Enhanced Ectasia Susceptibility Screening

Faria-Correia MD, PhD

Fernando Faria Correia, MD, PhD

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Progressive "iatrogenic" keratectasia

- First described by Seiler in 1998
  - Progressive steepening and loss of visual acuity soon after LASIK in a case of forme fruste keratoconus (FFKC)
- Emerged as a very severe complication for LVC procedures
- **Prevention** is best strategy

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Known Risk Factors for Ectasia

- Pre-operative ectatic corneal disease
- Young Age
- Excessive laser ablation (high corrections)
- Thick LASIK Flap
- Low Preoperative Pachymetry

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LASIK "Math": Rule of 250

Pachymetry > (Flap + Ablation) + 'Safe' RSB

HOWEVER...

Cases with 200 µm or less that are stable

Cases with over 300 µm that had Ectasia

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Risk Assessment for Ectasia After Corneal Refractive Surgery

Randleman JB, Woodward M, Lynn MJ, Stulting RD.
Ophthalmology 2008; 115: 37-50

Comprehensive, weighted, risk factor scale significantly improves the identification of high risk eyes

Parameter	Point Value				
	4	3	2	1	0
Topography Pattern	Abnormal	Inf. Steep Skewed Radial Axis		Asymmetric Bowtie	Normal Symmetrical Bowtie
Residual Stromal Bed	<240µ	240 to 259µ	260 to 279µ	280 to 299µ	300µ
Age		18 to 21y	22 to 25y	26 to 29y	30y
Preoperative Pachymetry	<450µ	451 to 480µ	481 to 510µ		510µ
MR (SE)	>-14D	>-12 to -14D	>-10 to -12D	>-8 to -10D	-8D or less

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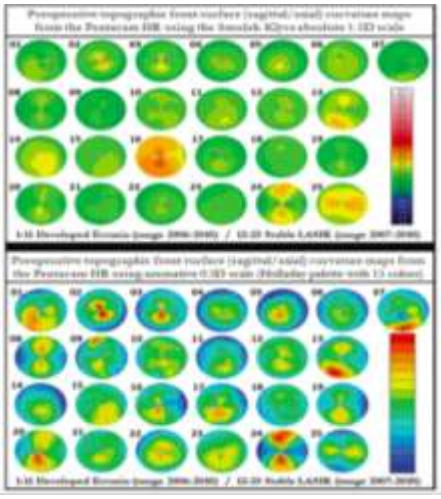
Variability of Subjective Classifications of Corneal Topography Maps From LASIK Candidates

[*J Refract Surg.* 2013;29(11):770-775.]

Isaac C. Ramos, MD; Rosane Correa, MD; Frederico P. Guerra, MD; William Trattler, MD; Michael W. Belin, MD; Stephen D. Klyce, PhD; Bruno M. Fontes, MD, PhD; Paulo Schor, MD; Michael K. Smolek, PhD; Daniel G. Dawson, MD; Maria Regina Chalita, MD, PhD; Jorge O. Cassi, MD; Milton Ruiz, MD; J. Bradley Randleman, MD; Renato Ambrósio, Jr., MD, PhD

CONCLUSION: There was significant inter-observer variability in the subjective classifications using the same scale, and significant intra-observer variability between scales. Changing from an absolute to a normative scale increased the scores on the classifications by the same examiner, but significant inter-observer variability in the subjective interpretation of the maps still persisted.



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Why we need Enhanced Screening Tests?

