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ORIGINAL ARTICLE

The effect of steep axis incision on astigmatism in cataract surgery

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Abstract

Purpose: This study aimed to evaluate the impact of clear corneal incisions on astigmatism in patients undergoing cataract surgery. The values of corneal astigmatism before and after surgery were compared, and the difference was analyzed.

Methods: A total of 50 patients (50 eyes) with regular astigmatism who underwent phacoemulsification due to cataracts were included in this study. The patient's pre-operative corneal astigmatism, keratometry values, and steep axis were calculated. The operation was performed by the same surgeon, and the phacoemulsification clear corneal incision was keratometrically placed on the steep axis. The results of the pre- and post-operative examinations of patients who underwent cataract surgery were retrospectively analyzed at the 1st month of astigmatism. The values of corneal astigmatism before and after surgery were compared, and the difference was examined.

Results: The mean age of the patients was 67.9±6.7 years. Of them, 26 (52%) were women and 24 were men (48%). After surgery, the patient's best-corrected visual acuity was 20/20. Furthermore, their mean keratometric steep axis was 108.6°±34.9°. It was observed that the patients' pre- and post-operative corneal astigmatism were 1.24±0.7 diopter (D) and 0.83±0.58 D, respectively. When the values were compared, a difference of 0.41±0.25 D was observed, which was statistically significant ($p<0.001$). The mean pre-operative flat keratometry was 42.98±0.78 D, and the mean pre-operative steep keratometry was 44.24±0.78 D. On the other hand, the mean post-operative flat keratometry was 42.99±0.79 D, and the mean post-operative steep keratometry was 43.84±0.74 D.

Conclusion: Clear corneal incision during cataract surgery flattens the cornea in the meridian of the incision, which potentially lessens pre-existing astigmatism. This method can reduce glass dependence among patients in secondary hospitals with no available toric intraocular lenses.

Keywords: Astigmatism; cataract surgery; keratometry; management of astigmatism; steep axis.

Cataract surgery is one of the most commonly performed surgeries in the world. Advances in refractive surgery have increased the efficacy of refractive disorder treatment. This led to the increased expectations of patients in unsupported best-corrected visual acuity post-operative cataract surgery. It is aimed at achieving post-operative spherical correction in cataract surgeries and reducing or eliminating pre-operative astigmatism in each patient.[1,2] To obtain satisfactory refractive results for the patient after cataract surgery, it is important to correct previous spherical defects using accurate biometry and intraocular lens (IOL) power calculation and to manage corneal astigmatism defects using an appropriate method before cataract surgery.[3]

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During cataract surgery, various methods are employed to reduce pre-existing astigmatism. These methods include placement of phacoemulsification incision on the corneal steep axis, corneal and limbal relaxing incisions, and implantation of a toric IOL.[1,4-7] These methods can be used alone or in combination to correct astigmatism. Because each method has its own advantages and disadvantages, the ideal method varies from person to person.

It has been observed that clear corneal incisions can reduce pre-existing astigmatism by flattening the cornea if the incision is placed along the steep corneal axis.[4] In patients with corneal astigmatism value <1 diopter (D), the preferred approach is to place the phacoemulsification incision on the steep corneal meridian.[8] It has been demonstrated that incisions as small as 2.4 mm flatten the cornea up to 0.5 D in the axis of insertion. To correct more astigmatism, longer incisions may be used.[9,10] Some studies have reported that surgery-induced astigmatism of 0.5 D can be induced by a 3.2 mm clear corneal phacoemulsification incisions.[11]

In this study, the extent of change made in corneal astigmatism compared with the pre-operative was examined by making a keratometric corneal incision on the steep axis in cataract surgery.

Materials and Methods

This study included 50 patients aged between 50 and 80 years who underwent cataract surgery in a secondary hospital where toric IOLs were not available. Careful refraction and keratometric measurements were performed preoperatively. The patients' pre- and post-operative astigmatism values were retrospectively analyzed. Corneal astigmatism was included, whereas lenticular astigmatism was excluded.

Patients with irregular astigmatism, a history of corneal pathology and corneal or intraocular surgery, and ocular inflammation were excluded from the study. Before the cataract surgery, the patients underwent complete ophthalmic examination, manifest and cycloplegic refraction examination, and Goldmann applanation tonometry. The results of the patients' pre- and post-operative examinations were retrospectively examined at the 1st-month control.

Corneal astigmatism analysis was conducted using KR-1 auto kerato-refractometer (Topcon). This system detects automatic measurement of the eye's central keratometry (flat and steep axes). Measurements were performed 3 times by the same experienced technician. The patients' keratometric steep axis was recorded.

