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Possible corneal aberrometric changes after upper eyelid ptosis surgery

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Abstract

Background: Congenital upper eyelid ptosis is a common benign disorder in children that may cause visual and functional problems as well as cosmetic problems. Treatment of ptosis is indicated in cases of visual impairment or cosmetic problems. Vision is hampered not just when the pupil is obscured by the eyelid but also when refractive errors occur. Ptosis can cause astigmatism through interference with the visual axis (stimulus deprivation) and lead to amblyopia.

Objectives: This study aimed to investigate the changes in the shape and function of the cornea by topography, aberrometry, and orbscan in the eye with congenital ptosis before and after surgery.

Methods: This descriptive analytical study was performed on 15 patients aged 5–30 years with unilateral congenital ptosis who met the inclusion criteria. Complete ophthalmological examinations were performed on all patients. Patients underwent ptosis correction surgery in the form of levator resection. The patients were referred to the paraclinical unit for corneal imaging before and one month after the surgery, and topography, orbscan, and aberrometry were performed in the ptotic eyes before and after the operation (30 eyes).

Results: The mean age of the patients was 21.8 ± 5.9 years. The minimum astigmatism changes in the orbscan of ptotic eyes were 43.31±1.5 D before the surgery and 43.8±1.5 D after the surgery, which was significant (P = 0.02). No significant changes were observed in other findings of the orbscan. Also, the mean changes of vertical coma in aberrometry of ptotic eyes were significant before and after the surgery (P = 0.02). None of the topographical variables in ptotic eyes showed significant changes before and after the surgery. In patients with corneal astigmatism > 1 D, some aberrometric changes were statistically significant (HO w/o Z400 6mm, P = 0.023).

Conclusion: Ptosis surgery corrects vertical coma in aberrometry and minimum keratometry (Sim'K Min) in orbscan, but it has no effect on other measured items. If there is corneal astigmatism > 1D, the aberrometric changes following surgery are more obvious.

Keywords: Corneal, Aberrometry, Eyelids, Surgery.

Introduction

Congenital ptosis of the upper eyelid is a common disease caused by inadequate levator muscle development that can be persistent in the absence of good treatment.[1] Although not all patients require surgical repair, surgical correction of congenital ptosis can be important in maintaining normal visual development and function over time. Surgery is necessary when the eyelid obstructs the visual axis, leading to visual deprivation or amblyogenic astigmatism.[2]

Ptosis can have a variety of aesthetic, psychological, or functional impacts on an individual. It is a reversible cause of decreased peripheral vision and can affect both the upper and central vision.[3] In normal circumstances, a healthy upper eyelid applies constant pressure to the surface of the eye. However, upper ptosis can structurally alter the eye's surface, particularly the cornea.[4] Amblyopia is more prevalent in congenital ptosis, increasing its incidence by 50%. It can arise due to refractive errors or visual deprivation.[5,6] Several studies have addressed the high association between ptosis and disorders like refractive errors, astigmatism, and amblyopia, indicating its functional effects.[7] Ptosis of the upper eyelid can cause changes in the eye surface, but the influence of ptosis on high-order aberrations and visual acuity is not yet fully understood. Furthermore, few studies have analyzed the impact of congenital ptosis on high-order aberrations.[4] In evaluating corneal parameters, various methods have been introduced, with corneal topography, orbscans, and corneal aberrometry being the most common. This study focuses on the evaluation of corneal shape and surface parameters in patients with congenital ptosis before and after surgery to correct ptosis.

Objectives

This prospective study aimed to analyze the profile of high-order aberrations (HOAs) in eyes with unilateral congenital ptosis, specifically in children under 15 years old. We also compared these HOA profiles with those of our normal fellow eyes in the same group.

Methods

Our study is a prospective observational-comparative analysis of 30 eyes from 15 patients. We obtained informed consent from all patient guardians, and the Institutional Review Board of our hospital approved our study. We recruited patients between the ages of 5 and 30 with unilateral congenital ptosis from the oculoplastic specialty clinic of Khatam-al-Anbia Eye Hospital and Eye Research Centre for a period of six months. Patients with complicated congenital ptosis, tear film abnormality, abnormal bells phenomenon, high ametropia (more than 2D), a history of previous ocular surgery, jaw-winking phenomenon, strabismus, or bilateral ptosis were excluded. We conducted visual acuity tests using Snellen's distance vision acuity charts, and the visual acuity was presented as the decimal equivalent.