- Cases with risk factors with stable results
- False positives and negatives ERSS (Ectasia Risk Score System)
  - 8% of cases with ectasia had a false negative AND
  - 6% of normal controls were incorrectly classified as being at high risk for ectasia (false positive)

  Randleman JB, Trattler WB, Doyle Stulting R, Am J Ophthalmol 2008
- "unexplained" cases of Ectasia after LASIK

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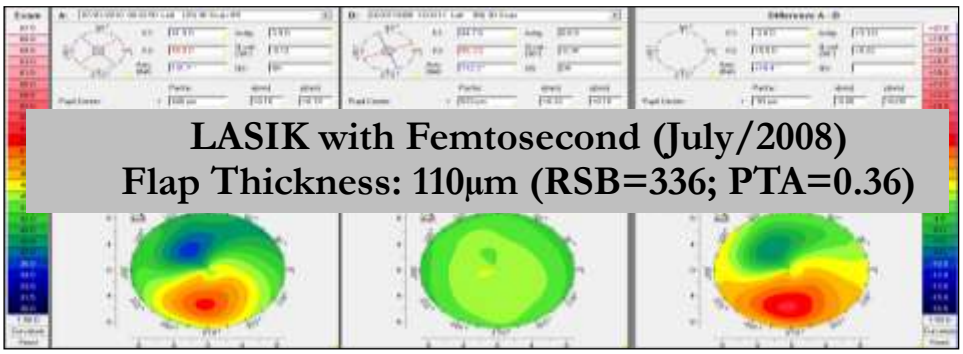
We need Enhanced Screening!

- "unexplained" cases of Ectasia after LASIK

Age	Eye	Sph	Cyl	Axis
31.9	L	-5.75	-0.50	95



LASIK with Femtosecond (July/2008)
Flap Thickness: 110µm (RSB=336; PTA=0.36)

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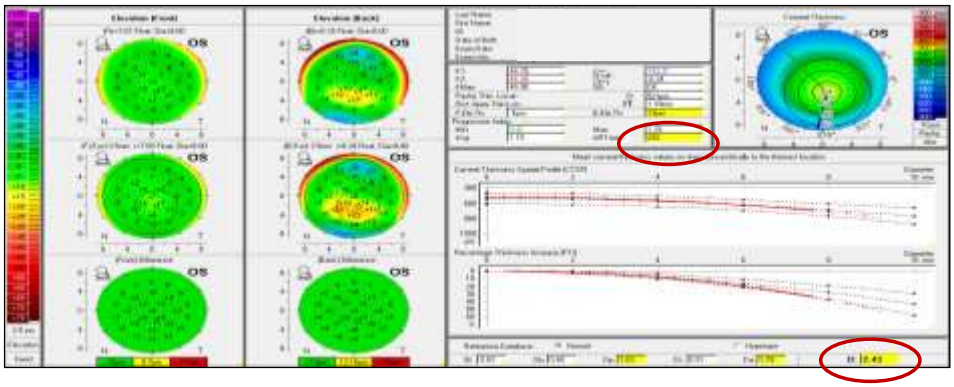
Enhanced Screening: Pre Op ToMography (Belin/Ambrósio Display – BAD)



- ART-Max <412: Ectasia susceptibility
- BAD D > 1.44

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Pathophysiology of Post-LVC Ectasia

- **Pre-operative 'abnormal' or 'susceptible' cornea**
  - Subclinical ectasia
  - Forme Fruste Keratoconus
- **Post-operative 'biomechanically weak' cornea**
  - Excessive ablation
  - Induced by a thick-flap
  - Chronic eye rubbing

Any cornea may undergo biomechanical failure and develop Ectasia

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"Forme Fruste Keratoconus is defined as a very susceptible cornea for ectasia progression and may present with `normal` topography."

Renato Ambrósio Jr, MD, PhD (2009)

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Ectasia Study: Corneal Tomography

- Oculus Pentacam HR (Wetzlar, Germany) data from one eye randomly selected:
  - 439 Normals (Pre-op stable LASIK, N)
  - 364 Clinical keratoconus (KC)
  - 241 Forme fruste keratoconus (fellow eyes with `normal topography`*, FFKC)

*no evidence of keratoconus on Oculus TKC and/or Nidek Corneal Navigator

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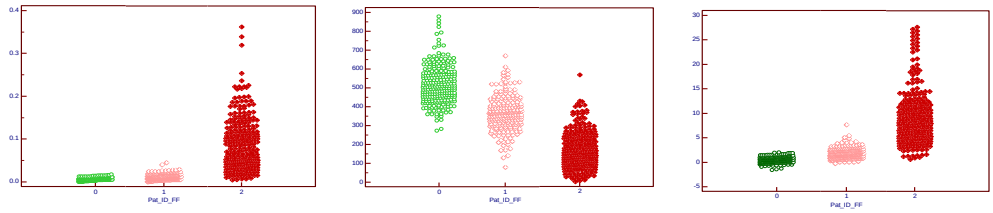
Results: Best Parameters

IHD (Front Surface)
- AUC=0.992 for KC (95% CI: 0.970 to 0.994)
- AUC=0.781 for FFKC (95% CI: 0.741 to 0.817).

