Defining the risky cornea

Why we need and how to use **enhanced corneal analysis technology**

RIO DE JANEIRO/BRAZIL Since the first report of a progressive "iatrogenic" keratectasia after laser vision correction (LVC) by Seiler in 1998, the screening for ectasia risk became one of the most important topics of Refractive Surgery.

Although rare, ectasia was rapidly recognized as a severe complication due to the very high potential for vision impairment or morbidity, leading to malpractice liability claims and lawsuits.

The hypothesis of altered biomechanical properties of the cornea as being the reason for ectasia development was considered since the first report which was related to a case of "forme fruste keratoconus" (FFKC) that had ectasia progression after LASIK. In fact, ectasia occurs due to the chronic biomechanical failure process of the corneal stroma with the inability to support the unremitting stresses caused by intraocular (IOP) pressure, extra-ocular muscles' actions, eyelid blinking, and other forces such as eye rubbing. Ectasia is much more common after LASIK, but has been also reported after surface ablation procedures. This is because the lamellar LASIK flap cut has a biomechanical impact on the cornea, which varies accordingly to flap thickness, in addition to the effect of the excimer corneal stromal ablation. Interestingly, there are reported cases of unilateral keratectasia after LASIK, while the fellow eye remained stable after photo-refractive keratectomy (PRK), or due to a thinner flap LASIK procedure. Thereby, the basic physiopathological reasons for biomechanical failure and ectasia progression after LVC are:

1. preoperative innate abnormally weak biomechanical properties of the patient's corneal stroma
2. the degree of biomechanical weakening caused by the LVC procedure.

However, in practice, these two mechanisms coexist. We could also imply that every cornea may undergo ectasia depending on the preoperative predisposition (susceptibility) and the dwindling of biomechanical properties caused by the procedure.

Proper screening

Preventing ectasia depends on proper screening for cases at high risk or susceptibility for biomechanical failure, which represent a major challenge for refractive surgeons. Placido disc-based corneal topography and central corneal thickness (CCT) have a recognized historical role for screening refractive candidates. It is well established that topographical evaluation of the front corneal curvature is sensitive to detect mild ectatic disease in patients with relatively normal distance corrected visual acuity and biomicroscopy. As an attempt to improve the efficiency for screening ectasia risk prior to LVC, the ectasia risk scoring system (ERSS) was developed based on a retrospective case-control study to integrate other clinical variables, such as the level of correction, residual stromal bed (RSB) and patient's age. The ERSS was validated by a second study, which confirmed abnormal corneal topography and age as the most important risk factors for ectasia. However, there were 8% of false negatives, and a higher incidence of false negatives was also reported, which may had been related to different criteria for classifying corneal topography. In fact, there is significant variability on the classification of corneal topography maps even when considering fellowship trained specialists. Also, there are cases with ectasia with no recognized risk factors, which provide unquestionable evidence for the need to go beyond, definitively not over, standard classic diagnostic methodology for screening ectasia risk.

Enhanced criteria

Novel enhanced screening criteria based on 3-D corneal tomography and biomechanical analysis were proposed by the Rio de Janeiro Corneal Tomography and Biomechanics Study Group (Figure 1) in 2008. "Corneal ToMography" has been acknowledged as a different diagnostic method from ToPography, which provides a three dimensional reconstruction of the cornea, enabling the calculations of elevation maps of the front and back surfaces of the cornea along with pachymetric mapping. While different technologies are available in many commercially available instruments, it is of fundamental importance that validated objective criteria for diagnostic interpretation and proper understanding of the generated data are critical for the clinician to take full advantage of the technology. Along with the description of the corneal thickness profile, we introduced the concept of relational thickness, which considers the thinnest value in relation to the grade of increase in thickness towards the periphery. The combination of the tomographic thickness evaluation and corneal elevation was the basis for the development of the Belin/Ambrósio Enhanced Ectasia Display (BAD), which has been demonstrated to significantly enhance the ability to detect ectasia and its susceptibility. The standard deviation from normality (towards ectasia) is calculated for multiple parameters, which are combined using logistic regression analysis and other artificial intelligence methods for providing the BAD-D. Faria-Correia et al., in a study using Pentacam (Oculus, Wetzlar, Germany), reported the performances of different parameters for detecting keratoconus, finding the BAD-D as the most accurate. Also, studies involving topographically normal eyes of patients with clinically evident keratoconus in the fellow eye, defined as FFKC by Klyce, confirmed BAD-D as the most accurate parameter.

Different cut off values and accuracies by the receiver operator characteristic curves (ROC) exist when studying the detection of clinical and subclinical (FFKC) keratoconus. For example, the BAD-D has a cut off of 2.11 for detecting keratoconus with an area under the ROC curve (AUC) of 1.0 (100% sensitivity and 100% specificity), while the cut off is 1.22 for detecting FFKC, with AUC of 0.975 (sensitivity of 93.6% and specificity of 94.5%). However, while such cases of FFKC have been used by many authors such as Saad, Buehren, Smadja, and Sanctis to demonstrate a significant improvement for detecting mild cases of ectasia, this group of cases may not be ideal as some cases may have true unilateral ectasia due to excessive ocular trauma such as eye rubbing.

