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| RESEARCH ARTICLE

Topographic Changes in Superior Corneal Incision versus Temporal Corneal Incision in Cataract Surgery: A Comparative Study

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| ABSTRACT
Cataract surgery is the most common surgical procedure globally, impacting around 95 million individuals. Age-related degeneration and other eye and general disorders can affect patients' visual prognosis. Pentacam, a Scheimpflug imaging device, can help assess fully developed swollen cataracts and determine suitable surgical approaches. Current methods neglect posterior corneal astigmatism, leading to limited studies on posterior corneal shape changes after cataract surgery. Corneal topography and smaller incision sizes can help reduce SIA and improve refractive outcomes. The study aims to compare the topographic corneal changes after cataract surgery with superior versus temporal incision. The study involved 40 patients with age-related cataracts and corneal astigmatism who underwent phacoemulsification at a Benghazi teaching eye hospital. The procedure involved a main 2.6-mm clear corneal incision, paracentesis incision, and injection of DisCoVisc into the anterior chamber. The patients were divided into two groups based on the incision site. The study found no significant differences in preoperative biometrics, but there was a significant improvement in uncorrected visual acuity post-operatively in both superior and temporal incision groups. Corneal astigmatism also showed a significant increase in both groups. The mean visual acuity decreased slightly one month after surgery but stabilized at three months. Refractive measurements showed a slight improvement in the diopter sphere from preoperative to one month postoperative but no significant change. The study suggests the surgery had a significant impact on measurements taken, indicating a successful outcome. Superior incision placement and temporal incision selection can improve surgical outcomes and refractive outcomes in ICL surgery.

| KEYWORDS

Topographic Changes; Superior Corneal Incision; Temporal Corneal Incision; Cataract Surgery

| ARTICLE INFORMATION

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1. Introduction

Cataract surgery is the most common surgical procedure globally, with research on intraocular lenses (IOLs) primarily focusing on early postoperative visual acuity(Hecht, 2023).

Cataracts impact around 95 million individuals globally (Liu, 2017). Researchers have calculated that 47.8% of persons over the age of 50 have cataracts (Resnikoff, 2002). Both anterior and posterior pole ocular degeneration are age-related (Patoni, 2021). In addition, the visual prognosis of patients might be affected by other eye and general disorders, which can have a substantial impact on the structures of the eye and ocular surgery (Stanca, 2020; Teodoru, 2023).

The global prevalence of cataract surgery, now the sole treatment available, has steadily risen in correlation with the average lifespan of the general populace, making it the most prevalent ophthalmic surgical procedure in numerous nations(Teodoru, 2023).

Precise preoperative assessment and strategic planning are crucial to ensure a favorable surgical outcome and mitigate the likelihood of complications. Within this particular framework, the assessment of fully developed swollen cataracts using Pentacam might serve as a crucial instrument to enhance its influence on surgical precautions(Daya, 2020).

The Pentacam is a Scheimpflug imaging device that allows for the analysis of the anterior portion of the eye using high-resolution three-dimensional pictures. The Pentacam provides a detailed assessment of the density, location, and shape of the cataract. Offering accurate data on the specific degree of opacity of the lens and its impact on the lens structure aids surgeons in determining suitable surgical approaches(Chang,2016).

Sutureless clear corneal incisions (CCI) have become standard since 1990 to minimize postoperative astigmatism and promote visual rehabilitation. However, corneal surgically-induced astigmatism still occurs, with severity depending on the incision's length, width, and site. Precise estimation of corneal power and astigmatism is critical for anterior segment refractive surgery. Current methods neglect the contribution of posterior corneal astigmatism, leading to limited studies on posterior corneal shape changes after cataract surgery(Piao, 2020).

Corneal degeneration can impact the structure of the corneal extracellular matrix , which in turn can alter wound healing and corneal topographic measurements following cataract surgery(Resch, 2008).