ART-Max (Relational Pachy)
- AUC=0.992 for KC (95% CI: 0.980 to 0.997)
- AUC=0.877 for FFKC (95% CI: 0.844 to 0.905).

BAD-D (version 3)
- AUC=0.995 for KC (95% CI: 0.982 to 0.998)
- AUC=0.892 for FFKC (95% CI: 0.861 to 0.919).



0 = Stable LASIK **1 = FFKC** **2 = KC**

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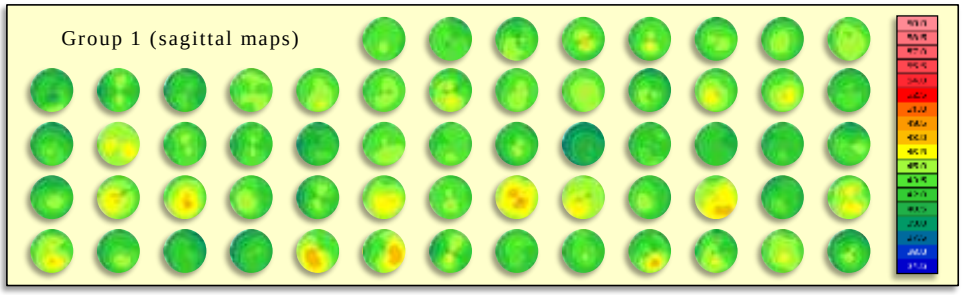
Enhanced Ectasia Susceptibility Screening based on clinical and tomographic data

- The EESS is a combined function designed to enhance accuracy in detecting ectasia risk.
- In the first study, the EESS was developed based on logistic regression analysis of clinical and Pentacam data from 266 eyes (141 patients) with stable LASIK outcomes (minimal follow-up of 24 months) and 22 eyes that developed ectasia.*

*** Ramos et al., Enhanced Screening for Ectasia Susceptibility among LASIK Candidates.** ***ESCRS Interative Poster. Amsterdam 2013.*** **1st. Prize Refractive Poster Award.**

- Current study further refine and validates the sensitivity in a larger population comprised of 60 eyes from 46 patients that developed ectasia (Group 1). Same stable LASIK group as control (Group 2).



Note: 22 eyes from group 1 were used for the initial analysis presented at ESCRS 2013.

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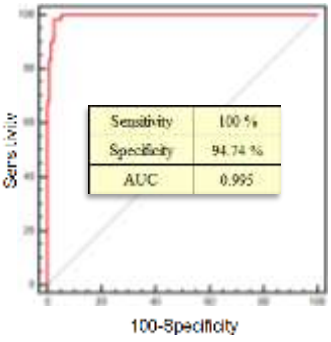
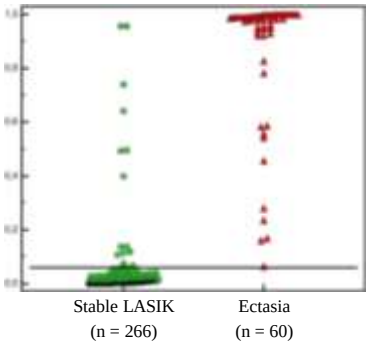
Results - "Enhanced Ectasia Susceptibility Screening"

- The EESS obtained 100% of sensitivity and 94.74% of specificity to distinguish post-LASIK ectasia cases from stable LASIK cases.

