Corneal elevation and keratoconus indices in a 40- to 64-year-old population, Shahroud Eye Study

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Abstract

Purpose: To determine the corneal elevation values and keratoconus indices in the 40- to 64-year-old population and their changes with aging.
Methods: The 6311 invitees of this study were selected through random cluster sampling, and 5190 of them participated in the study (response rate = 82.2%). Here, we analyzed results of Pentacam acquisitions in 4148 respondents. Cases of keratoconus and forme fruste keratoconus (FFKC) were determined using topography and clinical data. Studied variables included keratoconus indices, central corneal thickness readings, maximum elevations on the anterior and posterior surfaces, and elevation values at the thinnest point, anterior steepest point, and posterior steepest point in healthy, FFKC, and keratoconus groups.
Results: In all subjects, the mean maximum elevations were 6.80 ± 5.0 μm and 16.60 ± 7.7 μm on the anterior and posterior corneal surfaces, respectively. Maximum elevation values on the anterior and posterior corneal surfaces showed significant correlations in the keratoconus, FFKC, and healthy groups ($P < 0.002$). Maximum anterior elevation correlated with age ($r = 0.11$, $P < 0.001$), but maximum posterior elevation showed no such correlation ($P = 0.476$). Keratoconus indices demonstrated significant changes with age ($P < 0.001$).
Conclusion: Anterior elevation values slightly increase with age, and keratoconus indices change as well. Elevation readings and keratoconus indices in the keratoconus group and FFKC cases are higher than the healthy corneas although their values could be compared with other studies on younger participants.

Keywords: Corneal elevation; keratoconus; Pentacam; cross-sectional study; adult

Introduction

Elevation-based corneal imaging techniques provide valuable information about the anterior and posterior corneal surface elevation properties which were not generated by placido disk-based topography.[1,2] Knowledge of these indices is important in the preoperative examination of refractive surgery candidates, the diagnosis of early stages and progression of keratoconus, and keratoconus patients undergoing collagen cross-linking or ring implantation for treatment. The Pentacam HR (Oculus Optikgeräte GmbH, Wetzlar, Germany) employs the Scheimpflug imaging technique and provides information regarding corneal surface irregularity and

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asymmetry in addition to elevation data, and uses them to compute indices for the diagnosis of keratoconus.

In the recent decade, using evidence of natural cross-linking, which occurs with aging[3] and in diabetic patients,[4] collagen cross-linking has become a treatment option to halt disease progression in cases of keratoconus. Stable keratometry and elevation readings from the corneal surfaces are evidence of the efficacy of this treatment method. Studies on keratoconus patients have mainly focused on the 20–40 year age groups, and thus, there is limited information about changes in corneal elevation and irregularity in older ages. Availability of such data in the Shahroud Eye Cohort Study provides more comprehensive knowledge on corneal changes in keratoconic subjects. This report, which is based on a population study, explores these indices in the 40–64 year age group.

Methods

The Shahroud Eye Cohort Study commenced during 2009–2012 using random cluster sampling from the 40- to 64-year-old population of Shahroud city. Detailed methodology of the survey has been published elsewhere.[5] In brief, 300 clusters of 20 persons each were selected, and after determining the households in each cluster, they were invited to participate in the study by approaching them at their door and interviewing household members. Respondents were informed about the objectives and methods of the survey, and they were enrolled after signing written informed consents. The Ethics Committee of Shahroud University of Medical Sciences approved this study.

Examinations included bilateral acquisitions with the Pentacam HR which were done between 9:00 am and 1:00 pm, at least 3 h after participants' wakeup time. In the present report, we used demographic and Pentacam data from the first phase of the survey. Version 1.17r72 of the Pentacam device software and version 6.03r15 of the data management software were used.

From Pentacam data, we recorded readings of the central corneal thickness, mean keratometry, maximum anterior and posterior elevation in the central 6 mm zone (MAE and MPE, respectively), anterior elevation at the thinnest point, posterior elevation at the thinnest point, anterior and posterior elevations at the steepest point of the anterior corneal surface, and anterior and posterior elevations at the steepest point of the posterior corneal surface. Elevation measurements were in reference to a floating sphere that best fit the 8.0 mm zone.

