Original Article

Levator palpebrae superioris function and corneal astigmatism in university students with normal eyelid morphology

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ABSTRACT

Background: Eyelids have been shown to influence corneal shape. The effects of eyelid pathologies on corneal astigmatism have been widely investigated. This study aimed to determine the correlation between levator palpebrae superioris (LPS) muscle function and with-the-rule (WTR) corneal astigmatism in university students with normal eyelid morphology.

Methods: This was a cross-sectional study with a sample of 58 university students of Chinese origin selected by simple random sampling at the University College Sedaya International (UCSI) University Optometry Clinic, Kuala Lumpur, Malaysia. We included participants aged 18 to 30 years, regardless of sex, with normal eyelid morphology, normal LPS function, and WTR corneal astigmatism. For LPS muscle function, the distance of the upper eyelid margin from the maximal downgaze to the upgaze was measured, while the frontalis function was negated by the thumb of the examiner. Corneal astigmatism was measured using a manual Keratometry (Topcon OM-4; Topcon Corporation, Tokyo, Japan).

Results: Of the 58 participants, 23 (39.7%) were men and 35 (60.3%) were women. The mean ± standard deviation (SD) age was 23.22 ± 1.77 years. For all participants, the means ± SDs for LPS muscle function and corneal astigmatism were 14.72 ± 1.74 mm and - 1.16 ± 0.47 D, respectively. Of the 58 participants, 25 and 33 had low and moderate WTR corneal astigmatism, respectively. The mean LPS muscle functions were not significantly different between the low and moderate WTR corneal astigmatism groups ($P > 0.05$). A positive but statistically insignificant correlation ($r = + 0.14$; $P > 0.05$) was found between LPS muscle function and WTR corneal astigmatism.

Conclusions: We found no significant difference in the mean LPS muscle function between low and moderate WTR corneal astigmatism groups in young university students of Chinese origin with normal eyelid morphology. Furthermore, no significant correlation was found between LPS muscle function and low-to-moderate WTR corneal astigmatism.

KEY WORDS

levator palpebrae superioris, muscle function, function, corneal, astigmatism, university student, eyelid, normal morphology, Chinese

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INTRODUCTION

Astigmatism accounts for approximately 13% of refractive errors in the human eye [1]. Astigmatism has two main components: corneal astigmatism and lenticular astigmatism. Corneal astigmatism is classified according to the axis as *with-the-rule* (WTR), *against-the-rule* (ATR), and *oblique* astigmatism. WTR, the most common, occurs mostly in young adults aged 20 to 30 years [2, 3]. Astigmatism is also categorized based on degree into *low* (< - 1.00 DC), *moderate* (≥ - 1.00 DC and < - 3.00 DC), and *high* astigmatism (≥ - 3.00 DC) [4].

Corneal astigmatism may be associated with ocular surgery, eyelid pressure, unequal tension of extraocular muscles, eyelid morphology, and visual tasks [5-9]. Mechanical interaction between the eyelids and cornea influences corneal shape and astigmatism. Eyelid tension and elasticity, eyelid pressure, eyelid pathology, and lid surgery influence corneal astigmatism [8, 10]. Lid pressure due to chalazion, ptosis, blepharospasm, post-surgical eyelid swelling, and lid-loading procedures for lagophthalmos increase corneal astigmatism [8, 11]. Levator palpebrae superioris (LPS) muscle function, lid fissure height, and margin reflex distance were found to have a direct correlation in ptotic eyes [12].

Eyelid surgery, mainly levator resection or levator complex tightening in a ptotic eye, has produced significant astigmatism changes and average keratometry and corneal astigmatism reduction [13, 14]. Corneal astigmatism was also induced by modification of the anterior corneal surface by a ptotic eyelid [14]. A study found that eyelid surgery involving the LPS muscle produced statistically significant changes in corneal astigmatism, with a 0.83 D increment of astigmatism in a ptotic eye [13]. Another study found a reduction in keratometry of 0.15 ± 0.47 D and corneal astigmatism of 0.26 ± 1.12 D after eyelid ptosis surgery [14].

The effect of eyelid pathologies on corneal astigmatism has been widely investigated. This study aimed to investigate the correlation between LPS muscle function and WTR corneal astigmatism among university students with normal eyelid morphology.

METHODS

This was a cross-sectional study with a sample of 58 university students of Chinese origin chosen by simple random sampling from October 2019 to May 2020 at University College Sedaya International (UCSI) University Optometry Clinic at its Kuala Lumpur Campus (South Wing). The study was approved by the institutional review board and ethics committee of UCSI University, and it followed the principles of the Declaration of Helsinki. The participants were briefed on the study and provided written informed consent.

