CHANGES IN APICAL CORNEAL CURVATURE IN UNILATERAL PRIMARY PTERYGIUM AND NORMAL ADULTS USING SIMULATED-K AND CORNEAL IRREGULARITY MEASUREMENT

MOHD RADZI HILMI, PhD (CORRESPONDING AUTHOR)

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

mohdradzihilmi@iium.edu.my

NUR HIDAYAH MUSA, B.OPTOM (HONS.)

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

nurhidayah_musa@ymail.com

KHAIRIDZAN MOHD KAMAL, MS (OPHTHAL)

DEPARTMENT OF OPHTHALMOLOGY, KULLIYYAH OF MEDICINE, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

Khairidzan@gmail.com

MOHD ZULFAEZAL CHE AZEMIN, PhD

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

zulfaezal@iium.edu.my

NUR NABILAH MARUZIKI, BOPTOM (HONS.)

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

nsolehah94@gmail.com

NUR AIN NORAZMAR, BOPTOM (HONS.)

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

ainazmariium@gmail.com

MARDHIAH SYAZWANI NASIR, BOPTOM (HONS.)

DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA (IIUM), JALAN SULTAN AHMAD SHAH, BANDAR INDERA MAHKOTA, 25200 KUANTAN, PAHANG, MALAYSIA

marsyadhiani_2210@yahoo.com

ABSTRACT

Introduction: This paper aimed to describe variation in apical corneal curvature between unilateral primary pterygium and normal adults utilizing simulated-K and corneal irregularity measurement corneal indices. **Methods:** A total of 100 participants comprise 50 unilateral primary pterygium eyes from 50 patients and 50 normal adults were recruited in this study. Diagnosis and classification of primary pterygium were done by a consultant ophthalmologist (KMK). Standard optometric examinations were performed in all participants. Simulated-K (SimK) and corneal irregularity measurement (CIM) was objectively measured using a corneal topographer. Three measurements based on best image quality for SimK and CIM were taken by single operator in a same visit. Difference for both SimK and CIM parameters between primary pterygium and normal groups were determined via independent T-test. **Results:** Overall mean and standard deviation (n = 120) of SimK and CIM were found higher in primary pterygium group (9.06 ± 4.49 D and 11.48 ± 3.12) compared to normal (1.63 ± 0.67 D and 0.62 ± 0.24) respectively. Independent T-test results showed significance difference in SimK and CIM values between primary pterygium groups and normal (both $P < 0.001$). **Conclusions:** Both SimK and CIM corneal indices can be an important tool in describing and predicting changes on the corneal curvature due to pterygium progression. However, it is worth to note that the detectability of changes in anterior corneal curvature is limited to 5 mm of central corneal curvature.

Keywords: pterygium; morphology; Simulated-K; corneal irregularity measurement; corneal curvature

INTRODUCTION

Pterygium is defined as an abnormal fibrovascular lesion which originates from the bulbar conjunctiva and progresses towards central cornea (Ang, Chua and Tan, 2007). Prevalence of pterygium has been closely associated with chronic ultraviolet (UV) ray exposures (Liu et al., 2013) and limbal stem-cell alteration at corneo-limbal junction (Chui et al., 2011). It is an established fact that pterygium is a significant factors which contribute to induced corneal astigmatism which closely related to its physical properties such as its horizontal width or its total area (Mohammad-Salih and Sharif, 2008). However, it is worth to note that clinically not all large size of pterygium induced significant astigmatism, as based on our clinical observation small pterygium size could also give similar effects.

Tan et al., (1997) has proposed classification of pterygium based on its clinical appearance. This classification is based on three (3) types or grades known as type I - atrophy, type II - intermediate and type III - fleshy. The classification framework was based on loss of translucency of pterygium tissue which relates to increased fleshiness that signifies abnormal fibrovascular growth of pterygium. Apart from this grading, there are several clinical grading has been suggested in evaluating pterygium which based on its morphologies as shown in Table 1 below.

Several clinical grading's has been suggested in evaluating pterygium. Pterygium can be assessed based on several methods such as via its morphology (Mohd Radzi et al., 2017), extension or length (Chui et al., 2011; Farhood and Kareem, 2012; Kheirkhah et al., 2012;), its size (Mohammad-

Salihand Sharif, 2008; Altan-Yaycioglu et al., 2013; Vives et al., 2013) and based on its encroachment relative to the corneal size (Mohammad-Salih and Sharif, 2008; Mohd Radzi et al., 2017).

