Review Article

Corneal scheimpflug topography: An overview

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The purpose of this article is to study the basic Scheimpflug corneal topography technology and instrumentation. Initially describes the reason that led us to look for new technologies outside the Placido disk, the operating principle of this technology (ORBSCAN), and downstream equipment of similar instruments (PENTACAN and GALILEI). Next presents the results that give us the afore mentioned devices (maps) and the method of reading and interpreting them.

Key Words: *Cornea; Topography; Placido; Scheimpflug*

INTRODUCTION

The cornea is the most important refractive element in the eye as it is responsible for two-thirds of the refractive power of the emmetropic eye. The shape of the cornea is therefore of great importance for vision, both for the quantity (degrees of ametropia) and for the quality of vision (types and degrees of error). With an objective evaluation of the corneal morphology we can select the appropriate correction (glasses, contact lenses or refractive surgery). This finding was an important reason for focusing the interest of the scientific community on methods of studying corneal "topography". The term "corneal topography" is commonly used to describe the measurement, analysis and mapping of the morphology of the anterior surface of the cornea by topographic criteria. Newer topographic technologies allow for the mapping of additional parameters, such as corneal posterior surface area, thickening, corneal elevation, etc. [1-3].

From topography with “Placido disk” to topography “Scheimpflug imaging”

The vast majority of topographic devices are based on Placido disk topography. They are based on the magnification of the corneal reflection and calculate the corneal curvature, with the exception that topography can cover a larger area. The main advantage of Placido disk technology devices is their affordable purchase price. They provide relative accuracy in measuring corneal curvature and astigmatism, but have significant disadvantages, such as sensitivity to focus and specificity of focus (the corneal tip is placed on the visual axis of the device). Any measurement errors in the center of the cornea tend to be transmitted to the periphery. In addition, measurements of classical topographic devices are confined to a relatively small area of the cornea, thus being inaccurate in the recording of abnormal cornea and the resulting elevation data being relatively inaccurate. For the aforementioned reasons the need to find new technology was imperative.

The first evolutionary model, Orbscan I [4-6] used scanning slit technology to measure not only the thickness but also the topography of the cornea. However, optical section technology was not sufficient for anterior corneal topography, and the manufacturer developed Orbascacn II, which incorporates scanning slit technology and Placido disc keratoscopy technology for improved curvature topography. anterior surface of the cornea.

Orbscan [7-10] takes advantage of the diffuse reflection from a series of 40 slit luminous incisions (20 optical incisions to the right and 20 to the left with an incidence angle of 45 degrees. The optical incisions are similar to those of a slit The optical section system measures elevation data from 240 points per section and calculates the thickness and elevation of the anterior and posterior surface of the cornea throughout the surface When light from a light beam passes through a visual medium such as the cornea, it is separated into the part of the reflected beam and into the refracted part. The refracted beam penetrates the surface of the medium and partially diffuses from the optical media components. the diffraction caused by the corneal layer and the crystalline lens is important, so the diffused reflected images of the corneal and crystalline lens are illuminated without much loss of brightness through the lens, the tear film and aqueous humor (Figure 1).

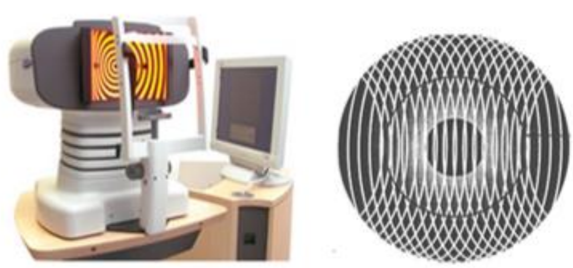

Figure 1) Orbscan topographer.

The main advantages of Orbscan are the best recording data for elevation and curvature of the cornea, large recording zones and less device sensitivity to focus and focus as well as less tear film dependence.

But there are disadvantages as well, such as high purchase costs, longer data processing time and the specialized knowledge required to use it. Because the system is based on corneal reflections, if there is some cloudiness in the cornea it is likely to produce inaccurate maps.

