• Clinical Research •

Factors associated with corneal astigmatism change after ptosis surgery

Natpatsorn Mongkolareepong, Nattapong Mekhasingharak, Oranicha Pimpha

Department of Ophthalmology, Naresuan University Hospital, Naresuan University, Phitsanulok 65000, Thailand

Correspondence to: Nattapong Mekhasingharak. Department of Ophthalmology, Faculty of Medicine, Naresuan University Hospital, Naresuan University, Phitsanulok 65000, Thailand. buntosi@yahoo.com

Received: 2021-03-07 Accepted: 2021-06-26

Abstract

● **AIM:** To evaluate the predictive factors of postoperative corneal astigmatism change in ptosis patients who underwent ptosis surgical repair.

● **METHODS:** Patients who underwent levator resection at Oculoplastic service of the Department of Ophthalmology, Naresuan University Hospital, Thailand between September 2017 and August 2019 were retrospectively evaluated. Changes in degree and axis of corneal astigmatism after ptosis surgery were compared based on patient factors consisting of age at operation, sex, preoperative margin-reflex distance (MRD) 1, and preoperative degree and axis of corneal astigmatism.

● **RESULTS:** Forty-two eyes of 28 patients were included in the study. Wilcoxon signed ranks test showed a significant postoperative corneal astigmatism change only in a subgroup of eyes with preoperative astigmatism of ≥1.5 diopters (D; *P*=0.006). Furthermore, 72.2% (13/18) of the eyes with preoperative astigmatism of ≥1.5 D showed a reduction of astigmatism after eyelid surgery, with the mean astigmatic change of 0.65 D. Majority of preoperative eyes demonstrated with-the-rule astigmatism pattern (45.2%), of which 57.9% showed a reduced degree of astigmatism.

● **CONCLUSION:** In patients undergoing ptosis surgery, the data demonstrate for the first time the association between postoperative corneal astigmatism change and a preoperative corneal astigmatism of ≥1.5 D. Thus, we encourage considering severity of corneal astigmatism prior to cataract or refractive surgery planning in ptosis patients, especially with toric-intraocular lens, to avoid the possibility of calculation error.

● **KEYWORDS:** corneal astigmatism; ptosis surgery; levator resection

DOI:10.18240/ijo.2022.04.08

Citation: Mongkolareepong N, Mekhasingharak N, Pimpha O. Factors associated with corneal astigmatism change after ptosis surgery. *Int J Ophthalmol* 2022;15(4):576-580

INTRODUCTION

Blepharoptosis, an eyelid disorder, can cause visual disturbance at any age ranging from infants as congenital ptosis to aponeurotic ptosis in the elderly. Other types included mechanical, myogenic, and neurogenic ptosis[1-2]. Patients may experience a decreased vision as the covering lid constricts the superior visual field and/or causes refractive errors, mainly corneal astigmatism.

Explanation have been proposed indicating the causation of corneal astigmatism in ptosis patients to be a result of eyelid pressure against the cornea, which alter the corneal shape toward with-the-rule (WTR) astigmatism[3]. The corneal astigmatism degree is changeable postoperatively based on several reports, some showed significant results[4-8]. Postoperative axis shift has also been reported. Wilson *et al*[4] demonstrated a trend of a decreased degree of WTR astigmatism in patients who underwent ptosis surgery. A similar result was reported in Savino *et al*'s study[5]. However, Merriam *et al*[9] found the opposite trend of an increased WTR astigmatism to also be possible.

Few studies have been conducted to identify factors associated with the degree of astigmatism change after ptosis surgery[6-8]. In this study, we evaluated corneal astigmatism value of patients who underwent ptosis surgical repair to find the association between patient factors and postoperative corneal astigmatism change. The changing pattern of corneal astigmatism axis after surgery was also identified.

SUBJECTS AND METHODS

Ethical Approval All patients underwent levator resection procedure by the same experienced surgeon, with informed consent obtained preoperatively. This study was approved by the Human Research Ethics Committee of the Faculty of Medicine Naresuan University in accordance with the Declaration of Helsinki.

Eligible Patients This is a retrospective study evaluated patients diagnosed with congenital or acquired ptosis who underwent ptosis surgical repair at Oculoplastic Service of the Department of Ophthalmology, Naresuan University Hospital, Phitsanulok, Thailand between September 2017 and August 2019.