ROC curve



Dot-Plot Diagram



Cut-off	0.0570
Standard Error	0.0024
95% Confidence Interval	0.979 to 1.000
Z Statistic	206.375
Level p	< 0.0001

- The parameters that comprise the EESS are: **Age, Flap Thickness, Ablation Depth, IHD, and Belin-Ambrósio Deviation Index (BAD-D).**

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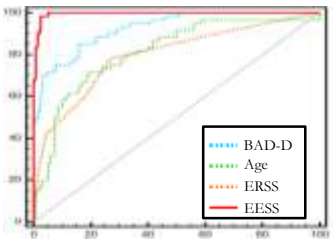
Discussion

- EESS was further refined and validated in a larger population of ectasia cases.
- **EESS was statistically better in pairwise comparisons of ROC Curves by DeLong´s Method than all parameters, including BAD-D (Graph).**
- Ectasia after LASIK occurs due to a combination of preoperative predisposition (better characterized by tomography) and the impact of LASIK procedure on corneal structure.
- **Age, a surrogate of biomechanical properties, significantly impact regression analysis.**



Conclusion

- Artificial intelligence strategies should be applied to optimize accuracy in diagnosis, using conscious and validated combinations of parameters.
- The EESS represents a superior method for detecting risk for ectasia after LASIK.

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Patient Data

- **29 years old**
- **Nurse**
- **Pre-OP subjective Refraction**:
  - OD: -3.50 -0.25 @ 50º (10/10)
  - OS: -3.50 -0.50 @ 105º (10/10)
- **Slit-lamp examination:**
  - AO: MGD mild; tear film with debris

Corneal ToMography

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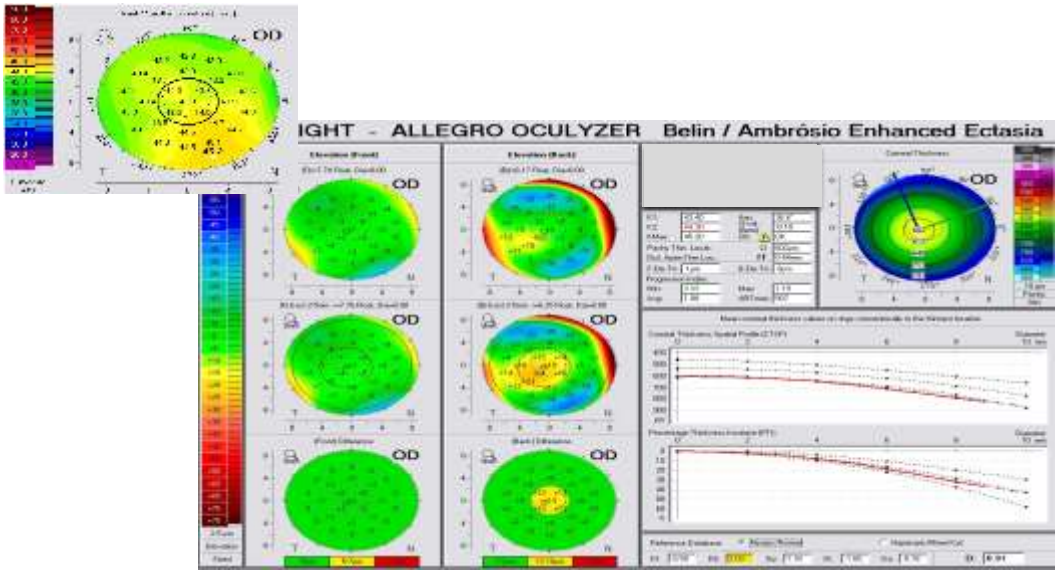