Minor alterations in the surface topography might have a negative impact on visual acuity. Corneal topography is a precise and consistent approach that assesses the curvature of the cornea and its refractive power (and can determine the degree of surgically induced astigmatism). Additional parameters, such as the surface regularity index (SRI) and the surface asymmetry index (SAI), along with the calculated potential visual acuity (PVA), offer a more comprehensive assessment of the corneal surface (Resch, 2008)

Previous studies have shown that smaller incision sizes help in reducing the SIA and

provide better refractive outcomes (Resch, 2008; Sharma, 2023; Sheoran, 2022).

The study aims to compare the topographic corneal changes after cataract surgery with superior versus temporal incision.

2. Subject and methods

Study design: prospective observational study

Study setting: Benghazi Teaching Eye Hospital. From December 2023 to April 2024.

Sample size: The study involved 40 eyes from 40 patients who underwent phacoemulsification

Inclusion criteria: All patients were diagnosed with age-related cataracts with corneal astigmatism .

Exclusion criteria The study excluded cases with previous ocular surgery, surgical complications, and corneal or macular pathology.

Ophthalmologic examinations:

i. Refraction, Unaided visual acuity (UAVA), and best corrected visual acuity (BCVA),
ii. Slit-lamp biomicroscopy,
iii. Intraocular pressure was measured using Goldman tonometry.
iv. Dilated Fundus examination.
v. corneal topography
vi. IOL biometry Surgical procedure

The procedure involved patients being divided into two groups based on the incision site: temporal and superior. All the surgeries were performed by surgeon Dr. H. E, associate professor of ophthalmology, under topical anesthesia with BENOX (Benoxinate hydrochloride) 0.4% sterile ophthalmic solution 1o ml: After pupils were dilated with Tropicamide Phenylephrine Eye Drops. A main 2.6-mm clear corneal incision was made, followed by a 1-mm paracentesis incision that spaced 90 degrees from the main incision. Once DisCoVisc (sodium chondroitin sulfate-sodium hyaluronate, Alcon, USA) was injected into the anterior chamber, a capsulorhexis was performed in a 5.0–6.0-mm diameter circle. Then, a hydro dissection with a balanced salt solution was performed. Phacoemulsification and aspiration were performed using the CENTURION vision system phacoemulsification platform. After the complete removal of the lens, the capsular bag and anterior chamber were injected with DisCoVisc. A foldable intraocular lens, which aimed for postoperative refraction between 0 and − 0.50 diopters, was injected into the capsular bag through the main incision. After the DisCoVisc was removed, the incisions were hydrated with a balanced salt solution.

In order to evaluate the M-SIA and SVM-SIA, we used vector analysis and the astigmatism double-angle plot tool from the American Society of Cataract and Refractive Surgery's website (https://ascrs.org/tools/astigmatism-double-angle-plot-tool) (Abulafia, 2018) to display the individual SIA distributions. Following the same procedure as before, we also measured the flattening effect along the meridian of the incision, with a positive value indicating a flattening and a negative value of a steepening(Alpins, 1997).

Statistical analysis: Data were collected, tabulated, and analyzed using the SPSS program, version 23; continuous variables will be presented as mean values -/+ standard deviation (SD), and categorical variables will be presented as percentages.

The normality of all data samples was first checked using the Shapiro-Wilk test. Then, since the data fulfilled the criteria for normal distribution, the paired t-test was used for statistical analysis to compare pre-and post-surgical data. Unless otherwise Mann–Whitney U, The Friedman test indicated, the results are expressed as mean ± standard deviation, and a value of $P < 0.05$ was considered statistically significant.

3. Results

Table 1 shows the preoperative demographics of the study population. We found no significant differences in the preoperative biometrics, such as age ($P = 0.5$), sex ($P=0.5$), or past medical history uncorrected (0.376).

There was a statistical significance for preoperative Uncorrected visual acuity ($P = 0.04$*); there was a significant improvement in uncorrected visual acuity in both the superior and temporal incision groups post-operatively ($P = 0.211$),

corneal astigmatism (0.513)., or mean keratometry k1 and k2 ($P = 0.817$, 0.192) respectively, between the temporal and superior incision groups. Table 3 shows the visual and refractive outcomes of the cataract surgery for the temporal and superior incision patient groups.