Patient Factors Patient factors were identified and recorded. The data included age at operation, sex, preoperative margin-reflex distance (MRD) 1, and preoperative degree and axis of corneal astigmatism. Subgroups of each factor were classified to evaluate the associations with the degree of astigmatism change at 6-week postoperatively.

Age was categorized into ≥50y and <50y; MRD1 values was divided into -2 to 0 and 1 to 3. The degree of preoperative corneal astigmatism was divided into <1.5 diopters (D) and ≥1.5 D, and axis of corneal astigmatism was classified as WTR (steep axis within 90°±30°), against-the-rule (ATR; steep axis within 0° to 30° or 150° to 180°), and the axis which falls beyond these ranges is classified as oblique astigmatism.

A comprehensive ophthalmological examination was performed. Data recorded included visual acuity, refraction, anterior segment exam, fundus exam, eye motility, and levator function.

Astigmatism value was obtained from an average of 3 consecutive values measured using Nidek Tonoref II Autorefractor Keratometer. Exclusion criteria were previous corneal surgery, presence of pterygium, keratoconus, severe ocular surface disease, neurological/mechanical/traumatic ptosis, or preoperative MRD1 of >3.

The primary outcome was the degree of corneal astigmatism change at 6-week postoperatively. The secondary outcome was the corneal astigmatic axis pattern, pre- and post-operative.

Surgical Techniques All congenital ptosis patients underwent supramaximal levator resection and all acquired cases underwent a levator resection procedure. Skin crease was marked at the desired height. The 2% lidocaine with 1:100 000 adrenaline was injected subcutaneously along the eyelid crease. Skin incision was done with a scalpel blade no.15. Dissection was made deeper through orbicularis muscle, orbital septum and preaponeurotic fat with Westcott scissors and electrocautery to identify the underlying levator aponeurosis. The levator aponeurosis was then dissected off the tarsal plate and extend superiorly off the müller's muscle to the desired level. In case of supramaximal levator resection, the dissection was continued superiorly to a level above Whitnall's ligament. Partial-thickness 6-0 silk sutured was placed from upper one third of tarsal plate in horizontal mattress fashion to the levator muscle at a desired level and tied with a temporary bowtie for intraoperative level adjustment. Additional suture was placed nasally and temporally. Eyelid crease was made with prolene 7-0 suture between inferior cut edge of pretarsal aponeurosis and levator aponeurosis. Skin was closed with interrupted sutures nylon 6/0.

Statistical Analysis A Shapiro-Wilk test was used to evaluate the normality of the data. Variables were reported in mean value±SD. The analysis comparing preoperative and postoperative astigmatism values was done using Wilcoxon signed ranks test. A *P*-value of <0.05 was considered statistically significant. The prevalence of axis pattern was reported in percentage. The analysis was performed with SPSS version 17.0.

RESULTS

Forty-two eyes of 28 patients were included in the study. Of the 42 eyes, 8 eyes of 7 patients were congenital ptosis with mean age of 16.75y (range, 4-53y) and 34 eyes of 21 patients were acquired ptosis with mean age of 63.71y (range, 38-76y). Data representing the means of pre- and post-operative corneal astigmatism were summarized in Table 1. Overall, the means of postoperative astigmatism showed a reduction value compared to means of preoperative astigmatism in all subgroups, except for the subgroups of eyes with astigmatism of <1.5 D and eyes with oblique astigmatism. The means of astigmatism change at 6-week postoperatively of each subgroup ranged from 0.25 to 0.65 D.

The analysis of different astigmatism values between pre- and postoperative by the Wilcoxon signed ranks test showed a significant value in only one subgroup which is eyes with preoperative astigmatism of ≥1.5 D (*P*=0.006; Figure 1). Thirteen of 18 eyes (72.2%) with preoperative astigmatism of ≥1.5 D showed a reduction degree of astigmatism after eyelid surgery, with the mean astigmatic change of 0.65±0.52 (0-1.75) D.

The majority of preoperative eyes demonstrated WTR astigmatism pattern (45.2%), compared with 38.1% of ATR and 16.7% of oblique pattern (Table 2) with a mean age of 42.15±24.14, 67.25±7.20, and 60.42±10.72y respectively.

