HOSTED BY

ELSEVIER

CrossMark

Available online at www.sciencedirect.com

ScienceDirect

Journal of Current Ophthalmology 28 (2016) 75–80

http://www.journals.elsevier.com/journal-of-current-ophthalmology

Original research

Evaluation of corneal higher order aberrations in normal topographic patterns

Ali Mirzajani [a], Sattar Aghataheri [a,*], Mohammad Ghoreishi [b], Ebrahim Jafarzadepour [a], Mohadese Mohammadinia [b]

[a] *Department of Optometry, Iran University of Medical Sciences, Tehran, Iran*
[b] *Persian Eye Clinic, Isfahan, Iran*

Received 4 February 2016; revised 10 March 2016; accepted 11 March 2016
Available online 4 April 2016

Abstract

Purpose: This study reports the characteristics of corneal higher order aberrations (HOAs) in eyes with normal topographic pattern using the Pentacam scheimpflug system.

Methods: In this prospective, observational, comparative study, 165 eyes of 97 patients separated into five groups based on corneal topographic patterns were enrolled. All eyes received a comprehensive ophthalmologic examination including corneal tomographic analysis with the Pentacam system. Keratometry, corneal cylinder, and corneal aberrometric data were recorded and analyzed. Root mean square values (RMS) were calculated for corneal HOAs up to the 6th order, total coma, total trefoil, total spherical aberration, total tetrafoil, and higher order astigmatism. Evaluation of these data to discriminate between the five groups was assessed using the analysis of variance test by Generalized Estimation Equation Linear Model.

Results: Corneal HOAs were found to be significantly higher for Asymmetric Bow Tie and Irregular groups than other groups ($p = <0.001$). RMS of total coma aberration (Z_3^{-1}, Z_3^{1}, Z_5^{-1}, Z_5^{1}) were significantly greater in the Asymmetric Bow Tie pattern than others, and RMS of total Spherical aberration (Z_4^{0}, Z_6^{0}) was significantly higher in the Irregular pattern than other groups ($p = <0.001$). The results of our study demonstrate that a tendency toward significant higher values of trefoil, tetrafoil, and higher order astigmatism in Irregular pattern (all $p < 0.05$). Significantly higher amounts of 3rd order RMS in Asymmetric Bow Tie group and 4th to 6th order RMS in Irregular pattern group were other outcomes of our study ($p = <0.001$).

Conclusions: Based on results in this study, there were a good correlation between corneal topographic pattern and corneal HOAs in normal eyes. These results indicate that the corneal HOAs values are largely determined by the topographic patterns. A larger sample size would perhaps have been beneficial to yield in more accurate outcomes.

Keywords: Topography pattern; Pentacam; Corneal higher-order aberrations

Introduction

Detection of subtle corneal abnormalities or even normal corneas with potential of postoperative visual complications among refractive surgery candidates is important because sometimes patients complain about poor quality of vision even when their visual acuity is 20/20 postoperatively. However, operating on an undetected keratoconic cornea is a major cause of post refractive surgery ectasia.[1]

* Corresponding author. Iran University of Medical Sciences, Tehran, Iran. Tel.: +98 02122221577.
E-mail address: Sattaraghataheri@gmail.com (S. Aghataheri).
Peer review under responsibility of the Iranian Society of Ophthalmology.

http://dx.doi.org/10.1016/j.joco.2016.03.001

Some studies compared higher order aberrations (HOAs) between keratoconic and normal eyes and reported Keratoconus produces significantly higher levels of ocular and corneal aberrations in comparison to normal eyes.[2–16] Based on results of these studies, HOAs can be used to distinguish early Keratoconus from normal and to grade the severity of Keratoconus.[16] Additionally, correlation between corneal topographic indices such as irregularity and keratometry with HOAs was demonstrated in a previous study.[17] Another study showed corneal HOAs correlate with topographic patterns.[18]

The purpose of this study was to compare corneal HOAs, measured with the Pentacam scheimpflug system between normal topographic patterns.

Methods

In this prospective, observational, comparative study, 165 eyes of 97 patients, ranging in age from 20 to 35 years old (59 females/38 males) with normal topographic cornea who were scheduled for refractive surgery in Isfahan Persian Eye Clinic were enrolled. The eyes were divided into five differentiated groups based on corneal topographic patterns. We consider the same sample size for all pattern groups.