To determine the accurate position of the upper eyelid, we assessed the primary gaze in the repose position. The marginal reflex distance (MRD1) measurement, defined as the distance from the central light reflex on the cornea to the upper eyelid margin in the primary position, was used. We also measured PFH, levator muscle function, corneal sensation, Bell's phenomenon, extra ocular movements, slit lamp biomicroscopy, fundus examination, and tear film abnormality tests (break-up time and corneal staining) in all eyes. Corneal topography was recorded using a computed topographic system (Orbscan, Bausch & Lomb, Rochester, NY), and aberometry, corrected distance visual acuity (CDVA), and uncorrected distance visual acuity were measured in both eyes using Snellen visual acuity charts. We also measured ocular higher-order aberrations using the Zywave workstation (Bausch & Lomb, Rochester, NY), which employs the Hartmann-Shack principle.

To account for diurnal variation, all aberrometry measurements were taken between 2-6 PM. A single examiner conducted aberrometry readings in both the ptosis and fellow eyes of patients. Homatropine 2% eye drops were uniformly utilized for dilatation and mydriasis during the dilated aberrometry examination. To ensure consistency in measurements, higher order aberrations were taken as standard for all eyes at a pupil size of 6mm. Patients were instructed to blink twice to ensure a smooth corneal surface and reproducible measurement. For uniformity in measurements, the upper eyelid was mechanically lifted in all eyes just prior to the aberrometry examination to visualize the centroids. The Zywave station result table efficiently selected the best three readings with the lowest reliability criteria for analysis. (Note: the lower the reliability criteria, the better the repeatability.)

To prevent errors related to enantiomeric midline symmetry, we made essential corrections in the signed values based on Smolek et al.'s recommendations.[8] Specifically, we flipped the sign of odd symmetric terms about the y axis in the left eye to combine the data in a single database and assess mirror symmetry. We then compared the aberration profile of ptosis eyes with those of the normal fellow eyes of the patients. Both preoperative and postoperative imaging were conducted, with the postoperative imaging occurring a month after the surgery.

Statistical analysis

The data were expressed as the mean±SD, or percentage and frequency. Independent-t test test was used to compare the parameters between groups. All statistical analyses were performed with SPSS (version 16.0, SPSS

Inc, Chicago, IL, USA). A "P-value" less than 0.05 was considered significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. Institutional Review Board approval was obtained. The present study did not interfere with the process of diagnosis and treatment of patients and all participants signed an informed consent form.

Results

This study investigates the effect of ptosis surgery on aberrometric and topography changes in the ptotic eye of 15 patients with congenital ptosis. The study group consisted of 9 men and 6 women with a mean age of 21.8±5.9 years. Of the 15 patients, 1 was under 10 years old, 10 were between 10 and 20 years old, and 4 were over 20 years old [Figure 1]. The data distribution was normal according to the K-S test.

The study examines the changes in corneal keratometry, aberrometry, and topography before and after ptosis surgery using Paired T-tests. The minimum keratometry changes were significant ($p<0.05$) before and after surgery [Table 1].

Vertical coma changes in the aberrometry were also significant ($p<0.05$) before and after surgery [Table 2]. However, topography changes were not significant before and after surgery [Table 3].

Table 4 compares aberrometric changes in congenital ptosis eyes before and after surgery, specifically in patients with astigmatism larger or less than 1D. The results indicate a significant ($p<0.05$) change in HO w/o Z400 6mm.

