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A Survey on Detection of Keratoconus

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ABSTRACT

Keratoconus is a progressive corneal disease characterized by central thinning and steepening of the corneal curvature. The progressive nature of this disease leads to increased myopia and irregular corneal astigmatism, which decrease visual acuity and visual quality. Corneal topography is the primary diagnostic tool for keratoconus detection, and pachymetry data and corneal aberrations are also commonly used. Recently, tomographic measurements using optical coherence tomography and corneal biomechanical indices have been used. In incipient and subclinical keratoconus, the use of a single parameter as a diagnostic factor is not sufficiently accurate. In these cases, the use of algorithms and predictive models is necessary. In this paper we discuss new approaches for the early detection of keratoconus.

Keywords : Keratoconus detection, tomographic measurements, corneal, primary diagnostic tool

I. INTRODUCTION

The eye comprises of three concentric layers: an outer fibrous tunic and nurturing that includes the sclera and the cornea; a layer in the middle, vascular and pigmented, which includes the choroid, ciliary body and the iris, and an inner layer of nerve elements; the retina. The interior of the eyeball contains fluid under pressure and is divided into the anterior and posterior compartments, which contain aqueous humor and vitreous body respectively, together with the lens and inserts [1].

The Keratoconus (QC), is the most common corneal ectasia. There is great variability in the incidence of QC, due to suspicious stage it is difficult to establish a diagnosis. The QC also known as keratoconus anterior (QCA), is a corneal alteration that takes the form of a cone which normally is located in central or apical area of the cornea. The prevalence rate is 1 per 2000 inhabitants in the general population [2].

The correlation between the anterior and posterior corneal shape in keratoconus has been also investigated [3,4] and its potential diagnostic value have been also even evaluated. A comprehensive analysis of this relationship can be performed by means of geometric modeling enabling the characterization of the human cornea. We previously validated the use of some new indices based on an innovative morphogeometric modeling of the corneal structure for the detection of keratoconus. The current study is a continuation of this research by confirming the diagnostic ability of the morphogeometric indices developed but in a larger sample of patients as well as by creating a new predictive model of detection of incipient keratoconus based on the combination of such indices.

II. RELATED WORKS

Naoyuki Maeda et.al [5] presented the detection of keratoconus patterns on video keratography which is important for screening candidates for refractive surgery and for studying the genetic basis of keratoconus. Three quantitative approaches to identifying keratoconus from video keratographic information to examine the limitations and capabilities of each test and to determine their suitability for use in the clinical setting

P. Perissutti et.al [6] discussed the utilization of neural networks for the automatic identification of keratoconus from corneal maps, using 9 previously selected objective parameters, were compared. The keratoconus is an asymmetrical pathology, sometimes mono lateral, while the maps of normal eyes and of congenital astigmatism are more often symmetrical. So they compared two methods, the first (monocular) in which each eye is considered alone and the second (binocular) in which information from both eyes of the same subject are the input of the neural network. The binocular information could in fact improve the ability of the neural network to identify the keratoconus corneo topographic patterns.

YARON S. RABINOWITZ et.al [7] presented the differential diagnosis of keratoconus includes keratoglobus, pellucid marginal degeneration and Terrine□s marginal degeneration. Contact lenses are the most common treatment modality. When contact lenses fail, corneal transplant is the best and most successful surgical option. Despite intensive clinical and laboratory investigation, the etiology of keratoconus remains unclear. Clinical studies provide strong indications of a major role for genes in its etiology. Video keratography is playing an increasing role in defining the genetics of keratoconus, since early forms of the disease can be more accurately detected and potentially quantified in a reproducible manner. Laboratory studies suggest a role for degradative enzymes and proteinase inhibitors and a possible role for the interleukin-1 system in its pathogenesis, but these roles need to be more clearly defined.

Filippo Castiglione et.al[8], discussed the keratoconus index (KI) which is a new biometric parameter to make diagnosis and to follow the development of the keratoconus in human eyes. Using images from an ultrasound biomicroscope, we show a semi-automatic method to speed up the computation of the KI.