We also extracted Pentacam keratoconus indices including index of surface variance, index of vertical asymmetry, keratoconus index, central keratoconus index, index of height asymmetry, index of height decentration, and minimum sagittal curvature from the topometric display.

To identify cases of keratoconus, we applied Holladay topographic criteria,[6] which are as follows:
1) "Apex of the cone is not centered at the 6-o'clock semimeridian, 2) the cone should appear round on the tangential map, 3) steep keratometry >45.00 diopters, 4) corneal
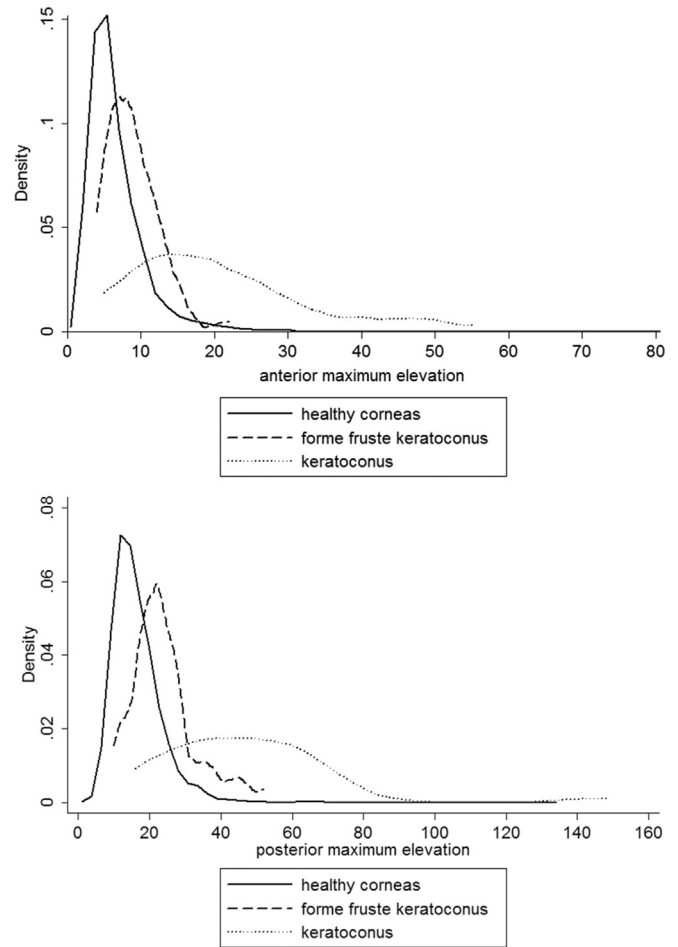

Fig. 1. Distribution of density of anterior and posterior maximum elevation in healthy corneas, forme fruste keratoconus, and keratoconus people.

thickness at the apex of the cone is approximately 30 μm thinner than the corresponding distance above the pupil center, and 5) topographic patterns are not symmetric (more than 1.5 diopter superior-inferior power difference in 4 mm central zone)."

Cases with all the above criteria in one or both eyes were categorized in the keratoconus group. Individuals who met all criteria except the 2nd and 3rd items were classified as forme frusta keratoconus (FFKC). Cases with any history of ocular surgery and those with evidence of corneal vascularization, corneal irregularities (i.e. PMD), or corneal opacity on clinical examination were excluded from the study. All other participants were grouped as healthy. In all three eye groups, right eye data were used in the analysis unless the diagnosis of keratoconus or FFKC pertained to the left eye only.

Mean central corneal thickness, mean keratometry, and elevation variables were compared among the three groups using multinomial logistic regression tests. The effect of age on the studied variables was assessed in a regression model. Cluster sampling was accounted for in estimating standard errors and averages. Associations between elevation parameters were determined using the Pearson correlation test. Statistical significance was based on a 0.05 level.