We included participants regardless of sex with normal eyelid morphology, normal LPS function (mean ± standard deviation [SD]: 11.9 mm ± 1.6 mm), WTR corneal astigmatism (steep cylinder axis of the cornea was within 30 degrees of the horizontal axis, where the steep corneal meridian was vertical), and aged 18 to 30 years. Participants with previous eyelid surgery, oblique or ATR corneal astigmatism, a neurologic or ocular disease that could influence eyelid function or position, anterior or posterior segment abnormalities, or contact lens use were excluded.

Detailed history taking and ocular examinations were performed on all participants, including visual acuity measurement using a Snellen chart (automated chart projector, ACP-8 series; Topcon Corporation, Tokyo, Japan), cover test, extraocular motility test, a manual keratometery (Topcon OM-4; Topcon Corporation, Tokyo, Japan) to measure the degree of corneal astigmatism, objective refraction and subjective refraction using a retinoscope (Welch Allyn 3.5V Streak Retinoscope, Welch Allyn, Inc., NY, USA), anterior and posterior segment slit-lamp examination (Topcon SL-D7, Topcon Corporation, Tokyo, Japan), and LPS muscle function test using Berke's method.

LPS muscle function was measured using Berke's method [15]. The patient is instructed to sit down and then look down as far as possible. The examiner then uses a thumb to exert as much pressure as possible around the eyebrow area of the forehead. This is to prevent the frontalis muscle from influencing the measurements. After the frontalis muscle function is inhibited, the patient is instructed to look upward as high as possible with the head still. The distance of movement in the middle of the upper eyelid margin is measured and recorded in millimeters. The normal range for the LPS muscle function test result is considered to be 11.9 ± 1.6 mm in both men and women [15].

Corneal astigmatism was measured using manual Keratometry (Topcon OM-4; Topcon Corporation, Tokyo, Japan) [16]. The manual keratometer is a monopositional device, with varying image sizes, and fixed object size. It measures central corneal power at a diameter of around 3.0 to 3.5 mm. The instrument has vertical and horizontal prisms and simultaneously measures both principal meridians without adjustment of the orientation of the keratometry [16]. Corneal astigmatism was recorded for each participant. To obtain an accurate and

Table 1. Summary of study data and analysis

Variable	Value	*P*-value
Age (y), Mean ± SD	23.22 ± 1.77	-
Sex (Male / Female), n (%)	23 (39.7) / 35 (60.3)	-
WTR (n = 58), Mean ± SD	-1.16 ± 0.47	-
LMF in all (n = 58), Mean ± SD	14.72 ± 1.74	-
LMF in low WTR (n = 25), Mean ± SD	14.96 ± 1.95	*P* value = 0.203 (Mann–Whitney U test)
LMF in moderate WTR (n = 33), Mean ± SD	14.54 ± 1.57	
Correlation between LMF and WTR	+ 0.14	*P* value = 0.306 (Spearman correlation test)

Abbreviations: y, years; SD, standard deviation; n, number; %, percentage; WTR, with-the-rule corneal astigmatism; LMF, levator palpebrae superioris muscle function.

reproducible measurement, patients were instructed to blink twice to smooth the corneal surface. To further ensure reproducible measurements of the keratometry data, the measurement was performed twice.

IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA) was used for analysis. To assess for normality of the data distribution, the Kolmogorov–Smirnov test was used. A P value < 0.001 was produced, indicating non-normal distribution. Therefore, the non-parametric Mann–Whitney U test was used to evaluate for significant differences between LPS muscle function and degree of WTR corneal astigmatism. For correlational analysis between LPS muscle function and WTR corneal astigmatism, the Spearman rank correlation test was used. With an alpha value taken at 5%, statistical significance was set at a P value < 0.05.

RESULTS

Fifty-eight participants from the UCSI University Optometry Clinic were recruited for this study, 23 of whom were men (39.7%) and 35 of whom were women (60.3%). The mean ± SD age was 23.22 ± 1.77 years (range: 21 to 29 years). For all participants, the mean ± SD for LPS muscle function and corneal astigmatism were 14.72 ± 1.74 mm (range: 10–18 mm) and -1.16 ± 0.47 D (range: - 0.21 D to - 2.23 D), respectively (Table 1).

Of the 58 participants, 25 had low and 33 had moderate WTR corneal astigmatism. The non-parametric Mann–Whitney U test was used to compare the mean LPS muscle function between the low and moderate WTR corneal astigmatism groups and found no statistically significant difference (P > 0.05). A positive but statistically insignificant correlation (r = + 0.14; P > 0.05) was found between the mean LPS muscle function and WTR corneal astigmatism (Table 1).

DISCUSSION

This study showed no significant difference in LPS muscle function between the different degrees of WTR corneal astigmatism in normal participants. Furthermore, we found no significant correlation between LPS muscle function and WTR corneal astigmatism among university students of Chinese origin with normal eyelid morphology.