Corneal ToMography

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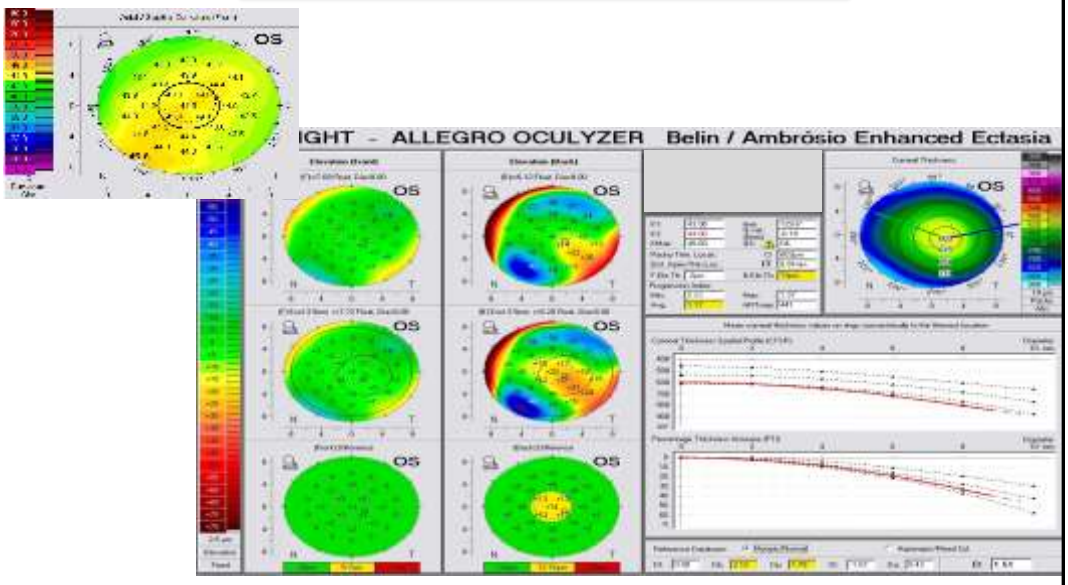

BrAIn Cornea Risk Calculator

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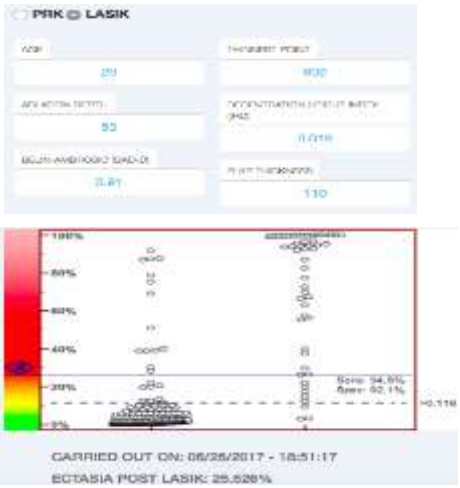
RIGHT EYE



LEFT EYE

BrAIn Cornea Risk Calculator

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RIGHT EYE

LEFT EYE

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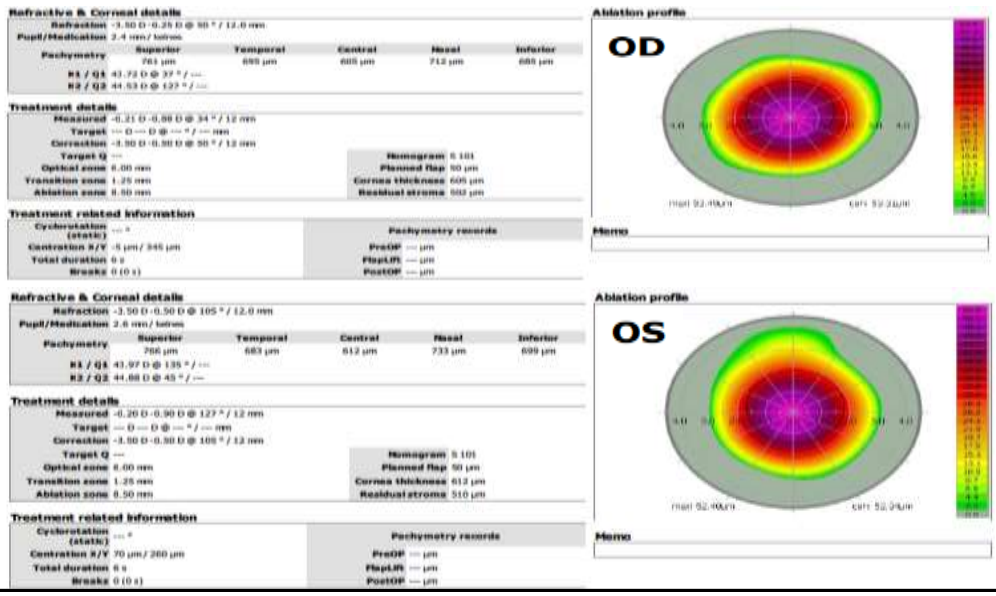
Contoura - PRK