Figures 1 and 2 show preoperative and postoperative corneal astigmatism in magnitude and double angle plots for displaying individual SIA distributions, respectively, in the temporal and the superior incision groups. In the temporal incision group, the magnitude of corneal astigmatism was significantly increased, from 2.36 (9.72) diopter (D) preoperatively to 0.98 (0.84) D postoperatively (Friedman test, $P < 0.789$). The M-SIA was 0.48 ± 0.30 D, and the SVM-SIA was 0.23 ± 0.52 D at a meridian of 82°. The flattening effect was 0.43 ± 0.51 D.

Furthermore, in the superior incision group, the magnitude of corneal astigmatism showed a similar trend, with a decrease from 2.54 (1.02) D preoperatively to 1.12 (0.91) D postoperatively (Wilcoxon signed-rank test, $P < 0.675$). The M-SIA was 0.54 ± 0.25 D, and the SVM-SIA was 0.31 ± 0.48 D at a meridian of 78°. The flattening effect was 0.42 ± 0.49 D.

In the temporal incision group, The M-SIA was 0.52 ± 0.28 D, and the SVM-SIA was 0.39 ± 0.45 D at a meridian of 75°. The flattening effect for the temporal group was 0.41 ± 0.47 D.

There was a significant improvement in uncorrected visual acuity in both the superior and temporal incision groups post-operatively. The mean visual acuity for both groups decreased slightly one month after surgery but then stabilized at three months with no significant difference between the two incision sites ($P>0.05$) (Table 2).

The refractive measurement for the right eye revealed a slight improvement in the diopter sphere from preoperative to one month postoperative, with a decrease from 0.65 to -0.12, but no significant change. Cylinder diopter measurements also showed a slight decrease but not statistically significant. A slight decrease in the K1 preoperative score was observed, but a more noticeable decrease at three months postoperative, suggesting a decline in cognitive function. No significant difference in K2 measurements was found between preoperative and one month postoperative, but a slight increase in K2 measurements at three months postoperative. The differences in measurements were not statistically significant, but a significant difference in K2 measurements was found between one month and three months postoperative.

In summary, the data from the studied left eyes shows a significant improvement in the sphere in diopter one month post-operative, with a P value of 0.004 for the superior incision group; there were significant changes in the measurements taken at three months post-operative compared to preoperative values. Specifically, there was a noticeable difference in the K1 and K2 values, with a P value of(0.020, <0.001), (0.008,0.001) respectively. These findings suggest that the surgery had a significant impact on the measurements taken, indicating a successful outcome for the patients involved in the study. Further analysis is needed to fully understand the implications of these results and their potential impact on future surgical procedures.

Table 1. Baseline characteristics of the two groups

Character	Temporal	Superior	P value
Mean age (SD)	61.7(9.4)	59.7 (10.7)	0.5
Male	8 (40%)	9 (45%)	0.5
Female	12 (60%)	11(55%)	
Libyan	16(80%)	19(95%)	0.171
Not Libya	4 (20%)	1(5%)	
Benghazi	15 (75%)	16 (80%)	0.5
Outside Benghazi	5 (25%)	4 (20%)	
Positive Past medical history	10 (50%)	12 (60%)	0.376
Right	12 (60%)	9 (45%)	0.264
Left	8 (40%)	11 (55%)	

Table 2. Uncorrected visual acuity pre& post-operative of superior and temporal incision

Measurement	Mean (SD)		P value
	Temporal	Superior	
Pre-operative	0.69 (0.75)	1.13 (0.71)	0.04*
One month post-operative	0.59 (0.19)	0.63 (0.43)	0.231
Three months post-operative	0.59 (0.18)	0.62 (0.43)	0.211
P value	0.072	0.076	

Table 3. Penta cam 4 map refraction preoperative, one month, and three-month post-operative of superior and temporal incision