Jack T. Holladay et.al [9] discussed the ability to detect and diagnose suspicious to advanced keratoconus will enable the exclusion of patients at risk for corneal ectasia after corneal refractive surgery. Earlier detection of forme fruste keratoconus may lead to earlier intervention. The specificity and sensitivity of the various automated keratoconus screening software are still not adequate for broad clinical use.3,4 Most of these automated detection programs cannot accurately classify suspicious topographies with an adequate degree of reliability.3,4 It is precisely these suspicious cases that cause clinicians the most difficulty. To date, a thorough clinical and topographic examination by the ophthalmologist is still requisite for keratoconus detection. This article presents the use of the OPD Scan II (Optical Path Difference Scanning System II; NIDEK Co Ltd, Gamagori, Japan) combined with clinical features to screen for keratoconus

Fatemeh Toutounchian et.al[10] presented Artificial intelligence algorithm to find Keratoconus by employing features of topographical map of eye. These features are obtained by Pentacam and extracted by topographical images of eye via image processing techniques. We provide a dataset of the topographical images of eye by Pentacam in about six months and experts provide labels explaining if the images show sign of Keratoconus or they are suspect to keratoconus. This paper employs 82 topography maps of eye from dataset and classifies them into two categories: Normal (n=47) and Keratoconus (n=35). We use 12 features of each map as the input of a classifier. These classifiers are artificial Neural Network.

George Asimellis et.al [11] surveyed the standard keratoconus grading scale (Pentacam®-derived Amsler□Krumeich stages) compared to corneal irregularity indices and best spectacle-corrected distance visual acuity (CDVA). Patients and methods

Two-hundred and twelve keratoconus cases were evaluated for keratoconus grading, anterior surface irregularity indices (measured by Pentacam imaging), and subjective refraction (measured by CDVA). The correlations between CDVA, keratometry, and the Scheimpflug keratoconus grading and the seven anterior surface Pentacam-derived topometric indices index of surface variance, index of vertical asymmetry, keratoconus index, central keratoconus index, index of height asymmetry, index of height decentration, and index of minimum radius of curvature were analyzed using paired two-tailed t-tests, coefficient of determination (r2), and trendline linearity.

Murat Ucar et.al [12] defined a new classification method for detecting keratoconus based on statistical analysis and to realize the prediction of these classified data with intelligent systems. 301 eyes of 159 patients and 394 eyes of 265 refractive surgery candidates as the control group have been used for this study. Factor analysis, one of the multivariate statistical techniques, has been mainly used to find more meaningful, easy to understand, and independent factors amongst the others.

Valter Wellington Ramos Junior et.al[13] a modified GAADT algorithm approach is presented for blind inversion of channels. The use of this technique is justified here because of the small number of samples. In this situation, gradient-like algorithm fails because it is very difficult to obtain a good estimation of statistics (score function, pdf, etc,). Optimization using GAADT in all situations of classification analysis gives a good performance.

M. A. Valdes-Mas et.al [14] proposed a new approach based on Machine Learning to predict astigmatism in patients with keratoconus (KC) after ring implantation. KC is a non-inflammatory, progressive thinning disorder of the cornea, resulting in a protrusion, myopia and irregular astigmatism. The intracorneal ring implantation surgery has become a suitable technique to deal with keratoconus without the need of a corneal transplant. Two machine learning (ML) classifiers based on artificial neural network and a decision tree were used in this work.

Manmohan Singh et.al [15] presented the mechanical properties of tissues can provide valuable information about tissue integrity and health and can assist in detecting and monitoring the progression of diseases such as keratoconus. Optical coherence elastography (OCE) is a rapidly emerging technique, which can assess localized mechanical contrast in tissues with micrometer spatial resolution. In this work they presented a noncontact method of optical coherence elastography to evaluate the changes in the mechanical properties of the cornea after UV-induced collagen cross-linking. A focused air-pulse induced a low amplitude (μm scale) elastic wave, which then propagated radially and was imaged in three dimensions by a phase-stabilized swept source optical coherence tomography system.

