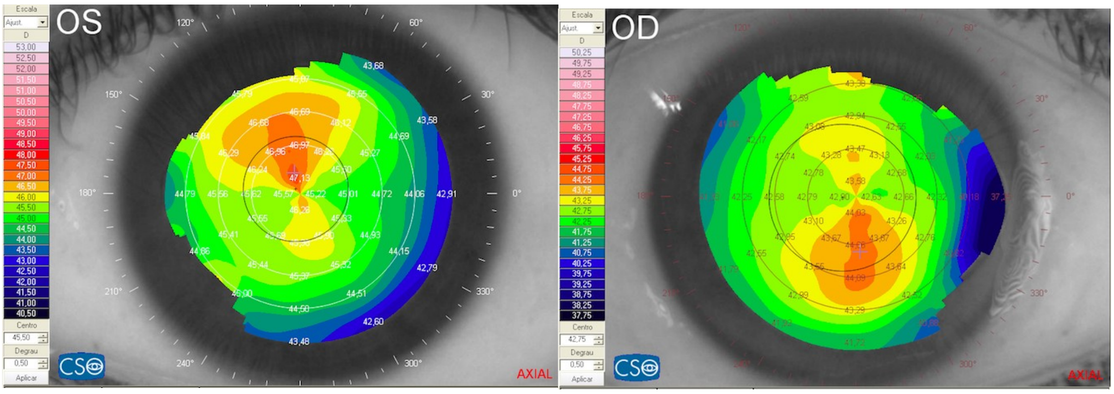


Figure 2. Regular and symmetrical astigmatism or symmetrical bow-tie pattern.



Figures 3 and 4. Regular astigmatism with higher asymmetry (a) and lower asymmetry (b) or an asymmetrical bow-tie pattern.

The classification of irregularity is possible in cases in which the most curved and most planar meridians lose orthogonality. Some classifications of irregularity are presented in the literature [10,11]. Visual classification can be achieved by observing the local increase in the curvature, with the subsequent loss (amputation) of the corresponding bow-tie image on the opposite hemimeridian (Figure 5).

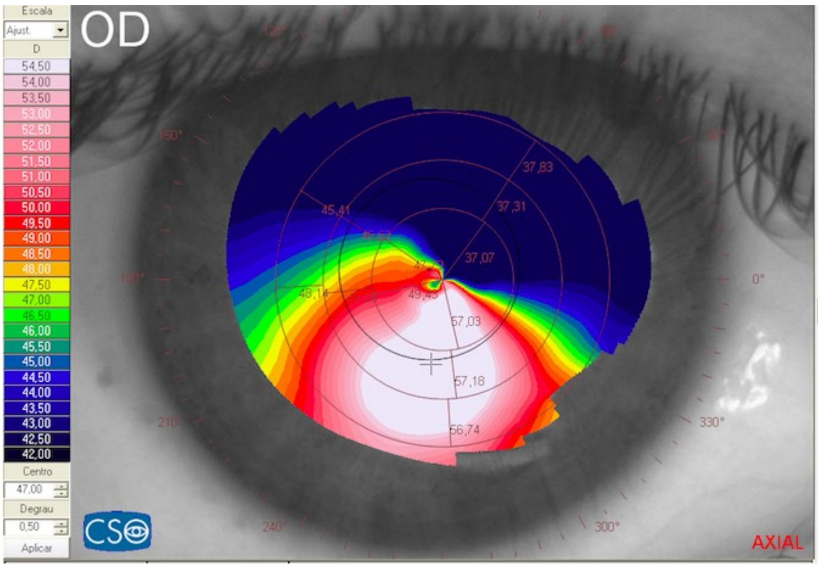


Figure 5. Irregular astigmatism or irregular topographic pattern.

3. Identifying the corneal asphericity coefficient (Q)

The cornea and IOL are involved in image formation in the retina. Advancements in IOL design have allowed the customization of the implant according to the corneal pattern. Therefore, the study of the corneal surface by topography is critical because this technique allows the diagnosis of irregularities on the corneal surface and the determination of Q, which is the rate of change in the curvature of a lens as we move away from the center[12]. The calculation of Q allows the determination of the longitudinal spherical aberration (LSA) generated by the cornea, and this optical phenomenon occurs when the corneal wavefront tangentially reaches the periphery of a spherical lens, increasing its convergence effect and producing a second focus (positive LSA) anterior to the main focus (Figure 6)[12,13].