Table 1: Current available clinical pterygium grading based on its morphology

Morphology	Evidence from literatures
Fleshiness	Tan et al., 1997; Mohd Radzi et al., 2017
Extension or length	Chui et al., 2011; Farhood and Kareem, 2012; Kheirkhah et al., 2012
Size or total area	Mohammad-Salih and Sharif, 2008; Altan-Yaycioglu et al., 2013; Vives et al., 2013
Encroachment relative to the corneal size	Mohammad-Salih and Sharif, 2008; Mohd Radzi et al., 2017

Apical corneal curvature changes are commonly measured using Simulated-K (SimK) (Farhood and Kareem 2012; Kheirkhah et al., 2012; Kheirkhah et al., 2012; Altan-yaycioglu et al., 2013; Viveset al., 2013). SimK is an index which characterizes estimation of total corneal astigmatism based on measurement of anterior corneal curvature (Eom et al., 2014). Simulated-K index characterise corneal curvatures in the central 3-mm optical zone of cornea. The steep simulated K-reading is the steepest meridian of the cornea, using only the points along the central pupil area with 3-mm diameter. The flat simulated K-reading is the flattest meridian of the cornea and is, by definition, 90° apart, with the normal value of SimK is approximately 43.00 ± 2.00 Dioptres (D). These readings gave an idea about the central corneal curvature that is frequently visually most significant.

In contrast, corneal irregularity measurement (CIM) is an index which signifies the probability of irregular anterior corneal surface. CIM value indicates the regularity of the corneal surface, with normal CIM values are between 0.03µm to 0.68µm, whereas 0.69µm to 1.0µm are considered as borderline and abnormal values are between 1.1µm to 5.0µm. A higher CIM values would indicates higher probability of irregular anterior corneal surface and ocular pathologies. In a simple term, CIM is a measurement in describing changes of the corneal regularity in comparison with the normal corneal shape. However, CIM is rarely addressed as a clinical parameter in describing peripheral corneal lesion such as pterygium. Nonetheless, CIM has been used in describing other corneal pathologies such as keratoconus and pellucid marginal degeneration (PMD).

Although numerous works (Ozdemir and Cinal, 2005; Yagmur et al., 2005; Maheshwari, 2007; Mohammad-Salih and Sharif, 2008; Farhood and Kareem, 2012; Kheirkhah et al., 2012; Kheirkhah et al., 2012; Altan-yaycioglu et al., 2013; Vives et al., 2013) had proven that progression of pterygium does induce changes on the anterior corneal curvature, based on our literature search, lack of evidence found which employs CIM in describing effects of pterygium on anterior corneal curvature. Hence, this study aims to evaluate the changes in apical corneal curvature in primary pterygium utilizing two (2) corneal indices (SimK and CIM).

METHODS

A total of 100 participants comprise of 50 unilateral primary pterygium eyes from 50 patients and 50 normal adults were recruited in this study who visits a tertiary ophthalmic centre in East Coast of Malaysia in order to display a wide range of severity of pterygium patients. All participants in this study were selected based on specific criteria. Inclusion criteria include established diagnosis of primary pterygium, both genders were included with age ranges from 20 to 70 years and free from any history of ocular trauma, ocular surgery, contact lens wear, and any ocular anterior segment disease other than pterygium which may affect vision as previously described (Mohd Radzi et al., 2017; CheAzemin et al., 2015; Azemin, Hilmi and Kamal, 2014; CheAzemin et al., 2014). Diagnosis of primary pterygium was performed by a consultant ophthalmologist (KMK). The study was conducted according to recommendation of the tenets of Declaration of Helsinki and approved by the International Islamic University Malaysia (IIUM) research ethical committee (IREC) (IIUM/310/G13/4/4-125). Written and informed consent was obtained from all participants prior any procedures performed.

All participants undergo standard optometric examination comprises dry refraction, slit-lamp examination and fundus examination. Then, each participant's average central corneal curvature (SimK) and corneal irregularity measurement (CIM) was objectively measured using Zeiss ATLAS™ 995 corneal topographer (Zeiss Meditec, Inc, Dublin, USA). Three measurements were taken and the measurement with the best image quality was taken as the SimK and CIM value. These measurements were done by single operator and performed on the same visit. All data were then been exported to statistical software.