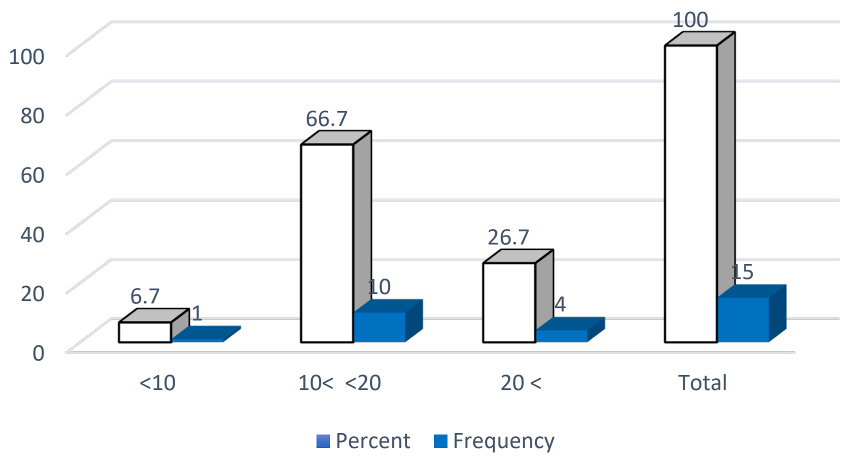

Figure 1. Age breakdown of patients with congenital ptosis

Table 1. Orbscan changes in patients with congenital ptosis in ptotic eye before and after surgery

Variable	Ptotic eye before surgery	Ptotic eye after surgery	P value
Anterior elevation Diff (mm)	0.01±0.004	0.011±0.03	0.43
Posterior elevation Diff (mm)	0.013±0.004	0.013±0.004	0.65
Sim's ks astig (D)	-1.46±0.96	-0.26±0.85	0.19
Max (D)	44.7±1.6	45.13±1.5	0.10
Min (D)	43.31±1.5	43.8±1.5	0.02*
3 mm zone (D)	1.3±0.48	1.26±0.4	0.7
Astig Pwr (D)	1.4±1.04	1.2±0.89	0.41
5 mm zone (D)	2.07±1	2.32±1.4	0.61
Thinnest (μm)	561.4±27.8	562.13±26.7	0.75

Table 2. Aberrometric changes in ptotic eye in patients with congenital ptosis before and after surgery

Variable	Ptotic eye after surgery	Ptotic eye before surgery	P value
Higher order 6 mm (μm)	0.42±0.13	0.41±0.1	0.89
HO w/o Z400 6mm (μm)	0.39±0.13	0.37±0.14	0.53
Vertical trefoil (μm)	0.12±0.017	0.4±0.23	0.09
vertical coma (μm)	-0.08±0.02	-0.002±0.13	0.02 *
Horizontal trefoil (μm)	0.06±0.02	0.03±0.01	0.61
Horizontal coma (μm)	-0.05±0.01	-0.09±0.06	0.39
Quadrafoil (μm)	-0.007±0.002	-0.006±0.001	0.97
4th order sph aberration (μm)	-0.12±0.09	-0.09±0.01	0.40

Table 3. Topography changes of ptotic eye in patients with congenital ptosis before and after surgery

Variable	Ptotic eye after surgery	Ptotic eye before surgery	P value
Ks	44.97±1.4	44.89±1.7	0.85
Kf	43.64±1.6	43.54±1.7	0.45
Cyl	1.14±0.83	1.36±1.2	0.14
SRI	0.34±0.12	0.34±0.11	0.98
SAI	0.43±0.19	0.3±0.17	0.08
IAI	2.8±0.7	0.37±0.04	0.33

Table 4. Aberrometric changes in ptotic eye in patients with congenital ptosis before and after surgery in astigmatism greater and less than 1 D

Variable	Higher order 6 mm	HO w/o Z400 6mm	Vertical trefoil	vertical coma	Horizontal trefoil	Horizontal coma	Quadrafoil	4^{th} order sph aberration
P value	0.06	0.02*	0.45	0.28	0.69	0.96	0.24	0.37

*significant in Independent-t test

The severity of ptosis was evaluated in the patients, with most of them (80%) having moderate ptosis [Table 5]. The study highlights the important correlation between ptosis surgery and corneal keratometry and aberrometry changes, which should be taken into account when considering ptosis surgery in patients who are also candidates for refractive surgery.

Table 5. Distribution of severity of ptosis in patients with congenital ptosis participating in the study

Severity of ptosis	Frequency	%	Difference MRD (mm)
Mild	2	13.3	2
Moderate	12	80	3
Severe	1	6.7	4

Discussion

Congenital ptosis can cause visual deprivation, leading to astigmatism and, potentially, amblyopia. Surgical interventions are available to correct ptosis, and some patients may require multiple surgeries. Early surgery may be critical for children with amblyopia due to astigmatism.[9] Previous studies have examined changes in astigmatism and amblyopia following ptosis correction surgery.

Sassenbach et al.[10] studied keratoconus in the correction of unilateral ptosis and discovered that changes in astigmatism following ptosis correction were driven by changes in the vector of forces on the cornea. Such changes were typically transient but could affect a patient's vision for months following surgery. Correcting upper eyelid ptosis sometimes reveals asymptomatic irregular astigmatism, including vertical coma.