The same surgeon performed the surgeries and used the same hand. The corneal incision was made approximately 0.2 mm anterior to the edge of the limbal vessels using a 2.8-mm disposable blade. In all patients, a single-piece, foldable, hydrophobic acrylic IOL was inserted through the 2.8-mm main corneal incision. All surgeries were completed without sutures and complications.

The present study was conducted in accordance with the Declaration of Helsinki and was approved by the research ethics committee (Decision date: February 07, 2023, No: 2023/01-01).

Statistical analyses were conducted using SPSS version 22. Descriptive statistics were presented using mean and standard deviation for numerical variables and numbers and percentages for categorical variables. Normal distribution of the data was tested using the Kolmogorov–Smirnov. Student's t-test was used for statistical analysis. The overall error level of type 1 was set at 5% for statistical significance.

Results

The patients included in this study had a mean age of 67.9±6.7 years, and 24 (48%) and 26 (52%) of them were men and women, respectively. Furthermore, 56% of them were operated on the right eye and 44% on the left eye.

The patients' demographic and keratometric data are presented in Table 1. After surgery, the best-corrected visual acuity of the patients was 20/20. Their mean keratometric steep axis was 108.6°±34.9°. The pre-operative corneal astigmatism value of the patients was 1.24±0.7 D, whereas the post-operative corneal astigmatism was 0.83±0.58 D (Fig. 1). Comparing the values before and after cataract

Table 1. Demographic characteristics of patients

Characteristics	Value
Patients (n)	50
Mean age (years)	67.9±6.7
Range of age (years)	52–80
Gender (male/female)	26/24
Best-corrected visual acuity (Snellen)	20/20
Mean pre-operative corneal astigmatism (Diopter)	1.24±0.7
Mean steep axis (Degree)	108.6±34.9
Mean post-operative corneal astigmatism (Diopter)	0.83±0.58
Mean pre-operative keratometry (Diopter)	
Flat keratometry (Diopter)	42.98±0.78
Steep keratometry (Diopter)	44.24±0.78
Mean post-operative keratometry (Diopter)	
Flat keratometry (Diopter)	42.99±0.79
Steep keratometry (Diopter)	43.84±0.74
Change in astigmatism (Diopter)	0.41±0.25

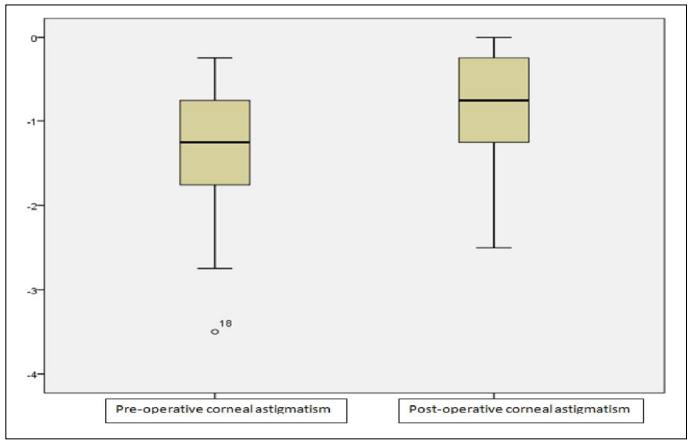

Fig. 1. Comparison of pre-operative corneal astigmatism and post-operative corneal astigmatism.

surgery, a difference of 0.41±0.25 D was observed, which was statistically significant ($p<0.001$). The mean pre-operative flat keratometry value was 42.98±0.78 D, and the mean pre-operative steep keratometry value was 44.24±0.78 D. On the other hand, the mean post-operative flat keratometry value was 42.99±0.79 D, and the mean post-operative steep keratometry value was 43.84±0.74 D.

Discussion

The increasing efficacy of refractive surgery in treating refractive disorders improved patients' expectations in unsupported best-corrected visual acuity post-operative cataract surgery. Corneal incisions made on the steep axis during cataract surgery reduce corneal astigmatism and relieve the need for glasses postoperatively. On-axis incisions are a very basic approach for corneal astigmatism correction. This study aimed to investigate the extent of change in astigmatism following cataract surgery without the use of toric IOLs.