Classification of sample groups was based on topographic patterns described by Bogan's and colleagues.[19] According to this classification, the color-coded topographic maps were grouped into the following patterns: round, oval, symmetric bow tie, asymmetric bow tie, and irregular.

All participants were asked to stop wearing soft contact lenses for at least one week and rigid gas-permeable contact lenses for at least one month before obtaining measurements. Eyes with any ocular pathology such as dry eye, glaucoma, Keratoconus, retinal diseases, systemic conditions such as connective tissue disorders, and history of ocular surgery were excluded. A complete ocular examination including slit-lamp biomicroscopy, cycloplegic refraction, best spectacle distance visual acuity, intra-ocular pressure and dilated fundus examination, and corneal topographic analysis with the Pentacam system (Oculus Optikgerate, Wetzlar, Germany) was performed.

The Oculus Pentacam HR (OCULUS Optikgerate GmbH, Wetzlar, Germany) is a non-invasive system that can provide measurements of corneal HOAs up to the 10th order of the Zernike polynomials which uses a rotating Scheimpflug camera that takes 100 images with 500 measurement points on the anterior and posterior corneal surfaces over a 180-degree rotation. The elevation data from all these images are combined to form a three-dimensional reconstruction of the corneal structure. After processing all this information, the internal software provides a large number of different calculations. Then the corneal elevation profile was automatically converted into corneal wavefront data.

In the current study, the Pentacam software version 6.02r10 was used. All measurements were obtained by an experienced operator using same system and procedure. The patient was asked to blink and then look at the fixation target before each measurement. The examiner adjusted the joystick until appropriate alignment of the scan center on the center of pupil was achieved. The system automatically took 100 images of the cornea within the two-second period. Scans not meeting acceptable criteria (blinks during the scan or other artifacts) according to the Pentacam software indications were repeated. Only measurements with an "ok" reading were included.

The study was approved by the Ethics Committee of Iran University of Medical Sciences, and all experiments conformed to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants after explaining the purpose of the study.

Statistical analysis

Corneal higher order aberrations were compared for normal topographic pattern groups. The following data were compared between the study groups mean keratometry, corneal astigmatism, and root-mean–square (RMS) of the corneal wavefront. From the 10 order Zernike coefficients measured by the instrument, the following RMS groups were examined: total higher order (all terms included in the third, fourth, fifth, and sixth order); total coma (including Z_3^{-1}, Z_3^{1}, Z_5^{-1}, and Z_5^{1}); vertical coma (Z_3^{-1}); total trefoil (including Z_3^{-3}, Z_3^{3}, Z_5^{-3}, and Z_5^{3}); total spherical aberration (including Z_4^{0} and Z_6^{0}); total tetrafoil (including Z_4^{-4}, Z_4^{4}, Z_6^{-2}, and Z_6^{2}); and higher order astigmatism (including Z_4^{-2}, Z_4^{2}, Z_6^{-1}, and Z_6^{1}). All Zernike coefficients and RMS values were calculated for a pupil diameter of 6.0 mm.

Statistical analysis was performed using the software SPSS version 17.0 for Windows (SPSS, Chicago, IL, USA). All data were expressed as mean ± standard deviation. Normality of all data samples was checked by means of the Kolmogorov–Smirnov test. In this study, the correlation between eyes was low in RMS of HOAs ($r = 0.156$), so data from both eyes was analyzed. For analysis of variance to comparison between groups, General Linear Model Test was used. P values less than 0.05 were considered statistically significant.

Results

This study included 165 eyes from 97 subjects. Thirty-three eyes in each group were evaluated and analyzed. The demographics data of all groups studied are presented in Table 1.

According to the qualitative classification system of normal corneal topography based on the Bogan's et al.'s study, we included 33 eyes in each pattern group. There were no statistically significant differences among any of pattern groups for age and sex. The mean k and corneal astigmatism for all eyes was 43.83 ± 1.25 (range 40.1–46.6) and 1.28 ± 0.957 (range 0.0–4.70), respectively. Although there were statistically significant differences in mean keratometric power between groups ($p = 0.002$), the correlation between K mean and pattern was not significant ($p = 0.146$).

Corneal astigmatism was 0.573 ± 0.26 D for Round, 0.973 ± 0.382 D for Oval, 2.58 ± 0.82 D for Symmetric Bow Tie, 1.69 ± 0.75 D for Asymmetric Bow Tie, and 0.594 ± 0.49