	Measurement	Mean (SD)		P value
		Temporal	Superior	
K1	Preoperative	43.00 (1.67)	42.24 (1.72)	0.076
	One month post-operative	42.47 (1.47)	41.84 (1.13)	0.102
	Three months post-operative	42.47 (1.47)	41.84 (1.13)	0.102
Difference		-0.54 (1.36)	-0.39 (1.08)	0.817
P value		0.029*	0.009*	
K2	Preoperative	43.84 (1.63)	43.5 (2.27)	0.192
	One month post-operative	43.49 (1.23)	43.07 (1.97)	0.102
	Three months post-operative	41.38 (9.63)	43.07 (1.97)	0.192
Difference		-2.46 (9.41)	-0.45 (1.10)	
P value		0.003*	0.056*	
K max	Preoperative	43.34 (1.64)	41.86 (5.21)	0.183
	One month post-operative	42.98 (1.28)	42.51 (1.26)	0.174
	Three months post-operative	42.96 (1.29)	42.54 (1.26)	0.221

Difference		-0.39 (1.11)	0.68 (4.88)	0.738
P value		0.080	0.004*	
Astigmatism	Preoperative	0.98 (0.84)	1.28 (1.75)	0.698
	One month post-operative	1.13 (0.86)	1.27 (1.85)	0.607
	Three months post-operative	3.34 (9.64)	1.27 (1.85)	0.444
Differences		2.36 (9.72)	-0.02 (0.44)	0.513
P value		0.789	0.623	

Table 4. Refractive measurements before and after cataract surgery, one month, three months post-operative of superior and temporal incision (right eye)

Measurement	Time	Mean (SD)		P value
		Temporal	Superior	
Sphere in diopter.	Preoperative	0.65 (10.95)	0.12 (2.84)	0.478
	One month post-operative	-0.12 (1.49)	0.34 (1.49)	0.478
	Three months post-operative	-0.12 (1.49)	0.34 (1.49)	0.495
Difference		1.54 (3.59)	0.19 (2.18)	0.594
P value		0.264	0.607	
Cylinder in diopter	Preoperative	-0.76 (1.61)	-1.29 (1.89)	0.367
	One month post-operative	-0.93 (1.47)	-1.16 (2.04)	0.788
	Three months post-operative	-0.75 (1.58)	-1.3 (1.93)	0.473
Difference		0.09 (1.35)	-0.04 (1.19)	0.678
P value		0.729	0.695	
Axis in degree	Preoperative	101.32 (38.52)	126.57 (40.89)	**0.014***
	One month post-operative	88.68 (36.89)	116.25 (40.65)	**0.016***
	Three months post-operative	86.32 (40.75)	116.25 (40.64)	0.093
Difference		-15.0 (40.99)	-11.05 (41.25)	0.546
P value		0.368	0.926	
K 1	Preoperative	43.05 (1.71)	42.55 (1.43)	0.508
	One month post-operative	42.58 (2.15)	42.10 (1.26)	0.508
	Three months post-operative	42.58 (2.15)	42.10 (1.26)	0.298
Difference		-0.48 (0.96)	-0.44 (0.79)	0.898
P value		**0.01***	**0.002***	
K2	Preoperative	43.53 (2.15)	43.83 (2.22)	0.811
	One month post-operative	43.53 (2.15)	43.83 (2.22)	0.811
	Three months post-operative	44.08 (1.83)	44.19 (2.13)	0.978
Differences		-0.54 (1.09)	-0.36 (0.62)	0.943
P value		0.189	**0.002***	

Table 5. refractive measurements before and after cataract surgery, one month, three months post-operative of superior and temporal incision (Left eye)