A corneal astigmatism value of 0.75 D or higher after cataract surgery can lead to symptomatic blurring of vision, image ghosting, reduced uncorrected visual acuity, and halos.[12] To be free from the use of glasses, patients need to have an astigmatism value of 0.50 D or less postoperatively.[13] Astigmatism in one eye mainly includes anterior corneal astigmatism and lenticular astigmatism. It does not play a role after cataract surgery unless there is a complication, such as lenticular astigmatism, intraoperative zonular separation, vitreous prolapse, or viscoelastic involvement causing IOL curvature.[2,14]

The occurrence of corneal astigmatism after cataract surgery depends on the location, configuration, and size of the cataract incision; the presence or absence of wound suture; the optical center of the cornea; and the surgical approach.[15,16] Most surgeons performing cataract surgery make a clear corneal phacoemulsification incision at the steepest point of the corneal meridian.[17] It has been observed that if the corneal incision is placed along the steep corneal axis, it flattens the cornea and reduces residual astigmatism.[4] To strengthen the flattening effect of the clear corneal incision, the incision needs to be larger.[18,19] The more central the incision, the stronger its flattening effect in that meridian. Short tunnels have been observed to exert a stronger flattening effect than long tunnels in penetrating incisions.[7,19] A study by Kaufmann et al. reported that a limbal relaxing incision was superior to the vertical-axis incision in correcting more than 1.5 D of astigmatism during cataract surgery.[20] For corneal astigmatism of up to 3 D, one or two peripheral corneal relaxing incisions can be used. Alternatively, a toric IOL can be implanted for corneal astigmatism of up to 4 D. Patients with astigmatism of 4.5–7 D can undergo a toric IOL implantation and peripheral corneal relaxing incision placement.[3]

It has been observed that superior corneal and scleral incisions cause more changes in corneal astigmatism than temporal incisions. Furthermore, there was a less astigmatic change in the temporal incision and higher surgery-induced astigmatism in the nasal incision.[8]

It is estimated that approximately 50% of individuals aged above 60 years have an astigmatism value of more than 1.0 D.[21] Ninn-Pedersen et al. reported that approximately 22% of patients who underwent cataract surgery had pre-existing corneal astigmatism of 1.5 D or higher.[22] Another study found that approximately 35%–40% of patients who underwent cataract surgery had astigmatism of more than 1.0 D and that 19%–22% of them had astigmatism of more than 1.5 D.[5,23] The pre-operative corneal astigmatism in our study population was found to be 1.24±0.7 D.

Corneal astigmatism of up to 1 D can be corrected by making a clear corneal incision on the steep axis. Incisions as small as 2.4 mm have been shown to flatten the cornea by up to 0.5 D in the axis where they are placed. Correction of high astigmatism value can be achieved by longer incisions.[9,10] Previous studies have demonstrated that a corneal phacoemulsification incision of 3.2 mm results in an astigmatism of 0.5 D due to surgery.[11] Furthermore, some studies have reported that an incision made on the steep axis can reduce pre-operative astigmatism by 1–2 D, depending on several factors.[24-26] In our study, a difference of 0.41±0.25 D was observed in astigmatism

in the 2.8-mm corneal incision made on the steep axis. A similar study using keratometric findings found that the mean pre-existing corneal astigmatism decreased from 2.6 D (±1.2) to 1.4 D (±0.9) postoperatively.[26] In our study, it decreased from 1.24±0.7 D to 0.83±0.58 D.

Hashemi et al. reported that the mean flat keratometry value between the ages of 51 and 60 years was 43.19 D and that the mean steep keratometry value was 44.10 D. Between the ages of 61 and 70 years, the mean flat keratometry value was 43.43 D and the mean step keratometry value was 44.51 D. For individuals aged 70 and above, the mean flat keratometry value was 43.10 D and the mean steep keratometry value was 44.56 D.[27] In our study, the mean pre-operative flat keratometry value was 42.98±0.78 D and the mean pre-operative steep keratometry value was 44.24±0.78 D.

The limitations of this study are the limited number of cases and its retrospective nature. In light of all these findings, prospective, long-term, multicenter, and more comprehensive studies are warranted.

Conclusion

A clear corneal incision made on the steep axis in cataract surgery flattens the cornea in the incision meridian and can therefore reduce pre-existing astigmatism. Furthermore, keratometric placement of the incision on the steep axis during phacoemulsification is one of the most frequently used methods to reduce astigmatism after cataract surgery and to ensure glass independence. This method can reduce glass dependence among patients in secondary hospitals with no available toric IOLs.

Ethics Committee Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Tepecik Training and Research Hospital (Decision date: 07.02.2023, No: 2023/01-01).