Klimek et al. found that levator resection in unilateral congenital ptosis leads to a significant change in astigmatism. The mean increase in postoperative cylindrical refractive error was 0.83 D [13], which necessitates careful postoperative refraction after unilateral levator resection in congenital ptosis. Savino et al. showed that anterior levator complex tightening in congenital ptosis repair revealed a significant difference in corneal astigmatism [14]. The corneal topography after eyelid ptosis surgery showed a reduction in the apical keratometry front from 46.31 ± 1.76 D to 44.47 ± 2.34 D postoperatively. Both studies proved that eyelid surgery involving LPS muscle function influenced astigmatism. Their inclusion of patients with ptosis and surgical interventions in the above studies were the factors responsible for the discrepancies between their results and ours. We included normal eyes with normal eyelid morphology and no surgical interventions, and this yielded a different outcome.

The pressure exerted on the cornea by the ptotic eyelid may be higher than that of the normal eyelid, which causes corneal modification [14]. In our study, the mean LPS muscle function was 14.72 ± 1.74 mm. This is within the normal range for Asian individuals as reported by Park et al. using Berke's method [15], as used in our study. Normal LPS function might exert less pressure over the cornea, lessening the changes in corneal astigmatism. Normal LPS muscle function among our participants with normal eyelid morphology may lead to no significant correlation between LPS muscle function and WTR corneal astigmatism. We found no study to

support or contradict the absence of correlation between LPS muscle function and WTR corneal astigmatism in the same setting as the current study.

In patients with ptosis, there was a direct correlation between LPS muscle function and palpebral fissure height [12]. The lower the LPS muscle function, the lower was the palpebral aperture height. A study by Read et al. suggested that both corneal astigmatism power and axis were significantly correlated with a horizontal palpebral aperture in individuals with normal eyelid morphology. Individuals with WTR central corneal cylinder axes had a significant and negative correlation with the primary gaze palpebral fissure width [17]. Correlation between vertical palpebral fissure height and corneal cylindrical power was absent in our participants with normal eyelid morphology and WTR corneal astigmatism. Kim et al. [18] investigated changes in central corneal power and corneal astigmatism after levator resection and blepharoplasty. The upper eyelid repositioning using levator resection led to greater changes in corneal curvature than blepharoplasty [18]. Future studies are necessary to clarify whether the reported changes in corneal curvature after ptosis surgery are due to the nature of the disease itself or are only due to the type of surgical ptosis repair.

Mongkolareepong et al. [19] investigated corneal astigmatism change in 42 eyes with either congenital or acquired ptosis that underwent supramaximal levator resection and levator resection procedure, respectively. Preoperatively, most of the eyes (45.2%) had a WTR astigmatism pattern, of which 57.9% revealed a reduction in the degree of astigmatism. In eyes with preoperative astigmatism of ≥ 1.5 D, postoperative corneal astigmatism changed significantly. The same subgroup revealed a reduction in astigmatism postoperatively. Although we purposefully included only participants with WTR corneal astigmatism, we did not find any significant correlation between LPS muscle function and low to moderate WTR corneal astigmatism. Future studies in normal individuals with high WTR corneal astigmatism could reveal previously unknown correlations.

Ozturk Karabulut and Fazil found no significant changes up to six months postoperatively in the mean corneal astigmatism, axis shift, and corneal curvature of patients with mild ptosis who underwent Müller's muscle conjunctival resection [20]. There are two possible explanations for the absence of significant changes. These findings might be due to the negligible effect of mechanical interaction between the upper eyelid and the eyeball in patients with mild ptosis. Likewise, the absence of correlation between LPS muscle function and WTR corneal astigmatism in our participants could imply an insignificant effect of upper lid mechanical pressure on corneal curvature in eyes with morphologically normal eyelids. In addition, it could be due to the type of surgical ptosis repair [20]. Future studies are needed for further clarification.

Our study revealed the absence of a correlation between LPS muscle function and WTR corneal astigmatism. We found no study in the same setting as the current study to support or contradict this result. However, this study was limited by the lack of a subgroup with high WTR corneal astigmatism and normal lid morphology to confirm the significance of our findings. Furthermore, in this study university students of Chinese origin were chosen. Thus, recruiting participants with various racial backgrounds and normal ocular examinations in different subgroups could negate the effect of race on final correlation results. Additionally, future studies including more data from normal participants, such as all dimensions of palpebral fissures, corneal thickness and diameter, ATR, and oblique corneal astigmatism might reveal previously unexplored correlations or differences.

CONCLUSIONS

We found no significant difference in mean LPS muscle function between groups with low and moderate WTR corneal astigmatism in young university students of Chinese origin with normal eyelid morphology. Furthermore, we found no significant correlation between LPS muscle function and low to moderate WTR corneal astigmatism.

ETHICAL DECLARATIONS

Ethical approval: Necessary permissions were obtained from UCSI University Clinical Research Ethics Committee (IEC-2019-FMHS-058) before this study. Written informed consent was obtained from all participants, and the principles of the Declaration of Helsinki were adhered to throughout this study.
Conflict of interests: None

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