After a surgical repair, the WTR group showed a predominant reduction of WTR astigmatism in 57.9% (11/19). Other patterns of changes were also observed, including an increased degree of WTR astigmatism in 26.3% (5/19), a change to oblique axis in 10.5% (2/19) and one eye with no astigmatism change (5.3%). Meanwhile, the eyes with preoperative ATR astigmatism exhibited a rising degree of ATR in 37.5% (6/16), a reduction in 50% (8/16), no change in one eye, and one eye with a change to oblique axis. Also, most of the eyes with preoperative oblique astigmatism experienced a shift of the axis towards ATR astigmatism (5/7; 71.4%).

DISCUSSION

Previous studies reported that ptosis lid can generate pressure onto superior cornea which leads to the change of corneal

Table 1 Preoperative and postoperative mean corneal astigmatism mean±SD (range)

Factor (*n*=42)	Preop. astigmatism	Postop. astigmatism	Posto. astigmatism change	*P*[b]
Age (y)				
<50 (*n*=8)	2.03±1.61 (0.25-4.50)	1.53±1.48 (0.25-4.50)	0.63±0.64 (0.00-1.75)	0.088
≥50 (*n*=34)	1.21±0.87 (0.00-3.00)	1.20±0.79 (0.00-3.00)	0.50±0.34 (0.00-1.50)	0.959
Gender				
Male (*n*=16)	1.44±1.11 (0.00-4.25)	1.33±1.13 (0.25-4.50)	0.58±0.39 (0.25-1.50)	0.618
Female (*n*=26)	1.33±1.08 (0.25-4.50)	1.22±0.84 (0.00-2.75)	0.49±0.42 (0.00-1.75)	0.686
MRD1				
1-3 (*n*=28)	1.14±1.03 (0.00-4.25)	1.06±0.75 (0.00-2.75)	0.51±0.41 (0.00-1.75)	0.840
-2-0 (*n*=14)	1.82±1.06 (0.50-4.25)	1.66±1.18 (0.25-4.25)	0.55±0.42 (0.00-1.50)	0.397
Preop. astigmatism				
<1.5 D (*n*=24)	0.63±0.35 (0.00-1.25)	0.82±0.47 (0.00-1.75)	0.43±0.28 (0.00-1.00)	0.051
≥1.5 D (*n*=18)	2.36±0.90 (1.50-4.50)	1.85±1.11 (0.25-4.50)	0.65±0.52 (0.00-1.75)	0.006[a]
Axis				
WTR (*n*=19)	1.54±1.32 (0.00-4.50)	1.30±1.12 (0.25-4.50)	0.58±0.51 (0.00-1.75)	0.242
ATR (*n*=16)	1.47±0.87 (0.25-3.00)	1.42±0.81 (0.50-3.00)	0.58±0.28 (0.00-1.00)	0.774
Oblique (*n*=7)	0.68±0.45 (0.25-1.25)	0.79±0.64 (0.00-1.75)	0.25±0.20 (0.00-0.05)	0.334

MRD1: Margin-reflex distance 1; WTR: With-the-rule astigmatism; ATR: Against-the-rule astigmatism. [a]*P*<0.05 shows the statistical significance; [b]Wilcoxon signed ranks test (pairs 2 variable).

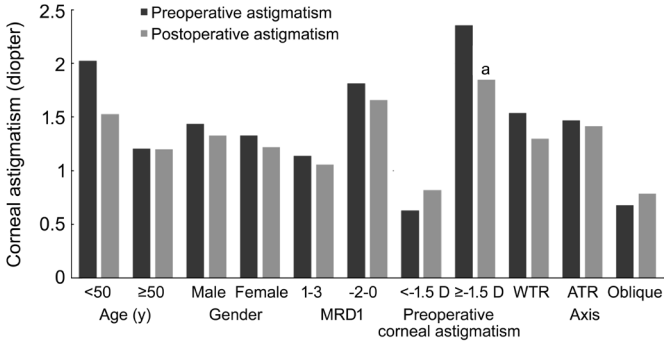

Figure 1 Preoperative and postoperative mean corneal astigmatism of each patient factor MRD1: Margin-reflex distance 1; WTR: With-the-rule astigmatism; ATR: Against-the-rule astigmatism. [a]*P*<0.05 shows the statistical significance.