The Orbscan device helped diagnose the subclinical keratoconus using the curved and elevation map of the posterior surface. The primordial (subclinical) keratoconus does not have much elevation in the anterior corneal surface because the epithelium normalizes the curvilinear and elevation maps making the cone invisible. However, the posterior surface, with the unilateral endothelium, cannot normalize the cone, and extensibility is evident with Orbscan topography. Thus, these patients are treated differently and more safely to avoid postoperative extensor (patient information, postponement or combination with cross-linking) [10,11].

Principle of Scheimpflug topography

The latest technology to attract the attention of both researchers and clinical scientists is Scheimpflug imaging, in honor of Austrian Captain Theodore

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Scheimpflug, who developed it as he researched ways to improve the quality of aerial photography. This technique is implemented on Oculus 'Pentacam Comprehensive Eye Scanner and Ziemer Ophthalmic Systems' Galilei device. The principle of operation is based on a simple observation: when the plane we want to photograph forms an angle with the plane of the film, if we tilt the lens so that the perpendicular to the optical axis bisects the angle formed by the plane of the subject and the film, then the whole subject of photography is focused regardless of the depth of field (Figure 2).

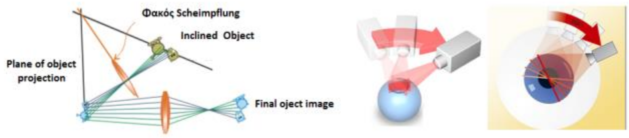

Figure 2) Scheimpflug operating principle.

Of the above two devices, the former uses a Scheimpflug rotary camera and the second two rotary cameras and a Placido disk. Their potential is impressive: Pentacam can produce curved and elevation maps from the anterior and posterior surfaces of the cornea and caliper maps of the cornea and anterior chamber. It can still calculate the capacity of the anterior chamber and cross-section the crystalline lens, revealing opacities.

The Galilei device features two rotating Scheimpflug cameras and a Placido disk, and can do all of the above, while eye-popping claims that it can produce maps of the lens. These devices are not affected by minor corneal opacities such as Orbscan, while they can accurately calculate the point and curvature of the cornea, and in conjunction with elevation maps, they can accurately calculate the refractive power throughout cornea. This is because, knowing the exact topography, it can calculate the angle at which a ray of light falls on the cornea, using Snell's law (Figure 3).

Figure 3) Pentacam and Galilei devices.

The new GALILEI G2, is a dual Scheimpflug/Placido system, capable of merging all data into a 3D corneal reconstruction and anterior chamber biometrics.

Corneal topography reading maps

Scheimpflug technology topographers have the ability to provide a range of multicolor maps each giving different information on the cornea.

Axial map: It is the most common map and very easy to read, as it gives us information on corneal curvature with a simple color scheme. In more detail the warm colors identify the steepest areas, while the cold ones define the flat ones (Figure 4-left).

The disadvantage is that it is unable to visualize minor changes in curvature and that it lacks precision in the representation of the corneal circumference [8].

Tangential map: It is a map depicting the meridian radius of curvature of the cornea calculated by measuring infinite intervals along the meridians. It provides greater accuracy in calculating corneal curvature, as it provides accurate measurement of local curvature changes (Figure 4- right).

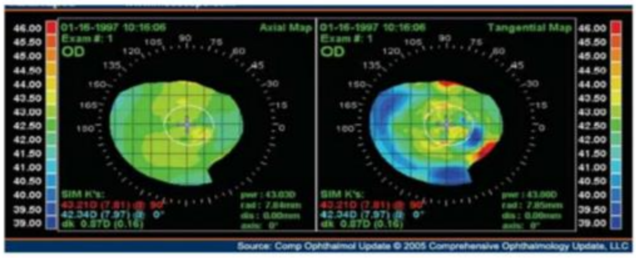

Figure 4) Left: Axial map, Right: Tangential map.

Elevation map: Map showing the elevation difference of the cornea from a reference surface. Most of the time the surface chosen is in the form of a sphere. The best topographic approximation of the actual corneal surface is done with the so-called best-fit sphere (BFS). Sometimes it can be done with an aspheric and a topical reference surface (BFTA). Warm colors give the highest points (above the reference surface) and the coldest ones the lowest (Figure 5).