Measurement	Time	Mean (SD)		P value
		Temporal	Superior	
Sphere in diopter.	Preoperative	-2.18 (3.05)	-2.92 (2.42)	0.112
	One month post-operative	-1.68 (2.79)	-1.03 (1.22)	0.574
	Three months post-operative	-1.38 (3.06)	-0.28 (2.016)	0.087
Difference		0.67 (1.46)	1.94 (2.13)	0.100
P value		0.297	**0.004***	
Cylinder in diopter	Preoperative	-0.39 (1.64)	-1.19 (1.28)	0.131
	One month post-operative	-1.29 (1.38)	-1.0 (1.25)	0.803
	Three months post-operative	-1.42 (1.23)	-0.95 (1.56)	0.846
Difference		-0.88 (2.34)	0 (0.88)	0.580
P value		0.767	0.961	
Axis in degree	Preoperative	99.12 (48.19)	95.06 (53.40)	0.960
	One month post-operative	113.95 (45.90)	83.95 (39.28)	0.038*
	Three months post-operative	113.95 (45.90)	80.39 (44.58)	0.033*
Difference		12.06 (64.23)	-16.03 (44.72)	0.085
P value		0.717	**0.020***	
K 1	Preoperative	42.98 (1.85)	42.45(1.94)	0.279
	One month post-operative	42.57 (1.93)	41.97 (1.36)	0.368
	Three months post-operative	42.50 (1.89)	41.97 (1.36)	0.439
Difference		-0.48 (0.90)	-0.48 (1.14)	0.532
P value		**0.001***	**0.002***	
K2	Preoperative	44.16 (1.89)	43.57 (1.99)	0.232
	One month post-operative	43.20 (2.85)	42.63 (2.40)	0.360
	Three months post-operative	43.53 (1.82)	43.09 (1.53)	0.464
Differences		-0.63 (0.91)	-0.48 (0.85)	0.246
P value		**0.008***	**<0.001***	

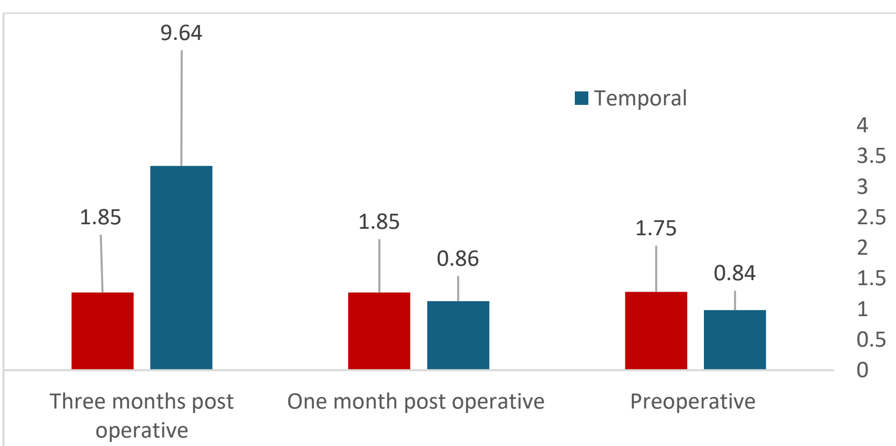

Figure 1 Graph showing the magnitude of corneal astigmatism preoperatively and 3 months postoperatively in the temporal and superior incision groups. The bar represents the standard deviation. D, diopters. *Indicates a statistically significant difference