Table 2 Characteristics of preoperative and postoperative astigmatic axis

Preop.astigmatic axis	*n* (%)	Postop. axis change	*n* (%)
WTR	19 (45.2)	Decrease degree	11 (57.9)
		Increase degree	5 (26.3)
		Not change	1 (5.3)
		Change to oblique axis	2 (10.5)
ATR	16 (38.1)	Decrease degree	8 (50)
		Increase degree	6 (37.5)
		Not change	1 (6.2)
		Change to oblique axis	1 (6.2)
Oblique	7 (16.7)	Change to ATR	5 (71.4)
		Change to WTR	1 (14.3)
		Not change	1 (14.3)

WTR: With-the-rule astigmatism; ATR: Against-the-rule astigmatism.

curvature, resulting in corneal astigmatism, particularly a WTR astigmatism[3]. Several reports established the modifiability of this condition as observed in the change of corneal astigmatism, either in the degree or axis, after surgical correction[4-15]. Wilson *et al*[4] evaluated the effect of eyelid lifting, using eyelid speculum, and found a reduction of WTR astigmatism in cornea with more than 1.00 D of WTR astigmatism. Savino *et al*[5] also found a significant reduction of WTR astigmatism in patients who underwent ptosis surgical repair.

Several studies attempted to compare the degree of corneal astigmatism change among various eyelid surgery procedures. A retrospective study by Zinkernagel *et al*[6] found a significant change of postoperative corneal astigmatism in patients who underwent ptosis surgery and blepharoplasty with reduction of the entire fat pad, in contrast to insignificant value in the groups with skin-only blepharoplasty and blepharoplasty with reduction of the medial fat pad. This study reflects the correlation between the severity of eyelid abnormality and the significant astigmatism value change postoperatively. A similar result was reported by Kim *et al*[7]; patients underwent levator resection exhibited more corneal curvature change compared with those who underwent blepharoplasty.

To our knowledge, there are limited studies attempting to identify predictive factors for a corneal astigmatism change in patient who underwent ptosis repair surgery[6-8]. Our study, therefore, analyzed postoperative corneal astigmatism change based on patient factors. The results showed a significant postoperative astigmatism change in a subgroup of eyes with more severe baseline preoperative astigmatism value, in other words, eyes with preoperative astigmatism of ≥1.5 D (*P*=0.006).

Unlike two previous mentioned studies which exhibited the correlation between high severity of lid pathology and high value change of astigmatism postoperatively[6-7], our study showed no significant result in group with severe ptosis as indicated by MRD1. Further investigation should be done to assess the association between severity of ptosis and amount of preoperative astigmatism.

A range of means astigmatism change in our study was 0.25 to 0.65 D, corresponding to a previous finding by Brown *et al*[16] which reported an average of 0.6 D in corneal astigmatism change in patient underwent reposition lid ptosis.

Cataract and ptosis may co-exist in the same patient. The change of corneal astigmatism of at least 0.5 D might cause a visual problem in patients with high demand visual function[16]. Also, in our study, significant postoperative astigmatism change was found in a subgroup of eyes with astigmatism of ≥1.5 D with a mean change of 0.65±0.52 (0.00-1.75) D. Regarding findings above, this might put patients who underwent cataract surgery prior to lid correction, at risk of unsatisfied visual outcome from a refractive change after ptosis surgery, despite a precise initial intraocular lens (IOL) calculation. Although the majority of patients in a subgroup of preoperative corneal astigmatism of ≥1.5 D showed a decreased degree of astigmatism postoperatively (72.2%), the direction was unpredictable and other patterns were observed, including the increase in the degree of astigmatism value and axis change. The latter might substantially affect patients requesting for toric-IOL implantation.

Refractive surgery is one of the most popular elective ophthalmic procedures performed in the world. Denisova and Barmettler[17] suggested that patients electing to have ptosis repair, should be fully healed prior to any refractive surgery to allow both refractive changes and eyelid positions to stabilize prior to the refractive surgery. We agree with this suggestion, especially in patients with either high preoperative astigmatism or dry eye syndrome.

