CORNEAL IMAGING UPDATES

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Abstract: *Corneal imaging has an important role in clinical ophtalmological practice. Modern anterior segment imaging techniques improved the approach of various corneal diseases and brought new therapeutical options. Refractive surgery, preoperatively screening for keratoconus or other ectatic disorders are the major entities that can benefit from this technique and cannot be accomplished without previous performing corneal imaging. The increased incidence of the ectatic diseases and the patient's requirement of discarding spectacles by performing refractive surgery made us highlight the importance of this aspects. The aim of this paper is to emphasize the role of each technique in regards to its underlying principles, interpretation, utility and application in different pathologies.*

The corneal pathology can be assessed through various methods, each one with its advantages and weaknesses. According to its morphology the corneal evaluation can be done by using pachimetry, keratometry, tomography, corneal aberrometry or corneal topography.(1) Non-contact instruments were developed to measure the reflected light of the anterior surface of the cornea. This investigations can asses quantitative or qualitative the corneal parameters and can be based on reflection or projection.(2) The cornea has a prolate shape and accounts for 74% of refraction in the eye, providing approximately 43.5 dioptres, so an accurate evaluation of its properties is important in clinical practice.(3)

Principles and uses of corneal imaging

The principles of keratometry consist of projecting a concentric set of white rings onto the convex anterior surface of the cornea. The surface acts as a transparent mirror and reflects part of the incident light. This measurement takes readings from two points, rotates 90 degrees and takes another reading from two points that are approximately 90 degrees apart, so these measurements are perpendicular one on each other. This measurement is a quantitative one. Distorsion in the mires can mean scars or irregularity of the cornea, elliptical mires indicate astigmatism and keratoconus can be suspected if the mires are asymmetric. A classification of the ectatic disorders can be achieved by performing this technique. Corneal topography uses the principles of Placido disc reflection (projection-based, Placido-based or elevation-based measurement) and generates a range of refractive maps, measures the anterior curvature of the cornea and shows the surface conditions and local distorsion.The concentric rings projected onto the cornea take readings from thousands of points, covering a significant larger surface of the convex anterior cornea. The generated maps are colour-coded, warm colours indicate steeper regions of the cornea and cold colours indicate flatter regions.(4) The *refractive power map* uses Snell's law of refraction to identify the refractive power of the cornea based on its radius of curvature at all points.

Figure no. 1. Placido disk (5)

The local radius of curvature map consists of a tangential map that detects local irregularities of the cornea, corneal ectatic diseases.(5) Postoperatively changes, for example anterior surface irregularity after Descemet's Stripping Endothelial Keratoplasty (DESK) can impair the visual acuity and corneal topography can evaluate the changes in morphology.(6) Corneal ectatic changes induced by LASIK treatment are iatrogenic and consist of chronic biomechanical defect.(7) Tangential corneal topography should always be considered in preoperatively subclinical keratoconus screening. Corneal imaging quantifies subsequents changes in asphericity and evolution of the ectatic diseases can be evaluated by topographic improvement and pachymetric progression after surgical treatment.(8) *The axial map* uses the keratometric formula to determine the dioptric power of the cornea at all points and displays axial radius of curvature. *The distorsion maps* display the optical quality of the surface and the *profile*

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difference map shows the difference in curvature from an assumed normal aspheric cornea.(9)

The utility of corneal imaging are:

- *Refractive surgery*-patient suitability for this technique can be appreciated preoperatively by identifing corneal shape, thickness, surface anomalies, ectasia or keratoconic patterns.(10) Steepening and thinning of the cornea are considered to be irreversible in refractive surgery, and the postoperatively ectasia can be preventable if high-risk topographic or pachymetric maps are identified on time.(11) Abnormal preoperative topography, especially low preoperative corneal thickness should reconsider the correction of the refractive error. Postoperatively topography rates the dioptric changes created, assesses decentred or incomplete ablation and postexcimer ectasia. The preoperatively topographic risk factors are considered the central corneal thickness under 500 µm, central keratometry over 47 diopters, against the rule astigmatism over 2 diopters and residual stromal bed thickness under 250 µm.(12)
- *Keratoconus*- topography is the gold standard in screening suspects, monitoring progression and establishing therapeutic approach. Keratometry gives limited assessment of this pathology and slit lamp examination can be normal in early stages. Early corneal imaging signs in keratoconus can consist of inferior steepening and thinning, skewed axis, increased keratometry values on K reading and computerized corneal topography.(13) In subclinical forms of keratoconus lack of enantiomorphism (the mirror symmetry between the two eyes) is highly suggestive for this pathology.(14) The topography can indentify any asymmetry based on mathematical formulas (Zernicke's polynomials) and methods of analizing (Fourier's analyze).(15)

Table no. 1. Corneal imaging in keratoconus (16)

Corneal topography	OCT and Scheimpflug tomography
- mapping the cornea	- biometry of anterior segment
- grade the ectatic risk	- central and periferic pachimetry
- identifies the irregular astigmatism	- evaluates the corneal thinning, oedema, opacities
- assesses the inferior steepening and thinning	- assesses the depth of intrastromal rings placement
- establishes the ring placement and place for cross-linking	-evaluates the line-up of intrastromal rings

- *preoperatively planning and postsurgery astigmatism*-corneal anterior and posterior astigmatism can be identified using topography and this can also guide the placement of the incisions in order to reduce the refractive error.(17) The corneal warpage is a transient topographic change induced by long term rigid contact lenses use. Morphologically it appears as central, irregular astigmatism, oblate cornea and butterfly-like asymmetry. The topography before refractive surgery should be performed after one week of stopping the use of soft contact lenses and one month for the rigid lenses.(18)
- *corneal distorsions*- localized corneal scars or pterygium can change the normal morphology of the cornea and topography can assess this changes.
- *cataract surgery*-corneal topography can determine the optical power of the cornea and provides an assessment of the corneal astigmatism in choosing a toric implant intraocular lens.(19)
- *other uses*- contact lens fitting, orthokerathology or intrastromal ring placement. Corneal topography can also help in making the differential diagnosis of pellucid marginal degeneration and keratoconus. In pellucid marginal degeneration the topographic findings are caracteristic, strongly suggestive for this pathology, but with low specificity. Tipically, PMD has a claw-shaped pattern on corneal topography.(20)

Corneal tomography is based on cross-sectional imaging and provides information about all surfaces of the cornea, both the anterior and posterior elevation and also its thickness.(21) Tomography performs pachymetry maps, gives information about the anterior chamber depth and can calculate the density of corneal tissue. As principle, the tomography uses Scheimpflug slit projection or scanning slit, high frequency ultrasound or optical coherence tomography. The acquisition is made by a camera rotating 180 degrees, taking pictures and readings at different angles for two seconds. It results a three dimensional image of the cornea. Tomography can also assess the lens.(22)

Conclusions:

All of the corneal imaging techniques described above in conjunction with the clinical presentation can lead to an accurate diagnosis and best therapeutic approach. Short lasting, non-contact and reproducible assessments, these measurements had proven their effectiveness in clinical practice and brought a new range of possibilities in interpretation and monitoring the progression of multiple corneal diseases.

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