Effect of depth of the sclerocorneal incision on postoperative corneal astigmatism in manual small-incision cataract surgery

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Purpose: To determine the effect of depth of scleral tunnel incision measured by anterior segment OCT on postoperative corneal astigmatism by comparing the change of magnitude of corneal astigmatism between superficial and deep sclerocorneal tunnel incision in manual small-incision cataract surgery (SICS). **Methods:** Depths of sclerocorneal incision of 72 eyes of patients undergoing uncomplicated manual SICS and attending regular follow-up schedule were assessed with anterior segment OCT at 6-week post-op follow-up. **Results:** The overall mean ± standard deviation (SD) change of astigmatism for superficial incision, that is, ≤399 μm, was 0.44 ± 0.30 and that for deeper, that is, ≥400 μm, was 0.13 ± 0.48 and the change was significantly higher in ≤399 μm group than in ≥400 μm group (*P* = 0.003). In both superior and temporal incision locations, the mean ± SD change of astigmatism for ≤399 μm incision was 0.48 ± 0.29 and 0.40 ± 0.30, respectively, and that for ≥400 μm was 0.03 ± 0.34 and 0.23 ± 0.57, respectively. The change of astigmatism was significantly higher in ≤399 μm incision group overall (*P* = 0.003) and also higher in both superior and temporal incision location groups (*P* = 0.001 and *P* = 0.479, respectively). **Conclusion:** The depth of sclerocorneal incision had a statistically significant effect on the change of astigmatism following manual SICS, with superficial incision (≤399 μm) causing a higher change than deeper incision (≥ 400 μm).

Key words: Astigmatism, depth of incision, sclerocorneal tunnel, SICS

Cataract surgery, the commonest surgery conducted worldwide for visual rehabilitation, is now considered as a refractive surgery.[1] Improvement in surgical techniques, skills, and comparable postoperative outcome in both phacoemulsification and manual small-incision cataract surgery (SICS) has raised the patient's expectations regarding visual outcome. Spectacle-free good postoperative vision is considered as the normal. Minimal postoperative astigmatism will meet these expectations as high astigmatism is an important cause of poor uncorrected visual acuity after cataract surgery.[2]

Manual SICS through a sclerocorneal tunnel incision is becoming popular[3] as it has the advantages of sutureless wound closure with excellent outcome at lesser cost, lesser surgical time, and less complications,[4,5] but is often discredited for the higher postoperative astigmatism in comparison to phacoemulsification because of a relatively larger incision. Several variables like location, length, width, and shape of sclerocorneal incision determine the postoperative astigmatism.[4]

It is established by various studies that preexisting corneal astigmatism can be modified by changing the site of incision temporally,[6] restricting the size of incision to 4 mm[7] with the shape of incision designed to be inverted V (Chevron) pattern[8] and making the incision at a steeper axis.[9,10] However, the role of depth of sclerocorneal section in inducing post-op

astigmatism or modifying preexisting astigmatism in manual SICSs has not been studied well.

The present study was conducted to determine the effect of depth of scleral tunnel incision measured by anterior segment Optical Coherence Tomography (OCT), on postoperative corneal astigmatism. The change of magnitude of corneal astigmatism between superficial and deep sclerocorneal tunnel incision in SICS was compared by a properly designed study in which the effect of other confounding factors like length, size, and site of incision were made constant to avoid their confounding effect on the result. The site of incision was made either at superior or temporal location depending on the steeper axis, in order to minimize the pre-existing astigmatism.

Methods

One hundred patients selected by non-probability consecutive sampling and advised to undergo SICS at a tertiary eye hospital between April 2021 and June 2021 were enrolled for this study after obtaining written informed consent. Eyes with any other ocular complications like glaucoma or other inflammatory condition or any surgical complications that could alter wound healing were excluded from the study. All patients underwent optical biometry with IOL Master 700,

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and the steeper keratometry (K) value obtained from the IOL Master was considered for choosing incision location. The patients were explained about the purpose of the study, and their consent was taken for documentation and publication of data obtained from the study, as per the ethical principles mentioned in the Declaration of Helsinki.