WTR astigmatic pattern is found predominantly in children and will gradually transform to ATR astigmatism with increasing age[18-20]. We also know that the ptosis lid can have a pressure effect on peripheral cornea which leads to a WTR astigmatism[3]. Our patients revealed a similar trend as the majority of ptosis patients showed a WTR astigmatism (45.2%) preoperatively. For patients with ATR astigmatism (38.1%), an older mean age (67.25±7.20y) was found, compared with 42.15±24.14y in WTR group. This might reflect the substantial effect of ATR patterns found in aging cornea overcoming the effect of lid pressure. Another confounding effect, such as the duration from onset of ptosis to date of surgery, which may or may not influence the reversibility of the cornea astigmatism value, has not been included in this study.

According to axis patterns, most of the previous studies reported that corneal astigmatism tend to decrease the degree of WTR (or increase the degree of ATR) astigmatism after eyelid surgery[4-5]. In our study, the changing of axis after ptosis correction was non-uniform. Although many cases with preoperative WTR and oblique astigmatism showed a decreased degree of WTR astigmatism after surgery, this was not revealed in the preoperative ATR group. Moreover, the preoperative axis was a statistically insignificant factor in our study. Therefore, it cannot be used as the predictive factor for postoperative corneal change.

Although numbers of reports have revealed a similar trend of significant corneal astigmatism change after ptosis surgery, follow-up periods were varied, ranging between 6wk and 4mo[5-7,16]. Long term change was evaluated in a recent study from Yamamoto *et al*[21] which showed a significant astigmatism change at 6mo postoperatively. While all of the suggested durations to perform cataract surgery after ptosis repair were proposed according to the results of follow-up periods being reported, there was an uncertainty on stability of astigmatism value postoperative and a longitudinal study should be done to assess a definite timing at which steady astigmatism value was achieved[21].

Some studies found an astigmatism pattern correlated with corneal ectasia in ptosis patient. However, ptosis alone was insufficient to cause corneal ectatic disease which was known to be a multifactorial condition[22]. A prospective study found tomographic value of subclinical keratoconus in severe congenital blepharoptosis[22]. Another study from Kim *et al*[23] also reported ptosis inducing superior keratoconus. In our study, we excluded overt keratoconus cases as its natural history may confound with the effect of lid pressure to normal cornea. However, as we do not perform tomography in routine practice, it might be possible to falsely recruit subclinical keratoconus case into the study. Limitations were expected, given that this study was a single-center retrospective study. Also, the astigmatism values obtained from autokeratometer, may result in less comprehensive data in comparison to corneal topography values in which data was not available in this study since the method was not performed routinely in our center. The attempt at a long-term data analysis was incapable due to the relatively high rate of loss follow up.

Nevertheless, in patients undergoing ptosis surgery, the data demonstrated for first time the association between postoperative corneal astigmatism change and a preoperative corneal astigmatism of ≥1.5 D. Thus, in patients with such predictive factor, surgery sequence should be considered, as conducting ptosis surgery prior to cataract or refractive surgery might provide a better refractive outcome, especially with toric-IOL implantation.

ACKNOWLEDGEMENTS

Authors' contributions: Mongkolareepong N initiated the project, designed the data collection tools, monitored the data collection for the whole trial, wrote the statistical analysis plan, cleaned and analyzed the data, as well as drafted and revised the manuscript. Mekhasingharak N initiated the project, designed the data collection tools, monitored the data collection for the whole trial, revised the manuscript, approved the final manuscript prior to journal submission, and supervised the study. Pimpha O designed the data collection tools, and revised the manuscript.

Conflicts of Interest: Mongkolareepong N, None; **Mekhasingharak N,** None; **Pimpha O,** None.

REFERENCES

1 Díaz-Manera J, Luna S, Roig C. Ocular ptosis: differential diagnosis and treatment. *Curr Opin Neurol* 2018;31(5):618-627.

2 de Figueiredo AR. Blepharoptosis. *Semin Ophthalmol* 2010;25(3):39-51.

3 Gullstrand A. Helmholtz's treatise on physiological optics. *The cornea.* New York: Dover Publications Inc. 1962:320-321.

4 Wilson G, Bell C, Chotai S. The effect of lifting the lids on corneal astigmatism. *Am J Optom Physiol Opt* 1982;59(8):670-674.

5 Savino G, Battendieri R, Riso M, Traina S, Poscia A, D'Amico G, Caporossi A. Corneal topographic changes after eyelid ptosis surgery. *Cornea* 2016;35(4):501-505.