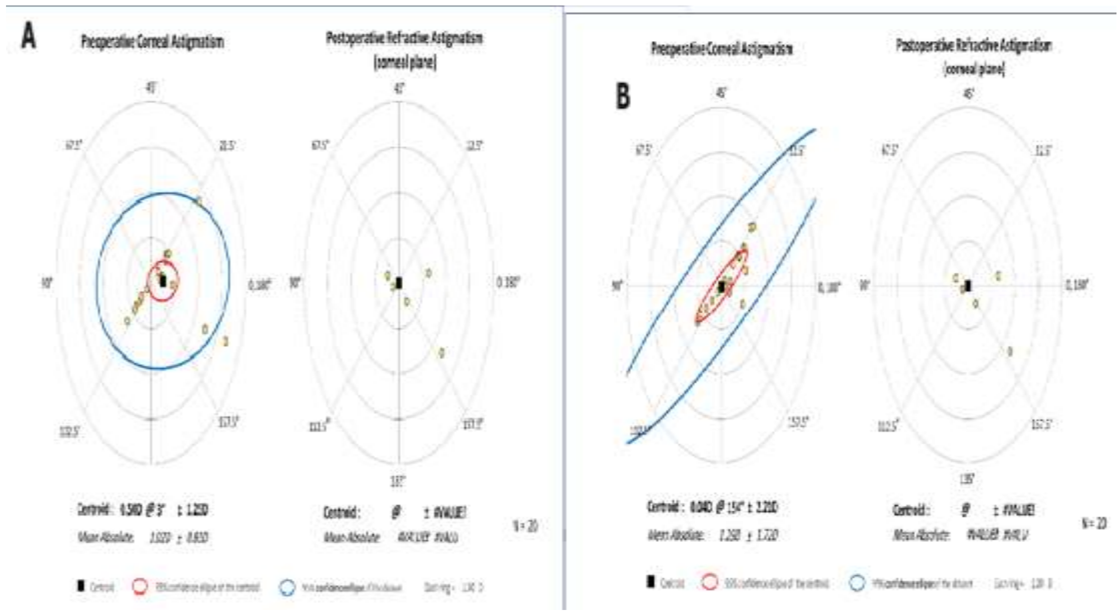

Figure 2 Double-angle plot of the distribution of astigmatism of the anterior, posterior, and total corneal surfaces before cataract surgery. (A) The distribution of preoperative anterior corneal astigmatism (yellow dots). The centroid was 0.5D@3°±1.25D (black block). The mean absolute value was 1.02D±0.83D. (B) The distribution of preoperative posterior corneal astigmatism (yellow dots). The centroid was 0.40D@154±0.2.20D (black block). The mean absolute was 1.25D±1.72D.

4. Discussion

0.98 (0.84)	1.28 (1.75)	0.698
1.13 (0.86)	1.27 (1.85)	0.607
3.34 (9.64)	1.27 (1.85)	0.444
(9.72)	-0.02 (0.44)	0.513
0.789	0.623	

Topography is a useful screening tool for corneal surface irregularities. It can reveal dramatic distortion or irregularity of the mires, potentially changing the approach to surgery. Keratometry has long been the gold standard for assessing astigmatic alterations; however, it is not applicable to peripheral corneal abnormalities or central corneal irregularities (Sanders,1993; Martin, 1993). Optometry and ophthalmology frequently employ computer-assisted video keratography (CVK) to provide comprehensive, detailed, and impartial evaluations of corneal tomography and topography(Joo, 1997). For both healthy and keratoconic eyes(Kosekahya, 2018), the Pentacam biometric system yields accurate readings for topometric indices and corneal power(Kosekahya, 2018). This study is conducted to compare the topographic corneal changes after cataract surgery with superior versus temporal incision.

In addition, there were no significant differences in the preoperative demographics, and were well-matched between the groups, allowing for a more accurate comparison of outcomes post-surgery. Furthermore, the lack of significant differences in past medical history indicates that any potential confounding factors were minimized in this study.

In contrast to the superior approach, which traditionally offers benefits like not requiring the surgeon to adopt a different surgical posture and providing support for the surgeon's hands on the forehead, the temporal approach is more popular among less experienced surgeons because it does not(Sinskey, 1994) Research by Kimura et al.(1999) shows that compared to a superior incision, an oblique incision causes reduced postoperative astigmatism. In the better method, the ATR rate is relatively high. Compared to the superior method, SICS with the temporal approach stabilizes the refraction better while using much less SIA(Ayena, 2015). Since the temporal incision is located farther from the visual axis than the superior incision, any flattening caused by the wound is less likely to impact the corneal curvature at the visual axis, resulting in a minimal amount of WTR astigmatism. Additionally, the incision-inducing ATR is subject to drag from both gravity and the natural retraction of the eyelids when the incision is situated on top. According to the literature, there is a significant rate of ATR astigmatism in superior incisions (Gokhale, 2005). Since it is located farthest from the eye's natural axis of vision, the temporal incision is astigmatically neutral. Unlike the superior incision, which is subject to gravitational pull and the upper lid's massaging action, the temporal incision is free of these complications. Because the incision runs parallel to the force vector, these effects are effectively countered when the incision is placed at the right time (Gokhale, 2005). The benefits of the temporal incision over superior incisions, as mentioned by Malik et al. (2012), include reduced SIA and improved exposure for deep-set eyes. In a study of cataract patients with preoperative ATR astigmatism who underwent temporal approach MSICS, the researchers found an average SIA value of 0.75 ± 0.4067D. In contrast, Edmund Arther et al. (2016) found an SIA value of 1.62 ± 0.90D in a comparable group of patients who had MSICS using the superior approach. They came to the conclusion that the superior-temporal and temporal approaches to MSICS result in better visual quality than the superior approach, which had higher SIA. In a study conducted by Gokhale et al. (2005), it was discovered that superior tunnels for MSICS generate more astigmatism than temporal and superotemporal tunnels. For superior incisions, the mean astigmatism was 1.28D at 2.9°; for superotemporal incisions, 0.20D at 23°; and for temporal incisions, 0.37D at 90°. Contrarily, superotemporal incision is superior to temporal incision because it combines the best features of the two approaches, as reported by Pawar et al. (2012).