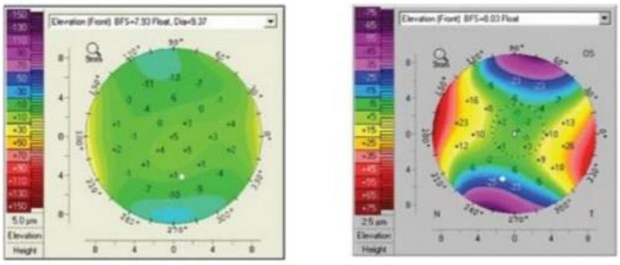

Figure 5) Left: Elevation map of normal eye, Right: Elevation map of Astigmatic eye.

Refractive map: A map expressing dioptric power, not curvature. That is, how the light diffracts from the cornea to pass through the keratometric axis. It is calculated according to Snell's law. Conventional imaging matches are 44 dpt for normal cornea (usually green), more than 46 dpt for more convex corneas (warm colors), and less than 42 dpt for flat cornea (cold colors). It is useful for understanding the effects of a surgery [8].

Pachymetry map: Map depicting the thickness of the cornea throughout the area measured in micrometers. Both Orbscan and Pentacam topography provide corneal thickness maps throughout, so they are superior in terms of ease of contact with ultrasound since no contact is required. Green represents the normal corneal thickness, purple and warm colors indicate thicker areas, while red is used to indicate thinner areas. Studies show that Orbscan tends to overestimate the thick cornea and underestimate the thinnest. Using data from the two corneal surfaces, Pentacam determines the corneal thickness at all points. The system has proven to be highly reliable and yields results similar to ultrasound. It seems to be advantageous, compared to Orbscan, in post-operative eyes (Figures 6 and 7).

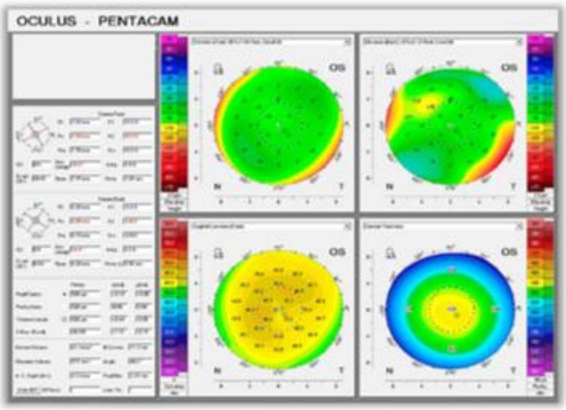

Figure 6) Corneal topography. Maps from Pentacam.

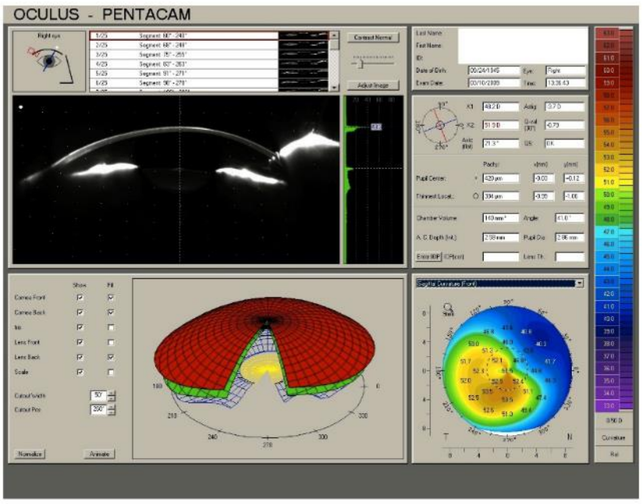

Figure 7) Corneal topography. Pentacam maps with anterior chamber image.

Difference map: They are maps that result from the difference of two others. That is, they give us information about differences in prices and curves between two original maps. They are useful in preoperative and postoperative controls as well as in the use or interruption of contact lenses (Figure 8).