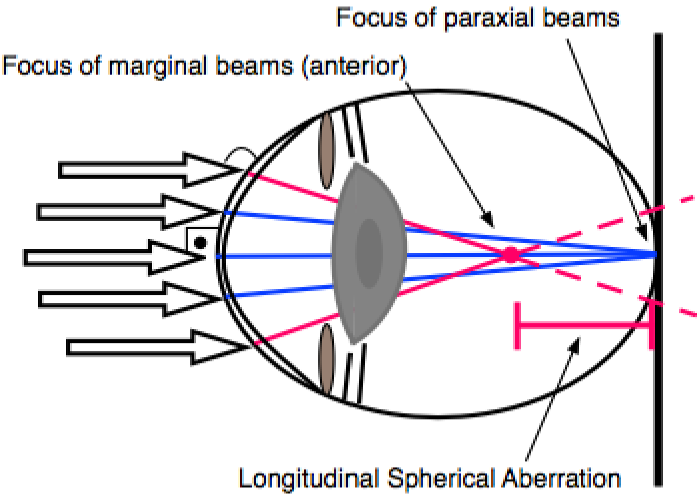


Figura 6 - Aberração Esférica Longitudinal

Therefore, the physician plans the implantation of the lens according to LSA of each manufacturer. LSA of the lens is given in microns, and thus the corneal LSA determined by topography should also be in microns. IOLs can have a positive LSA, as is the case of spherical lenses[14], or neutral or negative LSA, as is the case of aspherical IOLs [15].

4. Corneal topography versus monofocal and multifocal IOLs

The implantation of monofocal IOLs is usually indicated in cases in which the degree of astigmatism is less than or equal to 1.0 D. Refractive astigmatism should be considered because it may contain a residual crystalline component, leading to misinterpretations of the actual corneal astigmatism[16].

The use of multifocal and monofocal IOLs is also indicated for the same degree of astigmatism. In these cases, the level of astigmatism and the magnitude of corneal LSA should be considered (Figure 6). The extent of LSA and pupil size may enhance the visualization of halos, which occur with multifocal IOLs because of diffraction, resulting in lower contrast sensitivity and glare[15]. Another relevant consideration is to avoid the implantation of multifocal IOLs in cases in which an irregular topographic pattern is identified [16].

5. Importance of the lambda angle

The indication of implantation of multifocal IOLs is also based on the size of the lambda angle of each eye (Figure 7). Topography calculates the lambda angle by measuring the distance between the center of the pupil and the Purkinje reflection (corneal apex or center of the inner ring of the Placido disk). The presence of the Purkinje reflex shifted nasally is caused by the compensation to the temporal position of the macula. The aberrations generated by the nasal displacement of the corneal vertex relative to the pupillary axis are naturally neutralized by the lens. After cataract surgery, this neutralization is broken and corneal wavefront aberration, generated by a high lambda angle (greater than 0.2 mm), can reach the multifocal IOL and reduce the quality of vision[17,18,19,20].

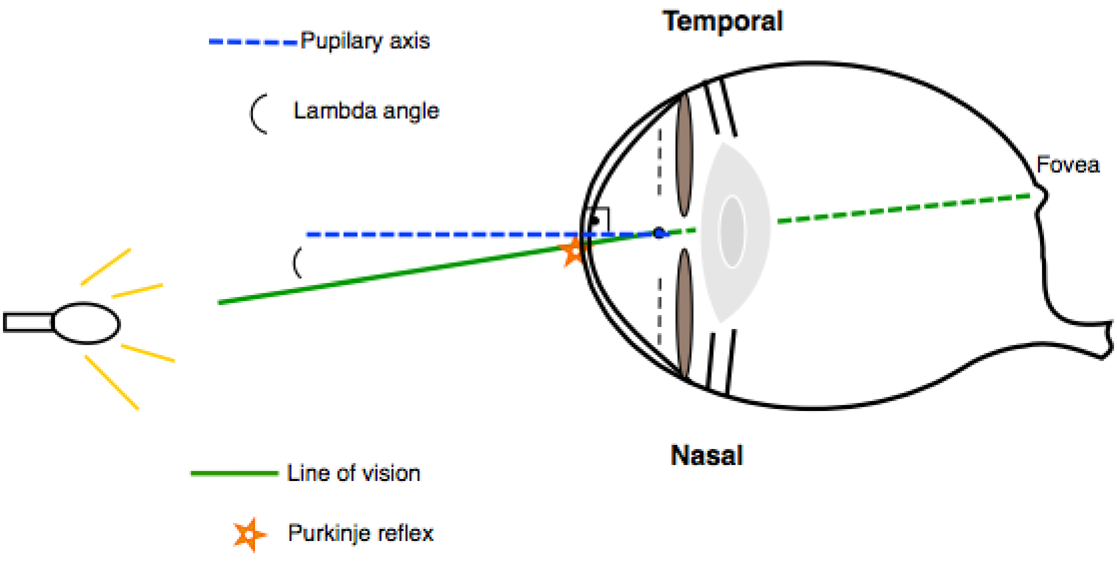


Figure 7. Schematic representation of the lambda angle.

