

REVIEW

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Corneal topography in keratoconus: state of the art

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Abstract

The morphological characterization of the cornea using corneal topographers is a widespread clinical practice that is essential for the diagnosis of keratoconus. The current state of this non-invasive exploratory technique has evolved with the possibility of achieving a great number of measuring points of both anterior and posterior corneal surfaces, which is possible due to the development of new and advanced measurement devices. All these data are later used to extract a series of topographic valuation indices that permit to offer the most exact and reliable clinical diagnosis. This paper describes the technologies in which current corneal topographers are based on, being possible to define the main morphological characteristics that the keratoconus pathology produces on corneal surface. Finally, the main valuation indices, which are provided by the corneal topographers and used for the diagnosis of keratoconus, are also defined.

Keywords: Placido disc, Detection system, Topographer, Diagnosis

Background

Despite earlier works in the study of the human cornea, the first morphological characterizations for clinical diagnosis were made through the simple observation of the external appearance of the ocular surface [1]. At the beginning of the XVII century, Schiöener [2] proposed the first device for the characterization of corneal morphology, comparing the reflection of the image generated by the corneal anterior shape with different calibrated spheres. Later, in the mid-nineteenth century, the Goode keratoscope appeared and enabled a corneal examination using the lateral reflection of a bright square object projected onto the patient's cornea. Current corneal topography is based on the development of the Goode keratoscope by Antonio Placido da Costa [3], who developed it in 1880. This device was a variant that allowed a precise measurement of the anterior corneal surface through the projection of a circular plate onto the cornea. This plate, supported by a handle, contains a series of concentric rings and a hole in its center, allowing the doctor to see the reflected catoptries

image of the corneal surface of a patient located back to the light incidence. In the late nineteenth century, Javal performed the first qualitative analysis of the corneal morphology, joining Placido discs to his ophthalmometer and installing a viewer to obtain a wider field of the corneal image; he also proposed to photograph the image generated and to represent it on a diagram, which was aimed to analyze the variations in the curvature observed in the corneal surface. In 1896, Gullstrand [4, 5] presented the first quantitative assessment of the Placido discs' images. He joined the discs to his photokeratoscope and examined the corneal photographs using a microscope in order to calculate the corneal curvature by a numerical algorithm.

In the early 80s, images were digitalized by hand and later computationally analyzed. Then, with the development of new computer equipment, the automation of this process appeared by capturing the image with a digital camera and its immediate computational analysis. The first fully automated corneal topographer was called Corneal Modeling System (CMS-1), developed by Computed Anatomy Inc. (New York, USA).

This article discusses the current technologies of corneal topographers and is aimed at: i) describing how they enable the main morphological measurements that

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