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Original research

The normal distribution of corneal eccentricity and its determinants in two rural areas of north and south of Iran

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Abstract

Purpose: The aim of this study was to determine the distribution of corneal eccentricity (E-value) in a normal population and to examine related factors.

Methods: In this cross-sectional study, two villages were selected in Iran using multistage cluster sampling. Selected persons were invited to have a comprehensive eye examination. Examinations in each village were performed at a specific location under standard conditions. After testing for vision and refraction and conducting the slit-lamp exam, E-value was measured with Pentacam.

Results: Of the 3851 selected individuals, 3314 participated in the study. After applying the exclusion criteria, data from 2610 subjects was used in the analysis for this report. Mean E-value was 0.53 [95% confidence interval (CI): 0.52 to 0.54]. E-value was not significantly different between males and females. Mean E-value reduced with age from 0.60 in subjects aged 6–20 years to 0.47 in subjects older than 70 years. The hyperopic group of participants had significantly lower E-value than myopic and emmetropic ones ($P < 0.001$). The relationship of E-value with age, gender, and other anterior segment variables and spherical equivalent was examined in a multiple linear regression model. In multiple linear regression model, age (coef = −0.003), spherical equivalent refraction (coef = −0.005), pupil diameter (coef = 0.018), anterior chamber volume (coef = −0.001), and anterior chamber angle (coef = 0.003) significantly correlated with E-value.

Conclusions: The results of this study showed that the cornea in normal populations is prolate, and the degree of prolateness varies by age, such that older age is associated with a less prolate cornea. This study showed that factors such as age and refractive errors and anterior chamber indices influence the E-value.

Keywords: Corneal eccentricity; Distribution; Cross sectional study; Determinants

Introduction

The cornea, which is the most important refractive surface, does not conform to a spherical shape, and the corneal radius of curvature varies from the center to the periphery. In other words, the corneal surface is an aspheric surface.[1] Notably, corneal eccentricity (E-value) is one of the important parameters in determining the shape of the corneal surface. In fact,

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eccentricity describes the rate of corneal flattening from the center to the periphery. Due to differences in peripheral and central corneal curvature and corneal shape, eccentricity values can vary. The eccentricity value is between zero and one in prolate corneas, and it is less than zero in oblate corneas.[2]

Knowledge of normal eccentricity values at different ages has implications for identifying corneal abnormalities such as keratoconus, contact lens fitting, refractive surgery, cataract surgery, and IOL power calculation.[2−4] In contact lens fitting, the corneal shape determines the relationship between the cornea and the lens. Corneas with the same keratometry readings may be different in terms of eccentricity. Therefore, when the contact lens base curve is based only on keratometry values, the selected lens can have a wrong fit.[2] The eccentricity parameter also has importance in describing changes in corneal shape when studying the results of orthokeratology.[5] According to previous studies, eccentricity can be a diagnostic factor for the early diagnosis of keratoconus in its primary stages, and it has been suggested that eccentricity increases before slit-lamp signs appear.[3] Some studies suggest that the eccentricity value in normal adult population is from 0.4 to 0.6,[6−9] but it can be greater than 0.8 in keratoconus patients.[3] According to the available literature, this index also has significant implications for refractive surgery.[10] Induced astigmatism as a result of cataract surgery is related to several factors; however, the highest amount of induced astigmatism is seen in corneas with high anterior eccentricity.[4] Given the extensive applications for eccentricity, it seems necessary to perform more studies regarding this parameter in wide age ranges.

There are few studies concerning E-value and its relationship with age, gender, refractive errors, central corneal thickness, and anterior chamber depth (ACD), and as mentioned, all studies have been restricted to a limited age range.[7−9,11,12] This study was conducted to determine the normal range of eccentricity in a wide age range and examine its relationship with demographic variables, refractive errors, and a number of anterior segment parameters.

Methods

In the present cross-sectional study, the target sample was the rural Iranian population. Details of the methodology of this study have been presented in previous reports[13,14]; however, a brief summary is presented here for review.

Sampling in this study was conducted using a multistage cluster sampling approach. Two rural regions were selected randomly from the north and southwest of Iran. After selecting these two regions, the rosters of all villages in these two regions were prepared, and a number of villages in proportion to the total number of villages in each region were selected: 5 villages from the northern region and 15 from the southwest. All people over the age of 1 were invited to participate in this study, and those who were willing to participate signed a written consent. In the case of children, the parents signed the consent forms. Two optometrists conducted the vision tests, and one ophthalmologist performed the ophthalmic examinations under standard conditions.

Vision tests included measurement of uncorrected vision, corrected vision with current glasses, and corrected vision with the Snellen E chart from a distance of 6 m. First, refraction was tested with an auto-refractometer (NIDEK ARK-510A Auto Refractor/Keratometer, Japan) for each individual, and then the results were checked through retinoscopy (Heine Beta 200 retinoscope, HEINE Optotechnik, Germany). After these examinations, a slit-lamp (BM 900, Haag Streit, USA) examination was done, and finally, Pentacam HR (Oculus, Inc., Lynnwood, WA) imaging was performed for all subjects over 5 years of age. If the machine reported an error in imaging, artificial tears were instilled, and images were retaken after 10 min. The latest version of the device (6.03r11) and Pentacam software (1.17r72) were used. To minimize bias as a result of diurnal variations, imaging sessions were held between 9 a.m. and 2 p.m., allowing for at least 3 h of awake time by the time of the examinations. Subjects with a history of intraocular surgery, history of any corneal surgery, use of contact lenses at the time of the study, corneal opacities, pterygium, strabismus, keratoconus, scissoring reflex on retinoscopy, Fleischer rings on slit-lamp examination, corneal dystrophy, and ptosis were excluded. Also, Pentacam images displaying an error status were excluded from the study.

Ethical issues

The Ethics Committee of Mashhad University of Medical Sciences approved the study protocol, which was conducted in accord with the tenets of the Declaration of Helsinki. The consent forms were signed by the parents or guardians of children below 18 years.

Statistical analysis

In this study, mean E-value and its 95% confidence interval (CI) was determined. Since cluster sampling was applied, the design effect was considered in the data analysis. Simple and multiple linear regression was used to explore relationships.

A backward linear regression model was employed to determine the final model of the variables affecting E-value. One-way analysis of variance was used to investigate the variation of E-value among the categories of refractive error. Then the post-hoc Scheffe test was applied to determine the means differences.

Results

Of the 3851 selected individuals for this study, 3314 subjects participated in the study. A total of 2681 subjects were examined with the Pentacam examinations and were eligible for enrollment in this study. Of these subjects, 71 were excluded from the analysis because of the missing E-value, and 2610 subjects were eligible for inclusion in this report. After excluding outliers, the final analysis was done on data

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