All patients were operated by a single surgeon with a 4-mm frown-shaped, curved scleral incision located either superiorly or temporally based on the steep K, either between 60° and 120° or between 150° and 30°, respectively. The incision was centered 2 mm from the limbus, and on either end of the frown incision, two 2-mm radial cuts were made to increase the external wound size without inducing much astigmatism. A minimal bipolar cautery was used for hemostasias. Sclerocorneal tunnel extended up to 1.5–2 mm into clear cornea, and the internal incision was made and extended up to 8 mm. The side pockets were created and they were made larger if the nucleus was expected to be large. After the cataract removal, all the patients were implanted with a foldable intraocular lens placed inside the bag. All cases where the wound was compromised in any way were not included for data analysis. The depth of the wound was calculated at 1 week follow-up by doing anterior segment OCT with ANTERION multimodal imaging (Heidelberg Engineering) and the depth was measured at the limbus (sclerocorneal junction). Based on the depth of the incision as obtained from the anterior segment OCT, the patients were divided into two groups for comparison, Group (Superficial) patients in whom the incision was superficial ($\leq$399 µm) and Group (Deep) patients in whom the depth was $\geq$400 µm.

Out of the 100 patients included in the study, 16 cases were excluded because of compromised sclerocorneal wound and 12 cases were excluded for nonadherence to follow-up schedule. Seventy-two patients completed both first week and 6-week follow-up, and their keratometry data was taken for the study and analyzed.

The keratometric cylinder and axes of each cornea were measured preoperatively and at 6 weeks post-op to calculate the surgically induced astigmatism (SIA). The diopter of SIA for each interval was also calculated by the vector analysis method.

Statistical analysis

Data processing and analysis were undertaken by using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 24.0. The associations of categorical variables like age, gender, laterality of eye, and depth of incision were studied by using cross-tabulation procedure and Chi-square test of independence. Comparison of mean ± standard deviation (SD) of age, pre-op and post-op astigmatism, depth of incision, and change of astigmatism was made by using independent sample *t*-test. Even though the sample size has not been calculated a priori, however, the post hoc power analysis was done using the software G*Power 3.1.9.4 for paired sample *t*-test, independent sample Mann–Whitney test, and linear regression analysis used in the study and produced a power of >0.90, which indicated the adequacy of sample size.[11] Comparison of pre-op and post-op astigmatism within each incision location (superior and temporal) was made by using paired sample *t*-test. Comparison of pre-op and post-op astigmatism grouping within each incision location was studied by using nonparametric marginal homogeneity test. Comparison of median (interquartile range [IQR]) of change of astigmatism between both the depths of incision within each incision location was made by using nonparametric Mann–Whitney U test. Relationship of depth of incision to change of astigmatism at each incision location was studied by using linear regression analysis. A cut-off value of $P < 0.05$ was considered as statistically significant.

Results

In the present study, 72 eyes of patients who underwent uncomplicated manual SICS and attended regular follow-up schedule were included for analysis. Out of the 72 eyes, 37 (51.38%) were left eyes and 35 (48.62%) were right eyes

Table 1: Association of variables with incision location

Variables	Classification	Incision location				Total (*N*=72)		*P*
		Superior (*n*=33)		Temporal (*n*=39)				
		No.	%	No.	%	No.	%	
Age group	$\leq$60	13	39.4	8	20.5	21	29.2	0.016#
	61–70	19	57.6	21	53.8	40	55.6	
	>70	1	3	10	25.6	11	15.3	
Gender	Male	21	63.6	24	61.5	45	62.5	0.855#
	Female	12	36.4	15	38.5	27	37.5	
Eye	Right	15	45.5	20	51.3	35	48.6	0.622#
	Left	18	54.5	19	48.7	37	51.4	
Depth of incision	$\leq$399 µm	19	57.6	24	61.5	43	59.7	0.733#
	$\geq$400 µm	14	42.4	15	38.5	29	40.3	
Age in years*		61.8±6.3		66.2±7.5		64.2±7.3		0.009$
Pre-op astigmatism*		0.9±0.6		1.1±0.8		1.0±0.7		0.237$
Depth of incision*		381.7±78.3		378.0±76.0		379.7±76.5		0.839$
Post-op astigmatism*		0.6±0.4		0.7±0.7		0.7±0.6		0.255$
Change of astigmatism*		0.3±0.4		0.3±0.4		0.3±0.4		0.650$