6 Zinkernagel MS, Ebneter A, Ammann-Rauch D. Effect of upper eyelid surgery on corneal topography. *Arch Ophthalmol* 2007;125(12):1610-1612.

7 Kim YK, In JH, Jang SY. Changes in corneal curvature after upper eyelid surgery measured by corneal topography. *J Craniofac Surg* 2016;27(3):e235-e238.

8 Numata A, Yunoki T, Otsuka M, Hayashi A. Corneal topographic changes after blepharoptosis surgery in patients with deepening of the upper eyelid sulcus. *Jpn J Ophthalmol* 2021;65(2):282-287.

9 Merriam WW, Ellis FD, Helveston EM. Congenital blepharoptosis, anisometropia, and amblyopia. *Am J Ophthalmol* 1980;89(3):401-407.

10 Gandhi A, Mehta A, Naik M. Does frontalis sling surgery for congenital ptosis change the corneal topography and refractive characteristics postoperatively? *Clin Ophthalmol* 2020;14:3667-3673.

11 Bee YS, Tsai PJ, Lin MC, Chu MY. Factors related to amblyopia in congenital ptosis after frontalis sling surgery. *BMC Ophthalmol* 2018;18(1):302.

12 Zheng XD, Yamada H, Mitani A, Shiraishi A, Kamao T, Goto T. Improvement of visual function and ocular and systemic symptoms following blepharoptosis surgery. *Orbit* 2021;40(3):199-205.

13 Wu XS, Zhang JY, Ding X, Cao Y, Zhu XW, Li R, Li L, Lin M, Li J. Amblyopia and refractive status in congenital ptosis: the effect and timing of surgical correction. *Ann Plast Surg* 2021;87(1):49-53.

14 Ozturk Karabulut G, Fazil K. Corneal topographical changes after müller's muscle-conjunctival resection surgery. *Ophthalmic Plast Reconstr Surg* 2019;35(2):177-181.

15 Paik JS, Kim SA, Park SH, Yang SW. Refractive error characteristics in patients with congenital blepharoptosis before and after ptosis repair surgery. *BMC Ophthalmol* 2016;16(1):177.

16 Brown MS, Siegel IM, Lisman RD. Prospective analysis of changes in corneal topography after upper eyelid surgery. *Ophthalmic Plast Reconstr Surg* 1999;15(6):378-383.

17 Denisova K, Barmettler A. Oculoplastic considerations for refractive procedures. *Curr Opin Ophthalmol* 2020;31(4):241-246.

18 Gudmundsdottir E, Jonasson F, Jonsson V, Stefánsson E, Sasaki H, Sasaki K. "With the rule" astigmatism is not the rule in the elderly. Reykjavik Eye Study: a population based study of refraction and visual acuity in citizens of Reykjavik 50y and older. Iceland-Japan Co-Working Study Groups. *Acta Ophthalmol Scand* 2000;78(6):642-646.

19 Fledelius HC, Stubgaard M. Changes in refraction and corneal curvature during growth and adult life. A cross-sectional study. *Acta Ophthalmol* (*Copenh*) 1986;64(5):487-491.

20 Schuster AKG, Pfeiffer N, Schulz A, Hoehn R, Ponto KA, Wild PS, Blettner M, Beutel ME, Lackner KJ, Münzel T, Mirshahi A. Refractive, corneal, and ocular residual astigmatism: distribution in a German population and age dependency-the Gutenberg Health Study. *Graefes Arch Clin Exp Ophthalmol* 2018;256(2):445-446.

21 Yamamoto R, Ono T, Toyono T, Shirakawa R, Noda M, Yoshida J, Miyai T. Assessment of long-term anterior and posterior topographic changes in the cornea after ptosis surgery using Fourier harmonic analysis. *Cornea* 2021;40(4):440-444.

22 Zhu TP, Ye X, Xu PF, Wang JY, Zhang HN, Ni HL, Su ZA, Ye J. Changes of corneal tomography in patients with congenital blepharoptosis. *Sci Rep* 2017;7(1):6580.

23 Kim T, Khosla-Gupta B, Debacker C. Blepharoptosis-induced superior keratoconus. *Am J Ophthalmol* 2000;130(2):232-234.