Detection of ectatic corneal diseases based on pentacam

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Received 17 April 2015; accepted 13 November 2015

Abstract

Pentacam is a rotating Scheimpflug-based corneal and anterior segment tomographer that gives as comprehensive analysis of corneal 3D geometry. With this device the detection of mild keratoconus or ectasia susceptibility is possible. This is fundamental for screening ectasia risk prior to laser vision correction. The identification of susceptible cases at risk for developing progressive iatrogenic ectasia should go beyond (but not over) corneal front surface topography.

Keywords: Keratoconus, Pentacam, Scheimpflug image, Diagnosis, ectasia

Erkennung von Hornhautektasien mit der Pentacam

Zusammenfassung

Die Pentacam ist ein optischer Tomograph zur Vermessung und 3D-Analyse der Hornhaut und des vorderen Augenabschnittes basierend auf einer rotierenden Scheimpfluganordnung. Mit diesem System kann eine Hornhautektasie oder ein Keratokonus bereits im frühen Stadium der Erkrankung erkannt werden. Besondere Bedeutung kommt einem Screening derartiger Erkrankungen zu wenn eine refraktive Laserkorrektur der Fehlsichtigkeit im Rahmen einer PRK oder LASIK ansteht, da bereits das Anfangsstadium einer pathologischen Hornhautveränderung als eindeutiger Risikofaktor für eine iatrogene Keratektasie nach der Laserkorrektur gewertet wird. Mit bisherigen Hornhauttopographen, die sich auf die Vermessung der Hornhautoberfläche beschränken, konnte dieser Risikofaktor nicht zuverlässig bewertet werden.

Schlüsselwörter: Keratokonus, Pentacam, Scheimpflugaufnahme, Diagnose, Hornhautektasie

Laser vision correction innovates and improves in parallel with advances in technology. New laser devices and new diagnostic tools that can better screen candidates for refractive procedures are continuously being developed. Despite this high tech arsenal, iatrogenic keratectasia remains the major postoperative concern. [1] In this review we seek to assess how the anterior segment tomography can help prevent this surgical complication and bring new methods of analysis of the scan data.

Laser refractive procedures produce physical changes that weaken corneal biomechanical properties. If this weakening is higher than the necessary threshold to maintain stability on corneal shape and curvature, postoperative ectasia occurs. In theory, this complication occurs more frequently

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in corneas with preexisting biomechanical fragility or predisposition (susceptibility), such as keratoconus (clinical or subclinical)[2,3], and in normal corneas submitted to a higher than normal impact from surgery that critically weakens its biomechanical properties to a point that it cannot maintain corneal shape and curvature no longer[2,4], or, in postoperative clinically stable cornea, another biomechanical stress, such as vigorous eye rubbing in response to allergic conjunctivitis, is added to cornea resulting in chronic biomechanical failure of the cornea.[5]

The measure of the biomechanical properties of the cornea is at an early stage. There are two commercial available devices based on noncontact tonometry that are beginning with in vivo measures: the Ocular Response Analyzer (Reichert) and the Corvis ST (Oculus). While we do not have a current definitive clinical method for measuring corneal biomechanical properties, proper characterization of geometric properties of the cornea is fundamental to understand the susceptibility or predisposition of each cornea to undergo biomechanical failure.[6–8] The Pentacam (Oculus Optikgeräte GmbH, Wetzlar, Germany) is a cornea and anterior segment tomography device, based on a rotating Scheimpflug camera. Its optical cross-sectional analysis allows imaging of both the anterior and posterior corneal surfaces and, thus, derives a full pachymetric map. It also provides several other data that can be helpful to detect ectasia such as corneal aberrometry and densitometry.[9] This comprehensive information of cornea structure is of great value to preoperative screening before laser vision correction.

Anterior Surface evaluation

Preoperative abnormal topographic patterns have been described in patients who developed post-LASIK ectasia since its first reports in 1998.[10,11] The ectasia risk scoring system (ERSS) takes into account this feature as the most important risk factor, but also considers the biomechanical impact from surgery, and other patient's preoperative data.[2]

The topometric indices of the Pentacam analyze anterior surface data in an objective manner. It provides 7 indices:

- Index of surface variance (ISV): an expression of cornea surface irregularity.
- Index of vertical asymmetry (IVA): the value of curvature symmetry, with respect to the horizontal meridian as the axis of reflection.
- Keratoconus index (KI): the ratio between mean radius values in the upper and lower segment.
- Central keratoconus index (CKI): the ratio between mean radius values in a peripheral ring divided by a central ring.
- Index of height asymmetry (IHA): similar to the IVA, but based on corneal elevation.
- Index of height decentration (IHD): this index is calculated from a Fourier analysis and provides the degree of decentration in the vertical direction, calculated on a ring with radius 3 mm.
- Minimum radius of curvature (Rmin): this index corresponds to the point of maximum anterior curvature.

It has been reported that these indices were accurate for discriminating clinical defined keratoconus from normal eyes. Faria-Correia and coworkers reported a sensitivity of 90.4% and 89.3% and specificity of 98% and 98.5% using a cut-off >35 and >0.021 for ISV and IHD, respectively.[12] Both parameters were also well correlated to best spectacle-corrected distance visual acuity (CDVA), topographic keratoconus grading[13], and OCT-derived epithelial mapping.[14]

In the following Figure there is an eye with low curvature but altered topometric indices from a patient with advanced keratoconus in the other eye (Figure 1).

A key concept is that ectasia can occur in some cases even in the absence of anterior surface changes. These cases have very mild (i.e., subclinical) disease or even susceptibility or predisposition to undergo biomechanical failure and ectasia progression. This explains the reported cases of ectasia after LASIK without identifiable risk factors when excluding thick flap or excessive tissue ablation.[15,16] In fact, the current concept is that we must consider data beyond corneal surface for a comprehensive preoperative screening that aims to detect ectasia susceptibility.[1,6]

The Belin-Ambrósio enhanced ectasia display (BAD)

The BAD provides a comprehensive ectasia screening by combining enhanced elevation data and pachymetric distribution data in an all-inclusive display. This gives the clinician a 3-D global view of corneal architecture or geometric structure and allows to objectively screen patients for mild ectatic disease.

Elevation maps

Elevation maps are typically calculated as the difference between the examined corneal surface (anterior or posterior) and a standard reference shape.[17] Thereby, the reference shape will play a fundamental role in the visual inspection and interpretation of these maps. Typically, the reference shape is calculated to get the best fit to the measured cornea. Different zone diameters can be considered to calculate the best fit surface, which can have different geometrical characteristics (i.e. sphere, toric ellipsoid). The 8 mm zone best-fit sphere (BFS) is useful for refractive screening since it allows the visual identification of subtle forms of ectatic disorders.[18]

Along with the standard anterior and posterior elevation maps using the BFS to the 8-mm zone, the enhanced BFS