The present study's results are in line with Sassenbach's findings,[10] indicating significant aberrometric changes in the vertical coma after surgery. The mean preoperative value was -0.002±0.001 μm and the postoperative value was -0.08±0.02 μm, with a p-value of <0.05.

The results of this investigation revealed a significant difference in aberrometric alterations in eyes with congenital ptosis before and after surgery, particularly in astigmatism > 1D in vertical coma ($p<0.05$). Similarly, Kirwan et al.[11] examined high-order aberrations in children with amblyopia and observed that high-order aberrations in eyes with amblyopia caused by strabismus and anisometropia were comparable to those in normal eyes. Unlike low-order aberrations, high-order aberrations do not contribute to the development of amblyopia.

A prospective study by Brown et al.[12] investigated changes in corneal shape in 22 patients who received upper eyelid surgery. Three months after ptosis correction, the mean dioptric changes measured by keratometry were approximately 0.60 D, with nearly 30% of patients experiencing astigmatic changes greater than 1.00 D.

Zinkernagel et al.[13] conducted a similar study in which corneal topography changes were investigated in 43 patients who underwent ptosis correction surgery. The results indicated a significant association between the severity of the upper eyelid anomaly and corneal topography changes following the surgery during the 3-month follow-up period. Therefore, patients with this condition should be advised about potential changes in vision resulting from ptosis surgery.

In this study, the changes in corneal shape and function were assessed using topography, aberrometry, and orbscan in ptotic eyes before and after surgery. It was found that the minimum keratometry decreased by 0.5 D following the surgery.

In a study by Owji et al.,[14] patients who underwent ptosis correction surgery were evaluated for refractive errors, MRD1, and levator muscle function before and after the surgery. The results revealed a correlation between astigmatism changes and MRD1 after the surgery. Notably, significant astigmatism changes were observed in eyes with MRD1 changes exceeding 2.5. In ptosis, amblyopia can result from various factors, such as astigmatism, strabismus, anisometropia, and stimulus deprivation.

In a study by Kumar et al.,[4] CDVA in both ptotic and normal eyes was compared. The results showed a significant difference in CDVA between the two eyes. Interestingly, only total coma was found to be associated with CDVA in ptosis, while no association was found for other aberrations.

It is important to note that some studies only utilize keratometry to evaluate the cornea, but this method only assesses the curvature of a small area and does not examine the apex of the cornea. In contrast, topography analysis provides more comprehensive information about the surface of the cornea.

Additionally, among studies that have assessed the impact of ptosis on topography and aberrometry, the present study was the first to investigate changes in both parameters simultaneously in these patients. Impressively, the results demonstrated that post-surgical eyelid pressure on the cornea could cause changes in its shape and refractive characteristics. Therefore, postoperative refractive assessments are paramount for these patients, and practitioners must inform them about potential vision changes.

This study aimed to explore the impact of ptosis surgery on the shape and function of the cornea using topography, aberrometry, and OBscan. The results showed that the minimum keratometry decreased by 0.50 D from a mean of 43.31±1.5 D to a mean of 43.81±1.5 D after surgery. However, no significant changes were observed in other Orbscan parameters ($P>0.05$). Notably, significant changes were noted in vertical coma, with mean values of -0.002±0.001 µm before surgery and -0.08±0.02 µm after surgery ($P<0.05$). It is important to note that this study did not use pentacam, which provides more detailed information about corneal shape. While the high-order aberration may result from corneal irregularities, it is unclear if the changes are due to ocular and corneal epithelium irregularities or other factors. Thus, it is advisable to gather additional data from other imaging modalities, such as pentacam, to fully understand the details of these changes.

Conclusions

The findings of this study suggest that ptosis surgery has a positive impact on correcting vertical coma in aberrometry and the Sim'K Min in orbscan. However, no significant changes were observed in other measured items. Notably, the results showed that if a patient has corneal astigmatism >1 D, the aberrometric changes following surgery are more prominent.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Corrected distance visual acuity: CDVA;
marginal reflex distance: MRD1;
palpebral fissure height: PFH.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Institutional Review Board approval was obtained. The present study did not interfere with the process of diagnosis and treatment of patients and all participants signed an informed consent form.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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