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3 M Postoperative Data

- **UCVA**
  - OD: 10/10+ (12/10 with -0.50 @ 175º)
  - OE: 12/10
- **Slit-lamp examination:**
  - AO: epithelium OK; MGD mild; tear film improving

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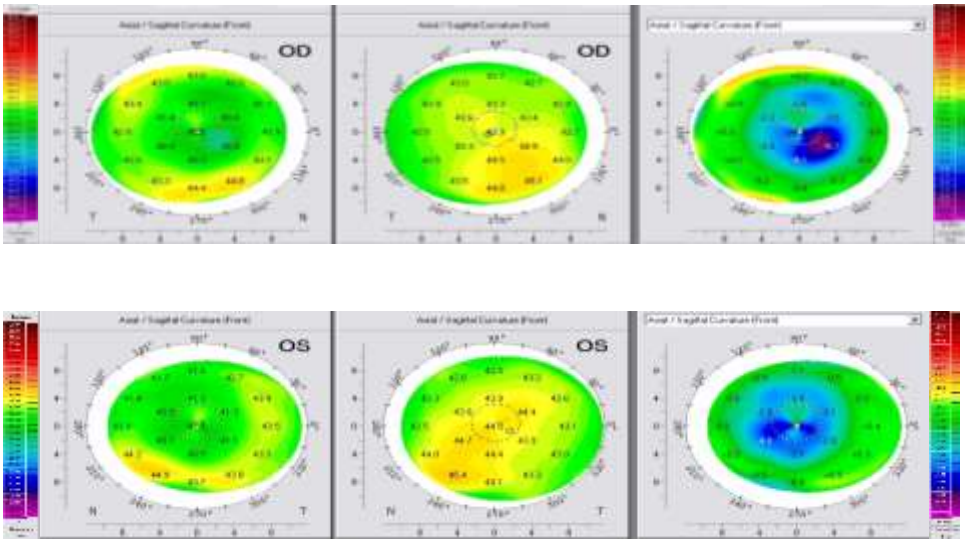
3 M Postoperative Data



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Go further beyond…

- Tomography is better to identity ectasia susceptibility (vs Topography)
- ALWAYS remember:
  - surgical-induced damage
  - Avoid chronic eye rubbing
- Integration of clinical data and Corneal Geometry
- Artificial intelligence and new technologies to combine

Integration of Scheimpflug Tomography and Biomechanics

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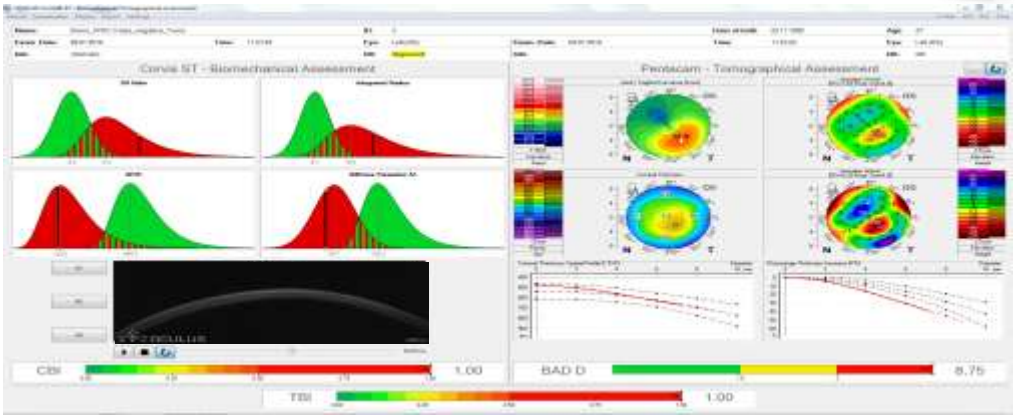