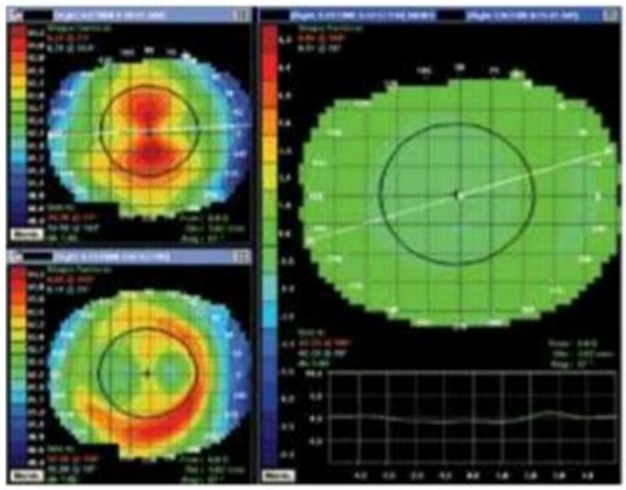

Figure 8) Difference Map.

Topographical indicators

Scheimpflug topographic indices are numbers that quantify the information collected from each topography. They also serve to differentiate between keratoconus and other corneal deformities, visual acuity assessment, and the use of contact lenses. They are divided into 3 categories:

Indices of the entire surface of the cornea,

Corneal circumference indices,

Indices that combine parts of the cornea.

The Indices are not the same for all topographic machines. Even the same Indices on different machines are calculated differently. Some of the most important indicators are:

SIMK: (Simulated Keratometry): provides information on curvature in the center of the cornea (3 mm in diameter). It is distinguished in SIMKS for its most convex corneal meridian and SIMKF for its most flat.

AVE-IN: indicates the central thickness of the cornea (in µm).

CSI: (Center Surrounded Index): is the power difference between the central and peripheral degrees of the cornea (3-6 mm) (Figure 9-right)

DSI: (Differential Sector Index): is the largest binocular power difference calculated over two circular sectors (Figure 9-left).

OSI: (Opposite Sector Index): is the largest binocular power difference across circular sectors (Figure 9-left).

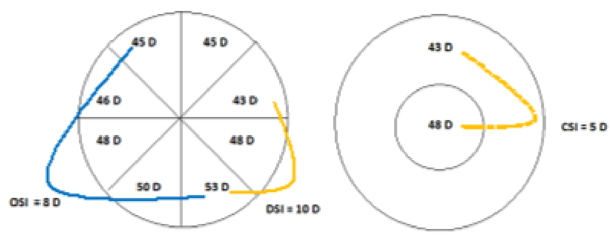

Figure 9) Left: OSI-DSI calculation, Right: CSI calculation.

AA: (Analyzed Area): is the ratio of the surface area used to calculate the parameters to the total corneal surface covered by the projected rings of the placido disk.

IAI: (Irregular Astigmatism Index): reports the average fluctuation of binocular power across the semiconductors between the placido rings.

SAI: (Surface Asymmetry Index): is the difference in corneal refractive power between points in the same ring, which are at opposite diameters.

I-S: (inferior-superior): represents the difference between the upper and lower corneal surface measured at dioptric force, three millimeters from the center of the cornea.

SRI: (Surface Regularity Index): indicates how smooth (spherical) a surface is. On a perfectly smooth surface, the index value is 0.

SDP: (Standard Deviation Power): Standard deviation of all measurements shown on the map.

KPI: (Keratoconus Prediction Index): is a linear relationship of the previous indicators and indicates the probability (%) that the topographic map has identified a keratoconus [7,10-14].

CONCLUSION

From the above we can infer the importance of the discovery of Scheimpflug technology. It is a tool for diagnosis, analysis and evaluation. It helps us actively diagnose pathological conditions such as stretches or other refractive conditions such as dystrophies, traumas, inflammations, and more. Also important is its role in evaluating the suitability of candidates for refractive surgery as well as in calculating the intraocular diaphragm strength for cataract surgery. It is also particularly useful for evaluating corneal morphology following surgery and for applying contact lenses to both normal and abnormal cornea.

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