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References

1. Amesbury EC, Miller KM. Correction of astigmatism at the time of cataract surgery. Curr Opin Ophthalmol 2009;20:19–24.
2. Núñez MX, Henriquez MA, Escaf LJ, Ventura BV, Srur M, Newball L, et al. Consensus on the management of astigmatism in cataract surgery. Clin Ophthalmol 2019;13:311–24. [CrossRef]
3. Grunstein LL, Miller KM. Astigmatism management at the time of cataract surgery. Expert Rev Ophthalmol 2011;6:297–305.
4. Buckhurst PJ, Wolffsohn JS, Davies LN, Naroo SA. Surgical correction of astigmatism during cataract surgery. Clin Exp Optom 2010;93:409–18. [CrossRef]
5. Ferrer-Blasco T, Montés-Micó R, Peixoto-de-Matos SC, González-Méijome JM, Cerviño A. Prevalence of corneal astigmatism before cataract surgery. J Cataract Refract Surg 2009;35:70–5. [CrossRef]
6. Taneja M. Management of astigmatism in cataract. Delhi J Ophthalmol 2015;25:252–8. [CrossRef]
7. Roberts TV. Cataract Surgery in Diseased Eyes. London: JP Medical Ltd.; 2014.
8. Altan-Yaycioglu R, Akova YA, Akca S, Gur S, Oktem C. Effect on astigmatism of the location of clear corneal incision in phacoemulsification of cataract. J Refract Surg 2007;23:515–8.
9. Ernest P, Hill W, Potvin R. Minimizing surgically induced astigmatism at the time of cataract surgery using a square posterior limbal incision. J Ophthalmol 2011;2011:243170.
10. Khokhar S, Lohiya P, Murugiesan V, Panda A. Corneal astigmatism correction with opposite clear corneal incisions or single clear corneal incision: Comparative analysis. J Cataract Refract Surg 2006;32:1432–7. [CrossRef]
11. Gross RH, Miller KM. Corneal astigmatism after phacoemulsification and lens implantation through unsutured scleral and corneal tunnel incisions. Am J Ophthalmol 1996;121:57–64. [CrossRef]
12. Nichamin LD. Astigmatism control. Ophthalmol Clin North Am 2006;19:485–93.
13. Rubenstein JB, Raciti M. Approaches to corneal astigmatism in cataract surgery. Curr Opin Ophthalmol 2013;24:30–4. [CrossRef]
14. Prasher P, Sandhu JS. Prevalence of corneal astigmatism before cataract surgery in Indian population. Int Ophthalmol 2017;37:683–9. [CrossRef]
15. Kohnen S, Neuber R, Kohnen T. Effect of temporal and nasal unsutured limbal tunnel incisions on induced astigmatism after phacoemulsification. J Cataract Refract Surg 2002;28:821–5.
16. Ermis SS. Surgically induced astigmatism after superotemporal and superonasal clear corneal incisions in phacoemulsification. J Cataract Refract Surg 2003;30:1316–9. [CrossRef]
17. Holladay JT, Cravy TV, Koch DD. Calculating the surgically induced refractive change following ocular surgery. J Cataract Refract Surg 1992;18:429–43. [CrossRef]
18. Hayashi K, Hayashi H, Nakao F, Hayashi F. The correlation between incision size and corneal shape changes in sutureless cataract surgery. Ophthalmology 1995;102:550–6. [CrossRef]
19. Devgan BU. Corneal Correction of Astigmatism During. United States: CRST International; 2007. p. 41–3.

20. Kaufmann C, Peter J, Ooi K, Phipps S, Cooper P, Goggin M, et al. Limbal relaxing incisions versus on-axis incisions to reduce corneal astigmatism at the time of cataract surgery. J Cataract Refract Surg 2005;31:2261–5. [CrossRef]
21. Vitale S, Ellwein L, Cotch MF, Ferris FL 3rd, Sperduto R. Prevalence of refractive error in the United States, 1999-2004. Arch Ophthalmol 2008;126:1111–9. [CrossRef]
22. Ninn-Pedersen K, Stenevi U, Ehinger B. Cataract patients in a defined Swedish population 1986-1990. II. Preoperative observations. Acta Ophthalmol (Copenh) 1994;72:10–5. [CrossRef]
23. Khan MI, Muhtaseb M. Prevalence of corneal astigmatism in patients having routine cataract surgery at a teaching hospital in the United Kingdom. J Cataract Refract Surg 2011;37:1751–5.
24. Beltrame G, Salvetat ML, Chizzolini M, Driussi G. Corneal topographic changes induced by different oblique cataract incisions. J Cataract Refract Surg 2001;27:720–7. [CrossRef]
25. Dam-Johansen M, Olsen T, Theodorsen F. The long-term course of the surgically-induced astigmatism after a scleral tunnel incision. Eur J Implant Refract Surg 1994;6:337–43.
26. Ben Simon GJ, Desatnik H. Correction of pre-existing astigmatism during cataract surgery: Comparison between the effects of opposite clear corneal incisions and a single clear corneal incision. Graefes Arch Clin Exp Ophthalmol 2005;243:321–6. [CrossRef]
27. Hashemi H, Yekta A, Shokrollahzadeh F, Aghamirsalim M, Ostadimoghaddam H, Hashemi A, et al. The distribution of keratometry in a population based study. J Curr Ophthalmol 2021;33:17–22.