The study found that both superior and temporal incision groups showed significant improvement in uncorrected visual acuity postoperatively (P = 0.211), with no discernible effect on visual acuity results. superior groups experienced a reduction in postoperative astigmatism, supporting the idea that the surgical intervention was beneficial. Patients in both groups had comparable visual outcomes after cataract surgery.

Our results demonstrated that the astigmatism changed by about (2.36) and (-0.02) in the temporal and superior incision groups, respectively, after cataract surgery; interestingly, the difference nor the difference between the group neither for the same group was statistically significant before and after the surgery. As for corneal astigmatism, our data revealed that while the superior corneal incision group had a considerable improvement, the temporal incision group saw a marked worsening. This finding is highlighted by Kamiya et al. (2021). This could be due to the fact that the majority of eyes in the former group already had astigmatism before the operation.

The shorter distance between the incision site and the corneal center in the superior incision group compared to the temporal incision group may explain why the astigmatism induced by the surgery in the temporal group is more frequent. This is because a 3.0-mm incision has a more noticeable impact on the former group(Kamiya, 2021). Personal SIA double-angle plots revealed some astigmatism dissimilarities in magnitude and direction, particularly in the temporal incision group.

The data indicates that cataract surgery results in stable and consistent refraction effects for patients. Both superior and temporal incisions can lead to similar visual outcomes.

After all, cataract surgery is one of several refractive procedures that attempts to fix spherical and cylindrical defects to the best of its ability. In order to improve the astigmatic results of toric ICL implantation, we think this information would be straightforward but useful for refractive surgeons and ICL makers.

The accuracy of corneal astigmatism measurements is generally comparable across various methods, but in some cases, keratometry measurements can be inaccurate and different from corneal topography measurements(Sanders, 1993; Roh, 2015). The classic auto keratometer has been shown to significantly influence the accuracy of astigmatism assessment in eyes with corneal irregularities. The shape of the cornea is best estimated using corneal topography and the Pentacam(Kobashi, 2012; Galindo-Ferreiro, 2017).

What follows is a list of the study's limitations. To start, we didn't check for astigmatism in the back of the eye. To determine the exact SIA after cataract surgery, it would be helpful to use a corneal tomographer to measure total corneal astigmatism, even if the quantity of posterior corneal astigmatism is much smaller than that of anterior corneal astigmatism [Martin, 1993, Joo, 1997]. Second, because this was a retrospective study, we couldn't account for the subjects' demographics, which could have introduced sample bias. This sample size may represent the real demographics of individuals requiring ICL surgery, although there were no significant variations in the preoperative demographics. Also, we didn't look at how toric ICLs fared in a clinical context when it came to treating astigmatism. Thus, it is not yet known if these SIA may affect the astigmatic results of toric ICL implantation in a clinical setting. However, we conclude that reducing WTR corneal astigmatism before ICL surgery is therapeutically helpful.

5. Conclusion

Superior and temporal incision placement results in less surgically induced astigmatism (SIA) compared to preoperative time points of the patients; further research is needed to determine the impact of toric ICLs on astigmatic outcomes in clinical settings. Preoperative management of corneal astigmatism can improve surgical outcomes in ICL surgery, optimizing visual outcomes for patients. Factors such as incision placement and toric ICL selection can minimize SIA and improve refractive outcomes. Future studies should explore the effectiveness of these strategies in enhancing the predictability and stability of astigmatic correction with ICLs. Advancements in technology, such as topography-guided treatments and wavefront analysis, can further enhance the accuracy of astigmatism correction with ICLs.

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