6. Corneal topography in the implantation of toric IOLs

Toric IOLs are usually indicated in cases in which astigmatism is more than 1.0 D. The presence of residual crystalline astigmatism should be investigated [21], and its presence is suspected in cases in which topographic astigmatism does not match refractive astigmatism [22]. The determination of the degree of astigmatism is followed by the location of its axis, and these data are fed into the toric IOL calculators for the development of the lenses. The implantation of IOLs should follow the axis indicated by the calculator of each manufacturer, and these values may deviate a little from those found in corneal topography because of the positioning of the main corneal incision used by the surgeon (Figure 8).

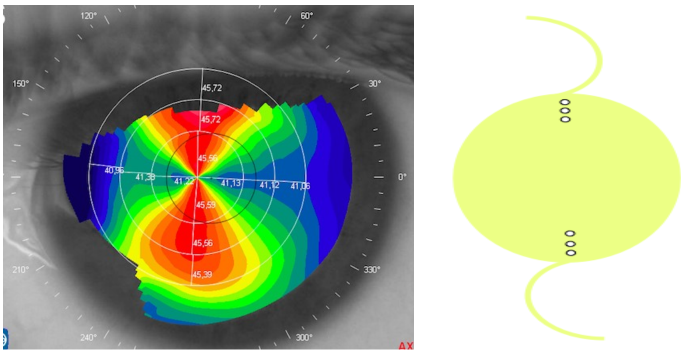


Figure 8. Topographic image of the most curved meridian and schematic representation of toric IOL, with the markings on the same axis of the most curved meridian of the topography.

The identification of an irregular topographic pattern should alert the surgeon about the contraindication of the implantation of toric IOLs.

Furthermore, the degree and location of astigmatism on the posterior surface of the cornea should be considered. Placido-disk corneal topography does not evaluate the posterior surface of the cornea. Previous studies suggest that the toricity of IOL should be calculated considering a decrease of 0.5 D in the toricity value in cases of with-the-rule astigmatism and an increase of 0.3 D in cases of against-the-rule astigmatism. Although the difference is small, it is important to follow this approach, especially in cases of astigmatism of small magnitude, because of the effects of proportionality. A better strategy is the calculation of the total refractive power of the cornea using the Scheimpflug method, in which the degree of astigmatism is determined in the anterior and posterior surface of the cornea with its final vector result[23,24,25].

7. Relaxing incisions (RIs)

The identification of the degree and axis of astigmatism is the main step in the planning of corneal or limbal RIs for the correction of astigmatism after cataract surgery [4]. Corneal topography becomes a valuable tool for the execution of RIs. The procedure can be performed with a diamond scalpel and a micron caliper or femtosecond laser [26].

RIs are classified into limbal and corneal (Figure 9). Limbal RIs are easier to execute, less dependent on pachymetry, and less susceptible to overcorrections and have faster stabilization and better postoperative corneal topography; it is used in degrees of astigmatism smaller than 3 D. The disadvantage is the larger size of the incision, typically 1–3 hours in arc length. In contrast, corneal RIs have a greater capacity of correction with smaller incisions but are more uncomfortable, have increased risk of perforation (pachymetry-dependent), and can cause overcorrections and irregular astigmatism[27,28].

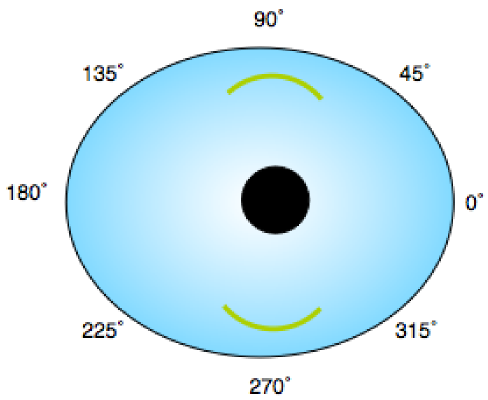


Figure 9. Relaxing corneal incision.

With-the-rule and against-the-rule astigmatisms are better tolerated than oblique astigmatism. Individuals with hyperopic astigmatism do not benefit because the spherical equivalents are not relatively affected. Therefore, it is indicated for spherical and planar-spherical equivalents of myopia in cases of high astigmatism, with the distortion of peripheral vision by glasses[28].

The greatest challenge of RIs is planning the degree and location of astigmatism to be corrected. In the case of orthogonal astigmatism, refraction can help because it produces a combination of corneal and crystalline astigmatism. The topographic axis should be followed in cases in which the meridians are not perfectly orthogonal[27,28].

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