*Mean±SD, #Chi-square *P* value, $independent sample *t* test *P* value

of 27 (37.5%) female patients and 45 (62.5%) male patients. In 33 eyes, the location of incision was superior and in 39 eyes, the location was temporal, decided as per the steep axis meridian. The mean ± SD age of patients was 64.17 ± 7.3, the age range varied from 39 to 85 years, and majority of the patients in both superior and temporal groups belonged to the age group of 60–70 years. The mean ± SD age in temporal group (66.21 ± 7.52) was significantly higher than that of superior incision location (61.76 ± 6.34) ($P = 0.009$). Males were more than females; the right eye and the left eye were evenly distributed in the sample. About 59.7% had an incision depth ≤399 μm and 40.3% had ≥400 μm depth. Gender, eye,

and depth of incision did not have significant association with incision location ($P > 0.05$). The mean ± SD of pre- and post-astigmatism, depth of incision, and change of astigmatism did not differ significantly between superior and temporal incision location ($P > 0.05$) [Table 1].

Table 2 presents comparison of mean pre- and postoperative astigmatism within superior, temporal incision location, and overall as well. The overall mean pre-op astigmatism ± SD was 0.98 ± 0.72, and it significantly reduced to 0.67 ± 0.58 at 6 weeks post-op ($P = 0.000$). In the superior incision group, the mean pre-op astigmatism ± SD was 0.87 ± 0.56, which significantly decreased to 0.58 ± 0.40 at 6 weeks post-op with $P = 0.000$. Similarly, in the temporal group, the mean ± SD pre-op astigmatism was 1.08 ± 0.83, which significantly decreased to 0.74 ± 0.70 post-op ($P = 0.000$).

The pre- and post-astigmatism were classified into four categories, that is, 0.0–≤0.5 D, >0.5–≤1.0 D, >1.0–≤1.5 D, and >1.5 D. In superior incision group, at pre-op, there were seven (21.2%) cases in 0.0–≤0.5 D range of astigmatism, 17 cases (51.5%) in >0.5–≤1.0 D range, and nine cases (27.3%) had more than 1.0 D of astigmatism. At post-op, the corresponding number (%) changed to 19 (57.6%), eight (24.2%), and six (18.2%), respectively. This showed significant improvement in the magnitude of astigmatism post-op over the existing pre-op ($P = 0.002$) values. Likewise, in temporal incision group, at pre-op, there were six (15.4%) cases in 0.0–≤0.5 D range of astigmatism, 15 (38.5%) in >0.5–≤1.0 D range, and 18 (46.1%) had more than 1.0 D of astigmatism. At post-op, the corresponding number (%) changed to 16 (41.0%), 15 (38.5%), and 8 (20.5%). This also showed significant improvement in the magnitude of astigmatism post-op over the pre-op ($P = 0.000$) values. Similarly, as a whole, there was significant improvement in the magnitude of astigmatism post-op over pre-op ($P = 0.000$) values. [Table 3]. The vector analysis conoid is presented in Fig. 1.

About 43.1% cases had change of axis of astigmatism in the range of 0–10°, 45.8% in the range of 11°–20°, and 8.3% in the range of 21°–30° between preoperative and postoperative keratometry values. Only two cases (2.8%) had an axis difference more than 30° and the remaining 70 (97.2%) cases remained within 30°. Thus, the change of axis of astigmatism between pre- and postoperative periods is valid even without beta conversion and vector analysis [Table 4].

Table 5 shows a comparison of change of astigmatism between the depth of incision in both incision location, that is, superior,
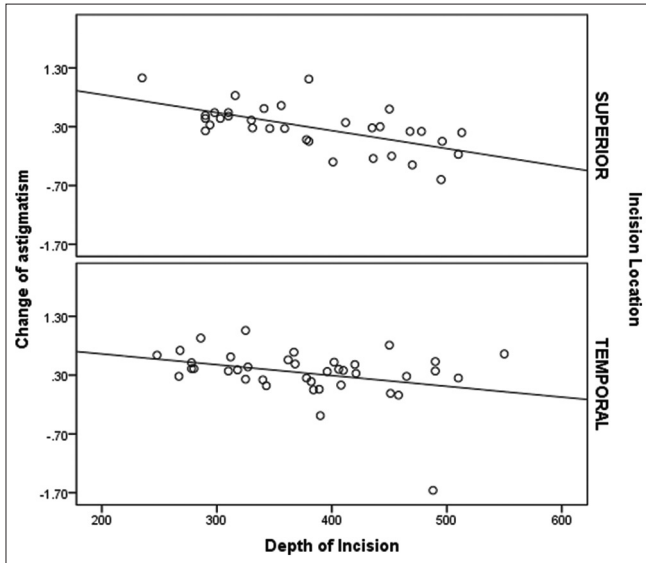