Statistical analyses were performed using IBM SPSS (Predictive analytics software) (Version 19, SPSS Inc., Chicago, IL, USA). Independent T-test was employed to evaluate the difference between both primary pterygium and normal groups for both SimK and CIM parameters. A significance level of $P < 0.05$ was set as the confidence level.

RESULTS

The analysis include 100 participants, with 53% (n = 53) were men. Normality testing was evaluated using ratio of skewness and kurtosis (George and Mallery, 2010), with ± 2.50 was taken as normal distribution. Normality testing showed normal data distribution for both groups.

The mean of SimK and CIM for primary pterygium group were 9.06 ± 4.49 D and 11.48 ± 3.12 respectively. In contrast, normal group showed lower values of SimK and CIM with 1.63 ± 0.67 D and 0.62 ± 0.24 respectively. Independent T-test results revealed that there were significance differences between normal and primary pterygium groups for both parameters (both $P < 0.05$). All results were summarized in Table 2.

Table 2 Comparison of SimK and CIM values between primary pterygium and normal group (n = 100)

Corneal Index	Group		P-value*
	Primary pterygium (Mean ± SD)	Normal (Mean ± SD)	
SimK (D)	9.06 ± 4.49	1.63 ± 0.67	P < 0.001
CIM	11.48 ± 3.12	0.62 ± 0.24	P < 0.001

SD: Standard Deviation
D: Dioptres
SimK: Simulated-K
CIM: Corneal Irregularity Measurement
*: Independent T-test (Significance level set at 0.05)

DISCUSSION

This study aims to evaluate the difference in apical corneal curvature utilizing two (2) corneal indices (SimK and CIM). Hence, this paper aim to demonstrate the usability of both indices in describing the changes in central 3-mm curvature of cornea (which also known as apical) between both normal and primary pterygium eyes. In this study, equal number of participants in both normal and primary pterygium group (both n = 30) were recruited to evaluate the difference in SimK and CIM relative to pterygium types in comparison with normal eyes.

Increase of SimK values indicates higher changes in anterior corneal curvature which indirectly signify induced-astigmatism. Simulated K (SimK) values simulate the traditional keratometer readings by expressing the curvature in two orthogonal axes (90° apart) in the central approximately 3 mm area of the apical cornea. SimK would display the average power and axis of both corneal meridians. Normally, SimK would give values which resemble the topographic image of cornea which provides information on the degree of severity and angle of astigmatism. With regards to pterygium patients, SimK would provide information on the progression of the disease, gross prediction of visual performance and also the needs of surgical intervention. Based on our findings, Pterygium group revealed significantly higher SimK compared to normal ($P< 0.05$). We postulate that pterygium could induce changes in corneal astigmatism in form of higher value of SimK due to its fleshiness appearance (Tan et al., 1997; Mohd Radzi et al., 2017; Mohd Radzi et al., 2018) which indirectly induce higher corneal toricity. The fleshiness appearance of pterygium also could give rise to obscured episcleral vessels which could signify presence of fibrovascular tissue due to excessive proliferative disorders (Touhami et al., 2005; Ribatti et al., 2007).

This study also found higher CIM values in pterygium group compared to normal ($P< 0.05$). Higher corneal irregularity measurement (CIM) indicates the anterior corneal curvature change towards irregular shape which does not resemble the 'normal' corneal shape known as prolate. With regards to pterygium, this finding showed that pterygium progression caused the corneal surface become irregular, which gives rise to unwanted corneal astigmatism (Roh et al., 2015). To the best of our knowledge, information on CIM related to pterygium is scarce. However, we suggest the irregularity of the corneal curvature could be due to compression of corneal curvature due to pterygium progression, which indirectly inducing corneal flattening on the pterygium region (Maheshwari, 2007). Corneal compression could be due to increase mechanical traction of pterygium tissue on the corneal surface and its tissue weight. Although these findings look promising, we need to highlight that both SimK and CIM only measures changes on the central cornea, approximately 5 - 6 mm centrally. Thus, the overall effect of pterygium progression is still unknown as it progresses from peripheral cornea.

CONCLUSION

Both SimK and CIM corneal indices can be an important tool in describing and predicting changes on the corneal curvature due to pterygium progression. However, it is worth to note that the detectability of changes in anterior corneal curvature is limited to 5 mm of central corneal curvature.

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DECLARATION OF INTEREST

The authors report no conflicts of interest.

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