Accurate individual parameter

In a study that retrospectively evaluated the preoperative clinical data and tomographic status of 23 cases that developed ectasia after LASIK, BAD-D was the most accurate individual parameter for detecting the risk of ectasia with a cut off of 1.29, having a sensitivity of 92.1%, and 87% of specificity, considering a population of 266 cases with stable tomography at least one year after LASIK. In this study, the ERSS showed a sensitivity of 52% and a specificity of 82% (data presented at ARVO 2013). While the BAD-D significantly enhanced the ability to detect the ectasia risk on cases with relatively normal topography and no other risk factor identified (Figure 2), there is still a conclusive need for improving the accuracy of the test.


Ambrósio (3)

Renato Ambrósio Jr.

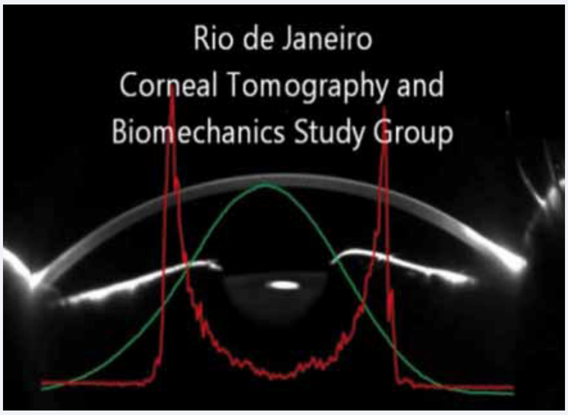

Figure 1: Rio de Janeiro Corneal Tomography and Biomechanics Study Group

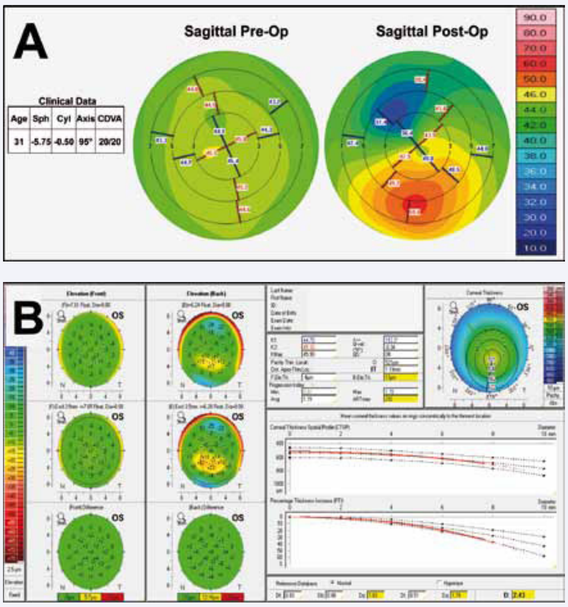

Figure 2. A. Clinical data and front surface curvature data prior and after LASIK; B. Preoperative Pentacam Belin/Ambrósio Display – BAD.

Novel combinations of tomographic and clinical parameters were performed by the BrAIN (Brazilian Study Group of Artificial Intelligence and Corneal Analysis), so that the accuracy was significantly improved with the ability to detect all cases of ectasia (100% sensitivity) and less than 2.5% of false positives (Ramos et al, ESCRS Poster 2013).

It is expected that these parameters will be clinically available soon, but studies for validating these new parameters will be needed.

Profile

Prof. Renato Ambrósio Jr., MD, PhD is director of the Cornea & Refractive Surgery of the Instituto de Olhos Renato Ambrósio and Visare-RIO - Refracta Personal Laser, founder and scientific director of the Rio de Janeiro Corneal Tomography and Biomechancis Study Group. The associate professor of ophthalmology of the Federal University of São Paulo and Pontific Catholic University (Brazil) is President of the Brazilian Society of Refractive Surgery as well as Vice-President of the Brazilian Council of Ophthalmology.

Along with tomographical evaluation, direct biomechanical characterization has also been possible since the introduction of the Ocular Response Analyzer (ORA, Reichert, Buffalo, NY) in 2005. The ORA is a non contact tonometer that monitors the corneal response to the air puff using the infra red reflection. Although promising, 14 studies demonstrated limited ability in screening for ectatic diseases when considering pressure derived parameters. However, parameters related to the infrared signal reflex that refers to the corneal deformation significantly improve the accuracy of the test The Corvis ST (Oculus, Wetzlar, Germany), introduced in 2011, integrates an ultra high speed Scheimpflug camera to monitor cornea deformation during non contact tonometry. A significant influence of IOP has been demonstrated which makes it a true challenge to understand the corneal biomechanical properties and predict its behavior. However, advanced technologies for tomographical and biomechanical analysis provide objective parameters which may be combined, along with clinical data, with the promise to enhance safety, as well as the efficiency of LVC procedures. ▪

Sat, 05.10. 14.00-16.00
Symposium: ESCRS/EuCornea Symposium: Refractive surgery in risky corneas: is it really safe for the patient? Main Lecture Hall

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