K.Vijay Chandra et.al [16] presented with the corneal diseases using NI VISION Assistant in LabVIEW. NI Vision for LabVIEW is a part of the NI VDM is a Library of LabVIEW used to develop machine vision and scientific imaging applications. The diseases and disorders affecting the cornea are many but only few of them are discussed in this paper. They are: Corneal Infections, Dry Eye, Keratoconus, and Allergies.

Sarah Ali Hasan et.al[17] presented to differentiate the Astigmatism from Keratoconus using Axial Topographic images. In the proposed algorithm, shape recognition is used for classification.

Riccardo Vinciguerra et.al [18] presented to evaluate the ability of a new combined biomechanical index called the Corvis Biomechanical Index (CBI) based on corneal thickness profile and deformation parameters to separate normal from keratoconic patients. Methods: Six hundred fifty-eight patients (329 eyes in each database) were included in this multicenter retrospective study. Patients from two clinics located on different continents were selected to test the capability of the CBI to separate healthy and keratoconic eyes in more than one ethnic group using the Corvis ST (Oculus Optikgeräte GmbH, Wetzlar, Germany). Logistic regression was employed to determine, based on Database 1 as the development dataset, the optimal combination of parameters to accurately separate normal from keratoconic eyes.

R. Mercatelli et.al [19], presents to investigate this anomaly by means of Second Harmonic Generation (SHG) microscopy, using an optical scheme relevant for clinical applications. In particular, we propose a method based on 3D correlation of SHG image stacks, able to appreciate statistical differences in the orientation distribution of sutural lamellae between healthy and keratoconic corneas. The proposed method offers the potential for diagnosing keratoconus in an early stage.

Irene Ruiz Hidalgo et.al [20] presents to evaluate the performance of a support vector machine algorithm that automatically and objectively identifies corneal patterns based on a combination of 22 parameters obtained from Pentacam measurements and to compare this method with other known keratoconus (KC) classification methods.

Eduardo Pinos-Vélez et.al [21] presents work the simulation and modeling of the human eye in order to determine the degree of involvement of keratoconus, as a tool for early diagnosis Presumptive diagnosis tool for the specialist, in such a way that they can take the necessary actions to control this disease. The information of images of the human eye, are used for the analysis in the various stages of keratoconus, through digital processing developed in free software.
Francisco Cavas-Martı´nez et.al[22] presents to characterize corneal structural changes in keratoconus using a new morphogeometric approach and to evaluate its potential diagnostic ability.

AntonioMartínez-Abad et.al [23] discussef laser refractive surgery has increased markedly in recent years, making the detection of corneal abnormalities extremely relevant. For this reason, an accurate diagnosis of clinical or subclinical keratoconus is critical. Corneal topography is the primary diagnostic tool for keratoconus detection, and pachymetry data and corneal aberrations are also commonly used. Recently, tomographic measurements using optical coherence tomography and corneal biomechanical indices have been used. In incipient and subclinical keratoconus, the use of a single parameter as a diagnostic factor is not sufficiently accurate. In these cases, the use of algorithms and predictive models is necessary.

Francisco Cavas-Martínez et.al[24] presented numerous tomographic indices for the detection of keratoconus risk. When the indexes based on corneal volume are analyzed, two problems are presented: on the one hand, they are not very sensitive to the detection of incipient cases of keratoconus because they are not locally defined in the primary developmental region of the structural abnormalities; and on the other hand, they do not register the geometric decomposition driven by the asymmetry present during the disease progression. This work performed a morphogeometric modeling of the cornea by the aid of CAD tools and using raw topographic data (Sirius system, CSO, Firenze). For this method, four singular points present on the corneal surfaces were located.

III. CONCLUSION

In this paper, we survey some papers related to detection of keratoconus. Through this paper, we got an overview of the current researches related to various techniques and methods of keratoconus detection. Although this paper study does not conclude the best method, but the results of experiments that have been conducted by previous researchers explained briefly. And also useful for future researchers who want to know the current researches related to detection of keratoconus.

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