Corneal Biomechanical Assessment in Clinical Practice. Limits and possibilities

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Current methods based on an air-puff

What results depend?

- Geometry (thickness, curvature and topography).
- Corneal material behavior.
- Confounder variables. IOP
- Air-puff characteristics (loading).
- Specular reflexion.
- Alignment and applanation zone.
- Only information of a 8 mm chord.
- Many non-repeatable variables.
Ocular Response Analyzer (ORA)

OCULUS Corvis ST
Biomechanical Parameters

First Applanation (A1):
- Time (AT1)
- (1) Deflection Length (AL1)
- Velocity (AV1)

Second Applanation (A2):
- Time (AT2)
- (5) Deflection Length (AL2)
- Velocity (AV2)

Highest Concavity (HC):
- (2) Amplitude (HCA)
- Time (HCT)
- (3) Radius (HCR)
- Velocity (HCV)
- (4) Deflection Length (HCL)
A linearly elastic material can be characterized by a single elastic modulus, defined by the slope of the stress-strain plot, which describes how much a load (stress) will deform (strain) the material under specific conditions.

A very fast applied load, as the case of an air-puff, will result in an almost pure elastic (hyperelastic), response during the loading and corneal hysteresis is observed only during the unloading phase of the air-puff load.


The maximum displacement of the apex due to the air pulse varies linearly with IOP for all corneal stiffness considered, with the largest displacement corresponding to the lowest IOP value.

Current methods based on an air-puff

- The right combination of corneal stiffness and IOP may result in the same maximal corneal deformation.

- It is not possible to distinguish between individual effects (IOP and material stiffness) without knowing the characteristic of one of them apriori, e.g. Cornea’s stiffness

  - Corneal biomechanical changes after refractive surgery should be compared with preoperative data.

  **Deformation Amplitude**

  - Overlapping Keratoconus and Normal Subjects in the area between 1.0 and 1.4mm with Corvis ST.


Current methods based on an air-puff

For a corneal thickness within the physiological range (500–600 microns), the maximal corneal displacement ranged within the reported clinical range (0.7–1.3 mm)

The biomechanical characterization using an air pulse pressure loading accounts for the contribution of the collagen fibers only partially (only the posterior part of the cornea), contrary to the case of an inflation test where the cornea works under tension all the time.


The mechanical response characterized by non-contact tonometry represents a combination of the mechanical behavior of the cornea under traction (associate with the collagen fiber network) and, but not less important, the mechanical behavior under compression of the stroma.


• Maintenance of corneal curvature
• Reduced lamellar interweaving and infrequent Bowman’s membrane insertions in keratoconus

Biomechanical Properties after refractive surgery

Dan Z Reinstein (2013)

550 µm thickness

75% SMILE (130-µm cap) 68% PRK 54% LASIK (110-µm flap)

TTS = Total tensile strength

The flap-based LASIK and ReLEx flex and the flap-free ReLEx smile result in similar reduction in corneal biomechanics when evaluated by Corvis ST.

- Retrospective Studies Fail in the absence of Preoperative data for comparison.
- It should be considered that the anterior corneal Surface preserved in SMILE is acting in compresión after the air-puff. The role of viscoelasticity should be considered.
### Conclusions

- Corneal Biomechanics with air-puff devices requires of a complex analysis based on knowledge of corneal structures.

- Many confounding variables as CT or IOP should be considered for identifying which changes in parameters are due to these variables or due to changes in corneal biomechanics.

- Preoperative data for comparison will increase the potential analysis between studies. Careful in the interpretation should be considered in retrospective studies.

- Future requires the mixed analysis of multiple parameters and the integration with corneal topography in a bidimensional characterization of corneal biomechanics.