Figure 1 : Scatter plot of depth of incision on change of astigmatism by incision location

Table 2: Comparison of pre op- and post op- astigmatism within incision location

Astigmatism	Total (N=72)	Superior (n=33)	Temporal (n=39)
	Mean±SD	Mean±SD	Mean±SD
Pre-op	0.98±0.72	0.87±0.56	1.08±0.83
Post-op	0.67±0.58	0.58±0.40	0.74±0.70
Paired sample *t* test *P* value	0.000	0.000	0.000

Table 3: Comparison of pre op- and post op- astigmatism within incision location

Astigmatism grouping	Incision location								Total			
	Superior				Temporal							
	Pre-op		Post-op		Pre-op		Post-op		Pre-op		Post-op	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0.0–≤0.5 D	7	21.2	19	57.6	6	15.4	16	41	13	18.1	35	48.6
0.5–≤1.0 D	17	51.5	8	24.2	15	38.5	15	38.5	32	44.4	23	31.9
>1.0–≤1.5 D	6	18.2	5	15.2	10	25.6	6	15.4	16	22.2	11	15.3
>1.5 D	3	9.1	1	3	8	20.5	2	5.1	11	15.3	3	4.2
Total	33	100	33	100	39	100	39	100	72	100	72	100
Marginal homogeneity test *P* value	0.002				0.000				0.000			

temporal, and overall. The depth of incision is divided into two groups, that is, superficial (≤399 μm) and deep (≥400 μm).

Figure 2: pre op- and post op- astigmatic conoid
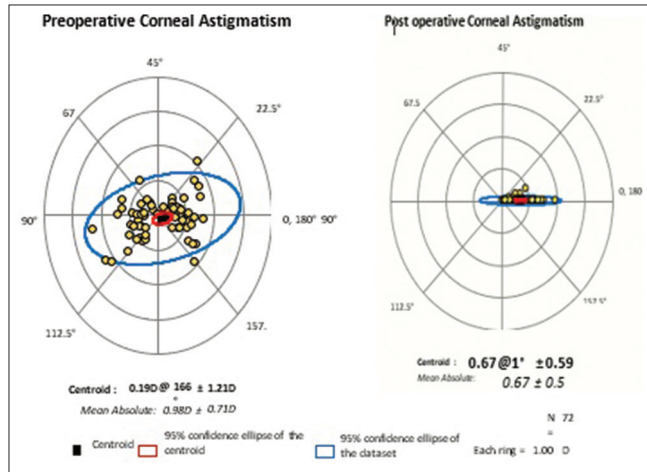
The overall mean ± SD change of astigmatism for ≤399 μm was 0.44 ± 0.30 with median (IQR) of 0.41 (0.25–0.61) and that for ≥400 μμ was 0.13 ± 0.48 with median (IQR) of 0.25 −0.11 to 0.39), and the change was significantly higher in ≤399 μm group than in ≥400 μm group (*P* = 0.003). In superior incision location, the mean ± SD change of astigmatism for ≤399 μm incision was 0.48 ± 0.29 with median (IQR) 0.44 (0.27–0.61) and that for ≥400 μμ was 0.03 ± 0.34 with median (IQR) of 0.13 (−0.26 to 0.29) and the change was significantly higher in ≤399 μm incision group (*P* = 0.001). In temporal incision location, the mean ± SD change of astigmatism for ≤399 μm was 0.40 ± 0.30 with median (IQR) 0.40 (0.22–0.60) and that for ≥400 μm was 0.23 ± 0.57 with median (IQR) of 0.37 (0.13–0.52). Though the difference was not statistically significant (*P* = 0.479), still the change was higher in ≤399 μm incision group in comparison to ≥400 μm group.

The regression analysis of depth of incision on change of astigmatism [Table 6, Fig. 2] revealed that overall, the depth of incision had a regression coefficient of − 0.002 on change of astigmatism, that is, it was significant (*P* = 0.000). R^2 value was 0.207, which implied that 20.7% of variation in the change of astigmatism is explained by the depth of incision. In the superior location, the depth of incision had a regression coefficient of −0.003, R^2 = 0.387, and the regression was significant (*P* = 0.000); 38.7% variation in change of astigmatism is explained by the depth of incision. In the temporal location, the depth of astigmatism had a regression coefficient of −0.002, R^2 = 0.106, and the regression was significant (*P* = 0.043); 10.6% variation in change of astigmatism is explained by the depth of incision. Though the R2 value is less in all the groups, still considering it along with the level of significance (*P* < 0.005) justifies the association between depth of incision and induced post-op corneal astigmatism.