TBI: Tomography/Biomechanical Index

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PURPOSE: To present the Tomographic and Biomechanical Index (TBI), which combines Scheimpflug-based corneal tomography and biomechanics for enhancing ectasia detection.

METHODS: Patients from different continents were retrospectively studied. The normal group included 1 eye randomly selected from 480 patients with normal corneas and the keratoconus group included 1 eye randomly selected from 204 patients with keratoconus. There were two groups: 72 ectatic eyes with no surgery from 94 patients with very asymmetric ectasia (VAE-E group) and the fellow eyes of these patients with normal topography (VAE-NT group). Pentacam HR and Corvis ST (Oculus Optikgeräte GmbH, Wetzlar, Germany) parameters were analyzed and combined using different artificial intelligence methods. The accuracies for detecting ectasia of the Belin/Ambrósio Deviation (BAD-D) and Corvis Biomechanical Index (CBI) were compared to the TBI, considering the areas under receiver operating characteristic curves (AUROCs).

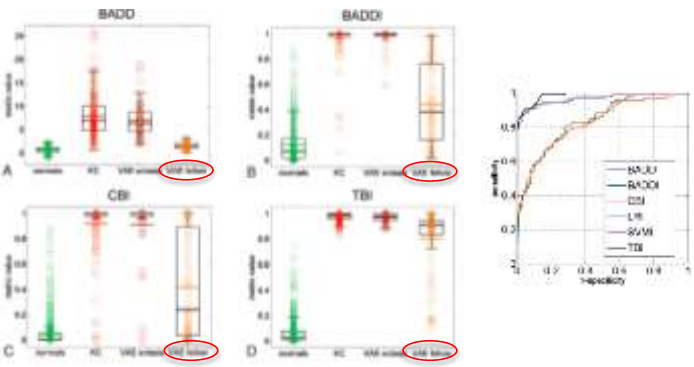
RESULTS: The random forest method with leave-one-out cross-validation (RF/LOOCV) provided the best artificial intelligence model. The AUROC for detecting ectasia (keratoconus, VAE-E, and VAE-NT groups) of the TBI was 0.996, which was statistically higher (DeLong et al., $P < .001$) than the BAD-D (0.956) and CBI (0.936). The TBI cut-off value of 0.75 provided 100% sensitivity for detecting clinical ectasia (keratoconus and VAE-E groups) with 100% specificity. The AUROCs for the TBI, BAD-D, and CBI were 0.985, 0.839, and 0.822 in the VAE-NT group (DeLong et al., $P < .001$). An optimized TBI cut-off value of 0.29 provided 90.4% sensitivity with 96% specificity in the VAE-NT group.

CONCLUSIONS: The TBI generated by the RF/LOOCV provided greater accuracy for detecting ectasia than other techniques. The TBI was sensitive for detecting subclinical (frustr) ectasia among eyes with normal topography in very asymmetric patients. The TBI may also confirm unilateral ectasia, potentially characterizing the inherent ectasia susceptibility of the cornea, which should be the subject of future studies.

[J Refract Surg. 2017;33(7):434-443.]

Integration of Scheimpflug-Based Corneal Tomography and Biomechanical Assessments for Enhancing Ectasia Detection

Renato Ambrósio, Jr., MD, PhD; Bernardo T. Lopes, MD; Fernando Faria-Correia, MD; Marcella Q. Salomão, MD; Jens Bühren, MD; Cynthia J. Roberts, PhD; Ahmed Elsheikh, PhD; Riccardo Vinciguerra, MD; Paolo Vinciguerra, MD



Thank you for your attention!

Cairo (Egypt) – 26/01/2018