Table 4: Distribution of axis difference by incision location

Axis difference (pre-op–post-op)	Incision location				Total	
	Superior		Temporal			
	No.	%	No.	%	No.	%
0-10	13	39.4	18	46.2	31	43.1
11-20	17	51.5	16	41	33	45.8
21-30	2	6.1	4	10.3	6	8.3
>30	1	3	1	2.6	2	2.8
Total	33	100	39	100	72	100

Table 5: Change of astigmatism between various depths of incision within incision location

Incision location	Depth of incision (μm)	Change of astigmatism			Mann–Whitney *U P*
		n	Mean±SD	Median (IQR)	
Overall	≤399	43	0.44±0.30	0.41 (0.25-0.61)	0.003
	≥400	29	0.13±0.48	0.25 (−0.11 to 0.39)	
Superior	≤399	19	0.48±0.29	0.44 (0.27-0.61)	0.001
	≥400	14	0.03±0.34	0.13 (−0.26 to 0.29)	
Temporal	≤399	24	0.40±0.30	0.40 (0.22-0.60)	0.479
	≥400	15	0.23±0.57	0.37 (0.13-0.52)	

IQR=interquartile range

Table 6: Regression analysis of depth incision on change of astigmatism by incision location

Incision location		Unstandardized coefficients		*t*	R^2	*P*
		B	Std. error			
Overall	(Constant)	1.232	0.219	5.629	0.207	0.000
	Depth of incision	−0.002	0.001	−4.278		0.000
Superior	(Constant)	1.457	0.269	5.416	0.387	0.000
	Depth of incision	−0.003	0.001	−4.426		0.000
Temporal	(Constant)	1.028	0.337	3.048	0.106	0.004
	Depth of incision	−0.002	0.001	−2.098		0.043

Discussion

The present study was conducted with the aim to determine the effect of depth of incision on astigmatism by comparing the change of astigmatism between preoperative and postoperative incision-induced astigmatism resulting from superficial (depth ≤399 µm) and deep (depth ≥400 µm) sclerocorneal incisions, keeping the incision location on steeper keratometric meridian and size of incision and distance from limbus constant in each case, not only to restrict induction of post-op astigmatism to the minimum, but also to prevent the confounding effect of the other variables on incision-induced astigmatism. Placing incisions on the steeper corneal meridian has been recommended during manual small incision cataract surgery (SICS) with the idea that there is flattening of the meridian on which the incision is placed.[12] Hence, with an on-axis incision, there is a reduction in the corneal power of the steeper meridian because of the flattening effect of the incision leading to minimal postoperative corneal astigmatism. In our study also, there is a significant reduction of magnitude of corneal astigmatism after surgery both in superior (P = 0.0230) and temporal (P = 0.0065) locations. The change in axis of astigmatism was also negligible with majority remaining within 30° on either side of the pre-op axis. Restricting the length of incision to 4 mm is also considered to be astigmatically neutral.[7]

Our results showed that by placing the incision at a steeper axis and restricting the length of incision to 4 mm, the postoperative corneal astigmatism was significantly lesser than the preoperative astigmatism (P = 0.000), with a minor change in the axis within 30° in either side. However, the change (decrease) in astigmatism was not same in every case, but there was wide variation signifying presence of another factor contributing to the amount of induced post-op astigmatism. Also, as per our study, the depth of the sclerocorneal incision was found to be impacting a change of astigmatism in a clinically and statistically significant way.

Conclusion

We found a statistically significant effect of depth of sclerocorneal incision on the change of astigmatism following manual SICS, with superficial incision causing a higher change than deeper incision. Hence, in order to have an astigmatically neutral postoperative refraction along with smaller section on the steeper corneal meridian, the depth of the incision can also be planned according to the amount of preoperative astigmatism, and for higher astigmatism, a superficial incision is beneficial and vice versa. Retrospective assessment of depth of sclerocorneal incision is the major limitation of our study. Hence, a prospective, randomized study design with an established method of deciding the depth of the incision during surgery in a larger sample will further establish the validity of our observation.

Conflicts of interest

There are no conflicts of interest.

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